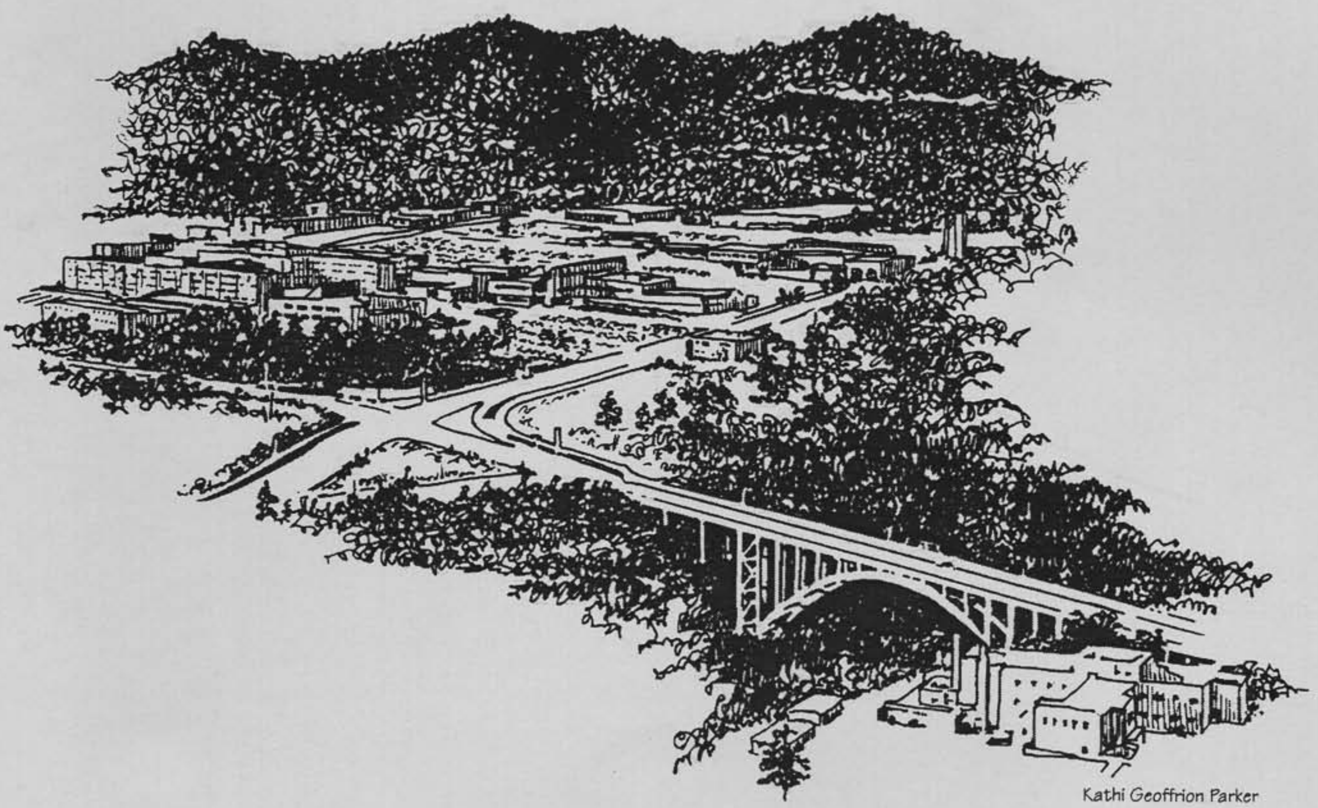
U.S. Department of Energy
Albuquerque Operations Office
Albuquerque, New Mexico

DOE/EIS - 0238
January 1999

Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory

Summary



Kathi Geoffrion Parker

THE LOS ALAMOS NATIONAL LABORATORY SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT PROCESS

The United States Department of Energy (DOE) has a policy (10 Code of Federal Regulations [CFR] 1021.330) of preparing a Site-Wide Environmental Impact Statement (SWEIS) for certain large, multiple-facility sites, such as the Los Alamos National Laboratory (LANL). The purpose of a SWEIS is to provide DOE and its stakeholders with an analysis of the environmental impacts resulting from ongoing and reasonably foreseeable new operations and facilities and reasonable alternatives at the DOE site. The SWEIS analyzes four alternatives for the continued operation of LANL to identify the potential effects that each alternative could have on the human environment.

The SWEIS Advance Notice of Intent, published in the *Federal Register* (FR) on August 10, 1994 (59 FR 40889), identified possible issues and alternatives to be analyzed. Based on public input received during prescoping, DOE published the Notice of Intent to prepare the SWEIS in the *Federal Register* on May 12, 1995 (60 FR 25697). DOE held a series of public meetings during prescoping and scoping to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the SWEIS. An Implementation Plan[1] was published in November 1995 to summarize the results of scoping, describe the scope of the SWEIS based on the scoping process, and present an outline for the draft SWEIS. The Implementation Plan also included a discussion of the issues reflected in public comments during scoping.

In addition to the required meetings and documents described above, the SWEIS process has included a number of other activities intended to enhance public participation in this effort. These activities have included:

- Workshops to develop the Greener Alternative described and analyzed in the SWEIS.
- Meetings with and briefings to representatives of federal, state, tribal, and local governments during prescoping, scoping, and preparation of the draft SWEIS.
- Preparation and submission to the Los Alamos Community Outreach Center of information requested by members of the public related to LANL operations and proposed projects.
- Numerous Open Forum public meetings in the communities around LANL to discuss LANL activities, the status of the SWEIS, and other issues raised by the public.

The draft SWEIS was distributed to interested stakeholders for comment. The comment period extended from May 15, 1998, to July 15, 1998. Public hearings on the draft SWEIS were announced in the *Federal Register*, as well as community newspapers and radio broadcasts. Public hearings were held in Los Alamos, Santa Fe, and Española, New Mexico, on June 9, 1998, June 10, 1998, and June 24, 1998, respectively.

Oral and written comments were accepted during the 60-day comment period for the draft SWEIS. All comments received, whether orally or in writing, were considered in preparation of the final SWEIS. The final SWEIS includes a new volume IV with responses to individual comments and a discussion of general major issues. DOE will prepare a Record of Decision no sooner than 30 days after the final SWEIS Notice of Availability is published in the *Federal Register*. The Record of Decision will describe the rationale used for DOE's selection of an alternative or portions of the alternatives. Following the issuance of the Record of Decision, a Mitigation Action Plan may also be issued to describe any mitigation measures that DOE commits to in concert with its decision.

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1. DOE *National Environmental Policy Act* regulations (10 CFR 1021) previously required that an implementation plan be prepared; a regulation change (61 FR 64604) deleted this requirement. An implementation plan was prepared for this SWEIS.

COVER SHEET

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agency: Incorporated County of Los Alamos

Title: Site-Wide Environmental Impact Statement for the Continued Operation of the Los Alamos National Laboratory, Los Alamos, New Mexico (DOE/EIS-0238)

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Abstract: DOE proposes to continue operating the Los Alamos National Laboratory (LANL) located in Los Alamos County, in north-central New Mexico. DOE has identified and assessed four alternatives for the operation of LANL: (1) No Action, (2) Expanded Operations, (3) Reduced Operations, and (4) Greener. Expanded Operations is DOE's Preferred Alternative, with the exception that DOE would only implement pit manufacturing at a level of 20 pits per year. In the No Action Alternative, DOE would continue the historical mission support activities LANL has conducted at planned operational levels. In the Expanded Operations Alternative, DOE would operate LANL at the highest levels of activity currently foreseeable, including full implementation of the mission assignments from recent programmatic documents. Under the Reduced Operations Alternative, DOE would operate LANL at the minimum levels of activity necessary to maintain the capabilities to support the DOE mission in the near term. Under the Greener Alternative, DOE would operate LANL to maximize operations in support of nonproliferation, basic science, materials science, and other nonweapons areas, while minimizing weapons activities. Under all of the alternatives, the affected environment is primarily within 50 miles (80 kilometers) of LANL. Analyses indicate little difference in the environmental impacts among alternatives. The primary discriminators are: collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand.

Public Comment and DOE Decision: The draft SWEIS was released to the public for review and comment on May 15, 1998. The comment period extended until July 15, 1998, although late comments were accepted to the extent practicable. All comments received were considered in preparation of the final SWEIS[1]. DOE will utilize the analysis in this final SWEIS and prepare a Record of Decision on the level of continued operation of LANL. This decision will be no sooner than 30 days after the Notice of Availability of the final SWEIS is published in the *Federal Register*.

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1. Changes made to this SWEIS since publication of the draft SWEIS are marked with a vertical bar to the right or left of the text.

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ABBREVIATIONS AND ACRONYMS

BNM	Bandelier National Monument
CAA	*Clean Air Act*
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CMIP	Capability Maintenance and Improvement Project
CMR	Chemistry and Metallurgy Research
CT EIS	Conveyance and Transfer of Certain Land Tracts at Los Alamos National Laboratory Environmental Impact Statement
D&D	decontamination and decommissioning
DARHT	Dual Axis Radiographic Hydrodynamic Test (Facility)
DOE	U.S. Department of Energy
EIS	environmental impact statement
ERPG	Emergency Response Planning Guideline
FR	*Federal Register*
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LCF	latent cancer fatality
LEDA	Low-Energy Demonstration Accelerator
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MEI	maximally exposed individual
MeV	million electron volts
MSL	Materials Science Laboratory

MW	megawatt
NA	not applicable
NEPA	*National Environmental Policy Act of 1969*, as amended
NMSF	Nuclear Materials Storage Facility
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
PEIS	programmatic environmental impact statement
PHERMEX	Pulsed High-Energy Radiation Machine Emitting X-Rays
PL	public law
PSSC	project-specific siting and construction
RCRA	*Resource Conservation and Recovery Act*
rem	roentgen equivalent man
ROD	Record of Decision
SCC	Strategic Computing Complex
SHPO	State Historic Preservation Office(r)
SNM	special nuclear material
SSM	Stockpile Stewardship and Management
SWEIS	site-wide environmental impact statement
TA	Technical Area
TCP	traditional cultural property
TRU	transuranic (waste)
TSFF	Tritium Science and Fabrication Facility
TSTA	Tritium Systems Test Assembly
UC	University of California
U.S.	United States

U.S.C.	United States Code
WETF	Weapons Engineering Tritium Facility
WM	waste management

SUMMARY
MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this SWEIS. Definitions of technical terms can be found in volume I, chapter 10, Glossary.

SCIENTIFIC NOTATION

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using scientific notation, as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either right (for a positive power of 10) or left (for a negative power of 10). If the value given is 2.0×10^3, move the decimal point three places (insert zeros if no numbers are given) to the right of its current location. The result would be 2,000. If the value given is 2.0×10^{-5}, move the decimal point five places to the left of its present location. The result would be 0.00002. An alternative way of expressing numbers, used primarily in the appendixes of this SWEIS, is exponential notation, which is very similar in use to scientific notation. For example, using the scientific notation for 1×10^9, in exponential notation the 10^9 (10 to the power of 9) would be replaced by E+09. (For positive powers, sometimes the "+" sign is omitted, and so the example here could be expressed as E09.) If the value is given as 2.0×10^{-5} in scientific notation, then the equivalent exponential notation is 2.0E-05.

UNITS OF MEASUREMENT

The primary units of measurement used in this report are English units with metric equivalents enclosed in parentheses.

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). The following list presents these metric prefixes:

giga	1,000,000,000 (10^9; E+09; one billion)
mega	1,000,000 (10^6; E+06; one million)
kilo	1,000 (10^3; E+03; one thousand)
hecto	100 (10^2; E+02; one hundred)
deka	10 (10^1; E+01; ten)
unit	1 (10^0; E+00; one)
deci	0.1 (10^{-1}; E-01; one tenth)
centi	0.01 (10^{-2}; E-02; one hundredth)
milli	0.001 (10^{-3}; E-03; one thousandth)

micro 0.000001 (10^{-6}; E-06; one millionth)

nano 0.000000001 (10^{-9}; E-09; one billionth)

pico 0.000000000001 (10^{-12}; E-12; one trillionth)

DOE Order 5900.2A, *Use of the Metric System of Measurement*, prescribes the use of this system in DOE documents. Table MC–1 lists the mathematical values or formulas needed for conversion between English and metric units. Table MC–2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

RADIOACTIVITY UNIT

Part of this report deals with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC–3). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit of mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of these.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually expressed in terms of effective dose equivalent and reported numerically in units of rem (Table MC–4). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in Table MC–5.

CHEMICAL ELEMENTS

A list of selected chemical elements, chemical constituents, and their nomenclature is presented in Table MC–6.

TABLE MC–1.—*Conversion Table*

MULTIPLY	BY	TO OBTAIN	MULTIPLY	BY	TO OBTAIN
ac	0.405	ha	ha	2.47	ac
°F	(°F -32) x 5/9	°C	°C	(°C x 9/5) + 32	°F
ft	0.305	m	m	3.28	ft
ft^2	0.0929	m^2	m^2	10.76	ft^2
ft^3	0.0283	m^3	m^3	35.3	ft^3
gal.	3.785	l	l	0.264	gal.
in.	2.54	cm	cm	0.394	in.
lb	0.454	kg	kg	2.205	lb
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
mi	1.61	km	km	0.621	mi
mi^2	2.59	km^2	km^2	0.386	mi^2
mi/h	0.447	m/s	m/s	2.237	mi/h
nCi	0.001	pCi	pCi	1,000	nCi
oz	28.35	g	g	0.0353	oz
pCi/l	10^{-9}	µCi/ml	µCi/ml	10^{9}	pCi/l
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
ppb	0.001	ppm	ppm	1,000	ppb
ton	0.907	metric ton	metric ton	1.102	ton

TABLE MC–2.—*Names and Symbols for Units of Measure*

LENGTH	
SYMBOL	**NAME**
cm	centimeter (1 x 10^{-2} m)
ft	foot
in.	inch
km	kilometer (1 x 10^{3} m)
m	meter
mi	mile
mm	millimeter (1 x 10^{-3} m)
µm	micrometer (1 x 10^{-6} m)
VOLUME	
SYMBOL	**NAME**
cm^3	cubic centimeter
ft^3	cubic foot
gal.	gallon
$in.^3$	cubic inch
l	liter
m^3	cubic meter
ml	milliliter (1 x 10^{-3} l)
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard
RATE	
SYMBOL	**NAME**
Ci/yr	curies per year
cm^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
kg/yr	kilograms per year
km/h	kilometers per hour
mg/l	milligrams per liter
MGY	million gallons per year
MLY	million liters per year
m^3/yr	cubic meters per year
mi/h or mph	miles per hour
µCi/l	microcuries per liter
pCi/l	picocuries per liter

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

NUMERICAL RELATIONSHIPS	
SYMBOL	**MEANING**
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
2σ	two standard deviations
TIME	
SYMBOL	**NAME**
d	day
h	hour
min	minute
nsec	nanosecond
s	second
yr	year
AREA	
SYMBOL	**NAME**
ac	acre (640 per mi^2)
cm^2	square centimeter
ft^2	square foot
ha	hectare (1 x 10^4 m^2)
$in.^2$	square inch
km^2	square kilometer
mi^2	square mile
MASS	
SYMBOL	**NAME**
g	gram
kg	kilogram (1 x 10^3 g)
mg	milligram (1 x 10^{-3} g)
µg	microgram (1 x 10^{-6} g)
ng	nanogram (1 x 10^{-9} g)
lb	pound
ton	metric ton (1 x 10^6 g)
oz	ounce

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

TEMPERATURE	
SYMBOL	**NAME**
°C	degrees Celsius
°F	degrees Fahrenheit
°K	degrees Kelvin
SOUND/NOISE	
SYMBOL	**NAME**
dB	decibel
dBA	A-weighted decibel

TABLE MC–4.—*Names and Symbols for Units of Radiation Dose*

RADIATION DOSE	
SYMBOL	**NAME**
mrad	millirad (1 x 10^{-3} rad)
mrem	millirem (1 x 10^{-3} rem)
R	roentgen
mR	milliroentgen (1 x 10^{-3} R)
μR	microroentgen (1 x 10^{-6} R)

TABLE MC–3.—*Names and Symbols for Units of Radioactivity*

RADIOACTIVITY	
SYMBOL	**NAME**
Ci	curie
cpm	counts per minute
mCi	millicurie (1 x 10^{-3} Ci)
μCi	microcurie (1 x 10^{-6} Ci)
nCi	nanocurie (1 x 10^{-9} Ci)
pCi	picocurie (1 x 10^{-12} Ci)

TABLE MC–5.—*Radionuclide Nomenclature*

SYMBOL	RADIONUCLIDE	HALF-LIFE	SYMBOL	RADIONUCLIDE	HALF-LIFE
Am-241	americium-241	432 yr	Pu-241	plutonium-241	14.4 yr
H-3	tritium	12.26 yr	Pu-242	plutonium-242	3.8×10^5 yr
Mo-99	molybdenum-99	66 hr	Pu-244	plutonium-244	8.2×10^7 yr
Pa-234	protactinium-234	6.7 hr	Th-231	thorium-231	25.5 hr
Pa-234m	protactinium-234m	1.17 min	Th-234	thorium-234	24.1 d
Pu-236	plutonium-236	2.9yr	U-234	uranium-234	2.4×10^5 yr
Pu-238	plutonium-238	87.7 yr	U-235	uranium-234	7×10^8 yr
Pu-239	plutonium-239	2.4×10^4 yr	U-238	uranium-238	4.5×10^9 yr
Pu-240	plutonium-240	6.5×10^3 yr			

TABLE MC–6.—*Elemental and Chemical Constituent Nomenclature*

SYMBOL	CONSTITUENT	SYMBOL	CONSTITUENT
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
Ar	argon	Pu	plutonium
B	boron	SF_6	sulfur hexafluoride
Be	beryllium	Si	silicon
CO	carbon monoxide	SO_2	sulfur dioxide
CO_2	carbon dioxide	Ta	tantalum
Cu	copper	Th	thorium
F	fluorine	Ti	titanium
Fe	iron	U	uranium
Kr	krypton	V	vanadium
N	nitrogen	W	tungsten
Ni	nickel	Xe	xenon
NO_2^-	nitrite ion	Zn	zinc
NO_3^-	nitrate ion		

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SUMMARY

S.1 INTRODUCTION

S.1.1 Background Information

In accordance with the *Atomic Energy Act of 1954* (42 United States Code [U.S.C.] §2011), as amended, and the *Energy Reorganization Act of 1974* (42 U.S.C. §5801), the U.S. Department of Energy (DOE) has responsibilities that have been grouped into four principal missions: national security, energy resources, environmental quality, and science. DOE's responsibilities under these missions are fulfilled through program offices established to manage related aspects of DOE missions. Specific elements of these DOE missions are assigned to DOE sites across the country, including DOE's system of national laboratories. Each of these sites houses facilities established and maintained to support DOE responsibilities. The capabilities established at these facilities also may be used to support other federal agencies, government groups, utilities, universities, and private industry.

The Los Alamos National Laboratory (LANL) is one of DOE's national laboratories. LANL is a multidisciplinary, multipurpose institution engaged in theoretical and experimental research and development. DOE has assigned elements of each of its four principal missions to LANL, and has established and maintains several capabilities in support of these mission elements; these capabilities also support other federal agencies and other organizations in accordance with national priorities and policies. Because the mission elements assigned to LANL are managed by multiple DOE program offices, LANL is referred to as a "multi-program site."

LANL is located in north-central New Mexico, 60 miles (97 kilometers) north-northeast of Albuquerque, 25 miles (40 kilometers) northwest of Santa Fe, and 20 miles (32 kilometers) southwest of Española in Los Alamos and Santa Fe Counties (Figure S.1.1–1). LANL and the surrounding region are characterized by forested areas with mountains, canyons, and valleys, as well as diverse cultures and ecosystems.

The area is dominated by the Jemez Mountains to the west and the Sangre de Cristo Mountains to the east. These two mountain ranges and the State of New Mexico are divided north to south by the Rio Grande. LANL is located on the Pajarito Plateau, a volcanic shelf on the eastern slope of the Jemez Mountains at an approximate elevation of 7,000 feet (2,135 meters). The Pajarito Plateau is cut by 13 steeply sloped and deeply eroded canyons that have formed isolated finger-like mesas running west to east. The Santa Fe National Forest, which includes the Dome Wilderness Area, lies to the north, west, and south of LANL. The American Indian Pueblo of San Ildefonso and the Rio Grande border the site on the east, and the Bandelier National Monument (BNM) and Wilderness Area lie directly south.

A large variety of natural and cultural resources lie within the LANL region. The Pajarito Plateau is one of the longest continually occupied areas in the U.S. The archaeological and historical resources of the LANL site reflect the length of temporal occupation as well as the diversity in the cultures of its occupants. American Indian and Hispanic communities and the ruins of prehistoric cultures surround LANL.

The ecosystems in the region are diverse due to the 5,000-foot (1,525-meter) gradient that extends between the Rio Grande Valley on the eastern edge of LANL and the top of Pajarito Mountain on its western border. Variations in precipitation and temperature and differences in

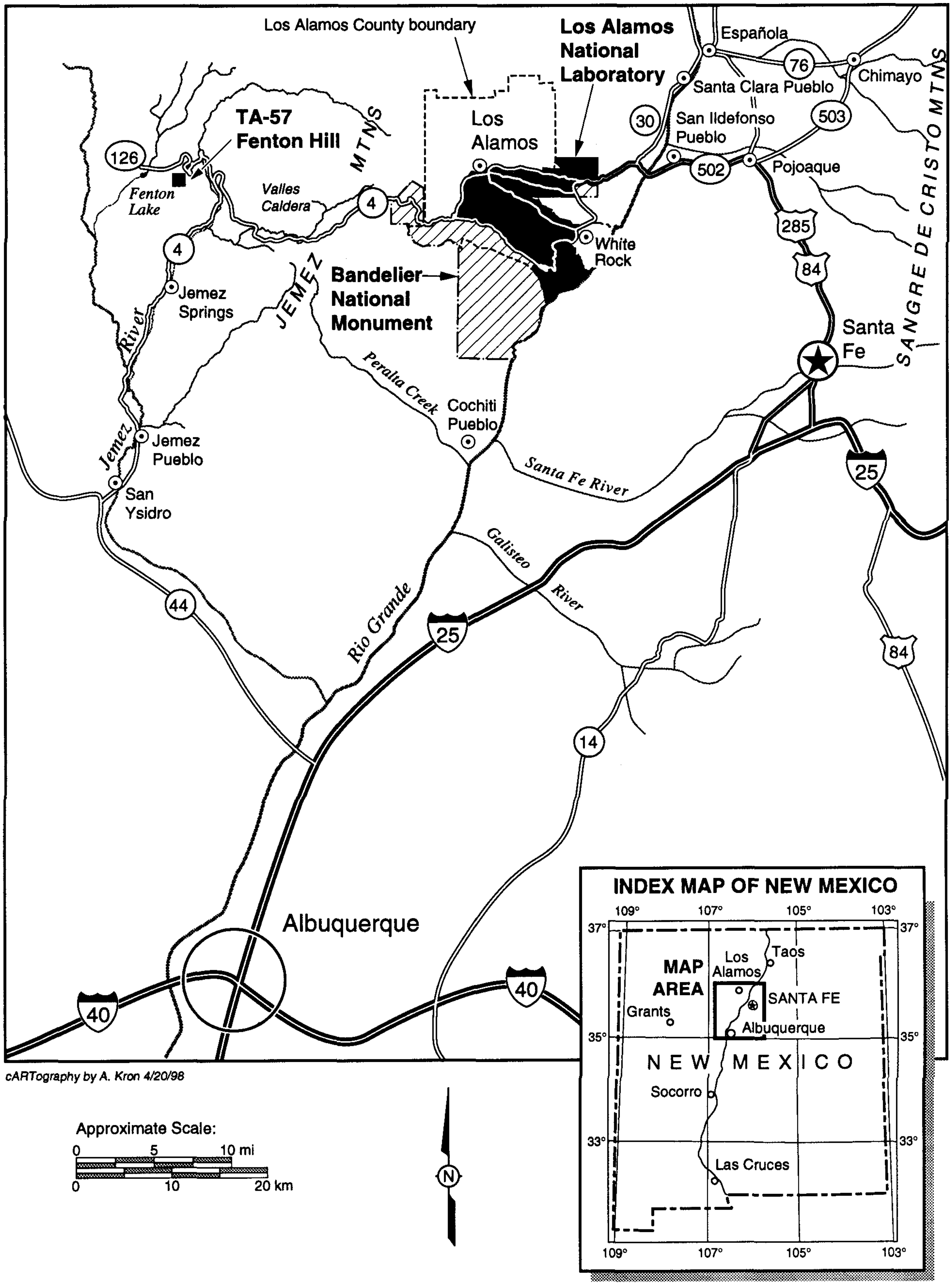

FIGURE S.1.1–1.—*Location of the Los Alamos National Laboratory.*

the amount of sunlight that reach the north-facing and south-facing canyon slopes have resulted in a diversity of plant life, wildlife, and soils.

LANL occupies an area of approximately 27,832 acres (11,272 hectares), or approximately 43 square miles (111 square kilometers), of which 86 percent lies within Los Alamos County and 14 percent within Santa Fe County. The Fenton Hill site (Technical Area [TA]–57), a remote site 20 miles (32 kilometers) west of LANL, occupies 15 acres (6 hectares) in Sandoval County on land leased from the U.S. Forest Service.

DOE performs much of its work through its contractors. The contractor for the operation of LANL is the University of California (UC). The LANL-affiliated workforce includes employees of UC and its subcontractors, of which the major employers are Johnson Controls World Services, Inc., and Protection Technology of Los Alamos. LANL employs both technical and nontechnical subcontractors, as well as consultants on a temporary basis. At the end of March 1996, the LANL-affiliated workforce totaled 12,837.

LANL is divided into 49 separate TAs. These TAs (which are not numbered sequentially) compose the basic geographic configuration of LANL (Figure S.1.1–2 and Table S.1.1–1). LANL has 2,043 structures containing 7.9 million square feet (734,700 square meters), of which 1,835 are buildings, totaling 7.3 million square feet (678,900 square meters). The other structures consist of such items as meteorological towers, pumphouses, water towers, manhole covers, and small storage sheds.

S.1.2 Public Involvement

Under DOE's compliance strategy for the *National Environmental Policy Act of 1969* (NEPA) (42 U.S.C. §4321), a site-wide environmental impact statement (SWEIS) is prepared to examine the environmental impacts of operations at a multi-program site (10 Code of Federal Regulations [CFR] 1021.330). A SWEIS was prepared for the operation of LANL in 1979. That document and subsequent NEPA reviews for specific project or program activities have served as the NEPA basis for operations at LANL since 1979. Changes in the world political situation have the potential to alter the role of and the operations at LANL, as well as change reasonably foreseeable actions that may be taken during the next 10 years (e.g., the assignment of new mission elements to LANL as a result of other programmatic NEPA reviews). Thus, DOE is preparing this SWEIS to replace the 1979 SWEIS, and future NEPA documents at LANL will be tiered from or reference this SWEIS. This SWEIS addresses operation of LANL (from 1997 through 2006) across the approximately 43 square miles (111 square kilometers) of government land under the administrative control of DOE. DOE is the lead agency and Los Alamos County is a cooperating agency (due to the interdependence of county and DOE planning) in the preparation of this SWEIS.

The process for the preparation of this SWEIS was designed to enhance the participation of members of the public. The SWEIS Advance Notice of Intent, published in the *Federal Register* (FR) on August 10, 1994 (59 FR 40889), identified possible issues and alternatives to be analyzed. It was followed by a series of public meetings intended to both provide information on LANL and the plans for the SWEIS and to obtain public input regarding the scope of the SWEIS. Based on the input received during this "prescoping" period, DOE prepared and published the Notice of Intent to prepare the SWEIS on May 12, 1995 (60 FR 25697). This publication was also followed by a series of public meetings to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the

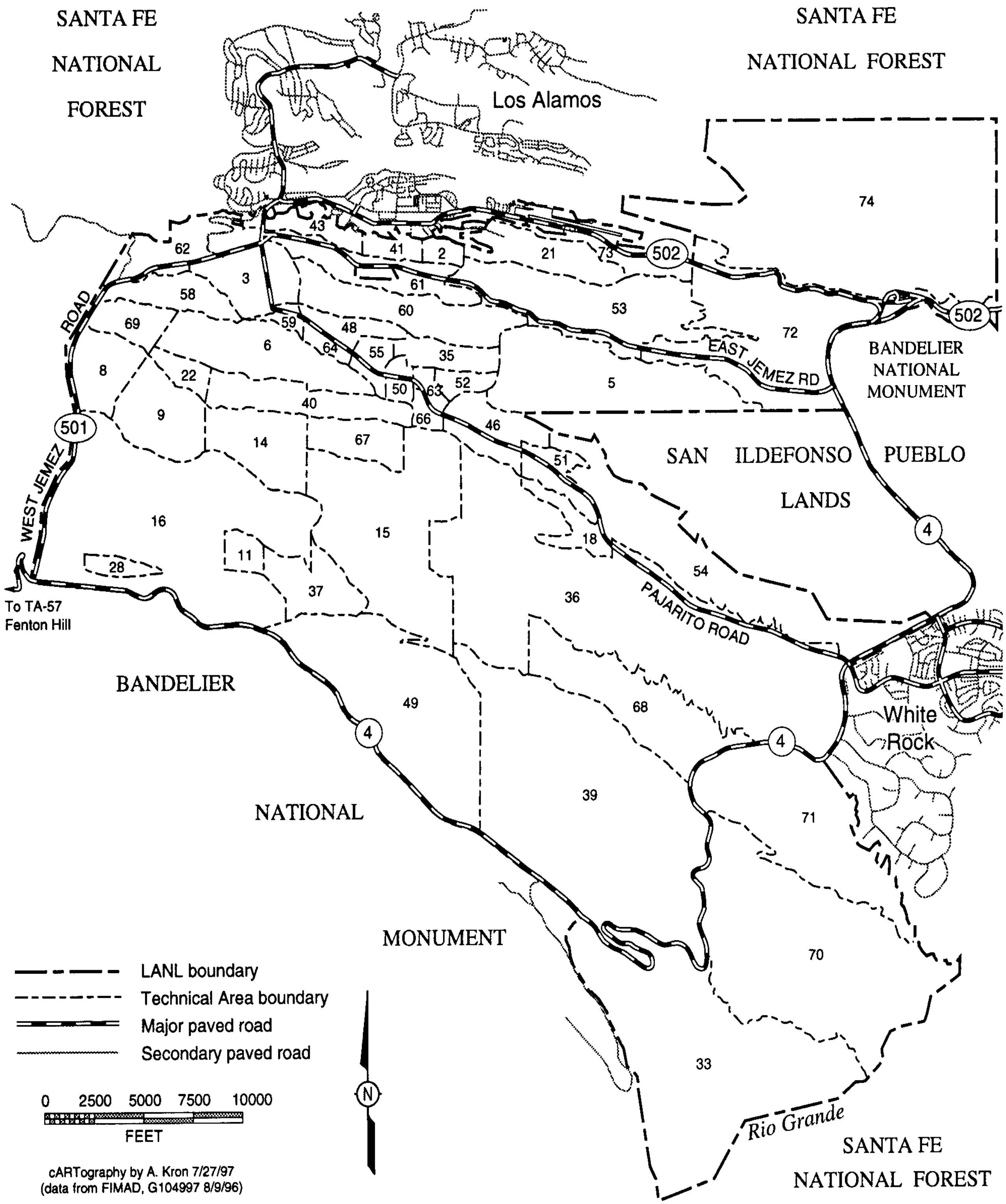

FIGURE S.1.1–2.—*Technical Areas of Los Alamos National Laboratory*.

TABLE S.1.1–1.—*Overview of Technical Areas and Their Associated Activities*

TECHNICAL AREA[a]	ACTIVITIES
TA–0	LANL has about 180,000 square feet (16,722 square meters) of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos townsite and White Rock. The Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos townsite.
TA–2 (Omega Site)	Omega West Reactor, an 8-MW nuclear research reactor, is located here. It was placed in a safe shutdown condition in 1993. It is currently being removed from the nuclear facilities list and will be transferred into the decontamination and decommissioning (D&D) program possibly during 1998. All fuel has been removed from this reactor.
TA–3 (Core Area)	The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in the main TA. TA–3 contains major facilities such as the Chemistry and Metallurgy Research (CMR) Building, the Sigma Complex, the Main Shops, and the Materials Science Laboratory (MSL). Other buildings house central computing facilities, chemistry and materials science laboratories, earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA–3 contains about 50 percent of LANL's employees and floor space.
TA–5 (Beta Site)	This site contains some physical support facilities such as an electrical substation, test wells, and environmental monitoring and buffer areas.
TA–6 (Two-Mile Mesa Site)	This site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending decommissioning.
TA–8 (GT-Site [or Anchor Site West])	This is a dynamic testing site operated as a service facility for LANL. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x-ray machines with potentials up to 1 MeV and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
TA–9 (Anchor Site East)	At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.
TA–11 (K-Site)	These facilities are used for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.
TA–14 (Q-Site)	This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.
TA–15 (R-Site)	This site houses the Pulsed High-Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility, a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for dynamic experiments and hydrodynamic testing. TA–15 also is the site for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility (now under construction), whose major feature will be its intense high-resolution, dual-machine radiographic capability. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.
TA–16 (S-Site)	Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons components and subsystems. It is the site of the Weapons Engineering Tritium Facility (WETF) that focuses on research and applications using tritium. Development and testing of high explosives, plastics, and adhesives, and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TABLE S.1.1–1.—*Overview of Technical Areas and Their Associated Activities*-Continued

TECHNICAL AREA[a]	ACTIVITIES
TA–18 (Pajarito Laboratory Site)	This is a nuclear facility that studies both static and dynamic behavior of multiplying assemblies of special nuclear materials (SNMs). SNMs are used to support a wide variety of activities for stockpile management, stockpile stewardship, emergency response, nonproliferation, safeguards, etc. In addition, this facility provides the capability to perform hands-on training and experiments with SNM in various configurations below critical.
TA–21 (DP-Site)	This site has two primary research areas: DP West and DP East. DP West has been in the D&D Program since 1992, and about half of the facility has been demolished. DP West continues to provide office space for ongoing functions. Some activities conducted at DP West, primarily in inorganic and biochemistry, are being relocated during 1997 and 1998, and the remainder of the site scheduled for D&D in future years. DP East is a tritium research site and includes the Tritium Science and Fabrication Facility (TSFF) and Tritium Systems Test Assembly (TSTA).
TA–22 (TD-Site)	This site is used in the development of special detonators to initiate high-explosives systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.
TA–28 (Magazine Area A)	This is an explosives storage area.
TA–33 (HP-Site)	The old, High-Pressure Tritium Laboratory Facility is being decommissioned. Tritium operations at this site were suspended in 1990, and the tritium inventory and operations were moved to WETF at TA–16. The National Radio Astronomy Observatory's Very Large Baseline Array Telescope is also located at this site.
TA–35 (Ten Site)	Activities include nuclear safeguards research and development that are concerned with techniques for nondestructive detection, and identification and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy density physics, metallurgy, ceramic technology, and chemical plating.
TA–36 (Kappa-Site)	This TA has four active firing sites that support explosives testing. Nonnuclear ordnance tests are conducted here, including tests of armor and armor-defeating mechanisms, as well as tests of shockwave effects on explosives and propellants. Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.
TA–37 (Magazine Area C)	This is an explosives storage area.
TA–39 (Ancho Canyon Site)	The behavior of nonnuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation-of-state measurements, and pulsed-power systems design.
TA–40 (DF-Site)	This site is used in the development of special detonators to initiate high-explosives systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.
TA–41 (W-Site)	Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.
TA–43 (Health Research Laboratory)	This site is adjacent to the Los Alamos Medical Center. Research performed at this site includes structural, molecular, and cellular radiobiology; biophysics; mammalian radiobiology; mammalian metabolism; biochemistry; and genetics. The DOE Los Alamos Area Office is also located within TA–43.
TA–46 (WA-Site)	Activities include applied photochemistry research such as the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater System Consolidation Plant is located at the east end of this site.
TA–48 (Radiochemistry Site)	Research and development activities at this site include a wide range of chemical processes such as nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

TABLE S.1.1–1.—*Overview of Technical Areas and Their Associated Activities*-Continued

TECHNICAL AREA[a]	ACTIVITIES
TA–49 (Frijoles Mesa Site)	This site is currently restricted to carefully selected functions because of its location near BNM and past use in high-explosives and radioactive materials experiments. The Hazardous Devices Team Training Facility and the Antenna Test Range are located here. A helicopter pad used for wildfire response and storage for interagency wildfire response supplies are also located here.
TA–50 (Waste Management Site)	Activities include management of the industrial liquid and radioactive liquid waste received from various TAs. Activities also include development of improved methods for solid waste treatment and containment of radionuclides removed by treatment.
TA–51 (Environmental Research Site)	Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are studied at this site.
TA–52 (Reactor Development Site)	A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.
TA–53 (Los Alamos Neutron Science Center)	This site includes the Los Alamos Neutron Science Center (LANSCE), the LANSCE linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility. Also located at TA–53 are the Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator (LEDA), and research and development activities in accelerator technology and high-power microwaves.
TA–54 (Waste Disposal Site)	Activities consist of radioactive and hazardous solid waste management, including storage, treatment, and disposal operations.
TA–55 (Plutonium Facility Site)	This facility provides research and applications in chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms, as well as research into material properties and fabrication of parts for research and stockpile applications. Additional activities include the means to safely and securely ship, receive, handle, and store nuclear materials, as well as manage the wastes and residues produced by TA–55 operations. The Nuclear Materials Storage Facility (NMSF) is located at this TA.
TA–57 (Fenton Hill Site)	This site is located about 20 miles (32 kilometers) west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains, and was the location of LANL's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. Because of the high elevation and remoteness of Fenton Hill, a gamma ray observatory is located at the site, and other astrophysics experiments are planned.
TA–58 (Two-Mile North Site)	This site is reserved for multi-use experimental sciences requiring close functional ties to activities currently located at TA–3.
TA–59 (Occupational Health Site)	Occupational health and safety and environmental activities are conducted at this site. Environmental, safety and health offices, and emergency management facilities are also located here.
TA–60 (Sigma Mesa)	This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.
TA–61 (East Jemez Road)	This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.
TA–62 (Northwest Site)	This site is reserved for multi-use experimental science, public and corporate interface, and environmental research and buffer zones.
TA–63 (Pajarito Service Area)	This site is a major growth area with environmental and waste management functions and facilities. This area contains physical support facilities operated by Johnson Controls, Inc.
TA–64 (Central Guard Site)	This is the site of the Central Guard Facility and headquarters for the Hazardous Materials Response Team.
TA–66 (Central Technical Support Site)	This site is used for industrial partnership activities.
TA–67 (Pajarito Mesa Site)	This area is a buffer zone, designated as a TA in 1989. No operations or facilities are currently located here.

TABLE S.1.1–1.—*Overview of Technical Areas and Their Associated Activities*-Continued

TECHNICAL AREA[a]	ACTIVITIES
TA–68 (Water Canyon Site)	This is a dynamic testing area.
TA–69 (Anchor North Site)	This undeveloped TA serves as an environmental buffer for the dynamic testing area.
TA–70 (Rio Grande Site)	This undeveloped TA serves as an environmental buffer for the high-explosives test area.
TA–71 (Southeast Site)	This undeveloped TA serves as an environmental buffer for the high-explosives test area.
TA–72 (East Entry Site)	This is the site of the Protective Forces Training Facility (Live Firing Range).
TA–73 (Airport Site)	This area is the Los Alamos Airport. DOE owns the airport, and the County of Los Alamos manages, operates, and maintains it under a leasing arrangement with DOE. Use of the airport by private individuals is permitted with special restrictions.
TA–74 (Otowi Tract)	This large area, bordering the Pueblo of San Ildefonso on the east, is isolated from most of LANL. This site contains LANL water wells and future well fields.

[a] The concept of technical areas (TAs) was implemented during the first 5 years of LANL's existence; however, the early TA designations did not cover all land within the LANL boundary and, in the early 1980's, LANL's TA numbering system was revamped to provide complete coverage. Because all TAs received new numbers, a correlation between the historic system and the current system does not exist. In addition, in the current system, some numbers were reserved for future TAs. Sites that have been closed or abandoned were incorporated into adjacent TAs.

MW = Megawatt, MeV = million electron volts

SWEIS. Nearly 1,300 comments from 215 commentors were recorded. The most significant requests and concerns raised were:

- A preference for a nonnuclear mission for LANL
- Imposing a moratorium on current or proposed projects until the SWEIS is completed
- Inclusion of "green" and shut-down and clean-up alternatives
- Reservations regarding waste management strategies, treatment, and disposal options, as well as waste transportation issues
- An interest in having environmental restoration activities included in the SWEIS
- Requests that the SWEIS be put on hold until the completion of the *Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (SSM PEIS) (DOE 1996) and the *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997)

Based on consideration of the input received in this "scoping" period, DOE published an implementation plan[1] to summarize the results of the scoping process, describe the scope of the SWEIS, and present the planned outline for the draft SWEIS. In addition to these activities, there were several other efforts to obtain public input regarding the SWEIS, including: workshops; meetings with and briefings to representatives of federal, state, tribal, and local governments; meetings with various interested groups; open forum sessions in several communities around LANL; and preparation of responses to requests for information (including requests that information be placed in the Los Alamos Community Outreach Center).

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1. DOE NEPA regulations (10 CFR 1021) previously required that an implementation plan be prepared; a regulation change (61 FR 64604) deleted this requirement. An implementation plan was prepared for the SWEIS.

SWEIS Terminology

Mission. *In this SWEIS, "missions" refer to the major responsibilities assigned to DOE (described in this section). DOE accomplishes its major responsibilities by assigning groups or types of activities (referred to in this SWEIS as mission elements) to its system of national laboratories, production facilities, and other sites.*

Programs. *DOE is organized into Program Offices, each of which has primary responsibilities within the set of DOE missions. Funding and direction for activities at DOE facilities are provided through these Program Offices, and similar/coordinated sets of activities to meet Program Office responsibilities are often referred to as programs. Programs are usually long-term efforts with broad goals or requirements.*

Capabilities. *This refers to the combination of facilities, equipment, infrastructure, and expertise necessary to undertake types or groups of activities and to implement mission assignments. Capabilities at LANL have been established over time, principally through mission assignments and activities directed by Program Offices. Once capabilities are established to support a specific mission assignment or program activity, they are often used to meet other mission or program requirements (e.g., the capability for advanced/ complex computation and modeling that was established to support DOE's national security mission requirements may also be used to address needs under DOE's science mission).*

Projects. *This is used to describe activities with a clear beginning and end that are undertaken to meet a specific goal or need. Projects can vary in scale from very small (such as a project to undertake one experiment or a series of small experiments) to major (e.g., a project to construct and start up a new nuclear facility). Projects are usually relatively short-term efforts, and they can cross multiple programs and missions, although they are usually "sponsored" by a primary Program Office. In this SWEIS, this term is usually used more narrowly to describe construction (including facility modification) activities (e.g., a project to build a new office building or a project to establish and demonstrate a new capability). Construction projects considered reasonably foreseeable at LANL over the next 10 years are discussed and analyzed in this SWEIS.*

DOE released the draft SWEIS in May 1998, for review and comment by the State of New Mexico, Indian tribes, local governments, other federal agencies, and the general public. The formal public comment period lasted 60 days, ending on July 15, 1998. Comments were accepted and considered after close of the comment period to the extent practicable.

DOE considered all comments to evaluate the accuracy and adequacy of the draft SWEIS and to determine when the SWEIS text needed to be corrected, clarified, or otherwise revised. DOE gave equal weight to spoken and written comments, comments received at the public hearings, and comments received in other ways. Comments were reviewed for content and relevance to the environmental analysis contained in the SWEIS. Each comment was addressed individually in volume IV, chapter 3 of the SWEIS.

Commentors raised several common topics during the SWEIS public comment process that the DOE has addressed in the Major Issues section located in chapter 2 of volume IV. In some cases, commentors raised issues that were not within the scope of this SWEIS, such as comments regarding opposition to nuclear weapons. To the extent practicable, DOE addressed these comments in the Major Issues section and in the individual responses.

The key areas of concern that emerged from public comments on the draft SWEIS were as follows:

- Commentors expressed a general opposition to nuclear weapons. Comments were received questioning why the draft SWEIS does not address the impacts that expanding operations at Los Alamos will have on the proliferation of nuclear weapons. Expanded operations at LANL contradict the 1970 Nonproliferation Treaty. Commentors stated that DOE should focus their resources on environmental technologies and not on nuclear weapons.
- DOE's implementation of the NEPA process was unclear to commentors, in particular, how public input is considered in NEPA documents and the factors that DOE considers in its decision-making process. Commentors expressed frustration over the perception that DOE is not addressing their concerns in a serious manner. Commentors also questioned why the draft SWEIS did not consider the cost impacts of each alternative in its analysis.
- Commentors believed that DOE had not considered an adequate range of alternatives. Commentors stated that the alternatives discussed in the draft SWEIS are inadequate because they fail to include any alternative that considers the closure and cleanup of LANL. They questioned how DOE selected levels of operations for each alternative. Commentors also questioned why there is little difference in the impacts among the alternatives.
- Commentors questioned the impacts of LANL operations on the regional aquifer and the safety of the drinking water. They stated that the draft SWEIS did not provide adequate site-wide plans for the monitoring, protection, and remediation of surface water and groundwater. Requests also were made for clarification of the hydrogeologic mechanism for the surface water to groundwater connection at LANL. Commentors stated that LANL's current monitoring program should be upgraded to obtain information about the source of recharge to the main aquifer and the sources of contaminants to the main aquifer. Comments also were received on the analyses of impacts to groundwater.
- Concern was expressed that LANL's pit production activities will have the same kind of safety problems that occurred at the Rocky Flats Plant. Commentors expressed concern that fires releasing radioactive materials would occur at the Plutonium

Facility. Concern was expressed that DOE had not adopted any safety measures as a result of the 1969 Rocky Flats Plant fire. Commentors believe that LANL will become a bomb production factory.

- Commentors expressed concern about the consequences of potential seismic activities at LANL, specifically at the Chemistry and Metallurgy Research (CMR) Building (TA–3) and Plutonium Facility (TA–55), and the impact of the results of ongoing seismic studies. Questions also were raised about the frequency of seismic events in the LANL region and the potential release of radioactive materials from such an event.
- The need for expansion of the low-level radioactive waste (LLW) disposal capacity at the TA–54/Area G Disposal Facility was questioned. Concern was expressed that impacts both natural and cultural, on San Ildefonso Pueblo lands would be irreversible. Commentors also expressed concern about the importation of low-level waste from other DOE sites. Concerns about further restriction of movement of the elk herd, due to a security fence surrounding Area G, also were expressed. Commentors were concerned about migration of contaminated wastes to the groundwater if leaks were to occur in disposal cells. Commentors stated that the draft SWEIS was deficient because it did not analyze the removal of all waste from TA–54.
- Commentors questioned the lack of specific quantitative risk analyses in the SWEIS on environmental restoration sites and the absence of data about environmental restoration sites in the context of various environmental settings. Commentors believed that more information on specific measures should be provided so that public comment could be provided on this program. Commentors questioned the impacts of not environmentally restoring each contaminated site at LANL. Questions were raised about the use of bounding analysis in describing the overall impacts of environmental restoration activities at LANL.
- Concern was expressed about the management of cultural resources at LANL and the depth of the traditional cultural properties study performed for the SWEIS. Commentors questioned whether DOE seeks and utilizes input on cultural resources from affected Indian tribes. Concern also was expressed that the impacts of the operation of LANL would have an irretrievable impact on cultural resources in the area, including spiritual or unseen resources.
- Commentors questioned the adequacy of the environmental justice analysis in the SWEIS and the steps taken to protect minority or low-income populations. Commentors stated that expansion of Area G at TA–54, which is located adjacent to San Ildefonso Pueblo lands, constitutes a disproportionately high and adverse impact on the minority community of San Ildefonso.
- Commentors stated that DOE should have an integrated approach for the management of natural resources at LANL to provide better protection of resources. Commentors stated that the draft SWEIS is deficient in the quantification of direct, indirect, and cumulative impacts to natural resources. Wildlife habitat fragmentation was another concern of commentors.
- Concern was expressed by commentors that implementation of the Expanded Operations Alternative would strain the electrical power demand in the region. Commentors requested clarification on the steps to be taken by DOE to address the electrical power supply issue. Concern also was expressed that if electrical supply shortages were to occur, equipment monitors or other safety equipment could fail, potentially causing environmental impacts.

- Commentors stated the draft SWEIS does not provide an adequate analysis of the environmental and health impacts of a major forest fire at LANL. Commentors stated that the draft SWEIS only examines the effects of a fire to specific facilities and initiated within those facilities. It was recommended that the environmental consequences of a catastrophic wildfire be addressed in the section on accidents.
- Commentors disagree with the claim in the draft SWEIS that LANL was in compliance with standards of the *Clean Air Act* (CAA), and specifically, that LANL is in full compliance with the radiological emissions under National Emission Standards for Hazardous Air Pollutants. Commentors stated that an independent auditor found that LANL was noncompliant, but these findings were disputed. The final SWEIS should discuss the auditors' findings, justification for the claim of CAA compliance, and steps to be taken by DOE and LANL if the CAA standards are exceeded.
- Commentors stated that the draft SWEIS did not consider the impacts of stormwater runoff events at LANL, noting that storm runoff events can be a significant pathway for the off-site migration of contaminants. Many storms over the years and numerous canyon systems, as noted by the commentors, create a potential for cumulative off-site migration of contaminants.

S.1.3 Changes to the Draft SWEIS

DOE revised the draft SWEIS in response to comments received from other federal agencies; tribal, state, and local governments; nongovernmental organizations; the general public; and DOE reviews. The text was changed to provide additional environmental baseline information, to correct inaccuracies and make editorial corrections, and provide additional discussion of technical considerations to respond to comments and clarify text. In addition, DOE updated information due to events or decisions made in other documents since the draft SWEIS was provided for public comment in May 1998.

S.1.3.1 *Summary of Significant Changes*

Revised Preferred Alternative

In the draft SWEIS, the DOE's Preferred Alternative was the Expanded Operations Alternative. In this final SWEIS, the Expanded Operations Alternative remains the Preferred Alternative with one modification, as noted below. The modification to the Preferred Alternative involves the level at which pit manufacturing will be implemented at LANL. Under the Expanded Operations Alternative, DOE would expand operations at LANL, as the need arises, to increase the level of existing operations to the highest reasonably foreseeable levels, including the full implementation of pit manufacturing up to the capacity of 50 pits per year under single-shift operations (80 pits per year using multiple shifts). However, as a result of delays in the implementation of the Capability Maintenance and Improvement Project (CMIP) and recent additional controls and operational constraints in the CMR Building (instituted to ensure that the risks associated with the CMR Building operations are maintained at an acceptable level), the DOE has determined that additional study of methods for implementing the 50 pits per year production capacity is warranted. In effect, because DOE has postponed any decision to expand pit manufacturing beyond a level of 20 pits per year in the near future, the revised Preferred Alternative would only implement pit manufacturing at this level. This postponement does not modify the long-term goal announced in the Record of Decision (ROD) for the SSM PEIS (up to 80 pits per year using multiple shifts).

Enhanced Pit Manufacturing

As described above, as a result of delays in the implementation of the CMIP and recent additional controls and operational constraints in the CMR Building (chapter 2, section 2.2.2.3), DOE has postponed any decision to implement the pit manufacturing capability beyond a level of 20 pits per year (14 pits is the No Action level). DOE believes it can expand the pit manufacturing capability to 20 pits at TA–55 without significant infrastructure upgrades and still meet its near-term mission requirements. When the additional studies are completed, DOE will provide the appropriate NEPA review, tiered from this SWEIS, to implement the pit manufacturing capability beyond the 20 pits per year capacity. The project-specific siting and construction (PSSC) analysis for the Enhancement of Plutonium Pit Manufacturing (in volume II of this SWEIS) no longer states a "Preferred PSSC Alternative." The Preferred Alternative would only implement pit production at a level of 20 pits per year. However, for completeness and to bound the impacts of implementing pit production at LANL, the "Utilize Existing Unused Space in the CMR Building" Alternative (the Preferred PSSC Alternative in the draft SWEIS) is still included in the Expanded Operations Alternative as the "CMR Building Use" Alternative. The ROD for the SWEIS will only include a decision regarding the operations to implement the pit production mission at LANL for up to 20 pits per year. This change is reflected in volume II, part II.

Wildfire

The scenario that a wildfire could encroach on LANL was analyzed and included in the accident set presented for all the alternatives. The detailed wildfire analysis, referred to as the SITE–04 accident, is presented in appendix G, section G.5.4.4 of volume III of this SWEIS. A summary of the impacts is presented in chapter 5.

Comparison Between the Rocky Flats Plant and LANL

An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and LANL are included in appendix G, section G.4.1.2. A summary is included in chapter 5.

CMR Building Seismic Upgrades

DOE has decided not to implement the seismic upgrades as part of the CMR Building Upgrades Project, Phase II, as a result of (1) new seismic studies (chapter 4, section 4.2.2.2, and appendix I) released after the draft SWEIS was issued indicating the additional hazard of a seismic rupture at the CMR Building and (2) DOE's postponement of any decisions to implement the pit manufacturing capability beyond 20 pits per year in the near future. Although the seismic rupture risk does not have a substantial effect on the overall seismic risk (chapter 2, section 2.2.2.3), it is an aspect of risk that cannot be cost-effectively mitigated through engineered structural upgrades. Given that assessment, the DOE is considering more substantial actions that are not yet ripe for analysis in the SWEIS (e.g., replacement of aging structures). The overall goal of DOE's evaluation is ultimately to reduce the risk associated with a seismic event, should one occur. In the meantime, DOE is taking actions to mitigate seismic risks through means other than seismic upgrades (e.g., minimizing material at risk and putting temporarily inactive material in process into containers). In any event, DOE is presenting the larger and more conservative impacts (no seismic upgrades) for the SITE–01, SITE–02, and SITE–03 accidents. Therefore, SITE–01, SITE–02, and SITE–03 accidents were revised to include new seismic data published after the draft SWEIS was released and to exclude the mitigation of the impacts of implementing the seismic upgrades. The detailed revised analysis is presented in appendix G. A summary of the impacts is presented in chapters 3 and 5.

Strategic Computing Complex

The impacts of constructing and operating the proposed Strategic Computing Complex (SCC) project, primarily electric power demand and water usage, were incorporated into all the alternatives analyzed. Water usage was not increased in these analyses because DOE and LANL committed to no net increase of water as a result of conservation measures and recycling of treated wastewater from the Sanitary Wastewater System Consolidation Plant, TA–46, as cooling water for the SCC project.

Conveyance and Transfer of DOE Land

DOE has begun the preparation of an EIS for the Conveyance and Transfer of Certain Land Tracts at LANL (CT EIS). The CT EIS, scheduled to be released in draft form for public review and comment in early 1999, will analyze the impacts of conveying and transferring certain tracts of land to the County of Los Alamos and the U.S. Department of the Interior in trust for the Pueblo of San Ildefonso. The CT EIS also will present the cumulative impacts of the land being developed by either the County of Los Alamos or the Pueblo of San Ildefonso, as well as the impacts of continuing to operate LANL.

S.1.3.2 *Next Steps*

The SWEIS ROD, to be published no sooner than 30 days after the Notice of Availability of the final SWEIS has been issued, will explain all factors, including environmental impacts, that the DOE considered in reaching its decision. The ROD will also identify the environmentally preferred alternative or alternatives. If mitigation measures, monitoring, or other conditions are adopted as part of DOE’s decision, these will summarized in the ROD, as applicable, and will be included in the Mitigation Action Plan that would be prepared following the issuance of the ROD. The Mitigation Action Plan would explain how and when mitigation measures would be implemented and how the DOE would monitor the mitigation measures over time to judge their effectiveness.

S.2 ALTERNATIVES TO MEET THE PURPOSE AND NEED FOR AGENCY ACTION

S.2.1 Purpose and Need for Agency Action

As directed by the President and Congress, DOE has the core mission to provide for stewardship and management of the nuclear weapons stockpile. DOE also has other national security, energy resources, environmental quality, and science missions. These missions are national in scope, and aspects are carried out at various DOE facilities. The purpose of continued operation of LANL is to provide support for DOE missions.

The need to continue to operate LANL is based on the unique facilities and expertise of the staff located there. These facilities and this expertise provide key capabilities within the broad areas of:

- Theoretical research, including parameter estimation, mathematical modeling, and high-performance computing
- Experimental science and engineering ranging from bench-scale to multisite, multitechnology facilities (including accelerators, radiographic facilities, etc.)
- Advanced and nuclear materials research and development, and technological applications, including weapons component testing, fabrication, stockpile assurance, replacement, surveillance, and maintenance (including theoretical and experimental activities)

DOE assignments to LANL use and build upon these capabilities. DOE's need to continue to operate LANL is focused on DOE's obligation to ensure a safe and reliable nuclear stockpile in accordance with national security policy.

S.2.2 Proposed Action and Alternatives

DOE proposes to continue operating LANL in support of DOE's national missions. The decisions that DOE expects to make as a result of the alternatives analyzed in this SWEIS will satisfy the purpose and need presented above. The decisions include the level of operation for LANL, as well as specific decisions regarding construction projects that are ripe for decision on a schedule compatible with the SWEIS. In particular, two of these construction projects involve multiple facilities and operations across LANL: (1) the site-specific implementation of the pit production mission assigned in the ROD regarding SSM (61 FR 68014, December 1996), and (2) the disposition of LLW off the site or the expansion of on-site disposal capacity. DOE also will select from appropriate mitigation measures to reduce or avoid potential impacts associated with the alternative and project-level decisions.

This SWEIS evaluates four broad alternative levels of operation at LANL: No Action, Expanded Operations, Reduced Operations, and "Greener."

The No Action Alternative analyzed in this SWEIS reflects the levels of operation at LANL that are currently planned (that is, the levels of operations that would be undertaken in the absence of a decision to change operational levels). This includes operations that provide for continued support of DOE's four primary missions, but would not include an increase in the existing pit manufacturing capacity (which is 14 pits per year) nor expansion of the LLW disposal facility at TA–54 (the remaining space in the existing Area G footprint would be used, but some LLW would be shipped for off-site disposal). This alternative includes the maintenance of existing capabilities, continued support/infrastructure activities, and facility construction or modification projects throughout LANL that have previous NEPA reviews (projects not previously reviewed under NEPA, as listed in the Expanded Operations Alternative, would not proceed under this alternative).

The Expanded Operations Alternative would expand operations at LANL, as the need arises, to increase the level of existing operations to the highest reasonably foreseeable levels, and to fully implement the mission elements assigned to LANL. This includes the impacts of the full implementation of pit manufacturing (discussed further in section S.2.5.2) up to a capacity of 50 pits per year under single-shift operations (80 pits per year using multiple shifts). This alternative also includes the expansion of the LLW disposal site at TA–54 (discussed further in section S.2.5.1). This alternative also includes the continued maintenance of existing and expanded capabilities, continued support/infrastructure activities, and implementation of several facility construction or modification projects at TA–53 (the long-pulse spallation source, the 5-megawatt target/blanket experimental area, the Dynamic Experiment Laboratory, and the Exotic Isotope Production Facility), which have not previously been reviewed under NEPA (construction projects throughout LANL that have previous NEPA reviews would proceed as planned). The TA–53 projects proposed do not have meaningful siting and construction alternatives at LANL because they are dependent on the delivery of an accelerator beam that is not provided at other LANL facilities. (Construction of a new accelerator solely to provide for these activities is not considered reasonable.)

The Reduced Operations Alternative reflects the minimum levels of operation at LANL considered necessary to maintain the capabilities to support DOE missions over the near term. While the capabilities are maintained under this alternative, this may not constitute full support of the mission elements currently assigned to LANL. This alternative reflects pit manufacturing at a level below the existing capacity (at 6 to 12 pits per year) and reflects shipment of much of the LLW generated at LANL for off-site disposal (on-site disposal would be limited to those waste types for which LANL has a unique capability at Area G). This alternative includes the maintenance of existing capabilities, continued support/infrastructure activities, and facility construction or modification projects throughout LANL that have previous NEPA reviews; some of the projects previously reviewed under NEPA would be reduced in scope or eliminated (e.g., the Low-Energy Demonstration Accelerator [LEDA] would only be operated at the lower end of its energy range).

The Greener Alternative reflects increased levels of operation at LANL in support of nonproliferation, basic science, and materials recovery/stabilization mission elements, and reduced levels of operation in support of defense and nuclear weapons mission elements. All LANL capabilities are maintained for the short term under this alternative; however, this may not constitute full support of the nuclear weapons mission elements currently assigned to LANL. This alternative reflects pit manufacturing at a level below the existing capacity (at 6 to 12 pits per year) and reflects shipment of much of the LLW generated at LANL for off-site disposal (on-site disposal would be limited to those waste types for which LANL has a unique capability at Area G). This alternative includes the maintenance of existing capabilities, continued support/infrastructure activities, and implementation of several facility construction or modification projects at TA–53 (the long-pulse spallation source, the 5-megawatt target/blanket experimental area, the Dynamic Experiment Laboratory, and the Exotic Isotope Production Facility), which have not previously been reviewed under NEPA (other projects throughout LANL that have previous NEPA reviews would also proceed). As discussed above for the Expanded Operations Alternative, these TA–53 projects do not have meaningful siting and construction alternatives. The name and general description for this alternative were provided by interested public stakeholders as a result of the scoping process.

In the draft SWEIS, the DOE's Preferred Alternative was the Expanded Operations Alternative. In this final SWEIS, the Expanded Operations Alternative remains the Preferred Alternative with one modification, as noted below. The modification to the Preferred Alternative involves the level at which pit manufacturing will be implemented at LANL. Under the Expanded Operations Alternative, DOE would expand operations at LANL, as the need arises, to increase the level of existing operations to the highest reasonably foreseeable levels, including the full implementation of pit manufacturing up to the capacity of 50 pits per year under single-shift operations (80 pits per year using multiple shifts). However, as a result of delays in the implementation of the CMIP and recent additional controls and operational constraints in the CMR Building (instituted to ensure that the risks associated with the CMR Building operations are maintained at an acceptable level), the DOE has determined that additional study of methods for implementing the 50 pits per year production capacity is warranted. In effect, because DOE has postponed any decision to expand pit manufacturing beyond a level of 20 pits per year in the near future, the revised Preferred Alternative would only implement pit manufacturing at this level. This postponement does not modify the long-term goal announced in the ROD for the SSM PEIS (up to 80 pits per year using multiple shifts). The Preferred Alternative, as the Expanded Operations Alternative, also includes the expansion of the LLW disposal site at TA–54 (discussed further in section S.2.5.1). The Preferred Alternative also includes the continued maintenance of existing and expanded capabilities, continued support/infrastructure activities, and implementation of several facility construction or modification projects at TA–53 (the long-pulse spallation source, the 5-megawatt target/blanket experimental area, the Dynamic Experiment Laboratory, and the Exotic Isotope Production Facility), which have not previously been reviewed under NEPA (construction projects throughout LANL that have previous NEPA reviews would proceed as planned). The TA–53 projects proposed do not have meaningful siting and construction alternatives at LANL because they are dependent on the delivery of an accelerator beam that is not provided at other LANL facilities. (Construction of a new accelerator solely to provide for these activities is not considered reasonable.)

S.2.3 Alternatives Considered But Not Analyzed

Comments received during prescoping and scoping were considered by DOE. Some of the alternatives suggested for future operation of LANL were considered but not analyzed. These alternatives and the reasons they were eliminated from detailed analysis are presented below:

- *Decontamination and Decommissioning of LANL.* Under this alternative, LANL operations would be phased out, and all facilities of LANL would be decontaminated and decommissioned as soon as practicable. This alternative is not analyzed in the SWEIS because it is considered unreasonable in the foreseeable future under the terms of the *National Defense Authorization Act of 1994* (Public Law [PL]103-160), subsequent authorizations, and presidential policy statements on the future of the national laboratories (DOE 1995). Under this act (and subsequent authorizations) and national security policy, the maintenance of a safe and reliable nuclear weapons stockpile will remain a cornerstone of the U.S. nuclear deterrent for the foreseeable future, and the continued vitality of all three DOE weapons laboratories (LANL, Lawrence Livermore National Laboratory, and Sandia National Laboratories) are essential to ensuring national security.
- *Elimination of All Weapons-Related Work from the Continued Operation of LANL.* Under this alternative, operation of LANL would continue, but all weapons work would cease except currently authorized pit disassembly, material stabilization, and material storage. This alternative is not analyzed in the SWEIS because it is considered unreasonable in the foreseeable future under the terms of the *National Defense Authorization Act of 1994* (PL 103-160) and presidential policy statements on the future of the national laboratories (DOE 1995). Additionally, LANL has an integral role within the system of national laboratories to support all DOE missions, including the national security mission. Elimination of the operations that support the national security mission would adversely affect DOE's ability to meet its mission requirements under the terms of the *Atomic Energy Act*, as amended (42 U.S.C. §2011). Even relocation of the capabilities that exist at LANL to another DOE site could not be accomplished within the next 10 years while maintaining continuous support of DOE's national security responsibilities.
- *Operating LANL Exclusively as a National Environmental Research Park.* Under this alternative, DOE would operate LANL exclusively in support of environmental research that would contribute to understanding how people can best live in balance with nature while enjoying the benefits of technology. This alternative is not analyzed in the SWEIS because it is considered unreasonable in the foreseeable

future, given LANL's role in supporting DOE's national security mission (as discussed in the two previous alternative discussions on this matter). LANL was designated as a National Environmental Research Park in 1977, and research activities associated with this designation continue.

- *Privatizing the Operations of LANL*. Under this alternative, the operations of LANL would be privatized. This alternative is not analyzed in the SWEIS because it is not considered reasonable in the foreseeable future, given the terms of the *Atomic Energy Act*, as amended (42 U.S.C. §2015). This act governs the transfer of real property and limits what DOE can do with real properties. The *Atomic Energy Act* also governs what can be done with respect to government responsibilities regarding nuclear materials and access to information classified under this act. Although this alternative is not considered reasonable, it should be noted that the environmental impacts of operations under this alternative would not likely be any different from those presented in this SWEIS; the environmental consequences of operating LANL are primarily functions of the specific activities assigned to LANL and the facilities, equipment, and procedures used to implement them (and these would not be expected to change due to privatization).

S.2.4 Approach Used to Describe the SWEIS Alternatives in Detail

LANL is a multifaceted institution, funded primarily to undertake a broad range of theoretical and experimental research and development as well as undertaking various applications (including some production activities) for DOE and other federal agencies. The research and development activities throughout LANL are dynamic by their very nature, with the norm being continual change within the limits of the facility capabilities, authorizations, and operating procedures. Activities at LANL take place across approximately 43 square miles (111 square kilometers), including over 2,000 structures with about 7.9 million square feet (about 735,000 square meters) of floorspace. The size of the site and the diversity of the activities on the site present a challenge in terms of providing a useful description of alternatives for the operation of LANL (the goal being to provide the public and decision makers with an understanding of the alternatives and their consequences without providing encyclopedic details on every process and range of activities across the entire site).

Knowing that some activities are of more interest than others, the operations, buildings, and physical setting of LANL were all reviewed to determine an approach that would provide meaningful descriptions and analyses. The approach selected was to describe activities at two levels of detail. One level describes the entirety of operations in a summary fashion. Activities were grouped into the broad areas of: (1) theory, modeling, analysis and high-performance computation; (2) experimental science and engineering; and (3) research, development, and applications using advanced and nuclear materials (including both theoretical and experimental elements). The additional operations necessary to support these activities (such as administrative and technical services [e.g., human resources, safeguards and security, facilities, and environment, safety, and health], public/corporate interface [including the Bradbury Science Museum], and physical support and infrastructure [such as warehouses, storage, utilities, and waste handling]) are also described at a summary level. This is a sufficient level of description to support the analysis of environmental impacts for the majority of activities at LANL because these activities have little potential for environmental impacts. Many of these activities were not projected to change across the alternatives, and their contributions to environmental impacts were carried as a constant factor in the analysis of each of the alternatives.

Activities of interest tend to be concentrated within certain facilities. The more detailed description of activities at LANL were therefore focused on the operations within a limited set of facilities. Criteria were established to determine which of the facilities at LANL (often a facility is composed of multiple buildings) should be the subjects of the more detailed description and analysis. These facilities were designated SWEIS "key" facilities and are the facilities that house activities that are critical to meeting DOE assignments to LANL, and:

- House operations that have the potential to cause significant environmental impacts, or
- Are of most interest or concern to the public (based on scoping comments received), or
- Would be the most subject to change due to recent programmatic decisions.

The 15 key facilities identified in Table S.2.4–1 represent the source of over 99 percent of all radiation doses to LANL personnel, over 99 percent of all radiation doses to the public, over 90 percent of all radioactive liquid waste generated, over 90 percent of the radioactive solid waste generated, and about 30 percent of the chemical waste generated (the other 70 percent is generated throughout all other LANL facilities). Operations in these key facilities were projected to change in accordance with the alternatives, and any changes in support or infrastructure activities that derive from the changes in operations were analyzed as part of those operational levels. As noted above, operations in the non-key facilities and their contributions to impacts are included as a constant factor in the analyses of each of the alternatives.

TABLE S.2.4–1.—*Identification of Key Facilities for Analysis of LANL Operations*

KEY FACILITY	TECHNICAL AREA
Plutonium Facility Complex	TA–55
Tritium Facilities	TA–16 & TA–21
Chemistry and Metallurgy Research Building	TA–3
Pajarito Site	TA–18
Sigma Complex	TA–3
Materials Science Laboratory	TA–3
Target Fabrication Facility	TA–35
Machine Shops	TA–3
High Explosive Processing Facilities	TA–8, TA–9, TA–11, TA–16, TA–28 & TA–37
High Explosive Testing Facilities	TA–14, TA–15, TA–36, TA–39, & TA–40
Los Alamos Neutron Science Center	TA–53
Health Research Laboratory	TA–43
Radiochemistry Laboratory	TA–48
Waste Management Operations: Radioactive Liquid Waste Treatment Facility	TA–50 & TA–21
Waste Management Operations: Solid Radioactive and Chemical Waste Facilities	TA–50 & TA–54

S.2.5 Consideration of Future Projects

DOE and researchers at LANL frequently develop new ideas and proposals for which funding and programmatic support are requested. Such proposals vary in terms of size, complexity, and potential environmental impact. Many of these proposals are characterized as projects. These are typically research, development, and applications activities across LANL. Some of these activities also require construction or modification of facilities or equipment. The discussion in this section focuses on these construction and modification projects.

Potential construction projects and facility modifications were reviewed to determine which were considered reasonably foreseeable; some of those reviewed were considered too speculative to analyze within the SWEIS. However, several construction projects and facility modifications recently proposed are considered reasonably foreseeable and are included in the SWEIS alternatives (identified by alternative in section S.2.2) and impact analyses. It is expected that the ROD for this SWEIS will include decisions on these projects, unless they were previously reviewed under NEPA. (The previous decisions on these activities are not being revisited in this SWEIS, and these are included in all of the SWEIS alternatives.)

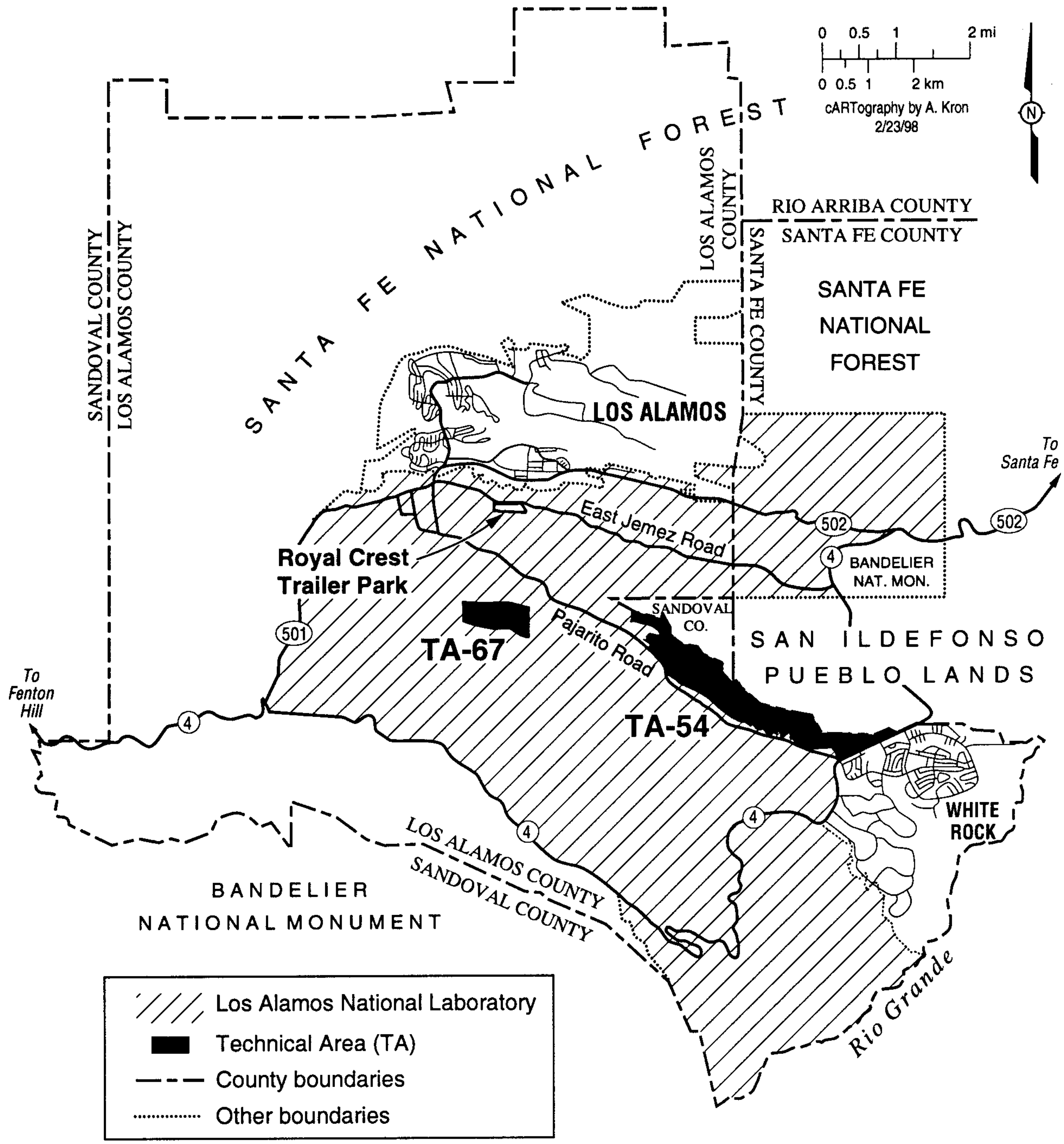
Two of these construction projects have reasonable siting and construction alternatives that are being considered: the Expansion of TA–54/Area G Low-Level Waste Disposal Area (included in both the Preferred Alternative and Expanded Operations Alternative) and the Enhancement of Plutonium Pit Manufacturing (included only in the Expanded Operations Alternative). These siting and construction alternatives are examined in detail in volume II of the SWEIS. The PSSC analyses presented in volume II provide an examination of a set of alternatives specific to each of these projects in greater detail than the description and analysis presented in volume I of the SWEIS. The impacts associated with these siting and construction activities are included in the impacts presented for the Expanded Operations Alternative in volume I. These projects and the PSSC alternatives considered are presented below.

S.2.5.1 *Expansion of TA–54/Area G Low-Level Waste Disposal Area*

Under any of the SWEIS alternatives, more LLW would be generated than can be disposed of in the existing footprint of the Area G LLW disposal site. While the other three SWEIS alternatives include (in varying amounts) shipments of LLW for off-site disposal, the Expanded Operations Alternative (and Preferred Alternative) reflects expansion of the LANL LLW disposal capacity and continued on-site disposal of LANL LLW. Five alternatives in two TAs (TA–54 and TA–67) are considered for the expansion of the on-site LLW disposal capacity (Figures S.2.5.1–1 and S.2.5.1–2):

- Develop Zone 4 at TA–54 (a site almost immediately west of the existing disposal site).
- Develop Zone 6 at TA–54 (a site located to the northwest of the existing disposal site and Zone 4).
- Develop the North Site at TA–54 (located north of Zone 6).
- Develop an undeveloped site at another LANL TA (TA–67, an undeveloped site northwest of TA–54, is used as an example).
- Develop both Zones 4 and 6 in a step-wise fashion (expand these areas as demand requires); this is DOE's Preferred Alternative for this PSSC.

The impacts of this action are included in the site-wide impacts presented and are also described separately in section S.3.



TA-54: Solid waste management area
Includes:
–current LLW disposal area (existing footprint of Area G)
–undeveloped mesa top area, alternative LLW disposal locations (Zone 4, Zone 6, and North Site)

TA-67: Undeveloped mesa top area, alternative LLW disposal location

FIGURE S.2.5.1–1.—*Location of LANL, TA–54, and TA–67.*

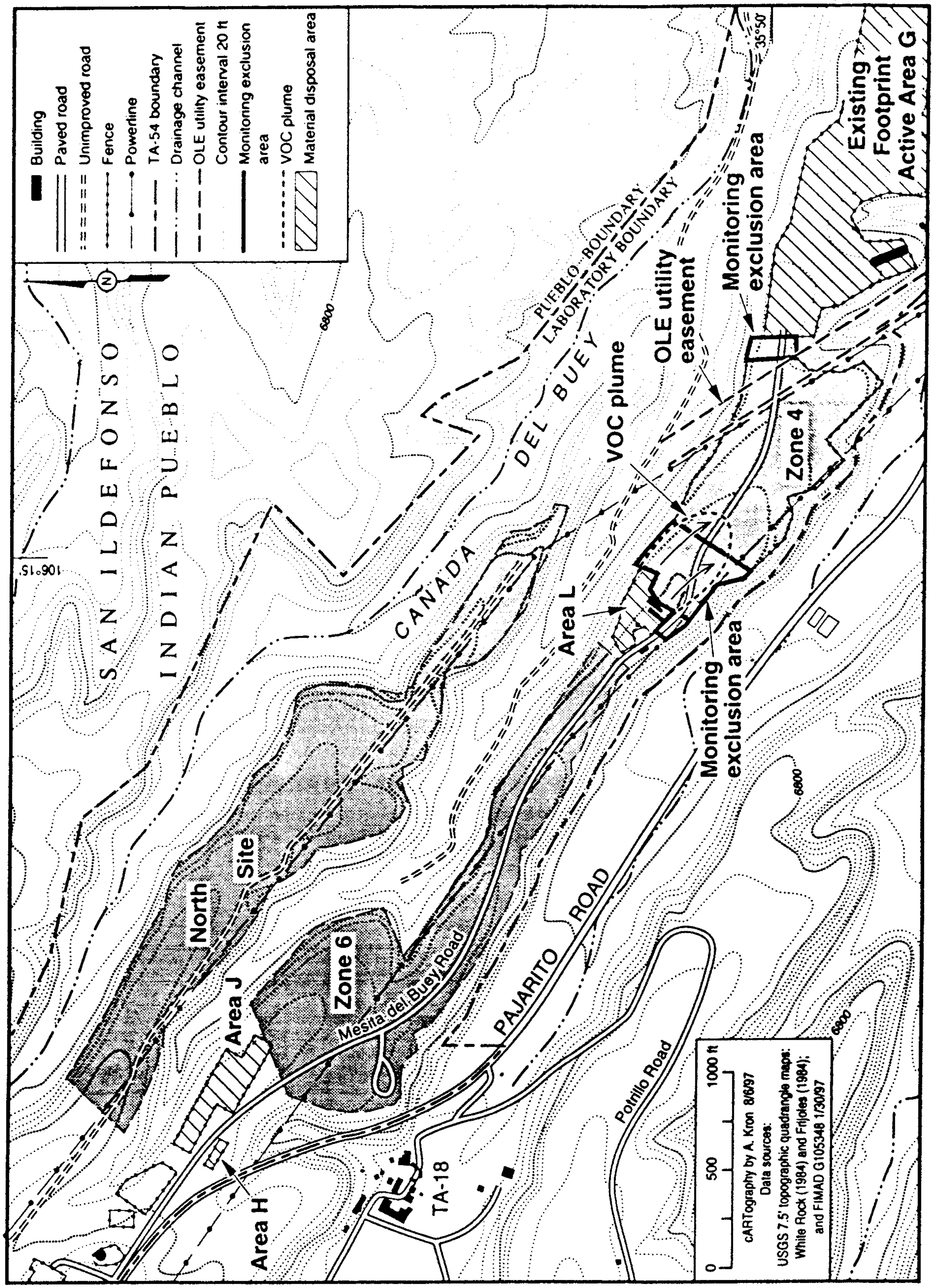


FIGURE S.2.5.1–2.—*Location Within TA–54 of Zones 4 and 6, Areas H, J, and L, and North Site.*

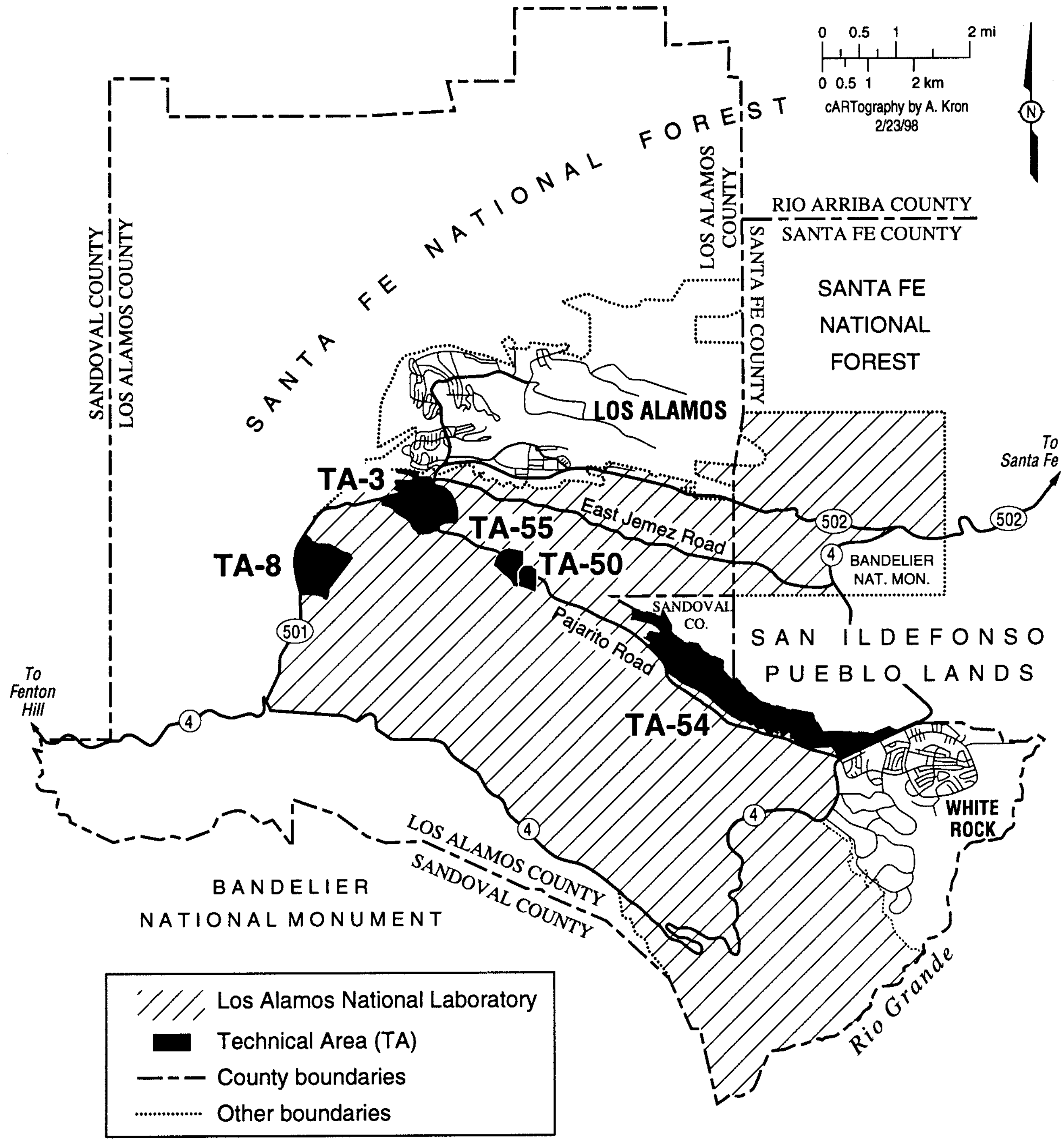
> ***Terminology Related to Pit Production***
>
> ***Pit Fabrication/Manufacturing****—For purposes of the SWEIS, these terms are synonymous. LANL has an existing capability to fabricate or manufacture plutonium parts. That is, the equipment, knowledge, supporting infrastructure, and administrative procedures and controls exist at LANL to create plutonium metallic shapes to precise specifications. This capability is currently used in support of existing missions for research and development and will be used to rebuild some of the pits destroyed in stockpile surveillance activities.*
>
> ***Pit Production****—For the purposes of the SWEIS, this term is used to describe the fabrication/ manufacturing of a relatively large quantity of parts (as compared to the research and development and prototype capability). In the ROD for the SSM PEIS, DOE decided to meet its need for a pit production capability by enhancing its existing fabrication/ manufacturing capability at LANL. This enhancement consists of changes to optimize material flows, remove "choke points" that limit the quantity that can be made, improve efficiency, and replace or upgrade equipment to improve process yield and reliability.*

S.2.5.2 *Enhancement of Plutonium Pit Manufacturing*

The Expanded Operations Alternative reflects implementation of the pit production mission recently assigned to LANL (DOE 1996) by enhancing the existing capability to manufacture pits. The capacity that results from this enhancement would allow for up to 50 pits to be fabricated each year under single-shift operations (80 pits per year under multiple-shift operations).

As a result of delays in the implementation of the CMIP and recent additional controls and operational constraints in the CMR Building (instituted to ensure that the risks associated with CMR Building operations are maintained at an acceptable level), the DOE has determined that additional study of methods for implementing the 50 pits per year production capacity is warranted. In effect, the DOE has postponed the decision to implement the pit manufacturing capability beyond a level of 20 pits per year (14 pits is the No Action level). The DOE believes it can expand the pit manufacturing capability to 20 pits at TA–55 without significant infrastructure upgrades and still meet its near-term mission requirements. This postponement does not modify the long-term goal announced in the ROD for the SSM PEIS (up to 80 pits per year using multiple shifts). The Preferred Alternative would only implement pit manufacturing at a level of 20 pits per year. However, for completeness and to bound the impacts of implementing pit production at LANL, the "CMR Building Use" Alternative is still included in the Expanded Operations Alternative. Pit manufacturing activities at LANL are supported by several TAs at LANL (Figure S.2.5.2–1). Three alternatives are considered for the enhancement of pit manufacturing:

- Utilize existing unused space in the CMR Building at TA–3 (make existing vacant space at this nuclear facility operational and move some operations from the Plutonium Facility at TA–55 to this space to make enough space available in the Plutonium Facility [referred to as building number TA–55–4] for the expanded pit manufacturing operation). This is referred to as the "CMR Building Use" Alternative.
- Brownfield Plutonium Facility (build a new nuclear facility on previously disturbed land at TA–55 and move some operations from TA–55–4 to this facility to make enough space available in TA–55–4 for the expanded pit manufacturing operation).
- Add-on to the TA–55–4 Plutonium Facility (build an addition to the existing Plutonium Facility, TA–55–4, and establish the



TA-3:	Analytical Chemistry and Non-Nuclear Parts
TA-8:	Radiography
TA-50:	Radioactive Liquid Waste Treatment
TA-54:	Solid Waste Handling and Low-Level Radioactive Waste Disposal
TA-55:	Processing, Handling, and Storage of Plutonium

FIGURE S.2.5.2–1.—*Location of LANL Operations that Support Pit Manufacturing.*

expanded pit manufacturing operations within this addition—alternatively, some operations in the existing space could be moved into this addition to make space for the expansion in the existing TA–55–4 space).

These upgrades would be phased to first increase the capacity of existing operations to 20 pits per year, followed by completion of the modifications to achieve the end-point production capacity. Under each of these alternatives, transportation of materials between TA–55 and TA–3 would increase substantially (more so for the "CMR Building Use" Alternative than for the Brownfield and Add-On to TA–55–4 alternatives). Because this increase would result in increased on-site transportation risk and inconvenience to motorists in the area (roads are closed to other motorists while many of these shipments take place), DOE is considering an option to construct a dedicated road between TA–55 and TA–3 that would be closed to the public, but that would decrease the transportation risk and inconvenience to motorists in the area during shipment of materials between these TAs. The construction of this road is part of the bounding PSSC Alternative and is included in the SWEIS Expanded Operations Alternative. However, this road would not be constructed at the 20 pits per year production rate (that is, under the Preferred Alternative), nor would process activities associated with pit manufacturing be moved to the CMR Building.

While the impacts of the actions described in this PSSC are included in the site-wide impacts presented, the impacts specific to these actions are also described separately in chapter 3 of the SWEIS (section 3.6), chapter 5 (section 5.3), and in this summary (section S.3).

S.3 PRINCIPAL ENVIRONMENTAL ISSUES AND COMPARISON OF ENVIRONMENTAL IMPACTS

This section contains three parts. The first, section S.3.1, presents a summary comparison of the potential consequences of the four alternatives for the continued operation of LANL. The second, section S.3.2, is a comparison of the potential consequences (including both construction and operations) of the alternatives for two projects that depend upon or span multiple facilities at LANL: the Expansion of the TA–54/Area G Low-Level Waste Disposal Area, and the Enhancement of Plutonium Pit Manufacturing. (The construction and operations for these two projects are included only in the Expanded Operations Alternative.) The third part, section S.3.3, highlights the Environmental Restoration Project impacts and benefits due to the unique nature of this activity (as compared to other LANL activities) and the level of public interest in these activities.

DOE and LANL conduct all activities in adherence with applicable laws, regulations, and other requirements. Chapter 7 summarizes the requirements governing operations at LANL.

S.3.1 Consequences of SWEIS Alternatives

Site-wide environmental consequences are summarized in two tables. Table S.3.1–1 summarizes the potential consequences of normal operations of LANL under the four alternatives. Table S.3.1–2 addresses the potential consequences of a range of transportation and operational accidents possible at LANL. Accidents evaluated include: natural phenomena, process accidents,

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
LAND RESOURCES				
Land Use	No changes projected, except where specific environmental restoration actions change use from waste disposal back to research and development or explosives land uses (none specifically known at this time).	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Visual Resources	Temporary and minor changes due to equipment associated with construction and environmental restoration activities.	Same as No Action Alternative, plus effects of lighting for the transportation corridor constructed under this alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Noise	Continued ambient noise at existing levels, temporary and minor noise associated with construction, and explosives noise and vibration at increased frequencies and at the same amplitudes as compared to recent experience.	Individual activities similar to those under No Action Alternative. Additional construction would result in additional temporary and minor noise. Noise and vibration associated with explosives testing is more frequent under this alternative, but the amplitude is the same as compared to No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
GEOLOGY AND SOILS				
Geology	LANL activities are not expected to change geology in the area, trigger seismic events, or substantively change slope stability.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Soils	Minimal deposition of contaminants to soils and continued removal of existing contaminants under the Environmental Restoration Project.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
WATER RESOURCES				
Water Use	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 13 feet (4.0 meters).	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 15 feet (4.6 meters).	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 10 feet (3.1 meters).	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 14 feet (4.3 meters).
National Pollutant Discharge Elimination System (NPDES) Outfall Volumes	261 million gallons per year (988 million liters per year) discharged from outfalls (an increase of about 28 million gallons per year [106 million liters per year] from recent discharges).	278 million gallons per year (1,052 million liters per year) discharged from outfalls (an increase of about 45 million gallons per year [170 million liters per year] from recent discharges).	218 million gallons per year (825 million liters per year) discharged from outfalls (a decrease of about 15 million gallons per year [57 million liters per year] from recent discharges).	275 million gallons per year (1,041 million liters per year) discharged from outfalls (an increase of about 42 million gallons per year [159 million liters per year] from recent discharges).
Effect of Outfall Flows on Groundwater Quantities	No substantial changes to groundwater quantities are expected, as compared to recent experience, due to outfall flows.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Surface Water Quality	Outfall water quality should be similar to or better than in recent experience, so surface water quality on the site is not expected to change substantially as compared to existing quality.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Surface Contaminant Transport	Continued outfall flows are not expected to result in substantial contaminant transport off the site.	Similar to No Action Alternative; the small increase in outfall flows (as compared to No Action) are not expected to result in substantial contaminant transport off the site.	Same as No Action Alternative.	Same as Expanded Operations Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Groundwater Quality	Mechanisms for recharge to groundwater are highly uncertain; thus, the potential for LANL operations to contaminate groundwater is highly uncertain. It is possible that increased discharges could increase contaminant transport beneath Los Alamos Canyon and Sandia Canyon and off the site due to increased recharge to intermediate perched groundwater. No other effects can be projected based on existing information.	Same as No Action Alternative.	Although NPDES outfall flows are lower than in the other alternatives, it is still possible that the flows under this alternative could transport contaminants beneath Los Alamos Canyon and Sandia Canyon and off the site.	Same as No Action Alternative.
AIR QUALITY				
Criteria Pollutants	Criteria pollutant emissions are not expected to exceed ambient air quality standards and are not expected to approach levels that could affect human health.	Same as No Action Alternative. Construction activities associated with the Expansion of Area G and the Enhancement of Pit Manufacturing would be transitory and would not be expected to degrade air quality substantially.	Same as No Action Alternative.	Same as No Action Alternative.
Toxic Pollutants	Toxic air pollutants, including carcinogenic pollutants, are not expected to approach levels that could affect human health.	Firing site toxic emissions and the total of carcinogenic pollutant emissions exceeded screening values; but, more detailed analysis does not indicate that these emissions would have a significant effect on ecological resources or human health (see comments under those resource areas). Construction activities associated with the Expansion of Area G and the Enhancement of Pit Manufacturing would be transitory and would not be expected to degrade air quality substantially.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Emissions Dose to the Public Maximally Exposed Individual (MEI)	3.1 mrem/year to the LANL MEI (see human health effects below).	5.4 mrem/year to the LANL MEI (see human health effects below).	1.9 mrem/year to the LANL MEI (see human health effects below).	4.5 mrem/year to the LANL MEI (see human health effects below).
Radioactive Emissions Population Dose	About 14 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).	About 33 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).	About 11 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).	About 14 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).
ECOLOGICAL AND BIOLOGICAL RESOURCES				
Biological Resources, Ecological Processes, and Biodiversity	No significant adverse impacts projected for biological resources, ecological processes, or biodiversity, including threatened and endangered species.	Same as the No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Habitat Reduction	No reduction in habitat projected.	Removal of about 7 acres (2.8 hectares) of habitat for small mammals and birds, plus fencing that could alter large mammal movement, are associated with the proposed dedicated road between TA–55 and TA–3. Gradual removal of up to approximately 41 acres (17 hectares) of pinyon-juniper woodland associated with the Area G expansion; corresponds to small wildlife habitat loss and disturbance.	Same as No Action Alternative.	Same as No Action Alternative.
Ecological Risk	No significant risk to biotic communities due to LANL legacy contamination or contamination due to ongoing operations.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
HUMAN HEALTH				
Public Health —Radiological (inhalation, ingestion, and external radiation pathways)[a]	Average total ingestion dose to: • Los Alamos County resident: 3.9 mrem/year of operation (2.0 x 10^{-6} excess latent cancer facilities (LCFs)/year of operation). • Non-Los Alamos County resident: 7.5 mrem/year of operation (3.8 x 10^{-6} excess LCFs/year of operation). • Nonresident recreational user: 0.2 mrem/year of operation (1.0 x 10^{-7} excess LCFs/year of operation). • Resident recreational user: 0.6 mrem/year of operation (2.8 x 10^{-7} excess LCFs/year of operation). Air pathway dose to: • LANL MEI: 3.11 mrem/year of operation (1.6 x 10^{-6} excess LCFs/ year of operation). • Total population: 14 person-rem/ year of operation (0.007 excess LCF/year of operation).	Average total ingestion doses are the same as under the No Action Alternative. Air pathway dose to: • LANL MEI: 5.44 mrem/year of operation (2.7 x 10^{-6} excess LCFs/ year of operation). • Total population: 33 person-rem/ year of operation (0.017 excess LCF/year of operation).	Average total ingestion doses are the same as under the No Action Alternative Air pathway dose to: • LANL MEI: 1.88 mrem/year of operation (9.4 x 10^{-7} excess LCFs/ year of operation). • Total population: 11 person-rem/ year of operation (0.005 excess LCF/year of operation).	Average total ingestion doses are the same as under the No Action Alternative. Air pathway dose to: • LANL MEI: 4.52 mrem/year of operation (2.3 x 10^{-6} excess LCFs/ year of operation). • Total population: 14 person-rem/ year of operation (0.007 excess LCF/year of operation).
Public Health —Chemical	No significant effect to off-site residents or to the recreational user.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Special Pathways[b]	No significant effect through special pathways (< 1 x 10^{-6} excess LCFs/ year of operation).	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Worker Health—Radiological[a]	• Collective worker dose: 446 person-rem/year of operation (0.18 excess LCF/year of operation). • Average (non-zero) worker dose: 0.14 rem/year of operation (0.00005 excess LCF/year of operation).	• Collective worker dose: 833 person-rem/year of operation (0.33 excess LCF/year of operation). • Average (non-zero) worker dose: 0.24 rem/year of operation (0.000096 excess LCF/year of operation).	• Collective worker dose: 170 person-rem/year of operation (0.07 excess LCF/year of operation). • Average (non-zero) worker dose: 0.08 rem/year of operation (0.00003 excess LCF/year of operation).	• Collective worker dose: 472 person-rem/year of operation (0.19 excess LCF/year of operation). • Average (non-zero) worker dose: 0.14 rem/year of operation (0.00005 excess LCF/year of operation).
Worker Health—Chemical	1 to 3 reportable chemical exposures per year (none expected to result in serious injury or in fatalities).	2 to 5 reportable chemical exposures per year (none expected to result in serious injury or in fatalities).	Same as No Action Alternative.	Same as No Action Alternative.
Worker Health—Physical Safety Hazards	About 460 reportable cases per year.	About 507 reportable cases per year.	About 417 reportable cases per year.	Same as No Action Alternative.
ENVIRONMENTAL JUSTICE				
Environmental Justice Impacts	No disproportionately high or adverse impacts to minority or low-income populations identified.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
CULTURAL RESOURCES				
Prehistoric Resources	Negligible to minor potential for effects to some prehistoric resources due to shrapnel or vibrations from explosives testing. However, inspection of resources does not indicate that past operations have caused such effects. Other effects of ongoing operations are negligible or small compared to legacy contamination and natural effects.	Similar to the impacts under No Action, except that Expanded Operations would mean increased frequency of explosives testing (potentially accelerating any damage due to shrapnel and ground vibration). In addition, the Expansion of Area G could affect 15 sites potentially eligible for the National Register of Historic Places; it is anticipated that a determination of no adverse effect would be achieved based on a data recovery plan.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Historic Resources	Negligible potential for future operations to add contaminants that may limit preservation options. Other effects of ongoing operations are negligible or small compared to legacy contamination and natural effects.	Similar to the impacts under No Action, except that Expanded Operations would mean increased frequency of explosives testing (potentially accelerating damage due to shrapnel and ground vibration).	Same as No Action Alternative.	Same as No Action Alternative.
Traditional Cultural Properties	Unknown due to a lack of information on specific traditional cultural properties. Potential for effects to all types of traditional cultural properties due to changes in water quality and quantity, erosion, explosives testing shrapnel, noise and vibrations from explosives testing, and contamination from ongoing operations. Security at LANL can prevent access by traditional communities to some traditional cultural properties.	Unknown due to a lack of information on specific traditional cultural properties. Similar to the impacts under No Action, except that Expanded Operations would mean increased frequency of explosives testing (potentially accelerating damage due to shrapnel, ground vibration, and noise). Additionally, traditional cultural properties could be affected by the Expansion of Area G; coordination with the four Accord Pueblos would be pursued to identify and mitigate any potential adverse effects.	Same as No Action Alternative.	Same as No Action Alternative.
SOCIOECONOMICS, INFRASTRUCTURE, AND WASTE MANAGEMENT				
LANL Employment	9,977 full-time equivalents	11,351 full-time equivalents	9,347 full-time equivalents	9,968 full-time equivalents
Tri-County Employment	Increase of 691 full-time equivalents, as compared to the 1995 regional employment, about 85,720.	Increase of 2,186 full-time equivalents, as compared to 1995 regional employment.	Decrease of 33 full-time equivalents, as compared to 1995 regional employment.	Increase of 680 full-time equivalents, as compared to 1995 regional employment.
Tri-County Population	Increase of 1,377 people, as compared to the estimated 1996 Tri-County population of 165,938.	Increase of 4,230 people, as compared to the 1996 estimated population.	Decrease of 64 people, as compared to the 1996 estimated population.	Increase of 1,316 people, as compared to the 1996 estimated population.
Tri-County Personal Income	Increase of about $53 million, as compared to the 1994 estimate of $3.5 billion.	Increase of $172 million, as compared to the 1994 estimate.	Decrease of $6 million, as compared to the 1994 estimate.	Increase of $55 million, as compared to the 1994 estimate.
Maximum Annual Electrical Demand	717 gigawatt-hours	782 gigawatt-hours	508 gigawatt-hours	782 gigawatt-hours

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Peak Electrical Demand	108 megawatts (exceeds supply during winter and summer months). May result in area brownouts.	113 megawatts (exceeds supply during winter and summer months). May result in area brownouts.	88 megawatts (exceeds supply during winter months and within the existing supply the rest of the year). May result in brownouts.	113 megawatts (exceeds supply during winter and summer months). May result in area brownouts.
Maximum Annual Natural Gas Demand	1,840,000 decatherms (well within existing supply capacity).	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Maximum Annual Water Demand	712 million gallons per year (2,695 million liters per year) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water.)	759 million gallons per year (2,873 million liters per year) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water.)	602 million gallons per year (2,279 million liters per year) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water.)	759 million gallons per year (2,873 million liters per year) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water.)
Annual Chemical Waste Generation	6,264,953 pounds (2,886,000 kilograms)	7,164,045 pounds (3,249,000 kilograms)	6,345,990 pounds (2,878,000 kilograms)	6,372,450 pounds (2,890,000 kilograms)
Annual LLW Generation (includes low-level mixed waste [LLMW])	344,246 cubic feet (9,752 cubic meters)	454,417 cubic feet (12,873 cubic meters)	338,209 cubic feet (9,581 cubic meters)	382,123 cubic feet (10,825 cubic meters)
Annual Transuranic (TRU) Waste Generation (includes Mixed TRU Waste)	18,956 cubic feet (537 cubic meters)	19,274 cubic feet (546 cubic meters)	6,707 cubic feet (190 cubic meters)	8,825 cubic feet (250 cubic meters)
Increase in Contaminated Space	Increase of 63,000 square feet (5,853 square meters), as compared to the index.	Increase of 73,000 square feet (6,782 square meters), as compared to the index.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE S.3.1–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
TRANSPORTATION (INCIDENT FREE)				
Public Radiation Exposure (Off-Site Shipments)[a]	• Along route: 3.3 person-rem/year of operation (0.0017 excess LCF/ year of operation). • Sharing route: 30 person-rem/year of operation (0.015 excess LCF/ year of operation). • At rest stops: 210 person-rem/year of operation (0.11 excess LCF/year of operation). • MEI: 0.0003 rem/year of operation (1.5 x 10^{-7} excess LCFs/year of operation).	• Along route: 4.2 person-rem/year of operation (0.0021 excess LCF/ year of operation). • Sharing route: 37 person-rem/year of operation (0.019 excess LCF/ year of operation). • At rest stops: 270 person-rem/year of operation (0.14 excess LCF/year of operation). • MEI: 0.0004 rem/year of operation (1.9 x 10^{-7} excess LCFs/year of operation).	• Along route: 3.5 person-rem/year of operation (0.0017 excess LCF/ year of operation). • Sharing route: 31 person-rem/year of operation (0.015 excess LCF/ year of operation). • At rest stops: 230 person-rem/year of operation (0.12 excess LCF/year of operation). • MEI: 0.0003 rem/year of operation (1.6 x 10^{-7} excess LCFs/year of operation).	• Along route: 3.6 person-rem/year of operation (0.0018 excess LCF/ year of operation). • Sharing route: 33 person-rem/year of operation (0.015 excess LCF/ year of operation). • At rest stops: 250 person-rem/year of operation (0.12 excess LCF/year of operation). • MEI: 0.0003 rem/year of operation (1.7 x 10^{-7} excess LCFs/year of operation).
Worker (Drivers) Radiation Exposure[a]	• Off-site: 470 person-rem/year of operation (0.19 excess LCF/year of operation). • On-site: 4.2 person-rem/year of operation (0.0018 excess LCF/year of operation).	• Off-site: 580 person-rem/year of operation (0.23 excess LCF/year of operation). • On-site: 10.3 person-rem/year of operation (0.0041 excess LCF/year of operation).	• Off-site: 510 person-rem/year of operation (0.21 excess LCF/year of operation). • On-site: 4.3 person-rem/year of operation (0.0017 excess LCF/year of operation).	• Off-site: 530 person-rem/year of operation (0.21 excess LCF/year of operation). • On-site: 4.5 person-rem/year of operation (0.0018 excess LCF/year of operation).

MEI = Maximally exposed individual (a hypothetical individual who takes no protective actions and receives the maximum potential dose). An MEI may be defined for a particular event or location or for the entire site. The LANL MEI is the MEI at LANL in the location that receives the highest possible dose out of all potential locations (used in this SWEIS for inhalation pathway analyses).

mrem = millirem

Note: The impacts of implementing the proposed actions in the Surplus Plutonium Disposition EIS, Lead Test Assembly (section 1.5.8); Siting, Construction, and Operation of the Spallation Neutron Source (section 1.5.9); and CT EIS (section 1.5.10) are summarized in chapter 5, section 5.6.

[a] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

[b] Special pathways refers to the analyses performed regarding potential exposures to radioactive or other hazardous contaminants through pathways or practices associated with the traditional activities of communities in the area (e.g., smoking or drinking [as teas] locally grown herbs, increased ingestion of local fishes, or uses of soils or clays in arts and crafts).

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
TRANSPORTATION ACCIDENTS[c,f]					
Vehicle Accidents (No Cargo Release)	Accidents per year	4.5	9.0	4.9	5.2
	Resulting injuries per year	3.8	7.6	3.3	3.8
	Resulting fatalities per year	0.38	0.78	0.33	0.44
Release of Radioactive Cargo (Bounding Off-Site Accidents)	Radiation dose (person-rem/year)	2.8	3.0	2.8	3.0
	Resulting in excess LCF per year of operation (total along entire route)	0.0014	0.0016	0.0014	0.0016
Release of Radioactive Cargo (Bounding On-Site Accidents)	Plutonium-238:				
	• Accidents per year	8.8×10^{-8}	1.7×10^{-7}	8.8×10^{-8}	8.8×10^{-8}
	• MEI dose (rem)	8.7	8.7	8.7	8.7
	• Resulting MEI risk	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCFs/year)	1.4×10^{-6} rem/year (5.8×10^{-10} excess LCFs/year)	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCFs/year)	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCFs/year)
	Irradiated targets:				
	• Accident frequency	3.1×10^{-6}	3.2×10^{-6}	2.9×10^{-6}	3.2×10^{-6}
	• MEI consequence	Acute fatality	Acute fatality	Acute fatality	Acute fatality
	• Resulting MEI risk	3.1×10^{-6} fatalities/year	3.2×10^{-6} fatalities/year	2.9×10^{-6} fatalities/year	3.2×10^{-6} fatalities/year
Release of Chemical Cargo	Chlorine: Injuries per year (total)	0.006	0.013	0.0056	0.006
	Chlorine: Fatalities per year (total)	0.0016	0.0036	0.0015	0.0016
	Propane: Injuries per year (total)	0.0014	0.0031	0.0014	0.0014
	Propane: Fatalities per year (total)	0.00035	0.00076	0.00032	0.00035

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
ACCIDENTS (OTHER THAN TRANSPORTATION ACCIDENTS AND WORKER PHYSICAL SAFETY INCIDENTS/ACCIDENTS)[c]					
SITE–01: Site-Wide Earthquake with Severe Damage to Multiple Low-Capacity Facilities[a]	Event frequency (per year)	0.0029	0.0029	0.0029	0.0029
	MEI dose (rem)	20	20	20	20
	Public exposure (person-rem) excess LCF	27,726 16	27,726 16	27,726 16	27,726 16
SITE–02: Site-Wide Earthquake with Severe Damage to Multiple Moderate-Capacity Facilities[a]	Event frequency (per year)	0.00044	0.00044	0.00044	0.00044
	MEI dose (rem)	34	34	34	34
	Public exposure (person-rem) excess LCF	41,340 24	41,340 24	41,340 24	41,340 24
SITE–03: Site-Wide Earthquake with Severe Damage to Essentially All Facilities[a,d]	Event frequency (per year)	0.000071	0.000071	0.000071	0.000071
	MEI dose (rem)	247	247	247	247
	Public exposure (person-rem) excess LCF	210,758 134	210,758 134	210,758 134	210,758 134
SITE–04: Site-Wide Wildfire Consuming Combustible Structures and Vegetation	Event frequency (per year)	0.1	0.1	0.1	0.1
	MEI dose (rem)	< 25	< 25	< 25	< 25
	Public exposure (person-rem) excess LCF	675 0.34	675 0.34	669 0.33	675 0.34
RAD–12: Plutonium Release from a Seismically Initiated Event	Event frequency (per year)	Approximately 1.5×10^{-6}	Approximately 1.5×10^{-6}	Approximately 1.5×10^{-6}	Approximately 1.5×10^{-6}
	MEI dose (rem)	138	138	138	138
	Public exposure (person-rem) excess LCF	Approximately 35,800 18	Approximately 35,800 18	Approximately 35,800 18	Approximately 35,800 18
	Worker consequences	Any in the facility would be killed by explosion or falling debris.	Any in the facility would be killed by explosion or falling debris.	Any in the facility would be killed by explosion or falling debris.	Any in the facility would be killed by explosion or falling debris.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
CHEM–01: Single Cylinder Chlorine Release from Potable Water Treatment Station (TA–0)	Event frequency (per year)	0.0012	0.0013	0.0011	0.0012
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2[b]	 12 43	 12 43	 12 43	 12 43
	Worker consequences	If workers are present, there is potential for worker injury or fatality.	If workers are present, there is potential for worker injury or fatality.	If workers are present, there is potential for worker injury or fatality.	If workers are present, there is potential for worker injury or fatality.
CHEM–02: Multiple Cylinder Chlorine Release from Toxic Gas Storage Facility (TA–3)	Event frequency (per year)	0.00013	0.00015	0.00012	0.00013
	MEI	NA	NA	NA	NA
	Public exposed to > ERPG–3 or > ERPG–2	292	292	292	292
	Worker consequences	Possible injuries or fatalities to workers present at time of accident or responding to accident.	Possible injuries or fatalities to workers present at time of accident or responding to accident.	Possible injuries or fatalities to workers present at time of accident or responding to accident.	Possible injuries or fatalities to workers present at time of accident or responding to accident.
CHEM–03: Single Cylinder Chlorine Release from Toxic Gas Storage Facility (TA–3)	Event frequency (per year)	0.00012	0.00012	0.00012	0.00012
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 239 263	 239 263	 239 263	 239 263
	Worker consequences	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
CHEM–04: Bounding Single Container Release of Toxic Gas (Selenium Hexaflouride) from Toxic Gas Cylinder Storage (TA–54)	Event frequency (per year)	0.004	0.004	0.004	0.004
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 0 0	 0 0	 0 0	 0 0
	Worker consequences	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.
CHEM–05: Bounding Multiple Cylinder Release of Toxic Gas (Sulfur Dioxide) from Toxic Gas Cylinder Storage (TA–54)	Event frequency (per year)	0.00051	0.00051	0.00051	0.00051
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 0 0	 0 0	 0 0	 0 0
	Worker consequences	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.
CHEM–06: Chlorine Gas Release from Plutonium Facility (TA–55) Process Line	Event frequency (per year)	0.063	0.063	0.063	0.063
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 7 102	 7 102	 7 102	 7 102
	Worker consequences	Unlikely that workers are present; but if present, there is potential for worker injury.	Unlikely that workers are present; but if present, there is potential for worker injury.	Unlikely that workers are present; but if present, there is potential for worker injury.	Unlikely that workers are present; but if present, there is potential for worker injury.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–01: Plutonium Release from Container Storage Area Fire Involving TRU Waste Drums (TA–54)	Event frequency (per year)	0.0016	0.0016	0.0016	0.0016
	MEI dose (rem)	46	46	46	46
	Public exposure (person-rem) excess LCF	72 0.04	72 0.04	72 0.04	72 0.04
	Worker consequences	Potential for plutonium inhalation, but no fatalities would be expected.	Potential for plutonium inhalation, but no fatalities would be expected.	Potential for plutonium inhalation, but no fatalities would be expected.	Potential for plutonium inhalation, but no fatalities would be expected.
RAD–03: Reactivity Excursion at Pajarito Site (TA–18) Kiva #3, Vaporizing Some Enriched Uranium Fuel and Melting the Remainder	Event frequency (per year)	3.4×10^{-6}	3.4×10^{-6}	3.4×10^{-6}	3.4×10^{-6}
	MEI dose rem[e]	150	150	150	150
	Public exposure (person-rem) excess LCF	110 0.06	110 0.06	110 0.06	110 0.06
	Worker consequences	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.
RAD–05: Aircraft Crash with Explosion and/or Fire at TA–21 Resulting in Tritium Oxide Release	Event frequency (per year)	5.3×10^{-6}	5.3×10^{-6}	5.3×10^{-6}	5.3×10^{-6}
	MEI dose (rem)	0.01	0.01	0.01	0.01
	Public exposure (person-rem) excess LCF	24 0.01	24 0.01	24 0.01	24 0.01
	Worker consequences	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–07: Plutonium Release due to Container Storage Area Fire Involving TRU Waste Drums (TA–50)	Event frequency (per year)	0.00015	0.0003	0.00011	0.00015
	MEI dose (rem)	74	74	74	74
	Public exposure (person-rem) excess LCF	1,300 0.69	1,300 0.69	1,300 0.69	1,300 0.69
	Worker consequences	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.
RAD–08: Aircraft Crash with Explosion and/or Fire at the TRU Waste Area at TA–54	Event frequency (per year)	4.3×10^{-6}	4.3×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
	MEI dose (rem)	22	22	22	22
	Public exposure (person-rem) excess LCF	400 0.2	400 0.2	400 0.2	400 0.2
	Worker consequences	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.
RAD–09: TRU Waste Drum Failure or Puncture at TA–54, Area G (results are for typical drum)	Event frequency (per year)	0.4	0.49	0.4	0.4
	MEI dose (rem)	0.41	0.41	0.41	0.41
	Public exposure (person-rem) excess LCF	4.3 0.002	4.3 0.002	4.3 0.002	4.3 0.002
	Worker consequences	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–13: Plutonium Melting and Release Accident at Pajarito Site (TA–18) Kiva #3	Event frequency (per year)	0.000016	0.000016	0.000016	0.000016
	MEI dose (rem)	120	120	120	120
	Public exposure (person-rem) excess LCF	160 0.08	160 0.08	160 0.08	160 0.08
	Worker consequences	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.
RAD–15: Plutonium Release from a Wing Fire at the CMR Building (in TA–3)	Event frequency (per year)	0.000032	0.000032	0.000032	0.000032
	MEI dose (rem)	40	91	40	40
	Public exposure (person-rem) excess LCF	1,700 0.85	3,400 1.7	1,700 0.85	1,700 0.85
	Worker consequences	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.
RAD–16: Aircraft Crash with Explosion and/or Fire at the CMR Building (in TA–3) Resulting in a Plutonium Release	Event frequency (per year)	3.5×10^{-6}	3.5×10^{-6}	3.5×10^{-6}	3.5×10^{-6}
	MEI dose (rem)	3	3	3	3
	Public exposure (person-rem) excess LCF	56 0.03	56 0.03	56 0.03	56 0.03
	Worker consequences	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
WORK–01: Worker Fatality Due to Inadvertent High Explosives Detonation	Event frequency (per year)	0.001 to 0.01	0.0015 to 0.015	0.0008 to 0.008	0.0006 to 0.006
	Worker injuries or fatalities	1 to 10 injuries or fatalities.	1 to 10 injuries or fatalities.	1 to 10 injuries or fatalities.	1 to 10 injuries or fatalities.
WORK–02: Worker Illness or Fatality Due to Inadvertent Biohazard Contamination	Event frequency (per year)	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1
	Worker injuries or fatalities	1 injury or fatality.	1 injury or fatality.	1 injury or fatality.	1 injury or fatality.
WORK–03: Multiple Worker Fatality Due to Inadvertent Nuclear Criticality Event	Event frequency (per year)	< 0.00001	< 0.00001	< 0.00001	< 0.00001
	Worker exposures or fatalities	Substantial doses and possible fatalities.	Substantial doses and possible fatalities.	Substantial doses and possible fatalities.	Substantial doses and possible fatalities.
WORK–04: Worker Injury or Fatality Due to Inadvertent Nonionizing Radiation Exposure	Event frequency (per year)	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1
	Worker injuries or fatalities	Typically 1, rarely several, injuries or fatalities.	Typically 1, rarely several, injuries or fatalities.	Typically 1, rarely several, injuries or fatalities.	Typically 1, rarely several, injuries or fatalities.
WORK–05: Worker Exposure to Plutonium Released from a Degraded Storage Container at TA–55	Event frequency (per year)	0.23	0.23	0.23	0.23
	Worker injuries or fatalities	1 or 2 workers potentially exposed to plutonium inhalation.	1 or 2 workers potentially exposed to plutonium inhalation.	1 or 2 workers potentially exposed to plutonium inhalation.	1 or 2 workers potentially exposed to plutonium inhalation.

MEI = Maximally exposed individual (a hypothetical individual who takes no protective actions and receives the maximum potential dose). An MEI may be defined for a particular event or location or for the entire site. The LANL MEI is the MEI at LANL in the location that receives the highest possible dose out of all potential locations (used in this SWEIS for inhalation pathway analyses).

ERPG = Emergency Planning Response Guideline

NA = Not Applicable

[a] Workers in buildings that are structurally damaged or collapse could be injured or killed, but the number of workers injured or killed cannot be predicted a priori. Worker excess latent cancer fatalities due to radiological releases in an earthquake and worker injuries or fatalities due to chemical releases in an earthquake are expected to be small or modest increments to the impacts directly attributable to the earthquake (e.g., the collapse of structures). The estimates of event frequencies and impacts are conservative.

[b] ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without irreversible or serious health effects or symptoms that could impair their abilities to take protective action. ERPG–3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without life-threatening health effects.

[c] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the LCFs per year expresses is incremental number of fatal cancers anticipated in the exposed population for each year of operation.

[d] There is a potential for fault rupturing to occur at the CMR Building (TA–3–29) at a somewhat lower frequency than the SITE–03 earthquake (estimated at 1 to 3 x 10^{-5} per year). Should this occur in association with the SITE–03 earthquake, a conservative estimate results in an additional 133,833 person-rem population exposure (increasing excess LCFs by 99), and an increase to the MEI of 134 rem.

[e] The MEI dose is provided, under this accident scenario, for an individual located on Pajarito Road at a distance of 164 feet (50 meters) from the facility, even though Pajarito Road would be closed to the public during outdoor operations.

TABLE S.3.1–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

[f] Transportation accidents are typically calculated using computer codes, considering varying accident rates for route types, varying populations along the routes, and other factors. The calculated risks are presented as the product of the accident frequency and the accident consequence; for such calculations, the frequency and consequence terms are not readily accessible from the calculational results. As such, this table reflects the risks associated with transportation accidents, but generally does not separately present the consequence and frequency terms. The on-site radioactive transportation analyses were done by hand calculations, and for these accidents, frequency, consequence, and risk are all presented separately in the table.

Note: Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same.

and accidents resulting from external human activities (such as airplane crashes and transportation accidents).

The major contributors to environmental impacts of operating LANL are wastewater discharges and radioactive air emissions.

- Historic discharges to Mortandad Canyon from the Radioactive Liquid Waste Treatment Facility have resulted in above background residual radionuclide (americium, plutonium, strontium-90, and cesium-137) concentrations, as well as nitrates in alluvial groundwater and sediments.
- Plutonium deposits have been detected along the Rio Grande between Otowi and Cochiti Lake.
- The principal contributors to radioactive air emissions have been and continue to be the Los Alamos Neutron Science Center and high explosives testing activities.

In addition, trace amounts of tritium have been detected in some samples from the main aquifer. (Isolated results have indicated the presence of other radionuclides. However, results have not been duplicated in previous or subsequent samples, making these results suspect.)

The analysis in the SWEIS indicates that there would be very little difference in the environmental impacts among the SWEIS alternatives analyzed. The major discriminators among alternatives would be: collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand. The separate analyses of impacts to air and water resources constitute some of the source information for analysis of impacts to human health and the environment. As can be seen from those presentations, the variation across the alternatives is not of a sufficient magnitude to cause large differences in effects.

Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same. The following information highlights the similarities and differences between the consequences of alternatives.

S.3.1.1 *Land Resources*

There is little difference in the impacts to land resources between the No Action, Reduced Operations, and the Greener Alternatives. Differences among the alternatives are primarily associated with operations in existing facilities, and very little new development is planned. Therefore, these impacts are essentially the same as currently experienced. The Expanded Operations Alternative has very similar land resources impacts to those of the other three alternatives, with the principal differences being attributable to the visual impacts of lighting along the proposed transportation corridor and the noise and vibration associated with increased frequency of high explosives testing (as compared to the other three alternatives).

S.3.1.2 *Geology, Geological Conditions, and Soils*

There is little difference in the impacts to these resources across the alternatives. Wastewater discharge volumes with associated contaminants do change across the alternatives, but not to a degree noticeable in terms of impacts (such as causing soil erosion, for example). Under all of the alternatives, small quantities (as compared to existing conditions) of contaminants would be deposited in soils due to continued LANL operations and the Environmental Restoration Project (discussed further in section S.3.3) would continue to remove existing contaminants at sites to be remediated.

Geological mapping and fault trenching studies at LANL are currently underway or recently completed to better define the rates of fault movements, specifically for the Pajarito Fault, and the location and possible southern termination of the Rendija Canyon Fault. Appendix I of the SWEIS presents a detailed status of the ongoing and recently completed seismic hazard studies, as well as the implications of these studies for LANL and DOE. That report indicates that slip rates (recurrence intervals for earthquakes) are within the parameters assumed in the 1995 seismic hazards study at LANL (chapter 4, section 4.2.2.2).

S.3.1.3 *Water Resources*

Water demand under all alternatives (section S.3.1.9, below) is within existing DOE Rights to Water, and would result in average drops of 10 to 15 feet (3.1 to 4.6 meters) in the water levels in DOE well fields over the next 10 years. Except for cooling water used for the TA–53 accelerator facilities, there are not predominant industrial water users at LANL. Usage, therefore, will remain within a fairly tight range among the alternatives. The related aspect of wastewater discharges is also within a narrow range for that reason. Outfall flows range from 218 to 278 million gallons (825 to 1,052 million liters) per year across the alternatives, and these flows are not expected to result in substantial changes to existing surface or groundwater quantities. Outfall flows are not expected to result in substantial surface contaminant transport under any of the alternatives. Although mechanisms for recharge to groundwater are highly uncertain, it is possible that discharges under any of the alternatives could result in contaminant transport in groundwater and off the site, particularly beneath Los Alamos Canyon and Sandia Canyon, which have increased outfall flows. (The outfall flows associated with the Expanded Operations and Greener Alternatives would reflect the largest potential for such contaminant transport, and the flows associated with the Reduced Operations Alternative would have the least potential for such transport.)

S.3.1.4 *Air Quality*

Nonradioactive hazardous air pollutants would not be expected to degrade air quality or affect human health under any of the alternatives. The differences across the alternatives do not result in large changes in chemical usage. The activities at LANL are such that large amounts are not typically used in any industrial process (as may be found in manufacturing facilities); but research and development activities involving many users dispersed throughout the site are the norm. Air emissions are therefore not expected to change by a magnitude that would, for example, trigger more stringent regulatory requirements or warrant continuous monitoring. Radioactive air emissions change slightly, but are within a narrow range due to the controls placed on these types of emissions and the need to assure compliance with regulatory standards. The collective population radiation doses from these emissions range from about 11 person-rem per year to 33 person-rem per year across the alternatives (primarily from TA–53 and high explosives testing activities), and the radiation dose to the LANL maximally exposed individual ranges from 1.9 millirem per year to 5.4 millirem per year across the alternatives (primarily from the operations at TA–53). These doses are considered in the human health impact analysis.

S.3.1.5 *Ecological and Biological Resources*

No significant adverse impact to these resources is projected under any of the alternatives. The separate analyses of impacts to air and water resources constitute some of the source information for analysis of impacts in this area; as can be seen from those presentations, the variation across the alternatives are not of a sufficient magnitude to cause large differences in effects. The impacts of the Expanded Operations Alternative differs from those of the other alternatives in that there is some projected loss of habitat; however, this habitat loss is small (due to limited new construction) compared to available similar habitat in the immediate vicinity, and no significant adverse effects to ecological or biological resources is expected.

S.3.1.6 *Human Health*

The total radiological doses over the next 10 years to the public under any of the SWEIS alternatives are relatively small, as compared to doses due to background radiation in the area (about 0.3 rem per year) and would not be expected to result in any excess latent cancer fatalities (LCFs) to members of the public. Additionally, exposure to chemicals due to LANL operations under any of the SWEIS alternatives are not expected to result in significant effects to either workers or the public. Exposure pathways associated with the traditional practices of communities in the LANL area (special pathways) would not be expected to result in human health effects under any of the alternatives. The annual collective radiation dose to workers at LANL ranges from 170 person-rem per year to 833 person-rem per year across the SWEIS alternatives. (The difference is primarily attributable to the differences in Los Alamos Neutron Science Center (LANSCE) accelerator operations and TA–55–4 actinide processing and pit fabrication activities.) These dose levels would be expected to result in from 0.07 to 0.33 excess LCFs per year of operation, respectively, among the exposed workforce.

These impacts, in terms of excess LCFs per year of operation, reflect the numbers of excess fatal cancers estimated to occur among the exposed members of the work force over their lifetimes per year of LANL operations. The reader should recognize these estimates are intended to provide a conservative measure of the potential impacts to be used in the decision-making process and do not necessarily portray an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated impacts form an upper bound and that actual consequences could be less, but probably would not be worse. Worker exposures to physical safety hazards are expected to result in a range of 417 (Reduced Operations) to 507 (Expanded Operations) reportable cases each year; typically, such cases would result in minor or short-term effects to workers, but some of these incidents could result in long-term health effects or even death.

S.3.1.7 Environmental Justice

Executive Order 12898 (*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*) requires every federal agency to analyze whether its proposed action and alternatives would have disproportionately high and adverse impacts on minority or low-income populations. Based on the analysis of other impact areas, DOE expects few high and adverse impacts from the continued operation of LANL under any of the alternatives, and, to the extent impacts may be high and adverse, DOE expects the impact to affect all populations in the area equally. DOE also analyzed human health impacts from exposure through special pathways, including ingestion of game animals, fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of plant materials. The special pathways have the potential to be important to the environmental justice analysis because some of these pathways may be more important or viable for the traditional or cultural practices of minority populations in the area. However, human health impacts associated with these special pathways also would not present disproportionately high and adverse impacts to minority or low-income populations.

S.3.1.8 Cultural Resources

Under all of the SWEIS alternatives there is a negligible to low potential for impacts to archaeological and historic resources due to shrapnel and vibration caused by explosives testing and contamination from emissions. Logically, potential impacts would vary in intensity in accordance with the frequency of explosives tests and the operational levels that generate emissions (e.g., Reduced Operations would reflect the lowest potential, and Expanded Operations would reflect the highest potential). Recent assessments of prehistoric resources indicate a low potential compared to the effects of natural conditions (wind, rain, etc.). In addition to these potential impacts, the Expanded Operations Alternative includes the expansion of the LLW disposal site at TA–54, which contains several National Register of Historic Places (NRHP) sites; it is anticipated that a determination of no adverse effect to these resources would be achieved based on a data recovery plan.

The potential impacts to specific traditional cultural properties (TCPs) would depend on their number, characteristics, and location. Such resources could be adversely affected by changes in water quality and quantity, erosion, shrapnel from explosives testing, noise and vibration from explosives testing, and contamination from ongoing operations. Such impacts would vary in intensity in accordance with the frequency of explosives tests and the operational levels that generate emissions. The current practice of consultation would continue to be used to provide opportunities to avoid or minimize adverse impacts to any TCPs located at LANL.

S.3.1.9 Socioeconomics, Infrastructure, and Waste Management

LANL employment (including UC employees and those of the two subcontractors with the largest employment among the LANL subcontractors) ranges from 9,347 (Reduced Operations) to 11,351 (Expanded Operations) full-time equivalents across the alternatives, as compared to 9,375 LANL full-time equivalents in 1996. These changes in employment would result in changes in regional population, employment, personal income, and other socioeconomic measures. These secondary effects would change existing conditions in the region by less than 5 percent.

Peak electrical demand under the Reduced Operations Alternative exceeds supply during the winter months and may result in periodic brownouts. Peak electrical demand under the No Action, Expanded Operations, and Greener Alternatives exceeds the power supply in winter and summer; this may result in periodic brownouts. (Power supply to the Los Alamos area has been a concern for a number of years, and DOE continues to work with other users in the area and power suppliers to increase this supply.) Natural gas demand is not projected to change across the alternatives, and this demand is within the existing supply of natural gas to the area; however, the age and condition of the existing supply and distribution system will continue to be a reliability issue for LANL and for residents and other businesses in the area. Water demand for LANL ranges from 602 million gallons (2,279 million liters) per year to 759 million gallons (2,873 million liters) per year across the alternatives; the total water demand (including LANL and the residences and other businesses and agencies in the area) is within the existing DOE rights to water.

LANL chemical waste generation ranges from 3,173 to 3,582 tons (2,878,000 to 3,249,300 kilograms) per year across the alternatives. LANL LLW generation, including low-level mixed waste (LLMW), ranges from 338,210 to 456,530 cubic feet (9,581 to 12,837 cubic meters) per year across the alternatives. LANL transuranic (TRU) waste generation, including mixed TRU waste, ranges from 6,710 to 19,270 cubic feet (190 to 547 cubic meters) across the alternatives. Disposal of these wastes at on-site or off-site locations is projected to constitute a relatively small portion of the existing capacity for disposal sites; disposal of all LANL LLW on the site would require expansion of the LLW disposal capacity beyond the existing footprint of TA–54 Area G under all alternatives (although this is only included in the analysis of the Expanded Operations Alternative).

Radioactively contaminated space in LANL facilities would increase by about 63,000 square feet (5,853 square meters) under the No Action, Reduced Operations, and Greener Alternatives (due primarily to actions previously reviewed under NEPA but not fully implemented at the time the existing contaminated space estimate was established [May 1996]). The Expanded Operations Alternative would increase contaminated space in LANL facilities by about 73,000 square feet (6,782 square meters). The creation of new contaminated space implies a clean-up burden in the future, including the generation of radioactive waste for treatment and disposal; the actual impacts of such clean-up actions are highly uncertain because they are dependent on the actual characteristics of the facility technologies available and the applicable requirements at the time of the cleanup.

S.3.1.10 *Transportation*

Incident-free transportation associated with LANL activities over the next 10 years would be conservatively expected to cause radiation doses that would result in about one excess LCF to a member of the public and two excess LCFs to members of the LANL workforce over their lifetimes under each of the SWEIS alternatives. (Refer to the discussion of the limitations on quantitative estimates of excess LCF risks in section S.3.1.6.) There is little variation in impacts because effects are small, and the increased transport of radioactive materials is not enough to make a significant change in those small effects.

Transportation accidents without an associated cargo release over the next 10 years of LANL operations are conservatively projected to result in from 33 to 76 injuries and 3 to 8 fatalities (including workers and the public) across the alternatives. The bounding off-site and on-site transportation accidents over the next 10 years involving a release of cargo would not be expected to result in any injuries or fatalities to members of the public for any of the alternatives. Accidents were analyzed by type of material, and the maximum quantities were selected for analysis. These parameters do not change across the alternatives. Total risk also does not change appreciably across the alternatives because the frequency of shipments does not vary enough to substantially influence the result.

S.3.1.11 *Accidents (Other than Transportation Accidents and Worker Physical Safety Incidents/Accidents)*

The SWEIS accident analyses considered a variety of initiators (including natural and manmade phenomena), the range of activities at LANL, and the range of radioactive and other hazardous materials at LANL. Transportation accidents and the relatively frequent worker physical safety incidents/accidents were considered separately (sections S.3.1.10 and S.3.1.6, respectively). The accidents discussed in this section are those that bound the accident risks at LANL (other than transportation and physical safety incidents/accidents).

The operational accident analysis included four scenarios that would result in multiple source releases of hazardous materials: three due to a site-wide earthquake and one due to a wildfire. (Three different earthquake magnitudes were analyzed [labeled SITE–01, SITE–02, and SITE–03], resulting in three different degrees of damage and consequences and one wildfire scenario [labeled SITE–04].) These four scenarios dominate the radiological risk due to accidents at LANL because they involve radiological releases at multiple facilities and are considered credible (that is, they would be expected to occur more often than once in a million years), with the wildfire considered likely. Another earthquake-initiated accident, labelled RAD–12, is facility-specific (to Building TA–16–411) and is dominated by the site-wide earthquake accidents due to its very low frequency (about 1.5 x 10^{-6} per year). It is noteworthy that the consequences of such earthquakes are dependent on the frequency of the earthquake event, the facility design, and the amount of material that could be released due to the earthquake; such features do not change across the SWEIS alternatives, so the impacts of these accidents are the same for all four alternatives. The risks were estimated conservatively in terms of both the frequency of the events and the consequences of such events. (In particular, it is noteworthy that the analysis assumes that any building that would sustain structural or systems damage in an earthquake scenario does so in a manner that creates a path for release of material outside of the building.) The total societal risk of an accident is the product of the accident frequency and the consequences to the total population within 50 miles (80 kilometers). This risk, as presented in chapter 5 and in appendix G, ranges from 0.046 (SITE–01) and 0.034 (SITE–04) excess LCFs per year of operation, to extremely small numbers for most of the radiological accidents[2]. The societal risk for release of chemicals, such as chlorine, is calculated similarly as the product of the frequency and numbers of people exposed to greater than the selected guideline concentration, Emergency Response Planning Guideline (ERPG)–2[3]. The risks for chemical releases range from 6.4

2. As an example, for SITE–01 the societal risk of 0.046 excess LCFs per year was calculated by multiplying the event frequency of 0.0029 per year by the consequence to the population of 16 excess LCFs (Table S.3.1–2). The excess LCFs resulting from public exposure are calculated by an approved model, such as the MACCS code, or alternatively multiplying the public exposure of 27,726 person-rem (from accident analysis) by the conversion factor of 5 x 10^{-4} excess LCFs per person-rem (ICRP 1991).

3. ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without irreversible or serious health effects or symptoms that could impair their abilities to take protective action.

(SITE–01) people exposed per year of operation to vanishingly small numbers for some chemical releases. In general, such earthquakes would be expected to cause fatalities due to falling structures or equipment; this also would be true for LANL facilities. Thus, worker fatalities due to the direct effects of the earthquakes would be expected. Worker injuries or fatalities due to the release of radioactive or other hazardous materials would be expected to be small or modest increments to the injuries and fatalities due to the direct effects of the earthquakes.

Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same.

Plutonium accident risks to the public (other than those associated with the site-wide earthquake scenarios) are dominated by the puncture of a “typical” TRU waste drum (typical refers to the radioactivity of the drum contents), which is the highest frequency plutonium accident analyzed, and the release of plutonium from a fire in a TRU waste container storage area, which had one of the highest population doses from a plutonium accident. These accidents, labeled as RAD–09 and RAD–07, have societal risks of 0.0008 and 0.00011 excess LCFs per year, respectively, under the No Action Alternative. While other accident scenarios were considered and analyzed (including process risks in TA–55 and the CMR Building), their risks to the public are at least an order of magnitude lower because either they are associated with relatively infrequent initiating events (e.g., aircraft crashes), or because the event occurs within facilities that are designed with multiple features (referred to as defense in depth) that prevent or minimize releases to the public. The risks associated with plutonium accidents change slightly (less than an order of magnitude) across the SWEIS alternatives. Frequency or consequence increases (up to double that of No Action) for some accidents under the Expanded Operations Alternative, and frequency decreases (by up to 25 percent) from some accidents under the Reduced Operations Alternative. RAD–07 and RAD–09 remain the dominant plutonium accidents for public exposure under all alternatives.

An overview of the 1969 plutonium pit fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and TA–55–4 are presented in appendix G, section G.4.1.2. Substantial differences exist between the nuclear facility and operations being conducted in TA–55–4 today and those that were present at the Rocky Flats Plant in 1969. TA–55–4 was designed to correct the deficiencies detected in older facilities such as the Rock Flats Plant and is being upgraded to meet the even more stringent requirements of the 1990's, including enhanced seismic resistance and fire containment.

Worker risk due to plutonium accidents is highly dependent on the number of workers present at the time of the event, on the type of protective measures taken at the time of the accident, on the speed with which these measures are taken, and on the effectiveness of medical treatment after exposure; as such, worker risks cannot be predicted quantitatively or reliably. In general, worker risks due to plutonium released in an accident would be limited to those workers in the immediate vicinity of the accident, and the consequences would be an increased risk of excess LCFs due to inhalation of plutonium; any acute fatalities would only be expected due to the initiating event (e.g., an aircraft crash), not due to the plutonium release. Risks to workers change across alternatives only to the extent that frequencies of the events change (as discussed above for public risk from plutonium accidents).

The risks to the public associated with highly enriched uranium (labeled as RAD–03) and tritium (RAD–05) releases due to accidents, other than the site-wide earthquakes, are several orders of magnitude lower than those for the earthquake or for the plutonium accidents. Similarly, worker risks in such accidents are also substantially lower for these types of accidents (as compared to the worker risks for site-wide earthquakes or plutonium accident events). The risks to the public and to the workers associated with highly enriched uranium and tritium releases do not change across the alternatives because the frequencies of the initiating events and the amounts of material involved in the accident do not change across the alternatives.

The risk to the public from accidents that result in chemical releases (due to events other than the site-wide earthquakes and wildfire) at LANL dominate all other accident risks. In particular, the release of chlorine gas from TA–55 (labeled as CHEM–06) has a relatively high frequency and substantial consequences. The societal risk for this accident (again, the product of the frequency and consequence) is about six people per year who would be exposed to greater than ERPG–2 concentrations of chlorine. The site-wide wildfire also can release some chemicals that would be released by earthquakes. Because the frequency of the wildfire is much greater than that of earthquakes, SITE–04 has a societal risk of 1.1 people per year exposed to greater than ERPG–2 concentrations of formaldehyde. Three other accidents that result in chemical releases (CHEM–01, CHEM–02, and CHEM–03) have societal risks that are very similar to the risks associated with hazardous chemical releases from the site-wide earthquakes (up to 0.066 people per year exposed to greater than ERPG–2 concentrations of chlorine gas for CHEM–01). It is noteworthy that the scenario for CHEM–01 is associated with potable water treatment activities; such activities are typical of municipal water supply operations throughout the U.S. It is also noteworthy that the LANL potable water treatment process is being changed to a process that does not require that quantities of chlorine gas be stored for use. The risk associated with CHEM–06 would not be expected to change across the SWEIS alternatives; CHEM–01 and CHEM–02 have slight changes in risk across the alternatives (up to a 14 percent increase and an 8 percent decrease for CHEM–02) due to the operational changes (which change the frequencies of these accidents) associated with the Expanded Operations Alternative and the Reduced Operations Alternative.

As with other worker accidents discussed above, the risk of worker injury or fatality due to these chemical release accidents is highly dependent on whether workers are present at the time of the accident, the protective measures taken, how quickly protective measures are taken, and the effectiveness of medical treatment after the event. For CHEM–01, CHEM–03, and CHEM–06, it is unlikely that workers would be in the area at the time of the event (if workers were present, there is potential for worker injury or fatality). For CHEM–02, the fire and the chlorine release would be visible, and escape is likely for any workers present; if workers present do not escape, injury or fatality is possible. For CHEM–04 and CHEM–05, four or five workers are typically in the area during working hours; workers present could be injured or killed by missiles from the cylinder rupture or from exposure to the toxic gas. Risks to workers change across alternatives only to the extent that frequencies of the events change (as discussed above for public risk from chemical release accidents).

In addition to the discussions of worker risks for the accidents discussed above, four other accidents were analyzed specifically for potential risk to workers (these would not be expected to result in substantial risks to the public). Of the worker accidents analyzed (recalling that transportation and physical safety hazards are discussed separately, in sections S.3.1.10 and S.3.1.6, respectively), the highest frequency worker accidents would be associated with a biohazard contamination (WORK–02) or with an inadvertent exposure to nonionizing radiation (WORK–04); these would be expected to result in injury or fatality to one worker. Multiple worker injuries or fatalities are possible from either an inadvertent high-explosives detonation (WORK–01) or from an inadvertent nuclear criticality event (WORK–03). Risks to workers under any of these scenarios would not be expected to change across the SWEIS alternatives.

S.3.2 Project-Specific Consequences

This section summarizes the impacts of the proposed expansion of LLW disposal in Area G and the proposed enhancement of plutonium pit manufacturing operations, including siting and construction, as well as operational impacts, once construction is completed. The impacts reflected here are a subset of the impacts associated with the Expanded Operations Alternative (DOE's Preferred Alternative, with the exception that pit manufacturing would not be implemented at a 50 pits per year level, single shift, but only at a level of 20 pits per year in the near term).

S.3.2.1 *Expansion of TA–54/Area G Low-Level Waste Disposal Area*

The disposal of LLW in excavated disposal cells at LANL has been ongoing at Area G for a number of years. At this time, it appears that the disposal space remaining in the existing footprint at Area G will be exhausted within the next 10 years. The SWEIS examines the potential solutions to disposal of LLW through shipment off the site to the extent possible, use of the existing space to maximum capacity and shipment of the remaining waste to off-site locations, and expansion of LLW disposal space at LANL to accommodate on-site disposal for the foreseeable future.

As presented in section S.2.5.1 and discussed in detail in volume II, part I, expansion could be achieved by expansion of the existing disposal site at TA–54 (different TA–54 expansion options are considered), or by expansion into a new disposal site (TA–67 is examined as representative of such sites because it is the best characterized "new" site for such purposes). Expansion into Zones 4 and 6 at TA–54 is DOE's PSSC Preferred Alternative.

Land Resources

Alternatives for the development of additional disposal capacity on the site involve approximately 40 to 72 acres (16 to 29 hectares) depending on location. Locations at TA–54 involve areas that have historically been designated for waste management activities, while use of the TA–67 site would be a new land use designation. All sites present physical constraints on development of some type, such as required set backs from canyon rims and location of power lines, although the sites closest to existing disposal areas must also avoid monitoring exclusion zones established for investigations under the Environmental Restoration Project. Sites in the Zones 4 and 6 locations are closest to existing waste disposal activities. There would be no changes in visibility of any new site from current operations for any location other than TA–67. In that case, there would be increased visibility from Pajarito Road. As is currently the case, disposal cell excavation activities could slightly exceed background noise levels at the nearest residential area (White Rock) for all sites except the one at TA–67.

Geology and Soils

All new sites involve the same types of surface soils and the same underlying Bandelier Tuff as the current disposal site. There is evidence that TA–67 may have a geologic fault. Disposal activities would not be expected to cause seismic activity or change soil erosion or geology in the area; this is due in part to the practice of revegetating the land after a disposal cell is filled and closed. These activities are not expected to contribute substantially to soil contamination in the area; this is due in part to the geology in the area and disposal and closure practices intended to isolate the buried waste from interacting with the environment.

Water Resources

There are no differences among on-site disposal alternatives in this resource area. Activities are not expected to use large quantities of water. Additionally, current and planned disposal practices (e.g., isolation of the closed disposal cells) minimize the potential for water to run across the site and to transport contaminants. The geology in the area is also expected to contribute to the minimal transport of contaminants to either the surface or groundwater bodies in the area.

Air Quality

Short duration dust from excavation and diffuse emissions (mostly from open disposal cells) will be similar to recent historical experiences (which have not had any substantive effect on air quality), although road development for the TA–67 site would cause additional short-term dust and vehicle exhaust emissions. Additionally, if cleared trees are burned, the smoke would have a temporary effect on air quality. Finally, it is possible that excavation in Zone 4 could disturb a volatile organic compound plume from Area L, resulting in low concentration releases; it is expected that this plume would be avoided during excavation.

Ecological Resources

Total acreage disturbed is greatest for the TA–67 alternative because of the need for new road and infrastructure development, while the Zone 4 and 6 alternatives involve the least disturbance. Because the habitat is similar for all the on-site development alternatives, the extent of habitat loss is also greatest at the TA–67 site, and least at the Zone 4 and 6 locations within TA–54. The habitat change is expected to be relatively small under any of the PSSC alternatives, and similar habitat is available in the immediate area at both TA–54 and TA–67. This loss of habitat is not likely to affect species in the area. Loss of foraging habitat for peregrine falcons is less than 0.1 percent of the area's potential for all alternatives, except for the TA–67 alternative (where it would be about 1.3 percent). The loss of TA–67 habitat may have an adverse effect on the desirability of nesting habitat in the area for the Mexican spotted owl.

Human Health

There are no significant differences in this area among the PSSC alternatives, but effects on human health do potentially arise from operating the expanded waste disposal area. Worker health risks associated with LLW disposal range from radiation exposure (much less for individuals than the DOE radiation exposure standard) to occupational safety and health incidents and accidents related to excavation of disposal cells and equipment operations. These are similar in nature to existing worker health risks; however, the projected waste generation across LANL is higher under the Expanded Operations Alternative, so these worker impacts are slightly greater than have been experienced in recent history and greater than would be expected under the SWEIS No Action Alternative.

In general, public health impacts in the near term would be similar to those experienced in recent years due to effects on soil, water, and air quality; as discussed above, these are minimal (LANL 1998). The Area G Performance Assessment indicates that over the next 1,000 years the maximum health impacts to the public would be minimal (e.g., exposure from all pathways in White Rock and Pajarito Canyon is less than 0.1 millirem per year; exposure from all pathways in Cañada del Buey is less than 6 millirem per year).

Environmental Justice

Expansion of LLW disposal is not likely to result in disproportionately high or adverse impacts to minority and low-income populations.

Cultural Resources

Up to 15 known archeological sites could be affected by excavation activities at the Zone 4 and 6 locations, with the fewest known sites (4) potentially affected at the North Site location. Data recovery plans and consultations would be needed under all PSSC alternatives. (These have been completed for Zone 4.) It is expected that existing policies and procedures at LANL would minimize impacts by avoiding these sites, where possible. Where sites cannot be avoided, existing procedures call for data recovery in consultation with the New Mexico State Historic Preservation Office(r) (SHPO) and others, where appropriate. If TCPs are present in areas of excavation, they would either be destroyed by construction or diminished in value.

Socioeconomics, Infrastructure, and Waste Management

All alternatives for developing additional waste disposal areas require minimal additional workers (30 more, or about a 15 percent increase above the No Action Alternative levels for solid waste management operations). Additionally, these activities do not demand substantial amounts of water, electricity, or gas. Finally, the generation of secondary waste is attributed primarily to treatment, storage, and repackaging operations, not to waste disposal; thus, secondary waste generation would not be expected to change substantially.

Transportation

The SWEIS Expanded Operations Alternative (with on-site disposal) would increase on-site shipments substantially—to almost double the approximately 1,300 shipments per year under the No Action Alternative (due to greater waste generation under the Expanded Operations Alternative and the shipment of LLW off the site under the No Action Alternative). However, due to the low radionuclide concentrations in LLW, the relatively short distances travelled on site, and the low rate of accidents experienced for on-site shipments, this large difference in shipments does not equate to large differences in on-site transportation impacts (on-site transportation impacts under either the Expanded Operations or No Action Alternatives result in far less than one fatality or injury over the next 10 years due to traffic accidents and radiation doses related to such shipments), and waste shipments do not influence the bounding cargo accident risks.

In contrast, development and use of additional disposal capacity on site would reduce the off-site shipments of waste, as compared to the No Action Alternative (410 off-site LLW shipments per year under No Action Alternative, as compared to 33 under Expanded Operations). Again, the low concentrations of radionuclides in LLW would mean that these shipments contribute very little to incident-free radiation doses, and they do not bound the off-site cargo accident risk. While the longer off-site transportation mileage results in greater risks of vehicle accidents, injuries, and deaths, these are similar to the risks of increasing any vehicular traffic and are not unique to the fact that these are radioactive waste shipments. The off-site LLW shipments are a relatively small percentage of the total off-site shipment mileage under either the SWEIS No Action Alternative or the Expanded Operations Alternative.

Accidents

Accident risk associated with waste disposal operations for all alternatives are essentially the same. This is because the accident frequencies are relatively insensitive to the differences in waste volumes across the alternatives and because the consequences of an accident are dependent on the amount of material involved in the accident (which changes very little across the alternatives), not the total amount of generated or disposed waste. An additional factor is that waste disposal requires comparable packaging, handling, and certification in accordance with waste acceptance criteria whether it is disposed of on or off the site.

S.3.2.2 *Enhancement of Plutonium Pit Manufacturing*

The implementation of the plutonium pit production mission is examined in the SWEIS at varying levels. The No Action Alternative for operations includes the manufacturing of pits at a maximum rate of about 14 pits per year. Under the Expanded Operations Alternative, and as discussed in volume II, part II, DOE is considering the enhancement of the existing capability to optimize processes and remove process “choke” points to allow for production of up to 50 pits per year under single-shift operations (80 pits per year under multiple-shift operations). However, the DOE does not propose to implement pit manufacturing capability beyond a level of 20 pits per year in the timeframe of analyses for the SWEIS. The Preferred Alternative would only implement pit manufacturing at the 20 pits per year level in the near term. Nevertheless, the impacts of full implementation of the Enhancement of Plutonium Pit Manufacturing PSSC are included in the Expanded Operations Alternative. The DOE used the “CMR Building Use” Alternative to bound the impact analysis. Because other activities in TA–55 cannot be discontinued to make space available for the enhancement and operation, TA–55 does not have enough plutonium laboratory space available to undertake this and all other TA–55 activities described under the Expanded Operations Alternative. Options (alternatives) for providing the additional space required to accommodate Expanded Operations, including pit production, are discussed in detail in volume II, part II. Under the PSSC “CMR Building Use” Alternative for providing this additional space, some existing activities at TA–55–4 would be moved over to available space in the CMR Building, thus freeing space in TA–55–4 to accommodate pit production. This would take place in a phased manner: first, the existing capability would be increased to capacity of 20 pits per year; after that, the additional modifications would be made to achieve the 80 pits per year capacity (using multiple shifts).

The increased pit production will require additional transportation of materials between TA–55 and the CMR Building (at least an increase in transportation of samples, but potentially, the additional transportation of plutonium for CMR activities transferred from TA–55–4); DOE is proposing to construct a dedicated road to minimize impacts (road closures and accidents) to the public. Under the Preferred Alternative, these processes would not be moved to the CMR Building nor would the transportation corridor be built.

Land Resources

All project alternatives other than the No Action Alternative require the use of additional land, including land that would be used for an optional dedicated transportation corridor between TA–55 and TA–3. While the land disturbed under the "CMR Building Use" Alternative would be limited to that associated with the transportation corridor, the Brownfield and TA–55–4 Add-On Alternatives would each require about one additional acre, both of which are in developed areas of TA–55. The 7 acres (2.8 hectares) required for the optional transportation corridor have been disturbed previously but not developed. Fencing and security lighting along the road could result in visual impacts. There would be some short-duration increase in noise during construction of the road; once the road is constructed, traffic noise would not be substantially different from the existing traffic noise in the area. (Note that the road would not be constructed to establish the 20 pits per year capability under the Preferred Alternative, and the impacts associated with construction of that road would not be incurred.) Increased noise levels due to construction activity at TA–55 would occur under any of the PSSC alternatives. In addition, the "CMR Building Use" Alternative would result in increased construction noise at TA–3.

Geology and Soils

No changes in geology or soils are anticipated for either construction or operations under any PSSC alternative.

Water Resources

Minimal increase in water use is anticipated for either construction or operations under any of the PSSC alternatives. Some increases in radioactive liquid waste generation (associated with all activities under this alternative; pit production activities are not substantial contributors to this waste stream) would also be anticipated (a maximum increase of 2.6 million gallons [10 million liters] per year above the No Action Alternative level of about 6.6 million gallons [25 million liters] per year) under any of the PSSC alternatives. The location for wastewater discharge does not change from that under the SWEIS No Action Alternative.

Air Quality

The only potential construction air quality impacts are related to the emissions from construction equipment; these emissions would not exceed regulatory standards for criteria pollutants and would not be expected to affect air quality beyond the immediate vicinity of the construction work.

Operations under the "CMR Building Use" PSSC alternative in TA–55–4 and the CMR Building directly related to the implementation of pit production at LANL would result in minor increases in radioactive air emissions. For the CMR Building, an increase of 38 microcuries per year is attributable to pit production activities (the total difference between the No Action and Expanded Operations radioactive air emissions at the CMR Building is about 340 microcuries per year). For TA–55, a net increase (considering pit manufacturing increases and decreases due to activities moved to the CMR Building) of about 9 microcuries per year is attributable to pit production activities (the total difference between the No

Action and Expanded Operations radioactive air emissions at TA–55 is about 11 microcuries per year). Under the other PSSC alternatives, the radioactive air emissions would not increase as much at the CMR Building, but most of the total 47 microcuries in increased annual air emissions attributed to pit production in both facilities would occur at TA–55. At the 20 pits per year production rate (Preferred Alternative), radioactive air emissions for TA–55 and the CMR Building together would result in about a 20 microcuries per year increase due to pit production activities; the radioactive air emissions impacts under the Expanded Operations Alternative at this rate would be essentially the same as those presented under the "CMR Building Use" Alternative. No substantive changes in nonradioactive air emissions are expected due to these activities under any of the PSSC alternatives.

Ecological Resources

Construction of the dedicated access road under any of the PSSC alternatives would disturb about 7 acres (2.8 hectares) and would reduce peregrine falcon foraging and meadow jumping mouse habitats by this amount. Other potential effects include:

- Large mammals (bear, elk, deer, mountain lion, coyotes) could be restricted from accessing the land in the transportation corridor and transversing to lands beyond the corridor; this access restriction could also alter predator-prey associations, food use, and habitat use in the project area.
- Potential for increases in automobile/ animal collisions could result from elk and deer movement into areas these animals do not usually inhabit.

Only minimal changes in potential habitat would be associated with alternatives requiring construction at TA–55 or TA–3. The total loss of 7 (for the "CMR Building Use" Alternative) to 8 (for the other two alternatives) acres (2.8 to 3.2 hectares) of habitat is small compared to that available on the entire LANL site. (Under the Preferred Alternative, at the 20 pits per year rate, these impacts would not be incurred because the road would not be constructed.) No other ecological impacts from operations are anticipated.

Human Health

Occupational exposure to radioactive material during the construction and modification of existing nuclear facility space for the "CMR Building Use" PSSC alternative is expected to result in up to 45 person-rem (0.018 excess LCFs) to the involved workers. The other alternatives would have lower doses due to the reduced need for modification of existing nuclear facility spaces to accomplish the construction. Radiation doses to workers during operations that are directly related to pit production would constitute an increase of about 150 person-rem per year (the total difference in collective dose associated with all activities at LANL between No Action and Expanded Operations is about 387 person-rem per year). These occupational doses would not be expected to vary between the PSSC alternatives because the total work load would be the same, and the design criteria of the facilities would be the same regardless of implementation. This change in collective worker dose constitutes an incremental increase of about 0.06 excess LCF per year to the worker population involved in these activities. At the 20 pits per year rate (Preferred Alternative), worker exposures associated with pit production would be lower (about 130 person-rem per year lower than presented at the 80 pits per year rate). Thus, the worker population exposure and the estimated excess LCF risk associated with that exposure would be about 15 percent less than reflected for the Expanded Operations Alternative at the 80 pits per year rate.

Impacts to public health would not be expected to change substantially due to routine pit manufacturing operations. Except for transportation impacts (discussed below) and the contribution to public health impacts due to radiological air emissions, the remaining contributors to public health impacts do not change across the alternatives. As reflected in appendix B, (Table B.1.2.3–1), the radiological air emissions from TA–55 and CMR Building operations together contribute 1.005 person-rem per year and 1.853 person-rem per year under the No Action and Expanded Operations Alteratives, respectively. (The total collective public doses under these alteratives are about 14 and about 33 person-rem per year, respectively.) Of the total TA–55 and CMR Building air emissions, which lead to these collective public doses, about 1 percent of the curies emitted (under either the No Action or Expanded Operations Alternatives) are attributable to pit manufacturing, analytical chemistry support for pit manufacturing, actinide processing, and pit surveillance and disassembly activities (the activities that would be involved in the implementation of pit production at LANL under the Expanded Operations Alternative). Any variation to public health impacts between the PSSC alternatives would only be due to the differences in physical location of the air emission release points with relation to the publicly occupied areas, as discussed above in the air quality section.

Environmental Justice

Expansion of pit manufacturing is not likely to result in disproportionately high or adverse impacts to minority and low-income populations.

Cultural Resources

No impacts are anticipated under any of the PSSC alternatives due to construction or operations (prehistoric and historic sites are avoidable, and there are no known TCPs in the area).

Socioeconomics, Infrastructure, and Waste Management

Building modifications under the "CMR Building Use" PSSC alternative would employ about 221 construction workers over about a 3- or 4-year period (with peak employment for construction at 140 workers). The number of construction workers and project duration would be somewhat greater, but not substantially different for the other PSSC alternatives. Operations would increase employment by about 170 workers (the total difference between employment under No Action and Expanded Operations is about 1,374 workers). At the 20 pits per year rate (Preferred Alternative), construction and operations employment would be somewhat lower than reflected for the "CMR Building Use" Alternative. The employment differences are small compared to the total employment changes under the Expanded Operations Alternative. Thus, the impacts presented for the Expanded Operations Alternative are relatively insensitive to the PSSC alternatives and to the 20 pits per year phasing of pit production at LANL.

Utility use and contaminated space would not change substantially under the "CMR Building Use" PSSC alternative. The other two PSSC alternatives would require slightly more electrical power and would create about 15,000 square feet (1,400 square meters) of nuclear facility space that would be presumed as contaminated space.

Construction for the "CMR Building Use" PSSC alternative would generate about 15,100 cubic feet (426 cubic meters) of TRU waste, 10,200 cubic feet (288 cubic meters) of TRU mixed waste, 46,200 cubic feet (1,306 cubic meters) of LLW, and 1,100 cubic feet (31 cubic meters) of LLMW. The other PSSC alternatives would be expected to generate little, if any, radioactive waste (it could only be generated in equipment transfer to the new space). Pit manufacturing operations under the SWEIS Expanded Operations Alternative are not expected to generate substantial quantities of waste (as presented in the final SSM PEIS, this activity is expected to result in waste generation increases of less than 5 percent over current levels), except for TRU waste generation, which will increase from this activity by about 3,535 cubic feet (100 cubic meters) per year. (The total difference between No Action and Expanded Operations TRU waste generation is about 10,600 cubic feet [300 cubic meters] per year.) At the 20 pits per year level (Preferred Alternative), TRU waste generation would be about 530 cubic feet (15 cubic meters) per year.

Transportation

The Expanded Operations Alternative activities related to pit production would be expected to increase on-site shipments between TA–55 and the CMR Building by about 500 shipments per year (of plutonium sample solutions and plutonium metal, including components). Additionally, off-site shipments to and from Oak Ridge and Pantex are expected to increase by a total of about 50 shipments per year due to implementation of pit manufacturing at LANL. Even though the total risk is small (see chapter 3, Tables 3.6.2–1 and 3.6.2–2, Transportation Risks), these types of plutonium shipments are among those that bound both on-site and off-site transportation risk; additionally, such shipments are the main contributors to driver and public incident-free radiation doses. Because the portion of these shipments attributable to pit production operations is a small percentage of the total on-site (about 5 percent) and off-site (about 1 percent) shipments, transportation risks from pit production operations under the Expanded Operations Alternative are very small. Differences in shipment quantities are important contributors to the differences in transportation risk between the No Action and Expanded Operations Alternatives, although the absolute risk presented by these shipments is small. The construction of a dedicated transportation corridor between TA–55 and the CMR Building at TA–3 would further reduce risk associated with on-site shipments. At the 20 pits per year rate (Preferred Alternative), there would be somewhat fewer on- and off-site shipments in support of pit production; thus, the transportation impacts at that production rate would be slightly lower than presented for the Expanded Operations Alternative at 80 pits per year. Under the Preferred Alternative, the dedicated transportation route would not be constructed for implementation of the 20 pits per year rate.

Accidents

Accident risk associated with pit manufacturing operations (and those operations moved to the CMR Building to make space in TA–55 for pit production) are essentially the same under the No Action and Expanded Operations Alternatives. The reasons that there are such minor differences, given the differences in the number of pits manufactured, are that: accidents involving pit manufacturing activities themselves do not bound the risks associated with plutonium operations (chapter 3, section 3.6.2.11), although some of the support operations (e.g., waste handling and plutonium processing and recovery) are included in the set of bounding accidents analyzed; the frequencies of the bounding accidents are relatively insensitive to the number of pits manufactured (pit manufacturing activities are relatively small contributors to support operations throughputs); and, the consequences of accidents are dependent on the amount of material involved in the accident, which is relatively insensitive to the quantities of pits manufactured over a year. (That is, the difference in the number of pits produced over a year is dependent on process or room and does not change limits for the amount of material allowed to be in process at one time.) Any variation to accident risk between the PSSC alternatives would only be due to the differences in physical location of the release points with relation to the publicly occupied areas, similar to the discussion above in the air quality section.

S.3.3 Consequences of Environmental Restoration Activities

Environmental restoration activities, which include decontamination and decommissioning activities, are undertaken with the intent of reducing the long-term public and worker health and safety risks associated with contaminated sites or with surplus facilities and to reduce risk posed to ecosystems. Decisions regarding whether and how to undertake an environmental restoration action are made after a detailed assessment of the short-term and long-term risks and benefits for options specific to the site in question, and, at LANL, they are made primarily within the framework of the *Resource Conservation and Recovery Act* (RCRA).

Because there are no individual or specific environmental restoration actions proposed within the scope of the SWEIS (such actions are proposed and undertaken on a time scale that is not compatible with the preparation of this SWEIS), the impact analyses regarding such actions are presented in general terms based on the experiences of the program, to date. As noted in the ecological resources and human health impact analyses in chapter 5, LANL's influence on ecological and human health risk arises primarily from the legacy of past operations in the form of contaminants that were historically deposited on land and in water. An improvement in the risk posed by the LANL site is therefore expected from the removal of some of this legacy contamination. A principal impact from restoration actions is related to the generation of waste during the cleanup or decontamination and decommissioning. The waste generated must be stored, treated, or disposed. Waste generation from the totality of future environmental restoration actions is estimated in the SWEIS, and the risks associated with the transport, treatment, storage, and disposal of this waste are included in the analyses.

The short-term risks and controls associated with the environmental restoration activities include:

- *Fugitive Dust*. This is the suspension of soil, including contaminated soil, in the air, resulting in the potential for exposure or dispersal of this material. At LANL, this potential risk is typically controlled by frequently wetting the ground at the clean-up site; this reduces the amounts of material suspended in air, and thus, the risk to human health and the environment (LANL 1996).
- *Surface Runoff*. This is the transport of contaminants from the clean-up site by surface water flow across the site. At LANL, surface runoff is controlled by flow barriers, collection of surface water, or contouring the ground such that flow off the site is precluded (LANL 1995).
- *Soil and Sediment Erosion*. This is the transport of soil and sediment due to the force of wind and the intensity and frequency of precipitation. This potential risk is mitigated by covering clean-up sites with tarps during storm events to minimize the infiltration of water (LANL 1995).
- *Worker Health and Safety Risks.* Environmental restoration actions have similar risks to those discussed in the human health impact analyses in chapter 5. Activities can involve heavy equipment, uneven ground (e.g., trenches), solvents and other chemicals, and other hazards of this nature. Worker health and safety risks are mitigated with work plans, safety programs, protective equipment, and similar administrative, education, and physical protection measures.

S.4 MITIGATION MEASURES

The regulations promulgated by the Council on Environmental Quality (CEQ) to implement the procedural provisions of NEPA (42 U.S.C. §4321) require that an EIS include a discussion of appropriate mitigation measures (40 CFR 1502.14[f]; 40 CFR 1502.16[h]). The term "mitigation" includes the following:

- Avoiding an impact by not taking an action or parts of an action
- Minimizing impacts by limiting the magnitude of an action and its implementation
- Rectifying an impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments (40 CFR 1508.20)

This section describes mitigation measures that are built into the alternatives analyzed and those additional measures that will be considered by DOE to further mitigate the adverse impacts identified in the SWEIS. These measures address the range of potential impacts of continuing to operate LANL. The mitigation measures built into the alternatives analyzed (section S.4.1) are of two types: (1) existing programs and controls and (2) specific measures built into the alternatives that serve to minimize the effects of activities under the alternatives.

Additional mitigation measures that could further reduce the adverse impacts are discussed in section S.4.2. Commitments to mitigation measures would be reflected in the ROD following this SWEIS, with a more detailed description and implementation plan presented in a Mitigation Action Plan following the ROD.

S.4.1 Mitigation Measures Included in the SWEIS Alternatives

S.4.1.1 *Existing Programs and Controls*

The activities undertaken at LANL are performed within the constraints of applicable regulations, applicable DOE orders, contractual requirements, and approved policies and procedures. These requirements help to mitigate the potential adverse impacts of operations to the public, the worker, and the environment. For example, the application of DOE design standards results in more robust facility designs for modern nuclear facilities, which reduces the potential for catastrophic releases from such facilities in the event of earthquakes, high winds, or other natural phenomena.

DOE and LANL also have instituted policies and procedures that apply to work conducted at LANL that help to mitigate the potential adverse effects of operations. Examples include:

- Procedures that control work conducted at LANL
- Policies regarding the knowledge, skills, and abilities of personnel assigned to perform hazardous work
- Policies reflected in agreements with other entities that establish policies and protocols regarding consultations and other discussions regarding LANL activities
- Policies and procedures regarding the stoppage and restart of work where unexpected hazards or resources are identified

DOE also has established programs and projects at LANL to increase the level of knowledge regarding the surrounding environment, health of workers, health of the public around LANL, and the effects of LANL operations, as well as to avoid or reduce impacts and remediate contamination from previous LANL activities. These programs and projects help to reduce potential adverse impacts by providing for heightened understanding of the resources that could be impacted. Examples include:

- The Environmental Surveillance and Compliance Program
- The Threatened and Endangered Species Habitat Management Plan
- The Natural Resource Management Plan (in various stages of development)
- Studies of public and worker health in and around LANL
- Implementation of the Groundwater Protection Management Program Plan and the RCRA Hydrogeologic Workplan
- The Safeguards and Security Program
- Emergency management and response capabilities
- LANL's Fire Protection Program
- Pollution Prevention and Waste Minimization Programs
- Water and Energy Conservation Programs
- The Environmental Restoration Project
- Work to remedy foreseeable power supply and reliability issues

S.4.1.2 *Specific Mitigation Measures Incorporated in the SWEIS Alternatives*

Several specific mitigation measures are included in the SWEIS alternatives. Unless otherwise noted below, the analyses assume that these measures are implemented. These specific measures are:

- Development and use of a dedicated transportation corridor between TA–55 and TA–3 (TA–55 and TA–3, Expanded Operations Alternative) (This measure would not be implemented under the Preferred Alternative.)
- DOE's contribution to the Santa Fe Relief Route (all LANL facilities, all alternatives)[4]
- CMR Building Upgrades (CMR Building at TA–3, all alternatives)[5]
- Planned maintenance and refurbishment activities (e.g., Plutonium Facility at TA–55 and Sigma at TA–3, all alternatives)
- Radioactive Liquid Waste Treatment Facility upgrades (TA–50, all alternatives)
- Effluent reduction activities (all LANL facilities, all alternatives)
- Phased containment for Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility tests (one of the high explosives firing sites, all alternatives)
- Design of the long-pulse spallation source (TA–53, Expanded Operations and Greener Alternatives)[6]

S.4.2 Other Mitigation Measures Considered

In addition to those mitigation measures described in section S.4.1, other possible measures include:

- *Eliminate Public Access to Part or All of LANL*. At various times DOE has considered the possibility of closing public access to part or all of the LANL site. While this is typically suggested for security reasons, such an action would also tend to reduce public health risk by removing access to on-site locations that contribute most to public health risk.
- *Land Transfers and Financial Assistance*. Transfers of portions of LANL land are being examined. Such action would

4. Use of this route is addressed in the transportation impact analyses.

5. These upgrades are to maintain existing capabilities and to improve safety features.

6. The proposed design limits the emissions from this operation so that it contributes, at most, 1 millirem per year to the facility and site-wide MEI.

provide land resources that could be used to reduce economic dependence on LANL and/or provide the means for growth in housing, parks, and recreational space. On May 6, 1998, DOE published a Notice of Intent to prepare an EIS for the Proposed Conveyance and Transfer of Certain Land Tracts in the Federal Register (63 FR 25022).

- *Extensive Ethnographic Study.* An extensive ethnographic study regarding the traditional and cultural practices and resources in the LANL area could increase knowledge of specific TCPs at LANL and could provide opportunities for mitigation of impacts to specific TCPs. Attempts to identify specific TCPs at LANL have encountered concerns from traditional groups because of the potential for increased risk to these resources if they are identified.
- *Develop a Cultural Resources Management Plan*. Such a plan would include studies to increase the level of knowledge regarding potential shrapnel and vibration damage to resources near firing sites, existing levels of contamination for resources and plans to avoid levels that would limit data recovery, plans for management of former nuclear weapons complex properties, and implementation of programmatic agreements with the SHPO.
- *Develop a Wildfire Management Plan for the LANL Site*. Such a plan would reduce the fuel loading surrounding the site and around individual facilities that have moderate or higher vulnerability to burning as a result of wildfire. The probability of an approaching wildfire encroaching upon the site can be reduced by removing and thinning vegetation on the site boundary and within the site. Ongoing efforts to reduce the vegetation at the site boundary exist that would be accelerated. The vulnerability of individual facilities depends upon the amount and height of the exterior fuel loading and its proximity to the facility (see Evaluation of Building Fires in appendix G, section G.5.4.4). Consideration is being given to reducing the vulnerability of individual facilities that contribute potential public exposure. Long-term actions would be taken to reduce the fuel loads in the forested areas surrounding LANL, and a forest and land management program would be undertaken to prevent or mitigate the potential for large wildfires to occur. In the near term, mitigation actions, such as for TA–54, will be taken to ensure that the wildfire risk to this facility is reduced to low or extremely low prior to the start of the 1999 fire season.
- *Limited Power Supply.* DOE and other regional electric power users continue to work with suppliers to remedy foreseeable power supply and reliability issues. The impact analyses in this SWEIS emphasize the severity of these issues and the consequences if they are not resolved. Solutions to power supply issues are essential to mitigate the effects of power demand under all alternatives. DOE is committed to measures that will conserve energy and avoid, or at least minimize, periods of brownouts. Some of the measures being contemplated by DOE include: (1) limiting operation of large users of electricity to periods of low demand, (2) reduced operation of LEDA (not implement all phases of this project), and (3) contractual mechanisms to bring additional electric power to the region.

S.5 CLASSIFIED SUPPLEMENT

The discussions in this SWEIS are augmented by a classified supplement to the SWEIS. This supplement contains certain classified information and data related to the activities at LANL that, though important to support understanding of certain details underlying the SWEIS and its analyses, must be protected in accordance with the *Atomic Energy Act of 1954* (42 U.S.C. §2011). This information includes details associated with some operations, experiments, processes, or source terms. DOE presents as much information as possible in this unclassified document. Furthermore, the environmental impacts are fully contained in the results presented to the public in this unclassified document.

DOE invited the U.S. Environmental Protection Agency, the U.S. Department of Defense, the Accord Pueblos, and the State of New Mexico to review the classified supplement. Only those individuals with appropriate clearances and a need to know were given access to the classified information.

REFERENCES

DOE 1995 — Statement by the President: *Future of Major Federal Laboratories.* The White House, Office of the Press Secretary. 1995.

DOE 1996 — *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management.* U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. 1996.

DOE 1997 — *Waste Management Final Programmatic Environmental Impact Statement.* U.S. Department of Energy, Office of Environmental Management. DOE/EIS-0200. Washington, D.C. May 1997.

ICRP 1991 — "1990 Recommendations of the International Commission on Radiological Protection." Publication 60, Vol. 21, No. 1-3. *Annals of the ICRP*. Pergamon Press. New York, New York. 1991.

LANL 1995 — *Installation Work Plan for Environmental Restoration*, Revision 5. Los Alamos National Laboratory. Los Alamos, New Mexico. November 1995.

LANL 1996 — *Final Report for the Expedited Cleanup of Material Disposal Area (MDA) M, TA–9.* Appendix F, "Asbestos and RCRA Metal Air Results." Prepared by NES, Inc. for Los Alamos National Laboratory. Los Alamos, New Mexico. April 1996.

LANL 1998 — *Performance Assessment and Composite Analysis for the Los Alamos National Laboratory Low-Level Waste Material Disposal Area G*. Los Alamos National Laboratory. LA-UR-97-85. Los Alamos, New Mexico. Submitted to the U.S. Department of Energy March 1997. Approved October 1998.

ABOUT THE *NATIONAL ENVIRONMENTAL POLICY ACT*

The *National Environmental Policy Act* (NEPA) (42 United States Code [U.S.C.] §4321 *et seq.*) was enacted to ensure that federal decision makers consider the effects of proposed actions on the human environment and to lay their decisionmaking process open for public scrutiny. NEPA also created the President's Council on Environmental Quality (CEQ). The U.S. Department of Energy's (DOE's) NEPA regulations (10 Code of Federal Regulations [CFR] 1021) augment the CEQ regulations (40 CFR 1500 through 1508).

Under NEPA, an environmental impact statement (EIS) documents a federal agency's analysis of the environmental consequences that might be caused by major federal actions, defined as those proposed actions that may result in a significant impact to the environment. An EIS also:

- Explains the purpose and need for the agency to take action.
- Describes the proposed action and the reasonable alternative courses of action that the agency could take to meet the need.
- Describes what would happen if the proposed action were not implemented—the "No Action" (or status quo) Alternative.
- Describes what aspects of the human environment would be affected if the proposed action or any alternative were implemented.
- Analyzes the changes, or impacts, to the environment that would be expected to take place if the proposed action or an alternative were implemented, compared to the expected condition of the environment if no action were taken.

The DOE EIS process follows these steps:

- The Notice of Intent, published in the *Federal Register*, identifies potential EIS issues and alternatives and asks for public comment on the scope of the analysis.
- The public scoping period, with at least one public meeting, during which public comments on the scope of the document are collected and considered.
- The issuance of a draft EIS for public review and comment (for a minimum of 45 days), with at least one public hearing.
- The preparation and issuance of the final EIS, which incorporates the results of the public comment period on the draft EIS.
- Preparation and issuance of a Record of Decision, which states:
  - — The decision.
  - — The alternatives that were considered in the EIS and the environmentally preferable alternative.
  - — All decision factors, such as cost and technical considerations, that were considered by the agency along with environmental consequences.
  - — Mitigation measures designed to reduce adverse environmental impacts.
- Preparation of a Mitigation Action Plan, as appropriate, which explains how the mitigation measures will be implemented and monitored.

THE LOS ALAMOS NATIONAL LABORATORY SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT PROCESS

The United States Department of Energy (DOE) has a policy (10 Code of Federal Regulations [CFR] 1021.330) of preparing a Site-Wide Environmental Impact Statement (SWEIS) for certain large, multiple-facility sites, such as the Los Alamos National Laboratory (LANL). The purpose of a SWEIS is to provide DOE and its stakeholders with an analysis of the environmental impacts resulting from ongoing and reasonably foreseeable new operations and facilities and reasonable alternatives at the DOE site. The SWEIS analyzes four alternatives for the continued operation of LANL to identify the potential effects that each alternative could have on the human environment.

The SWEIS Advance Notice of Intent, published in the *Federal Register* (FR) on August 10, 1994 (59 FR 40889), identified possible issues and alternatives to be analyzed. Based on public input received during prescoping, DOE published the Notice of Intent to prepare the SWEIS in the *Federal Register* on May 12, 1995 (60 FR 25697). DOE held a series of public meetings during prescoping and scoping to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the SWEIS. An Implementation Plan[1] was published in November 1995 to summarize the results of scoping, describe the scope of the SWEIS based on the scoping process, and present an outline for the draft SWEIS. The Implementation Plan also included a discussion of the issues reflected in public comments during scoping.

In addition to the required meetings and documents described above, the SWEIS process has included a number of other activities intended to enhance public participation in this effort. These activities have included:

- Workshops to develop the Greener Alternative described and analyzed in the SWEIS.
- Meetings with and briefings to representatives of federal, state, tribal, and local governments during prescoping, scoping, and preparation of the draft SWEIS.
- Preparation and submission to the Los Alamos Community Outreach Center of information requested by members of the public related to LANL operations and proposed projects.
- Numerous Open Forum public meetings in the communities around LANL to discuss LANL activities, the status of the SWEIS, and other issues raised by the public.

The draft SWEIS was distributed to interested stakeholders for comment. The comment period extended from May 15, 1998, to July 15, 1998. Public hearings on the draft SWEIS were announced in the *Federal Register*, as well as community newspapers and radio broadcasts. Public hearings were held in Los Alamos, Santa Fe, and Española, New Mexico, on June 9, 1998, June 10, 1998, and June 24, 1998, respectively.

Oral and written comments were accepted during the 60-day comment period for the draft SWEIS. All comments received, whether orally or in writing, were considered in preparation of the final SWEIS. The final SWEIS includes a new volume IV with responses to individual comments and a discussion of general major issues. DOE will prepare a Record of Decision no sooner than 30 days after the final SWEIS Notice of Availability is published in the *Federal Register*. The Record of Decision will describe the rationale used for DOE's selection of an alternative or portions of the alternatives. Following the issuance of the Record of Decision, a Mitigation Action Plan may also be issued to describe any mitigation measures that DOE commits to in concert with its decision.

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1. DOE *National Environmental Policy Act* regulations (10 CFR 1021) previously required that an implementation plan be prepared; a regulation change (61 FR 64604) deleted this requirement. An implementation plan was prepared for this SWEIS.

COVER SHEET

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agency: Incorporated County of Los Alamos

Title: Site-Wide Environmental Impact Statement for the Continued Operation of the Los Alamos National Laboratory, Los Alamos, New Mexico (DOE/EIS-0238)

Contact: For further information concerning this Site-Wide Environmental Impact Statement (SWEIS), contact:

Corey Cruz, Project Manager
U.S. DOE, Albuquerque Operations Office
P.O. Box 5400, Albuquerque, NM 87185
Telephone: 505–845–4282 Fax: 505–845–6392

For general information on DOE's *National Environmental Policy Act* (NEPA) process, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance (EH–42)
U.S. DOE, 1000 Independence Avenue, SW, Washington, DC 20585
Telephone: 202–586–4600 or leave a message at 1–800–472–2756

Abstract: DOE proposes to continue operating the Los Alamos National Laboratory (LANL) located in Los Alamos County, in north-central New Mexico. DOE has identified and assessed four alternatives for the operation of LANL: (1) No Action, (2) Expanded Operations, (3) Reduced Operations, and (4) Greener. Expanded Operations is DOE's Preferred Alternative, with the exception that DOE would only implement pit manufacturing at a level of 20 pits per year. In the No Action Alternative, DOE would continue the historical mission support activities LANL has conducted at planned operational levels. In the Expanded Operations Alternative, DOE would operate LANL at the highest levels of activity currently foreseeable, including full implementation of the mission assignments from recent programmatic documents. Under the Reduced Operations Alternative, DOE would operate LANL at the minimum levels of activity necessary to maintain the capabilities to support the DOE mission in the near term. Under the Greener Alternative, DOE would operate LANL to maximize operations in support of nonproliferation, basic science, materials science, and other nonweapons areas, while minimizing weapons activities. Under all of the alternatives, the affected environment is primarily within 50 miles (80 kilometers) of LANL. Analyses indicate little difference in the environmental impacts among alternatives. The primary discriminators are: collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand.

Public Comment and DOE Decision: The draft SWEIS was released to the public for review and comment on May 15, 1998. The comment period extended until July 15, 1998, although late comments were accepted to the extent practicable. All comments received were considered in preparation of the final SWEIS[1]. DOE will utilize the analysis in this final SWEIS and prepare a Record of Decision on the level of continued operation of LANL. This decision will be no sooner than 30 days after the Notice of Availability of the final SWEIS is published in the *Federal Register*.

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1. Changes made to this SWEIS since publication of the draft SWEIS are marked with a vertical bar to the right or left of the text.

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VOLUME I
ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ACIS	Automated Chemical Inventory System
ACL	administrative control level
ACM	asbestos-containing material
ADTT	accelerator-driven transmutation technology
AEA	*Atomic Energy Act*
AEC	U.S. Atomic Energy Commission
AIP	Agreement in Principle
AIRNET	ambient air monitoring program
ALARA	as low as reasonably achievable
ALOHA™	Areal Locations of Hazardous Atmospheres (computer model)
ANSI	American National Standards Institute
AO	Administrative Order
APT	accelerator production of tritium
BAT	best available technology
BIA	Bureau of Indian Affairs
BIO	Basis for Interim Operation
BLM	Bureau of Land Management
BMP	best management practice
BNM	Bandelier National Monument
BOD	biochemical/biological oxygen demand
BTC	Beryllium Technology Center
°C	degrees Celsius

CA	composite analysis
CAA	*Clean Air Act*
CAD	computer-aided design
CAM	continuous air monitor
CAMP	Capital Assets Management Process
CAP–88	Clean Air Act Assessment Package for 1988
CBD	chronic beryllium disease
CCNS	Concerned Citizens for Nuclear Safety
CDE	committed dose equivalent
CDP	Census Designated Place
CDR	Conceptual Design Report
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
CH	contact-handled (waste)
CH TRU	contact-handled transuranic (waste)
Ci	curie
cm	centimeter
CMIP	Capability Maintenance and Improvement Project
CMR	Chemistry and Metallurgy Research
COD	chemical oxygen demand
CRMT	Cultural Resources Management Team
CT	Conveyance and Transfer (EIS)
CTBT	Comprehensive Test Ban Treaty

CVD	chemical vapor deposition
CVI	chemical vapor infiltration
CY	calendar year
D&D	decontamination and decommissioning
DARHT	Dual Axis Radiographic Hydrodynamic Test (Facility)
dB	decibel
dBA	decibels A-weighted frequency scale
DCG	derived concentration guide
DEGADIS	dense gas dispersion (computer model)
DNFSB	Defense Nuclear Facilities Safety Board
DEL	Dynamic Experiment Laboratory
DNA	deoxyribonucleic acid
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOP	detailed operating procedure
DOT	U.S. Department of Transportation
DU	depleted uranium
EA	environmental assessment
EDE	effective dose equivalent
EIS	environmental impact statement
EM	DOE Office of Environmental Management
EM&R	emergency management and response
EPA	U.S. Environmental Protection Agency
EPCRA	*Emergency Planning and Community-Right-to-Know Act*

ER	environmental restoration
ERPG	Emergency Response Planning Guideline
ES&H	Environmental, Safety and Health (division of LANL)
°F	degrees Fahrenheit
FAA	Federal Aviation Administration
FIFRA	*Federal Insecticide, Fungicide, and Rodenticide Act*
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FS MEI	facility-specific maximally exposed individual
ft	feet
FTE	full-time equivalent (employees)
FU	field unit
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram
GV	guideline value
GWPMPP	Groundwater Protection Management Program Plan
ha	hectares
HA	hazard analysis
HAP	hazardous air pollutant
HE	high explosives
HEFS	High Explosives Firing Site
HELWTF	High Explosives Liquid Wastewater Treatment Facility
HEPA	high-efficiency particulate air (filter)
HEPP	High Explosives Pulsed Power

HEU	highly enriched uranium
HEWTF	High Explosives Wastewater Treatment Facility
HI	hazard index
HLW	high-level waste
HRL	Health Research Laboratory
HSWA	*Hazardous and Solid Waste Amendments of 1984*
HT	tritium gas
HTO	tritiated water
HVAC	heating, ventilation, and air conditioning
HW	hazardous waste
IATA	International Air Traffic Association
ICF	inertial confinement fusion
ICRP	International Commission on Radiological Protection
IH	industrial hygiene
in.	inch
IPF	Isotope Production Facility
IR	infrared
IRIS	Integrated Risk Information System
ISC–3	Industrial Source Complex (Model) Version 3
ISCST3	Industrial Source Complex Short Term (Model)
JCI	Johnson Controls, Inc.
km	kilometer
LAC	Los Alamos County
LACEF	Los Alamos Critical Experiments Facility
LADF	Los Alamos Detonator Facility

LAMPF	Los Alamos Meson Physics Facility (former name for LANSCE)
LAMPRE	Los Alamos Molten Plutonium Reactor Experiment
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
lb	pound
LCF	latent cancer fatality
L/CHEM	low chemical hazard
LCO	limiting condition for operation
LDR	land disposal restrictions
LEDA	low-energy demonstration accelerator
L/ENS	low energetic source hazard
LIDAR	light detection and ranging
LIFT	Los Alamos International Facility for Transmutation
linac	linear accelerator
LLMW	low-level radioactive mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
LPSS	Long-Pulse Spallation Source
L/RAD	low radioactive hazard
LSA	low specific activity
m	meter
MAA	Material Access Area
MACCS	MELCOR Accident Consequences Code System
MAR	material-at-risk
M/CHEM	moderate chemical hazard

MCL	maximum contaminant level
MDA	Material Disposal Area
MEI	maximally exposed individual
MeV	million electron volts
MGD	million gallons per day
MGY	million gallons per year
mi	mile
MLY	million liters per year
MOU	memorandum of understanding
MOX	mixed oxide (fuel)
M/RAD	moderate radioactive hazard
MSL	Materials Science Laboratory
MW	megawatt
NA	not applicable (or not available)
NAAQS	National Ambient Air Quality Standards
NAGPRA	*Native American Graves Protection and Repatriation Act*
NCRP	National Council on Radiation Protection
NEPA	*National Environmental Policy Act of 1969*, as amended
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NIOSH	U.S. National Institute for Occupational Safety and Health
NM	New Mexico (State Road)
NMAC	New Mexico Administrative Code
NMDGF	New Mexico Department of Game and Fish

NMDL	New Mexico Department of Labor
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMSWA	*New Mexico Solid Waste Act*
NMSF	Nuclear Materials Storage Facility
NMWQCC	New Mexico Water Quality Control Commission
NOA	Notice of Availability
NOI	Notice of Intent
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NTS	Nevada Test Site
NTTL	neutron tube target loading
OEL	occupational exposure limit
OLM	Ozone Limiting Method
ORNL	Oak Ridge National Laboratory
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
OU	operable unit
OWR	Omega West Reactor
PA	performance assessment
PAL	plant-wide applicability limit
PCB	polychlorinated biphenyl

PDD	Presidential Decision Directive
PEIS	programmatic environmental impact statement
PF	Plutonium Facility
pH	a measure of acidity and alkalinity
PHERMEX	Pulsed High-Energy Radiation Machine Emitting X-Rays (facility)
PL	public law
PM	particulate matter
PM_{10}	particulate matter equal to or less than 10 micrometers aerodynamic diameter
PNM	Public Service Company of New Mexico
PPE	personal protective equipment
ppb	parts per billion
ppm	parts per million
PRA	probabilistic risk assessment
PrHA	process hazard analysis
PRS	potential release site
PSD	prevention of significant deterioration
psi	pounds per square inch
PSR	proton storage ring
PSSC	project-specific siting and construction
PTLA	Protection Technology of Los Alamos
rad	radiation absorbed dose
RAMROD	Radioactive Materials Research, Operations, and Demonstration (facility)
RANT	Radioactive Assay and Nondestructive Test (facility)
RCRA	*Resource Conservation and Recovery Act*
rem	roentgen equivalent man

RF	radiofrequency (also, respirable fraction)
RfC	inhalation reference concentrations
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA Facility Investigation
RH	remote-handled (waste)
RH TRU	remote-handled transuranic (waste)
RLW	radioactive liquid waste
RLWTF	Radioactive Liquid Waste Treatment Facility
ROD	Record of Decision
ROI	region of influence
RSRL	regional statistical reference level
RTG	radioisotopic thermoelectric generator
SA	safety assessment
SAL	screening action level
SAR	safety analysis report
SARA	*Superfund Amendment and Reauthorization Act*
SCC	Strategic Computing Complex
SDWA	*Safe Drinking Water Act*
SEER	Surveillance, Epidemiology, and End Results
SEIS-II	second supplemental environmental impact statement
SFNF	Santa Fe National Forest
SHEBA	Solution High-Energy Burst Assembly
SHPO	State Historic Preservation Office(r)
SIP	State Implementation Plan
SLEV	screening level emission value

SMAC	shipment mobility/accountability collection
SNM	special nuclear material
SNS	spallation neutron source
SPD	surplus plutonium disposition
SPSS	short-pulse spallation source
SSM	Stockpile Stewardship and Management
SST	safe secure transport
START	Strategic Arms Reduction Talks (or Treaty)
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
SWDA	*Solid Waste Disposal Act*
SWEIS	site-wide environmental impact statement
SWMU	solid waste management unit
SWPP	Stormwater Pollution Prevention Plan
SWSC	sanitary wastewater systems consolidation
T&E	threatened and endangered (species)
TA	Technical Area
TCP	traditional cultural property
TEDE	total effective dose equivalent
TFF	Target Fabrication Facility
TI	transport index
TLD	thermoluminescent dosimeter
TLV	threshold limit value
TRU	transuranic (waste)
TSCA	*Toxic Substances Control Act*

TSD	treatment, storage, and disposal
TSFF	Tritium Science and Fabrication Facility
TSR	technical safety requirement
TSTA	Tritium System Test Assembly
TW	test well
TWA	time-weighted average
TWISP	Transuranic Waste Inspectable Storage Project
UC	University of California
UCL	upper confidence limit
UNM	University of New Mexico
U.S.	United States
U.S.C.	United States Code
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound
WAC	waste acceptance criteria
WCRR	Waste Characterization, Reduction, and Repackaging (facility)
WCTF	Weapon Component Testing Facility
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Plant
WM	waste management
WNR	Weapons Neutron Research
WR	war reserve
WWTF	Waste Water Treatment Facility

VOLUME I
MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this SWEIS. Definitions of technical terms can be found in volume I, chapter 10, Glossary.

SCIENTIFIC NOTATION

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using scientific notation, as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either right (for a positive power of 10) or left (for a negative power of 10). If the value given is 2.0×10^3, move the decimal point three places (insert zeros if no numbers are given) to the right of its current location. The result would be 2,000. If the value given is 2.0×10^{-5}, move the decimal point five places to the left of its present location. The result would be 0.00002. An alternative way of expressing numbers, used primarily in the appendixes of this SWEIS, is exponential notation, which is very similar in use to scientific notation. For example, using the scientific notation for 1×10^9, in exponential notation the 10^9 (10 to the power of 9) would be replaced by E+09. (For positive powers, sometimes the "+" sign is omitted, and so the example here could be expressed as E09.) If the value is given as 2.0×10^{-5} in scientific notation, then the equivalent exponential notation is 2.0E-05.

UNITS OF MEASUREMENT

The primary units of measurement used in this report are English units with metric equivalents enclosed in parentheses.

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). The following list presents these metric prefixes:

giga	1,000,000,000 (10^9; E+09; one billion)
mega	1,000,000 (10^6; E+06; one million)
kilo	1,000 (10^3; E+03; one thousand)
hecto	100 (10^2; E+02; one hundred)
deka	10 (10^1; E+01; ten)
unit	1 (10^0; E+00; one)
deci	0.1 (10^{-1}; E-01; one tenth)
centi	0.01 (10^{-2}; E-02; one hundredth)
milli	0.001 (10^{-3}; E-03; one thousandth)

micro 0.000001 (10^{-6}; E-06; one millionth)

nano 0.000000001 (10^{-9}; E-09; one billionth)

pico 0.000000000001 (10^{-12}; E-12; one trillionth)

DOE Order 5900.2A, *Use of the Metric System of Measurement*, prescribes the use of this system in DOE documents. Table MC–1 lists the mathematical values or formulas needed for conversion between English and metric units. Table MC–2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

RADIOACTIVITY UNIT

Part of this report deals with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC–3). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit of mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of these.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually expressed in terms of effective dose equivalent and reported numerically in units of rem (Table MC–4). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in Table MC–5.

CHEMICAL ELEMENTS

A list of selected chemical elements, chemical constituents, and their nomenclature is presented in Table MC–6.

TABLE MC–1.—*Conversion Table*

MULTIPLY	BY	TO OBTAIN	MULTIPLY	BY	TO OBTAIN
ac	0.405	ha	ha	2.47	ac
°F	(°F -32) x 5/9	°C	°C	(°C x 9/5) + 32	°F
ft	0.305	m	m	3.28	ft
ft^2	0.0929	m^2	m^2	10.76	ft^2
ft^3	0.0283	m^3	m^3	35.3	ft^3
gal.	3.785	l	l	0.264	gal.
in.	2.54	cm	cm	0.394	in.
lb	0.454	kg	kg	2.205	lb
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
mi	1.61	km	km	0.621	mi
mi^2	2.59	km^2	km^2	0.386	mi^2
mi/h	0.447	m/s	m/s	2.237	mi/h
nCi	0.001	pCi	pCi	1,000	nCi
oz	28.35	g	g	0.0353	oz
pCi/l	10^{-9}	µCi/ml	µCi/ml	10^{9}	pCi/l
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
ppb	0.001	ppm	ppm	1,000	ppb
ton	0.907	metric ton	metric ton	1.102	ton

TABLE MC–2.—*Names and Symbols for Units of Measure*

LENGTH	
SYMBOL	**NAME**
cm	centimeter (1 x 10^{-2} m)
ft	foot
in.	inch
km	kilometer (1 x 10^{3} m)
m	meter
mi	mile
mm	millimeter (1 x 10^{-3} m)
µm	micrometer (1 x 10^{-6} m)
VOLUME	
SYMBOL	**NAME**
cm^3	cubic centimeter
ft^3	cubic foot
gal.	gallon
in.^{3}	cubic inch
l	liter
m^3	cubic meter
ml	milliliter (1 x 10^{-3} l)
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard
RATE	
SYMBOL	**NAME**
Ci/yr	curies per year
cm^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
kg/yr	kilograms per year
km/h	kilometers per hour
mg/l	milligrams per liter
MGY	million gallons per year
MLY	million liters per year
m^3/yr	cubic meters per year
mi/h or mph	miles per hour
µCi/l	microcuries per liter
pCi/l	picocuries per liter

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

NUMERICAL RELATIONSHIPS	
SYMBOL	**MEANING**
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
2σ	two standard deviations
TIME	
SYMBOL	**NAME**
d	day
h	hour
min	minute
nsec	nanosecond
s	second
yr	year
AREA	
SYMBOL	**NAME**
ac	acre (640 per mi^2)
cm^2	square centimeter
ft^2	square foot
ha	hectare (1 x 10^4 m^2)
in.^{2}	square inch
km^2	square kilometer
mi^2	square mile
MASS	
SYMBOL	**NAME**
g	gram
kg	kilogram (1 x 10^3 g)
mg	milligram (1 x 10^{-3} g)
µg	microgram (1 x 10^{-6} g)
ng	nanogram (1 x 10^{-9} g)
lb	pound
ton	metric ton (1 x 10^6 g)
oz	ounce

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

TEMPERATURE	
SYMBOL	**NAME**
°C	degrees Celsius
°F	degrees Fahrenheit
°K	degrees Kelvin
SOUND/NOISE	
SYMBOL	**NAME**
dB	decibel
dBA	A-weighted decibel

TABLE MC–3.—*Names and Symbols for Units of Radioactivity*

RADIOACTIVITY	
SYMBOL	**NAME**
Ci	curie
cpm	counts per minute
mCi	millicurie (1 x 10^{-3} Ci)
µCi	microcurie (1 x 10^{-6} Ci)
nCi	nanocurie (1 x 10^{-9} Ci)
pCi	picocurie (1 x 10^{-12} Ci)

TABLE MC–4.—*Names and Symbols for Units of Radiation Dose*

RADIATION DOSE	
SYMBOL	**NAME**
mrad	millirad (1 x 10^{-3} rad)
mrem	millirem (1 x 10^{-3} rem)
R	roentgen
mR	milliroentgen (1 x 10^{-3} R)
µR	microroentgen (1 x 10^{-6} R)

TABLE MC–5.—*Radionuclide Nomenclature*

SYMBOL	RADIONUCLIDE	HALF-LIFE	SYMBOL	RADIONUCLIDE	HALF-LIFE
Am-241	americium-241	432 yr	Pu-241	plutonium-241	14.4 yr
H-3	tritium	12.26 yr	Pu-242	plutonium-242	3.8×10^{5} yr
Mo-99	molybdenum-99	66 hr	Pu-244	plutonium-244	8.2×10^{7} yr
Pa-234	protactinium-234	6.7 hr	Th-231	thorium-231	25.5 hr
Pa-234m	protactinium-234m	1.17 min	Th-234	thorium-234	24.1 d
Pu-236	plutonium-236	2.9yr	U-234	uranium-234	2.4×10^{5} yr
Pu-238	plutonium-238	87.7 yr	U-235	uranium-234	7×10^{8} yr
Pu-239	plutonium-239	2.4×10^{4} yr	U-238	uranium-238	4.5×10^{9} yr
Pu-240	plutonium-240	6.5×10^{3} yr			

TABLE MC–6.—*Elemental and Chemical Constituent Nomenclature*

SYMBOL	CONSTITUENT	SYMBOL	CONSTITUENT
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
Ar	argon	Pu	plutonium
B	boron	SF_6	sulfur hexafluoride
Be	beryllium	Si	silicon
CO	carbon monoxide	SO_2	sulfur dioxide
CO_2	carbon dioxide	Ta	tantalum
Cu	copper	Th	thorium
F	fluorine	Ti	titanium
Fe	iron	U	uranium
Kr	krypton	V	vanadium
N	nitrogen	W	tungsten
Ni	nickel	Xe	xenon
NO_2^-	nitrite ion	Zn	zinc
NO_3^-	nitrate ion		

ABOUT THE *NATIONAL ENVIRONMENTAL POLICY ACT*

The *National Environmental Policy Act* (NEPA) (42 United States Code [U.S.C.] §4321 *et seq.*) was enacted to ensure that federal decision makers consider the effects of proposed actions on the human environment and to lay their decisionmaking process open for public scrutiny. NEPA also created the President's Council on Environmental Quality (CEQ). The U.S. Department of Energy's (DOE's) NEPA regulations (10 Code of Federal Regulations [CFR] 1021) augment the CEQ regulations (40 CFR 1500 through 1508).

Under NEPA, an environmental impact statement (EIS) documents a federal agency's analysis of the environmental consequences that might be caused by major federal actions, defined as those proposed actions that may result in a significant impact to the environment. An EIS also:

- Explains the purpose and need for the agency to take action.
- Describes the proposed action and the reasonable alternative courses of action that the agency could take to meet the need.
- Describes what would happen if the proposed action were not implemented—the "No Action" (or status quo) Alternative.
- Describes what aspects of the human environment would be affected if the proposed action or any alternative were implemented.
- Analyzes the changes, or impacts, to the environment that would be expected to take place if the proposed action or an alternative were implemented, compared to the expected condition of the environment if no action were taken.

The DOE EIS process follows these steps:

- The Notice of Intent, published in the *Federal Register*, identifies potential EIS issues and alternatives and asks for public comment on the scope of the analysis.
- The public scoping period, with at least one public meeting, during which public comments on the scope of the document are collected and considered.
- The issuance of a draft EIS for public review and comment (for a minimum of 45 days), with at least one public hearing.
- The preparation and issuance of the final EIS, which incorporates the results of the public comment period on the draft EIS.
- Preparation and issuance of a Record of Decision, which states:
  - — The decision.
  - — The alternatives that were considered in the EIS and the environmentally preferable alternative.
  - — All decision factors, such as cost and technical considerations, that were considered by the agency along with environmental consequences.
  - — Mitigation measures designed to reduce adverse environmental impacts.
- Preparation of a Mitigation Action Plan, as appropriate, which explains how the mitigation measures will be implemented and monitored.

CHAPTER 1.0 INTRODUCTION AND PURPOSE AND NEED FOR AGENCY ACTION

This chapter provides an introduction to the Los Alamos National Laboratory's role in supporting the U.S. Department of Energy's missions, a statement of the purpose and need for DOE's action, and an overview of the alternatives analyzed in this Site-Wide Environmental Impact Statement. In addition, this chapter explains DOE decisions that this SWEIS is intended to support and the relationship of this document to other environmental documentation prepared by DOE. At the conclusion of the chapter is an introduction to the objectives of the SWEIS and the approaches used in its preparation, along with a brief summary of the remaining chapters of the document.

The Los Alamos National Laboratory (LANL) is one of several national laboratories that support the U.S. Department of Energy's (DOE's) responsibilities for national security, energy resources, environmental quality, and science. LANL occupies approximately 43 square miles (111 square kilometers) of land owned by the U.S. Government and under the administrative control of DOE; it is located in north-central New Mexico, 60 miles (97 kilometers) north-northeast of Albuquerque and 25 miles (40 kilometers) northwest of Santa Fe (see Figure 1–1). An in-depth description of LANL's facilities and capabilities is contained in chapter 2 of this document.

DOE has prepared this Site-Wide Environmental Impact Statement (SWEIS) in accordance with the *National Environmental Policy Act* (NEPA) (42 United States Code [U.S.C.] §4321) to examine the environmental impacts associated with four alternatives for the continued operation of LANL. (Section 1.3 and chapter 3 provide additional detail regarding the alternatives analyzed.) In this SWEIS, DOE describes consequences (both on the site and off the site) of ongoing LANL operations, and compares the potential consequences of alternative levels of future operations.

1.1 LANL SUPPORT FOR DOE MISSIONS

Based on responsibilities described in the *Atomic Energy Act of 1954* (42 U.S.C. §2011) and the *Energy Reorganization Act of 1974* (42 U.S.C. §5801), DOE's principal missions are:

- *National Security*—This DOE mission includes the safety and reliability of the nuclear weapons in the stockpile, maintenance of the nuclear weapons stockpile in accordance with executive directives, stemming the international spread of nuclear weapons materials and technologies, and production of nuclear propulsion plants for the U.S. Navy.
- *Energy Resources*—This DOE mission includes research and development for energy efficiency, renewable energy, fossil energy, and nuclear energy.
- *Environmental Quality*—This DOE mission includes treatment, storage, and disposal of DOE wastes; cleanup of nuclear weapons sites; pollution prevention; storage and disposal of civilian radioactive waste; and development of technologies to reduce risks and reduce cleanup costs for DOE activities.
- *Science*—This DOE mission includes fundamental research in physics, materials

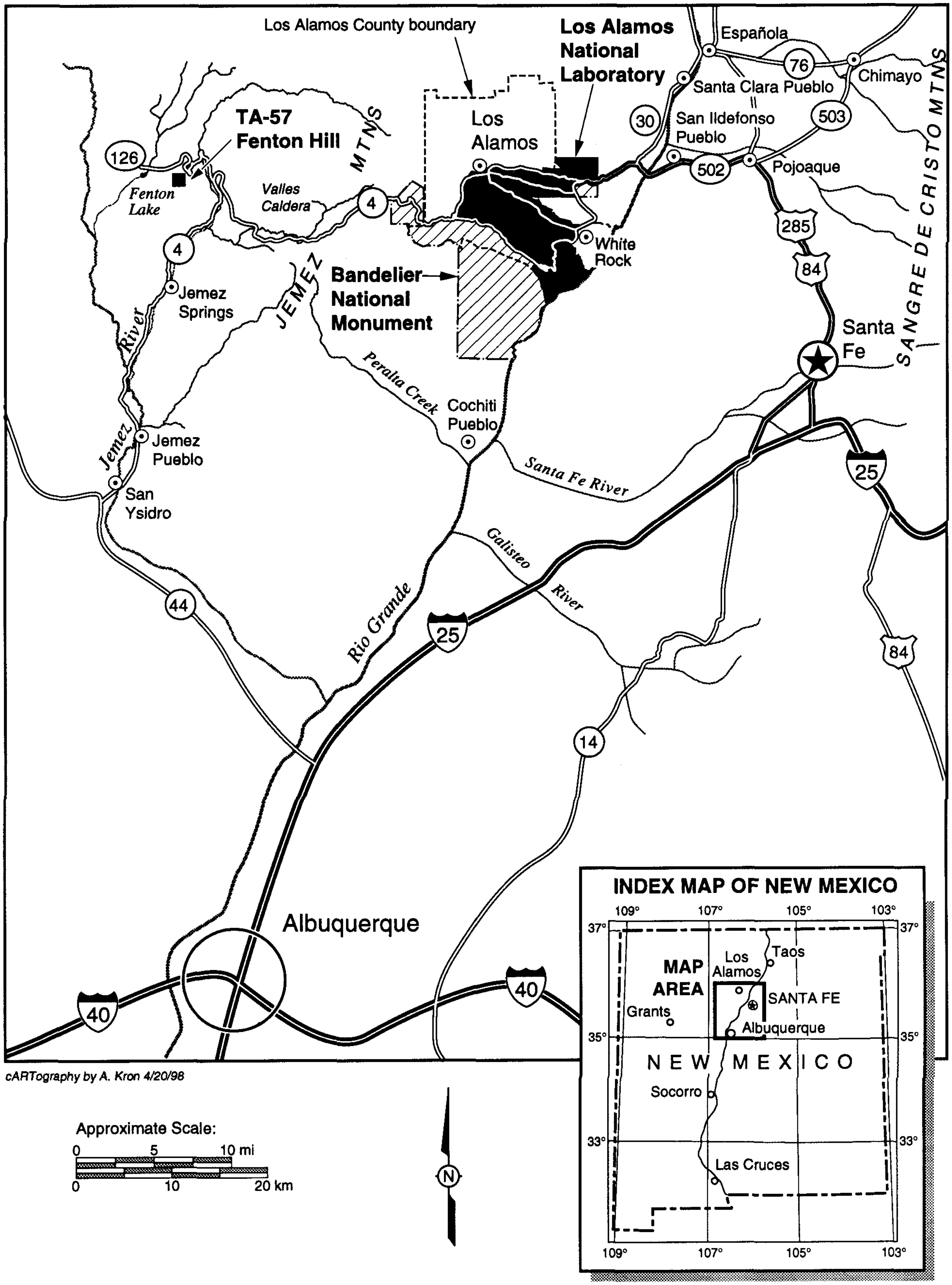

FIGURE 1–1.—*Location of the Los Alamos National Laboratory.*

science, chemistry, nuclear medicine, basic energy sciences, computational sciences, environmental sciences, and biological sciences. Work related to this mission often contributes to the other three DOE missions.

LANL provides support to each of these departmental missions, with a special focus on national security[1]. DOE assigns mission elements to LANL based on the facilities and expertise of the staff located there. Such assignments are made within the context of national security needs as expressed, for example, in Presidential Decision Directives; the *National Defense Authorization Act for Fiscal Year 1994* (Public Law [PL] 103-160) and other congressional actions; the U.S. Department of Defense (DoD) Nuclear Posture Review; treaties in force, such as the Nuclear Nonproliferation Treaty and the Strategic Arms Reduction Treaty (START) I, and treaties signed but not yet entered into force, such as the START II and the Comprehensive Test Ban Treaty (CTBT).

The existing facilities and areas of expertise at LANL have evolved since its inception in the early 1940's. In particular, LANL has developed facilities and expertise to perform:

- Theoretical research, including analysis, mathematical modeling, and high-performance computing
- Experimental science and engineering—ranging from bench-scale to multi-site, multi-technology facilities (including accelerators and radiographic facilities)
- Advanced and nuclear materials research, development, and applications, including weapons *components* testing, fabrication,

SWEIS Terminology

Mission. *In this SWEIS, "missions" refer to the major responsibilities assigned to DOE (described in this section). DOE accomplishes its major responsibilities by assigning groups or types of activities (referred to in this SWEIS as mission elements) to its system of national laboratories, production facilities, and other sites.*

Programs. *DOE is organized into Program Offices, each of which have primary responsibilities within the set of DOE missions. Funding and direction for activities at DOE facilities are provided through these Program Offices, and similar/coordinated sets of activities to meet Program Office responsibilities are often referred to as programs. Programs are usually long-term efforts with broad goals or requirements.*

Capabilities. *This refers to the combination of facilities, equipment, infrastructure, and expertise necessary to undertake types or groups of activities and to implement mission assignments. Capabilities at LANL have been established over time, principally through mission assignments and activities directed by Program Offices. Once capabilities are established to support a specific mission assignment or program activity, they are often used to meet other mission or program requirements (e.g., the capability for advanced/ complex computation and modeling that was established to support DOE's national security mission requirements may also be used to address needs under DOE's science mission).*

Projects. *This is used to describe activities with a clear beginning and end that are undertaken to meet a specific goal or need. Projects can vary in scale from very small (such as a project to undertake one experiment or a series of small experiments) to major (e.g., a project to construct and start up a new nuclear facility). Projects are usually relatively short-term efforts, and they can cross multiple programs and missions, although they are usually "sponsored" by a primary Program Office. In this SWEIS, this term is usually used more narrowly to describe construction (including facility modification) activities (e.g., a project to build a new office building or a project to establish and demonstrate a new capability). Construction projects considered reasonably foreseeable at LANL over the next 10 years are discussed and analyzed in this SWEIS (section 1.6.3)*

1. While LANL supports each of these four missions, LANL does not undertake work in all elements of the missions described. For example, LANL supports DOE's national security mission but LANL does not undertake production of nuclear propulsion plants for the U.S. Navy.

stockpile assurance, replacement, surveillance, and maintenance (including theoretical and experimental activities)

These capabilities allow LANL to conduct research and development activities such as high explosives processing, chemical research, nuclear physics research, materials science research, systems analysis and engineering, human genome "mapping," biotechnology applications, and remote sensing technologies applied to resource exploration and environmental surveillance.

Below is a description of LANL's assignments to support DOE's missions (with a focus on recent developments in these mission areas) and a description of how LANL fits within the DOE national laboratory system. In addition, the *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (SSM PEIS) (DOE 1996a) lists the major mission elements at LANL, including the primary DOE program offices that sponsor efforts under each of the mission elements listed (Table 3.2.6–1 of the SSM PEIS).

1.1.1 National Security Assignments to LANL

The following sections highlight LANL's principal assignments under the national security mission, including: stockpile stewardship and management[2], accelerator production of tritium, stabilization of commercial nuclear materials, nonproliferation, and other national security assignments.

1.1.1.1 *Stockpile Stewardship Assignments*

DOE's nuclear weapons research, development, and testing has evolved into a program referred to as "stockpile stewardship." Under this program, LANL is responsible (along with Lawrence Livermore National Laboratory and Sandia National Laboratories) for ensuring the safety and reliability of weapons systems in the stockpile for the foreseeable future, in the absence of underground testing. LANL has additional specific responsibilities for weapons of LANL design. Stockpile stewardship remains LANL's central responsibility, and this is the focus of much of the research and development throughout LANL.

DOE examined the environmental impacts of implementing this program at LANL and other DOE sites in the SSM PEIS (DOE 1996a). In the SSM PEIS, DOE identified a need for certain nuclear weapons experimental capabilities in addition to those that currently exist at DOE sites. In its Record of Decision (ROD) for the SSM PEIS (61 *Federal Register* [FR] 68014), DOE stated its intention to construct and operate *Atlas*, a research pulse-power facility at LANL, to assist in fulfilling this need. In addition, DOE decided that this facility will be installed in an existing building at LANL.

1.1.1.2 *Stockpile Management Assignments*

In addition to its responsibilities for stockpile stewardship, LANL also has been assigned responsibilities for stockpile management, which address DOE's production and maintenance of nuclear weapons, including component production and weapon disassembly, as well as stockpile surveillance and process development. Stockpile stewardship and stockpile management are parts of an integrated DOE program. LANL's nuclear weapons production capabilities were

[2] DOE has recently adopted the name "stockpile stewardship" to encompass all activities within the program recently referred to as "stockpile stewardship and management." However, stockpile stewardship and management is used in this SWEIS.

National Security Context for LANL Nuclear Weapons-Related Mission Assignments

LANL performs activities in support of DOE's national security mission, including assessment and certification of nuclear weapon safety and reliability, weapons-related research and development, some nonnuclear component production, pit fabrication, and surveillance of plutonium pits. DOE is obligated to conduct these activities in the context of presidential and congressional actions, and international treaties, including the following:

***START I, 1988**—Ratified in 1988, the START I negotiations between the U.S. and Russia aimed at limiting and reducing nuclear arms. One of DOE's missions is national security; LANL has a role in several elements of that mission, including arms control and nonproliferation via treaty verification programs.*

***Presidential Decision Directive (PDD), November 1993**—Presidential document that provided for the establishment of a program to maintain the U.S. nuclear stockpile (stockpile stewardship), preservation of a nuclear deterrent force without nuclear tests, and preservation of the technical and intellectual ability to design and maintain nuclear weapons. LANL and other weapons laboratories would preserve these abilities.*

***National Defense Authorization Act of 1994 (PL 103-160), November 1993**—Passed by Congress, PL 103-160 directed DOE to "establish a stewardship program to ensure the preservation of the core intellectual and technical competencies of the U.S. in nuclear weapons, including weapons design, system integration, manufacturing, security, use control, reliability assessment, and certification." Subsequent congressional actions have provided similar guidance and direction.*

***DoD Nuclear Posture Review, September 1994**—A report prepared by the DoD and approved by the President that addressed possible changes in U.S. nuclear policy. The report reaffirmed that nuclear weapons remain essential even though stockpiles will be reduced. It commits the U.S. to maintaining a safe and reliable nuclear deterrent and the core competencies of the U.S. in nuclear weapons without nuclear testing.*

***Nonproliferation Treaty, May 1995**—On May 11, 1995, 178 nations agreed to permanently extend the expiring Nuclear Nonproliferation Treaty that controls the spread of nuclear weapons technologies, limits the number of nuclear weapons states, and commits to the long-term goal of disarmament. The five nuclear states also agreed to work toward a comprehensive test ban and rapid negotiation of a treaty to end production of nuclear bomb material.*

***Presidential Announcement on the CTBT and Safeguards, August 1995**—The President announced the U.S. intent to seek a zero-yield CTBT, the requirement for a new annual certification procedure, and the establishment of safeguards for U.S. entry into a CTBT.*

***PDD, September 1995**—After an administration review of the laboratory systems of DOE, the President determined that "the continued vitality of all three DOE nuclear weapons laboratories will be essential: for the purpose of ensuring confidence in the safety and reliability of the nuclear weapons stockpile in the absence of nuclear testing." (DOE 1995a)*

***START II, January 1996**—The START II protocol, ratified by the U.S. Senate in January 1996, further reduces the limits of nuclear systems. Within DOE's national security mission, LANL has a substantial role in arms control and nonproliferation through intelligence analysis, technology research and development, treaty verification, fissile material control, and counterproliferation analysis.*

***CTBT, September 1996**—The CTBT, approved in September 1996 but not yet ratified, would prohibit nuclear tests of all magnitudes. DOE, with the assistance of the weapons laboratories, must meet the challenge of maintaining the nation's nuclear stockpile without underground testing and develop the verification technologies that will ensure compliance with the treaty.*

Note: For additional information, see the SSM PEIS (DOE 1996a), chapter 2, Purpose and Need.

developed in the 1940's as part of the Manhattan Project when LANL produced the first weapons components for the early nuclear weapons stockpile. Over time, most of the production activities were reassigned to other DOE facilities, and LANL's national security focus became nuclear weapons research, development, and testing (which has evolved into the Stockpile Stewardship Program).

In the early 1990's, DOE recognized that its responsibilities for the reduced nuclear weapons stockpile did not require the extensive complex of production facilities that was being maintained. Thus, DOE undertook a study to reconfigure this complex to a smaller, less expensive form. As a first step, DOE prepared the *Nonnuclear Consolidation Environmental Assessment for the Nuclear Weapons Complex Reconfiguration Program* (DOE 1993), focusing on consolidation arrangements for the nonnuclear operations associated with nuclear weapons production. As a result of that assessment, LANL received several new assignments that were complementary to work already being performed at LANL:

- Detonator production and calorimetry work was transferred from the Mound Plant in Ohio.
- Neutron tube target loading work was transferred from the Pinellas Plant in Florida.
- Beryllium technology work and production of nonnuclear pit components (a pit is a component of a nuclear weapon, as discussed in the text box on this page) were transferred from the Rocky Flats Plant (now known as the Rocky Flats Environmental Technology Site [RFETS]) in Colorado.

The next step was to reconfigure nuclear facilities in the weapons complex. In 1994, DOE defined its ongoing Stockpile Stewardship and Management Program; the SSM PEIS analyzed the environmental impacts of implementing this integrated program (DOE 1996a). The SSM PEIS studied options for consolidating nuclear weapons work at a smaller number of facilities and downsizing the remaining complex, as well as reestablishing plutonium pit production. Under the ROD for the SSM PEIS (61 FR 68014), DOE assigned LANL new work within both the Stockpile Stewardship Program (section 1.1.1.1) and the Stockpile Management Program. Specific to stockpile management, DOE decided to reestablish its pit production capability at LANL at a capacity significantly reduced from that of the Rocky Flats Plant at the height of the Cold War. (The pit production capability at the Rocky Flats plant had previously been shut down.)

Operation of a Nuclear Weapon

Nuclear explosions are produced by initiating and sustaining nuclear chain reactions in highly compressed material that can undergo both fission and fusion reactions. Modern strategic, and most tactical, nuclear weapons use a nuclear package with two assemblies: the primary assembly, which is used as the initial source of energy, and the secondary assembly, which provides additional explosive energy release. The primary assembly contains a central core, called the "pit," which is surrounded by a layer of high explosive. The "pit" is typically composed of plutonium-239 and/or highly enriched uranium (HEU) and other materials. HEU contains large fractions of the isotope uranium-235.

1.1.1.3 *Accelerator Production of Tritium Assignment*

DOE's work to reconfigure the nation's nuclear weapons complex also addressed the supply and recycling of tritium. Tritium is one of the materials used in modern nuclear weapons. However, tritium has a half-life of 12.26 years; that is, about 5.5 percent is lost every year, and the tritium in a nuclear weapon must be replaced periodically if the weapon is to remain reliable. In the past, DOE produced tritium in some of its nuclear reactors; at present, however, none of the DOE reactors that had been capable of producing tritium is in operation. As the number of nuclear weapons in the U.S. stockpile is decreased, tritium from retired weapons can be purified and repackaged. However, at some time in the near future, there will be insufficient tritium to meet DOE's mission requirements.

In the *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling* (Tritium PEIS) (DOE 1995b), DOE examined the environmental impacts of tritium production by means of both an accelerator and a commercial nuclear reactor. In the ROD for the Tritium PEIS (60 FR 63878), DOE decided on a dual-track approach that pursues production by both an accelerator and a commercial nuclear reactor for about 3 years. At the completion of this additional development work, DOE expects to make a final decision regarding which technology to pursue as the primary source of tritium.

Also in the Tritium PEIS ROD, DOE assigned to LANL the task of investigating the feasibility and consequences of designing, building, and testing the front-end, low-energy prototype for an accelerator that could produce tritium. DOE prepared the *Low-Energy Demonstration Accelerator (LEDA) Environmental Assessment* (DOE 1996b) to examine the site-specific environmental impacts of locating this research activity at LANL.

1.1.1.4 *Stabilization of Commercial Nuclear Materials Assignment*

Radioactive sealed sources are used in research and commerce for applications such as measuring the thickness of materials. These sources usually contain radionuclides such as plutonium or americium, packaged within multiple stainless steel jackets. Sealed radioactive sources for federal and commercial use were produced from materials supplied by the U.S. Atomic Energy Commission (AEC) and successor agencies (including DOE), beginning about 1950. Licensing was taken over by the U.S. Nuclear Regulatory Commission (NRC) when some AEC functions were reassigned to NRC in 1974.

These sealed sources have a finite life because the welds begin to fail after several years. Because the NRC has no facilities for managing unwanted and excess sources, owners of sealed sources who want to dispose of them have had no option for doing so. DOE addressed some of the health and safety concerns associated with unmanaged or abandoned sealed sources by reactivating a program to accept and manage plutonium-239 sources on an emergency basis. In the case of these sealed sources, management means chemically stabilizing, repackaging, or storing nuclear materials from the sources.

As more needs became apparent and after DOE prepared the *Radioactive Source Recovery Program Environmental Assessment* (DOE 1995c), DOE assigned the Radioactive Source Recovery Program to LANL building on the existing ability to manage these materials. In order to reduce the risk of personal injury resulting from unmanaged or abandoned sealed sources, the program now includes the proactive search for such sealed sources so that they can be brought to LANL and managed safely.

1.1.1.5 *Nonproliferation and Counter-Proliferation Assignments*

DOE has responsibility for national programs to reduce and counter threats from weapons of mass destruction (nuclear, biological, and chemical weapons). Activities conducted in this area include assisting with control of nuclear materials in states of the former Soviet Union, developing technologies for verification of the

CTBT, countering nuclear smuggling, safeguarding nuclear materials and weapons, and countering threats involving chemical and biological agents. These programs also include supporting continuation of the START process to further reduce nuclear weapons stockpiles.

LANL has been assigned research and development activities in support of these DOE responsibilities, including development of detection systems and technologies, assessment of foreign nuclear weapons capabilities, and responding to nuclear-related emergencies. In support of this assignment, LANL has:

- Provided much of the technology and expertise needed to verify treaties and implement various safeguards to ensure compliance with terms and conditions of treaties and agreements
- Undertaken satellite and remote sensing research to provide the technology to detect clandestine nuclear tests and other indicators of nuclear proliferation
- Undertaken research in personnel and vehicle monitoring and other nuclear safeguards technologies, which has helped to improve the security of many tons of plutonium and highly enriched uranium located in more than 50 facilities in the former Soviet Union
- Begun research aimed at countering nuclear smuggling and proliferation of chemical and biological weapons
- Assisted in the establishment, training, and technology development for DOE's Nuclear Emergency Search Team and Accident Response Group, which provide vital emergency response capabilities

1.1.1.6 *Other National Security Assignments*

LANL also measures and controls nuclear materials on the site and conducts research and development for such activities throughout DOE, including analytical chemistry and other destructive and nondestructive measurement techniques. LANL also performs research and demonstration activities regarding the disposition of surplus plutonium under DOE's Fissile Materials Disposition Program. While many of these activities support multiple mission elements, they are funded and managed under the national security mission.

1.1.2 Energy Resources Assignments

LANL's activities in this arena generally include: research to improve the safety and effectiveness of reactor operations; production of components for the radioisotopic power systems used in space exploration; geophysics and geothermal energy research; modeling and other support for the efficient use of fossil fuels; research and development related to the use of radioisotopes in industry, research, and healthcare; and research and development in the areas of global change, energy efficiency, and nuclear power.

After issuance of the *Medical Isotope Production Project: Molybdenum-99 and Related Isotopes, Environmental Impact Statement* (DOE 1996c), the related ROD assigned to LANL the fabrication of targets[3] for use in the production of molybdenum-99 for medical use (60 FR 48921). The fabricated targets are sent from LANL to Sandia National Laboratories in Albuquerque, New Mexico, where this medical isotope is actually produced.

1.1.3 Environmental Quality Assignments

LANL's support for this DOE mission includes:

3. A target, in this context, is material placed in a nuclear reactor to be bombarded with neutrons in order to produce radioactive materials.

- Development of environmental technologies to destroy explosives and propellants associated with DOE and DoD activities
- Research regarding appropriate treatment and handling of radioactive waste at the DOE sites at RFETS and Hanford
- Research on the coexistence of technology and the environment under the National Environmental Research Park Program
- Analytical and measurement support to characterize sites and materials in support of safe and effective waste disposal (e.g., the Waste Isolation Pilot Plant [WIPP])
- Operations to ensure the safe and effective treatment, handling, and disposal of waste generated at LANL

1.1.4 Science Assignments

LANL's facilities and expertise are utilized for research and development in the areas of theory, modeling and computation, engineering and experimentation, and advanced and nuclear materials. Recent examples of such research and development activities at LANL include:

- Application of high-energy protons to make high-resolution radiographs of rapid events in high-density material
- Application of experimentation and theory to predict how changes in polymer chemical structure, physical structure, and state of stress affect the mechanical properties of the materials
- Development of the high-performance parallel interface, which supports fast data-transfer network technology
- Development of a rapid, one-step method for making complex metal parts by fusing metal powder in the focal zone of a laser beam without the use of a mold, pattern, or forming die
- Measurements to study fundamental properties of neutrinos (a type of elementary particle)
- Studies of the human genome sequence and the structure of other biomolecules
- Development and fielding of sensors in support of nonproliferation, including detectors on Earth-orbiting satellites
- Research on the properties of actinide material that can affect their behavior where they are present in the environment
- Development of techniques to remotely detect atmospheric pollutants

In addition, LANL conducts nuclear criticality studies, performs reimbursable work for other federal agencies and for other sponsors (including the private sector), and allows university researchers to utilize its facilities. Each of these aspects of LANL's support for DOE's science mission are described below.

1.1.4.1 *Nuclear Criticality Studies*

DOE's science mission includes research intended to result in the avoidance of nuclear criticality accidents through understanding the processes of criticality and criticality control, continuing the research on criticality, and continuing to train individuals who will implement policies regarding criticality safety. At present, the only U.S. general criticality research program is at the Los Alamos Critical Experiments Facility (LACEF). In 1993, the Defense Nuclear Facilities Safety Board, an oversight organization, recommended to DOE that it continue the capability to carry on research in criticality. DOE has consolidated certain nuclear materials and machines used for criticality experiments at LANL to be maintained for the purposes of criticality experimentation and training (DOE 1996e).

1.1.4.2 *Reimbursable Work*

This work, sometimes termed "work for others," must be compatible with the DOE mission work conducted at LANL, and must be work that cannot reasonably be performed by the private sector. The nature of the Work for Others Program ranges from long-term work for other agencies to short-term work for industrial clients. Examples of such work for other agencies include:

- DoD development of conventional weapons technology, command and control detection systems, systems analysis and risk assessment, and environmental remediation of hazardous materials
- NRC analysis of reactor safety systems
- National Institutes of Health investigations into biological processes and genetic material

A small but growing amount of work performed by LANL is for industrial sponsors. These partnerships are often shorter-term projects such as modeling work on computer systems, applications of previous research, and new industrial product lines.

1.1.4.3 *University Research and Development*

LANL facilities may be used by universities and others to conduct research that could not otherwise be supported. For example, the Los Alamos Neutron Science Center (LANSCE) allows for university research into condensed matter science and subatomic physics, the results of which may be applicable to DOE missions or to commercial enterprise.

DOE also provides opportunities for university faculty and student training and research visits to LANL. Such programs allow DOE to combine scientific research with practical applications.

1.1.5 DOE National Laboratory System

LANL is part of the DOE national laboratory system that supports DOE's responsibilities and those of other federal agencies, government groups, utilities, and industry. DOE assigns mission elements or tasks to each of its national laboratories based on a variety of factors, including their existing areas of research and experimental capabilities. Table 1.1.5–1 shows the primary laboratory performers for each of the primary DOE missions.

1.2 PURPOSE AND NEED FOR AGENCY ACTION

The purpose of continued operation of LANL is to provide support for DOE's core missions as directed by Congress and the President. DOE's core missions and LANL's support of each of these missions are described in section 1.1.

DOE's need to continue to operate LANL is focused on its obligation to ensure a safe and reliable nuclear stockpile. The key capabilities of LANL that respond directly to this need include:

- Science-based performance safety and reliability evaluations and computer-based modeling of nuclear weapons components, particularly primaries and secondaries
- High-performance computing and computational science
- Weapons-related engineering
- Nuclear materials technology involving transuranic (TRU) materials
- Materials science, including behavior of materials under high temperature and pressure
- Engineering and high-energy physics, supporting activities such as accelerator production of tritium
- High explosives research and development and testing, including detonator development and production
- Tritium gas process development and applications, including neutron target tube loading
- Criticality studies

TABLE 1.1.5–1.—*Primary Laboratory Performers for DOE Missions*[a]

MISSION	PRIMARY LABORATORY PERFORMERS
National Security	Bettis Atomic Power Laboratory, Knolls Atomic Power Laboratory, Lawrence Livermore National Laboratory, **Los Alamos National Laboratory**, Sandia National Laboratories
Energy Resources	Argonne National Laboratory, Federal Energy Technology Center[b], National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory
Environmental Quality	Federal Energy Technology Center[b], Idaho National Engineering and Environmental Laboratory, Lawrence Livermore National Laboratory, **Los Alamos National Laboratory**, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories, Savannah River Technology Center
Science	Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, **Los Alamos National Laboratory,** Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Princeton Plasma Physics Laboratory, Stanford Linear Accelerator Center, Thomas Jefferson National Accelerator Facility

[a] Based on Table 2 of the *Strategic Laboratory Missions Plan—Phase 1*, Volume 1, July 1996, which was prepared by the DOE Laboratory Operations Board (DOE 1996f).
[b] Formerly referred to as the Morgantown Energy Technology Center/Pittsburgh Energy Technology Center.

- Specialty isotope production
- Neutron scattering experimentation for materials science and other purposes, including enhancing surveillance technologies
- Science and technology associated with nonproliferation and threat reduction
- Measurements to study fundamental nuclear and subatomic physics
- Studies of the structure of biomolecules
- Research on properties of actinide materials, including properties that can affect their behavior when they are present in the environment
- Development of techniques to remotely detect atmospheric pollutants

The continuing need for LANL to support the DOE's national security mission elements was recently confirmed by President Clinton, who stated, "to meet the challenge of ensuring confidence in the safety and reliability of our stockpile, I have concluded that the continued vitality of all three DOE nuclear weapons laboratories will be essential" (DOE 1995a). (LANL, Lawrence Livermore National Laboratory and Sandia National Laboratories are often referred to as the three "DOE nuclear weapons laboratories.")

For the foreseeable future, DOE, on behalf of the U.S. Government, will need to continue its nuclear weapons research and development, surveillance, computational analyses, components manufacturing, and nonnuclear aboveground experimentation. Currently, many of these activities are conducted solely at LANL. For example, LANL designed the nuclear components for the majority of the nuclear weapons that are expected to comprise the U.S. stockpile under current arms control agreements and treaties, and will continue to be responsible for assessing the safety and reliability of these weapons (Lawrence Livermore National Laboratory designed the others). Ceasing these activities would run counter to national security policy as established by Congress and the President.

DOE has evaluated and continues to evaluate its mission element assignments, including those at LANL, in other programmatic NEPA documents. LANL's mission element assignments are not under evaluation in the SWEIS.

1.3 OVERVIEW OF THE ALTERNATIVES CONSIDERED

Four alternatives were identified that would meet DOE's purpose and need. The alternatives analyzed in the SWEIS are:

- *No Action Alternative*. Under this alternative, LANL operations would continue at their currently planned levels.
- *Expanded Operations Alternative*. Under this alternative, LANL's level of operations would allow full implementation of earlier DOE decisions and current programs. This alternative represents the highest foreseeable level of future activities that could be supported by the LANL infrastructure.
- *Reduced Operations Alternative*. Under this alternative, LANL's operations would be reduced to the minimum levels that would maintain (for the near term) the capabilities necessary to support the mission elements currently assigned to LANL.
- *Greener Alternative*. Under this alternative, LANL's support for DOE nonproliferation, materials recovery stabilization, and basic science would be maximized. This alternative would also emphasize the use of LANL capabilities for energy and other nonweapons research, including waste treatment technology research and development. LANL's current support to DOE defense and nuclear weapons programs would be minimized.

The first three alternatives present differing operational levels of the same types of activities. The fourth, the "Greener" Alternative, was suggested and titled by stakeholders. This alternative would emphasize the use of LANL capabilities in nonweapons mission elements, as discussed above. In some cases, levels of operations in the Greener Alternative would be higher than in the No Action Alternative (but no higher than the levels reflected in the Expanded Operations Alternative). In other cases, operations under the Greener Alternative would be the same or less than those under the No Action Alternative (but not less than those reflected in the Reduced Operations Alternative).

In the draft SWEIS, the DOE's Preferred Alternative was the Expanded Operations Alternative. In this final SWEIS, the Expanded Operations Alternative remains the Preferred Alternative with one modification, as noted below. The modification to the Preferred Alternative involves the level at which pit manufacturing will be implemented at LANL. Under the Expanded Operations Alternative, DOE would implement pit manufacturing up to the capacity of 50 pits per year under single-shift operations (80 pits per year using multiple shifts). However, as a result of delays in the implementation of the Capability Maintenance and Improvement Project (CMIP) and recent additional controls and operational constraints in the Chemistry and Metallurgy Research (CMR) Building (instituted to ensure that the risks associated with the CMR Building operations are maintained at an acceptable level), the DOE has determined that additional study of methods for implementing the 50 pits per year production capacity is warranted. In effect, because DOE has postponed any decision to expand pit manufacturing beyond a level of 20 pits per year in the near future, the revised Preferred Alternative would only implement pit manufacturing at this level. This postponement does not modify the long-term goal announced in the ROD for the SSM PEIS (up to 80 pits per year using multiple shifts).

1.4 DECISIONS TO BE SUPPORTED BY THE SWEIS

The decisions that DOE expects to make as a result of the alternatives analyzed in this SWEIS would satisfy the purpose and need discussed in section 1.2. The decisions to be reached include the level of operation for LANL and specific decisions regarding facility construction or modification projects discussed across the alternatives, including: (1) the site-specific implementation of the plutonium pit production capacity assigned in the SSM PEIS ROD (61 FR 68014) and (2) the disposition of low-level radioactive waste, given the waste volumes associated with the decisions made regarding the level of operation of LANL. In addition, DOE will select mitigating actions presented in the SWEIS for implementation at LANL. These decisions will be announced in a ROD no sooner than 30 days after the issuance of the final SWEIS Notice of Availability (NOA) by the U.S. Environmental Protection Agency (EPA).

1.4.1 Public Comment Process on the Draft SWEIS

The draft SWEIS was developed after a series of public pre-scoping and scoping hearings to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the SWEIS. The scoping process and issues raised during the scoping phase are described in the SWEIS Implementation Plan (November 1995). DOE released the draft SWEIS on May 15, 1998, for review and comment by the State of New Mexico, Indian tribes, local governments, other federal agencies, and the general public. The formal public comment period lasted 60 days, ending on July 15, 1998. Comments received after close of the comment period were considered in the preparation of the final SWEIS to the extent practical.

DOE considered all comments to evaluate the accuracy and adequacy of the draft SWEIS and to determine when the SWEIS text needed to be corrected, clarified, or otherwise revised. DOE gave equal weight to spoken and written comments, comments received at the public hearings, and comments received in other ways. Comments were reviewed for content and relevance to the environmental analysis contained in the SWEIS. Each comment is addressed individually in volume IV, chapter 3 of the SWEIS.

Commentors raised several common topics during the SWEIS public comment process that the DOE has attempted to address in the Major Issues section located in chapter 2 of volume IV. In some cases, commentors raised issues that were not within the scope of this SWEIS, such as comments regarding opposition to nuclear weapons. To the extent practical, DOE addressed these comments in the Major Issues section and in the individual responses.

1.5 RELATIONSHIP TO OTHER DOE NEPA DOCUMENTS

In this SWEIS, DOE examines the environmental consequences of alternative levels of operation to meet the ongoing mission elements assigned to LANL. However, other DOE NEPA reviews recently completed or currently being conducted could affect LANL operations. Below, these DOE NEPA documents are summarized and their relationships to the SWEIS alternatives are identified.

DOE Waste Types

DOE is responsible for managing inventories of several types of wastes. These wastes are defined as follows:

Low-level radioactive waste *(LLW) includes all radioactive waste that is not classified as high-level waste (HLW), spent nuclear fuel (fuel discharged from nuclear reactors), TRU, uranium and thorium mill tailings, or waste from processed ore. LLW does not contain hazardous constituents that are regulated under the Resource Conservation and Recovery Act (RCRA) (42 U.S.C. §6901)*

Low-level radioactive mixed waste *(LLMW) contains both hazardous and low-level radioactive components. The hazardous component in LLMW is subject to regulation under RCRA.*

Transuranic waste *contains more than 100 nanocuries of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, and an atomic number greater than that of uranium (92). TRU waste has radioactive components such as plutonium.*

TRU mixed waste *is TRU waste that also has hazardous components, and thus, is mixed waste regulated under RCRA.*

High-level waste *is the highly radioactive waste that results from reprocessing spent nuclear fuel and irradiated targets from reactors. LANL has no HLW in its inventory.*

Hazardous waste *(HW) is defined as a solid waste that, because of its characteristics, may significantly contribute to an increase in mortality, or may pose a potential hazard to human health or the environment when improperly treated, stored, or disposed. RCRA defines a "solid" waste to include solid, liquid, semisolid, or contained gaseous material (42 U.S.C. §6901 et seq.). By definition, HW has no radioactive components.*

1.5.1 Waste Management Programmatic Environmental Impact Statement (DOE/EIS–0200)

NEPA Analysis

The *Waste Management Final Programmatic Environmental Impact Statement* (DOE 1997a) (WM PEIS) is a nationwide study examining the potential environmental impacts of managing five types of radioactive and hazardous wastes that result primarily from nuclear defense activities. The ROD for treatment and storage of TRU waste was issued on January 20, 1998 (63 FR 3629), and the ROD for nonwastewater hazardous waste was issued on August 5, 1998 (63 FR 41810). DOE plans to issue other RODs for other waste types at a later time. DOE will use the WM PEIS in deciding how to configure needed treatment, storage, and disposal capacity, depending on waste type. However, the specific location of a facility at a selected site may not be decided until completion of a subsequent site-wide or project-specific NEPA review.

Relationship to LANL

LANL currently generates and manages four types of waste analyzed in the WM PEIS: LLW, LLMW, TRU waste, and HW. The WM PEIS includes preferred alternatives for locations of treatment, storage, and/or disposal of each of the waste types analyzed. The following list briefly describes how LANL could be affected by the respective WM PEIS preferred alternatives.

- *LLW and LLMW Treatment.* Under the WM PEIS Preferred Alternative, LANL would treat its own LLW and LLMW on the site and would not receive LLW or LLMW from off-site locations for treatment.
- *LLW and LLMW Disposal.* Under the WM PEIS Preferred Alternative, LANL is one of six sites from which DOE would select two

or three preferred regional disposal sites, after further consultations with regulatory agencies, state and tribal governments, and other interested stakeholders; that is, LANL would either be a regional disposal site for LLW and LLMW or would ship these wastes off the site for disposal.

- *TRU Waste Treatment and Storage.* Under the TRU waste ROD (63 FR 3629), LANL will treat its own TRU waste on site and receive small amounts of TRU waste from Sandia National Laboratories in Albuquerque, New Mexico, for treatment and storage, pending its disposal.
- *HW Treatment.* Under the nonwastewater HW ROD, LANL will continue to use commercial facilities to treat most of its nonwastewater HW.

SWEIS Inclusion

The SWEIS analyzes on-site treatment of all of LANL's radioactive waste and the use of commercial facilities to treat most of its nonwastewater HW. The TRU waste inventory analyzed in the SWEIS includes the small amounts of such waste that would come to LANL from Sandia National Laboratories (in Albuquerque, New Mexico) under the WM PEIS ROD for TRU waste. The SWEIS also addresses the range of decisions (i.e., regional disposal at LANL or shipment off the site) that could be made concerning disposal of LLW and LLMW. If LANL is chosen as a regional disposal site for LLW and LLMW, the site-specific impacts of that decision would be addressed in further NEPA review tiered from the WM PEIS and this SWEIS.

1.5.2 Stockpile Stewardship and Management Programmatic Environmental Impact Statement (DOE/EIS–0236)

NEPA Analysis

The SSM PEIS addressed the facilities and missions to support the stewardship and management of the U.S. nuclear stockpile (DOE 1996a). The ROD was issued December 19, 1996 (61 FR 68014). The purpose of stockpile stewardship is to ensure the continued reliability and safety of U.S. nuclear weapons and the preservation of the U.S. core intellectual and technical competencies in nuclear weapons in the absence of underground nuclear testing. In order to accomplish this goal, it is necessary to provide the facilities and expert judgment to predict, identify, and provide solutions to problems that might affect the safety and reliability of nuclear weapons.

A primary goal of stockpile management is to provide an effective and efficient production capability for a smaller stockpile by downsizing and/or consolidating functions where appropriate. Stockpile management activities include dismantlement, surveillance, maintenance, evaluation, production, and repair or replacement of nuclear weapons and weapons components.

Relationship to LANL

LANL was one of the sites analyzed for several potential assignments in the SSM PEIS. Based on the SSM PEIS, DOE decided to reestablish DOE's plutonium pit production capability, as well as to construct and operate Atlas at LANL. Atlas is a pulse-powered experimental facility that will aid in studying the physics of secondaries of nuclear weapons. (It should be noted that the data for the SSM PEIS were provided at a level that supported mission element assignment decisions, except in the case of Atlas at LANL and two projects at other sites that were the subject of a complete project-level NEPA analysis. More extensive data were developed to analyze implementation of potential mission element assignments as part of the SWEIS process.)

The SSM PEIS also examined alternatives for assigning the production of high explosives components and the production of secondary assemblies to LANL. Thus, the SWEIS Notice of Intent (NOI) (60 FR 25697) included consideration of these mission element assignments in the Expanded Operations Alternative. Since that time, the SSM PEIS ROD assigned the high explosives component production to the Pantex Plant in Amarillo, Texas, and secondary assembly production to the Y-12 Plant in Oak Ridge, Tennessee. Because LANL was not assigned these mission elements, the SWEIS Expanded Operations Alternative no longer includes them[4].

SWEIS Inclusion

Because DOE has decided to proceed with Atlas, this project is included in all alternatives in the SWEIS. In addition, different levels of plutonium pit manufacturing operations are addressed in the different alternatives in the SWEIS.

Even though the SSM PEIS has assigned the pit production mission element to LANL at a higher rate of production (up to 80 pits per year using multiple shifts), than can be supported with the existing fabrication capacity, production at this level would not begin until an implementation decision is reached based on the SWEIS and until completion of a construction project to establish the higher level of production. At this time, DOE is evaluating its options for achieving this pit fabrication rate (tiered from the SSM PEIS). The Expanded Operations Alternative reflects the proposed construction of a project to enhance the existing manufacturing capability and operations to the level of 80 pits per year with multiple shift operations. However, it is possible that, over the next 10 years (the period of evaluation in the SWEIS), DOE could operate at the No Action Alternative level of pit fabrication operations (up to 14 pits per year), or slightly above that level (up to 20 pits per year, the DOE's Preferred Alternative) for some period of time, and later provide the full capacity. It is also reasonable that DOE could operate at Reduced Operations or Greener Alternatives levels of pit manufacturing (6 to 12 pits per year) for a period of time, while still maintaining a pit fabrication capability and the ability to return later to a higher capacity. Thus, the SWEIS analyzes all levels of operations that could reasonably occur over the next 10 years regarding the manufacturing of pits, given the recent assignment of pit production to LANL.

This approach is discussed further in volume II, section II.2, in the discussion on enhancement of pit manufacturing.

In May 1997, 39 organizations challenged the adequacy of the SSM PEIS by filing a complaint in the U.S. District Court for the District of Columbia, citing a total of 13 claims to support this allegation. In January 1998, these organizations amended their complaint, replacing the original 13 claims with two new claims that alleged that DOE is required to prepare a Supplemental PEIS because of new

4. The scope of the SWEIS was developed prior to the issuance of the SSM PEIS ROD. Thus, the Expanded Operations Alternative was originally defined to include the high explosives component production and the secondary assembly production mission elements. Accordingly, the environmental consequences of the Expanded Operations Alternative (described in chapter 5) include the impacts associated with these mission elements. However, because these activities do not contribute substantially to air quality, water resources, land use, socioeconomic, or other impact projections regarding LANL operations, the environmental consequences of the Expanded Operations Alternative, with or without these mission elements, are substantially the same. Therefore, DOE determined that it was not cost effective to restructure and reanalyze the alternative. To the extent that this affects the impact analyses, the environmental consequences of the Expanded Operations Alternative can be expected to be somewhat less than those identified in chapter 5.

information made available since the SSM PEIS was issued. One of the two new claims involved information concerning pit manufacturing at LANL. Pursuant to its regulations implementing NEPA, DOE prepared a supplement analysis of the pit manufacturing information contained in the amended complaint. Based on this supplement analysis DOE determined that a Supplemental PEIS was not required. The supplement analysis and the memorandum documenting DOE determination are included in this SWEIS as appendix H.

In an opinion and order issued on August 19, 1998, the court agreed that a supplemental PEIS is not required at this time and dismissed that part of the lawsuit involving the SSM PEIS. As part of the settlement, DOE agreed to prepare an additional Supplement Analysis of pit production based on (1) the results of several pending peer-reviewed seismic reports due to be issued by March 1999, and (2) technical analysis of the plausibility of a building-wide fire at Technical Area (TA)–55 under glove-box propagation or seismic or sabotage initiation. The Supplement Analysis is under preparation. A summary of the methodology used in the preparation of the Supplement Analysis is included in chapter 5, section 5.1.11.12. Information from the seismic reports published by the end of December 1998 have been incorporated into the SWEIS accident analyses.

1.5.3 Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement (DOE/EIS–0026–S2)

NEPA Analysis

WIPP is the proposed repository for retrievably stored defense TRU waste. In October 1980, DOE issued an EIS on proposed development of WIPP (DOE 1980). The January 1981 ROD (46 FR 9162) called for phased development of WIPP, beginning with construction of the WIPP facility. In 1990, DOE issued a supplemental EIS that considered previously unavailable information (DOE 1990). Based on this supplemental EIS, DOE decided to continue phased development.

DOE has issued a second supplemental EIS (SEIS-II) to analyze the impacts of TRU waste disposal at WIPP or continued storage at the generating sites (DOE 1997b). The SEIS-II updates the information contained in the previous EIS and supplemental EIS, analyzes various treatment alternatives for TRU waste, and examines any changes in environmental impacts due to new information or changed circumstances. Based on this analysis, DOE has decided (63 FR 3623, January 23, 1998) to dispose of defense-related TRU waste at WIPP up to legal limits, once the waste is treated to the WIPP waste acceptance criteria (WAC). DOE will transport TRU waste to WIPP by truck.

Relationship to LANL

The WIPP SEIS-II analyzes the impacts of LANL TRU waste treatment and subsequent transportation to WIPP, in accordance with current DOE planning schedules.

SWEIS Inclusion

The treatment of TRU waste to the WIPP WAC and transportation to WIPP is included in all SWEIS alternatives. The SWEIS transportation analyses address the use of the proposed route that would bypass the City of Santa Fe.

1.5.4 Medical Isotopes Production Project: Molybdenum-99 and Related Isotopes Environmental Impact Statement (DOE/EIS–0249)

NEPA Analysis

In the Molybdenum-99 EIS, DOE analyzed alternatives to establish, as soon as practical, a domestic capacity to produce molybdenum-99 and related medical isotopes for use by the U.S. healthcare community using the U.S. Food and Drug Administration-approved Molybdenum-99 production process (DOE 1996c).

Relationship to LANL

The ROD associated with the Molybdenum–99 and Related Isotopes EIS (60 FR 48921) states that DOE will use the facilities of Sandia National Laboratories, New Mexico, and LANL. Under this approach, DOE uses the CMR Building at LANL to fabricate the targets containing HEU. Molybdenum-99 is produced at Sandia National Laboratories. LLW from target fabrication at LANL is disposed of on the site, pending decisions based on the WM PEIS and this SWEIS.

SWEIS Inclusion

The modifications required to fabricate targets at LANL's CMR Building are relatively minor. Some interior walls will be removed, doors will be relocated, and gloveboxes with filtered exhaust systems will be installed. These activities and the target fabrication operations are included in all alternatives in the SWEIS.

1.5.5 Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement (DOE/EIS–0229)

NEPA Analysis

After completion of the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* (DOE 1996d), DOE decided in the related ROD how to implement its program to provide for safe and secure storage of weapons-usable fissile materials (plutonium and HEU) and a strategy for the disposition of surplus weapons-usable plutonium (62 FR 3014). The fundamental purposes of the program are to maintain a high standard of security and accounting for these materials while in storage and to ensure that plutonium produced for nuclear weapons and declared excess to national security needs is never again used for nuclear weapons.

Relationship to LANL

LANL participates in the research and development program to develop and demonstrate the technologies necessary for disposition and storage of plutonium. In particular, research and development regarding the conversion of surplus plutonium in weapons components to mixed oxide (MOX) reactor fuel is conducted at LANL.

SWEIS Inclusion

The research and development efforts supporting plutonium pit disassembly and MOX fuels development and demonstration are within the levels of operation addressed in the SWEIS. Specifically, the No Action, Reduced Operations, and Greener Alternatives include the current level of operation, and the Expanded Operations Alternative includes a higher level of these activities.

1.5.6 EIS on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site (DOE/EIS–0277)

NEPA Analysis

DOE has issued an EIS (DOE 1998d) to evaluate the potential environmental impacts associated with management of certain plutonium residues and scrub alloy currently being stored at RFETS in Golden, Colorado. The residues and scrub alloy are materials that were generated during the separation and purification of plutonium or during the manufacture of plutonium-bearing components for nuclear weapons. Alternatives analyzed in the Residues EIS include No Action, process for disposal without plutonium separation, and process for disposal or other disposition with plutonium separation. In its ROD (63 FR 66136) DOE selected processing technologies for these residues, including some that would involve separation of plutonium. In a second ROD, DOE will make a decision about technologies for pyrochemical salt residues. The preferred alternative is to preprocess at RFETS, with plutonium separation to take place at LANL. The impacts of off-site transportation and processing are analyzed in detail for the Savannah River Site and LANL.

Relationship to LANL

LANL participates in the research and development program to develop and demonstrate the technologies necessary for management (including the processing, measuring and storing) of plutonium residues. At times, LANL has processed and is expected to continue to process small quantities of unique or difficult-to-process residues from off-site locations. In addition, as noted above, the Residues EIS analyzed LANL as a possible site for processing some of RFETS' chloride salt residues.

SWEIS Inclusion

The development and demonstration activities for the processing, measuring, and storing of plutonium residues are within the levels of operation addressed under each of the SWEIS alternatives. The No Action Alternative includes the current level of such operations, and the Reduced Operations Alternative includes a level of operations lower than that in the No Action Alternative. The Expanded Operations and Greener Alternatives include a larger throughput of residue processing than the No Action Alternative, and in addition, include increases in the amount of off-site material that would be processed and transported from RFETS.

1.5.7 Pit Disassembly and Conversion Demonstration Environmental Assessment (DOE/EA–1207)

NEPA Analysis

DOE prepared an environmental assessment (EA) (DOE 1998a) to examine the environmental impacts of the proposed development and demonstration of an integrated pit disassembly and conversion process for fissile material disposition. The demonstration would involve the disassembly of up to 250 weapons components (pits) over 4 years and conversion of the recovered plutonium to plutonium oxide. DOE determined that this proposed action would not significantly affect the quality of the human environment and issued a Finding of No Significant Impact in August, 1998 (63 FR 44851). Because this EA was under preparation, the proposed action of 250 components was part of the Expanded Operations Alternative in the draft SWEIS.

Relationship to LANL

The proposed work would be conducted at LANL's Plutonium Facility at TA–55. No new facilities would need to be constructed to support the demonstration, although internal modifications to the facility would be required. All work would be performed in a series of interconnected gloveboxes using remote handling and computerized control systems.

SWEIS Inclusion

The modifications and conduct of the plutonium pit disassembly and conversion demonstration using up to 40 pits are within the level of operations addressed in the SWEIS No Action, Reduced Operations, and Greener Alternatives. Demonstration activities using up to 250 pits over 4 years is within the level of operations included in the SWEIS Expanded Operations Alternative. The Expanded Operations Alternative also includes continued use of the process equipment for pit disassembly by other programs after this demonstration project has been completed.

1.5.8 Surplus Plutonium Disposition Environmental Impact Statement (DOE/ EIS–0283)

NEPA Analysis

DOE is preparing an EIS (DOE 1998b) to evaluate the potential environmental impacts for the proposed siting, construction, and operation of facilities for plutonium disposition. These would include a facility to disassemble and convert plutonium pits into plutonium oxide suitable for disposition, a facility to immobilize surplus plutonium in glass or ceramic form, and a facility to fabricate plutonium oxide into MOX fuel. The EIS also examines the potential impacts of the siting, modification, and operation of existing facilities for the fabrication of lead test assemblies that would be used in MOX fuel qualification demonstrations. The Draft Surplus Plutonium Disposition EIS was issued in July 1998.

Relationship to LANL

DOE is analyzing LANL as one of five potential sites for the location of the fabrication of MOX fuel lead test assemblies demonstration as part of the surplus plutonium disposition program.

SWEIS Inclusion

The development and fabrication activities for the production of MOX fuel pellets would be a demonstration activity. The SWEIS includes continued development and demonstration activities for ceramic fuels. The impacts of implementing the Lead Test Assembly demonstration activities at LANL are presented in chapter 5, section 5.6. Facility information also is provided in chapter 2 (sections 2.2.2.1 and 2.2.2.15) regarding both operations.

1.5.9 EIS for Siting, Construction, and Operation of the Spallation Neutron Source (DOE/EIS–0247)

NEPA Analysis

DOE is evaluating the siting, construction, and operation of a proposed spallation neutron source (SNS) (DOE 1998c). This facility would consist of a proton accelerator system; a spallation target; and appropriate experimental areas, laboratories, offices, and support facilities to allow ongoing and expanded programs of neutron research. The proposed site for the SNS is the DOE-owned Oak Ridge National Laboratory in Oak Ridge, Tennessee. The alternative sites under consideration are three other DOE-owned laboratories: Argonne National Laboratory, Argonne, Illinois; LANL; and Brookhaven National Laboratory, Upton, New York. The public scoping period for this

EIS was completed in September 1997. A draft EIS was completed in December 1998.

This facility is considered complementary to existing accelerator-based spallation sources at LANL, and would not be intended to replace the existing facility.

Relationship to LANL

LANL is one of four alternatives for the SNS; though not the preferred site. If LANL is selected, the facility would be built on a currently undeveloped site. This project is independent of all current or planned future operations at LANL.

SWEIS Inclusion

The SNS EIS is being coordinated with this SWEIS so that it can make use of the information developed for the SWEIS and to ensure that the SNS EIS considers the LANL alternative in light of the information regarding LANL operations and the corresponding impacts, as described in this SWEIS. Impacts associated with the SNS project, including site development, utilities, and waste management are to be analyzed in the EIS specific to that project and are not included in the SWEIS.

1.5.10 EIS for the Proposed Conveyance and Transfer of Certain Land Tracts Located Within Los Alamos and Santa Fe Counties and Los Alamos National Laboratory

NEPA Analysis

DOE is preparing an EIS to assess the potential environmental impacts of conveying or transferring certain land tracts under the administrative control of DOE located within the Counties of Los Alamos and Santa Fe (the CT EIS). The EIS is evaluating the congressionally mandated action required under PL 105-119 of conveying certain land tracts to the County of Los Alamos and to the Secretary of the Interior in trust for the Pueblo of San Ildefonso.

Relationship to LANL

LANL is the only DOE site involved in the proposed action. The NEPA review is proceeding separately from the SWEIS.

SWEIS Inclusion

The SWEIS analysis does not include a consideration for changing the size or configuration of the LANL reserve through land conveyance or transfer, such as those to be included in this CT EIS. A draft CT EIS is expected to be released for public review and comment in early 1999. The impacts of implementing the proposed action are summarized in chapter 5, section 5.6 of the SWEIS. The SWEIS does take into account two proposals for land transfer or leasing that have already been analyzed by EAs with Findings of No Significant Impacts (FONSI) (discussed in section 1.6.2), although DOE has not reached a final decision to implement either of these proposals to date.

1.5.11 Environmental Assessment for the Proposed Strategic Computing Complex (DOE/EA-1250)

NEPA Analysis

DOE prepared an environmental assessment to evaluate the environmental impacts of construction and operation of a Strategic Computing Complex (SCC) within LANL's TA–3. The SCC will be a facility designed to house and operate an integrated system of computer processors capable of performing approximately 50 trillion floating point operations per second, as part of the Accelerated Strategic Computing Initiative in support of the Stockpile Stewardship and Management Program.

Relationship to LANL

LANL is the only site under consideration for the SCC. The SCC proposal was an allowable interim action, and the NEPA review proceeded separately from the SWEIS. Based on the EA, DOE determined that the proposed action would not significantly affect the quality of the human environment and issued a Finding of No Significant Impact in December 1998.

SWEIS Inclusion

The major impacts of the operation of the SCC will be on water consumption and use of electric power. The impacts of the construction and operation of the SCC are included in the levels of operation for all of the alternatives in the SWEIS.

1.6 OVERVIEW OF THE LANL SWEIS

General information regarding the NEPA process and the process DOE used in preparation of this SWEIS (including public involvement) are included on the inside covers of volume I of the SWEIS. Additional information specific to the SWEIS is described in this section, including the objectives of the SWEIS, DOE's approaches in preparing the document, the consideration of future projects in the SWEIS alternatives and analyses, the role of the Cooperating Agency, and a preview of the remaining sections of the document.

1.6.1 Objectives of the SWEIS

The environmental impacts of LANL operations have been addressed in the *Final Environmental Impact Statement: Los Alamos Scientific Laboratory Site* (DOE 1979) and in subsequent EISs, EAs, categorical exclusion determinations, and other types of environmental reviews for specific projects and activities. Changes in the world political situation have the potential to alter the role of LANL and its operations now and during the next 10 years, and this SWEIS is intended to support decision-making regarding LANL's operations. In this SWEIS, DOE is examining the environmental impacts of four alternatives for the continued operation of the laboratory (section 1.3 and chapter 3 provide descriptions of the alternatives analyzed).

Given the decisions DOE intends to make based on this SWEIS (section 1.4), the objectives of the SWEIS are to:

- Describe the current environment, current operations, and the impacts associated with the continued operation of LANL.
- Compare the environmental consequences, including cumulative impacts, of reasonable alternatives for the continued operation of LANL.
- Provide a sufficient level of information to facilitate routine decisions about, and verification of, operational status with respect to the SWEIS analyses.
- Provide the project-specific NEPA analyses for proposed projects (including the expansion of LLW disposal capacity at Area G and the enhancement of plutonium pit manufacturing at LANL) and include them in the overall SWEIS impact assessment.
- Serve as a site-wide document for tiering and reference information for future NEPA analyses at LANL.

1.6.2 SWEIS Approaches

To meet these objectives, DOE used the following approaches:

- The sources of potential impacts analyzed in the SWEIS are those associated with LANL operations within the 43-square-mile (111-square-kilometer) LANL main site and the 0.3-square-mile (0.77-square-kilometer) Fenton Hill site, located about 20 miles (32 kilometers) west of LANL.

- The SWEIS analyzes current and proposed activities that could occur over the next 10 years. DOE chose the 10-year period as one in which future activities could be reasonably anticipated and described. Predicting activities beyond 10 years would have been excessively speculative.
- Those operations that have the most potential for significant environmental and human health impacts, including areas of concern identified by the public during the scoping process, are described in detail by facility. Operations of lesser potential impact are described and analyzed at the site-wide level only.
- Descriptions of the affected environment are based on the geographical area of the potential impact. If the impact would be limited to a canyon or mesa top, the discussion is largely focused at that level. Parameters such as radiological air emissions and the potential consequences to air quality and human health are discussed at the regional level.
- The SWEIS also includes the impacts of a proposed land transfer and a proposed lease action that are currently being finalized. These proposals (Transfer of the DP Road Tract to the County of Los Alamos and Lease of Land for the Development of a Research Park) were analyzed in EAs (DOE 1997c and DOE 1997d). The Secretary of Energy is directed to make additional land transfers in the *Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriations Act of 1998* (PL 105-119, Section 632), but the actual parcels to be transferred are not sufficiently defined to allow for meaningful analysis in this SWEIS. On May 6, 1998, DOE published an NOI to prepare an EIS for the Proposed Conveyance and Transfer of Certain Land Tracts in the FR (63 FR 25022). (See Section 1.5.10.)
- The SWEIS generally describes the environmental restoration actions planned during the next 10 years to meet the requirements of LANL's Hazardous Waste Operating Permit and the various strategies for managing the resulting wastes. The types of impacts experienced and expected from such activities are described in general and are included with the site-wide impacts of each of the four alternatives analyzed in the SWEIS. These impacts are also analyzed in NEPA reviews and in RCRA documentation prepared using processes that include opportunities for public comment, within the framework agreed upon among DOE, the LANL management and operating contractor (University of California [UC]), and the New Mexico Environment Department (NMED).
- For the cumulative impact analysis, other proposals and plans by both private and government entities in the northern New Mexico area were reviewed, and their effects were considered together with those from LANL operations.

In this SWEIS, DOE also examines mitigation measures for impacts of LANL operations, planning strategies to protect and conserve natural and cultural resources, and waste management (treatment, storage, and disposal) strategies for LANL, including pollution prevention.

1.6.3 Consideration of Future Projects

DOE and researchers at LANL frequently develop new ideas and proposals for which funding and programmatic support are requested. Such proposals vary in terms of size, complexity, and potential environmental impact. Many of these proposals are characterized as projects. These are typically activities or groups of activities within the broad research, development, and applications activities across LANL. Some of these activities also require construction or modification of facilities or equipment. The discussion in this section focuses on these construction and modification projects.

Construction and facility modification projects being considered by and for LANL are of many sizes and levels of complexity and were identified using a variety of sources. These sources included Capital Assets Management Process (CAMP) Reports (e.g., LANL 1995), LANL Institutional Plans (e.g., LANL 1996), and other DOE NEPA documents and reports. The potential projects identified were reviewed to determine the appropriate level of analysis in the SWEIS. As a result of this process, potential LANL projects were placed into one of these three categories.

- *Projects for which NEPA review has been completed and for which a decision has been made prior to the completion of the SWEIS.* These projects support the DOE mission and DOE's ongoing program requirements and are included in all of the SWEIS alternatives. Any of these projects that are considered major federal actions meet the test for interim actions found in the Council on Environmental Quality's (CEQ's) regulations for implementing NEPA at 40 Code of Federal Regulations (CFR) 1506.1.
- *Site-specific proposed projects that are ripe for decision and are on the same schedule as the SWEIS and its ROD.* Several facility or equipment modification activities are described in the SWEIS (chapters 2 and 3). It is expected that the SWEIS will constitute the NEPA review for these projects. However, if the scope or design for these projects changes substantially in the future, additional NEPA review may be necessary. The construction projects analyzed include the expansion of LLW disposal capacity in Area G and the enhancement of plutonium pit manufacturing operations (to reestablish DOE's production capability for these weapons components). For these two project-level analyses, a description of the different locations within LANL considered and the environmental impacts of constructing those facilities at the different locations is included in volume II of the SWEIS, Project-Specific Siting and Construction (PSSC) Analyses. These construction activities and subsequent facility operations are included in the Expanded Operations Alternative (chapter 3, section 3.2), and the impacts of these activities are included in the impacts of the Expanded Operations Alternative (chapter 5, section 5.3) in volume I of the SWEIS.
- *Projects that are not reasonably foreseeable within the next 10 years.* Such projects are considered speculative; thus, they are not analyzed in the SWEIS. If such projects were eventually proposed, it is anticipated that they would require NEPA review prior to being undertaken. Such analyses would be tiered from the SWEIS that is in effect at the time.

1.6.3.1 *Emerging Actions at LANL*

Because LANL is a site of ongoing and evolving research and development, there may be potential actions or projects for which concepts are emerging or may emerge during the preparation of this SWEIS. Typically, such projects are still somewhat speculative or not at a sufficient stage of definition to allow for detailed NEPA analysis. These projects are not yet proposed (in the NEPA sense) and are not ripe for analysis in the SWEIS. If and when these projects are sufficiently defined, they would be subject to appropriate NEPA review at that time. For the purposes of public disclosure and to ensure the fullest possible description of site-wide activities, however, the following information is provided on some emerging projects.

- DOE currently is studying a variety of options for the renovation of infrastructure at TA–3 that would include replacing a number of aging structures either individually or as part of a multi-building effort. It is anticipated that one or more building replacements will be needed at TA–3. The construction would be of office and light laboratory buildings to continue housing the existing types of activities currently pursued at this TA. Planning for renovations and/or replacements is still being discussed, and impacts cannot yet be analyzed.
- An additional facility, the Los Alamos Nonproliferation and International Security Center, is also being studied. This building would consolidate about 80 percent of office and light laboratory activities undertaken at LANL for verification and intelligence purposes. The activities are currently undertaken in about 50 separate structures consisting of a variety of transportable facilities and various buildings spread out over five TAs. TA–3 is being considered as a potential site.
- As discussed further in chapter 4 (section 4.9.2.1) and chapter 6 (section 6.1.1) of this SWEIS, DOE and other users of electric power in the area have been working with suppliers to resolve foreseeable power supply and reliability issues. Some specific solutions to these issues are currently being examined for feasibility. In particular, DOE is examining the potential for constructing a power line that would extend from the existing Public Service Company of New Mexico (PNM) Norton substation southeast of LANL to existing LANL substations, and potentially to a new LANL substation (which would be constructed if this is determined to be a feasible solution).

As noted above, these projects would be subject to appropriate NEPA review when they are sufficiently defined for analysis.

1.6.4 Cooperating Agency

In November, 1995, DOE agreed to the request of the Incorporated County of Los Alamos, New Mexico, to be a Cooperating Agency in the preparation of the SWEIS. DOE and the County of Los Alamos believed this status to be appropriate given the interdependence of the county's planning and DOE's planning for LANL. DOE and the County of Los Alamos signed a Memorandum of Agreement that governs interactions with respect to the SWEIS. The county's participation in the SWEIS has included participation in planning meetings, development of analytical methodologies, data projections, and review of analyses for, and predecisional drafts of, the draft SWEIS. The county's participation has been greatest with respect to socioeconomic analyses, including utilities and infrastructure demands associated with LANL activities.

1.6.5 Organization of the SWEIS

The SWEIS is organized into four volumes and a classified appendix. The first volume contains the following parts:

- *Chapter 1* presents a description of LANL's role in supporting DOE's missions, the purpose and need for agency action, and an overview of the SWEIS.
- *Chapter 2* presents a detailed description of LANL's facilities and activities.
- *Chapter 3* describes the alternatives analyzed in the SWEIS and the alternatives not considered in detail, and provides comparison of the potential consequences of the alternatives for continued operations.
- *Chapter 4* presents a description of the affected environment as it exists under current conditions and provides the basis against which impacts resulting from actions under each alternative can be compared.

- *Chapter 5* describes the potential consequences that could result from implementing each of the alternatives.
- *Chapter 6* describes the mitigation measures that could be applied to minimize or reduce potential environmental consequences of the alternatives.
- *Chapter 7* presents a summary of the regulatory requirements and provides information on federal permits and licenses that apply to LANL operations, as well as agencies consulted in the preparation of this SWEIS.
- *Chapter 8* is a list of preparers of the SWEIS.
- *Chapter 9* is a list of individuals and organizations receiving a copy of the SWEIS.
- *Chapter 10* is a glossary of terms used in the SWEIS.
- *Chapter 11* contains copies of statements by contractors who worked on the SWEIS regarding potential conflicts of interest.
- *Chapter 12* is an index of key words or expressions used in this volume of the SWEIS.

The second volume of the SWEIS contains two parts and addresses the siting and construction impacts associated with the Expansion of TA–54/Area G Low-Level Waste Area (part I) and the Enhance of Plutonium Pit Manufacturing (part II).

The third volume of the SWEIS contains nine appendixes that present detailed information to support the analyses presented in chapter 5 of the SWEIS.

- Appendix A, Water Resources
- Appendix B, Air Quality
- Appendix C, Contaminant Data Sets Supporting Ecological and Human Health Consequence Analysis
- Appendix D, Human Health
- Appendix E, Cultural Resources
- Appendix F, Transportation Risk Analysis
- Appendix G, Accident Analysis
- Appendix H, Supplement Analysis for the Enhancement of Pit Manufacturing at Los Alamos National Laboratory, Stockpile Stewardship and Management Programmatic Environmental Impact Statement
- Appendix I, Report on the Status and Implications of Seismic Hazard Studies at LANL

The fourth volume of the SWEIS contains the public comments received on the draft SWEIS and DOE's responses. The volume contains three chapters.

- *Chapter 1* describes the public comment process for the draft SWEIS.
- *Chapter 2* discusses several topics associated with the comments received on the draft SWEIS that were of broad interest or concern. These topics were categorized as "Major Issues." This chapter reflects how these broad issues were considered.
- *Chapter 3* presents the comments received on the draft SWEIS and DOE's response to each individual comment.

The discussions in this SWEIS are augmented by a classified supplement to the SWEIS. This supplement contains certain classified information and data related to the activities at LANL that, though important to support understanding of certain details underlying the SWEIS and its analyses, must be protected in accordance with the *Atomic Energy Act of 1954* (42 U.S.C. §2011). This information includes details associated with some operations, experiments, processes, or source terms. DOE presents as much information as possible in this unclassified document. Furthermore, the environmental impacts are fully contained in the results presented to the public in this unclassified document.

DOE invited the EPA, the DoD, the Accord Pueblos, and the State of New Mexico to review the classified supplement. Only those individuals with appropriate clearances and a need to know were given access to the classified information.

References used for the preparation of this SWEIS are, to the extent practical, publicly available. To request assistance in obtaining or accessing any of these references, please contact Mr. Corey Cruz of DOE by the mechanisms described on the cover sheet for this volume.

1.7 CHANGES TO THE DRAFT SWEIS

DOE revised the draft SWEIS in response to comments received from other federal agencies; tribal, state, and local governments; nongovernmental organizations; the general public; and DOE reviews. The text was changed to provide additional environmental baseline information, to correct inaccuracies and make editorial corrections, and provide additional discussion of technical considerations to respond to comments and clarify text. In addition, DOE updated information due to events or decisions made in other documents since the draft SWEIS was provided for public comment in May 1998.

1.7.1 Summary of Significant Changes

1.7.1.1 *Revised Preferred Alternative*

In the draft SWEIS, the DOE's Preferred Alternative was the Expanded Operations Alternative. In this final SWEIS, the Expanded Operations Alternative remains the Preferred Alternative with one modification, as noted below. The modification to the Preferred Alternative involves the level at which pit manufacturing will be implemented at LANL. Under the Expanded Operations Alternative, DOE would expand operations at LANL, as the need arises, to increase the level of existing operations to the highest reasonably foreseeable levels, including the full implementation of pit manufacturing up to the capacity of 50 pits per year under single-shift operations (80 pits per year using multiple shifts). However, as a result of delays in the implementation of the CMIP and recent additional controls and operational constraints in the CMR Building (instituted to ensure that the risks associated with the CMR Building operations are maintained at an acceptable level), the DOE has determined that additional study of methods for implementing the 50 pits per year production capacity is warranted. In effect, because DOE has postponed any decision to expand pit manufacturing beyond a level of 20 pits per year in the near future, the revised Preferred Alternative would only implement pit manufacturing at this level. This postponement does not modify the long-term goal announced in the ROD for the SSM PEIS (up to 80 pits per year using multiple shifts).

1.7.1.2 *Enhanced Pit Manufacturing*

As described above, as a result of delays in the implementation of the CMIP and recent additional controls and operational constraints in the CMR Building (section 2.2.2.3), DOE has postponed any decision to implement the pit manufacturing capability beyond a level of 20 pits per year (14 pits is the No Action level). DOE believes it can expand the pit manufacturing capability to 20 pits at TA–55 without significant infrastructure upgrades and still meet its near-term mission requirements. When the additional studies are completed, DOE will provide the appropriate NEPA review, tiered from this SWEIS, to implement the pit manufacturing capability beyond the 20 pits per year capacity. The PSSC analysis for the Enhancement of Plutonium Pit Manufacturing (in volume II of this SWEIS) no longer states a "Preferred PSSC Alternative." The Preferred Alternative would only implement pit production at a level of 20 pits per year. However, for completeness and to bound the impacts of implementing pit production at LANL, the "Utilize Existing Unused Space in the CMR Building" Alternative (the Preferred PSSC Alternative in the draft SWEIS) is still included in the Expanded Operations Alternative as the "CMR Building Use" Alternative. The ROD for the SWEIS will only include a decision regarding the operations to implement the pit production mission at LANL for up to 20 pits per year. This change is reflected in volume II, part II of the SWEIS.

1.7.1.3 *Wildfire*

The scenario that a wildfire could encroach on LANL was analyzed and included in the accident set presented for all the alternatives. The detailed wildfire analysis, referred to as the SITE–04 accident, is presented in appendix G, section G.5.4.4 of volume III of this SWEIS. A summary of the impacts is presented in chapter 5.

1.7.1.4 *Comparison Between the Rocky Flats Plant and LANL*

An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and LANL are included in appendix G, section G.4.1.2. A summary is included in chapter 5.

1.7.1.5 *CMR Building Seismic Upgrades*

DOE has decided not to implement the seismic upgrades as part of the CMR Building Upgrades Project, Phase II, as a result of: (1) new seismic studies (chapter 4, section 4.2.2.2, and appendix I) released after the draft SWEIS was issued indicating the additional hazard of a seismic rupture at the CMR Building and (2) DOE's postponement of any decisions to implement the pit manufacturing capability beyond 20 pits per year in the near future. Although the seismic rupture risk does not have a substantial effect on the overall seismic risk (chapter 2, section 2.2.2.3), it is an aspect of risk that cannot be cost-effectively mitigated through engineered structural upgrades. Given that assessment, the DOE is considering more substantial actions that are not yet ripe for analysis in the SWEIS (e.g., replacement of aging structures). The overall goal of DOE's evaluation is ultimately to reduce the risk associated with a seismic event, should one occur. In the meantime, DOE is taking actions to mitigate seismic risks through means other than seismic upgrades (e.g., minimizing material-at-risk and putting temporarily inactive material in process into containers). In any event, DOE is presenting the larger and more conservative impacts (no seismic upgrades) for the SITE–01, SITE–02, and SITE–03 accidents. Therefore, SITE–01, SITE–02, and SITE–03 accidents were revised to include new seismic data published after the draft SWEIS was released and to exclude the mitigation of the impacts of implementing the seismic upgrades. The detailed revised analysis is presented in appendix G. A summary of the impacts is presented in chapters 3 and 5.

1.7.1.6 *Strategic Computing Complex*

The impacts of constructing and operating the proposed SCC project, primarily electric power demand and water usage, were incorporated into all the alternatives analyzed. Water usage was not increased in these analyses because DOE and LANL committed to no net increase of water as a result of conservation measures and recycling of treated wastewater from the Sanitary Wastewater Systems Consolidation Plant, TA–46, as cooling water for the SCC project.

1.7.1.7 *Conveyance and Transfer of DOE Land*

DOE has begun the preparation of an EIS for the Conveyance and Transfer of Certain Land Tracts at LANL. The CT EIS, scheduled to be released in draft form for public review and comment in early 1999, will analyze the impacts of conveying and transferring certain tracts of land to the County of Los Alamos and the U.S. Department of the Interior in trust for the Pueblo of San Ildefonso. The CT EIS also will present the cumulative impacts of the land being developed by either the County of Los Alamos or the Pueblo, as well as the impacts of continuing to operate LANL.

1.7.2 Next Steps

The ROD, to be published no sooner than 30 days after NOA for the final SWEIS has been issued, will explain all factors, including environmental impacts, that the DOE considered in reaching its decision. The ROD also will identify the environmentally preferred alternative or alternatives. If mitigation measures, monitoring, or other conditions are adopted as part of DOE's decision, these will summarized in the ROD, as applicable, and will be included in the Mitigation Action Plan that would be prepared following the issuance of the ROD. The Mitigation Action Plan would explain how and when mitigation measures would be implemented and how the DOE would monitor the mitigation measures over time to judge their effectiveness.

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REFERENCES

DOE 1979 — *Final Environmental Impact Statement: Los Alamos Scientific Laboratory Site.* DOE/EIS-0018. U. S. Department of Energy. Washington, D.C. 1979.

DOE 1980 — *Waste Isolation Pilot Plant Final Environmental Impact Statement.* U.S. Department of Energy, Albuquerque Operations Office. DOE/EIS-0026. Albuquerque, New Mexico. 1980.

DOE 1990 — *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement.* U.S. Department of Energy, Albuquerque Operations Office. DOE/EIS-0026-S1. Albuquerque, New Mexico. 1990.

DOE 1993 — *Nonnuclear Consolidation Environmental Assessment, Nuclear Weapons Complex Reconfiguration Program.* U.S. Department of Energy. DOE/EA-0792. Washington, D.C. June 1993.

DOE 1995a — Statement by the President: *Future of Major Federal Laboratories.* The White House, Office of the Press Secretary. 1995.

DOE 1995b — *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling.* U.S. Department of Energy, Office of Reconfiguration. DOE/EIS-0161. Washington, D.C. October 1995.

DOE 1995c — *Radioactive Source Recovery Program Environmental Assessment.* U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1059. Los Alamos, New Mexico. December 1995.

DOE 1996a — *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management.* U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. September 1996.

DOE 1996b — *Low-Energy Demonstration Accelerator Environmental Assessment.* U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1147. Los Alamos, New Mexico. April 1996.

DOE 1996c — *Medical Isotope Production Project: Molybdenum-99 and Related Isotopes, Environmental Impact Statement.* U.S. Department of Energy, Office of Nuclear Energy, Science and Technology. DOE/EIS-0249F. Washington, D.C. April 1996.

DOE 1996d — *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/EIS-0229. Washington, D.C. December 1996.

DOE 1996e — *Consolidation of Certain Materials and Machines for Nuclear Criticality Experiments and Training.* U.S. Department of Energy, Albuquerque Operations Office. DOE/AL-1104. Albuquerque, New Mexico. May 1996.

DOE 1996f — *Strategic Laboratory Missions Plan—Phase I,* Volume 1. U.S. Department of Energy, Laboratory Operations Board. July 1996.

DOE 1997a — *Waste Management Final Programmatic Environmental Impact Statement.* U.S. Department of Energy, Office of Environmental Management. DOE/EIS-0200. Washington, D.C. May 1997.

DOE 1997b — *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement.* U.S. Department of Energy, Albuquerque Operations Office. DOE/EIS-0026-S2. Albuquerque, New Mexico. September 1997.

DOE 1997c — *Environmental Assessment for the Lease of Land for the Development of a Research Park at Los Alamos National Laboratory.* U.S. Department of Energy. DOE/EA-1212. Los Alamos, New Mexico. October 1997.

DOE 1997d — *Environmental Assessment for the Transfer of the DP Road Tract to the County of Los Alamos.* U.S. Department of Energy. DOE/EA-1184. Los Alamos, New Mexico. January 1997.

DOE 1998a — *Pit Disassembly and Conversion Demonstration Environmental Assessment and Research and Development Activities.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/EA-1207. Washington, D.C. August 1998.

DOE 1998b — *Surplus Plutonium Disposition Environmental Impact Statement.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/Draft EIS-0283. Washington, D.C. July 1998.

DOE 1998c — *Environmental Impact Statement for Siting, Construction, and Operation of the Spallation Neutron Source*. U.S. Department of Energy. DOE/EIS-0247. In preparation, 1998.

DOE 1998d — *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site.* U.S. Department of Energy. DOE/EIS-0277. August 1998.

LANL 1995 — *Capital Asset Management Process, Fiscal Year 1997.* Los Alamos National Laboratory. LA-UR-95-1187. Los Alamos, New Mexico. 1995.

LANL 1996 — *Los Alamos National Laboratory Institutional Plan, FY 1997—FY 2002.* Los Alamos National Laboratory. LA-LP -96-77. Los Alamos, New Mexico. 1996.

CHAPTER 2.0
BACKGROUND ON LOS ALAMOS NATIONAL LABORATORY FACILITIES AND ACTIVITIES

This chapter provides a description of the activities and facilities at LANL. The chapter includes a description of the 49 technical areas and focuses on the activities at 15 key facilities. The role of the University of California in LANL's operation and recent funding levels are also presented.

LANL's current activities stem from its original mission to build the world's first nuclear weapon. In March 1943, a small group of scientists led by J. Robert Oppenheimer, came to the small community of Los Alamos to carry out Project Y of the Manhattan Project (1943 through 1945).

Although the original mission was assigned to a few hundred scientists and technicians, by the time the first nuclear bomb was tested at Trinity Site, the Los Alamos Laboratory consisted of more than 3,000 civilian and military personnel. In 1947, Los Alamos Laboratory was renamed the Los Alamos Scientific Laboratory, and in 1981 it was designated as a national laboratory and became LANL. Following World War II, LANL activities continued to focus on nuclear defense and related research and development, but gradually expanded to include nuclear energy and other high-technology civilian research and development, and over time grew to serve other government and civilian programs.

This chapter provides an overview of LANL's activities, both direct-funded (section 2.1.1) and support activities (section 2.1.2). It includes a discussion of responsibilities associated with operational safety at LANL (section 2.1.3). It also provides a description of LANL's technical areas (TAs) (section 2.2.1), the 15 facilities that were identified as key facilities for purposes of the SWEIS (section 2.2.2), and identification of nuclear and moderate hazard non-key facilities (section 2.2.3). Sections 2.3 and 2.4 discuss the role of the University of California (UC) at LANL and recent LANL funding levels, respectively.

2.1 OVERVIEW OF LANL ACTIVITIES

The mission assignments and programs at LANL are discussed in chapter 1. However, the essence of operations at LANL lies in its various research and development and some fabrication activities, as well as the support activities. These serve as the foundation upon which new assignments and tasks build and rely. These activities are described in this section.

LANL is funded primarily to use its capabilities in undertaking a broad range of theoretical and experimental research and development, as well as several production activities, for DOE and other federal agencies (these are referred to as direct-funded activities). Various support activities throughout LANL are essential to these undertakings.

Research and development activities are dynamic by their very nature, with the norm being continual change within the limits of facility capabilities, authorizations, and operating procedures. This section describes the direct-funded activities at LANL in three (overlapping) major areas:

- Theory, modeling, analysis, and computation (section 2.1.1.1)

- Experimental science and engineering (section 2.1.1.2)
- Advanced and nuclear materials research, development, and applications (section 2.1.1.3)

In addition, this section describes the support services needed to operate the site, such as site-wide management activities and ecological and natural resource management.

2.1.1 Categories of Direct-Funded Activities

The operations of LANL are diverse and dispersed throughout the large government reservation. A general description of the types of direct-funded activities undertaken at LANL can be summarized as follows.

2.1.1.1 *Theory, Modeling, and High Performance Computing*

This class of research and development includes theoretical activities that are primarily directed toward model development, analysis, and assessment. Individual research activities integrate basic theory and experimental data across multiple disciplines into realistic analytical and simulation models; analyze and validate the models through comparison with experiments (including dynamic and hydrodynamic tests) and other expert information; or integrate the models into computer programs for the assessment of complex systems. Examples of such complex systems include weapons performance and surety, energy systems, military systems, transportation, atmosphere and ocean environments, manufacturing and materials processes, nuclear facility performance and safety, and health system analysis. Another aspect of LANL activities of this type is fundamental theory in areas such as nuclear and particle physics, astrophysics, biology, plasma and beam physics, and materials.

Theory, modeling, and high-performance computing combines fundamental theory and numerical solution methods with high-performance computing to model a broad range of physical, chemical, and biological processes.

The operations supporting theory, modeling, and high-performance computing present risks similar to those of commercial or university administrative and research facilities; these are typically risks of industrial accidents/incidents.

2.1.1.2 *Experimental Science and Engineering*

Experimental science and engineering undertaken at LANL ranges from small-scale laboratory experimental activities and testing to the operation of one-of-a-kind facilities for measurements with radioactive, explosive, and hazardous materials and processes.

Experiments are conducted in nuclear and particle physics, astrophysics, chemistry, atomic and plasma physics, accelerator technology, hydrodynamics, laser science, and beam physics, as well as a wide range of technology applications of neutron scattering, transmutation technologies, plasma processing, radiography, microlithography, inertial fusion, and Earth and environmental sciences. The capability includes integrating theory and modeling with measurements from experiments that are made using a wide variety of instruments and techniques over a range of physical conditions.

These activities often utilize energy sources such as accelerators, high-powered lasers, high explosives, and pulsed-power systems. For example, Atlas and Pegasus-II provide pulse power for initiating hydrodynamic and other experiments and are located at TA–35, as is the Trident laser. (Atlas was analyzed in a project-specific appendix to the *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (SSM PEIS)

[DOE 1996a, Appendix K]). Many smaller lasers and pulsed-power devices are used throughout LANL. Analysis related to these types of experiments is conducted at several locations throughout LANL and supports further theoretical development.

The hazards associated with experimental science and engineering work are primarily due to the presence of energy sources, such as lasers, explosives, accelerator beams, and electricity. These energy sources pose the risk of injury or death to workers; however, they pose minimal risk to the public because the public does not have access to the energy sources. Other risks associated with this type of work are similar to industrial, administrative, and research work and could result in accidents/incidents. Specific experiments that use radioactive or other hazardous materials also involve risk to workers and to the public associated with exposure to such materials. (Public risk is associated with the radioactive and hazardous contents of effluents and emissions.)

A similar energy source at LANL is a very high powered radiofrequency source called the "Antenna Test and Calibration Range," which is an outdoor test range at TA–49. As with lasers and other energy sources, the primary hazards associated with this type of work are due to the energy sources (which pose a risk to workers) and other hazards typical of industrial, administrative, and research work that could result in accidents/incidents. Specific experiments that use radioactive or other hazardous materials also involve risk to workers and to the public associated with exposure to such materials.

2.1.1.3 *Advanced and Nuclear Materials Research, Development, and Applications*

These activities include those which are theoretical and experimental in nature, but because they are often focused on hazardous and nuclear materials, may require unique facilities and equipment.

Advanced materials include energetic materials (such as high explosives and detonators), hazardous materials (such as beryllium and toxic organics), and structural materials (such as high load-bearing metals and metal alloys, intermetallic compounds, ceramics, and certain organics such as plastics and polymers). Nuclear materials include highly enriched uranium, tritium, and transuranics (including plutonium). These materials are used both in weapons and nonweapons research, development, and applications.

Activities under this category include research regarding the nature of materials, for example:

- Physical and chemical behavior in a variety of environments
- Development of technologies for handling and processing hazardous and nuclear materials
- Development of fabrication technologies
- Development of measurement and evaluation technologies

In addition, the activities in this area include casting, forging, extruding, drawing, forming, and machining materials, including metals, ceramics, polymers, and electronic materials of many types in both bulk and thin film forms into complex shapes over a range of sizes. Applications include: complex electronic materials development and characterization; development and use of thin films, coatings, and membranes; and fabrication of components for nuclear weapons (e.g., for primaries, gas reservoirs, and secondaries) or mock-ups of such components and parts for research on the behavior of materials.

The hazards associated with this type of work are those associated with energy sources (as discussed in section 2.1.1.2 above), industrial accidents/incidents, exposure to hazardous materials, and exposure to radioactive materials. While all of these hazards could affect workers, hazardous and radioactive constituents in emissions and effluents, and radiation exposures associated with the handling of nuclear materials also have the potential to affect the public and the environment.

2.1.2 Supporting Activities

As with the research and development activities across LANL, many of the support activities and infrastructure of LANL have varied within a range of activities. Such activities are expected to continue with similar variance under all of the SWEIS alternatives. In addition, renovations and some increased power, water, and natural gas supplies will be required regardless of which alternative is chosen.

These supporting activities, which are not expected to change among the alternatives, are:

- Most aspects of site-wide waste management
- Infrastructure and central services
- Facility maintenance and refurbishment
- Environmental, ecological, cultural, and natural resource management; and environmental restoration, including decontamination and decommissioning

These activities are crucial to LANL's capabilities in supporting its assigned missions. However, these activities present minimal risk to the public and the environment, and the risks posed to workers are similar to those in any research laboratory (the site-wide consequence analyses do include the contribution of these operations). These activities are described below.

2.1.2.1 *Waste Management*

Waste treatment, storage, and disposal, although not the primary business at LANL, are central to all facilities and TAs within LANL. Sewage wastes and industrial solid (nonhazardous under the *Resource Conservation and Recovery Act* [RCRA]) wastes at LANL are managed similarly to commercial and municipal practices for these wastes throughout northern New Mexico (including use of sewage treatment plants and landfills). These are discussed in section 4.9.3 and are not elaborated upon further here. Radioactive and chemical wastes that result from LANL operations receive treatment in accordance with regulatory requirements and are stored for off-site disposal or are disposed of in designated sites at LANL.

DOE directed the preparation of waste management strategies for treatment, storage, and disposal of LANL-generated radioactive and hazardous chemical waste (*Waste Management Strategies for LANL,* LANL 1998b). The current strategy at LANL is characterized by utilization of existing on-site capabilities and cost-effective treatment and disposal. In addition, DOE also considered two other strategies: minimizing the on-site treatment and disposal and maximizing the on-site treatment and disposal. In *Waste Management Strategies for LANL,* these three strategies are applied (to the extent practicable) to each radioactive and chemical waste type generated at LANL for the volumes of waste projected under each SWEIS alternative. Additionally, each waste type is subdivided into treatability groups (groupings of waste types that would undergo similar treatment and disposal activities). Specific plans for treatment and disposal of LANL-generated waste are presented in *Waste Management Strategies for LANL* for each waste type by treatability group (LANL 1998b).

Only the current strategy is carried through the SWEIS alternative descriptions and analyses, for all waste types across the alternatives. An examination of the changes caused by employing these different strategies did not reveal any deciding factors that would cause a change in the current strategy for most waste streams. Low-level radioactive mixed waste (LLMW) (which is a mixture of hazardous and low-level radioactive waste [LLW]) is primarily shipped off the site for treatment and disposal, with minimal on-site treatment. LANL is a minor user of these off-site facilities, and no capacity constraints have been noted. A change in this strategy would require the development of on-site treatment and disposal capability, which is not currently envisioned. Should conditions change such that a specific proposal might become viable in the future (such as a substantial change in waste volume [e.g., if LANL were chosen as a regional disposal site for LLMW disposal, as discussed in chapter 1, section 1.5.1] or type), an analysis would be done at that time. Transuranic (TRU) waste is treated on site and stored pending shipment to the Waste Isolation Pilot Plant (WIPP), consistent with recent DOE decisions (discussed in SWEIS sections 1.5.1 and 1.5.3). LLW is the only waste type where more than one viable strategy exists, and those options are evaluated in this document. The limited disposal space remaining in Area G, and the potential effects of the Waste Management Programmatic Environmental Impact Statement (WM PEIS) Record of Decision (ROD), causes DOE to evaluate the effects of expanding Area G or pursuing a strategy of shipping LLW off the site. The differences in these strategies are reflected in the differences between the alternatives (Expanded Operations is the only alternative that includes expansion of Area G). The project-specific siting and construction (PSSC) analysis for the expansion of Area G in volume II of this document reflects siting and construction alternatives for on-site disposal of LLW.

The principal radioactive and hazardous chemical waste management facilities at LANL are located at TA–50 and TA–54. A wide variety of waste types are managed at these facilities, and these wastes are generated in gaseous, liquid, and solid forms throughout LANL. These include administratively controlled industrial solid wastes, toxic wastes, hazardous wastes, LLW, TRU wastes, and mixtures of the above (e.g., radioactively contaminated asbestos, which is a toxic radioactive waste). The management of these wastes requires many different activities, including waste minimization, waste characterization, volume reduction, and waste treatment, storage, and disposal operations. Detailed analyses of the waste management operations across the SWEIS alternatives are focused on those activities conducted at TA–50 and TA–54. All other waste management activities (outside of those performed in these two facilities) are not expected to change among alternatives.

Pollution prevention programs are common to all alternatives as well. These programs have been successful in reducing overall LANL wastes requiring disposal by 30 percent over the last 5 years. These programs are site wide but have facility-specific components, especially for the larger generators of radioactive and hazardous chemical wastes. Waste projections developed by alternative reflect only demonstrated waste minimization and pollution prevention improvements. Past reductions, however, indicate that this is a conservative assumption and that actual waste generated in the future should be less than that projected. The *Site Pollution Prevention Plan for Los Alamos National Laboratory* (LANL 1997a) describes the LANL Pollution Prevention and Waste Minimization Programs, as well as general program descriptions, recently implemented actions, specific volume reductions due to recent actions, and current development/demonstration efforts that have not yet been implemented.

The DOE Stockpile Management Process Development Program also plays an important role in pollution prevention. This program assures the improvement of current production processes for regulatory compliance and efficiency and the development of processes expected to be used for future production.

Numerous initiatives have been and are currently being funded through this program, which will minimize the waste being generated from production activities. Additional initiatives are anticipated in the upcoming years, which will result in avoidance of TRU and mixed TRU waste at the point of generation. Process Development Program tasks associated with waste minimization include electrorefining and molten salt extraction processing, glovebox decontamination, supercritical carbon dioxide cleaning development, chloride solvent extraction, enhanced waste immobilization, nitric acid recycle and nitrate destruction, density measurement technology, in-line TRU waste assay and packaging, plutonium machining development, reusable coated metal molds for casting, and plutonium die casting.

As with the pollution prevention program, the SWEIS waste projections only take credit for demonstrated technologies; actual waste generation should continue to be reduced due to this program. A description of the major stockpile management waste reduction initiatives is included in the *Waste Minimization Activities for Pit Production at LANL* (LANL 1996a).

2.1.2.2 *Infrastructure and Central Services*

LANL has 2,043 structures containing 7.9 million square feet (734,700 square meters), of which 1,835 are buildings, totaling 7.3 million square feet (678,900 square meters). The other structures consist of such items as meteorological towers, pumphouses, water towers, manhole covers, and small storage sheds. According to LANL's Fiscal Year (FY) 1997–2002 Institutional Plan (LANL 1996b), administration occupies 25 percent of LANL space, and storage and services (including power facilities) occupy approximately 20 percent (Figure 2.1.2.2–1). In other words, central services and infrastructure use almost half of LANL's facilities and space. These activities include:

- *Administrative/Technical Services*—Facilities used for support functions that include the Director's Office; Business; Human Resources; Facilities, Security and Safeguards; Environment, Safety, and Health; and communications.
- *Public/Corporate Interface*—Facilities, both restricted and unrestricted, that allow public and corporate access and use, including such facilities as the Oppenheimer Study Center, Bradbury Museum, and special research centers.
- *Physical Support and Infrastructure*—Facilities used for physical support of other laboratory facilities. These include warehouses, general storage, utilities, and wastewater treatment.

The natural gas and electric power needs at LANL are interdependent and are presented in this SWEIS by alternative. Options to meet the increased capacity, as well as reliability needs, are being studied and involve multiple organizations and communities in the area. Beyond simple maintenance and replacement as needed for components of these systems, a project-specific NEPA review will be conducted when sufficient definition for the specific options to meet projected needs has been developed.

While demand for water and electricity differs among alternatives, there are no changes proposed in this SWEIS with respect to DOE operations to provide and distribute these resources at LANL. Thus, these operations do not change across the alternatives analyzed and are included in all alternatives.

2.1.2.3 *Maintenance and Refurbishment*

LANL facilities have an estimated replacement cost of $4.2 billion, which includes buildings,

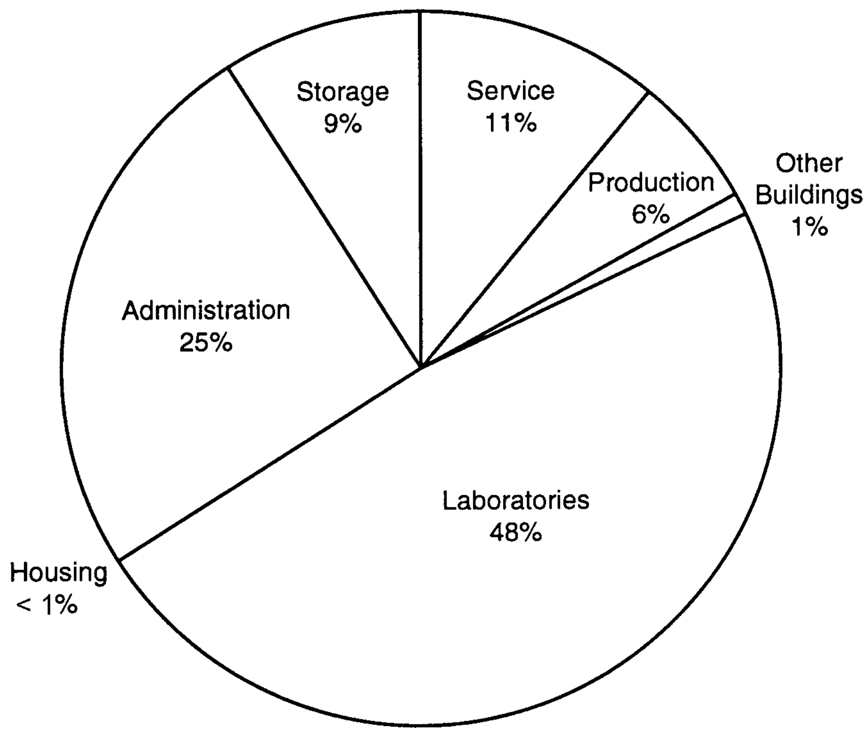


FIGURE 2.1.2.2–1.—*Gross Space Utilization by Function.*

infrastructure, and capital equipment. Many of the facilities at LANL are essential for DOE to meet mission requirements.

Many of the existing LANL facilities and equipment are approaching, or have already exceeded, their design life. Thus, the activities and cost to maintain these facilities and upgrade them to current standards are increasing. Currently, approximately 30 percent of laboratory facilities are more than 40 years old, with close to 80 percent of LANL facilities more than 20 years old. The 20-year design life of a facility is considered the standard age at which facility maintenance and operating costs significantly increase.

Many of these facilities are or soon will be one-of-a-kind in the consolidated DOE complex. Thus, their continued availability is essential for DOE to meet its mission requirements. Examples of the routine maintenance and refurbishment activities necessary to accomplish this and that are now underway or planned for each of the alternatives include:

- Maintaining and extending on-site roads and parking areas
- Replacing apparatus and components such as pumps and filters to retain and improve the performance and extend the usefulness of buildings and equipment
- Cleaning, painting, repairing, and servicing buildings, utility lines, and equipment
- Routine decontamination of equipment and facilities
- Erecting, operating, and demolishing support structures
- Relocating and consolidating equipment and operations from one building or area to another where similar activities are being performed
- Placing facilities in a safe shut-down condition when they will not be used for some time, if ever

DOE and LANL have the responsibility to upgrade buildings and equipment in order to protect the health, safety, and comfort of the operating personnel, the general public, and the environment (as discussed in section 2.1.3). Although these upgrades are often made in response to changed regulations, they are also made as proactive changes to prevent deterioration. These activities generally do not individually or collectively have significant impacts to the environment. These are accomplished within the organized framework of the laboratory support organization, including the waste management system. Typically, these upgrades are made in and around existing buildings, in developed areas, and along existing roadways. Examples of upgrades to enhance health, safety, and environmental protection include:

- Installing and maintaining high efficiency particulate air (HEPA) filters in work enclosures and building air exhaust systems
- Installing detection and emergency equipment such as radiation monitors, wash stations, and alarms
- Removing hazardous, toxic, and radioactive materials from buildings and areas to protect worker health and the environment
- Regrading, contouring, and revegetating disturbed areas
- Cutting and clearing fire protection buffers around facilities

Some of the typical maintenance and refurbishment projects at LANL are specific to the protection of the facilities, equipment, information, and materials located at LANL. There are specific upgrades being undertaken at LANL facilities to ensure compliance with safeguards and security requirements of DOE. Typically, these include replacement of equipment with similar items, upgrades to remove obsolete equipment, and upgrades to incorporate state-of-the-art technology. Those upgrades that are common to all SWEIS alternatives are those that need to be implemented in order to maintain the viability of existing facilities and ensure the availability of existing capabilities. Upgrades required for all alternatives for continued operations include:

- New security host systems (computer and software) including replacing some communications systems
- Replacement of sensors in Perimeter Intrusion Detection and Alarm Systems
- Installation of required alarms and access control panels

2.1.2.4 *Environmental, Ecological, and Natural Resources Management Activities*

DOE is responsible for the natural resources at LANL as a Natural Resources Trustee (DOE 1996d). In order to fulfill this responsibility, DOE and UC, as the DOE management and operating contractor for LANL, are implementing a Natural Resources Management Program integrating the ongoing natural resources management activities at LANL, which include:

- *Biological Management*—Includes research and characterization of biological resources (e.g., nongame and game species, wetlands and vegetation), habitat stabilization and renovation as necessary, and wildlife management.
- *Forest Management*—Addresses wildfire prevention, forest condition assessment, forest maintenance (including thinning and controlled burns), and firewood sales.
- *Threatened and Endangered Species Habitat Management*—Implements DOE responsibilities under the requirements of the *Endangered Species Act*, including species surveys and monitoring, habitat characterization and delineation, and implementation of project-specific mitigation and management measures, as needed.

- *Groundwater Protection*—Activities emphasize monitoring and characterization of groundwater resources, including the installation and maintenance of wells throughout LANL, sampling, analysis and characterization of quantities and qualities of groundwaters.
- *Watershed Management*—Activities include installation and maintenance of surface water monitoring stations, routine sampling and characterization, and surface water drainage stabilization and maintenance.
- *Air Quality Management*—Activities include installation of equipment and monitoring of stack emissions, ambient air quality monitoring stations, and air quality sample collection and analysis.

Results of these ongoing programs are reported in the LANL annual surveillance reports and other LANL documents. In addition, there are numerous small-scale research and development activities seeking to quantify the transport, fate, and effects of contaminants from historical LANL operations on environmental media and biological receptors. Some of these research and development activities are associated with the LANL Environmental Restoration Project.

Natural resources management activities are included in the site-wide analysis contained in all alternatives. These efforts are generally nonintrusive monitoring and surveillance activities that result in little disturbance to the environment. Construction activities for new wells or sampling stations undergo NEPA review as they are identified and proposed for development.

2.1.2.5 *Environmental Restoration*

Areas of known or suspected contamination resulting from past operations (i.e., legacy contamination) are being addressed by the Environmental Restoration (ER) Project. The ER Project at LANL was established by DOE in 1989 to assess and remediate potentially contaminated sites that either were or still are under LANL control. In 1996, the DOE Office of Environmental Management (EM) initiated a complex-wide strategy to accelerate site cleanup and enhance performance of the cleanup program. The national strategy focuses in particular on completing as much work as possible by the end of fiscal year 2006. Known as *Accelerating Cleanup: Paths to Closure* Report (DOE 1998b) (previously known as "2006 Plan"), it includes input from all major field sites, including LANL, to support EM's program planning process.

The ER Project is ongoing and its implementation is unaffected by the changes examined in the four alternatives in the SWEIS. The ER Project is included in all alternatives.

The primary objectives of LANL's ER Project are: (1) to protect human health and the environment from exposure to releases of wastes; (2) to meet the environmental cleanup requirements of the Hazardous and Solid Waste Amendments Module VIII of LANL's permit to operate under RCRA; (3) to conduct closure of historical treatment, storage, and disposal facilities; and (4) to decommission contaminated facilities considered to be surplus.

The ER Project provides formal and informal mechanisms through which stakeholders can participate in this corrective action process. NEPA review of corrective actions is performed as soon as enough information is available to make a meaningful determination on the appropriate level of review or analysis. These analyses, in combination with the remediation plans, are available to the public for review.

About 2,120 potential release sites (PRSs) have been identified at LANL by the ER Project. These sites are a combination of potential solid waste management units identified in the RCRA permit for LANL and potentially contaminated sites called "areas of concern," which may contain hazardous substances, such as radionuclides, that are not regulated under RCRA. As of September 1997, 1,370 of these sites had been identified as requiring no further action based on human health concerns; these sites will be reviewed in the future for ecological concerns. Included in these ecological concerns are threatened and endangered species.

The *Accelerating Cleanup: Paths to Closure* document (DOE 1998b) includes a schedule for the cleanup of the remaining approximately 700 to 750 sites. This schedule encompasses a period of 10 years, beginning with fiscal year 1998 and ending in fiscal year 2008. The number of cleanups per year varies from approximately 18 in fiscal year 2008 to 100 in fiscal year 2002. An important and integral part of the cleanup methodology and the need for any interim protection measures is ecological risk, which, again, includes threatened and endangered species. The location of threatened and endangered species, their habitat, or potential habitat in relation to these sites is an integral part of the site cleanup prioritization process.

Prior to 1994, the PRSs were organized into 24 operable units (OUs), for which RCRA Facility Investigation (RFI) work plans were written. In an effort to streamline the characterization and remediation process at LANL, the OUs were grouped into five field units (FUs). A sixth FU includes all of the Decommissioning Project areas. Geographic locations of the OUs are shown on Figure 2.1.2.5–1. While OUs are no longer used, they have been used in the recent past and in some of the documents used as references in the SWEIS. Table 2.1.2.5–1 presents the relationships between FUs, OUs, and TAs and the waste types that could be generated during characterization and remediation activities (note that Figure 2.2.1–1 reflects the locations of the TAs at LANL). Projection of waste types and quantities anticipated from remediation activities at the LANL PRSs over the lifetime of the ER Project (approximately the next 10 years) are included in the total waste projections for each of the SWEIS alternatives.

The LANL PRSs are diverse and include past material disposal areas (landfills), canyons, drain lines, firing sites, outfalls, and other random sites such as spill locations. The primary mechanisms for contaminant release from the ER sites are surface-water runoff carrying potentially contaminated sediments and soil erosion exposing buried contaminants. The main pathways by which released contaminants can reach off-site residents are through infiltration into alluvial aquifers, airborne dispersion of particulate matter, and sediment migration from surface-water runoff. The contaminants involved include volatile and semivolatile organics, polychlorinated biphenyls (PCBs), asbestos, pesticides, herbicides, heavy metals, beryllium, radionuclides, petroleum products, and high explosives.

Since 1990, LANL's ER Project has conducted over 100 cleanups. The ER Project has also decommissioned over 30 structures and conducted three RCRA closure actions during this period. Some major decommissioning activities are listed in Table 2.1.2.5–2. During these actions, no significant worker health and safety occurrences or environmental reportable incidents (contaminant releases) were reported.

DOE provides for surveillance, maintenance, decontamination, and decommissioning services for LANL's contaminated surplus or abandoned facilities following DOE guidelines and applicable regulations. The project's goal is to ensure that future programmatic uses of remaining facilities or surrounding areas are permitted without restriction. Major decontamination and decommissioning activities scheduled for completion in the next 10 years are shown in Table 2.1.2.5–3.

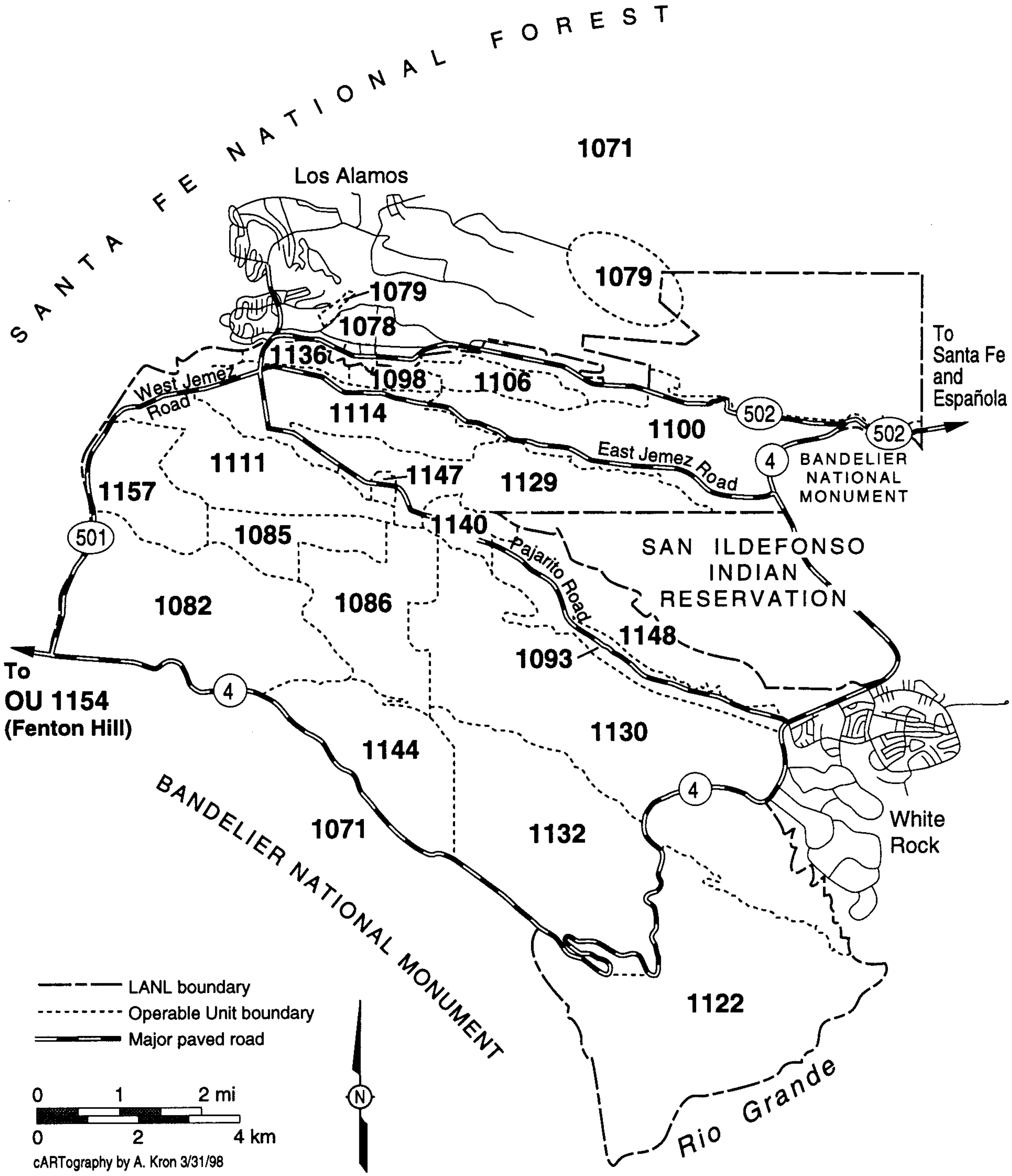


FIGURE 2.1.2.5–1.—*Geographic Locations of the Operable Units.*

TABLE 2.1.2.5–1.—*Summary of Environmental Restoration Project Field Units, Technical Areas, Operable Units, Potential Contaminants, and Waste Types Generated During Characterization/Remediation*

ER FIELD UNIT	LOCATION (TECHNICAL AREAS AND OPERABLE UNITS)	ENVIRONMENTAL RESTORATION SITES	CONTAMINANTS OF CONCERN	WASTE TYPES TO BE GENERATED DURING CHARACTERIZATION REMEDIATION
1	*TAs* 0, 1, 3, 10, 19, 21, 26, 30, 31, 32, 43, 45, 59, 60, 61, 64, 73, and 74 *OUs* 1071, 1078, 1079, 1106, 1114, and 1136	Consist of 664 potential release sites at Los Alamos townsite, old plutonium processing facility, municipal sanitary landfill, and historic land areas	High explosives, volatile and semivolatile organics, PCBs, asbestos, pesticides, heavy metals, radionuclides, and petroleum products	RCRA organics, RCRA metals, LLW, PCBs, industrial, sanitary, LLMW
2	*TAs* 12, 14, 15, 18, 20, 27, 36, 39, 53, 65, 67, 68, 71, and 72 *OUs* 1085, 1086, 1093, 1100, 1130, and 1132	Consist of 301 potential release sites all within DOE-controlled land at active/inactive firing sites, nuclear criticality research facility, and 0.5-mile (0.8-kilometer) long linear proton accelerator	Radionuclides, high explosives, organics, and heavy metals	RCRA organics, RCRA metals, LLW, LLMW
3	*TAs* 11, 13, 16, 24, 25, 28, 33, 37, 46, and 70 *OUs* 1082, 1122, and 1140	Consist of 555 potential release sites all within DOE-controlled land used for development and processing of high explosives and reactor components	High explosives, volatile and semivolatile organics, PCBs, asbestos, pesticides, herbicides, and radionuclides	RCRA organics, RCRA metals, LLW, PCBs, industrial, LLMW
4	*TAs* 2, 4, 5, 35, 41, 42, 48, 52, 55, 63, 66, and Canyons *OUs* 1049, 1098, and 1129	Consist of 260 potential release sites including 110 miles (177 kilometers) of canyon systems, reactor site, and other sites within DOE-controlled land	Radionuclides, high explosives, volatile and semivolatile organic compounds, and inorganics including heavy metals	RCRA organics, RCRA metals, LLW, LLMW
5	*TAs* 6, 7, 8, 9, 22, 23, 40, 49, 50, 51, 54, 57, 58, 62, and 69 *OUs* 1111, 1144, 1147, 1148, 1154, and 1157	Consist of 313 potential release sites including explosives development areas, major waste management areas, and the Fenton Hill geothermal site in the Jemez Mountains	Radionuclides, high explosives, volatile organic compounds, and metals	RCRA organics, RCRA metals, LLW, industrial, sanitary, asbestos, LLMW, TRU, mixed TRU
6	All TAs where surplus facilities are located	Facilities considered excess or surplus including the TA–35 Phase Separator Pit, TA–21 DP West Site, TA–33 Tritium Facility, TA–16 High Explosives Areas	Tritium, low-level radionuclides, asbestos, heavy metals, acids, volatile and semivolatile organics, high explosives	RCRA organics, RCRA metals, LLW, asbestos, LLMW, TRU, high explosives, mixed TRU

TABLE 2.1.2.5–2.—*Major Decommissioning Activities Completed to Date at LANL*

LOCATION	DECOMMISSIONING ACTIVITY	YEAR
TA–33–21	Disposition of a plutonium-contaminated experimental facility	1975
TA–21–12	Demolition of a plutonium filter facility	1975
TA–21–153	Decommissioning of an actinium-contaminated filter building	1981
TA–35	Decommissioning of the Los Alamos Molten Plutonium Reactor Experiment (LAMPRE I)	1981
TA–35	Decommissioning of a titanium-contaminated laboratory	1981
TA–35–7	Removal of contaminated air scrubbers	1981
TA–42	Decommissioning of a plutonium-contaminated incinerator facility	1981
TA–21	Decontamination of plutonium facility at DP West	1982
TA–3 to TA–50	Removal of radioactive liquid waste lines parallel Diamond Drive and Pajarito Road	1986
TA–2	Decommissioning of the water boiler reactor	1991
TA–52	Decommissioning of a reactor facility	1991
TA–35	Decommissioning of the Los Alamos Power Reactor Experiment (LAPRE II)	1991
TA– 35	Phase separator pit	1997

TABLE 2.1.2.5–3.—*Future Decommissioning Activities at LANL*

LOCATION	DECOMMISSIONING ACTIVITY	COMPLETION YEAR
TA–16	Certain high explosives areas at S-Site	2007
TA–21	Decommissioning of TA–21, DP West Site	2004
TA–33	Building 86, Tritium Facility	1999

2.1.3 Responsibilities for Safe Operations at LANL

This section describes the responsibilities for the safe operation of LANL, with a focus on nuclear facilities, as well as the policies and procedures in place to establish an understanding of the hazards and risks associated with these operations; to control operations such that workers, the public, and the environment are protected; and to improve safety performance and reduce the risks associated with the operation of LANL. This section provides an overview of these topics; other documents are cited that provide more comprehensive discussions.

DOE performs much of its work through its contractors. Therefore, the day-to-day responsibility for safe operation of nuclear facilities has also been delegated to contractors (e.g., UC at LANL). Through this delegation, the responsibility becomes shared but not relinquished by DOE. DOE line managers are responsible for assuring the safety of operations assigned to them, and this responsibility is delegated in part to contractors through formally established policies, programs, and processes.

There are numerous processes and levels of oversight for operations in existing nuclear facilities, for upgrades or changes to operations in existing nuclear facilities, and for start/restart of operations in existing or new nuclear facilities. All operations in DOE nuclear facilities are conducted only with authorization by DOE to operate. The form of DOE authorization is determined based on the hazard of the operations in the facility (including types and amounts of nuclear materials) and the evaluated risk of operating the facility. These evaluations may be in the form of a safety analysis report, a safety evaluation report, a Basis for Interim Operation, or other analysis or assessment document. (These are established in DOE Order 5480.22, *Technical Safety Requirements*, and DOE Order 5480.23, *Nuclear Safety Analysis Reports*.)

Contractor line management must operate nuclear facilities in accordance with the authorized DOE safety basis. LANL also operates within a standards-based Integrated Safety Management System (currently being implemented at DOE sites, including LANL) approved by DOE and contractually binding on UC for LANL operations. This system integrates the concept of "doing work safely" by institutionalizing the planning and execution of activities with the controls necessary to ensure that environment, safety, and health objectives are achieved. The contractor has a continuing obligation under the Integrated Safety Management System, and delegated line management safety responsibility, to self-assess and self-identify safety aspects of the work process and to address potential safety concerns with existing operations. Contractor line management must continually be confident that all operations being conducted are within acceptable safety risk (as agreed to by DOE), and may take independent action to partially or completely stop operations. At any time, the contractor, either at the management level or at the worker level, may cease operations for safety (or for any other relevant concern), and review internal processes and procedures, revise them as necessary, and restart operations when corrective actions are satisfactorily completed. At times, LANL has implemented this proactive approach by temporarily suspending operations to update training, or emphasize aspects of the safety basis for operations. This has been done recently in TA–55 (in 1994) and in the Chemistry and Metallurgy Research (CMR) Building at TA–3 (1997). DOE and LANL have also temporarily suspended operations to upgrade equipment or systems to meet current standards or to improve safety performance with state-of-the-art equipment (e.g., upgrades to fire suppression systems or replacement of outdated electrical systems); these types of upgrades happen frequently and are within the realm of maintenance and refurbishment, as described in section 2.1.2.3.

At times, it is possible that the DOE understanding of the risks associated with facility operations can change substantially. This could result, for example, from a different understanding of the hazards or from new information on health effects (e.g., a new determination that a material could threaten human health in ways not previously understood, identification of seismic risks that were not previously known, or identification of potential “common cause” failures for safety systems and their backups that were not previously known). In such cases, DOE and the contractor examine the implications of this new understanding with respect to the authorization basis to determine whether operational changes, facility or equipment upgrades, or other actions are appropriate.

Changes or upgrades to operations in a nuclear facility, or identification by either DOE or the contractor of potential concerns or needed changes in the authorized safety basis, must also be reviewed under formal DOE processes. Some of these changes or issues can be addressed by the contractor, and some of these require DOE resolutions, in accordance with processes established in DOE Order 5480.21, *Unreviewed Safety Questions*. Changes or upgrades to a facility are also subject to NEPA review under 10 Code of Federal Regulations (CFR) 1021 and DOE Order 451.1A.

Formal start/restart processes are also established in DOE Order 425.1, *Start-up and Restart of Nuclear Facilities*. Criteria are established in this order for invoking the formal DOE process of starting or restarting a nuclear operation, including a formal and independent DOE readiness review process for demonstrating that a facility is safe to operate, and authorizing the start/restart.

2.1.3.1 *Defense Nuclear Facilities Safety Board*

In addition to the responsibilities of DOE and UC, the Defense Nuclear Facilities Safety Board (DNFSB) also has broad oversight responsibilities. Under its enabling statute amending the *Atomic Energy Act*, (Public Law [PL] 100-456) the DNFSB is directed to:

- Review and evaluate the content and implementation of the standards relating to the design, construction, operation, and decommissioning of defense nuclear facilities of the DOE and recommend to the Secretary of Energy those specific measures that should be adopted to ensure that public health and safety are adequately protected.
- Investigate any event or practice at a DOE defense nuclear facility which the DNFSB determines has adversely affected or may adversely affect public health and safety.
- Review the design and construction of new DOE defense nuclear facilities.
- Analyze facility design and operational data.
- Provide a meaningful opportunity for public participation in the recommendation process.

The DNFSB stays closely attuned to the planning and execution of DOE’s defense nuclear programs, gathering its information from a broad range of sources, including but not limited to on-site technical evaluations by the DNFSB and its staff, critical review of DOE safety analyses by technical experts, and public meetings at headquarters and in the field.

The DNFSB has issued a number of recommendations for action as a result of its reviews and evaluations of DOE’s defense nuclear activities at LANL. DOE has in the past and continues to work closely with the DNFSB and its staff to respond to these recommendations as one means of ensuring the public health and safety.

2.2 DESCRIPTION OF LANL FACILITIES

LANL is located in north-central New Mexico, 60 miles (97 kilometers) north-northeast of Albuquerque and 25 miles (40 kilometers) northwest of Santa Fe (see Figure 1.1–1 in chapter 1). LANL occupies approximately 43 square miles (111 square kilometers) of land owned by the U.S. Government and under the administrative control of DOE. Most of LANL is undeveloped to provide a buffer for security, safety, and expansion possibilities for future use.

Approximately half of LANL's square footage is considered laboratory or production space; the remaining square footage is considered administrative, storage, service, and other space (LANL 1998c). The use of LANL space by function is shown in Figure 2.1.2.2–1.

All facilities at LANL (including those proposed, under construction, pre-operational, operational, or idle; DOE owned or leased; temporary or permanent; occupied or unoccupied) have been categorized according to hazards inherent to their actual operations or planned use. LANL operations not directly associated with a facility have also been similarly categorized.

DOE has identified two major hazard categories determined by the type and quantity of radionuclide: those with a potential nuclear (radiation) hazard (called nuclear facilities) and those with nonnuclear hazard potential (called nonnuclear facilities). As part of its safety analysis process for nuclear facilities or operations, DOE performs a hazard analysis of its nuclear activities and categorizes the facilities or operations based on the inventory of radioactive materials and the potential for unmitigated or uncontrolled release of these materials.

Nuclear Facilities Hazards Classification (DOE Order 5480.23)

***Category 1 Hazard**: Hazard analysis shows the potential for significant off-site consequences.*

***Category 2 Hazard**: Hazard analysis shows the potential for significant on-site consequences.*

***Category 3 Hazard**: Hazard analysis shows the potential for only significant localized consequences.*

For nuclear facilities, a Category 1 hazard categorization is usually applied to nuclear reactors. A Category 2 hazard categorization has been applied to facilities with potential for nuclear criticality events or that contain significant quantities of special nuclear materials (SNMs) and energy sources that could pose a risk to workers, the public and the environment on the site. Category 3, indicating potential for only localized consequences, has been applied to facilities with small quantities of SNMs. There are no Category 1 hazards or operations at LANL.

Facilities that do not meet the criteria for nuclear facilities (as defined in DOE Order 5480.23), but that still contain some amount of radioactive

Special Nuclear Material

SNM is defined in the Atomic Energy Act to mean (a) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material that is designated as special nuclear material, or (b) any material artificially enriched by any of the foregoing.

Nonnuclear Facility Hazard Classification (DOE Order 5481.1B)

***High hazard**: Have potential for on-site or off-site impacts to large numbers of people or for major impacts to the environment.*

***Moderate hazard**: Present considerable potential for on-site impacts to people or the environment, but at most only minor off-site impacts.*

***Low hazard**: Present minor on-site and negligible off-site impacts to people or the environment.*

material are called radiological facilities. Radiological facilities may be categorized under the nonnuclear facility categories as low radioactive hazard (L/RAD) or moderate radioactive hazard (M/RAD).

The number of nuclear and radiological facilities by TA is provided in Table 2.2–1. The number of nonnuclear facilities that have moderate or low chemical hazard categorization (M/CHEM or L/CHEM), and those with energetic source hazard (L/ENS) are also listed. LANL has no high-hazard nonnuclear facilities.

2.2.1 Technical Areas

LANL is divided into 49 separate TAs (Figure 2.2.1–1) (the TAs are not numbered sequentially). These TAs compose the basic geographic configuration of LANL. TA–3 is located on South Mesa and is the main, or core, TA where approximately half of the personnel are located. TA–3 serves as the central technical, administrative, and physical support facility for LANL. One TA is remote from the main area; the Fenton Hill site, TA–57, is located approximately 20 miles (32 kilometers) west of LANL.

A brief description of each TA operated by LANL is presented in Table 2.2.1–1. Additional information is provided in the *Description of Technical Areas and Facilities at LANL* (LANL 1998c).

2.2.2 SWEIS Key Facilities

To facilitate a logical and comprehensive evaluation of the potential environmental impacts of the four alternatives for future operations of LANL, the SWEIS focuses on those facilities or operations that meet the following screening criteria. The facilities identified as key for the purposes of the SWEIS are those that house activities that are critical to meeting assignments given to LANL, and:

- House operations that have potential to cause significant environmental impacts, or
- Are of most interest or concern to the public based on scoping comments received, or
- Would be the most subject to change due to recent programmatic decisions

To identify the SWEIS key facilities, all LANL structures were evaluated. Of the over 2,000 numerically identified structures within the 43-square-mile (111-square-kilometer) area of LANL, most are used for offices, storage, or support functions. Buildings or facilities considered to have minimal environmental impact, such as office buildings, transportables, trailers, guard houses, and passageways were eliminated from detailed consideration as key facilities. DOE thus eliminated over 1,900 structures from identification as key facilities for the SWEIS. The remaining facilities or operations were evaluated based on operational emphasis, facility operations and capabilities, and physical location. Individual facilities or groups of facilities that are closely related were then evaluated against the criteria listed above.

Table 2.2.2–1 identifies the 15 key facilities. The locations of the key facilities are shown in Figure 2.2.2–1. Taken together, the key

TABLE 2.2–1.—*Number of Nuclear and Moderate/Low Hazard Facilities at LANL by Technical Area[a]*

TECHNICAL AREA	NUCLEAR FACILITIES		NONNUCLEAR FACILITIES				
	CATEGORY 2	CATEGORY 3	M/RAD	M/CHEM	L/RAD	L/ENS	L/CHEM
TA–0				4			
TA–2					4		
TA–3	2	4		1	4	1	8
TA–8	4					5	
TA–9						32	2
TA–11						4	
TA–14						7	
TA–15					4[b]	11	
TA–16	3			1		61	3
TA–18	4				5		
TA–21	2	1		2	4		2
TA–22						25	1
TA–28						5	
TA–33		1				3	
TA–35[c]		2		1	2	8	
TA–36					1	11	
TA–37						24	
TA–39					2	14	
TA–40						22	
TA–41			4		1		7
TA–43						1	2
TA–46				1	2	9	1
TA–48		1					
TA–49						3	
TA–50	2				1		
TA–53		1			21	5	
TA–54	19			1	1		17
TA–55	2[d]				1	7	2
TA–72				1		2	
TA–73				1			

M/ = moderate hazard, L/ = low hazard, RAD = radiological, ENS = energetic source, and CHEM = chemical.
[a] TAs without nuclear or moderate/low hazard facilities are not shown. LANL does not have any Category 1 nuclear facilities.
[b] Includes a facility not yet operational.
[c] In addition, TA–35 has one facility that is a low hazard environmental source facility, TA–35–85 (LANL 1998c), due to its mercury inventory.
[d] The Nuclear Materials Storage Facility is included, although it is not yet operational (discussed in section 2.2.2.1).

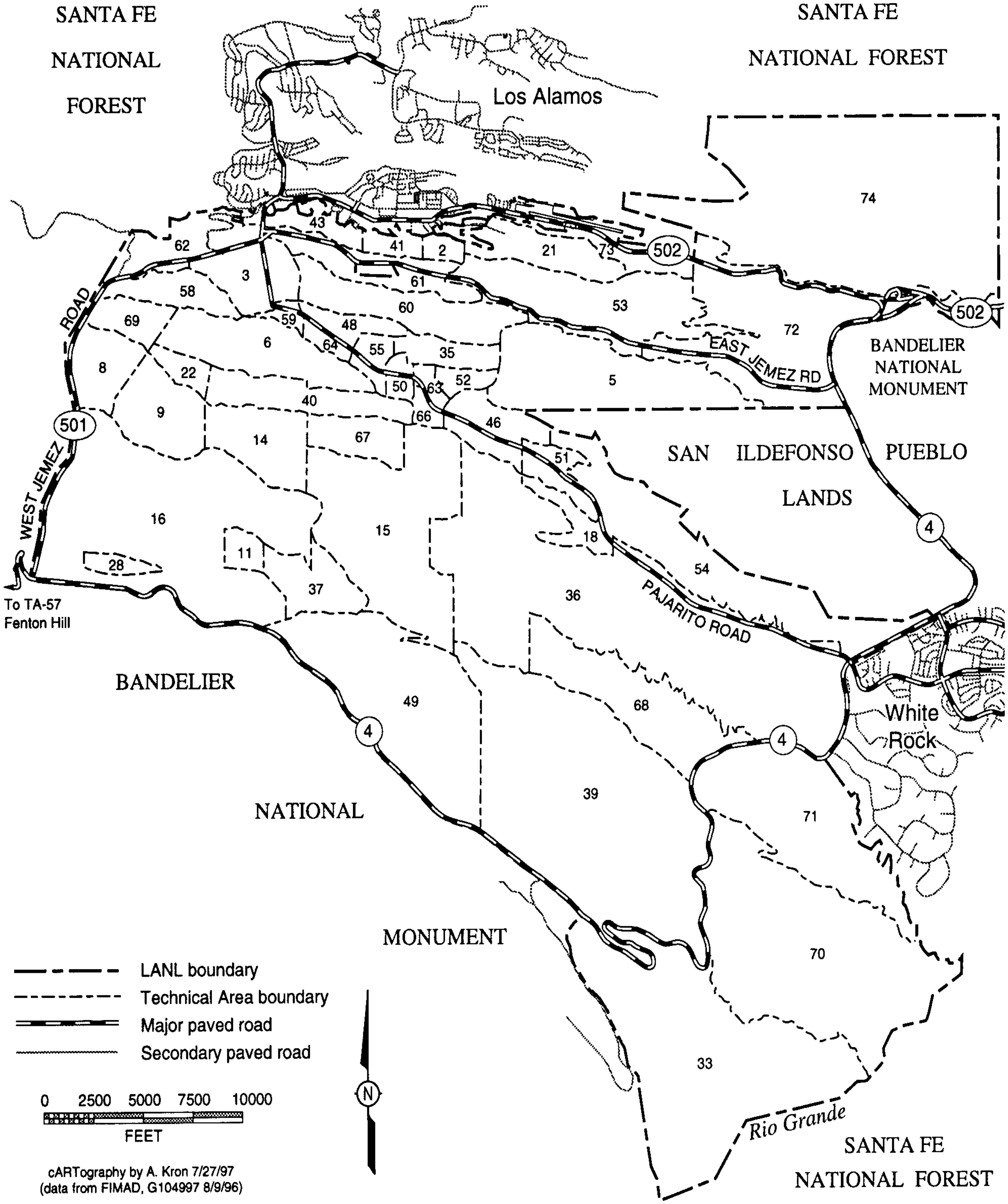


FIGURE 2.2.1–1.—*Technical Areas of Los Alamos National Laboratory.*

TABLE 2.2.1–1.—*Overview of Technical Areas and Their Associated Activities*

TECHNICAL AREA[a]	ACTIVITIES
TA–0	LANL has about 180,000 square feet (16,722 square meters) of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos townsite and White Rock. The Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos townsite.
TA–2 (Omega Site)	Omega West Reactor, an 8-MW nuclear research reactor, is located here. It was placed in a safe shutdown condition in 1993. It is currently being removed from the nuclear facilities list and will be transferred into the decontamination and decommissioning (D&D) program possibly during 1998. All fuel has been removed from this reactor.
TA–3 (Core Area)	The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in the main TA. TA–3 contains major facilities such as the CMR Building, the Sigma Complex, the Main Shops, and the Materials Science Laboratory (MSL). Other buildings house central computing facilities, chemistry and materials science laboratories, Earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA–3 contains about 50 percent of LANL's employees and floor space.
TA–5 (Beta Site)	This site contains some physical support facilities such as an electrical substation, test wells, and environmental monitoring and buffer areas.
TA–6 (Two-Mile Mesa Site)	This site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending decommissioning.
TA–8 (GT-Site [or Anchor Site West])	This is a dynamic testing site operated as a service facility for LANL. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x-ray machines with potentials up to 1 MeV and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
TA–9 (Anchor Site East)	At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.
TA–11 (K-Site)	These facilities are used for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.
TA–14 (Q-Site)	This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.
TA–15 (R-Site)	This site houses the Pulsed High-Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility, a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for dynamic experiments and hydrodynamic testing. It also is the site for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility (now under construction), whose major feature will be its intense high-resolution, dual-machine radiographic capability. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.
TA–16 (S-Site)	Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons components and subsystems. It is the site of the Weapons Engineering Tritium Facility (WETF) that focuses on research and applications using tritium. Development and testing of high explosives, plastics, and adhesives, and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TABLE 2.2.1–1.—*Overview of Technical Areas and Their Associated Activities*-Continued

TECHNICAL AREA[a]	ACTIVITIES
TA–18 (Pajarito Laboratory Site)	This is a nuclear facility that studies both static and dynamic behavior of multiplying assemblies of nuclear materials. SNMs are used to support a wide variety of activities for stockpile management, stockpile stewardship, emergency response, nonproliferation, safeguards, etc. In addition, this facility provides the capability to perform hands-on training and experiments with SNM in various configurations below critical.
TA–21 (DP-Site)	This site has two primary research areas: DP West and DP East. DP West has been in the D&D Program since 1992, and about half of the facility has been demolished. DP West continues to provide office space for ongoing functions. Some activities conducted at DP West, primarily in inorganic and biochemistry, are being relocated during 1997 and 1998, and the remainder of the site scheduled for D&D in future years. DP East is a tritium research site and includes the Tritium Science and Fabrication Facility (TSFF) and Tritium Systems Test Assembly (TSTA).
TA–22 (TD-Site)	This site is used in the development of special detonators to initiate high-explosives systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.
TA–28 (Magazine Area A)	This is an explosives storage area.
TA–33 (HP-Site)	The old, High-Pressure Tritium Laboratory Facility is being decommissioned. Tritium operations at this site were suspended in 1990, and the tritium inventory and operations were moved to WETF at TA–16. The National Radio Astronomy Observatory's Very Large Baseline Array Telescope is also located at this site.
TA–35 (Ten Site)	Activities include nuclear safeguards research and development that are concerned with techniques for nondestructive detection, and identification and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy density physics, metallurgy, ceramic technology, and chemical plating.
TA–36 (Kappa-Site)	This TA has four active firing sites that support explosives testing. Nonnuclear ordnance tests are conducted here, including tests of armor and armor-defeating mechanisms, as well as tests of shockwave effects on explosives and propellants. Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.
TA–37 (Magazine Area C)	This is an explosives storage area.
TA–39 (Ancho Canyon Site)	The behavior of nonnuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation-of-state measurements, and pulsed-power systems design.
TA–40 (DF-Site)	This site is used in the development of special detonators to initiate high-explosives systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.
TA–41 (W-Site)	Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.
TA–43 (Health Research Laboratory)	This site is adjacent to the Los Alamos Medical Center. Research performed at this site includes structural, molecular, and cellular radiobiology; biophysics; mammalian radiobiology; mammalian metabolism; biochemistry; and genetics. The DOE Los Alamos Area Office is also located within TA–43.
TA–46 (WA-Site)	Activities include applied photochemistry research such as the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater Systems Consolidation Project is located at the east end of this site.
TA–48 (Radiochemistry Site)	Research and development activities at this site include a wide range of chemical processes such as nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

TABLE 2.2.1–1.—*Overview of Technical Areas and Their Associated Activities*-Continued

TECHNICAL AREA[a]	ACTIVITIES
TA–49 (Frijoles Mesa Site)	This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosives and radioactive materials experiments. The Hazardous Devices Team Training Facility and the Antenna Test Range are located here. A helicopter pad used for wildfire response and storage for interagency wildfire response supplies are also located here.
TA–50 (Waste Management Site)	Activities include management of the industrial liquid and radioactive liquid waste received from various TAs. Activities also include development of improved methods for solid waste treatment and containment of radionuclides removed by treatment.
TA–51 (Environmental Research Site)	Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are studied at this site.
TA–52 (Reactor Development Site)	A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.
TA–53 (Los Alamos Neutron Science Center)	This site includes the Los Alamos Neutron Science Center (LANSCE), the LANSCE linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility. Also located at TA–53 are the Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator (LEDA), and research and development activities in accelerator technology and high-power microwaves.
TA–54 (Waste Disposal Site)	Activities consist of radioactive and hazardous solid waste management including storage, treatment, and disposal operations.
TA–55 (Plutonium Facility Site)	This facility provides research and applications in chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms, as well as research into material properties and fabrication of parts for research and stockpile applications. Additional activities include the means to safely and securely ship, receive, handle, and store nuclear materials, as well as manage the wastes and residues produced by TA–55 operations. The Nuclear Materials Storage Facility (NMSF) is located at this TA.
TA–57 (Fenton Hill Site)	This site is located about 20 miles (32 kilometers) west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains, and was the location of LANL's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. Because of the high elevation and remoteness of Fenton Hill, a gamma ray observatory is located at the site, and other astrophysics experiments are planned.
TA–58 (Two-Mile North Site)	This site is reserved for multi-use experimental sciences requiring close functional ties to activities currently located at TA–3.
TA–59 (Occupational Health Site)	Occupational health and safety and environmental activities are conducted at this site. Environmental, safety and health offices, and emergency management facilities are also located here.
TA–60 (Sigma Mesa)	This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.
TA–61 (East Jemez Road)	This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.
TA–62 (Northwest Site)	This site is reserved for multi-use experimental science, public and corporate interface, and environmental research and buffer zones.
TA–63 (Pajarito Service Area)	This site is a major growth area with environmental and waste management functions and facilities. This area contains physical support facilities operated by Johnson Controls, Inc.
TA–64 (Central Guard Site)	This is the site of the Central Guard Facility and headquarters for the Hazardous Materials Response Team.
TA–66 (Central Technical Support Site)	This site is used for industrial partnership activities.
TA–67 (Pajarito Mesa Site)	This area is a buffer zone, designated as a TA in 1989. No operations or facilities are currently located here.

TABLE 2.2.1–1.—*Overview of Technical Areas and Their Associated Activities*-Continued

TECHNICAL AREA[a]	ACTIVITIES
TA–68 (Water Canyon Site)	This is a dynamic testing area.
TA–69 (Anchor North Site)	This undeveloped TA serves as an environmental buffer for the dynamic testing area.
TA–70 (Rio Grande Site)	This undeveloped TA serves as an environmental buffer for the high-explosives test area.
TA–71 (Southeast Site)	This undeveloped TA serves as an environmental buffer for the high-explosives test area.
TA–72 (East Entry Site)	This is the site of the Protective Forces Training Facility (Live Firing Range).
TA–73 (Airport Site)	This area is the Los Alamos Airport. DOE owns the airport, and the County of Los Alamos manages, operates, and maintains it under a leasing arrangement with DOE. Use of the airport by private individuals is permitted with special restrictions.
TA–74 (Otowi Tract)	This large area, bordering the Pueblo of San Ildefonso on the east, is isolated from most of LANL. This site contains LANL water wells and future well fields.

[a] The concept of technical areas (TAs) was implemented during the first 5 years of LANL's existence; however, the early TA designations did not cover all land within the LANL boundary and, in the early 1980's, LANL's TA numbering system was revamped to provide complete coverage. Because all TAs received new numbers, a correlation between the historic system and the current system does not exist. In addition, in the current system, some numbers were reserved for future TAs. Sites that have been closed or abandoned were incorporated into adjacent TAs.

MW = Megawatt, MeV = million electron volts

TABLE 2.2.2–1.—*Identification of Key Facilities for Analysis of LANL Operations*

KEY FACILITY IDENTIFICATION	TECHNICAL AREA
Plutonium Facility Complex	TA–55
Tritium Facilities	TA–16 & TA–21
CMR Building	TA–3
Pajarito Site (including the Los Alamos Critical Experiments Facility [LACEF])	TA–18
Sigma Complex	TA–3
MSL	TA–3
Target Fabrication Facility	TA–35
Machine Shops	TA–3
High Explosive Processing Facilities	TA–8, TA–9, TA–11, TA–16, TA–28 & TA–37
High Explosive Testing Facilities	TA–14, TA–15, TA–36, TA–39, & TA–40
LANSCE	TA–53
Health Research Laboratory (HRL)	TA–43
Radiochemistry Laboratory	TA–48
Waste Management Operations: Radioactive Liquid Waste Treatment Facility	TA–50 & 21
Waste Management Operations: Solid Radioactive and Chemical Waste Facilities	TA–50 & TA–54

facilities represent the great majority of exposure risks associated with continuing operations at LANL because these facilities represent:

- Over 99 percent of all radiation doses to LANL personnel
- Over 99 percent of all radiation doses to the public
- Over 90 percent of all radioactive liquid waste generated
- Over 90 percent of the radioactive solid waste generated
- Approximately 30 percent of chemical waste (both RCRA regulated and industrial) generated; the remaining 70 percent of chemical wastes are generated in very small volumes throughout the balance of the laboratory in individual bench-scale and laboratory experiments and in analytical chemistry support activities

Practically all of the facilities that are nuclear facilities or moderate hazard nonnuclear facilities are included as key facilities in the SWEIS. The only moderate hazard nonnuclear facilities not included are water treatment stations using chlorine (these nonnuclear facilities are considered in the accident analysis as discussed in section 5.1.11) and two nonoperating nuclear facilities, Omega West Reactor (fuel has been removed) and a tritium facility at TA–33, which have been stabilized, contain only minimal inventories and are awaiting decontamination and decommissioning (section 2.2.3).

LANL actions anticipated over the next 10 years within the key facilities are identified for each alternative, as described in chapter 3 and analyzed in chapter 5.

2.2.2.1 *Plutonium Facility Complex (TA–55)*

The facilities at TA–55 are located on a 40-acre (16-hectare) site about 1 mile (1.6 kilometers) southeast of TA–3 (Figure 2.2.2.1–1). TA–55 is one of the larger TAs at LANL. The main complex has five connected buildings: Administration Building (55–1), Support Office Building (55–2), Support Building (55–3), Plutonium Facility (55–4), and Warehouse (55–5) (listed in Table 2.2.2.1–1). The Nuclear Materials Storage Facility (NMSF, 55–41) is separate from the main complex but shares an underground transfer tunnel with 55–4. (Note that these buildings are sometimes referred to as Plutonium Facility [PF]–1, PF–2, PF–3, PF–4,

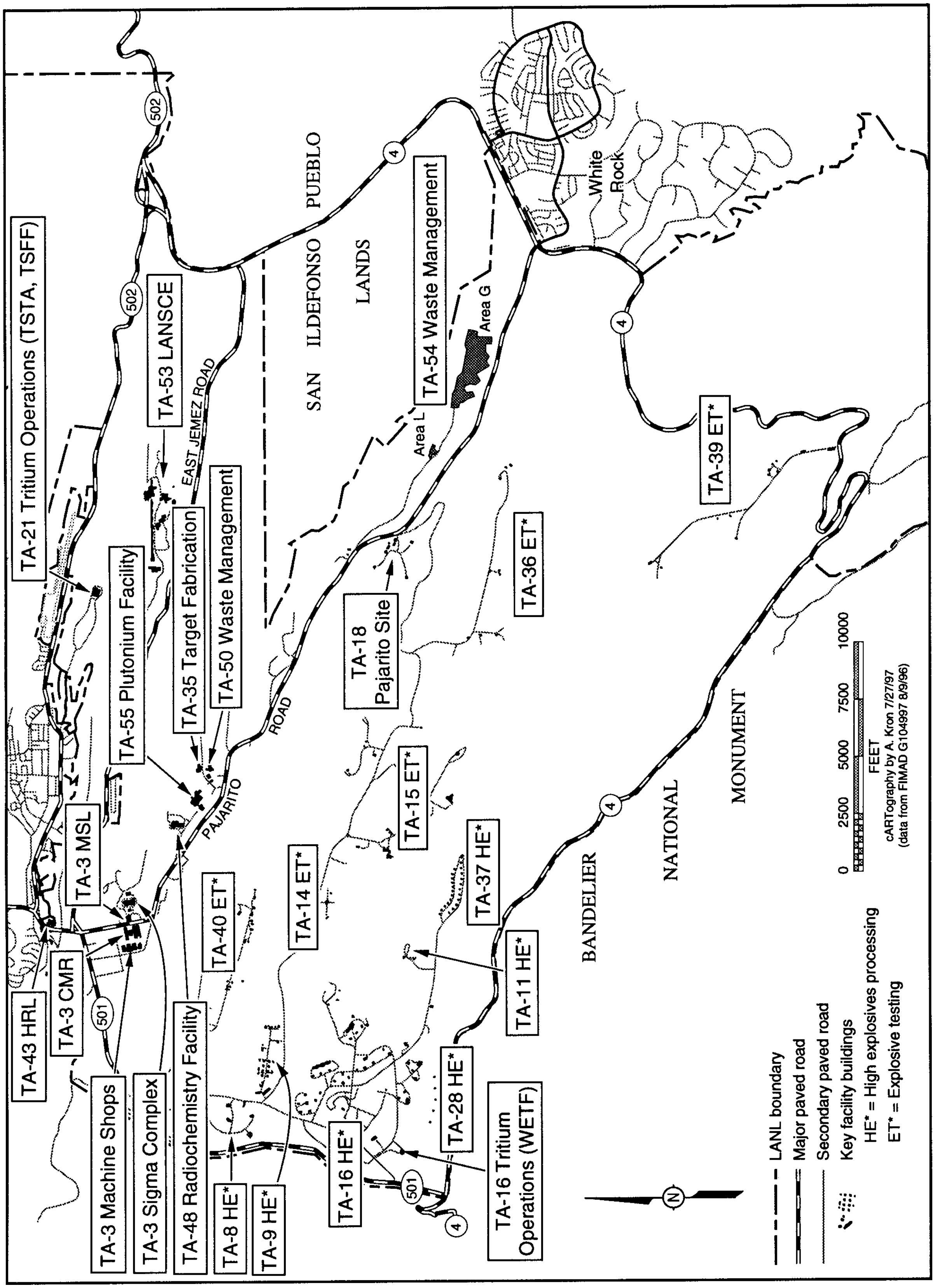


FIGURE 2.2.2–1.—*Key Facility Locations Within LANL.*

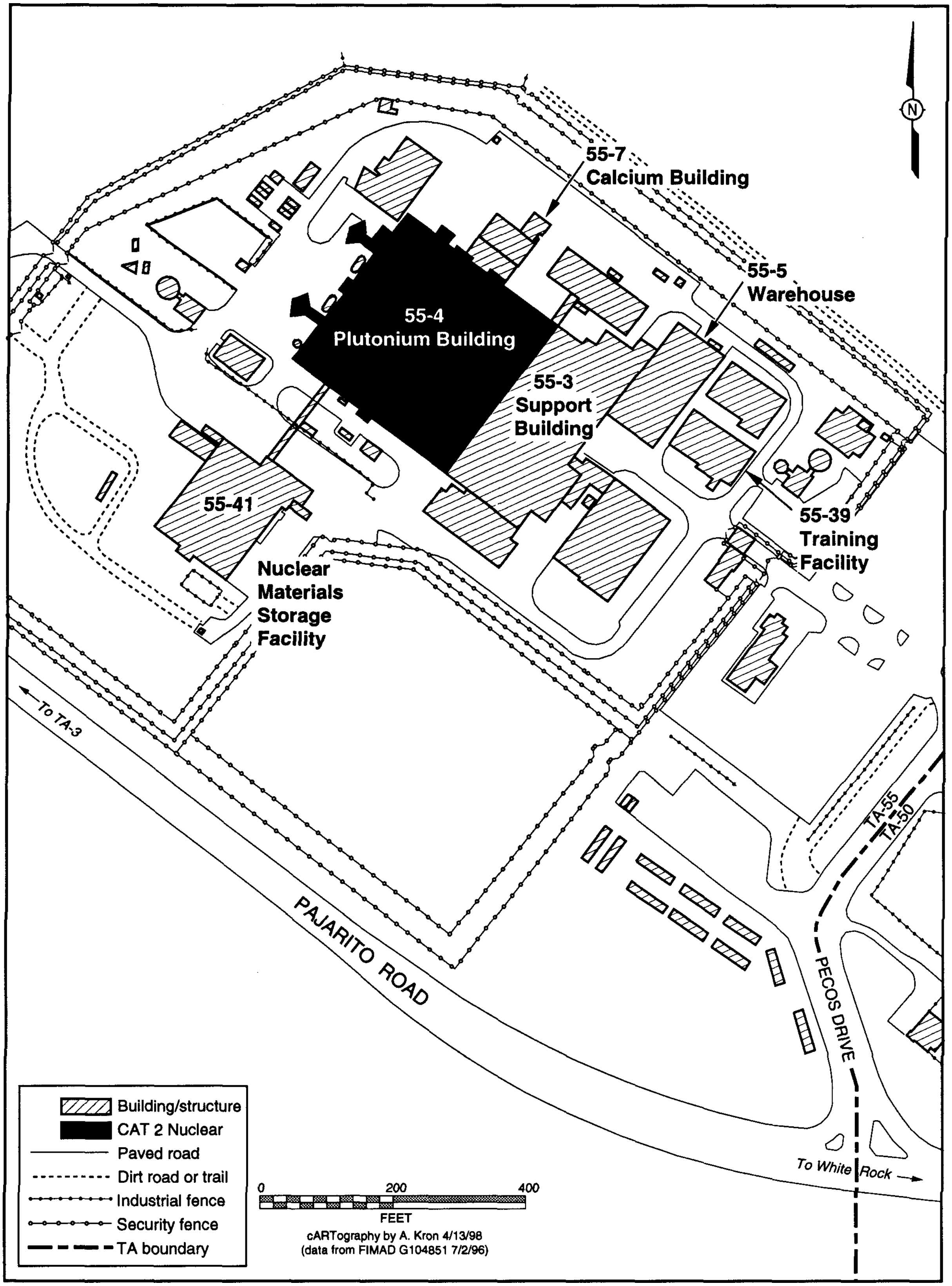


FIGURE 2.2.2.1–1.—*TA–55 Plutonium Facility Complex.*

TABLE 2.2.2.1–1.—*Principal Buildings and Structures of the Plutonium Facility Complex (TA–55)*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–55	Offices, Laboratories: 55–1, 2, 3, 20, 39, 107, 110, 114, 124, 135, 136, 137, 138, 139, 144, 145, 177, 264
	Plutonium Building: 55–4
	Warehouse: 55–5
	Calcium Building: 55–7
	Materials Control and Accountability Support Building: 55–28
	Training Center: 55–39
	Nuclear Materials Storage Facility: 55–41
	Process Support Building: 55–42
	Assessment Buildings: 55–43, 142
	Generator Building: 55–47
	TRU Drum Storage Building: 55–185

PF–5, and PF–41.) After renovations are completed, the NMSF will provide intermediate-term storage for up to 7.3 tons (6.6 metric tons) of LANL's SNM inventory, mainly plutonium. Various support, storage, security, and training structures are located throughout the main complex. The cornerstone research and development facility at TA–55 is the Plutonium Facility (55–4). Plutonium is processed at this facility, which is a two-story laboratory of approximately 151,000 square feet (14,028 square meters). The Plutonium Facility complex has the capability to process and perform research with the range of actinide materials (actinides are a series of chemically similar, mostly synthetic, radioactive elements with atomic numbering ranging from 89 [actinium] through 103 [lawrencium] and including thorium [90], uranium [92], plutonium [94], and americium [95]). The discussion focuses on plutonium because most of the work in this facility is done with plutonium; work done with other actinides is similar in nature.

Description of Facilities

Building TA–55–4 is categorized as a Hazard Category 2 nuclear facility (see the text box on Nuclear Facilities Hazards Classification in section 2.2), and was built to comply with seismic standards for Hazard Category 1 buildings. The ventilation system in the facility has four zones. The overall design concept for the Plutonium Facility separates the building into two halves, separated by a fire wall and other fire safety features. TA–55–4 was designed to correct the deficiencies that led to the 1969 Rocky Flats fire. An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and TA–55–4 are presented in appendix G, section G.4.1.2. Two facilities (TA–55–3 and TA–55–5) are designated as low hazard chemical facilities, and one facility (TA–55–7) has a low hazard energetic source classification. The other facilities at TA–55 are designated as no hazard facilities. (These are administrative, technical, and general storage buildings, passageways, and pump stations.)

The NMSF (TA–55–41) is located to the west of the main Plutonium Facility complex (shown in Figure 2.2.2.1–1) but shares an underground transfer tunnel with that facility. The building's main vault area is a two-level design, 36 feet (11 meters) tall by 55 feet (17 meters) wide by 150 feet (46 meters) long, of reinforced concrete. The lower level is below grade (i.e., it is below the surface of the ground). The office, mechanical, and receiving area is a single-story concrete structure 85 feet (26 meters) wide by 150 feet (46 meters) long. The ventilation stack rises 17 feet (5 meters) above the roof line. The NMSF was designed to be an intermediate-duration (up to 50 years) storage facility for the LANL inventory of plutonium, uranium, and other actinides and to be the central shipping and receiving point for nuclear materials at TA–55. The design capacity is 7.3 tons (6.6 metric tons) of SNM in metal and oxide forms, which will make the facility Hazard

Category 2, once it is authorized to operate. Although construction was completed in 1987, the facility has never been operated because of major design and construction deficiencies.

Design for renovation of this facility is currently underway. The actual renovations are scheduled to begin in 2000, but are not yet funded. Renovations are scheduled for completion in 2005, and the facility is expected to be operational in 2005. The NMSF renovation project includes:

- Installing a drywell storage array system
- Reworking the air flow system to allow the storage array to be passively cooled by convection of ambient air
- Constructing a new mechanical penthouse for heating, ventilation, and air conditioning equipment
- Reconfiguring the administrative support area, security system, decontamination stations, and mechanical room
- Adding reinforcement to the structure
- Reconstructing the Material Access Area (MAA)

The facility is planned to operate as a passive air-cooled storage structure with air intake at the lower level and exhaust through the stack. A taller stack (as compared to the existing one) might be required for the passive convective cooling system to operate effectively. Alternatively, an active cooling system may be considered appropriate.

A material accountability and assay area may be established in the NMSF as support for the storage, shipping, and receiving functions. Nondestructive assays may be performed at the NMSF on sealed containers as they are received and before they are shipped, to verify identity and quantity of package contents. The primary containers of nuclear materials will not be opened within NMSF. Because materials in the vault area are stored in sealed containers, the vault area will not be high HEPA filtered; the air in the receiving area, material assay area, and change rooms will exhaust through HEPA filters.

Description of Capabilities

The capabilities at TA–55 include many operations by which actinides (primarily plutonium):

- Are used in research on and characterization of physical and chemical properties and metallurgy of these materials and alloys.
- In weapons component form are taken apart or disassembled into metal scrap to be recovered.
- In metal scrap form are recovered (or reprocessed) into oxide and metal forms (stabilized) that may be stored or redirected into fabrication, research and development processes, or may be dispositioned.
- In residue form are dissolved and chemically processed to recover the plutonium as metal, oxalate or oxide, for further processing.
- In metallic form are manufactured into components or parts useful in research or weapons applications.
- In metal or oxide form are processed (or fabricated) into materials useful as sources of heat and nuclear power (fuel pellets and rods).
- Can be converted from metal to oxide and visa versa.
- In any of the above forms serve as feedstock for various research and development activities.
- Measurement technologies are developed for material control, nonproliferation, international inspection applications.

Terminology Related to Pit Production

Fabrication/Manufacturing—*For purposes of the SWEIS, these terms are synonymous. LANL has an existing capability to fabricate or manufacture plutonium parts. That is, the equipment, knowledge, supporting infrastructure, and administrative procedures and controls exist at LANL to create plutonium metallic shapes to precise specifications. This capability is currently used in support of existing missions for research and development and will be used to rebuild some of the pits destroyed in stockpile surveillance activities.*

Production—*For the purposes of the SWEIS, this term is used to describe the fabrication/ manufacturing of a relatively large quantity of parts (as compared to the research and development and prototype capability). In the ROD for the SSM PEIS, DOE decided to meet its need for a pit production capability by enhancing its existing fabrication/ manufacturing capability at LANL. This enhancement consists of changes to optimize material flows, remove "choke points" that limit the quantity that can be made, improve efficiency, and replace or upgrade equipment to improve process yield and reliability.*

The processing capabilities can be divided into manufacturing steps and reprocessing or recovery steps. Processes can also be considered as "wet" or "dry" in terms of the relative volumes of radioactive liquid wastes produced. Chemical reprocessing operations are generally considered wet because they generate radioactive liquid wastes from precipitation, wash, and ion exchange elution steps. The nitrate and chloride aqueous processes produce acid and caustic streams containing most of the radioactive content in the aqueous waste from TA–55.

Manufacturing processes are considered to be dry because they involve metal forming and oxide pressing operations that do not produce aqueous wastes containing dissolved actinides. Similarly, pyrochemical processing and other recovery processes that utilize heat to effect separations (e.g., tritium separations) are considered dry processes.

Division into wet and dry processes is complicated because 95 percent by volume of the radioactive liquid waste effluent from TA–55 is industrial wastewater, water used in various cooling processes within the facility. All the manufacturing and pyrochemical operations and many of the reprocessing operations require water for cooling. This includes water used in cooling processing equipment (cooling jackets on ion exchange columns and metal melting furnaces) and the discharge from the heating, ventilation, and air conditioning system that serves the radioactive processing areas in TA–55–4.

The principal activities conducted at the Plutonium Facility are described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

Plutonium Stabilization. Stabilization encompasses a variety of plutonium (and other actinide) recovery operations. The goal of this activity is to improve the storage condition of legacy plutonium in the LANL inventory. Some of the existing containers show signs of corrosion. Further, the stability of some of the materials can be improved through reprocessing, cleaning, high-firing (oxidizing at relatively high temperatures) oxides, and storage in improved containers. As of early 1996, the inventory included 1.2 tons (1.1 metric tons) of metallic plutonium, 0.83 tons (0.75 metric tons) of plutonium in residue forms, and 0.83 tons (0.75 metric tons) of plutonium in oxide forms. Under all of the alternatives, the plan is to reprocess 10 percent of the metal form, all of the residues, and 15 percent of the oxides to a stable oxide form. The remainder of the metal will be cleaned and remaining oxides will be high-fired. After these stabilization steps, the materials will be repackaged under inert atmosphere (an atmosphere free of materials that may initiate chemical reactions) in pressure-closure cans that are then placed in outer cans that are welded closed. These will be stored until needed to support program requirements. The processes that will be used to clean metallic plutonium, to convert metal to oxide, to reprocess the scrap material, and to high-fire oxides are parts of the regular chemical processing capability in operation at TA–55. The length of time that would be taken to complete these activities varies among the alternatives.

Manufacturing Plutonium Components. The goal of this activity is to take purified plutonium metal and use it to manufacture pits or other items for research and development or to manufacture components for the nuclear weapons stockpile. This capability includes the fabrication of samples and parts for research applications, including dynamic experiments, subcritical experiments (at the Nevada Test Site), fundamental research on plutonium at the Los Alamos Neutron Science Center (LANSCE), and has been used in the past to fabricate pits for nuclear tests. Some equipment, tools, designs, and documentation specific to pit manufacturing have been moved from the Rocky Flats Plant to LANL. Changes will be made in the manufacturing process to reduce waste production and worker exposure. In general, the processes and procedures used for this capability differ in capacity, in technology, and in safety and environmental measures as compared to those previously used at the Rocky Flats Plant. Some aspects of the manufacturing process such as welding and coating technologies are still being developed. Pure metal will be cast to a very close approximation of the final dimensions (near net shape). This will reduce the need for extensive machining and reduce the production of waste and scrap (as compared to techniques used in the past). Some final machining and polishing will be required. The plutonium items produced may be encapsulated or coated with stainless steel, beryllium, or other materials. At every step, the pieces are inspected and samples are taken for analysis. Those finished components that meet the specifications may be stored in the Plutonium Facility vault or NMSF pending shipment or research use. Those that do not meet specifications are reprocessed into plutonium metal.

Surveillance and Disassembly of Weapons Components. The goal of this activity is to conduct a series of nondestructive and destructive evaluation on pits removed from the stockpile and/or from storage, as well as for materials being considered in process development activities. These evaluations determine the effects of aging and other stresses on pits, as well as the compatibility of materials used or being considered for use in weapons. They are a part of the stockpile reliability and safety analysis and documentation programs that DOE has conducted for the nuclear weapons stockpile since pit production was initiated. The evaluation program was transferred from the Rocky Flats Plant to LANL in the early 1990's. Beginning with the intact pit, a series of tests are made to determine the changes in the materials from which the pit was constructed. Tests include leak testing, weighing, dimensional inspection and measurements, dye penetration tests, and radiography. Some of the pits evaluated at LANL are returned to storage after these nondestructive analyses (to be analyzed again at a later date). Other pits are taken apart (disassembled) for further tests, which include metallography, micro-tensile testing, and chemical analysis. The scrap remaining after these destructive tests is reprocessed. Any pit fabricated at LANL or sent to LANL could be evaluated or disassembled through these processes.

Actinide Materials Science and Processing Research and Development. Several aspects of materials research on plutonium (and other actinides) are conducted at TA–55. In general, these include metallurgical and other characterization of materials, and measurements of physical materials properties. These measurements provide data that support assessments of the safety and reliability performance of nuclear weapons, including the behavior of aging weapons components and replacement components and their suitability for certification. They also support other activities at LANL, such as characterizing samples for components, including those produced at TA–55, for experiments conducted at LANL or elsewhere, as well as measurements surveillance of stockpile components. Activities to develop new measurements for enhanced surveillance also are conducted at the facility. In addition, measurements at TA–55 study the properties of plutonium materials and samples at high strain rates using a 40-millimeter projectile launcher Impact Test Facility, apparatus such as Kolsky (split Hopkinson) Bars, and other bench-scale capabilities to measure mechanical and physical properties. These operations are usually conducted in gloveboxes and involve relatively small amounts of plutonium, as compared with other activities at TA–55.

In addition, research at TA–55 supports development and assessment of technologies for manufacturing and fabrication of components, a capability discussed previously in this section. These activities include research on welding and bonding processes and research associated with casting, machining, and other forming technology. In addition, measurements associated with fire-resistance of weapons components are conducted at TA–55.

Actinide processing (also called recovery and reprocessing) includes methods by which plutonium and other actinides can be extracted, concentrated, and converted into forms easier to store and to use in other activities. The discussion below focuses on plutonium because this accounts for most of the processing activity at TA–55, but the discussion also applies to the many other actinides used in research at LANL.

The ease with which plutonium may be recovered depends upon the form of the material:

- *Recoverable*—Metal components, ash, sand, slag, castings, combustible and noncombustible equipment, impure oxides, sweepings, organic solutions, alloys, various salts, and filter residues
- *Difficult to recover further*—Leached metal, decontaminated components, and evaporation residues
- *Practically irrecoverable*—Vitrified material and ceramic forms

The form, recoverability, and the concentration of plutonium remaining determines whether the material will be discarded as waste or treated with further reprocessing steps. Aspects of this reprocessing capability are described below.

Actinide recovery processing typically involves dissolving materials in nitric or hydrochloric acid using the physical and chemical characteristics of the actinide (e.g., using solvent extraction or ion-exchange processes) to preferentially extract it as a high purity solution. The high-purity actinide can then be removed from the solution (through precipitation and filtration) and converted to an oxide or oxalate form. Finally, the oxides and oxalates can be converted to metal using a variety of chemical processing techniques, including high temperature oxidation and electrochemical techniques. Waste solutions from these processes are pre-treated (redistilled to reclaim acid and precipitate nitrate sludges if appropriate) before being discharged as radioactive liquid waste to TA–50 (described in section 2.1.2.14).

Tritium separation is a special type of actinide processing. Tritium sorbs into many actinide materials where it is strongly held. Tritium can be removed from these materials by heating the material in an inert atmosphere. The actinide material is then cooled and removed. The dedicated glovebox line at TA–55–4 containing the furnace and associated equipment is called the Special Recovery Line.

The hydride-dehydride process is another special type of actinide processing. This process is used in the Advanced Recovery and Integrated Extraction System and may be used in other disassembly and material recovery processes. This process converts plutonium metal to plutonium hydride, which can be easily removed from other materials. The plutonium hydride can then be converted to either plutonium metal or oxide. The hydrogen used in this process is recycled. Although this process was designed for pits, other forms of metallic plutonium that are amenable to hydriding could also be reprocessed using this technique.

Actinide materials that emit alpha particles, such as plutonium or americium, have been intimately mixed with a material such as beryllium or beryllium oxide, to produce a strong and long-lasting source of neutrons, which is then sealed in stainless steel cladding. The U.S. Government provided about 20,000 of these neutron sources to universities, industry, and governmental agencies, which are licensed through the U.S. Nuclear Regulatory Commission (NRC) to utilize such materials. Most of these sources are no longer in use and, through an agreement with the NRC, they are being returned to DOE for reprocessing (using actinide recovery processes) at LANL. At present, plutonium-239/beryllium sources are being reprocessed at TA–55, but the capability could be used to reprocess americium-241/ beryllium sources as well.

In addition, this actinide reprocessing capability includes research into new recovery and decontamination techniques, research regarding the fundamental properties of actinides, analytical and nondestruction measurement of actinides (including development of new techniques), and research regarding nuclear fuels.

Fabrication of Ceramic Based Fuels. LANL develops and demonstrates ceramic based nuclear reactor fuel fabrication technologies. LANL has demonstrated the ability to produce such fuel, including prototype mixed oxide (MOX) fuel from plutonium and uranium. This demonstration involves processing of metals and oxides. Plutonium and uranium oxides are mixed together, and made into a ceramic form which is pressed into pellets. The pellets are sealed in cladding materials as a fuel rod. Fuel rods can be bundled together into fuel assemblies.

Plutonium-238 Research, Development, and Applications. Plutonium-238 has the interesting properties of being minimally fissile (making it more difficult to sustain a chain reaction) yet producing a large amount of heat through radioactive decay. This isotope is used to provide a long-term reliable source of heat that can be used directly and can be converted into electricity when assembled into radioisotopic thermoelectric generators (RTGs). The electricity produced by the RTGs has been used to operate mechanical devices, instruments, and communications on remote sensing devices such as spacecraft and to activate switches in some nuclear weapons designs. RTGs and units called milliwatt generators have been produced, tested, and reprocessed at the Plutonium Facility for many years, and RTG research and development (including design), fabrication, and testing activities continue. Plutonium-238 activities are kept separate from the other plutonium processes to avoid cross-contamination of isotopes. After the RTGs are produced, they are extensively tested for integrity, resistance to mechanical shocks, and heat generation rate.

Aqueous reprocessing of plutonium-238 material uses the same processing techniques as used for other actinides as discussed above.

Storage, Shipping, and Receiving. Under this activity, LANL stores, packages, measures (using variety of destructive and nondestructive techniques), ships, and receives nuclear materials. These activities are housed throughout TA–55–4, with storage currently in the TA–55–4 vault and projected in NMSF upon completion of the renovation project.

2.2.2.2 *Tritium Facilities (TA–16, TA–21)*

Tritium is a radioactive isotope of hydrogen. LANL tritium operations are primarily conducted at three facilities: Weapons Engineering Tritium Facility (WETF), Tritium Systems Test Assembly (TSTA) Facility, and Tritium Science and Fabrication Facility (TSFF) (see Figures 2.2.2.2–1 and 2.2.2.2–2 and Table 2.2.2.2–1). WETF is located at TA–16; TSTA and TSFF are located at TA–21. Operations involving the removal of tritium from actinide materials are conducted at LANL's TA–55 Plutonium Facility. These operations are described in section 2.2.2.1. Limited research, instrument calibration, analytical, and storage activities involving tritium are conducted at other LANL facilities; however, the primary potential environmental impacts from tritium operations at LANL reside with the three tritium facilities listed above. These facilities support several tritium-related programs at LANL and play an important role in DOE's energy research and nuclear weapons programs.

At various times, DOE has considered whether to consolidate TA–21 tritium operations and activities at the TA–16 WETF site; most recently, this was discussed as a potential project to begin in the year 2000 and be completed by the year 2006. However, any consolidation of tritium operations and activities is speculative at this time and for this reason is not included in SWEIS analyses. If such a project were proposed by DOE, additional NEPA analysis would be pursued, tiering from the SWEIS. There will continue to be movement of tritium operations and activities among the tritium operations facilities in order to optimize use of equipment and personnel and to increase programmatic efficiency.

Description of Facilities

The Weapons Engineering Tritium Facility, a Hazard Category 2 nuclear facility, is located in Building 16–205, in the southeast section of TA–16. Planning for WETF began in 1981 with construction occurring between 1982 and 1984. WETF began operation in 1989. Construction of an addition to WETF was started in 1993 and completed in 1994. Except for the mezzanine area in Building 205, WETF is a single-level structure with approximately 7,885 square feet (732 square meters) of floor area. The equipment in the building includes gas transfer and pumping systems, gloveboxes, a glovebox exhaust system, a system of monitors and alarms, and subsystems to contain any leaked tritium gas and tritiated wastewater.

Tritium-related activities occur in the contiguous tritium-handling-areas, which are served by a ventilation system that exhausts to a 60-foot (18-meter) stack. The stack, which is northeast of 16–205, is equipped with continuous air monitors that are equipped with a tritium bubbler system for determining tritiated water and gas ratios in the effluent air stream. There is no liquid discharge from Building

TABLE 2.2.2.2–1.—*Principal Buildings and Structures of the Tritium Facilities*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–16	Weapons Engineering Tritium Facility Processing Building: 16–205 Formerly the Weapons Components Test Facility: 16–450
TA–21	Tritium Systems Test Assembly Facility: 21–155 Tritium Science and Fabrication Facility: 21–209

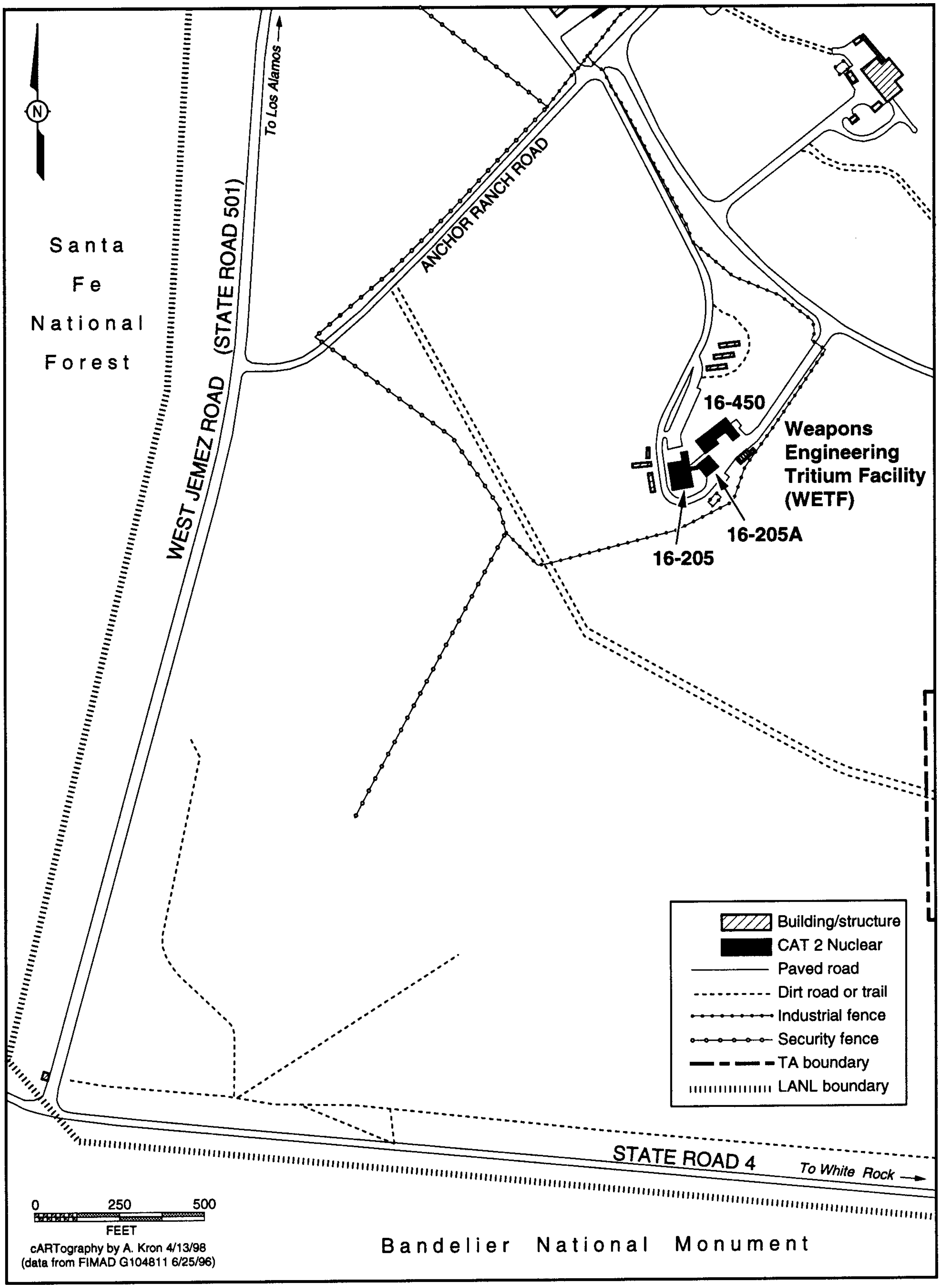


FIGURE 2.2.2.2–1.—*TA–16 Tritium Facilities (WETF).*

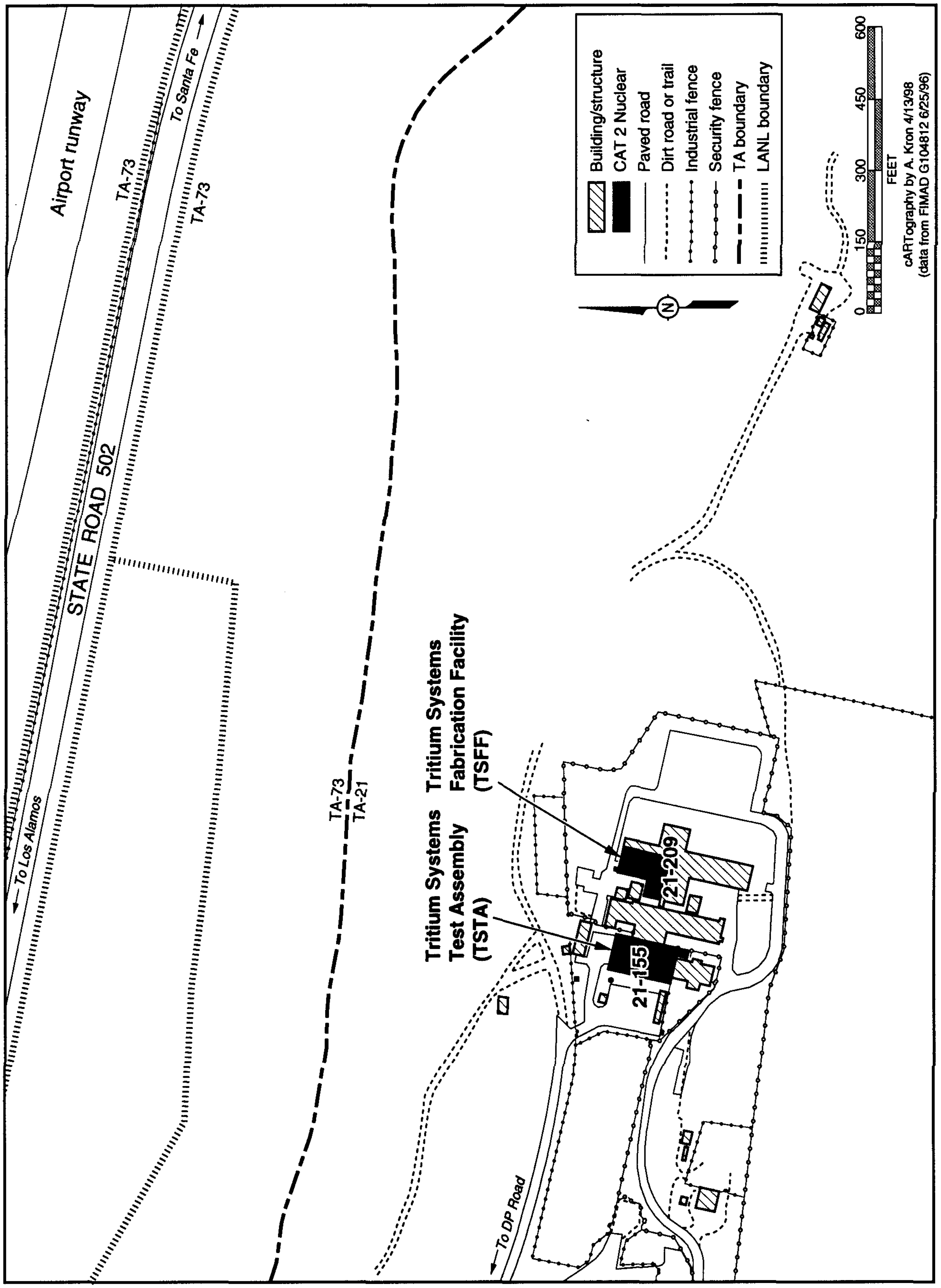


FIGURE 2.2.2.2–2.—*TA–21 Tritium Facilities (TSTA and TSFF).*

16–205 to a National Pollutant Discharge Elimination System (NPDES) outfall or directly to the Radioactive Liquid Waste Treatment Facility (RLWTF); the small amounts of contaminated mop water are collected and stored in a tank at the facility, then transported by radioactive liquid waste tanker truck to the RLWTF. The facility is functionally divided into multiple areas including an operations control area, tritium-handling areas, and support areas. Walls, roofs, and air locks separate the tritium handling areas from the rest of the facility. The support areas include offices, restrooms, and rooms that house equipment. An adjacent building (TA–16–450) will be connected to WETF, along with a new exhaust air stack, change room, and mechanical building. These changes are scheduled during the late 1990's for neutron tube target loading (NTTL) operations and related research (DOE 1995a). This building will receive a hazard category designation when it is authorized by DOE to operate.

Planning for the Tritium Systems Test Assembly facility at TA–21 began in 1977 after LANL was chosen to develop, demonstrate, and integrate technologies related to the deuterium-tritium fuel cycle for large-scale fusion reactor systems. Construction was completed and pre-tritium testing initiated in 1982. TSTA is a Hazard Category 2 nuclear facility. The TSTA facility is located at TA–21 (also called DP Site). TA–21 has two primary research areas: DP West and DP East. The DP West area is currently under decontamination and decommissioning. The TSTA facility is located at the DP East research area.

An existing building (21–155N) was modified to accommodate TSTA. The main experimental tritium area (Room 5501) has 3,700 square feet (344 square meters) of floor area. Two small laboratories are connected to the 5501 ventilation system, which also services the main experimental tritium area. In the same building, but in the area surrounding the main experimental area, there is an additional 5,993 square feet (557 square meters) of floor space that is used for the Control Room, Support Center, office area, equipment rooms, and a diesel generator. Another existing building (21–155S), which has 3,819 square feet (355 square meters) of floor area, is used for office and shop space.

In addition to the main building, there is 1,506 square feet (140 square meters) of storage space in a metal warehouse (Building 21–213) located north of the main experimental area. The east end of this building has been sectioned off and is used as a storage area for tritium contaminated equipment. There is also a portable building (Building 21–369) located on the west side of the main laboratory, which adds an additional 753 square feet (70 square meters) of office space. One stack, which is located at the northwest corner of TA–21–155N, services the TSTA tritium experimental areas.

The TSFF, a Hazard Category 2 nuclear facility, is a tritium research and development facility located in Building 209 at TA–21. The TSFF facility is located east of the TSTA facility at the DP East research area. The building was built in 1964 as a chemistry process building and modified in 1974 to accommodate tritium operations associated with nuclear weapons development and test programs. TSFF is a 3,228-square-foot (300-square-meter) block-walled area within the Building 21–209, which is a one-story building with a basement. TSFF is serviced by a process exhaust air treatment system that discharges into an exhaust ventilation system that discharges room air and treated process air to a 75-foot (23-meter) high exhaust air stack.

The radioactive materials used at WETF, TSTA, and TSFF are primarily tritium gas and metal hydride storage beds, some of which contain depleted uranium powder. Several nonradioactive toxic and hazardous substances, such as methanol and acetone, are used in small quantities to clean and maintain processing equipment at the three facilities. These are common solvents and cleaners found in most modern chemistry laboratories.

Description of Capabilities

The principal activities conducted at WETF, TSTA, and TSFF are described below. The manner in which these activities will vary among the alternatives is described in chapter 3.

High-Pressure Gas Fills and Processing (WETF). High-pressure gas fills and processing operations for research and development and nuclear weapon systems are performed at WETF at TA–16–205. High-pressure gas containers (reservoirs) are filled with tritium/deuterium gas mixtures to specified pressures in excess of 10,000 pounds per square inch. This capability is also used for filling experimental devices (e.g., small inertial confinement fusion [ICF] targets that require high pressure tritium gas).

Gas Boost System Testing and Development (WETF). Modern nuclear weapons are equipped with gas boost systems that use hydrogen isotopes including tritium. These systems and their components need ongoing maintenance, testing, development, gas replacement, and modifications to maintain safety and reliability. WETF provides highly specialized boost system function testing and experimental equipment. Also, more efficient and effective boost systems are under development and tested at WETF.

Cryogenic Separation (TSTA). To separate pure gas species from gaseous mixtures, a distillation technique is used, known as cryogenic distillation. The technique combines super cooling and high vacuum technologies for separating gaseous mixtures. This capability is used to separate gaseous tritium from other gases at TSTA. It is possible that other tritium facilities, such as WETF, at LANL could use this technique in the future.

Diffusion and Membrane Purification (WETF, TSTA, TSFF). Different gaseous species of elements move (diffuse) through membranes and other barriers at rates that depend on their molecular weight. Also, gaseous species penetrate (pass through) certain membranes differently based on their molecular size. Gas separation and purification techniques have been developed based on these two characteristics of the gaseous species. Currently, several systems exist that utilize a multi-step membrane diffusion process for effective and efficient gas separations.

All three LANL tritium facilities currently possess or plan to have the operational capability to separate and purify tritium from gaseous mixtures using diffusion and membrane purification techniques.

Metallurgical and Material Research (WETF, TSTA, TSFF). Tritium handling capabilities at the WETF, TSTA, and TSFF facilities accommodate a wide variety of metallurgical and material research activities. One example of this type of research is the investigation into the ability of various containers to remove hydrogen isotopes (including tritium) from a flowing stream of nitrogen and other inert gases. In application, this capability may be used to clean up exhaust air streams and the air in tritium containment areas without generating tritiated water, a more hazardous form of tritium.

Thin Film Loading (TSFF, WETF). The thin film loading process capability involves chemically bonding a radioactive gas, tritium, to a metallic surface. These operations are currently conducted at TSFF, but are being moved to WETF.

Tritium for the NTTL thin film loading operations are contained within a small hydride collection bed, which is refilled periodically. The hydride bed collects the tritium gas in a metal hydride form and holds it until the bed is heated to a temperature of 1,110 degrees

Fahrenheit (°F) (600 degrees Celsius [°C]). Hence, the release of tritium from the bed is a well-controlled process and the tritium cannot be released from the bed at normal temperatures. The process is conducted under vacuum conditions in an inert atmosphere.

The NTTL thin film loading system is constructed in a modular fashion. The basic modules include the loader itself, several control racks, a glovebox and hood with all internal and external attachments, a gas purifier, a chiller, and several oil-free vacuum pumps.

Gas Analysis (WETF, TSTA, TSFF). It is essential for nuclear material control and accountability, as well as experimental purposes, to have the capability to measure the composition and quantities of the gases used. Mass spectrometers are common laboratory measurement instruments used at the three LANL tritium facilities to measure the composition of gas samples. Also, Raman spectrometry is used for real time gas analysis. Other techniques such as beta scintillation counting are also used for real time and batch gas analysis. The amount of gas, including tritium, that is needed for any of these measurement techniques is small.

Calorimetry (WETF, TSTA, TSFF). Calorimetry is a well established nondestructive method used for measuring the amount of tritium in a container. This method is based on the measurement of heat flow from a container. The radioactive decay of tritium gives off heat at a rate that is directly proportional to the amount of tritium contained in gas containers. No tritium leaves the container in the performance of calorimetry measurements.

Solid Material and Container Storage (WETF, TSTA, TSFF). Safe storage of hydrogen isotopes including tritium is an important capability of all three LANL tritium facilities. Tritium in gaseous form may be stored in either specially designed dual wall containers or certified shipping containers. Tritium gas may also be safely stored in metal hydride form contained in dual wall containers. The metal hydride that forms when tritium reacts with the metallic powder in the container is a very stable compound. Tritium can be released from this compound by heating the container to several hundred degrees Celsius. Accountable quantities of tritium are stored in these ways in designated areas that have been approved for such storage.

Tritium oxide (tritiated water) can also be stored in solid form when it is adsorbed (gathered on a surface in a condensed layer) on molecular sieves. Molecular sieves are made with materials that adsorb tritiated water in the fine pores on their surface, thus forming a solid material that can be stored in containers. Tritiated water adsorbed on molecular sieves is physically stable. Tritiated water is released from the molecular sieve when the temperature is raised above the boiling point for water.

2.2.2.3 *Chemistry and Metallurgy Research Building (TA–3–29)*

The CMR Building (TA–3–29) was designed within TA–3 as an actinide chemistry and metallurgy research facility (Table 2.2.2.3–1). The main corridor with seven wings was constructed in 1952 (Figure 2.2.2.3–1). In 1960, a new wing (Wing 9) was added for activities that must be performed in hot cells (a hot cell is an enclosed area that allows for the

TABLE 2.2.2.3–1.—*Principal Buildings and Structures in the Chemical and Metallurgy Research Building*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–3	CMR Laboratory: 3–29 Hot Waste Pump House: 3–154

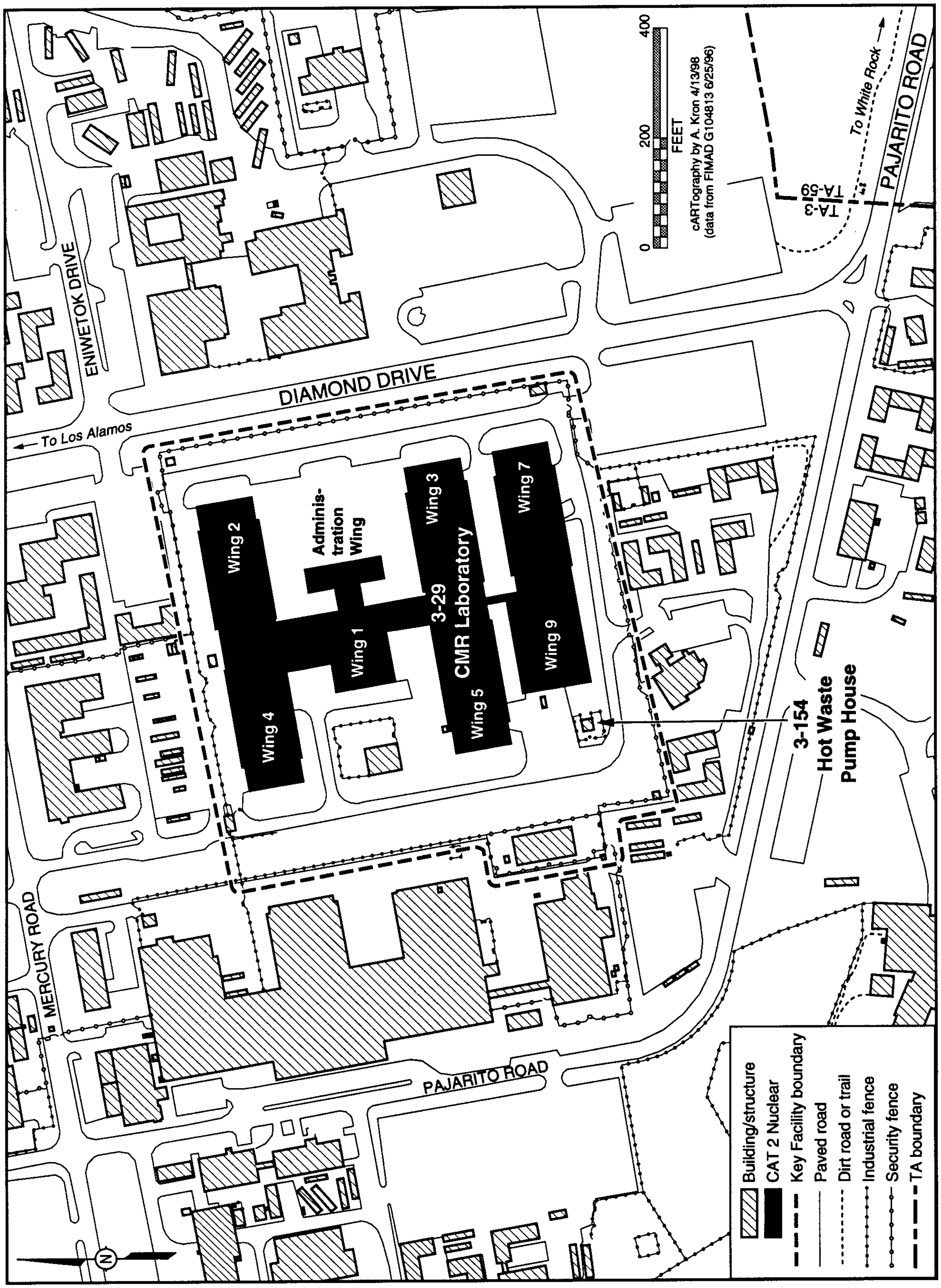


FIGURE 2.2.2.3–1.—*TA–3 Chemistry and Metallurgy Research Building.*

remote handling of highly radioactive materials). Wings 6 and 8 were never constructed. The three-story building now has eight wings connected by a spinal corridor and contains a total of 550,000 square feet (51,097 square meters) of space. It is a multiple-user facility in which specific wings are associated with different activities. It now is the only LANL facility with full capabilities for performing SNM analytical chemistry and materials science.

Description of Facility

CMR facilities include hot cells and SNM vaults. Waste treatment and pretreatment conducted within the facility is sufficient to meet waste acceptance criteria for receiving facilities, on site or off site. In addition, these facilities are used to support various activities at other LANL locations. TA–55 (described in section 2.2.2.1) provides support to CMR in the areas of materials control and accountability, waste management, and SNM storage.

The aqueous waste from radioactive activities and other non-hazardous aqueous chemical wastes from the CMR Building are discharged into a network of drains from each wing specifically designated to transport waste solutions to the RLWTF in TA–50 (described in section 2.2.2.14) for treatment and disposal. The primary sources of radioactive inorganic waste at the CMR Building include laboratory sinks, duct wash-down systems, and overflows and blowdowns from circulating chilled-water systems. The facility infrastructure is designed with air, temperature, and power systems that are operational nearly 100 percent of the time. Power to these systems is backed up with an uninterruptable power supply. The CMR Building has one NPDES outfall, which discharges seasonally into Mortandad Canyon at a rate of one gallon per minute. This outfall is slated for waste stream corrections as part of LANL's outfall reduction plan. The CMR Building was constructed in the early 1950's to the industrial building code standards in effect at that time. Over the intervening years, DOE has systematically identified and corrected some deficiencies and upgraded some systems to address changes in standards or improve safety performance. Beginning in 1970, these included:

- Ventilation system upgrades (1973 to 1974)
- Fire protection system upgrades (1978)
- Surety facility upgrades (1981, 1992)
- Asbestos repair and removal (1984 to present)
- Acid drain line replacement (1984)
- Evacuation system—public address system and alarms (1984)
- Curbing installed around equipment (1985)
- Vacuum system for continuous air monitors (1987)
- Exhaust duct cool-down system (1987)
- Heating, ventilation, and air conditioning controls (1987)
- Main storage vault (1987 to 1994)
- Alarm monitors (1988)
- PCB transformer replacement (1989)
- Removal of natural gas service from the building (1990)
- Stack emissions monitoring system (1991)
- Air sampling probes (1991)
- SNM waste assay facility (1991)

However, these upgrades have not kept up with the aging of the building or increasingly stringent safety standards. A more comprehensive series of upgrades was identified and authorized by DOE addressing specific safety, reliability, consolidation, and safeguards issues. These were prioritized, with the highest priority being assigned to equipment replacements and activities essential to maintain the minimum safe operating conditions for an interim period of 5 to 10 years, while more comprehensive upgrades were developed. These upgrades were identified by DOE as routine maintenance work, having no significant potential for environmental consequences and not intended to prolong the useful life of the facility. These "Phase I" upgrades were categorically excluded by DOE from the need for further NEPA analysis. The proposed work and the status of completion as of March 1998 includes:

- Augmenting and replacing continuous air monitors in building wings (95 percent complete)
- Replacing some heating, ventilation, and air conditioning blowers (95 percent complete)
- Upgrading basic wing electrical systems (80 percent complete)
- Upgrading power distribution system (55 percent complete)
- Replacing the stack monitoring systems (75 percent complete)
- Installing an uninterruptable power supply for the stack monitoring systems in the laboratory wings (90 percent complete)
- Making limited (interim) improvements to the duct washdown system (89 percent complete)
- Improvements to acid vents/drains (41 percent complete)
- Modifying the sanitary sewer system (completed)
- Performing a fire hazard analysis (completed)
- Preparing an Engineering Assessment and Conceptual Design Report (CDR) (completed)

In addition to the highest priority (Phase I) upgrades, the CMR Building was recognized to require additional upgrading if it is to continue to perform the essential analytical chemistry and metallurgy operations for LANL's existing assignments in a safe, secure, and environmentally sound manner for an additional 20 to 30 years. These further upgrades are not intended to increase the capabilities of the facility nor allow new missions or functions to be located there. These Phase II Upgrades, analyzed in the *Environmental Assessment for the Proposed CMR Building Upgrades* (DOE 1997a) (and also presented in a Capital Asset Management Process Report [LANL 1996c]), include:

- *Seismic and Tertiary Confinement Upgrades.* Diagonal braces from walls to roof, exterior bracing from second floor to ground, internal vertical bracing, strengthening exterior columns, filling in window openings, and adding bracing to the Wing 9 hot cell supports would allow the CMR Building to meet seismic (earthquake resistance) criteria for a Hazard Category 2 facility.
- *Security Upgrades.* Building doorways and other openings would be changed to make human entry other than through the security stations much more difficult.
- *Ventilation Confinement Zone Separation in Wings 1, 3, 5, 7, and 9.* The ventilation systems in these wings would be improved by adding one-way flow baffles and liners in the ventilation ducts, installing better doors and vestibules, adding a new filter tower to Wing 3, and installing a separate glovebox exhaust system. These upgrades are intended to prevent backflow of air carrying radioactive materials and chemical fumes from contaminated areas such as gloveboxes to uncontaminated laboratories, corridors, and offices.
- *Standby Power and Communications Systems.* This upgrade would provide standby electrical power in case a power failure caused the ventilation system to fail. This back up power would maintain negative pressure in the laboratories of Wings 3, 5, 7, and 9, reducing the likelihood that contamination from a laboratory would be spread into other areas. A small generator will provide standby power to the ventilation system and the emergency communication system.
- *Wing 1 Upgrades.* Wing 1 will be decontaminated and a new heating, ventilation, and air conditioning system will

be installed to improve worker health and safety.

- *Operations Center Upgrades.* All building monitoring and control systems will be reported at a central location. This will include continuous air monitors (CAMs), stack monitors and alarms, fire alarm panels, heating, ventilation, and air conditioning and other building utilities, electrical substation switchgear, and glovebox sensors.
- *Chilled Water in Wings 3, 5, and 7.* The 40-year-old evaporative coolers in each wing will be replaced with refrigeration units. Chilled water is supplied to cool process equipment. A chilled water plant will be constructed outside the CMR Building, just west of Wing 1.
- *Main Vault CAMs and Dampers.* Detection capability for radioactive contamination will be enhanced by installing new CAMs in the main vault. The CAMs will be monitored in the CMR Building Health Physics Office. In addition, seismically qualified dampers will be installed in the vault ventilation ducts.
- *Acid Vents and Drains in Wings 3, 5, and 7.* The current acid vents and drains do not rinse or drain completely, allowing radioactive liquid waste residues to stand in nearly horizontal sections of the piping. These systems would be replaced to provide greater slope and better drainage. These wastes are discharged to the RLWTF.
- *Fire Protection Upgrades.* To improve the fire protection system, backflow preventers, fire dampers, and new fire alarm system panels will be installed throughout the CMR Building.
- *Operations Center Standby Power.* A standby generator will provide power to the Operations Center in the event the main system electrical power is lost.
- *Exhaust Duct Washdown Recycle System in Wings 3, 5, and 7.* This planned upgrade is a waste minimization initiative whereby the duct washdown system would be fitted with a system to recycle up to 80 percent of the water used to rinse away materials from the air exhaust that fall out on the duct surfaces. This upgrade is anticipated to decrease the volume of radioactive liquid waste from the duct washdown system by about 450,000 gallons per year (1,700,000 liters per year), to about 120,000 gallons per year (454,300 liters per year).
- *Wings 2 and 4 Safe Standby.* Wings 2 and 4, unneeded to accomplish current mission element assignments, would be placed in safe standby, meaning that loose contamination and some equipment would be removed and the remaining equipment would be placed in a safe and stable condition such that it could not be used.

In its finding of no significant impact regarding the CMR Phase II Upgrades, DOE stated that two potential upgrade designs were encompassed within the environmental assessment (DOE 1997a) analyses: upgrading Wings 3, 5, and 7 without moving office space currently located on the perimeter of each wing; and relocating the office space away from the laboratory functions while upgrading the laboratory space in those wings. In the latter case, two wings would be reconfigured as laboratory space and the third would be put into safe standby condition.

The CMR Phase II Upgrades are funded, and construction is expected to begin in mid 1998. These upgrades were originally scheduled for completion in 2004.

In early 1997, it became apparent that the costs of ongoing (Phase I) upgrades at the CMR Building would overrun the budgeted 1997 costs for that construction project. After considering budget, schedules, and project management issues, LANL, with DOE concurrence, suspended CMR Building Upgrades Project activities pending a thorough budget and project management review (Whiteman 1997). During 1997, several audit and assessment activities were completed by LANL and DOE in which root causes and corrective measures required to address project management issues were identified. Throughout the second half of 1997 and 1998, LANL and DOE have been implementing a series of corrective actions related to improving project management performance on the CMR Building Upgrades Project to allow project activities to resume.

In addition to the information discussed above regarding ongoing and planned upgrades, additional developments occurred during 1997 regarding CMR Building operations. These are highlighted here as contextual information. These developments are consistent with responsibilities and approaches regarding safe operations at LANL, as discussed in section 2.1.3.

On September 2, 1997, in response to safety considerations, LANL temporarily suspended operations within the CMR Building pending an in-depth review of all operations and procedures being implemented within the building to support ongoing LANL activities. During the period from September 1997 through April 1998, operations were resumed in a phased manner as work control and work authorization procedures were verified for each set of operations within the building (Gancarz 1997). Full resumption of CMR Building operations was authorized by DOE on April 17, 1998. To further improve operation of the CMR facility within a safe operating envelope for nuclear facilities, LANL Director Browne announced a new integrated management organization for the CMR Building in which the technical, operations, and facility management of the CMR Building would be integrated with that of TA–55. This reorganization became effective in January 1998 (Browne 1997).

In September 1997, DOE and LANL decided to develop a "Basis for Interim Operations" (BIO) at the CMR facility in lieu of a Safety Analysis Report in order to establish the safety authorization basis for the facility. This effort was completed in October 1998, with the issuance of the BIO and associated technical safety requirements (TSRs) that must be implemented according to a DOE/LANL approved plan over the next 2 years[1]. With the authorization basis established through the BIO, the CMR Building Upgrades Project is responding to meeting the TSR implementation requirements to ensure safe operations with the facility. TSR implementation requires certain facility modifications be completed. Throughout 1998, the CMR Building Upgrades Project was integrated into the BIO/TSR development process. On March 24, 1998, a workshop was held to evaluate CMR Building upgrades required to support BIO/TSR implementation. A second workshop was held on July 17, 1998, to further refine BIO/TSR implementation upgrades and additional upgrades related to safe, reliable operations within the CMR Building.

Based on the above information, the CMR Building Upgrades Project has resumed, and the first priority is the completion of CMR facility modifications required to implement the BIO/TSRs and satisfy compliance requirements. Formal restart of CMR Building Upgrades Project activities commenced on April 13, 1998, with DOE authorizing LANL to initiate activities in support of BIO/TSR implementation that are within the scope of the CMR Building Upgrades Project. Since April 1998, additional project activities have been authorized (repriortized, but within the original scope) by the DOE. Authorized CMR Building Upgrades Project activities since resumption include:

1. The approved CMR BIO includes a comprehensive accident analysis section, including a wing-wide fire scenario that is similar to an accident evaluated in this SWEIS. These analyses were compared, and it was found that, although modeling assumptions and methods varied significantly, the estimated consequences and frequency demonstrated a good agreement. See appendix G, section G.5.6.16, for further details.

- Fire protection panel replacement
- Transient combustible loading reduction
- Motor control centers replacement (completed)
- Duct washdown system refurbishment in Wings 3, 5, and 7
- Interim project management activities

Additional project activities under review or consideration currently include:

- Air compressor replacement
- Hood washdown system installation
- Heating, ventilation and air conditioning (HVAC) DP indicator installation
- Wing 9 ventilation system upgrades
- Emergency personnel accounting system installation
- Stack monitoring upgrades
- Hot cell upgrades, Wing 9 (several subprojects)

A crosswalk between the approved CMR Building Upgrades Project (Phases I and II) baseline and the authorized or under review work in support of the BIO/TSR implementation activities is given in Table 2.2.2.3–2.

All of the above-listed project activities were developed and reviewed during the March and July 1998 workshops. The DOE and LANL are continuing to define all required facility modifications based on ongoing evaluations of site or facility conditions and program requirements to support a rebaselining of the overall CMR Building Upgrades Project during 1999.

In 1996 through 1998, LANL geologists conducted detailed geologic studies in and around TA–3 and TA–55 and geologic trenching studies on the Pajarito Fault. Results from these studies indicate that a possible connection exists between the Pajarito, Rendija

TABLE 2.2.2.3–2.—*CMR Building Upgrades Project Crosswalk Between Phases I and II and 1998 Scope of Work Authorized or Under Review*

BASELINE DESCRIPTION	AUTHORIZED (A) OR UNDER REVIEW (R)
Fire protection upgrades, Phase II	• Fire protection panel replacement (A) • Transient combustible loading reduction (A)
Upgrading basic wing electrical systems, Phase I	Motor control centers replacement (A)
Duct washdown upgrade, Phase I[a]	Condition assessment upgrade (A) Duct washdown system refurbishment, Wings 3, 5, 7[b] (R)
Ventilation confinement zone separation upgrades, Phase II	• Air compressor replacement subsystems controlling HVAC dampers (R) • HVAC delta pressure indicator installation subsystem monitoring HVAC negative pressure (R) • Wing 9 Ventilation system upgrades (R)
Communications upgrades, Phase II	Emergency personnel accounting system (R)
Stack monitors upgrade, Phase I	Stack monitoring upgrades (R)
--	Hot cell upgrades - Wing 9 (R)

[a] Hood washdown upgrades may be addressed under facility operations administrative controls and is currently not included as a subproject.
[b] Only condition assessments for duct washdown have been authorized. Separate authorization will be issued for construction upon completion of assessments.

Canyon, and Guaje Mountain faults, which may increase the likelihood for fault rupture within TA–3 should a seismic event occur (see chapter 4, section 4.2.2.2, and appendix I). The earthquake accident frequencies utilized in appendix G have been compared to that which would be derived considering the results from the geologic mapping and trenching studies. Potential building seismic damage has been addressed for ground shaking and fault rupture, where appropriate, from earthquakes (volume III, appendix G, Table G.5.4–3). The seismic failure frequencies that were used in the accident analysis do not increase significantly as a result of seismic ground rupture. The basis for this conclusion is that the return period (the inverse of frequency) for a damaging fault rupture is significantly greater than the return periods used for damaging ground motion in the accident analysis. Because additional damage could result should a fault rupture occur at the CMR Building, a sensitivity study is performed for this scenario as part of the earthquake analysis (appendix G, SITE–03).

The DOE has decided not to implement the seismic upgrades as part of the CMR Building Upgrades Project, Phase II. This is a result of: (1) new seismic studies published after the draft SWEIS was released that indicated the additional hazard of a seismic rupture at the CMR Building (chapter 4, section 4.2.2.2, and appendix I) and (2) DOE's postponement of the decision to implement the pit manufacturing capability beyond 20 pits per year in the near future. Although the seismic rupture risk does not have a substantial effect on the overall seismic risk, it is an aspect of risk that cannot be cost-effectively mitigated through engineered structural upgrades. Given that assessment, the DOE is considering more substantial actions that are not yet ripe for analysis in the SWEIS (e.g., replacement of aging structures). The overall goal of DOE's evaluation is to ultimately reduce the risk associated with seismic event, should one occur. In the meantime, DOE is taking actions to mitigate seismic risks through means other than seismic upgrades (e.g., minimizing material at risk and putting temporarily inactive material in process into more sturdy containers).

Description of Capabilities

The operational CMR capabilities include both radioactive and nonradioactive substances. Work involving radioactive material (including uranium-235, depleted uranium, thorium-231, plutonium-238, and plutonium-239) is performed inside hoods, hot cells, and gloveboxes. Chemicals such as various acids, carcinogenic materials, and organic-based liquids are used in small quantities, generally in preparation of radioactive materials for processing or analysis.

The principal activities conducted at the CMR Building are described below. The manner in which these activities will vary among the alternatives is described in chapter 3.

Analytical Chemistry. Analytical chemistry capabilities involving the study, evaluation, and analysis of radioactive materials reside at the CMR Building. These activities support research and development associated with various nuclear materials programs, many of which are performed at other LANL locations on behalf of or in support of other sites across the DOE complex (e.g., Hanford Reservation, Savannah River Site, Sandia National Laboratories). Sample characterization activities include assay and determination of isotopic ratios of plutonium, uranium, and other radioactive elements; major and trace elements in materials; the content of gases; constituents at the surface of various materials; and methods to characterize waste constituents in hazardous and radioactive materials.

Uranium Processing. Operations essential for the stewardship of uranium products are conducted at this facility. They include uranium processing (casting, machining, and reprocessing operations, including research and development of process improvements and characteristics of uranium and uranium compounds), and the handling and storage of high radiation materials. The facility also provides limited backup to support the nuclear materials management needs for activities at TA–55 and also provides pilot-scale unit operations to back up the uranium technology activities at the Sigma Complex (described in section 2.2.2.5), other LANL facilities, and other DOE sites.

Destructive and Nondestructive Analysis. Destructive and nondestructive analysis employs analytical chemistry, metallographic analysis, measurement on the basis of neutron or gamma radiation from an item, and other measurement techniques. These activities are used in support of weapons quality, component surveillance, nuclear materials control and accountability, SNM standards development, research and development, environmental restoration, and waste treatment and disposal.

Nonproliferation Training. LANL utilizes measurement technologies at the CMR Building and other LANL facilities to train international inspections teams for the International Atomic Energy Agency. Such training may use SNM.

Actinide Research and Processing. Actinide research and processing at the CMR Building typically involves solids, or small quantities of solution. However, any research involving highly radioactive materials or remote handling may use the hot cells that are in Wing 9 of the CMR Building to minimize personnel exposure to radiation or other hazardous materials. CMR actinide research and processing may include separation of medical isotopes from targets, processing of neutron sources (DOE 1995d), and research into the characteristics of materials, including the behavior or characteristics of materials in extreme environments (e.g., high temperature or pressure).

Fabrication and Metallography. Fabrication and metallography at the CMR Building involves a variety of materials, including hazardous and nuclear materials. Much of this work is done with metallic uranium. The CMR Building can fabricate and analyze a variety of parts, including targets, weapon components, and parts used for a variety of research and experimental tasks.

2.2.2.4 *Pajarito Site: Los Alamos Critical Experiments Facility (TA–18)*

The Los Alamos Critical Experiments Facility (LACEF) and other experimental facilities are located at TA–18, which is known as Pajarito Site. TA–18 facilities are 3 miles (4.8 kilometers) from the nearest residential area, White Rock, and 0.25 miles (400 meters) from the closest technical area (Figure 2.2.2.4–1 and Table 2.2.2.4–1). These facilities are in a canyon near the confluence of Pajarito Canyon and Threemile Canyon. Some natural shielding is afforded by the surrounding canyon walls that rise approximately 200 feet (61 meters) on three sides.

Description of Facility

The facility consists of a main building, three outlying remote-controlled critical assembly buildings known as kivas, and several smaller laboratory, nuclear material storage, and support buildings. Kivas #1, #2, and #3 are Category 2 nuclear facilities. Each kiva is surrounded by a fence to keep personnel at a safe distance during criticality experiments, and the entire site is bounded by a security fence to aid in physical safeguarding of SNM. Site access is through a guarded portal.

The main laboratory building (Building 30) houses offices for group management, staff, and health physics personnel. There are several radioactivity counting rooms, an electronic

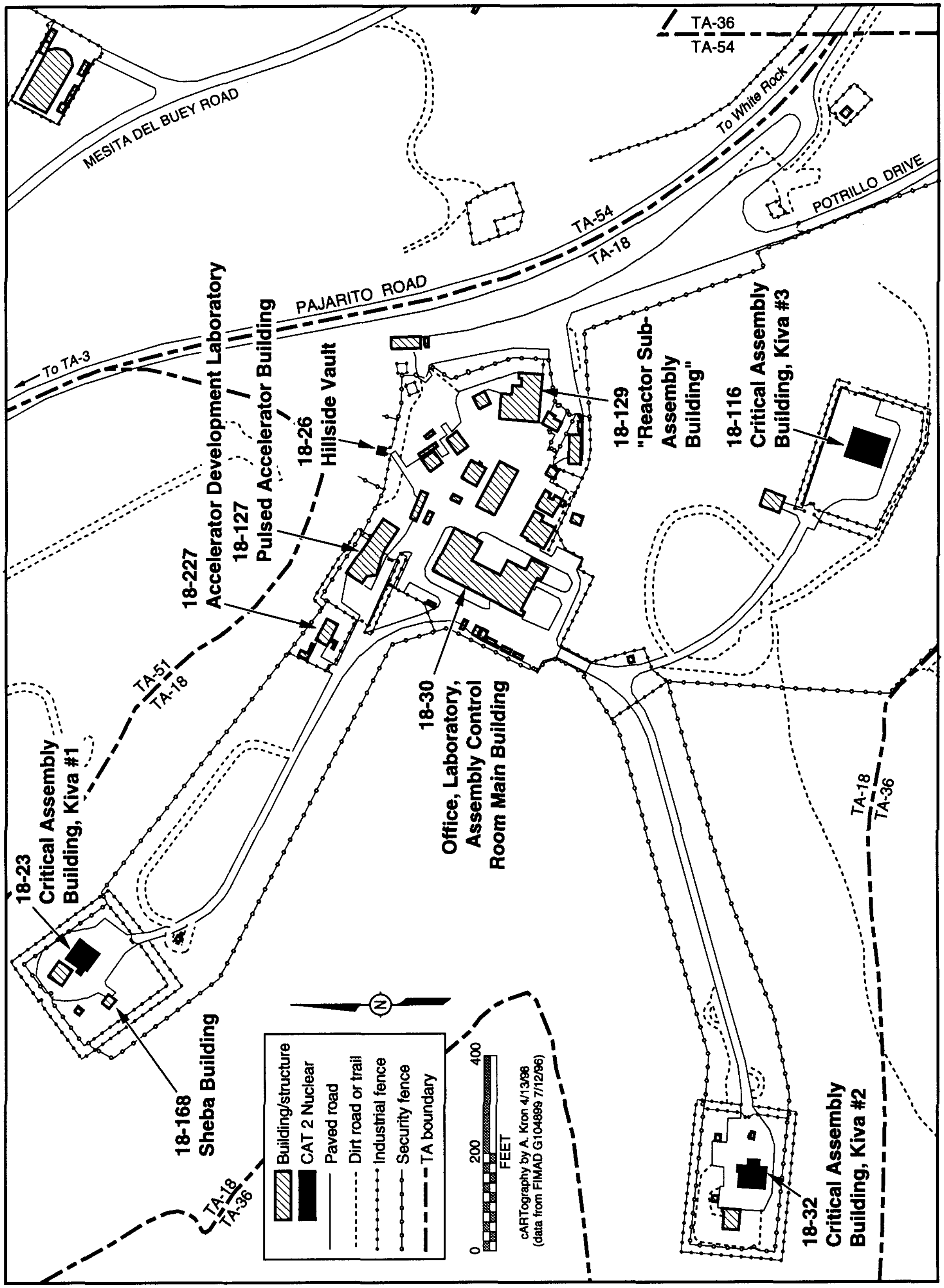


FIGURE 2.2.2.4–1.—*TA–18 Pajarito Site.*

TABLE 2.2.2.4–1.—*Principal Buildings and Structures of the Pajarito Site*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–18	Warehouse: 18–28
	Main Building: 18–30
	Pulsed Accelerator Building: 18–127
	Reactor Subassembly Building[a]: 18–129
	Critical Assembly Kivas: 18–23, 18–32, 18–116
	Vault: 18–26
	Sheba Building: 18–168
	Accelerator Development Laboratory: 18–227

[a] This is a historical name. This building is currently used for detector development and calibration and has never housed a nuclear reactor.

assembly area, the site machine shop, and the critical assembly control rooms in Building 30. Other support buildings are the Hillside Vault (Building 26) for nuclear material storage, the Pulsed Accelerator Building (Building 127) for projects requiring a "clean" radiation environment, and Building 129 for detector development and calibration.

Description of Capabilities

The principal TA–18 activities are the design, construction, research, development, and applications of critical experiments (that is, experiments having to do with nuclear criticality). These are conducted using five types of assemblies:

- Benchmark critical assemblies
- General purpose assembly machines
- Solution assemblies (which use fissile solutions)
- Prototype low power reactor assemblies (these do not need heat rejection systems)
- Fast-burst assemblies for producing fast-neutron pulses

TA–18 activities also include development, training, and applying nuclear diagnostic and accountability techniques. Nuclear materials control and handling, waste characterization, and criticality experiments are areas of particular interest. The Nuclear Emergency Search Team, Strategic Defense Initiative Program, and the Strategic Arms Reduction Treaty Verification Group all utilize TA–18 in fulfilling their program requirements. The TA–18 staff trains personnel from a variety of occupations and several countries in criticality safety as well as radiation detection and instrumentation.

Since 1948, thousands of criticality experiments and measurements have been performed at LACEF on assemblies using uranium-233, uranium-235, and plutonium-239 in various configurations, including nitrate, sulfate, and oxide compounds as well as solid, liquid, and gas forms. Critical assemblies at LACEF are designed to operate at low-average power and at temperatures well below phase change transition temperatures (which sets them apart from normal reactors) with low fission production and a minimal inventory. These assemblies are very flexible in terms of fuel loading, configuration, and the types and forms of material that can be used for experiments. Since these assemblies do not require forced convection cooling, a potential source of stored energy and fission products is eliminated. Post-shutdown cooling is unnecessary, and experiments are "walk-away" safe. Machine designs are relatively simple with the prime requirement being that operations are remotely controlled from a control room in Building 30 or from behind thick shielding.

Experiments employ fissile species such as uranium-233, uranium-235, and plutonium-239. Between experiments, these special nuclear materials are stored in designated storage areas at kivas or in the Hillside Vault.

Nuclear material is moved by truck to and from TA–18 over public roads in U.S. Department of Transportation (DOT)-approved shipping containers or using road closures on an as-required (infrequent) basis. The on-site TA–18 nuclear materials inventory is relatively stable, and consists primarily of isotopes of plutonium and uranium. The bulk of the plutonium is solid and is either clad or encapsulated; plutonium oxide is doubly canned. The use of toxic and hazardous chemicals is limited.

The criticality experiments generate very small amounts of fission products and there is essentially no radioactive waste. Criticality experiments do not release significant emissions to the atmosphere at the site.

The principal sets of experimental activities conducted at TA–18 are described below. The manner in which these activities would vary under each of the alternatives is described in chapter 3.

Dosimeter Assessment and Calibration. TA–18 critical assemblies are used to evaluate the performance of personnel radiation dosimeters. Nuclear accident dosimetry studies are conducted using the critical assembly radiation to simulate criticality accident radiation. The facility hosts national dosimetry intercomparison studies involving personnel and dosimeters from DOE and private nuclear facilities.

Detector Development. TA–18 personnel have developed and built nuclear materials detection instruments used to monitor pedestrians and vehicles, as well as hand-held and field-deployable neutron and gamma-ray detectors. TA–18 personnel also operate a simulation facility in which nuclear materials can be configured to develop and validate instruments and methods used in nuclear nonproliferation programs.

A new method of monitoring alpha-particle-emitting nuclear materials is undergoing development at TA–18 along with the development of detectors that can help assess potential threats from terrorist organizations. TA–18 personnel also train nuclear emergency search team personnel in the use of these instruments.

Materials Testing. The TA–18 facilities are used to characterize and evaluate materials, primarily by measuring the nuclear properties of these materials. The materials evaluated are typically structural materials or those to be used as shielding or neutron absorbers. Materials testing typically involves use of radiation sources or critical assemblies as radiation generators and measurement of radiation levels under a variety of conditions.

Subcritical Measurements. Subcritical measurements are those done on arrays of fissile material that are below the critical mass for material in a given form. Subcritical experiments may vary any or all of the factors that influence criticality (mass, density, shape, volume, concentration, moderation, reflection, neutron absorbers, enrichment, and interactions). Associated measurement techniques involve measuring some aspect of the neutron or gamma population in the material to assess its criticality state.

Fast-Neutron Spectrum. TA–18 has bare and reflected metal critical assemblies that operate on a fast-neutron spectrum. These assemblies typically have irradiation cavities in which flux foils, small replacement samples, or small experiments can be inserted. Typical experiments include evaluation of the reactivity of material samples, irradiation of novel neutron and gamma measuring instrumentation, and testing and calibrating radiation dosimeters.

Dynamic Measurements. Two fast-pulsed assemblies at TA–18 produce controlled, reproducible pulses of neutron and gamma radiation from tens of microseconds to several tens of milliseconds in duration. These pulses are useful for applications such as neutron physics measurements, instrumentation development, dosimetry, and materials testing.

Skyshine Measurements. The study of skyshine (radiation transported point to point without a direct line of sight) is a component of dosimetry primarily applicable to neutron producing processes and facilities. TA–18 uses critical assemblies to produce radiation fields to mimic those found around nuclear weapons production and dismantlement facilities, in storage areas, and in experimental areas.

Vaporization. The fast-pulsed assemblies at TA–18 have the capability of vaporizing fissile materials placed in a thermalizing material next to the assembly or in an internal cavity. These vessels are placed inside multiple containment vessels to prevent leakage of vaporized materials and fission products. This capability is useful for testing materials, measuring the properties of fissile materials, and testing reactor fuel materials in simulated accident conditions.

Irradiation. Several critical assemblies at TA–18 can have varying spectral characteristics in both steady state and pulsed modes. These assemblies are typically used for irradiating fissile materials and other materials with energetic responses for the purposes of testing and verifying computer code calculations.

2.2.2.5 *Sigma Complex (TA–3–66, TA–3–35, TA–3–141, and TA–3–159)*

The Sigma Complex consists of the main Sigma Building (Building 66) and its associated support structures, including the Beryllium Technology Facility (Building 141), the Press Building (Building 35), and the Thorium Storage Building (Building 159) (see Figure 2.2.2.5–1 and Table 2.2.2.5–1).

The Sigma Complex supports a large, multi-disciplinary technology base in materials fabrication science. This facility is used mainly for materials synthesis and processing, characterization, fabrication, joining, and coating of metallic and ceramic items. These capabilities are applied to a variety of materials, including uranium (depleted uranium and enriched uranium), lithium, and beryllium; the Sigma Complex is equipped to handle such materials safely. The current activities focus on limited production of special (unique or unusual) components, test hardware, prototype fabrication, and materials research in support of DOE programs in national security, energy, environment, industrial competitiveness, and strategic research. The Sigma Complex also provides support to research and development activities conducted elsewhere at LANL by constructing special pieces of equipment and test items.

Description of Facilities

The Sigma Building is designated as a Hazard Category 3 nuclear facility. The Sigma Building was built in 1958 and 1959, with an addition constructed in the late 1980's. It contains four levels and approximately 168,200 square feet of floor space (15,626 square meters). The Sigma Building is composed of four sectors. Three sectors built in the late 1950's were not constructed to current seismic design criteria (seismic upgrades are included in all alternatives). The fourth sector,

TABLE 2.2.2.5–1.—*Principal Structures and Buildings in the Sigma Complex*

TECHNICAL AREA	PRINCIPAL STRUCTURES AND BUILDINGS
TA–3	Sigma Building: 3–66 Press Building: 3–35 Beryllium Technology Facility: 3–141 Thorium Storage Building: 3–159

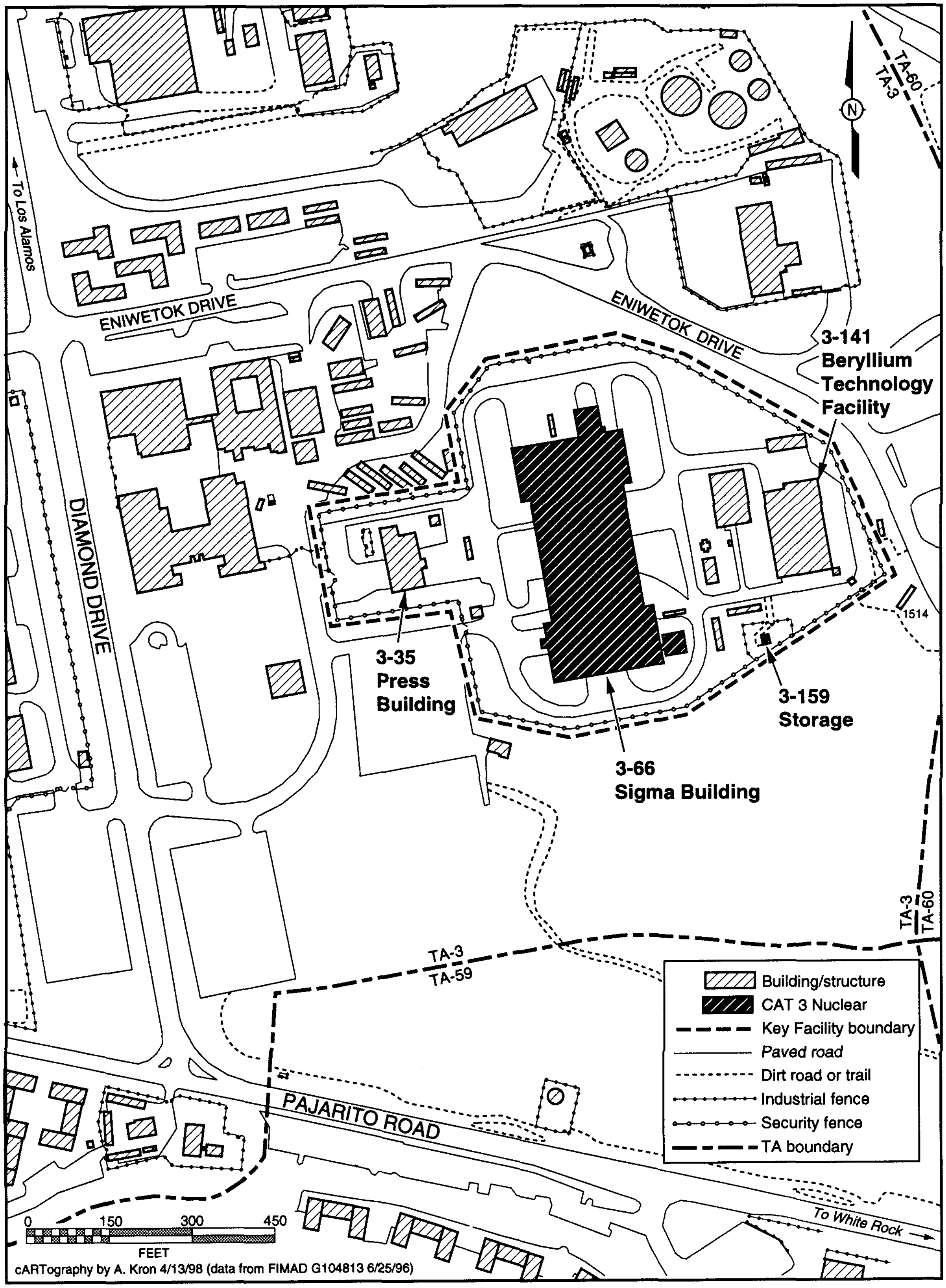


FIGURE 2.2.2.5–1.—*The Sigma Complex in TA–3.*

built in the late 1980's, meets current seismic design criteria. Hazardous chemicals such as concentrated acids and caustic solutions are used and stored at the Sigma Building. Sigma Building air exhausts through six major exhaust stacks and through numerous roof exhausts. Aqueous waste from enriched uranium processing and liquid chemical waste are routed to the RLWTF at TA–50 (described in section 2.2.2.14). Most of the liquid waste from the Sigma Complex is generated from the electroplating operation at the Sigma Building. Electrodeposition solutions are now vacuum distilled and re-used; the sludges are managed as RCRA wastes.

The Beryllium Technology Facility (3-141), formerly called the Rolling Mill Building, was built in the early 1960's and encompasses approximately 20,213 square feet (1,878 square meters) on three levels. This building does not have a hazard designation. The two sectors of the building meet current seismic design criteria. The building houses powder metallurgy activities, filament welding, ceramics research and development, and rapid solidification research. Fabrication work using beryllium and uranium/graphite fuels is performed here. The beryllium area has a permitted, monitored stack equipped with a HEPA filtered exhaust air system.

The Press Building (3-35) was built in 1953 and contains approximately 9,860 square feet (916 square meters) of space located on one floor and a partial basement. This building does not have a hazard designation and was not evaluated for seismic capability. A 5,000-ton (4,536-metric-ton) hydraulic press used for work with depleted uranium is operated here. One stack exhausts through HEPA filters. The exhaust stream is monitored for radioactive emissions. Aqueous waste from uranium processing and other nonhazardous operations is routed, via a pipeline, to the RLWTF at TA–50.

The Thorium Storage Building is designated as a Hazard Category 3 nuclear facility. Thorium is stored here, in both ingot and oxide form. This building is very small and was not evaluated for seismic capability.

Description of Capabilities

The primary activities conducted within the Sigma Complex are described below. The manner in which these activities would vary under each of the alternatives is described in chapter 3.

Research and Development on Materials Fabrication, Coating, Joining, and Processing. Materials synthesis and processing work addresses research and development on making items out of materials that are difficult to work with. The processes include applying coatings and joining materials using plasma, arc welding and other techniques. The materials used in fabrication are also reprocessed (i.e., separated into pure forms for reuse or storage).

Characterization of Materials. Materials characterization work includes understanding the properties of metals, metal alloys, ceramic-coated metals, and other similar combinations along with the effects on these materials and properties brought about by aging, chemical attack, mechanical stresses, and other agents.

Fabrication of Metallic and Ceramic Items. Materials fabrication includes work with metallic and ceramic materials, and combinations thereof. Items are fabricated out of uranium, both depleted and enriched in uranium-235. Stainless steel, lithium, various ceramics, and beryllium items are also fabricated. Items are fabricated on a limited production basis as well as one-of-a-kind and prototype pieces. One specific set of applications for this technology is the fabrication of nonnuclear weapons components. The responsibility for production of these components was assigned to LANL on the basis of the *Nonnuclear Consolidation*

Environmental Assessment (DOE 1993). This environmental assessment (EA) addressed the upgrades an interior modifications necessary for this assignment, and these upgrades and modifications are expected to continue through completion under all of the SWEIS alternatives (as identified in chapter 3).

2.2.2.6 *Materials Science Laboratory (TA–3–1698)*

The Materials Science Laboratory (MSL, TA–3–1698) is located in an unrestricted access area at the southeastern edge of TA–3 (Figure 2.2.2.6–1 and Table 2.2.2.6–1). The facility is a two-story modern laboratory of approximately 55,360 square feet of floor space (5,143 square meters) arranged in an H-shape. It is designed to accommodate scientists and researchers, including participants from academia and industry whose focus is on materials science research. The *Environmental Assessment for the Materials Science Laboratory* (DOE 1991) details the impacts of the new facility. The completion of the top floor of the MSL was planned and was included in the environmental assessment, but not funded in 1992. Completion of this floor is still desired but is not currently scheduled.

Description of Facilities

The MSL consists of 27 laboratories, 15 support rooms, 60 offices, 21 distinct materials research areas, and several conference rooms that are used by technical staff, visiting scientists and engineers, administrative staff, and building support personnel. It is constructed of precast concrete panels sealed to a structural framework, with concrete floors, drywall interior, casework, hoods, and a utility infrastructure. Safety controls throughout the complex include a wet-pipe sprinkler system, automatic fire alarms, chemical fume hoods, gloveboxes, HEPA-filtered heating, ventilation, and air conditioning, and safety showers.

TABLE 2.2.2.6–1.—*Principal Buildings and Structures of Materials Science Laboratory*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–3	Materials Science Laboratory: 3–1698

Limited quantities of radioactive isotopes are used at MSL. These include small quantities of solid sodium, zirconium, and depleted uranium. Because of the diversity of research within MSL, a large variety of small quantities of nonradioactive, toxic, and hazardous materials are also used. This is similar to the corrosive and reactive chemicals typically used to synthesize and clean materials in wet chemistry or mechanical property laboratories. For example, semiconductor additives such as tantalum metal and tungsten compounds, along with chromic acid and perchloric acid for metallography activities, are used in gloveboxes or fume hoods. Other acids such as hydrofluoric, phosphoric, and sulfuric, are used in various materials preparation activities and in laser operations. Small amounts of typical laboratory organic chemicals such as acetone, methyl alcohol, and methyl ethyl ketone are also used in MSL activities.

Description of Capabilities

There are four major types of experimentation supported at MSL: materials processing, mechanical behavior in extreme environments, advanced materials development, and materials characterization. These four areas, each of which are described below, contain over 20 capabilities that support materials research for DOE programs. Collaboration with private industry is also an important feature of much of the work performed at MSL. The manner in which these activities vary among the alternatives is described in chapter 3.

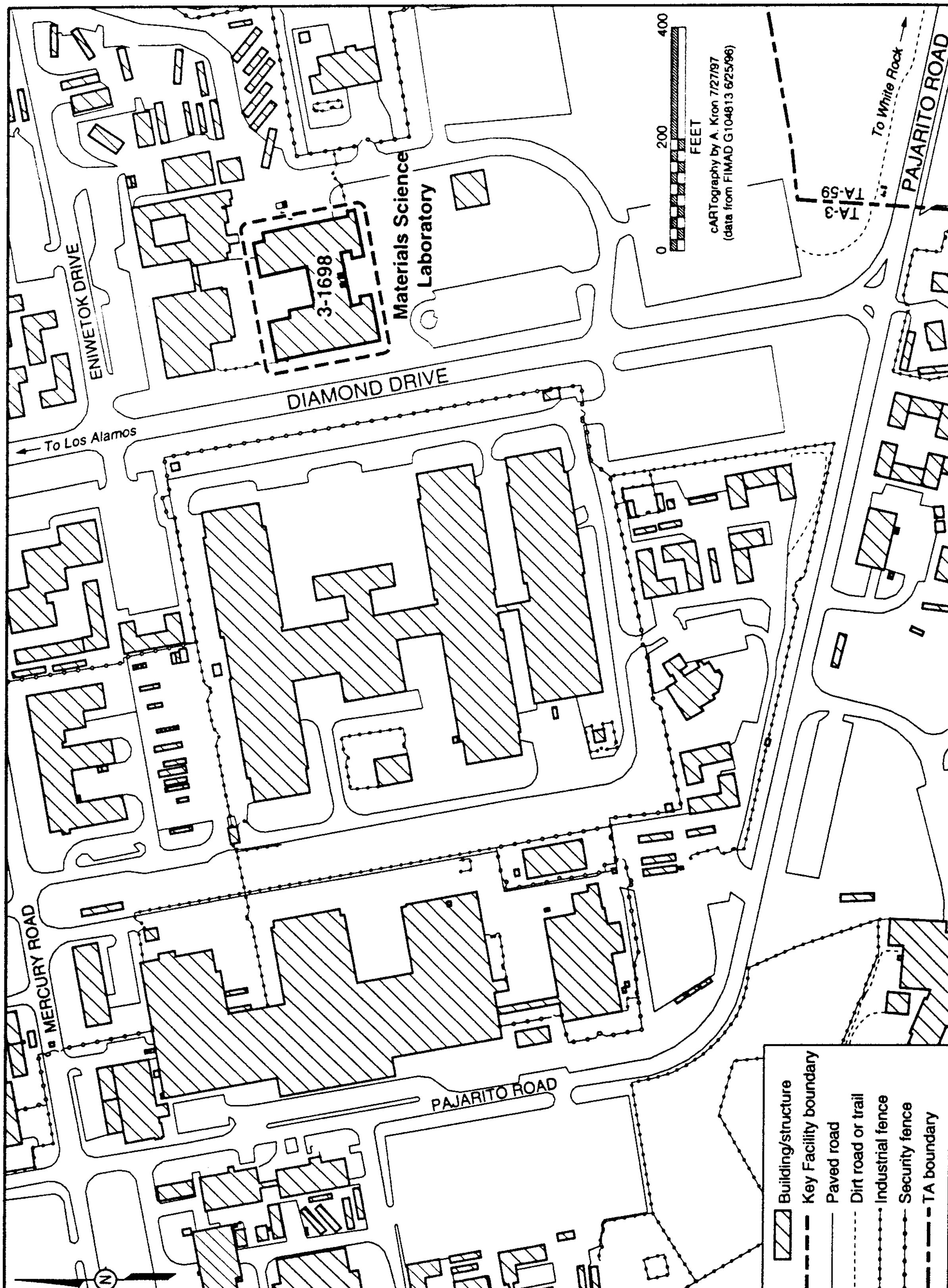


FIGURE 2.2.2.6–1.—*Materials Science Laboratory.*

Materials Processing. MSL supports the formulation of a wide range of useful materials through the development of materials fabrication and chemical processing technologies. The following synthesis and processing techniques represent some of the capabilities available in MSL for this area of research: wet chemistry, thermomechanical processing, materials handling, microwave processing, heavy equipment materials processing, single crystal growth synthesis, amorphous alloys, tape casting, inorganic synthesis, and powder processing.

Some of the laboratories, housing heavy equipment for novel mechanical processing of powders and non-dense materials, are configured to explore net shape and zero-waste manufacturing processes. Several laboratories are dedicated to the development of chemical processing technologies, including recycling and reprocessing techniques to solve current environmental problems.

Mechanical Behavior in Extreme Environments. The mechanical testing laboratories contain equipment for subjecting materials to a broad range of mechanical loadings to study their fundamental properties and characterize their performance. The laboratories utilized for this major area of materials science include dedicated space for mechanical testing; mechanical fabrication, assembly and machining research; metallography; and dynamic testing.

The mechanical testing laboratory offers capabilities to study multiaxial, high temperature, and high load behaviors of materials. The assembly areas consist of metalworking and experimental assembly areas that house a variety of electrically or hydraulically powered machines that twist, pull, or compress samples. The most energetic of these is a gas launcher, which projects a sample against an anvil at very high velocities. The MSL dynamic materials behavior laboratory is utilized by researchers for the study of high deformation rate behaviors. The dynamic testing equipment allows materials to be subjected to high rate loadings, including impact up to 1.2 miles (2 kilometers) per second. The metallography area contains equipment for sectioning, mounting, polishing, and photographing samples.

Advanced Materials Development. The various laboratories are configured for the exploration of new materials for high strength and high temperature applications. Many of the laboratories support synthesis and characterization of single crystals, nanophase, and amorphous materials, as well as providing areas for ceramics research including solid state, inorganic chemical studies involving materials synthesis. A substantial amount of effort in this area is dedicated to producing new high-temperature superconducting materials. MSL also provides facilities for synthesis and mechanical characterization of materials systems for bulk conductor applications.

Materials Characterization. Materials characterization provides the ability to understand the properties and processing of materials and to apply that understanding to materials development. MSL contains a collection of spectroscopy, imaging, and analysis tools for characterizing advanced materials. The electron microscopy laboratory area has four microscopes to characterize subnanometer to micrometer structures, including chemical analysis and high resolution electron holography. The optical spectroscopy laboratory allows ultrafast and continuous wave tunable resonance Raman scattering spectroscopy, high-resolution Fourier Transform Infrared absorption, and ultraviolet (UV) visible to near infrared (IR) absorption spectroscopy. The x-ray laboratory allows for the study of samples at temperatures up to 4,892°F (2,700°C) and pressures up to 80 kilobar. A metallography and ceramography support laboratory has the latest equipment for optical characterization. A laboratory area is provided to support surface-science study and corrosion characterization of materials.

2.2.2.7 *Target Fabrication Facility (TA–35)*

The Target Fabrication Facility (TFF) is approximately 61,000 square feet (5,667 square meters) of floor space with approximately 48,000 square feet (4,459 square meters) of laboratory area and 13,000 square feet (1,208 square meters) of office area (Figure 2.2.2.7–1 and Table 2.2.2.7–1). TFF is a two-story structure sited at TA–35 (Building 213) immediately to the east of TA–55, directly north of TA–50. Laboratories and offices occupy both the ground (lower) floor and the upper floor. In general, the structure is reinforced concrete. Vibration sensitive areas are supported on isolated concrete slabs. The HVAC system maintains a negative pressure (i.e., a pressure that is less than the pressure of the atmosphere outside the building) in the laboratories with both room air and hood exhaust vented to the atmosphere through filtered and, until 1995, monitored exhaust stacks. In 1995, monitoring was terminated when it was determined through analyses that monitoring was not required because of low facility chemical and radioactive material inventories. Sanitary waste is piped to the sanitary waste disposal plant near TA–46. Radioactive liquid waste and liquid chemical waste are shipped to TA–50 using a direct pipeline.

TABLE 2.2.2.7–1.—*Principal Buildings and Structures of Target Fabrication Facility*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–35	Target Fabrication Facility: 35–213

Description of Facilities

TFF maintains a beryllium machining capability used to manufacture structural shapes from beryllium. TFF is not a nuclear facility. Tritium was removed from the facility in 1993; however, operations involving tritium-contaminated materials are ongoing. Tritium contamination levels are low and are controlled below levels that would make this a nuclear facility. Depleted uranium coatings are no longer applied at TFF. Although a large number of chemicals are used, they are used in small quantities. TFF is designated as a moderate hazard chemical facility. The design for earthquake loads is in accordance with current applicable standards. Transportation in and out of the TFF consists of occasional deliveries and waste pickup typical of a research and development facility.

TFF houses the equipment and personnel for precision machining, physical vapor deposition, chemical vapor deposition, polymer sciences, and assembly of targets for inertial confinement fusion and physics experiments. These capabilities are complemented by personnel and equipment capable of performing high-technology material science, effects testing, characterization, and technology development.

Description of Capabilities

The three primary activities located at TFF are described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

Precision Machining and Target Fabrication. Precision machining operations produce sophisticated devices consisting of very accurate part shapes and often optical quality surface finishes. A variety of processes are used to produce the final parts, which include conventional machining, ultra-precision machining, lapping, and electron discharge machining. Dimensional inspections are performed during part production using a

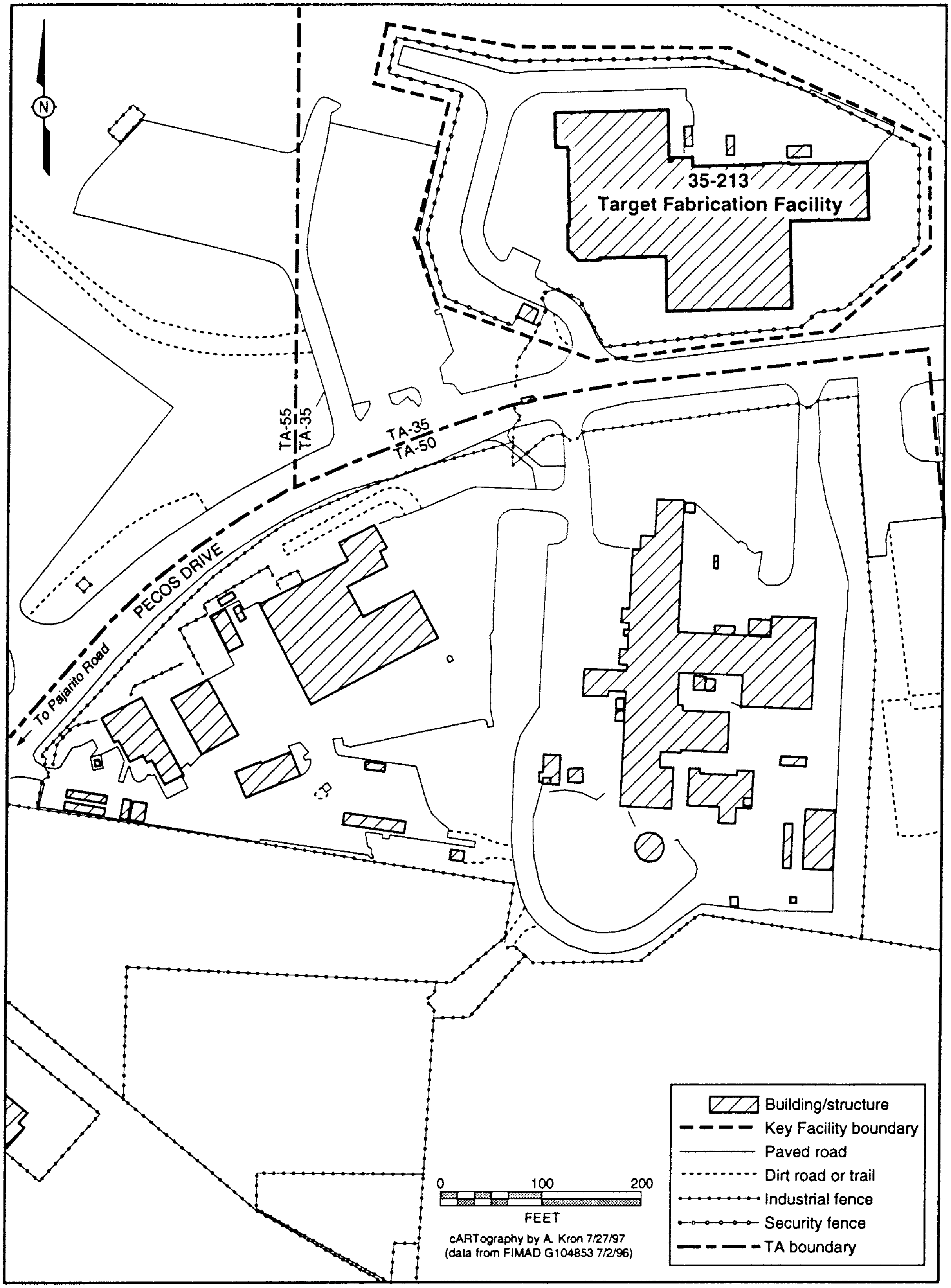


FIGURE 2.2.2.7–1.—*Target Fabrication Facility.*

variety of mechanically and optically based inspection techniques.

Polymer Synthesis. Polymer synthesis science formulates new polymers, studies their structure and properties, and fabricates them into various devices and components. Capabilities exist at TFF for developing and producing polymer foams by organic synthesis, liquid crystalline polymers, polymer host dye laser rods, microfoams and composite foams, high energy density polymers, electrically conducting polymers, chemical sensors, resins and membranes for actinide and metal separations, thermosetting polymers, and organic coatings. The materials and devices are typically prepared using solvents at temperatures ranging from 68° to 302°F (20° to 150°C) or by melt processing at temperatures from room temperature up to 572°F (300°C). A wide variety of analytical techniques are used to determine the structure and behavior of polymers, including spectroscopy, microscopy, x-ray scattering, thermal analysis, chromatography, rheology, and mechanical testing.

Chemical and Physical Vapor Deposition. Chemical vapor deposition (CVD) and chemical vapor infiltration (CVI) are processes used to produce metallic and ceramic bulk coatings, various forms of carbon (including pyrolytic graphite, amorphous carbon, and diamond), nanocrystalline films, powder coatings, thin films, and a variety of shapes up to 3.5 inches (9 centimeters) in diameter and 0.5 inches (1.25 centimeters) in thickness. CVD and CVI coating processes are routine operations that use a variety of techniques such as thermal hot wall, cold wall and fluidized bed techniques, laser assisted, laser ablation, radio frequency and microwave plasma techniques, direct current glow discharge and hollow cathode, and organometallic CVD techniques. The CVD process is used to produce thin film metallic, carbide, oxide, sulfide and nitride coatings. TFF scientists have also studied infiltrated materials using isothermal, thermal gradient, forced flow and plasma techniques. Polymer processing and extensive characterization is performed in conjunction with this work and occasionally, highly toxic substances such as nickel carbonyl, iron carbonyl, or arsenic hydride are handled.

Physical Vapor Deposition capabilities at TFF can apply layers of various materials on sophisticated devices with high precision. These layers, applied by various coating techniques, include a wide range of metals and metal oxides as well as some organic materials. Beryllium coatings applied to substrates by magnetron sputtering (performed in a specially ventilated vacuum chamber with HEPA filtered exhaust) is an example of physical vapor deposition performed at TFF.

2.2.2.8 *Machine Shops (TA–3)*

The main machine shops complex consists of two structures in the southwestern quadrant of TA–3: TA–3–39 and TA–3–102 (Figure 2.2.2.8–1 and Table 2.2.2.8–1). The two buildings are connected by a 125-foot (38-meter) long corridor. The machine shops provide special (unique or unusual) parts in support of other activities throughout LANL.

Description of Facilities

Building TA–3–39, the Beryllium Shop, was constructed in 1953, has a total floor space of approximately 134,000 square feet (12,449 square meters), and contains a variety of milling machines, vertical and horizontal lathes, surface grinders, internal and external grinders and assorted saws, laser cutter with

TABLE 2.2.2.8–1.—*Principal Buildings and Structures of Main Machine Shops*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–3	Machine Shops: 3–39
	Machine Shops: 3–102

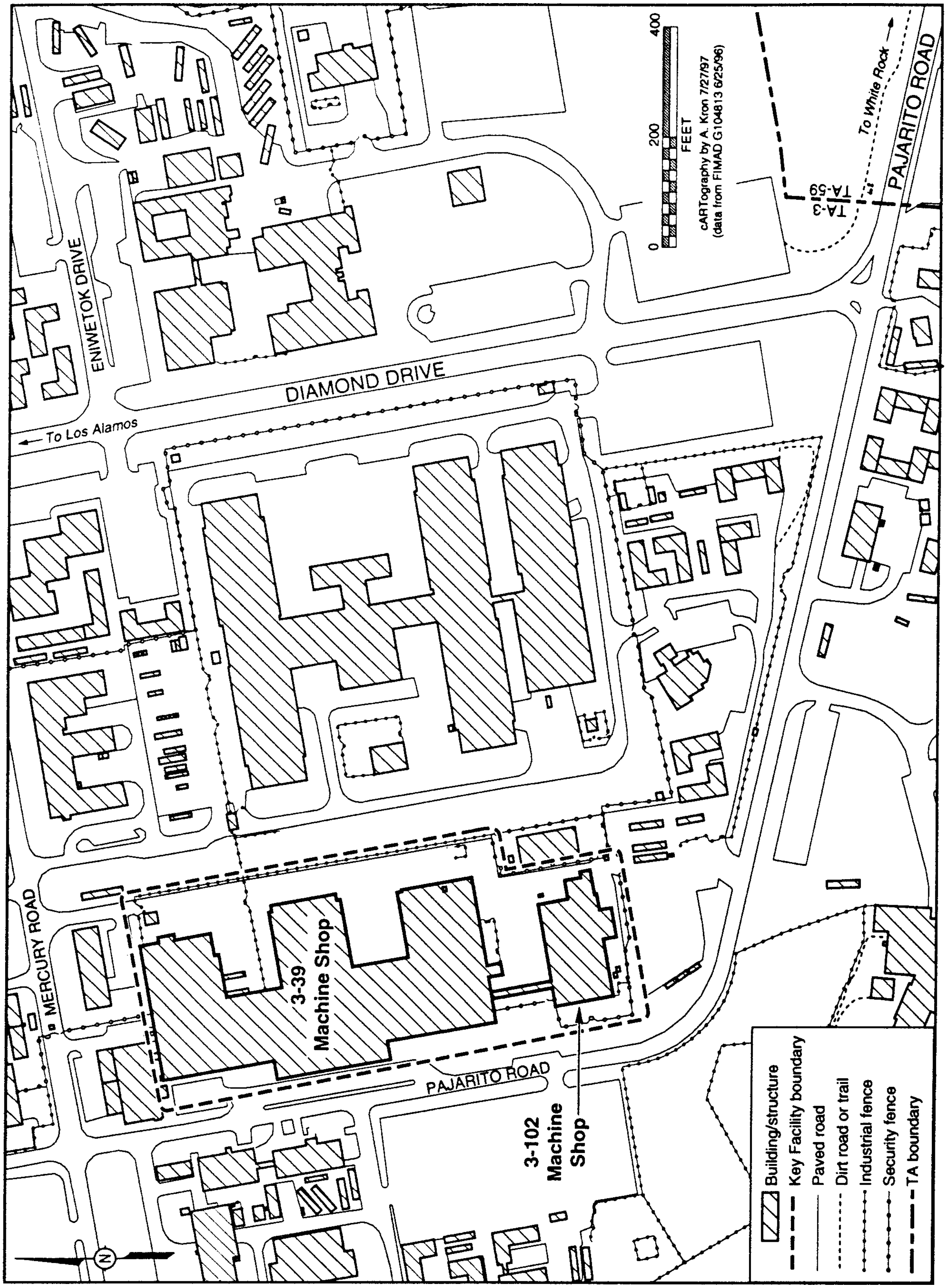


FIGURE 2.2.2.8–1.—*Main Machine Shops.*

welders, welding operations, and measuring equipment (Table 2.2.2.8–1). The Uranium Shop, TA–3–102, constructed in 1957, has a total floor space of approximately 12,500 square feet (1,161 square meters) and, like TA–3–39, contains a variety of metal fabrication machines.

The turnings and fines from depleted uranium fabrication result in a limited volume of radioactive waste. The use of depleted uranium is restricted to Building TA–3–102. While depleted uranium represents the bulk of the materials used, many other potentially hazardous materials (with toxic and pyrophoric characteristics) are used in this facility. These include materials such as beryllium and lithium compounds.

Description of Capabilities

Historically, LANL has maintained a prototype capability in support of research and development for nearly all of the components (parts) in nuclear weapons that are designed at LANL. The capabilities at the machine shops complex are: fabrication of specialty components, fabrication using unique or exotic materials, and dimensional inspection of the fabricated components. Each of these activities is described below. The manner in which these activities would vary among the alternatives are described in chapter 3.

Fabrication of Specialty Components. The fabrication of specialty components is the primary purpose for the existence of the machine shops complex. Specialty components are unique, unusual, or one-of-a-kind parts, fixtures, tools, or other equipment. These include components or equipment used in the destructive testing, replacement parts for the Stockpile Management Program, and gloveboxes for a variety of applications.

Fabrication Using Unique Materials. Fabrication using unique or exotic materials is one of the more important features of the machine shops complex. The list of unusual or unique materials routinely used includes depleted uranium, beryllium, and lithium (an extremely reactive material) and its compounds.

Dimensional Inspection of Fabricated Components. Dimensional inspection of the finished component is a standard step in the fabrication process and involves numerous measurements to ensure that the component is of the correct size and shape to fit into its allotted space and perform its intended function.

2.2.2.9 *High Explosives Processing*

The High Explosives (HE) Research and Development and Processing Facilities are located in parts of TA–8, TA–9, TA–11, TA–16, TA–22, TA–28, and TA–37 (Figures 2.2.2.9–1 through 2.2.2.9–8). These facilities were originally designed and built for production-scale operations during the early and mid 1950's and produced HE components for nuclear weapons in the U.S. stockpile reserve for several years (Table 2.2.2.9–1). LANL has historically upgraded and modernized processing equipment in these facilities to provide prototype HE components to meet the needs of the Nevada Test Site (NTS) program, hydrodynamic tests at LANL, detonator design and production, and other HE activities. Over the last few years, LANL has typically fabricated an average of 1,000 to 1,500 HE parts a year. With reductions in funding, many operations are being consolidated to reduce the number of buildings that must be maintained and the number of workers required.

Description of Facilities

TA–9 facilities with over 60,000 square feet (5,574 square meters) of floor space support HE synthesis, formulation, and characterization operations, as well as HE-related analytical chemistry, safety testing, process development, and stockpile surveillance. TA–16 facilities with over 280,000 square feet

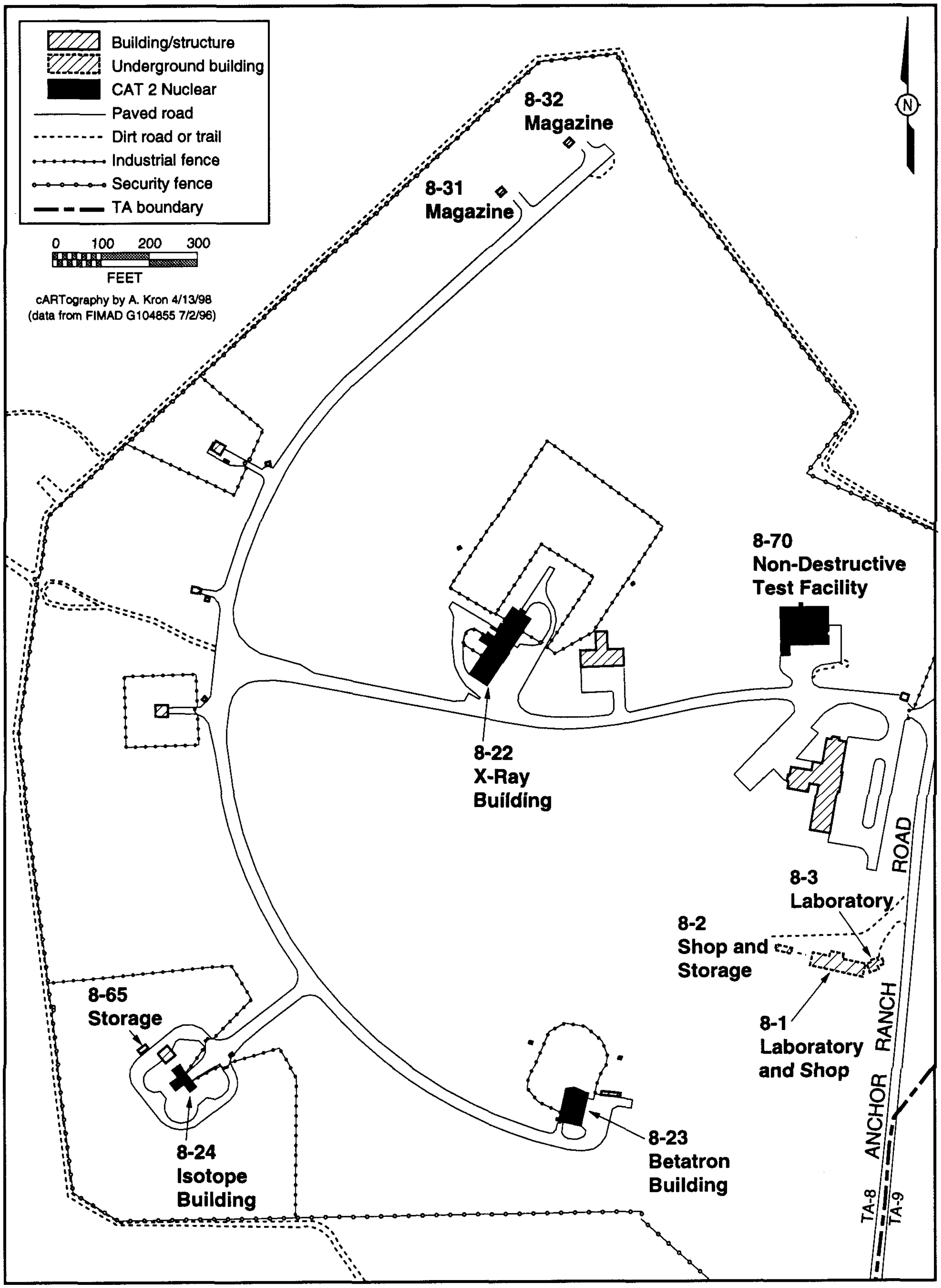
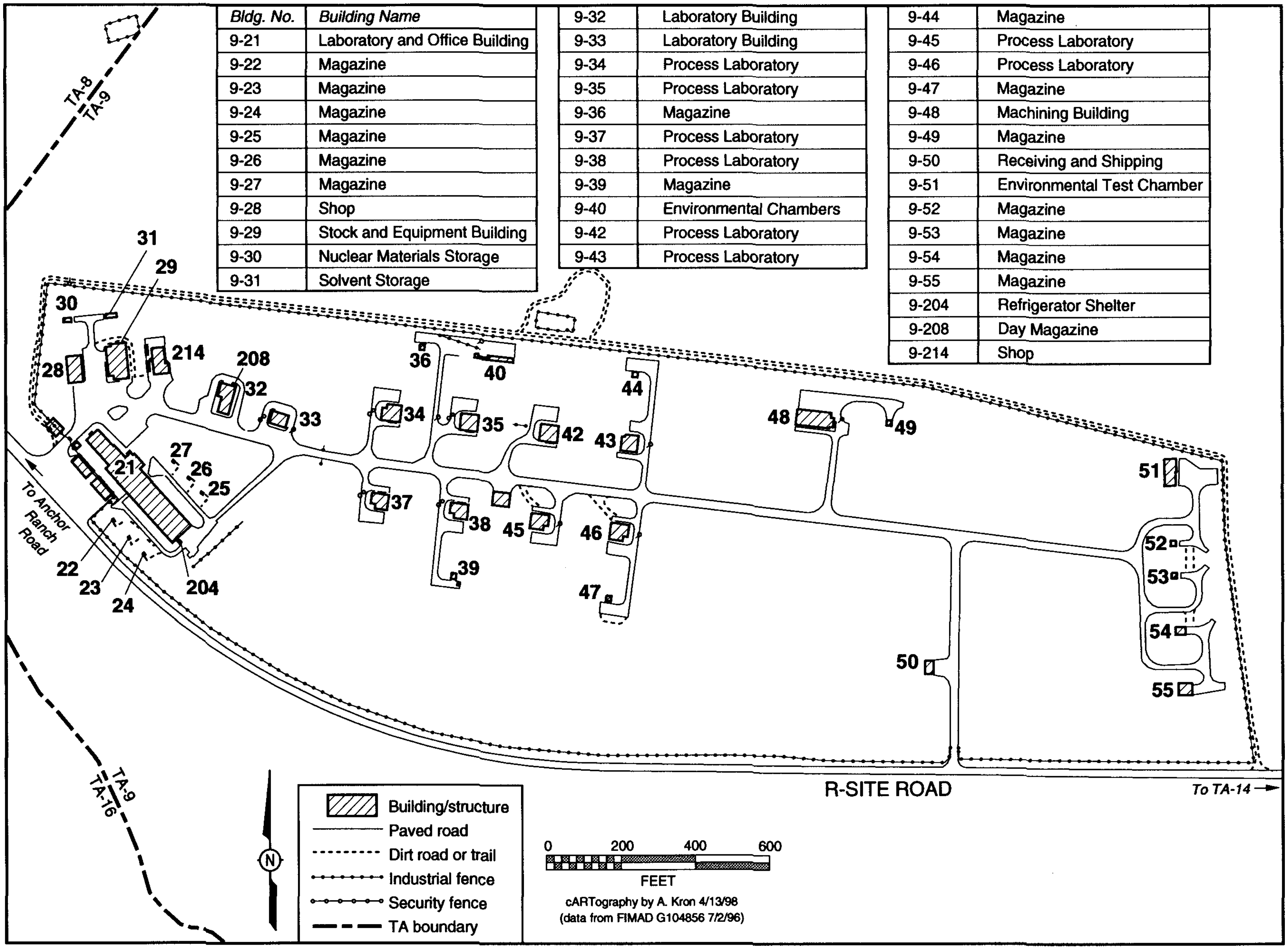


FIGURE 2.2.2.9–1.—*TA–8 High Explosives Processing.*



Bldg. No.	Building Name
9-21	Laboratory and Office Building
9-22	Magazine
9-23	Magazine
9-24	Magazine
9-25	Magazine
9-26	Magazine
9-27	Magazine
9-28	Shop
9-29	Stock and Equipment Building
9-30	Nuclear Materials Storage
9-31	Solvent Storage
9-32	Laboratory Building
9-33	Laboratory Building
9-34	Process Laboratory
9-35	Process Laboratory
9-36	Magazine
9-37	Process Laboratory
9-38	Process Laboratory
9-39	Magazine
9-40	Environmental Chambers
9-42	Process Laboratory
9-43	Process Laboratory
9-44	Magazine
9-45	Process Laboratory
9-46	Process Laboratory
9-47	Magazine
9-48	Machining Building
9-49	Magazine
9-50	Receiving and Shipping
9-51	Environmental Test Chamber
9-52	Magazine
9-53	Magazine
9-54	Magazine
9-55	Magazine
9-204	Refrigerator Shelter
9-208	Day Magazine
9-214	Shop

FIGURE 2.2.2.9–2.—*TA–9 High Explosives Processing.*

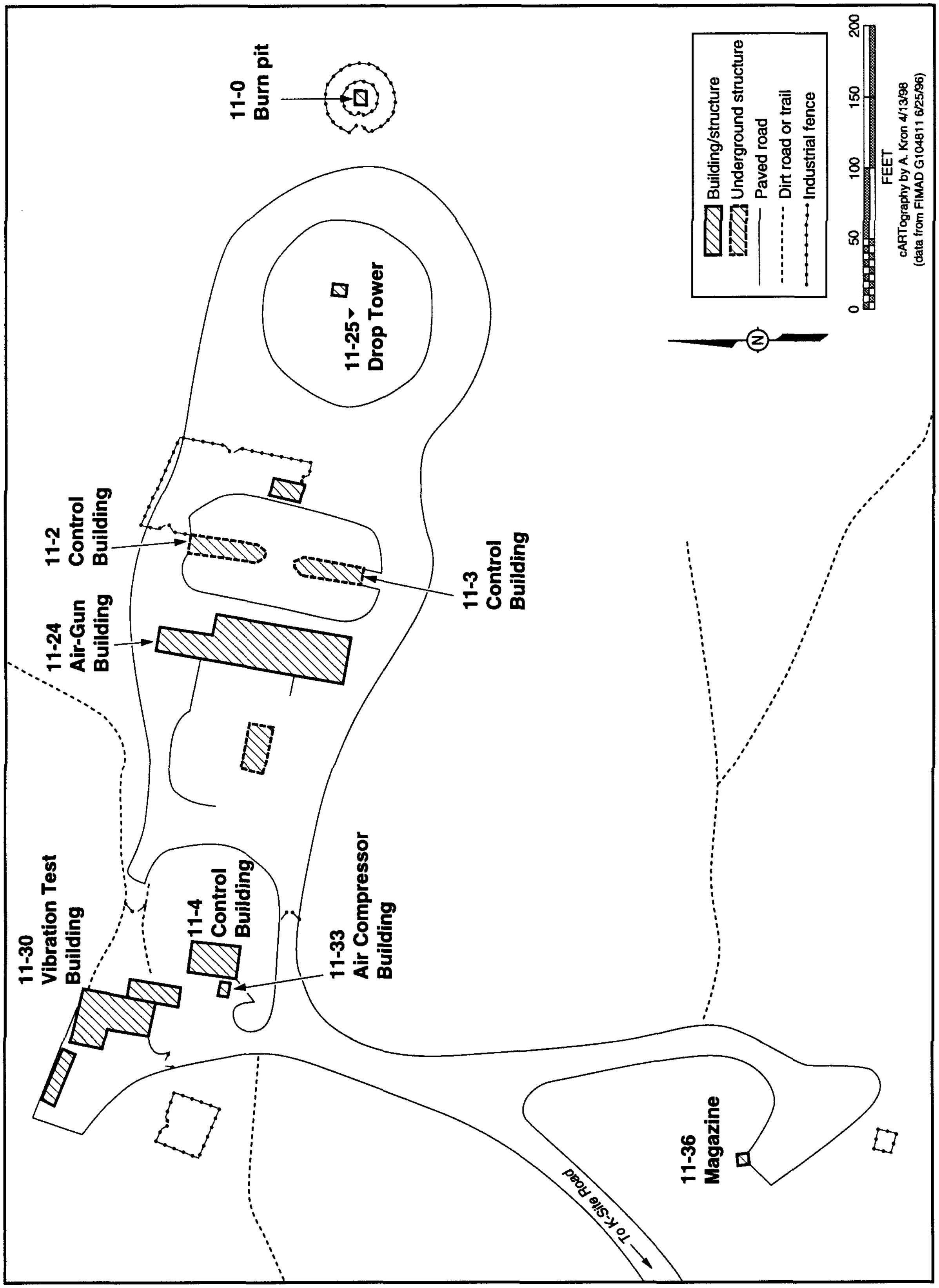


FIGURE 2.2.2.9–3.—*TA–11 High Explosives Processing.*

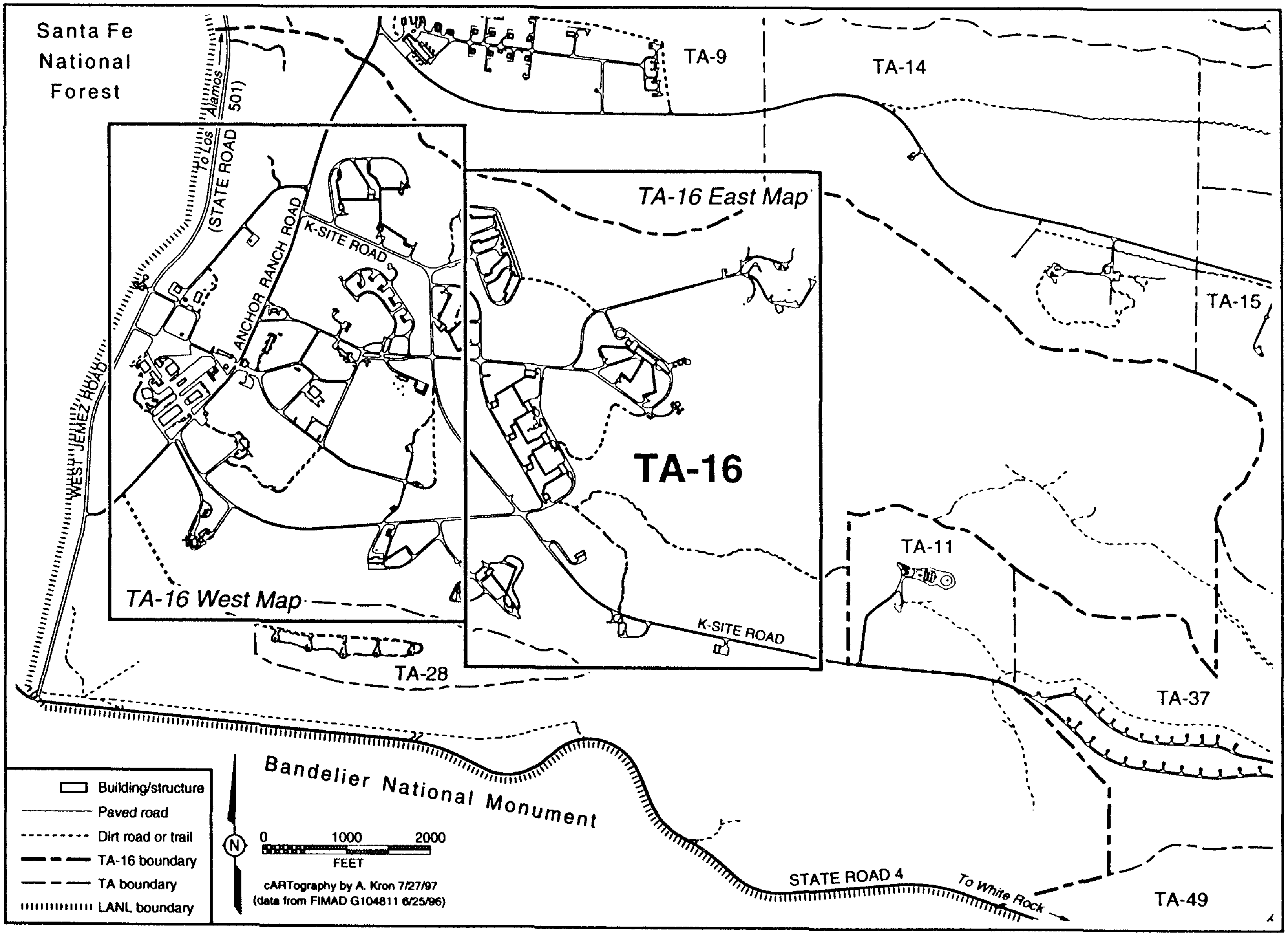
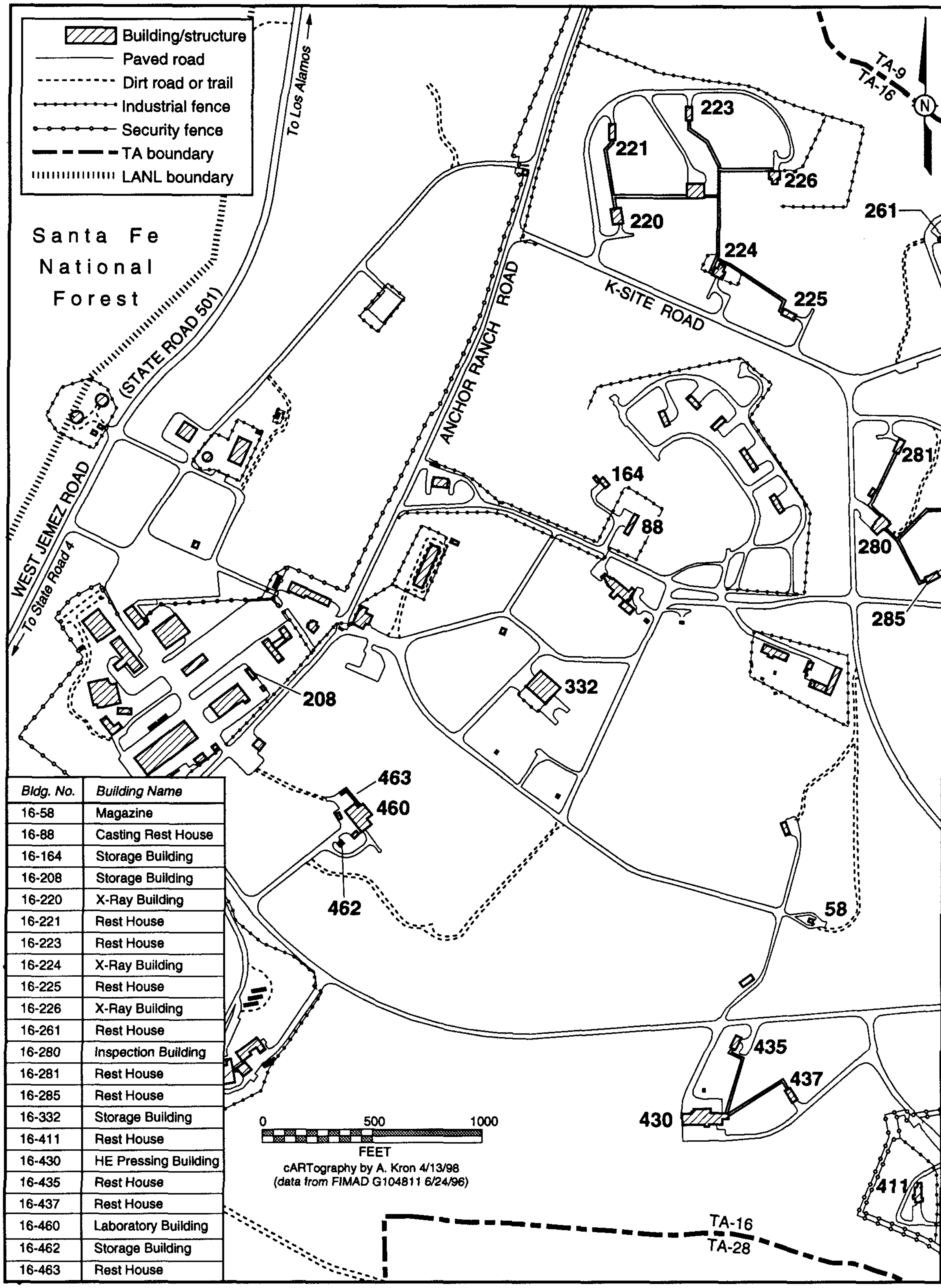
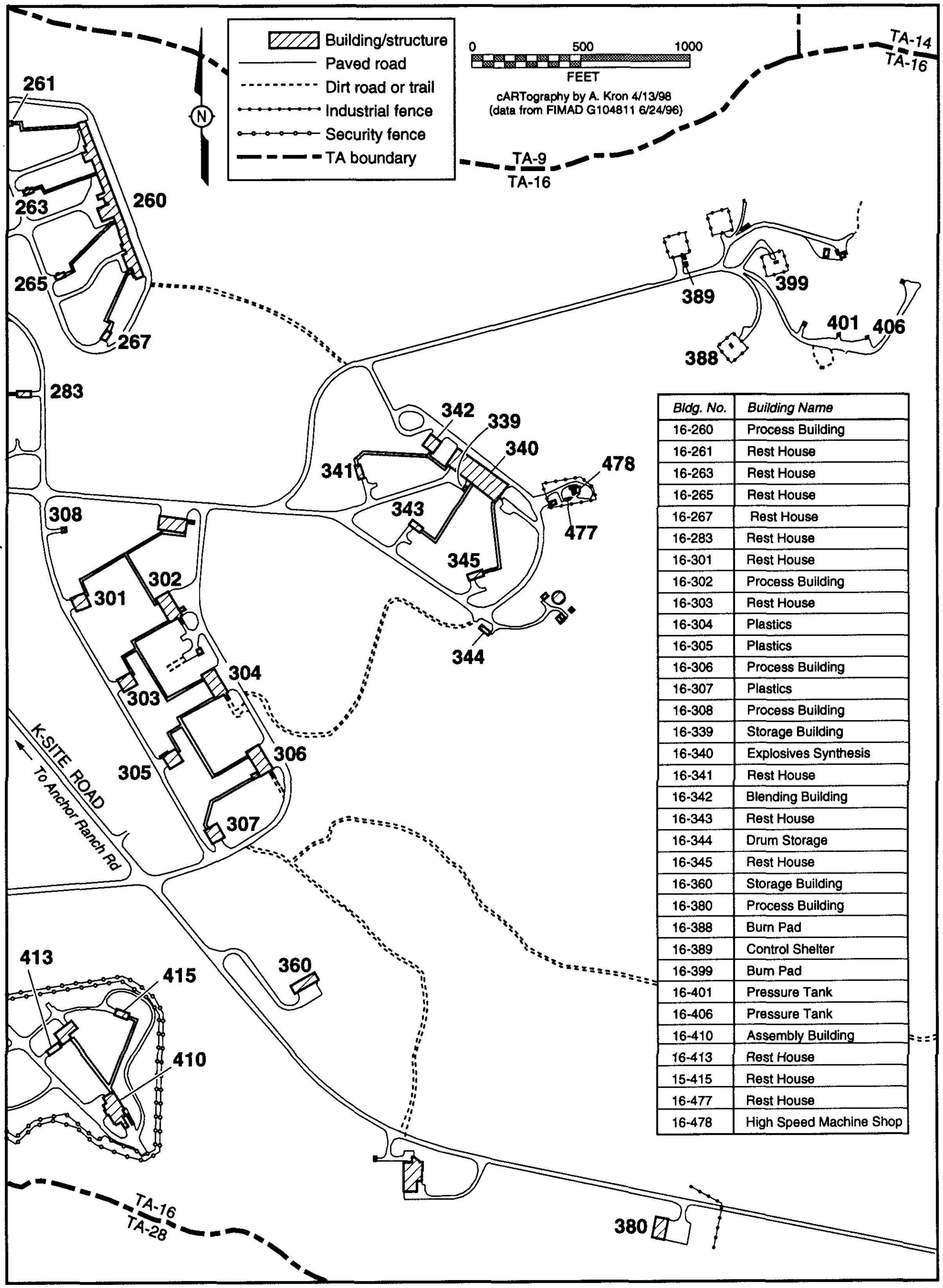


FIGURE 2.2.2.9–4.—*TA–16 High Explosives Processing.*



Bldg. No.	Building Name
16-58	Magazine
16-88	Casting Rest House
16-164	Storage Building
16-208	Storage Building
16-220	X-Ray Building
16-221	Rest House
16-223	Rest House
16-224	X-Ray Building
16-225	Rest House
16-226	X-Ray Building
16-261	Rest House
16-280	Inspection Building
16-281	Rest House
16-285	Rest House
16-332	Storage Building
16-411	Rest House
16-430	HE Pressing Building
16-435	Rest House
16-437	Rest House
16-460	Laboratory Building
16-462	Storage Building
16-463	Rest House

FIGURE 2.2.2.9–5.—*TA–16 West High Explosives Processing.*



Bldg. No.	Building Name
16-260	Process Building
16-261	Rest House
16-263	Rest House
16-265	Rest House
16-267	Rest House
16-283	Rest House
16-301	Rest House
16-302	Process Building
16-303	Rest House
16-304	Plastics
16-305	Plastics
16-306	Process Building
16-307	Plastics
16-308	Process Building
16-339	Storage Building
16-340	Explosives Synthesis
16-341	Rest House
16-342	Blending Building
16-343	Rest House
16-344	Drum Storage
16-345	Rest House
16-360	Storage Building
16-380	Process Building
16-388	Burn Pad
16-389	Control Shelter
16-399	Burn Pad
16-401	Pressure Tank
16-406	Pressure Tank
16-410	Assembly Building
16-413	Rest House
15-415	Rest House
16-477	Rest House
16-478	High Speed Machine Shop

FIGURE 2.2.2.9–6.—*TA–16 East High Explosives Processing.*

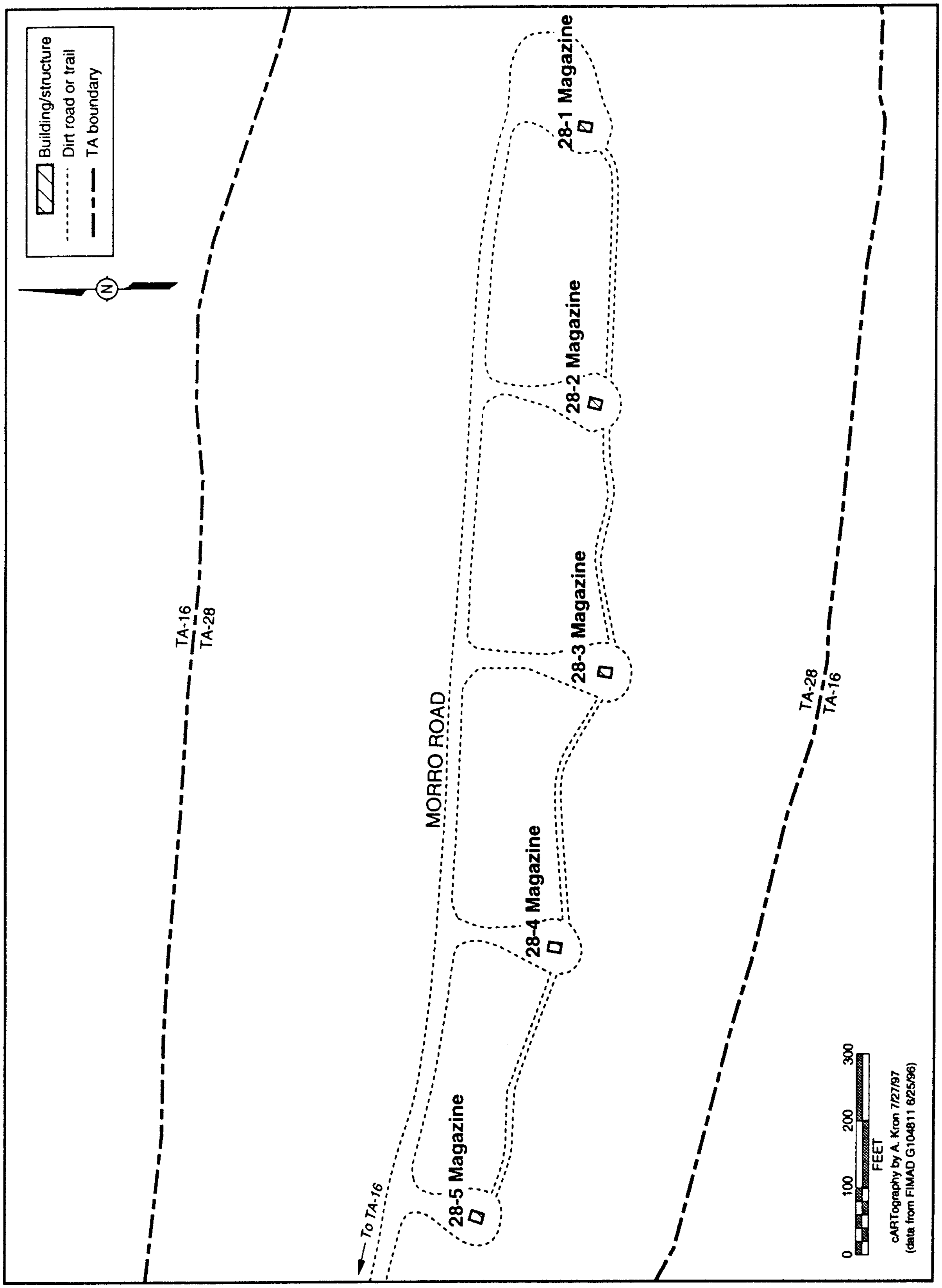


FIGURE 2.2.2.9–7.—*TA–28 High Explosives Processing.*

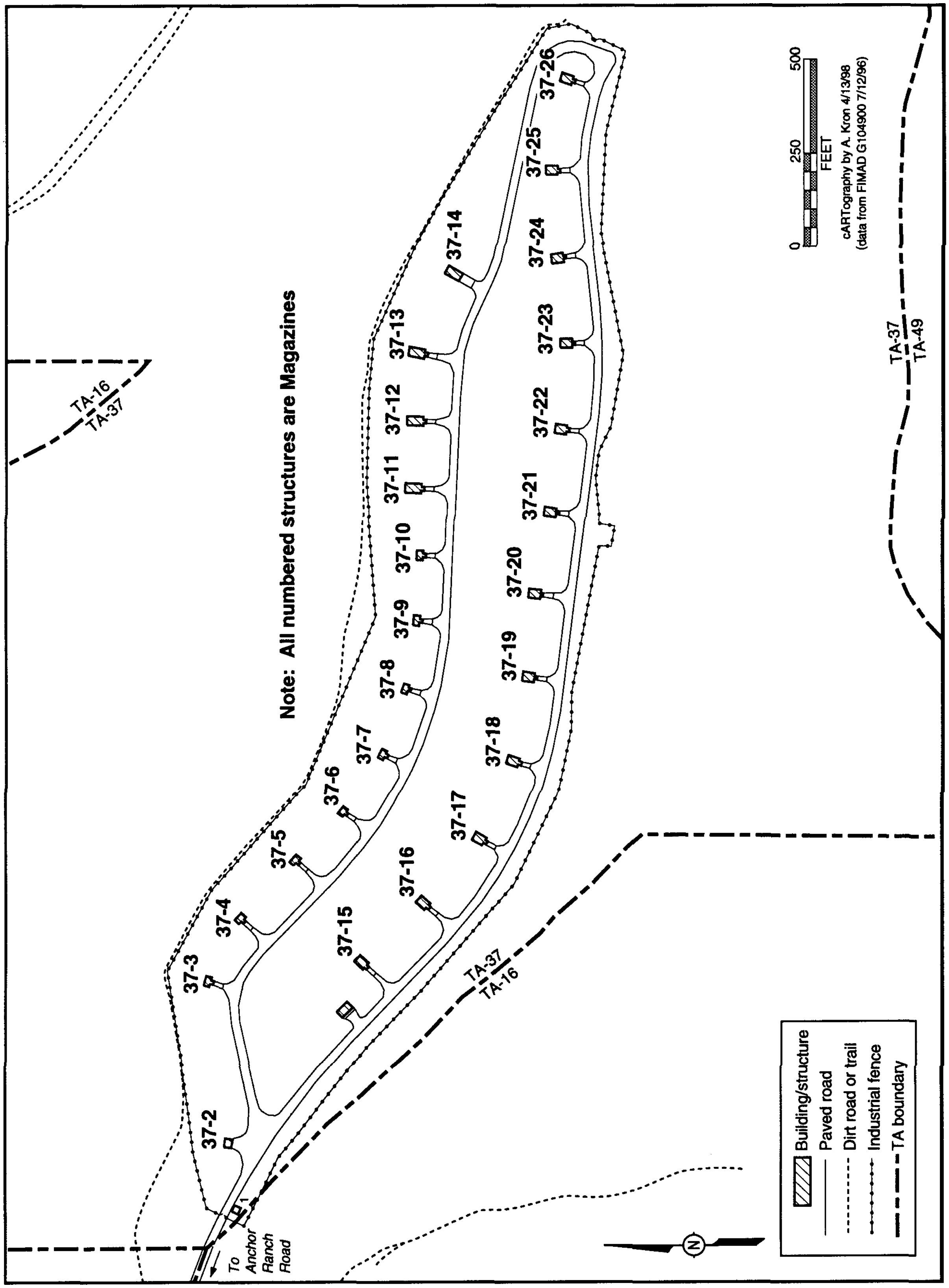


FIGURE 2.2.2.9–8.— *TA–37 High Explosives Processing.*

TABLE 2.2.2.9–1.—*High Explosives Processing Facilities: Identification of Principal Buildings/Structures*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–8	Nondestructive Testing/Radiography: 8–22, 23, 24, 70 Storage, Radiography Sources: 8–65
TA–9	Offices, Laboratories: 9–21, 32, 33, 34, 35, 37, 38, 42, 43, 45, 46 Service Magazines: 9–22, 23, 24, 25, 26, 27, 208 Shop Buildings: 9–28, 214 Nuclear Materials Storage: 9–30 Solvent Storage: 9–31 Magazines: 9–36, 39, 44, 47, 49, 52, 53, 54, 55, 204 Thermal Cycle Facility: 9–40 HE Machining Building: 9–48 Receiving and Shipping Building: 9–50 Detonator Storage: 9–51
TA–11	Control Buildings: 11–2, 3, 4 Air Gun Building: 11–24 Drop Tower: 11–25 Vibration Test Building: 11–30 Air Compressor Building: 11–33 Magazine: 11–36 Weapon Burn Test Facility: 11–0
TA–16	Instrumentation, Testing: 16–54 Magazine: 16–58 Storage Buildings: 16–164, 208, 332 Dark Room: 16–222 Process Buildings: 16–260, 306 Rest Houses (HE Magazines): 16–261, 263, 267 HE Assembly/Rest House: 16–265 Inspection Building: 16–280 Rest House/HE Shipping: 16–281 Rest House/Museum: 16–283 Rest House/HE Receiving: 16–285 Mock Explosives Prep (being vacated): 16–300 Rest House/HE Environmental Testing: 16–301 Process Building (being vacated): 16–302 Rest House (being vacated): 16–303 Plastics Buildings: 16–304, 305, 307 Solvent Storage: 16–339 Explosives Process Building: 16–340 Rest Houses: 16–341, 345, 411, 413, 415, 435, 437
TA–22	Detonation Systems Laboratory 22-90, 91, 93 Solvent Storage Shed 22-95 HE Storage Building 22-66, 67, 68, 69 Advanced Development Laboratory 22-34 HE Process Building 22-8 Magazines 22-7, 22–15, 16, 17, 18, 19, 20, 21, 22, 23
TA–28	Magazines, Protective Force: 28–1, 2, 3 Magazine, Explosives: 28–4 Magazine: 28–5
TA–37	Standard HE Magazines: 37–2 through 26

(26,013 square meters) of space support formulation, casting, pressing, machining, assembly, and a range of quality assurance operations. In addition, two beryllium operations are performed at TA–16. TA–11 comprises 12 buildings with 9,300 square feet (864 square meters) in which various environmental and safety tests are performed. The four principal buildings at TA–22, known as Los Alamos Detonator Facility (LADF), contain 50,000 square feet (4,650 square meters) supporting fabrication, testing, and surveillance of explosive detonation systems. In addition, LADF provides DOE-wide support for packaging and transportation of electro-explosive devices. TA–28 and TA–37 are magazine storage areas. The HE facilities at TA–8 occupy buildings with 14,500 square feet (1,347 square meters) in which nondestructive testing operations are performed.

All existing HE fabrication structures meet current applicable earthquake standards. Structures containing HE and those in which HE operations are conducted are constructed with 2-foot (0.6-meter) thick, steel-reinforced concrete walls designed to mitigate the effects of an accidental explosion. Most facilities include support areas for offices; break rooms; restrooms; electrical equipment; heating, ventilation, and air conditioning equipment; maintenance; and in-process staging for materials, components, tooling, and supplies.

TA–16 is categorized as a moderate hazard facility because of the presence of chlorine and a tritium facility. (WETF, described in section 2.2.2.2, is a separate “key” facility but is in the same TA as some of the HE processing facilities described here.) Two projects related to HE operations during the next 5 to 10 years were analyzed in the *Relocation of the Weapons Components Testing Facility Environmental Assessment* (DOE 1995b) and in the *Environmental Assessment, High Explosive Wastewater Treatment Facility* (DOE 1995d) (operational in October 1997). Another project is the TA–16 Steam Plant Conversion, a maintenance and refurbishment project that was completed and operational in September 1996.

Several permitted outfalls exist at TA–8, TA–9, TA–11, and TA–16. These outfalls are slated for modification as stated in the *Effluent Reduction Environmental Assessment* (DOE 1996c). Six of the outfalls will be eliminated completely, four outfalls are slated for waste stream consolidation, two outfalls are slated for outfall reduction, and one will decrease discharge rates as stated in the HE Wastewater Treatment Facility EA, and four will be decontaminated, but will continue to discharge. The disposition of the remaining outfalls will not change.

The HE processing facilities include support infrastructure for shipping, receiving, storage, packaging, and transportation. All receiving activities are conducted at TA–16, with storage at TA–28 and TA–37.

These facilities also include disposal facilities that are permitted by the State of New Mexico for disposal of HE waste and HE contaminated materials. A large flash pad is used to thermally remove HE contamination from other materials prior to burial. Two aboveground burning trays are used to destroy HE scrap and residue. Two sand filters remove water from sump sludge for drying and burning. One aboveground tray burns oil contaminated with HE. An incinerator is available for disposal of trash from the HE areas; such trash is presumed to be contaminated with HE due to association with HE processes. All water is filtered for HE and treated with activated carbon for solvent removal. Chemical oxygen demand, suspended solids, and acidity (pH) are measured prior to authorizing release to the environment. Non-HE hazardous wastes and LLW are trucked to the LANL waste management facilities.

Description of Capabilities

The major HE processing activities and their principal locations are described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

High Explosives Synthesis and Production. These activities include explosive-manufacturing capabilities such as synthesizing new explosives and manufacturing pilot-plant quantities of raw explosives and plastic-bonded explosives. These operations allow LANL to develop and maintain expertise in explosive materials and processes that are essential for long-term maintenance of stockpile weapons and materials. Most of the HE synthesis and small-scale production activities are conducted at TA–9. War Reserve detonator testing and production is conducted at TA–22, as discussed below under Research, Development, and Fabrication of High-Power Detonators.

High Explosives and Plastics Development and Characterization. These activities provide characterization data for any explosives application in nuclear weapons technology. Information on initiation and detonation properties of HE coupled with non-HE component information for modeling is essential to the design and safety analysis of a weapon. These activities are conducted at TA–9 and TA–40. A wide range of plastic and composite materials are used in nuclear weapons such as adhesives, potting materials, flexible cushions and pads, thermoplastics and elastomers. It is also necessary to have a thorough understanding of the chemical and physical properties of these materials to model weapons behavior. Most of the materials characterization work is conducted at TA–9, TA–16, and TA–40.

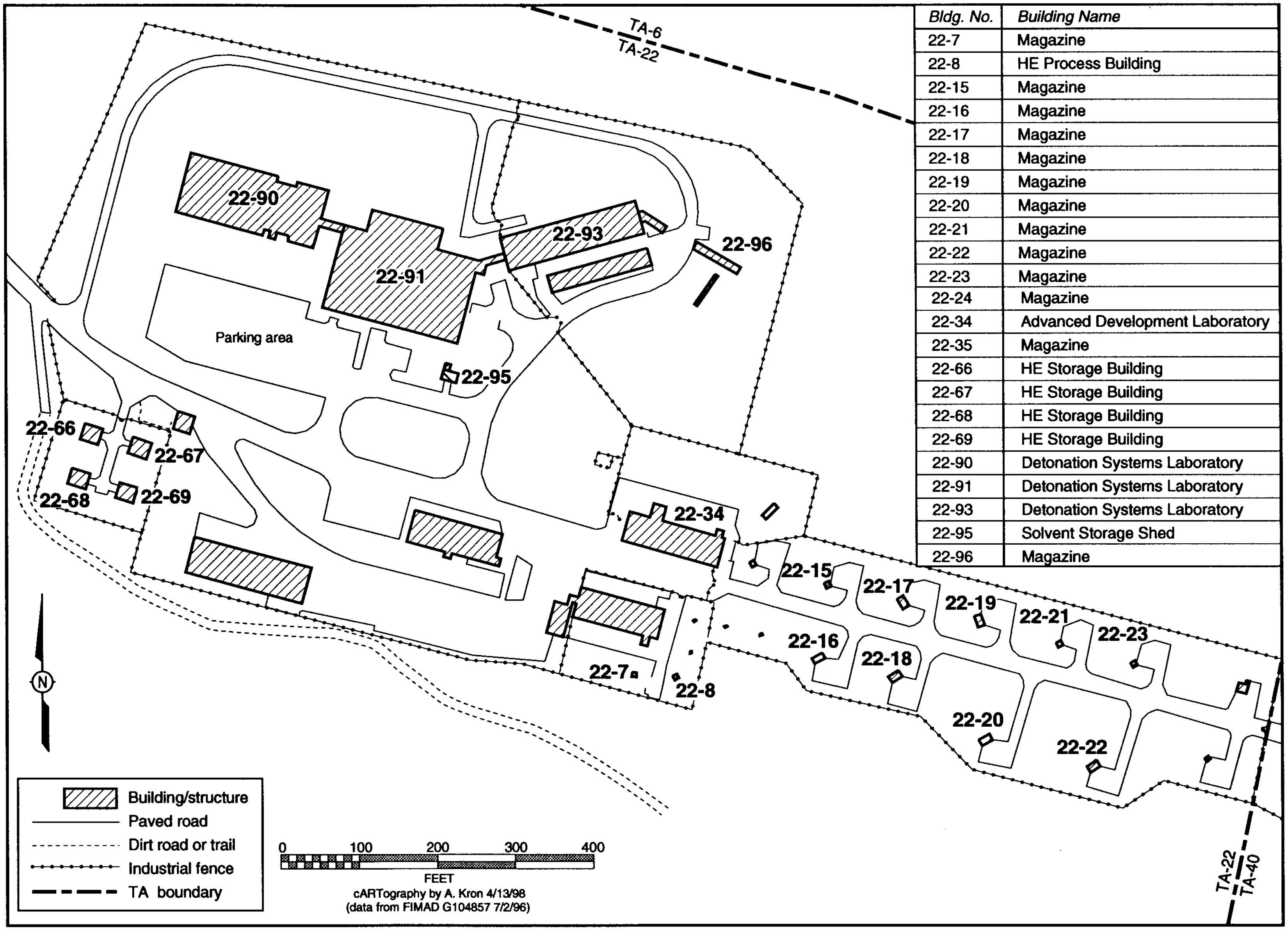
High Explosives and Plastics Fabrication. HE powders are typically compacted into solid pieces and machined to final specified shapes. Some small pieces are pressed into final shapes, and some powders, based upon their properties, are melted into stock pieces. Fabrication of plastic materials and components is a core capability associated with HE processing. Efforts are focused on weapons needs, but a wide variety of plastic and composite materials may be fabricated. Most of the HE and plastics fabrication is performed at TA–9 and TA–16.

Test Device Assembly. Test devices are assembled, ranging from full-scale nuclear explosive-like assemblies (where fissile material has been replaced by inert material) to material characterization tests. Assembly operations for the largest test devices are performed in TA–16. Smaller test assemblies may be prepared at the explosives testing support facilities at TA–9, TA–22, and TA–40. Radiography examinations of the final assembly are done at TA–8.

Safety and Mechanical Testing. Capabilities exist for measuring mechanical properties of explosives samples, including tensile, compression, and creep properties (i.e., change of materials shapes over time). Test assemblies can be instrumented with strain gages, pressure gages, or other diagnostic equipment. Safety testing, such as HE handling tests, drop tests, and impact tests, are used to evaluate abnormal conditions. Accelerated aging tests are conducted at TA–9. Most safety, mechanical, and environmental testing is conducted in laboratory and test buildings at TA–9, TA–11, and TA–16.

Research Development and Fabrication of High-Power Detonators. Capabilities at TA–22 include detonator design; printed circuit manufacture; metal deposition and joining; plastic materials technology; explosives loading, initiation, and diagnostics; lasers; and safety of explosives systems design, development, and manufacture. Detonators, cables, and firing systems for tests are built in this program. This also includes support to the DOE complex for packaging and transportation of electro-explosive devices.

The LADF (Figure 2.2.2.9–9) (Buildings 90, 91, 93, and 34) houses the research, development, and fabrication capabilities for detonation systems. This facility consists of three



Bldg. No.	*Building Name*
22-7	Magazine
22-8	HE Process Building
22-15	Magazine
22-16	Magazine
22-17	Magazine
22-18	Magazine
22-19	Magazine
22-20	Magazine
22-21	Magazine
22-22	Magazine
22-23	Magazine
22-24	Magazine
22-34	Advanced Development Laboratory
22-35	Magazine
22-66	HE Storage Building
22-67	HE Storage Building
22-68	HE Storage Building
22-69	HE Storage Building
22-90	Detonation Systems Laboratory
22-91	Detonation Systems Laboratory
22-93	Detonation Systems Laboratory
22-95	Solvent Storage Shed
22-96	Magazine

FIGURE 2.2.2.9–9.—*TA–22 Los Alamos Detonator Facility.*

connected buildings, one of which, Building 90, is an office wing connected to Building 91 by a corridor. Building 91 is designated as the inert half of the facility, meaning there are no high explosives processed there. The printed circuit manufacturing, cable fabrication, and electronics work is done in this facility.

In Buildings 93 and 34, bulk explosive powder is formed into detonator subassemblies and incorporated into final assemblies that are then measured, inspected, and prepared for storage or test firing. The area around the HE building (93 and 34) is enclosed by a fence with a locked gate, and access to the building is limited to authorized personnel. Small-scale testing activities are also performed in Building 34.

A facility may be constructed in the future as a separate detonator production facility. This action, which was analyzed in the Nonnuclear Consolidation EA (DOE 1993), was delayed from its original schedule; it is currently uncertain when this action might be undertaken.

2.2.2.10 *High Explosives Testing: TA–14 (Q-Site), TA–15 (R-Site), TA–36 (Kappa-Site), TA–39 (Ancho Canyon Site), and TA–40 (DF-Site)*

The facilities that make up the explosives testing operations are used primarily for research, development, test operations, and detonator development and testing related to DOE's stockpile stewardship and management programs (Figures 2.2.2.10–1 through 2.2.2.10–7). The firing sites specialize in experimental studies of the dynamic properties of materials under conditions of high pressure and temperature. The firing site facilities, occupying approximately 22 square miles (57 square kilometers) of land area, represent at least half of the total land area occupied by LANL (see Table 2.2.2.10–1).

Various radioactive and nonradioactive materials are used in the firing sites operations. Depleted uranium and plutonium metal are used in some of the operations (plutonium in such operations is contained to prevent release). Nonradioactive toxic or hazardous materials may include beryllium, copper, aluminum, and heavy metals. Other materials used are solvents such as acetone, chlorinated hydrocarbons, toluene, xylene, or 1,1,1–trichloroethane. Sulfur hexafluoride is used as an insulating gas in specialized high-voltage equipment.

There are 13 permitted NPDES outfalls located at the firing site operations. DOE plans to eliminate one of these outfalls as described in the *Environmental Assessment for Effluent Reduction* (DOE 1996c).

An ongoing construction project related to the TA–15 firing site operations is the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility, analyzed in the *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement* (DOE 1995c). The first axis for this facility is currently being installed and is expected to be operational by the end of 1999. The second axis is expected to be operational by the end of 2002.

Description of Facilities

HE testing activities are conducted in five TAs, having a total of 13 associated firing sites. (This number can change slightly over time.) All of the firing areas are located in remote locations on the Pajarito Plateau or within canyons of the plateau. Four of the areas are located on or just below Threemile Mesa. The nearest private residences to these four firing areas are in the Royal Crest Trailer Park north of Sandia Canyon located approximately 2 miles (3.2 kilometers) to the north, and White Rock, approximately 4 to 6 miles (6.4 to 9.7 kilometers) to the southeast. The following paragraphs contain descriptions of the five firing areas.

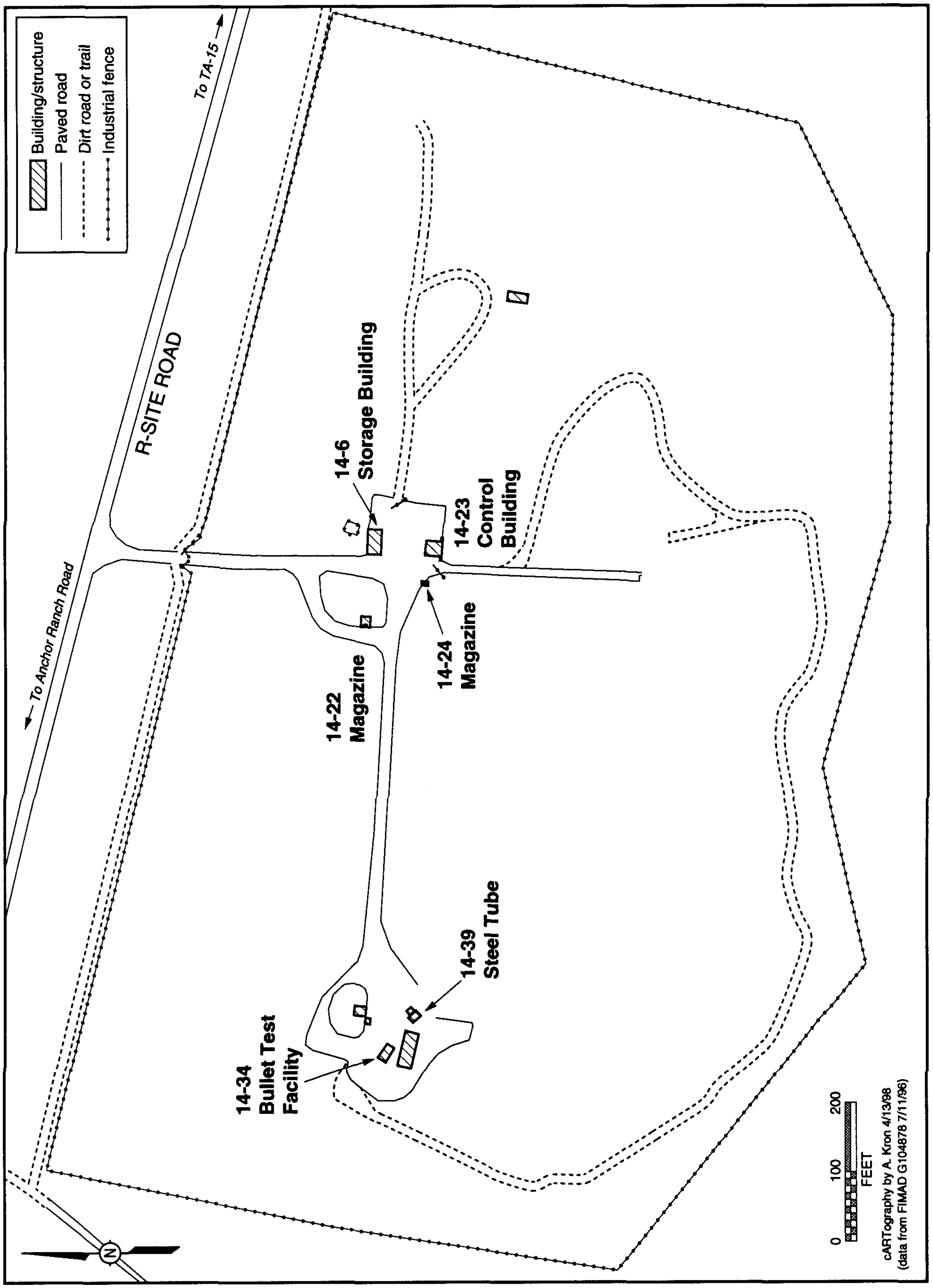


FIGURE 2.2.2.10–1.—*TA–14 High Explosives Testing.*

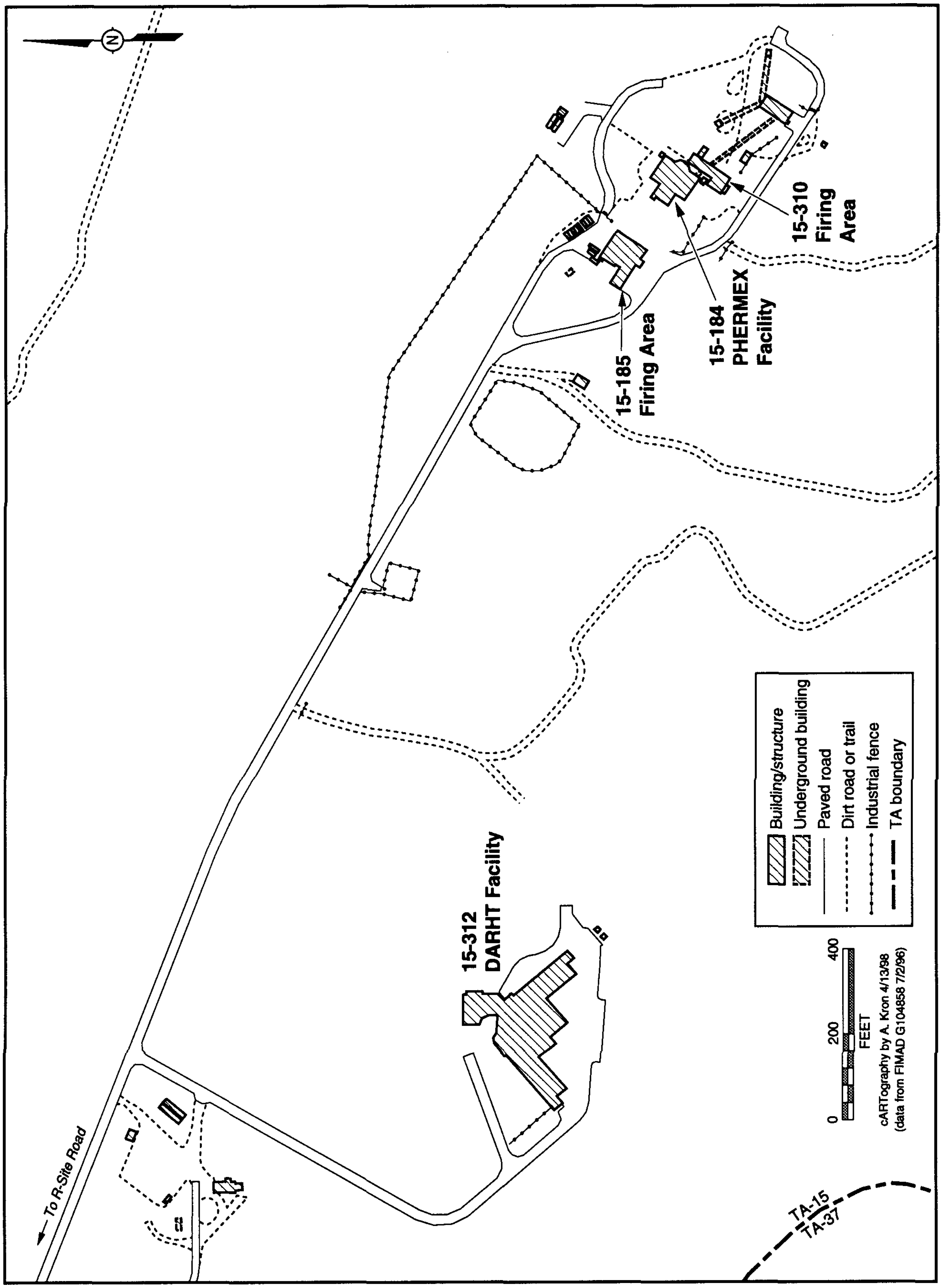


FIGURE 2.2.2.10–2.—*TA–15 West High Explosives Testing.*

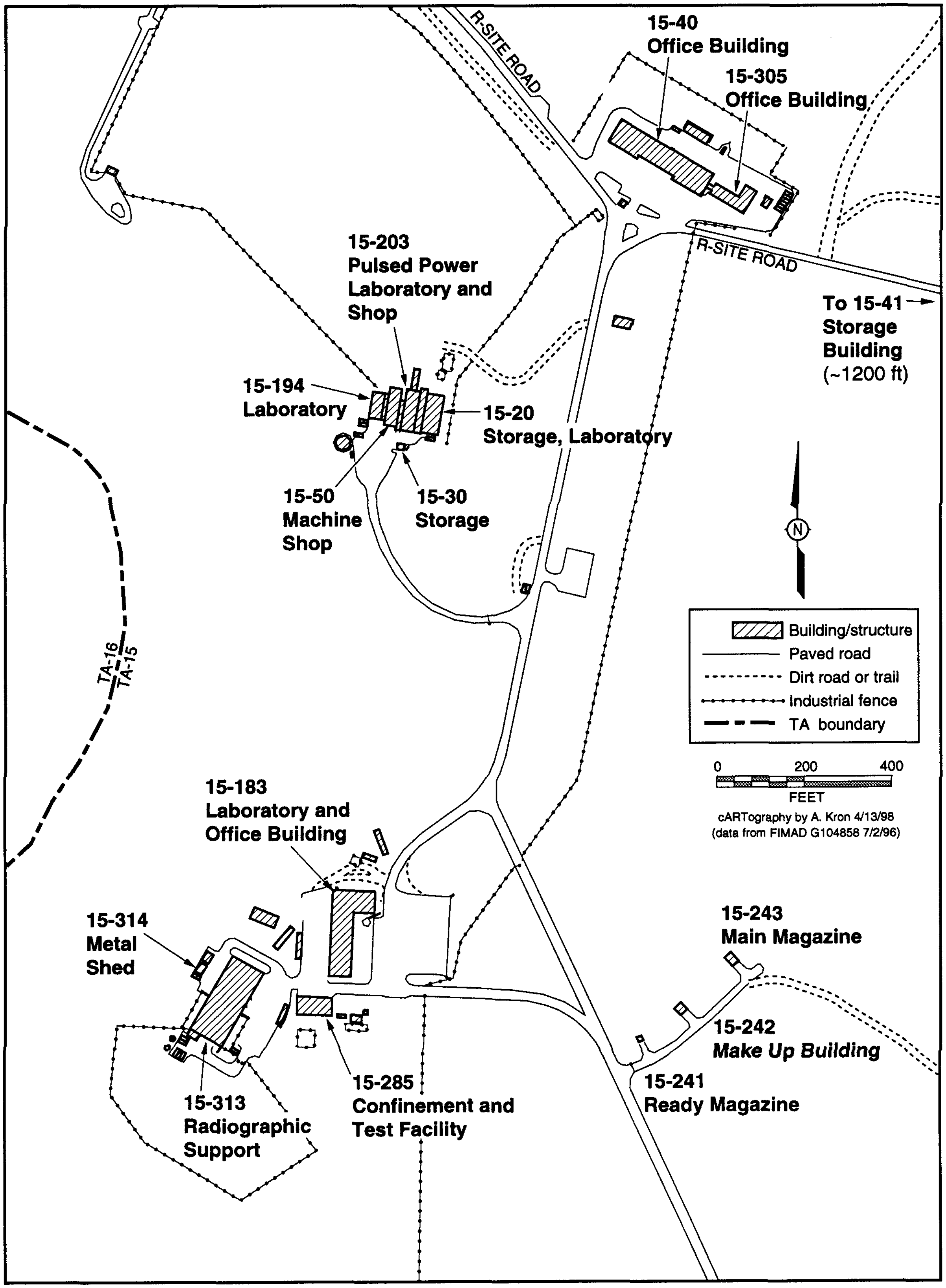


FIGURE 2.2.2.10–3.—*TA–15 Central High Explosives Testing.*

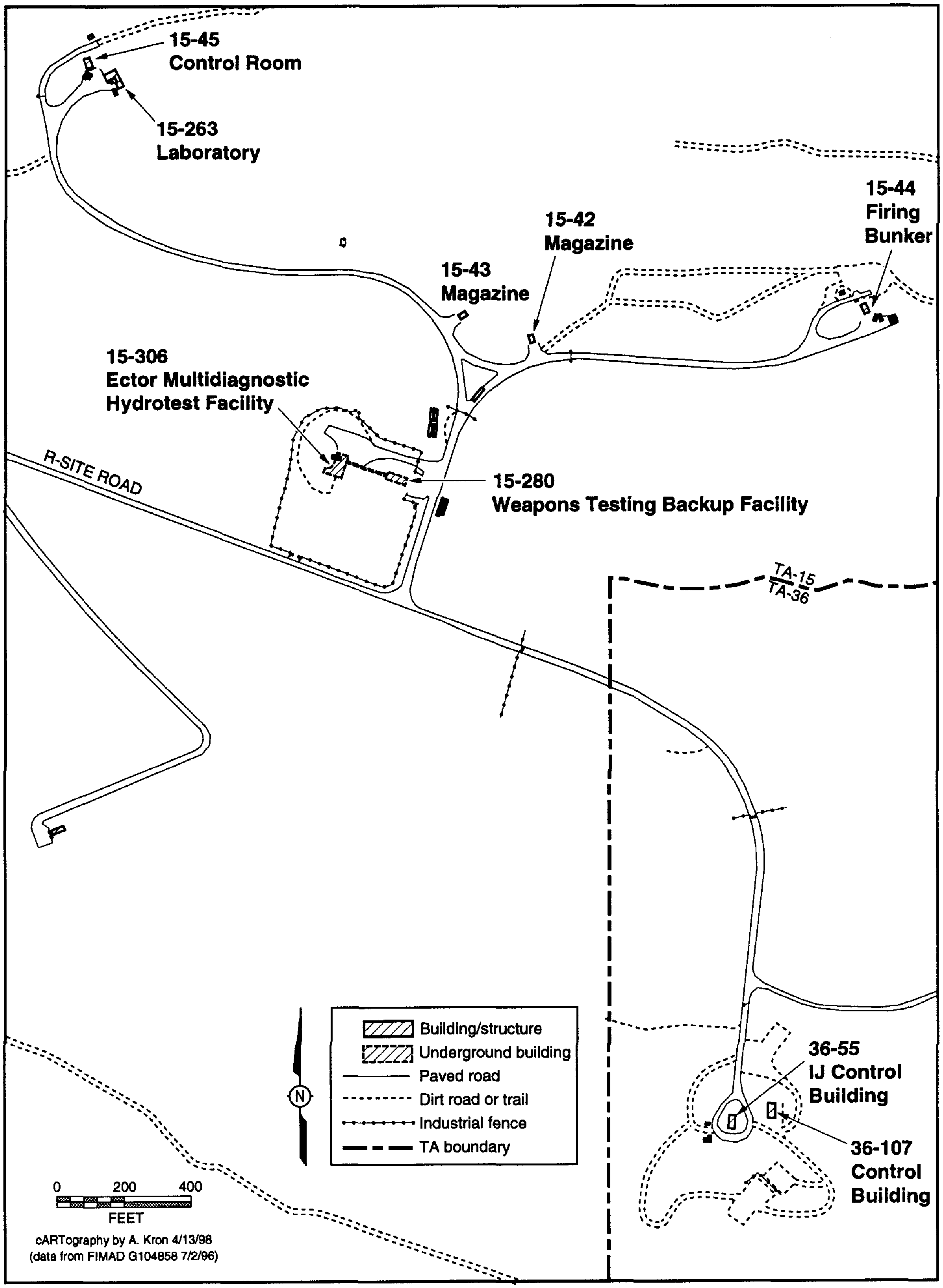


FIGURE 2.2.2.10–4.—*TA–15 East and TA–36 West High Explosives Testing.*

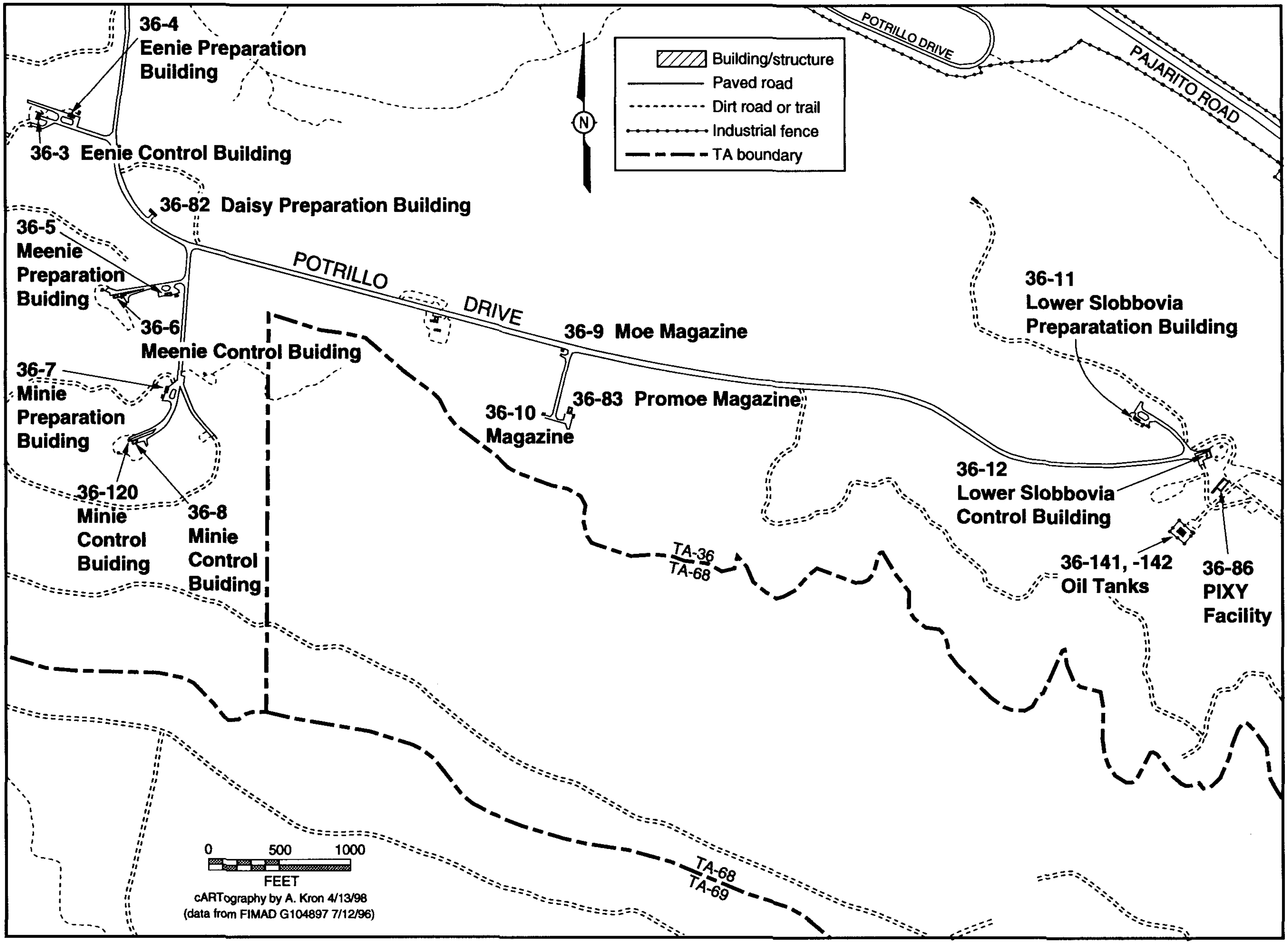


FIGURE 2.2.2.10–5.—*TA–36 East High Explosives Testing.*

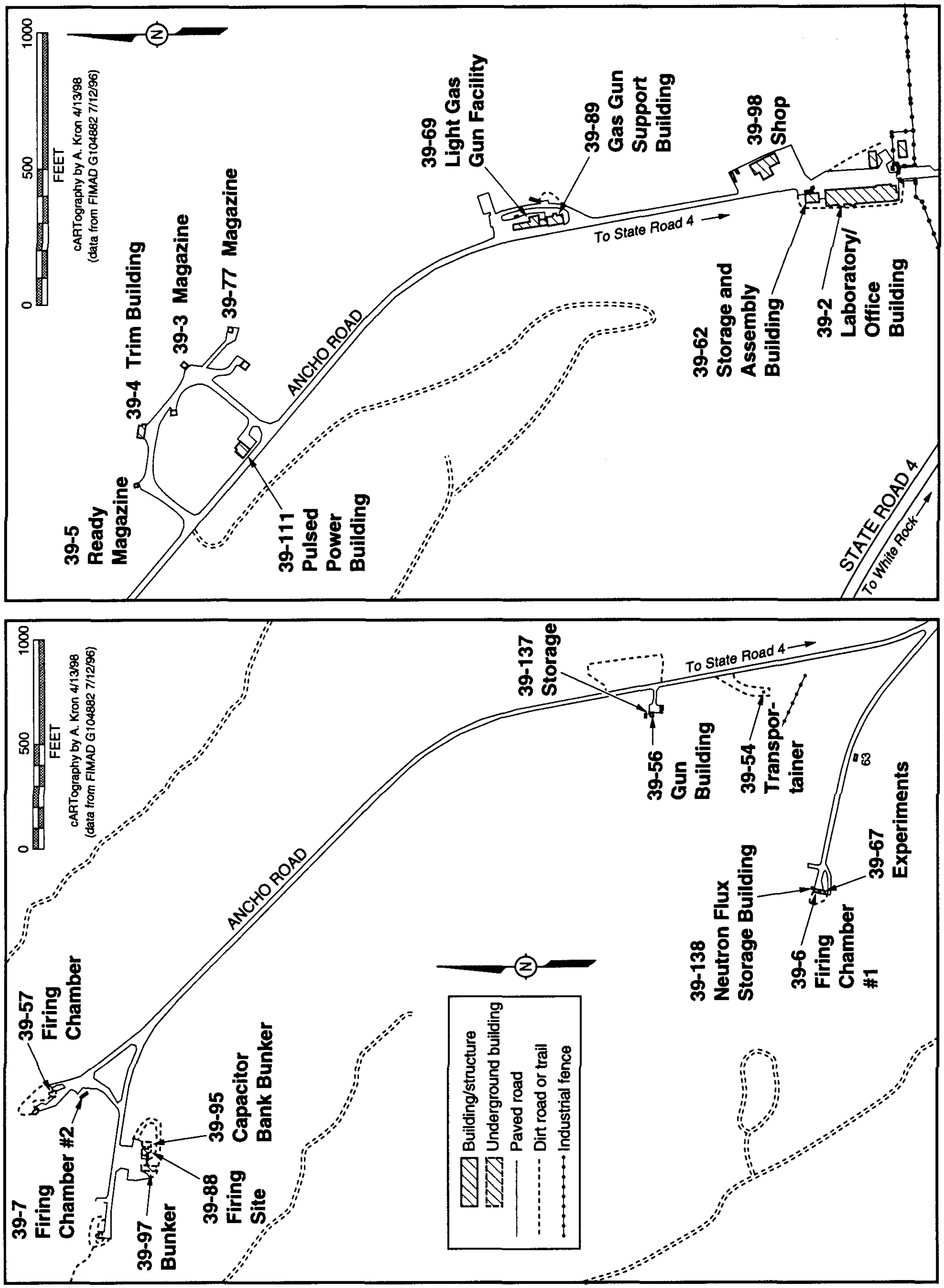
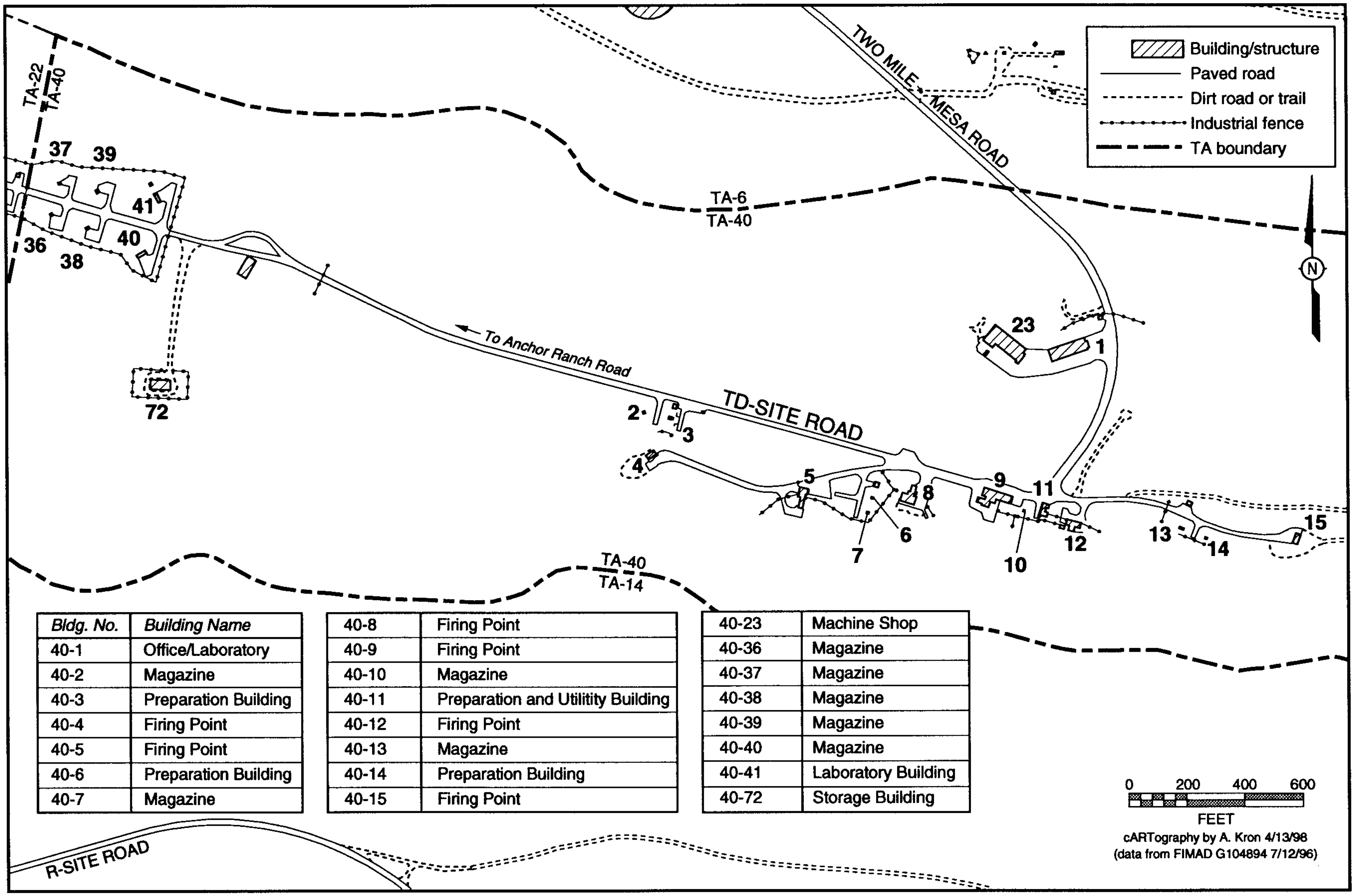


FIGURE 2.2.2.10–6.—*TA–39 High Explosives Testing.*



Bldg. No.	Building Name
40-1	Office/Laboratory
40-2	Magazine
40-3	Preparation Building
40-4	Firing Point
40-5	Firing Point
40-6	Preparation Building
40-7	Magazine
40-8	Firing Point
40-9	Firing Point
40-10	Magazine
40-11	Preparation and Utilitity Building
40-12	Firing Point
40-13	Magazine
40-14	Preparation Building
40-15	Firing Point
40-23	Machine Shop
40-36	Magazine
40-37	Magazine
40-38	Magazine
40-39	Magazine
40-40	Magazine
40-41	Laboratory Building
40-72	Storage Building

FIGURE 2.2.2.10–7.—*TA–40 East High Explosives Testing.*

TABLE 2.2.2.10–1.—*Principal Buildings and Structures of High Explosives Testing Facilities*

TECHNICAL AREAS	PRINCIPAL BUILDINGS AND STRUCTURES
TA–14 (Q-Site)	Warehouse: 14–6 Magazines: 14–22, 24 Control Room, Make-Up Room, Laboratory: 14–23
TA–15 (R-Site)	Firing Areas: 15–184, 185, 310 Weapons Testing Backup Facilities: 15–280 Ector Multidiagnostic Hydrotest Facility: 15–306 Firing Bunker: 15–44 Control Room: 15–45 Weapons Storage and Preparation: 15–41 Magazines: 15–42, 43, 241, 243 Make-Up Building, Short-Term Storage: 15–242 Storage, Laboratory: 15–20 Machine Shop: 15–50 Laboratory: 15–194 Storage: 15–30 Pulsed-Power Laboratory and Shop: 15–203 Offices Buildings: 15–40, 183, 305
TA–36 (Kappa-Site)	Offices, Laboratories: 36–1, 48, 84 Control Buildings: 36–3, 6, 8, 12, 107, 120 Preparation Buildings: 36–4, 5, 7, 11, 82 Magazines: 36–9, 10, 83 Firing Box: 36–21 Pixy Facility: 36–86 Oil Tanks: 36–141, 142
TA–39 (Ancho Canyon Site)	Main Office, Laboratories, Shops: 39–2 Magazines: 39–3, 5, 77 Trim Building: 39–4 Firing Sites: 39–6, 57, 88 Gas Gun Facility: 39–56 Storage and Assembly Building: 39–62 Gun Room, Instrument Room: 39–69 Gas Gun Support Building: 39–89 Shop: 39–98 Pulsed-Power Building: 39–111 Storage: 39–137, 138 Bunkers: 39–56, 95, 97 Experiments: 39–67
TA–40 (DF-Site)	Offices, Laboratories: 40–1 Machine Shops: 40–23 Gas Gun Facility: 40–9 Firing Sites: 40–4, 5, 8, 9, 15 Preparation Rooms: 40–3, 6, 11, 12, 14 Magazines: 40–2, 7, 10, 13, 36, 37, 38, 39, 40 Laboratory Building: 40–41

The major use of the TA–14, Q-Site, firing area is testing quantities of energetic materials (such as HE) that exceed the safety limits for these materials indoors at TA–9. Two firing sites are available at the Q-Site firing area. Up to 100 pounds (45.4 kilograms) of HE per test may be fired at this area. Characterization tests to determine the chemical and physical properties of energetic materials used to model weapons behavior are conducted at this site. DOE has applied for a RCRA permit for the disposal of explosives and explosives-contaminated materials at Q-Site by either detonation or by burning. Currently, waste disposal is performed under RCRA interim status requirements by either detonation or by burning.

TA–15, R-Site, contains three firing sites: Pulsed High-Energy Radiation Machine Emitting X-Rays (PHERMEX) facility, DARHT Facility, and R306, a general purpose firing site. The PHERMEX facility is capable of producing high-resolution x-ray pictures of very dense, fast-moving materials and is used primarily for weapons studies. The PHERMEX firing site is used for full-scale, multidiagnostic hydrodynamic tests and for smaller scale experiments, such as the study of HE or materials driven by HE that might require fast, high-resolution, high-intensity radiography. The firing site can handle up to 154 pounds (70 kilograms) of explosives on the firing runway in front of machines. Charges up to 1,600 pounds (730 kilograms) or more of explosives may be detonated at points east of the runway (at greater distance from the PHERMEX machine). All of the buildings adjacent to the firing site are constructed of heavily reinforced concrete.

The DARHT facility is currently under construction near the PHERMEX firing site. When completed, the DARHT facility will provide dual axis, multiple exposure radiographs at the highest penetration and resolution available for the study of devices and materials under hydrodynamic conditions. This facility will be used primarily in support of DOE's Stockpile Stewardship and Management Programs.

The third firing site at TA–15 is located at building R306. Currently, the R306 firing site is used for nonradiographic studies. This firing site and the nearby IJ firing site are current candidates for redevelopment and would probably continue to be used only for electrical, mechanical, and optical studies in the future. The IJ site is currently in safe standby.

Both open-air and contained explosives tests are performed at TA–15 as described in the DARHT EIS (DOE 1995c) and ROD (60 FR 53588).

TA–36, Kappa-Site, contains four active firing sites. A variety of diagnostic equipment is available at the four firing sites. A number of 2.3-million electron volts, 600-kiloelectronvolts, 450-kiloelectronvolts, and 150-kiloelectronvolts flash radiographic systems are also available. (These radiographic systems may also be used at other firing sites.) In addition to providing support for DOE nuclear weapons programs, the explosives testing and firing facilities at TA–36 are often used for a wide variety of nonnuclear ordnance testing for the U.S. Department of Defense (DoD). These tests may include warhead development, armor and armor-defeating mechanisms, explosives vulnerability to projectile and shaped-charge attack, warhead lethality studies, and the safety implication of shock waves on explosives and propellants. A total of 700 to 1,200 experimental firings are performed annually, using up to 5,000 pounds (2,270 kilograms) of explosives in a single test.

The Ancho Canyon Site, TA–39, is used for studying high-energy-density properties in experiments using explosives-driven pulsed power. Various phenomenological aspects of explosives, interactions of explosives, and explosions acting on other materials are also investigated. Gas guns are located at Ancho

Canyon for the testing of inert materials. Typically, open air detonation is used, and up to 4,400 pounds (2,000 kilograms) of explosives may be used in a single test. In the past, contained testing involving plutonium was performed here. DOE may perform such testing again in the future.

Firing sites TA–39–6 and TA–39–88 typically support high-explosives-driven, pulsed-power experiments to study high-energy-density and high magnetic fields for stockpile stewardship, basic research, or other applications. These firing sites also can be used for other HE experiments in materials phenomenology. The pulsed-power experiments usually involve HE detonations and high-voltage, energy-storage capacitor bank discharges. Currently, for operational efficiency TA–39–6 is the principal firing site used for HE experiments for the National High Magnetic Field Laboratory, though both sites can be used for such experiments. The firing sites at TA–39 and the gas guns are used to measure the characteristics of weapons materials driving by HEs. Tests associated with proliferation control and verification activities are performed here also. Equation-of-state experiments may also be carried out at TA–39 to determine the properties of materials at extreme conditions.

Three separate firing sites at TA–40, DF Site, are used for general testing of explosives or other materials and in the development of special detonators to initiate HE systems. One site is used for the characterization of energetic materials using two gas guns normally located at TA–40. Another site employs a containment system in the study of small-scale experiments (less than 22 pounds [10 kilograms] of HE). The third site includes a laboratory for growth of long HE crystals used to study the properties of explosives. The TA–40 facility has been used for many years for the testing of HE and physics experiments related to the nuclear weapons programs.

Some experiments at TA–40 include detonation of assemblies and configurations contributed by other groups at LANL. Experimental assemblies containing up to 55 pounds (25 kilograms) of explosives in various diagnostic configurations are routinely constructed and fired, while detonation of charges of up to 110 pounds (50 kilograms) can be studied.

Description of Capabilities

The major categories of HE testing activities across the firing sites are described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

Hydrodynamic Tests. A hydrodynamic test is a dynamic, integrated systems test of a mock-up nuclear package during which the high explosives are detonated and the resulting motions and reactions of materials and components are observed and measured. The explosively generated high pressures and temperatures cause some of the materials to behave hydraulically (like a fluid). Surrogate materials are used to replace the actual weapons materials in the mock-up nuclear weapons package, to ensure that there is no potential for a nuclear yield. Most hydrodynamic tests will be conducted at TA–15, with some being conducted at TA–36.

Dynamic Experiments. A dynamic experiment is an experiment to provide information regarding the basic physics of materials or characterize the physical changes or motion of materials under the influence of HE detonations. Some dynamic experiments involve SNM. Most dynamic experiments will be conducted at TA–15 and TA–36, with some experiments being conducted at TA–39 and TA–40. In the past, DOE has conducted dynamic experiments using plutonium metal. DOE may perform such studies again in the future at PHERMEX, DARHT, and other facilities. As a matter of policy, dynamic experiments involving plutonium would always be conducted inside containment vessels.

Explosives Research and Testing. Explosives research and testing activities are conducted primarily to study the properties of the explosives themselves as opposed to explosive effects on other materials. Examples include tests to determine the effects of aging on explosives, the safety and reliability of explosives from a quality assurance point of view, and fire resistance of explosives. Select explosive research and testing activities may be performed at any of the HE testing sites.

Munitions Experiments. Munitions experiments are those tests conducted to study the influence of external stimuli on explosives (i.e., projectiles or other impacts). These studies include work on conventional munitions for DoD. Most of the munitions experiments are expected be performed at TA–36, yet any of the other firing sites may be used as required.

High Explosives Pulsed-Power Experiments. High explosives pulsed-power experiments are those tests conducted to develop and study new concepts based on the use of explosively driven electromagnetic power systems. These experiments will be conducted primarily at TA–39.

Calibration, Development, and Maintenance Testing. Calibration, development, and maintenance testing are those experiments conducted primarily to prepare for more elaborate tests, and include tests to develop, evaluate, and calibrate diagnostic instrumentation or other systems. The calibration, development, and maintenance testing activities will be concentrated at TA–15 and TA–36, but may involve any of the HE testing sites.

Other Explosives Testing. Other explosives testing includes such activities as development of advanced HE and/or work to improve weapons evaluation techniques. Any of the HE testing sites may be used for select testing activities.

2.2.2.11 *Los Alamos Neutron Science Center (TA–53)*

LANSCE is the name applied to a group of facilities located at TA–53 (Figures 2.2.2.11–1 through 2.2.2.11–3). Initial construction of the original facility (then called the Los Alamos Meson Physics Facility, or LAMPF) was completed in 1970, and it remains one of the highest powered and largest research accelerators in the world. The LANSCE facility is located on a 750-acre (303-hectare) mesa top area, contains approximately 400 buildings and other structures, and houses about 700 personnel (Table 2.2.2.11–1). The number of personnel can increase by several hundred when the accelerator is in operation, as additional scientists are on site to monitor and participate in experiments.

LANSCE is LANL's major accelerator research and development complex. The facility produces intense proton beams and sources of pulsed spallation neutrons for neutron research and applications. The facility is composed of a high-power 800-million electron volt proton linear accelerator (linac), a proton storage ring (PSR), production targets at the Manuel Lujan Neutron Scattering Center (Manuel Lujan Center), and the Weapons Neutron Research (WNR) facility, and a variety of associated experiment areas and spectrometers. This facility uses particle beams to conduct basic and applied research in the areas of condensed matter science, materials science, nuclear physics, particle physics, nuclear chemistry, atomic physics, and defense-related experiments. LANSCE also produces medical radioisotopes. As a National User Facility for research in condensed matter sciences, LANSCE hosts scientists from universities, industry, LANL, and other research facilities from around the world.

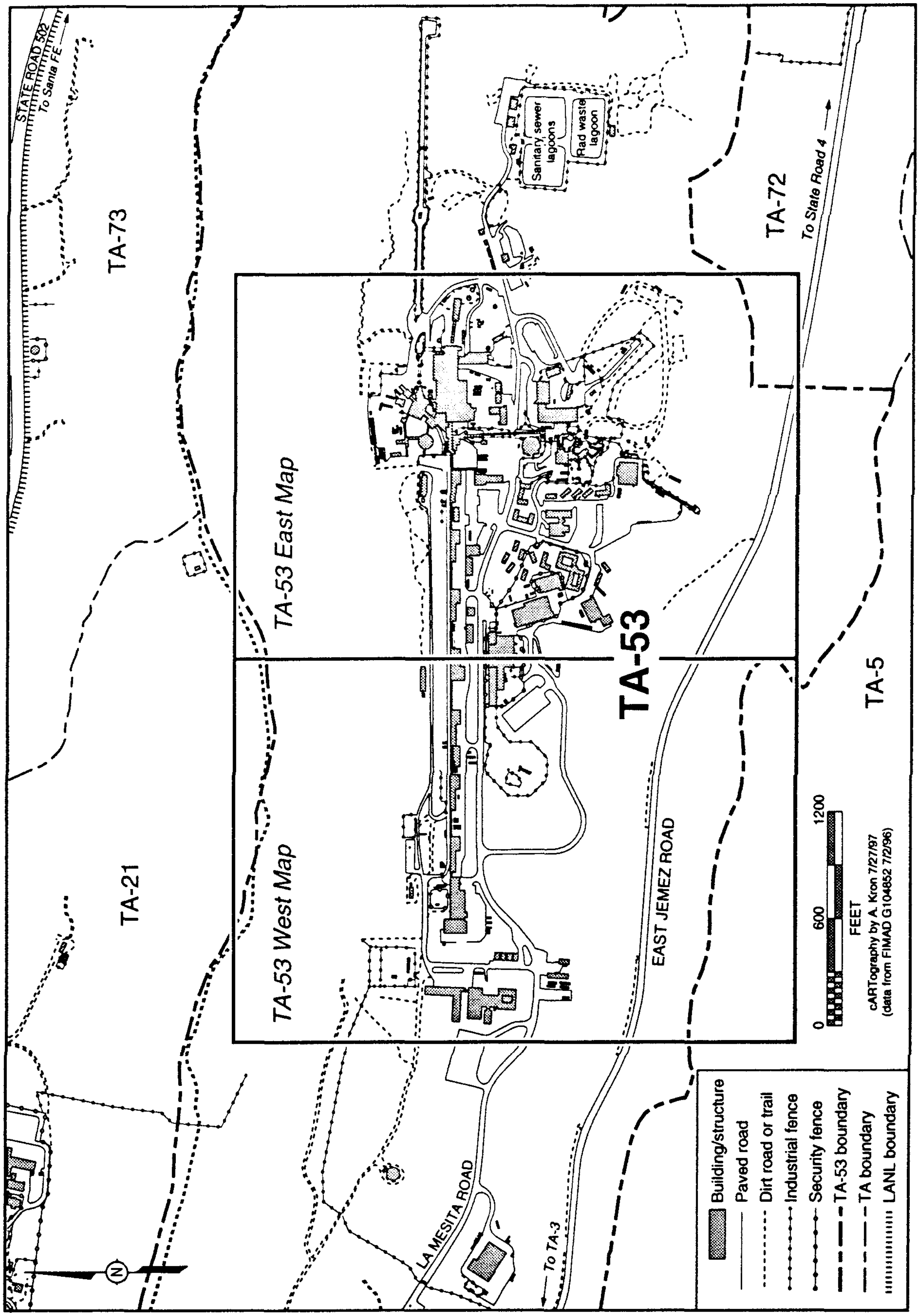


FIGURE 2.2.2.11–1.—*TA–53 Los Alamos Neutron Science Center.*

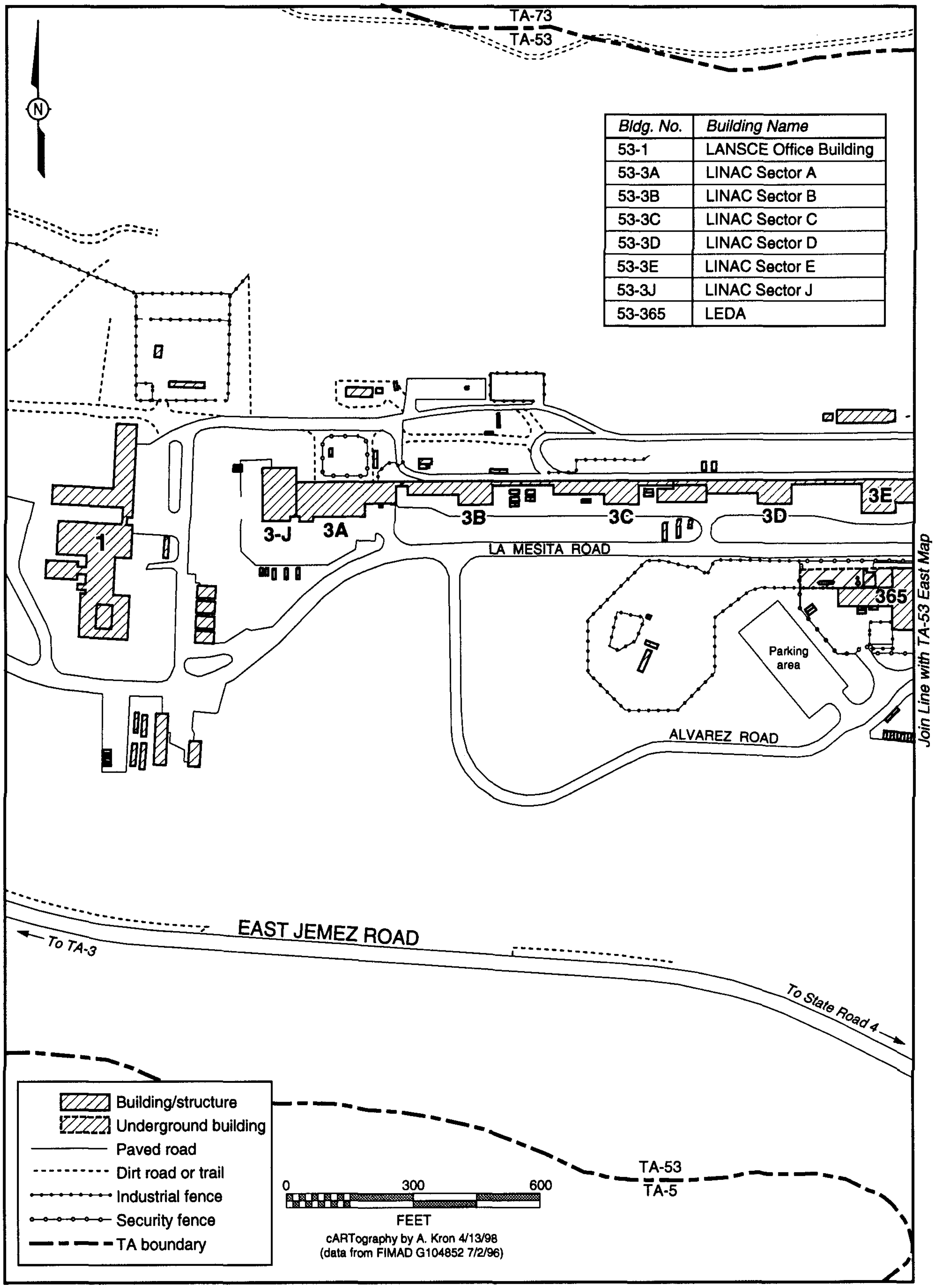


FIGURE 2.2.2.11–2.—*TA–53 Los Alamos Neutron Science Center West.*

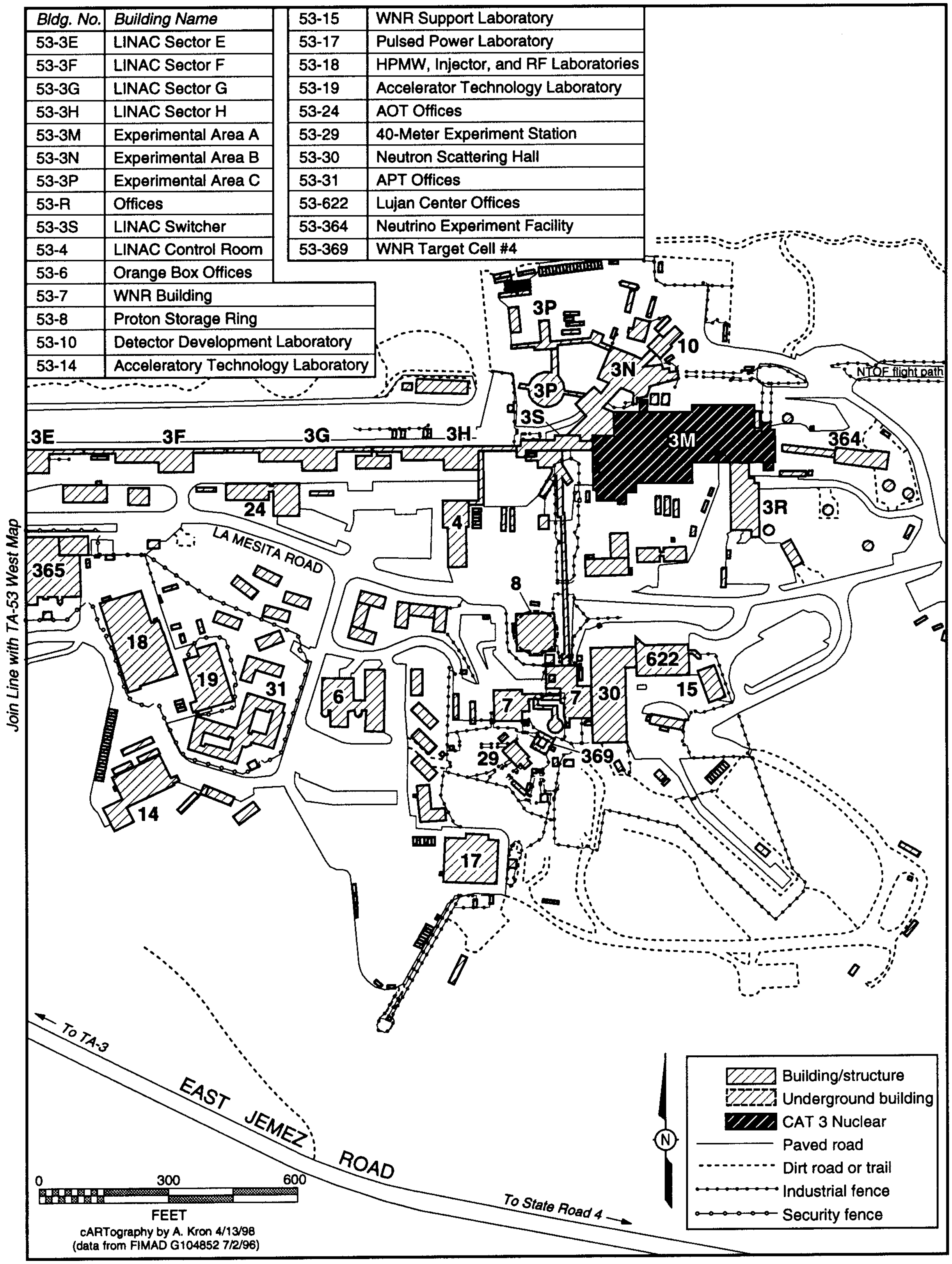


FIGURE 2.2.2.11–3.—*TA–53 Los Alamos Neutron Science Center East.*

TABLE 2.2.2.11–1.—*Principal Buildings and Structures of Los Alamos Neutron Science Center*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–53	**Accelerators:**
	Linear Accelerator Injector: 53–003J
	Proton Beam Linear Accelerator: 53–003A through H
	Linear Accelerator Switchyard: 53–003S
	Accelerator Control Room: 53–004
	Low Energy Demonstration Accelerator: 53–365
	Experimental Areas:
	Experimental Area A: 53–003M
	Experimental Area B: 53–003N
	Experimental Area C: 53–003P
	Neutrino Experiment Facility: 53–364
	Short-Pulse Spallation:
	Proton Storage Ring: 53–008
	Proton Storage Ring Equipment: 53–028
	Manuel Lujan Center Target, ER–1, Weapons Neutron Research Target #2: 53–007
	40-Meter Experiment Station: 53–029
	Manuel Lujan Center ER–2: 53–030
	Weapons Neutron Research Target #4: 53–369
	Major Laboratories:
	High-Resolution Accelerator Beam, Detector Development Laboratory: 53–010
	Accelerator Technology Laboratory (High-Powered Microwave and Advanced Accelerator): 53–014
	Weapons Neutron Research Support Laboratory: 53–015
	Pulsed-Power and Structures Laboratories: 53–017
	High-Powered Microwave, Injector and RF Laboratories: 53–018
	Accelerator Technology Laboratory: 53–019
	Other:
	LANSCE Office Building: 53–001
	Equipment Maintenance and Test Shop: 53–002
	"Orange Box" Office Building: 53–006
	Office Building: 53–024
	Office Building: 53–031
	Manuel Lujan Center Office Building: 53–622

LANSCE has 375 administrative, technical, physical support, and other buildings and structures assigned a no hazard classification. LANSCE also has 27 low hazard facilities. Twenty-one of these are classified as low hazard because of their radionuclide inventory and five due to potentially hazardous energy sources. LANSCE also contains one Hazard Category 3 nuclear facility, the isotope production facility within Building 53–003M (refer to Figure 2.2.2.11–3).

LANSCE accounts for more than 90 percent of all radioactive air emissions from LANL. These emissions come predominantly (greater than 95 percent) from stack ES–3, which ventilates Building 53–003, the linear accelerator and adjacent experimental stations. Additional emissions come from stack ES–2, which exhausts the PSR and experimental stations at the Manuel Lujan Center and WNR buildings. Both ES–2 and ES–3 are equipped with continuous monitoring equipment.

TA–53 contains six NPDES-permitted and NPDES-monitored outfalls. All of these outfalls discharge cooling tower blowdown. Three of the outfalls discharge into Los Alamos Canyon. The three remaining outfalls discharge into Sandia Canyon, one of which is slated for outfall reduction as part of LANL's Outfall Reduction Program. Effluent from two of the outfalls and from a former outfall has created three wetland areas in TA–53.

Low-level radioactive liquid wastes produced at LANSCE are collected and allowed to decay in four underground tanks prior to discharge to a lined lagoon. Two unlined wastewater lagoons (no longer used) collected sanitary wastes prior to construction of the sanitary waste treatment facility at TA–46. Traces of both radioactive and hazardous wastes have been discovered in the sludges in these lagoons, and they now require a formal closure under RCRA. Radioactive solid wastes such as beam line components and scrap metals, papers, and plastics are also produced at LANSCE. Small quantities of hazardous and toxic wastes such as liquid solvents, solvents on wipes, lead, and solder are produced from accelerator maintenance and development.

Support activities at TA–53 provide for facility and plant operating and engineering services, environment, safety, and health services and oversight, site and building physical security, visitor control, and facility specific training.

Description of Facilities

The heart of TA–53 is the linear accelerator, or linac, itself, Building 53–003. It is more than 0.5 mile (0.8 kilometer) in length, and has 316,000 square feet (29,390 square meters) of floor space. The building contains equipment to form hydrogen ion beams (protons and negative hydrogen ions), and to accelerate them to 84 percent of the speed of light. Ancillary equipment is used to transport the ion beams, maintain vacuum conditions in the beam transport system, and provide ventilation and cooling. Creating and directing the ion beam requires large amounts of power, much of it ultimately removed as excess heat. The beam tunnel itself is located 35 feet (11 meters) below grade (i.e., below the ground) to provide radiation protection. Above-surface structures house radio frequency power sources used to accelerate the beam.

In the linear accelerator, an 800-million electron volt proton beam is generated in three stages. The linear accelerator has the capability to simultaneously accelerate both H^+ and H^- ion beams. In the first stage, three injectors (Building 53–003J) generate ionized H^+ or H^- beams, which are accelerated to 4 percent of the speed of light (corresponding to an energy level of 0.75 million electron volts).

The second stage (Building 53–003A) consists of a 203-foot (62-meter) series of drift-tube linear accelerator sections. By alternately exposing the proton ion beam to, and shielding it from, an externally generated electromagnetic field, ions are accelerated and exit this second stage at 43 percent of the speed of light (corresponding to an energy level of 100 million electron volts).

The third stage (Buildings 53–003B through 53–003H) consists of a 2,400-foot (731-meter) long side-coupled cavity accelerator. Ions exit at 84 percent of the speed of light with an energy level of 800 million electron volt (Allred and Talley 1987, pp. 10-13).

The ion beam then enters a switchyard (Building 53–003S), where the H^+ and H^- beams are split and directed to Experimental Areas A, B, C, WNR Building, and/or the PSR. The PSR converts the negatively charged beam into short (250 nanoseconds) intense pulses of protons. These pulses are delivered to the Manuel Lujan Center neutron production target at a rate of 20 per second.

At present, the 800-million electron volt linear accelerator is the only operating proton beam at TA–53. This will change when the Low-Energy Demonstration Accelerator (LEDA) becomes operational in late 1998. The environmental impacts of this facility were analyzed in the *Low-Energy Demonstration Accelerator Environmental Assessment* (DOE 1996b). LEDA will generate lower-energy protons (40-million electron volts as compared to the 800-million electron volt beam discussed above), but at a much higher beam current (200 milliamps versus 1). LEDA operations will be conducted in Building 53–365.

Description of Capabilities

The major categories of LANSCE activities are described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

Accelerator Beam Delivery, Maintenance, and Development. Generation and delivery of the proton ion beams requires significant development and maintenance capabilities for all components of the 800-million electron volt accelerator, including the ion sources and injectors, the mechanical systems in the accelerator (including cooling water), all systems for the PSR and its associated transfer lines, and beam diagnostics in the accelerator and transfer lines. Beam development activities include beam dynamics studies, and design and implementation of new capabilities. This activity requires the coordination of many disciplines, including accelerator physics, high-voltage and pulsed-power engineering, mechanical engineering, materials science, radiation shielding design, digital and analog electronics, high vacuum technology, mechanical and electronics design, mechanical alignment, hydrogen furnace brazing, machining, and mechanical fabrication. These activities take place throughout Building 53–003 (800-million electron volt accelerator), and in Buildings 53–008/028 (PSR), 53–365 (LEDA), 53–002 (equipment maintenance and test shop), and Line D (Manuel Lujan Center and WNR).

The short-pulse spallation source enhancement will result in higher neutron flux and greater beam availability from experimenters in WNR and the Manuel Lujan Center. (This project was categorically excluded from further NEPA review.) The upgrade would enhance the existing H^+ beam and the PRS to operate at 200 microamps and 30 hertz (versus the current 70 microamps at 20 hertz) and will add from five to seven new neutron-scattering instruments to the Manuel Lujan Center. All modifications will occur within existing buildings.

Experimental Area Support. Experiments using proton and neutron beams are conducted by personnel from the LANSCE and Physics Divisions, other LANL organizations, and other users such as scientists from universities, other laboratories, and the international scientific community. These beam users require support from TA–53 personnel, whether preparing for, performing, or closing out their experiments. This support capability focuses on the maintenance, improvement and operational readiness of the high intensity beam line (Line A) and associated secondary beam lines and experimental areas at LANSCE. This requires the specification, engineering, design utilizing computer-aided design (CAD), fabrication (often using computer-aided manufacturing), installation, and checkout and maintenance of various beam line components (and their controls and interlocks) including: particle production targets, uncooled and water-cooled devices such as magnets, beam stops, vacuum enclosures and beam collimators (fixed and movable), and absorbers.

Support also includes: the design, operation, and maintenance of remote handling systems for highly activated components; the handling and transportation (usually for disposal) of highly activated components; and the specification, engineering, design and installation of radiation shielding. Shielding activities include Monte Carlo shielding calculations and heavy equipment (bridge cranes and forklifts) operation.

Support activities occur in all of the experimental support areas: A (Building 53–003M), B (53–003N), C (53–003P), Manuel Lujan Center (53–007, 53–029, and 53–030), WNR (53–007 and 53–369), and the neutrino experiment hall (53–364).

Radiofrequency Technology and Operation. The 800-million electron volt and LEDA accelerators require large power sources, and both are supplied at TA–53 by radiofrequency (RF) power sources. The capability to design, fabricate, operate, and maintain RF systems for accelerators and other applications is an important support function for LANSCE operations. This capability also provides the RF systems, including state-of-the-art fast feedback controls and high-power klystron amplifiers used in electron accelerator projects and other advanced accelerator concepts at TA–53. RF technology development also supports microwave materials processing and RF system design. Design work includes determining optimal systems for very high-power continuous-duty systems for applications such as accelerator production technology.

RF power generation for the 800-million electron volt accelerator primarily occurs in the above-surface portions of Building 53–003, Sectors A through H, and will occur in Building 53–365 for LEDA.

Neutron Research and Technology. Fundamental research is conducted on the interaction of neutrons with various materials, molecules, and nuclei to advance condensed matter science (including material science and engineering and aspects of bioscience), nuclear physics and LANL's capability in the study of dynamic phenomena in materials. Applied neutron research is conducted to provide scientific and engineering support to weapons stockpile stewardship and nonproliferation surveillance. Efforts include resonance neutron spectroscopy and neutron radiography. (Radiography using protons rather than neutrons is discussed below under Subatomic Physics Research.) Research is also performed to develop instrumentation and diagnostic devices by scientists from universities, other federal laboratories, and industry.

Accelerator-Driven Transmutation Technology. This research area probes the use of a fundamentally different approach to the management of nuclear waste by using an accelerator beam to convert plutonium and high-level radioactive wastes into safer elements. Planned experimental progression will start by performing tests to establish a technology base for materials handling and operation of liquid lead spallation neutron targets, including the assembly and testing of a Russian built lead/bismuth target (using a 1-megawatt target/blanket, expected to be categorically excluded from further NEPA review by May 1, 1998). This liquid lead technology could then be used to construct a target/blanket assembly for low-power (up to 5 megawatts) experiments with representative fission products and fissionable materials. These experiments will allow measurement of the production and removal of spallation products and fission products, and the testing of transmutation effectiveness in different configurations.

Subatomic Physics Research. Historically, a wide variety of subatomic physics research was conducted at this accelerator facility. Currently, experiments are conducted at the Liquid Scintillator Neutrino Detector Facility (Building 53–364) in conjunction with several universities. Atomic parity nonconservation experiments are conducted in Area A. These use a thin target to produce unstable isotopes, and detectors to measure their properties. Research built on subatomic physics techniques and knowledge is also developing the technology for, and use of, neutron and proton radiography for stockpile stewardship applications. Experiments to date have been directed at radiographing static objects using WNR and small, contained dynamic experiments in Line B, utilizing appropriate locations for access to the proton beam. These experiments have demonstrated the utility of the technique and provide data on explosives behavior. Experiments take place in Line C, which allows room for continued dynamic materials research studies and technique development. This research includes development and demonstration of advanced detectors.

Medical Isotope Production. The 800-million electron volt accelerator proton beam is used to produce radioisotopes used by the medical community for diagnostic procedures, therapeutic treatment, clinical trials, and biomedical research. Nearly 40 different medical radioisotopes have been produced and shipped in the 20 years of production at LANL. During 1995, for example, 75 shipments were made to user facilities in nine countries, including France, Germany, and Australia.

Isotopes are currently produced at the Isotope Production Facility (IPF), at the linear accelerator beam stop in Area A (Building 53–003M). The IPF currently makes use of that portion of the proton beam that is not consumed by and used for proton and neutron experiments and research. The IPF has nine independent stringers or target stations. A small amount of target material is loaded onto each movable stringer, and the stringer is inserted into the proton beam path. Remote handling equipment and water-cooled targets are required due to the high radiation levels (up to 50,000 roentgen per hour) and temperatures (up to 1,832°F [1,000°C]) generated by the spallation process. Isotope production and facilities will be relocated to a new 100-million electron volt station in an add-on to Building 53–003B. This change will result in more selective and more efficient isotope production and the generation of fewer byproduct isotopes (as compared to the current use of the 800-million electron volt beam).

are transported from TA–53 to the Radiochemistry Facility in TA–48 (described in section 2.2.2.13) for recovery of the desired radioisotopes from the target material.

High-Power Microwaves and Advanced Accelerators. High-power microwave research and experiments, mostly conducted in Buildings 53–014 and 53–018, occur in a number of technology areas: (1) high-power microwave, RF, and electromagnetic pulse sources that typically use multi-kiloampere, relativistic electron beams; (2) future linac power sources and directed energy; (3) explosively driven high-power microwave and RF systems for defense applications; (4) intense beam physics and modeling for application to high-power microwave source development; (5) high-power, free-electron lasers based on high-brightness electron accelerators; (6) high-brightness accelerator as a driver for an extreme UV source for lithography; (7) high-performance ground penetrating radar for environmental remediation; (8) application of high-power microwaves to industrial processing, such as chemical catalysis and environmental remediation; (9) microwave and electromagnetic pulse vulnerability and effects testing of weapons systems; (10) novel high-power microwave sources based on shock compression of solid materials; (11) advanced pulsed-power modulator development; (12) development of room-temperature and superconducting RF linac structures; and (13) development of advanced electron accelerators. Research also will be conducted to support development of the spallation neutron source (as discussed in chapter 1, section 1.5.9).

2.2.2.12 *Health Research Laboratory (TA–43)*

The Health Research Laboratory (HRL) complex within TA–43 includes the main HRL and 13 support buildings and facilities (Figure 2.2.2.12–1 and Table 2.2.2.12–1). The Life Sciences Division is the primary occupant of TA–43 and is responsible for management, and safety measures, procedures, and most of the research and experimental science activities at HRL. Three of the support buildings and structures have low hazard classifications. HRL is designated a low hazard as a radioactive material source and low hazard as a chemical source facility. One transportable building houses lasers and is designated low hazard as an energy source, and a safety storage shed where chemical waste is stored is assigned a low hazard as a chemical source. The other buildings have no hazard classification.

TABLE 2.2.2.12–1.—*Principal Buildings and Structures of the Health Research Laboratory*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–43	Offices, Laboratories: 43–1, 20, 24, 37 Sewage Lift Station: 43–10 Storage: 43–12, 28, 36, 46 Cooling Tower: 43–44 Computer/Instrument Assembly Building: 43–45 Chemical Storage Sheds: 43–47, 49, 61

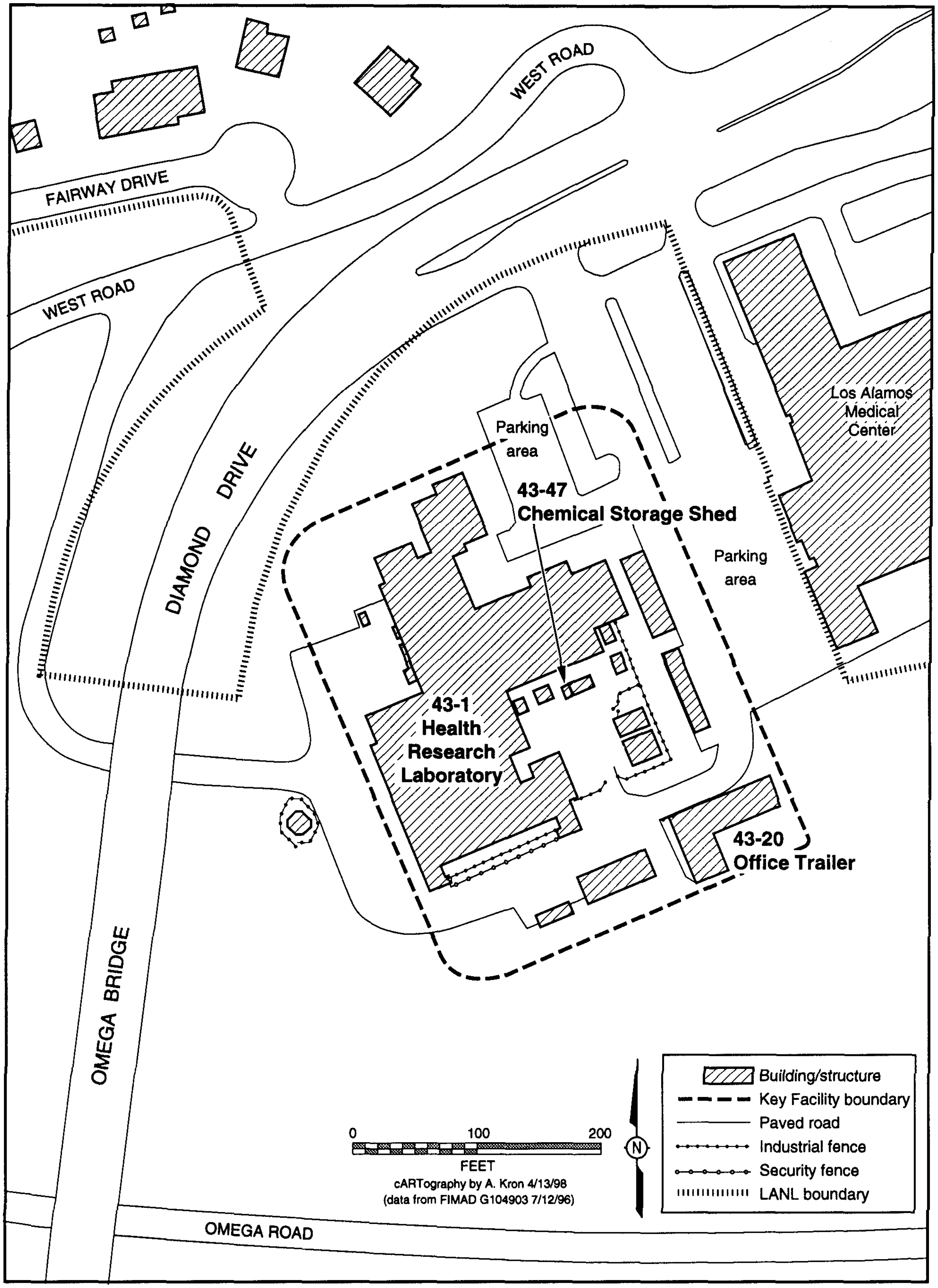


FIGURE 2.2.2.12–1.—*TA–43 Health Research Laboratory.*

Description of Facilities

Research areas in HRL focus on trying to understand the relationships between energy and health by studying the effects of different types of radiation and chemicals on cells and subcellular components. This research is important to DOE because of its work in nuclear fission and fossil fuels, both of which generate byproducts that can affect human health by damaging deoxyribonucleic acid (DNA) and can lead to carcinogenesis.

Small quantities of many toxic and hazardous chemicals are transported to and used in research projects at HRL. They include solvents, flammable materials, dilute suspect carcinogens, certain recombinant biological preparations, and compressed gasses. There are four low-level radioactive sources used for the irradiation of samples: two cesium-137 sources, one cobalt-60 source, and one plutonium-238 source. In addition, several sealed sources of depleted uranium (uranium-238) are used to check personnel monitoring equipment. Radioisotope-labeled compounds are also used in small volume operations and include phosphorus-32, phosphorus-33, and sulfur-35. All are short-lived (half lives in days) beta emitting radionuclides. Radioactive wastes are typically allowed to decay before being discarded. Operations at HRL may involve samples that contain radionuclides as well as dilute suspect carcinogens and other hazardous chemicals.

Chemical and radiological wastes produced at HRL are disposed of through LANL's waste management system. Animal tissues and carcasses are identified as infectious medical wastes and are disposed of as medical wastes (biohazard) through an off-site commercial firm that destroys such waste. All cells, subcellular materials, and culture media are sterilized and then disposed of along with solid wastes at the Los Alamos County Landfill. Wastes from the animal colony are also disposed of as administrative wastes in the Los Alamos County Landfill because the animals are not used as hosts for disease organisms and intact animals are not treated with radioactive materials (the animal colony has rats, mice, rabbits, and similar small mammals, but no primates or large mammals). Wastewater from animal colony cleaning operations is disposed of into the sanitary sewage system. All of the research activities at HRL produce low volumes of waste.

There is one outfall associated with HRL, and it discharges cooling water from lasers into Los Alamos Canyon. The Life Sciences Division is considering the elimination of this outfall and discharging cooling water instead to the Los Alamos County Sewage Treatment Facility. Further NEPA review would be prepared for any such proposal.

Because of its location, utilities (gas, water, and electricity) are delivered to HRL from Los Alamos County distribution systems. These delivery systems are metered, unlike most of the other facilities at LANL.

Description of Capabilities

The capabilities at HRL are described below.

Genomic Studies. These studies are directed at understanding the organization, replication, and regulation of complex genomes.

Cell Biology. Activities are directed at understanding how whole cells respond to insults from the environment, including ionizing radiation and oxidants.

Cytometry. Activities focus on developing, refining, and applying laser-based techniques for imaging and analyzing biological materials such as whole cells and subcellular organelles.

DNA Damage and Repair. Studies involve how DNA is damaged and how it is repaired.

Environmental Effects. Studies involve the ecology of microbes and how the DNA and protein components in microbes are changed as a result of changes that humans introduce into the environment.

Structural Cell Biology. These are activities to understand the structure, functions, and interactions of subcellular structures and biological macromolecules.

Neurobiology. These activities include studies of the functions of the human brain, using magnetic waves generated by the brain to map the areas that become active as the brain receives certain sensory stimuli and goes through thinking/reasoning activities.

In-Vivo Monitoring. This activity provides a service to other LANL operations. Extremely sensitive detection equipment measures photons emitted by the bodies of workers to determine whether they have inhaled any radioactive material.

2.2.2.13 *Radiochemistry Facility (TA–48)*

The Radiochemistry Facility at TA–48 was constructed from 1955 through 1957. The entire TA covers 116 acres (47 hectares), but the main buildings are enclosed behind a security fence on 8.6 acres (3.5 hectares) (Figure 2.2.2.13–1). TA–48 contains five research buildings: the Radiochemistry Laboratory (48–1), the Isotope Separator Facility (48–08), the Diagnostic Instrumentation and Development Building (48–28), the Advanced Radiochemical Diagnostics Building (48–45), and the Analytical Facility (48–107) (Table 2.2.2.13–1).

The Radiochemistry Facility is a research facility that fills three roles. Research supports environmental management projects (e.g., Yucca Mountain Project, plutonium stabilization), catalysis, basic energy, and other scientific endeavors. Chemistry research is performed in the areas of inorganic, actinide, organometallic, environmental, geochemistry and nuclear chemistry. The Radiochemistry Facility is also a production facility, using the hot cell in Building 48–01 to separate and package radioisotopes needed and used by researchers, physicians, hospitals, and pharmaceutical companies all over the world. In a typical year, the LANL isotopes program makes more than 150 shipments of up to 30 different isotopes, some of which are available only from LANL. In addition, the facility provides services to other LANL organizations (e.g., samples are analyzed at TA–48 as part of the environmental surveillance program).

TABLE 2.2.2.13–1.—*Principal Buildings and Structures of the Radiochemistry Facility*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–48	Radiochemistry Laboratory: 48–1 Isotope Separator Facility: 48–8 Diagnostic Instrumentation and Development Building: 48–28 Advanced Radiochemical Diagnostics Building: 48–45 Analytical Chemistry Facility: 48–107

Description of Facilities

Building 48–01 is a Hazard Category 3 nuclear facility, and the other four laboratory buildings are classified as low-level radiological hazard. Twenty-six other structures are classified as no hazard, including trailers, transportable buildings, metal sheds, office buildings, and storage facilities.

The Radiochemistry Laboratory is a single-story building with a basement and a penthouse. With slightly more than 100,000 square feet (9,300 square meters) of floor space, Building 48–01 is divided into several wings for differing types of research:

- Laboratory wings for light chemical analysis and research

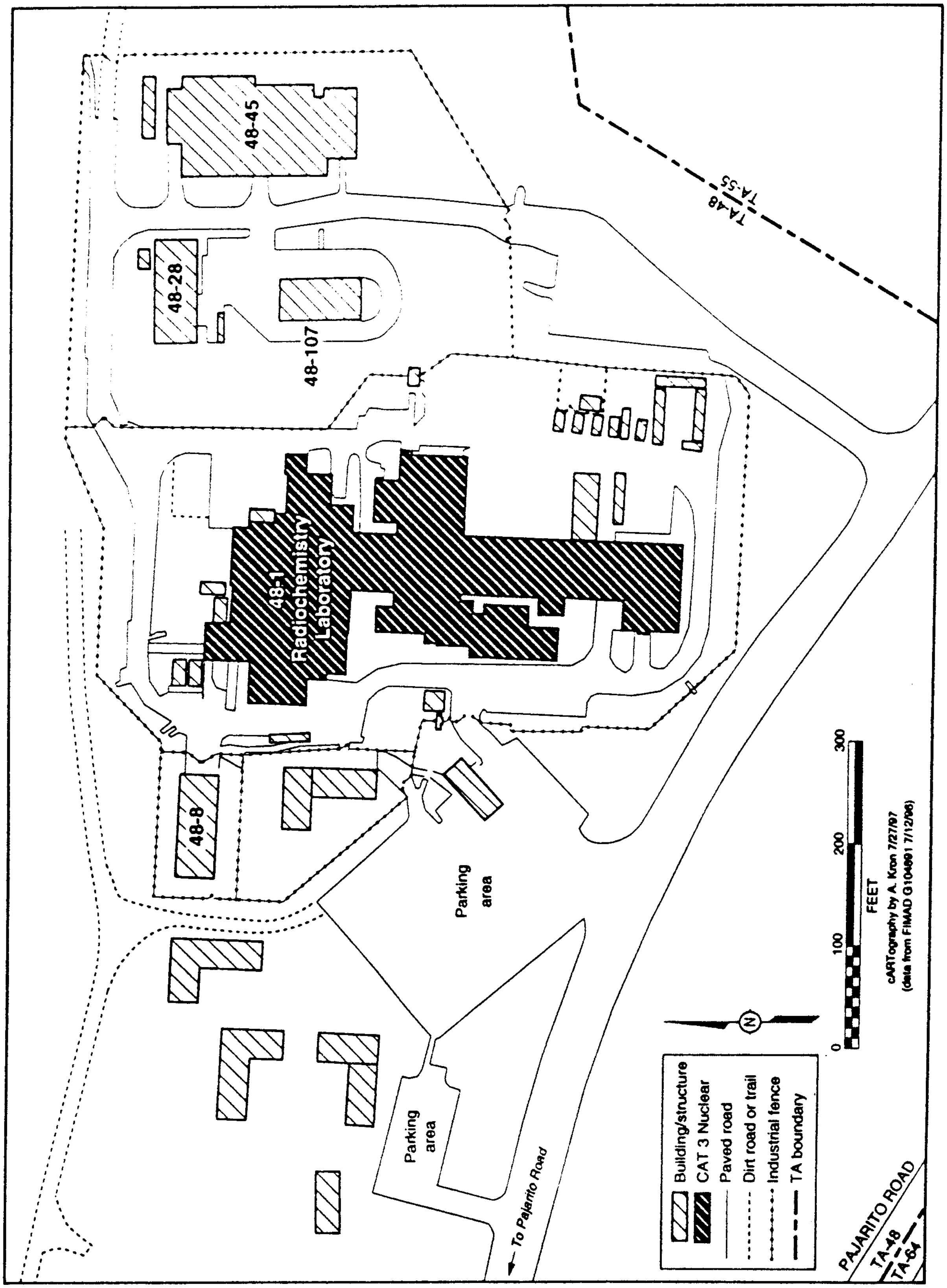


FIGURE 2.2.2.13–1.—*TA–48 Radiochemistry Facility.*

- A hot cell for the separation, packaging, and shipment of radioisotopes to medical facilities, research institutions, and pharmaceutical firms
- An alpha wing for research with plutonium and other alpha-emitting radionuclides
- A counting wing, which houses detectors and equipment for the assay of radioactive samples. There is also an office wing and a secure wing for historical weapons data. Most radiochemical research is conducted on the main floor, although a few laboratories are located in the basement. The basement also houses utilities, support systems, and ventilation exhaust fans and ductwork. Ventilation intake fans and heating and cooling units are located in the penthouse.

Three exhaust stacks at Building 48–01 are continuously sampled for radioactive emissions in accordance with requirements of the EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP): FE–7 (hot cell), FE–54 (the alpha wing), and FE–60 (hot cell dilution bench). Building 48–01 also discharges cooling tower waters through three outfalls into Mortandad Canyon.

Research at the Isotope Separator Facility (48–08) includes the separation and collection of radioactive isotopes for analytical quantification and the development of equipment used for isotope separation. Building 48–28 has two laboratories; one houses five laser systems and two mass spectrometers used for environmental research experiments, and the other is used to analyze radioactive water samples.

The Advanced Radiochemical Diagnostics Building (48–45) contains 11 chemistry and 7 instrument laboratories. These laboratories are clean rooms designed to minimize the effect of environmental factors on the accuracy of isotope measurements for experiments in solar physics, geosciences, biology, and atmospheric science.

The Analytical Chemistry Facility (48–107) contains four light chemistry laboratories and a laser laboratory and is used to support environmental research, catalysis research, and inorganic chemistry.

Description of Capabilities

There are several services and capabilities available at TA–48: radionuclide transport studies, environmental restoration support, ultra-low-level measurements, nuclear and radiochemistry, high-level beta/gamma chemistry, actinide TRU chemistry, data analysis, inorganic chemistry, structural analysis, and sample counting. Each of these is described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

Radionuclide Transport. Numerous chemical and geochemical investigations are undertaken that address concerns about hydrologic flow and transport of radionuclides. Areas of study include the sorption (binding) of actinides, fission products, and activation products in minerals and rocks, and the solubility and speciation of actinides in various chemical environments (e.g., environments associated with waste disposal). These studies are paired with the development of models to evaluate, for example, the parameters for performance assessment of mined geologic disposal systems.

Environmental Remediation. Environmental remediation capabilities at TA–48 fall into two categories: characterization and remediation of soils contaminated with radionuclides and toxic metals; and data analysis and integrated site-wide assessment. In characterizing and remediating soils contaminated with radionuclides and toxic metals, a major objective is to minimize the generation of large volumes of metal- and radionuclide-contaminated soils. The objective of data analysis and integrated side-wide assessment is to accelerate remediation through improved sampling schemes, clearer and more efficient evaluation of characterization data, and more effective tools for assigning priority to cleanup targets.

Ultra-Low-Level Measurements. Isotopic tracers and high-sensitivity measurement technologies have been developed to support the U.S. nuclear weapons program. The isotopic tracers can include both radioactive and nonradioactive isotopes, with emphasis on the nonradioactive. Some are commercially available, and some can be produced at LANL. The research staff also specializes in developing analytical techniques for a variety of problems in nuclear, environmental, and biological sciences.

Mass spectrometers detect and analyze samples as small as one-thousandth of one-billionth of a gram. Chemical separation procedures to isolate the element to be measured are conducted in a chemistry laboratory specially designed to keep the sample from being contaminated by natural or man-made sources. This technique can determine both the source and the amount of radioactive contamination. For example, these efforts allow determination of whether radiation in an environmental sample results from contamination from a nearby nuclear reactor or from radioactive fallout from global weapons testing. LANL researchers can also trace the migration of radioactive contamination through the environment.

Nuclear/Radiochemistry. Activities under this capability include developing radiation detectors, conducting radiochemical separations, and performing nuclear chemistry. Development, calibration, and use of radiation detectors include the use of off-the-shelf systems for routine measurement of radioactivity and development of new radiation detection systems for a number of special applications. LANL conducts both routine and special separations of radioactive materials from other radioactive species and stable impurities. These experiments have provided support to Hanford waste tank treatment activities and production of medical isotopes. Separations are based on traditional approaches that use commercially available ion-exchange media, extractants, and other reagents. LANL also develops new separations based on experimental chemical systems, using radioactive tracers to synthesize the chemicals and to characterize their performance.

Nuclear chemistry efforts use exotic laser-based atom traps for probing the interactions of energy and atoms in energy regimes not easily accessed by other techniques. This work requires conducting extensive laser spectroscopy, handling of radioactive materials, and interpreting the resulting data. In other nuclear chemistry efforts, targets are irradiated and isotopes are captured at LANSCE (described in section 2.2.2.11) or at off-site reactors to produce specific radioactive isotopes. These isotopes are then separated from impurities, and their neutron capture cross sections are measured at TA–48.

Isotope Production. This capability produces, chemically separates, and distributes isotopes to the medical and industrial user communities. TA–48 activities include preparing the target packages that will be irradiated to make isotopes, transporting these packages to the LANSCE accelerator (described in section 2.2.2.11), inserting them into the proton beam, retrieving them from the beam, and transporting them back to TA–48. Once the target packages arrive back at TA–48, they are disassembled and the target material is moved to a chemistry hot cell for processing to recover the desired isotopes. Post-irradiation activities associated with these targets must be carried out using remote handling techniques. Separated isotopes are packaged for shipment and are distributed to customers throughout the world.

Actinide/Transuranic Chemistry. The activities in the alpha wing are essentially the same as the radiochemical separations carried out in the rest of the facility. The materials handled are actinides and transuranics (elements with an atomic weight greater than that of uranium [92]) that require the special safe-handling environment provided in this wing.

Data Analysis. Data analysis is the process of taking information learned from all of the measurements made on a material and putting it into the context of the experimental design. This process is a paper exercise that turns data into useful information that will help answer experimenters' questions.

Inorganic Chemistry. Inorganic chemistry work at TA–48 includes two main categories of activities: (1) synthesis, catalysis, and actinide chemistry and (2) development of environmental technology. The former category includes chemical synthesis of new organometallic complexes, structural and reactivity analysis, organic product analysis, reactivity and mechanistic studies, and synthesis of new ligands for radiopharmaceuticals. Development of environmental technology includes designing and synthesizing ligands for selective extraction of metals, soil washing, development of membrane separators, photochemical processing, and ultrafiltration. Other work involves oxidation reduction studies on uranium and other metals for both environmental restoration and advanced processing.

Structural Analysis. Structural analysis at TA–48 includes the synthesis, structural analysis, and x-ray diffraction analysis of actinide complexes in both single-crystal and powder form. This capability supports programs in basic energy sciences, materials characterization, stockpile stewardship, and environmental management.

Sample Counting. Sample counting, the measurement of the quantity of radioactivity present in a sample, is accomplished with a variety of radiation detectors, each customized to the type of radiation being counted and the expected levels of radioactivity. All samples counted in the counting facility are sealed items that are placed inside appropriate detectors for a specified period of time. At the end of the count, the data are automatically processed through the computer system and results are presented to the users. Other activities in the counting room include system calibration, quality checks on system performance, and corrective action when problems occur.

2.2.2.14 *Radioactive Liquid Waste Treatment Facility (TA–50)*

TA–50 is located near the center of LANL (see Figure 2.2.2.14–1 and Table 2.2.2.14–1). Its 62 acres (25 hectares) are the home for 33 total waste management structures, including office trailers, tanks, storage sheds, and four buildings. Approximately 110 people participate in the following waste management activities:

- Treatment of radioactive liquid wastes
- Decontamination of respirators, equipment, instruments, vehicles, and waste items
- Size reduction of TRU waste
- Characterization of TRU waste

As discussed in the SWEIS Notice of Intent, the DOE had, at one time, proposed a construction project to replace the aging RLWTF. Given the

TABLE 2.2.2.14–1.—*Principal Buildings and Structures of the Radioactive Liquid Waste Treatment Facility*

TECHNICAL AREA	PRINCIPAL STRUCTURES AND BUILDINGS
TA–50	Radioactive Liquid Waste Treatment Facility: 50–1 Decontamination Trailer: 50–185

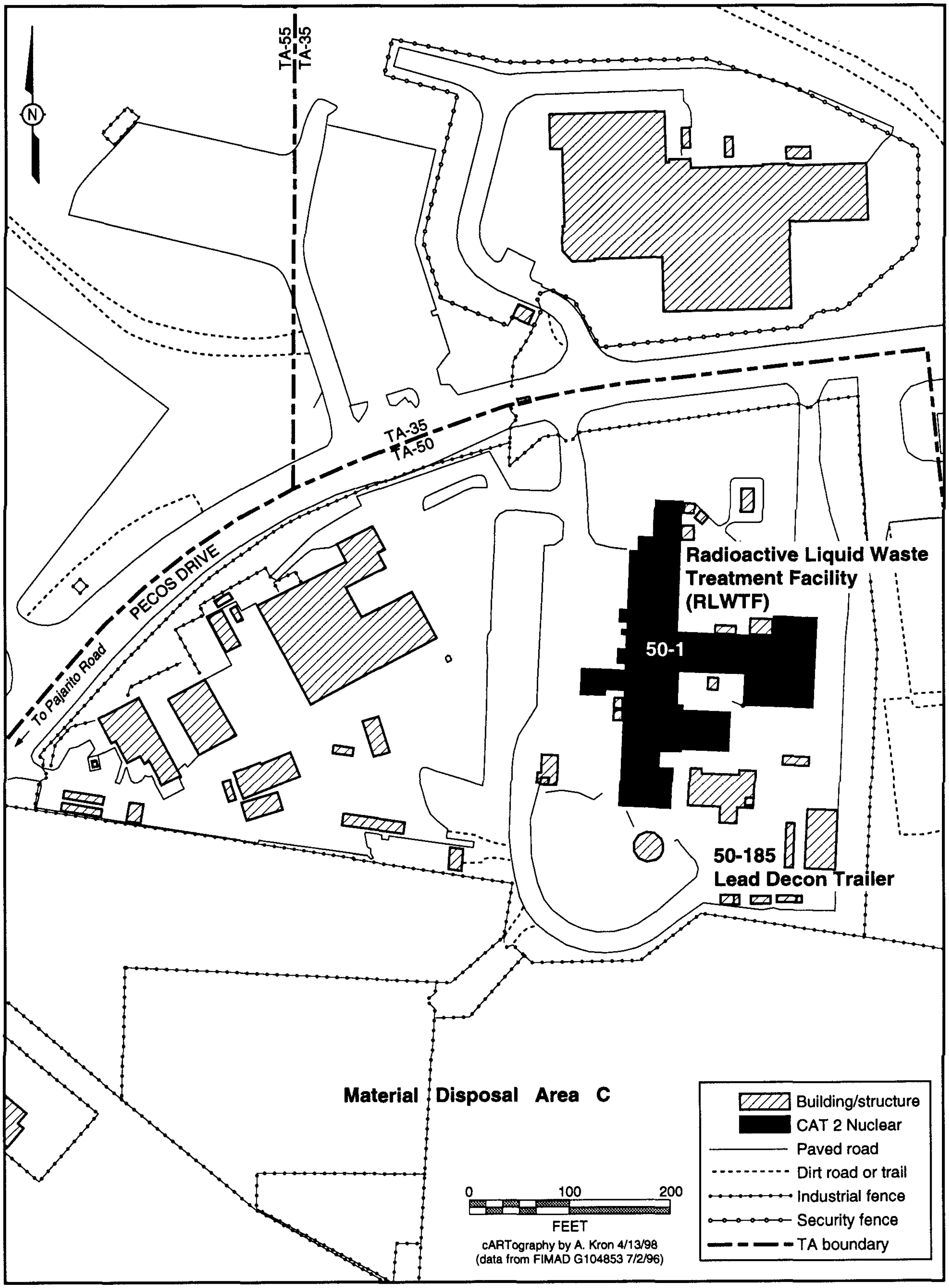


FIGURE 2.2.2.14–1.—*TA–50 Radioactive Liquid Waste Treatment Facility.*

cost of such a replacement facility, DOE withdrew that project and initiated studies to benchmark the "best in class" private-sector radioactive liquid waste treatment options. The DOE currently is considering various options for future liquid waste treatment, including the benefits of a centralized versus a decentralized approach (at the point of generation). In recognition of potential environment, safety, and human health issues associated with operations in an aging facility, as well as compliance issues regarding the effluent from the RLWTF, the DOE has been upgrading the facility and treatment technologies utilized. Upgrades have included retrofitting to upgrade or replace tanks and pipes (which are now double-walled), ventilation and air monitoring systems, and a treatment system (discussed later in this section). Future upgrades or replacement proposals would be subject to NEPA reviews tiered from this SWEIS.

Description of Facilities

Waste management operations at TA–50 principally take place at three facilities: the RLWTF, the Radioactive Materials Research, Operations, and Demonstration (RAMROD) Facility, and the Waste Characterization, Reduction, and Repackaging (WCRR) Facility. Activities in the RAMROD and WCRR facilities are associated with TRU wastes, and are described as part of the Solid Radioactive and Chemical Waste Facility (described in section 2.2.2.15).

RLWTF (Building 50–01) is the largest structure at TA–50 with 40,000 square feet (3,720 square meters) under roof. It is a Hazard Category 2 nuclear facility. Liquid wastes from the plutonium facility at TA–55 (described in section 2.2.2.1) are pre-treated in Room 60, then added to influent tanks that collect radioactive liquid waste from other LANL facilities. These combined liquid wastes are processed, then collected in tanks, and, if in compliance with regulatory standards, discharged into Mortandad Canyon. Improvements in treatment technology (ultrafiltration/reverse osmosis) are planned to come online by early 1999. LLW sludge from the chemical treatment step is drummed and sent to TA–54 for disposal, while TRU sludge is solidified and sent to TA–54 for storage pending eventual disposal (described in section 2.2.2.15).

The south wing of the basement of Building 50–01 houses equipment for the decontamination of personnel respirators from LANL operations, vehicles, equipment, portable instruments, precious metals, and scrap metal. Decontamination solutions are drained to influent tanks for radioactive liquid waste and LLW treatment operations. Decontamination allows re-use of respirators and equipment, and recycle of materials such as precious metals and scrap metals. It also reduces the volume of wastes that must be disposed.

The Lead Decontamination Trailer, Building 50–185, is located just behind the RLWTF. Here, contaminated lead bricks are subjected to a grit blast and subsequent water wash to remove radioactive contamination. Bricks are then re-used within the laboratory. Spent grit is packaged as solid LLW or TRU waste and sent to TA–54 for disposal or storage. Wash solutions are drummed, sampled, and transported to RLWTF for treatment.

There are seven concrete underground storage tanks (USTs) adjacent to RLWTF. These range in size from 2,600 to 75,000 gallons (9,840 to 283,875 liters). However, two of three existing influent USTs were replaced by four aboveground steel tanks. This 1.4-million-dollar modification to the tank farm (Building 50–02) was completed in 1997. The total influent holding capacity remains at 50,000 gallons (190,000 liters).

Each of the three major buildings at TA–50 has a stack for the discharge of equipment and/or process room air. Each of these stacks is equipped with a continuous air sampling device. Buildings 50–01 and 50–69 also have two additional ventilation stacks each that are not continuously sampled.

Approximately 5 million gallons (20 million liters) of treated effluent are discharged annually from RLWTF into Mortandad Canyon via NPDES Outfall #051. Discharges from RLWTF into Mortandad Canyon have created a small wetland area near this outfall.

An estimated 3.68 million cubic feet (103,000 cubic meters) of chemical, radioactive, and mixed solid wastes were buried from 1948 to 1974 in 7 pits and 108 shafts in former Material Disposal Area (MDA) C. MDA C covers 11.8 acres (4.78 hectares), is completely fenced in, and is being investigated as part of LANL's ER Project. Disposal pits and shafts lie 1,300 feet (397 meters) above the main aquifer. Surface waters drain to the northeast into Ten Site Canyon, a branch of Mortandad Canyon. There is no evidence of migration of wastes from Area C (LANL 1992).

In response to the November 1997 report of the DOE Inspector General on the RLWTF (DOE 1997b), DOE prepared a "make or buy" analysis of radioactive liquid waste collection and treatment at LANL, focusing on possible privatization of the RLWTF. The DOE concluded that the continued operation of the RLWTF by LANL was the appropriate course of action (Gurule 1998).

Description of Capabilities

Capabilities and operations performed at the RLWTF include: waste characterization, packaging, and labeling; waste transport, receipt, and acceptance; waste storage; liquid waste pre-treatment and treatment; and material decontamination. Each of these is described below. The manner in which these activities would vary among the alternatives is described in chapter 3.

Waste Characterization, Packaging, and Labeling. Waste characterization is the process of identifying and quantifying constituents of concern in waste streams, accomplished in one of three ways. The first, process knowledge, uses information in lieu of sampling and analysis to characterize the waste. The second, radiological testing, employs techniques such as gamma spectroscopy, liquid scintillation, and passive/active neutron scanning to determine types and quantities of radionuclides in a waste.

The third is waste sampling and analysis, which depends on the ability to obtain representative samples and on analytical reproducibility. The three methods may also be used together when characterizing a waste stream.

DOT regulations specify what types of containers are acceptable for transporting each type of waste and labeling requirements for each type of container. Waste generators perform the initial packaging and labeling operations, but waste management personnel sometimes perform two other packaging operations. Waste may be overpacked to ensure container integrity (e.g., by placing a 55-gallon drum into an 85-gallon drum). Wastes can also be repackaged to reduce storage and transportation costs. In this operation, waste management personnel either combine the waste from a number of smaller containers into a single container, or place smaller containers of waste into a larger container.

Waste Transport, Receipt, and Acceptance. Liquid wastes travel from generator facilities to the RLWTF at TA–50 by one of thee modes. Most radioactive liquid wastes are sent via an underground pipeline system that transfers liquids directly to RLWTF influent tanks. Other generators, not connected by the underground pipeline system, transfer their wastes into a special tanker truck for delivery to the RLWTF. Generators of small quantities of radioactive liquid wastes drum their wastes, then truck the drums to TA–50.

Waste receipt and acceptance occurs with every shipment of waste to a waste management facility. Activities typically include visual inspection of vehicle and container, cross-checking container labels and shipment manifests, radiation surveys of the vehicle and containers, and weighing of vehicles, and/or containers.

Waste Storage. Liquid and solid chemical, radioactive, and mixed wastes are stored at both TA–50 and TA–54. At TA–50, wastes are stored within the RAMROD Facility, adjacent to the WCRR Facility, and within influent storage tanks at the RLWTF.

Radioactive Liquid Waste Pre-Treatment. Radioactive liquid wastes from TA–21 (described in section 2.2.2.2) are pre-treated at Building 21–257 using pH adjustment (using sodium hydroxide), flocculation (using calcium hydroxide, ferric sulfate, and a polymer), settling, and filtration. Radioactive liquid wastes from TA–55 (described in section 2.2.2.1) are pre-treated in the same fashion in Room 60 of the RLWTF at TA–50. Pre-treated streams are added to similar radioactive liquid wastes from all other LANL generators, then treated in the main process line of the RLWTF.

Radioactive Liquid Waste Treatment. Beginning in early 1997, the main process for treatment of radioactive liquid wastes employs ultrafiltration and reverse osmosis. Ultrafiltration typically removes solids and dissolved materials as small as 10 nanometers in diameter, while reverse osmosis will remove materials less than 1 nanometer in size. The newer technology also reduces the amounts of most chemicals required by the pre-treatment process (calcium hydroxide, ferric sulfate, and polymers are not required, and sodium hydroxide use is approximately halved). Once treated, effluent is discharged via NPDES Outfall 051. Solid wastes generated from treatment processes are shipped to TA–54 for appropriate storage or disposal. In the summer of 1998, process equipment for nitrate reduction will be installed to ensure compliance with recent changes to groundwater discharge limits. The new process will use biological denitrification to reduce nitrate concentrations to 10 parts per million or lower. The new process is expected to become operational in mid 1999.

Decontamination Operations. Decontamination is performed by waste management personnel either to enable re-use of an item or to re-classify the waste type. Both activities are used primarily to achieve waste volume reduction. An example of the former activity is the removal of radioactive surface contamination from lead bricks, thus enabling the bricks to be re-used as shielding. An example of the second activity is the sorting and segregating of a waste item or package into its components (e.g., hazardous and radioactive) so that the waste is no longer a mixed waste. Decontamination operations take place in Buildings 50–01 and 50–185.

2.2.2.15 Solid Radioactive and Chemical Waste Facilities (TA–54 and TA–50)

TA–50 houses some solid waste facilities (Figure 2.2.2.15–1) in addition to the radioactive liquid waste facilities described in section 2.2.2.14. At 943 acres (382 hectares), TA–54 is one of the larger technical areas at LANL (Figures 2.2.2.15–1 through 2.2.2.15–4). There are 120 structures within TA–54, of which 101 house waste management personnel and operations (Table 2.2.2.15–1). Approximately 130 workers are needed to perform these treatment, storage, and disposal operations. A variety of wastes are managed at TA–54, including industrial, toxic, hazardous, LLW, TRU, and mixtures of the above. Waste forms are solid except for small quantities of gaseous or liquid hazardous, toxic, and mixed wastes. Storage, disposal, and some treatment operations are conducted.

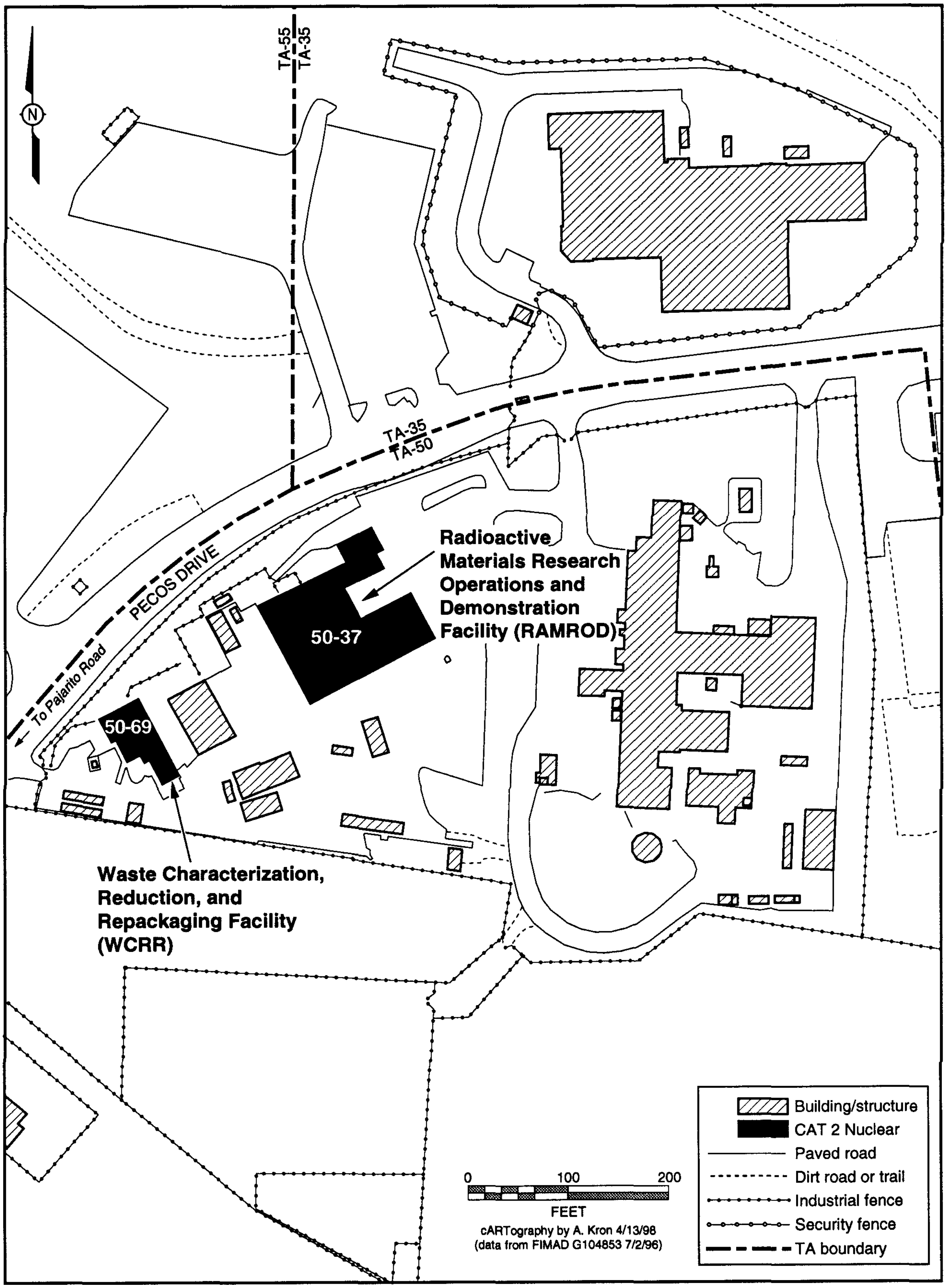


FIGURE 2.2.2.15–1.—*TA–50 Solid Radioactive and Chemical Waste Facilities.*

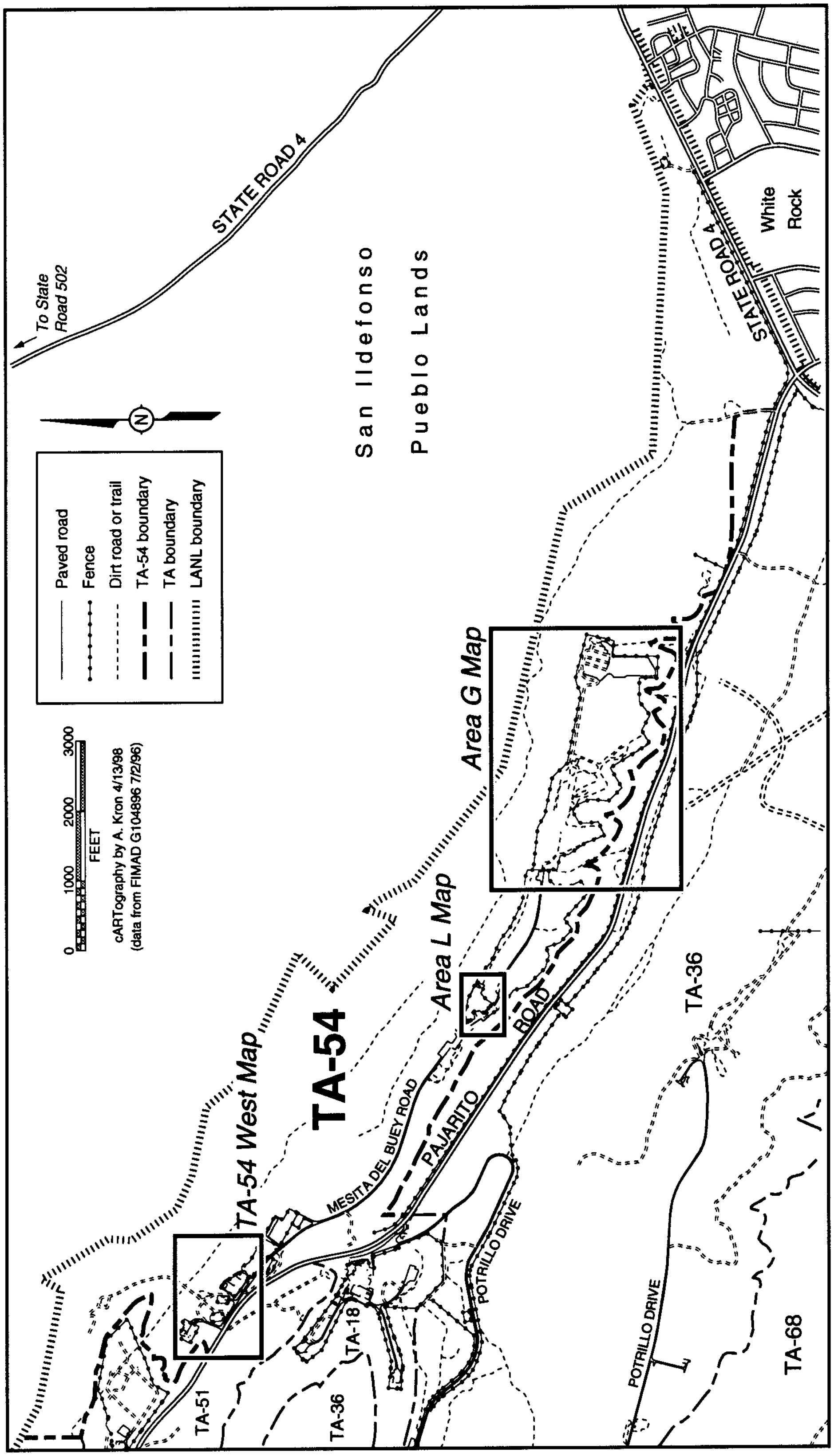


FIGURE 2.2.2.15–2.—*TA–54 Solid Radioactive and Chemical Waste Facilities.*

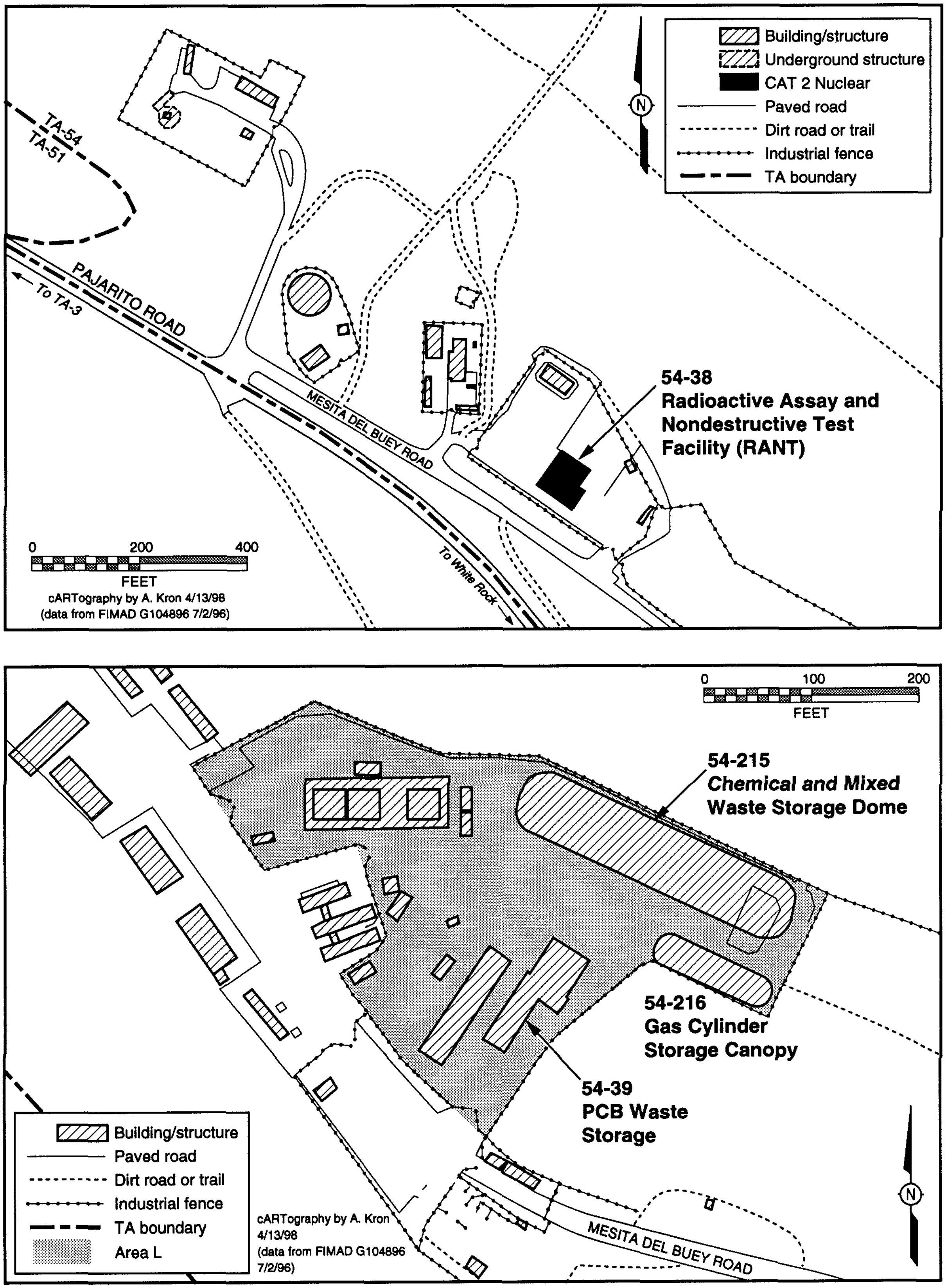


FIGURE 2.2.2.15–3.—*TA–54 Solid Radioactive and Chemical Waste Facilities.*

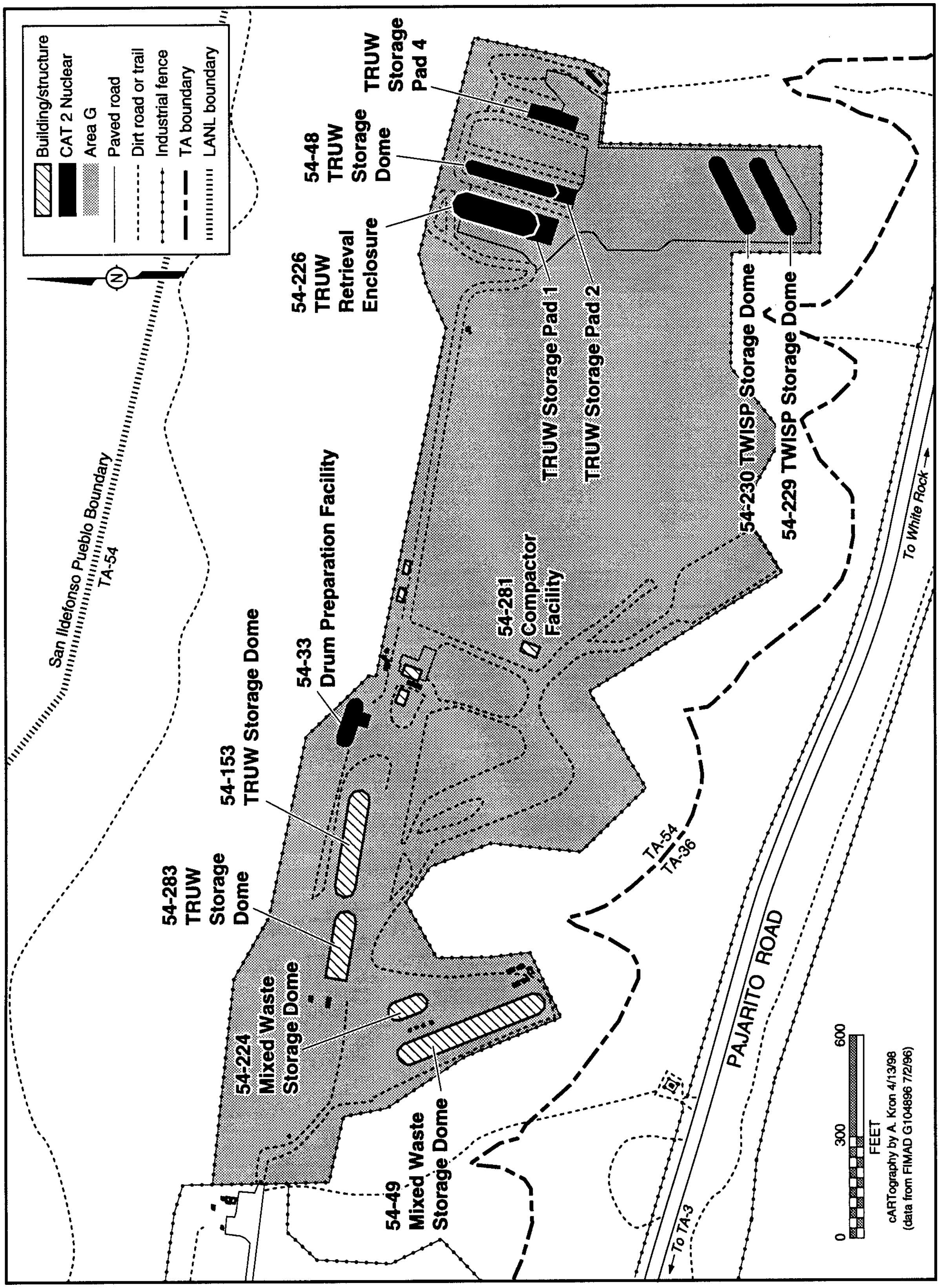


FIGURE 2.2.2.15–4.—*TA–54 Solid Radioactive and Chemical Waste Facilities.*

TABLE 2.2.2.15–1.—*Principal Buildings and Structures of the Solid Radioactive and Chemical Waste Facilities*

TECHNICAL AREA	PRINCIPAL BUILDINGS AND STRUCTURES
TA–50	Radioactive Materials Research, Operations, and Demonstration Facility: 50–37 Waste Characterization, Reduction, and Repackaging Facility: 50–69
TA–54	Drum Preparation Facility: 54–033 Radioactive Assay and Nondestructive Test (RANT) Facility: 54–038 PCB Storage Building: 54–039 TRU Waste Storage Domes: 54–048, 153, 283 Mixed Waste Storage Domes: 54–049, 215, 224 TRU Waste Retrieval Enclosure: 54–226 TRU Waste Storage Domes: 54–229, 230 Gas Cylinder Storage Canopy: 54-216 Earth-Covered Drums of TRU Waste: Pads 1, 2, 4 Compactor Facility: 54–281 Storage Dome for Supplies: 54–282

Description of Facilities

TA–54 West. The far west portions of TA–54 are the location for environment, safety, and health offices (Buildings 54–1001 through 54–1004), a research and development laboratory (Building 54–1009), and a potable water pumping station and chlorination facilities. None of these are waste management operations. TA–54 West is also the location of the Radioactive Assay and Nondestructive Test (RANT) Facility, Building 54–038, which is a Hazard Category 2 nuclear facility. This 6,900-square-foot (640-square-meter) structure is used to verify characterization data for unopened containers of TRU waste and solid LLW. Verification steps include container contamination surveys, container weighing, passive/active neutron assay to determine radionuclide content, and real-time radiography to confirm physical contents. RANT will also serve as the loading station for shipments of TRU waste to WIPP.

Area H. Radioactive wastes were disposed of in nine shafts between May 1960 and August 1986. (Historical information is insufficient to determine whether these wastes would be considered LLW or TRU waste under current classifications.) This 0.3-acre (0.12-hectare) site is now a Solid Waste Management Unit (SWMU) under the ER Project. Each shaft is 6 feet (1.8 meters) in diameter and 60 feet (18 meters) deep (with a capacity to hold 1,714 cubic feet [48 cubic meters] of wastes). This area was used for the disposal of classified wastes. Tritium contamination has been detected in soils adjacent to some of the shafts (LANL 1992). There are no aboveground structures at Area H.

Area J. Area J is 2.65 acres (1.07 hectares) in size and has been used since 1961 for the disposal of industrial solid wastes. The area has six disposal cells and four disposal shafts. Cells 1 and 2 are filled and capped with soil. Cell 3 is filled and capped with asphalt, and an asbestos transfer station is located on the asphalt. Cells 4, 5, and 6 are open. Two of the four shafts are filled and capped with concrete. Shafts 3 and 4 are less than 10 percent filled. Shafts are 6 feet (1.8 meters) in diameter and 60 feet (18 meters) deep, while pits vary in size (LANL 1992).

Disposal operations have interim status under RCRA, subtitle D, from the State of New Mexico. Five waste management operations are conducted at Area J:

- Administratively controlled industrial solid wastes (e.g., paper trash containing personnel information or contracts) are disposed. Three disposal cells are open; three have been filled to date. Waste volumes have been shrinking the past several years, and there is enough disposal capacity in the three unfilled cells for at least another 8 years of operation.
- Previously hazardous wastes. In the past, barium-contaminated soils were neutralized at TA–54, Area L, then disposed of at Area J in the same cells as industrial wastes. The last such disposal occurred in October 1993.
- Classified industrial wastes are disposed in shafts. There are four shafts, each 60 feet (18 meters) deep and 5 feet (1.5 meters) in diameter. Two of the shafts are filled and two nearly empty.
- Asbestos wastes are stored prior to shipment to a permitted asbestos disposal facility. Two roll-off containers are used to store friable asbestos wastes; nonfriable asbestos wastes are stored on an asphalt pad.
- Oil-contaminated soils are land farmed under an interim permit from the State of New Mexico. Soil is turned periodically, and soils are sampled for hydrocarbon content. The land farm covers an area of 8,200 square feet (763 square meters) (0.2 acre [0.08 hectare]) between Cells 1 and 6. Oil-contaminated soils have not been added to the land farm area since September 1992.

There are a number of storage sheds and a storage dome (Building 54–282) at the entrance gate to Area J. These hold supplies for all waste management operations at TA–54.

Area L. Area L is a 2.65-acre (1.07-hectare) operations site that is paved and fenced. Formerly used for the disposal of chemical wastes, the area is now used for receipt, storage, and shipment of *Toxic Substances Control Act* (TSCA), RCRA, and mixed wastes. These include hazardous waste (HW) (gaseous, liquid, and solid), PCB wastes (solid and liquid), liquid LLMW, and irradiated lead stringers from TA–53 (described in section 2.2.2.11).

Important structures within Area L are discussed below.

- *Liquid LLMW Storage Building 54–215.* This is a large (16,000-square-foot [1,490-square-meter]), new structure used for storing drums of LLMW. The building has a bermed asphalt floor, an unfiltered exhaust stack, interior lighting, and an overhead fire suppression system.
- *Gas Cylinder Canopy 54–216.* This one-walled, roofed facility (4,000 square feet [370 square meters]) is used to store gas cylinders until they can be shipped off site for treatment and disposal.
- *PCB Building 54–039 and Attached Canopy.* Liquid and solid PCB wastes are stored until they are shipped off site for treatment and disposal. Some of the waste liquids are also contaminated with hazardous and/or radioactive wastes.
- *Liquid Chemical Waste Storage Canopy 54–032*. Drums of liquid chemical wastes are segregated for compatibility, then stored in the appropriate section of this open structure.
- *Laboratory Pack Storage Units 54–068, 54–69, and 54–70*. Small quantities of HW are placed in 5-gallon (19-liter) laboratory packs. Laboratory packs are segregated for compatibility, then stored in these small sheds until shipped for treatment and disposal. Storage units are equipped with secondary containment.

- *Sampling, Shipment, and Treatment Canopies 54–058, 54–36, 54–35*. These sheltered pads have an overhead covering, but no sides. Canopy 54–035 contains two treatment tanks that are currently not in use. Canopy 54–036 holds equipment used to survey and sort mixed wastes.

Because Area L is covered with asphalt, stormwater is directed to a single outfall that discharges into Cañada del Buey at the northeast corner of the liquid LLMW storage dome 54–215. An overflow weir is used to measure discharge flow rates and volumes.

Chemical wastes were disposed of at Area L from the 1950's until December 1986. Inactive disposal units include 1 cell, 3 surface impoundments, and 34 shafts, with a total disposal capacity of 71,540 cubic feet (2,004 cubic meters) (LANL 1992). Noncontainerized solids and drummed, but without absorbent, liquids were disposed of in the unlined pit and shafts. Unlined surface impoundments B and C were used to evaporate treated salt solutions such as ammonium bifluoride and electroplating waste solutions. Unlined impoundment D was used to react lithium hydride with water and also served as secondary containment for waste oil tanks. This area is now being investigated under the LANL ER Project as part of Operable Unit 1148. To date, cadmium, chromium, and volatile organics have been detected in subsurface soils.

Area G. Area G is used principally for the disposal of solid LLW and the storage of TRU waste. Some LLMW is also currently stored in one part of Area G. Also, Area G has EPA approval for disposal of PCB waste (greater than 50 parts per million) in either disposal cells or shafts. However, only solid radioactively contaminated PCB waste may be disposed in Area G. Stabilized PCB waste also may be disposed, provided it has been stabilized in accordance with EPA requirements. Some treatment of LLW and TRU waste also takes place (e.g., compaction or other nondestructive volume reduction technologies). The legacy inventory buried at Area G includes TRU waste disposed of prior to 1971 and LLMW disposed of prior to the promulgation of RCRA in 1986. Important structures within Area G are presented in the PSSC analysis of the Expansion of Area G (see volume II, section I.1) and summarized below.

Disposal Cells and Shafts. At present, subsurface disposal units include 35 cells, approximately 260 shafts, and 4 trenches (Krueger 1994). The Area G disposal facility (Figure 2.2.2.15–5) has been a disposal site for LANL's solid radioactive waste since 1957, and is currently the only active disposal site for LLW.

Five cells (15, 31, 37, 38, 39) are currently in use. These five have a remaining disposal capacity of about 928,200 cubic feet (26,000 cubic meters). The existing footprint for Area G disposal operations has space for new cells that would add capacity for about another 357,000 cubic feet (10,000 cubic meters) of wastes. Continued disposal at TA–54 would require expansion of disposal operations beyond the current footprint. Alternatively, wastes would have to be packaged and shipped for off-site disposal.

Temporary Retrieval Dome, Building 54–226. This large (approximately 21,000 square feet [1,950 square meters]) fabric-covered dome structure is the site of the TRU Waste Inspectable Storage Project (TWISP), a multi-year project in which approximately 17,000 earth-covered containers of TRU waste will be retrieved, characterized, and placed into aboveground storage facilities. The dome provides an enclosure and weather protection for workers and is equipped with a ventilation system and HEPA filters. It will be dismantled and re-erected as retrieval operations proceed through TRU waste storage Pads 1, 2, and 4.

Drum Preparation Facility, Building 54–33. This facility has bays for steam cleaning and for

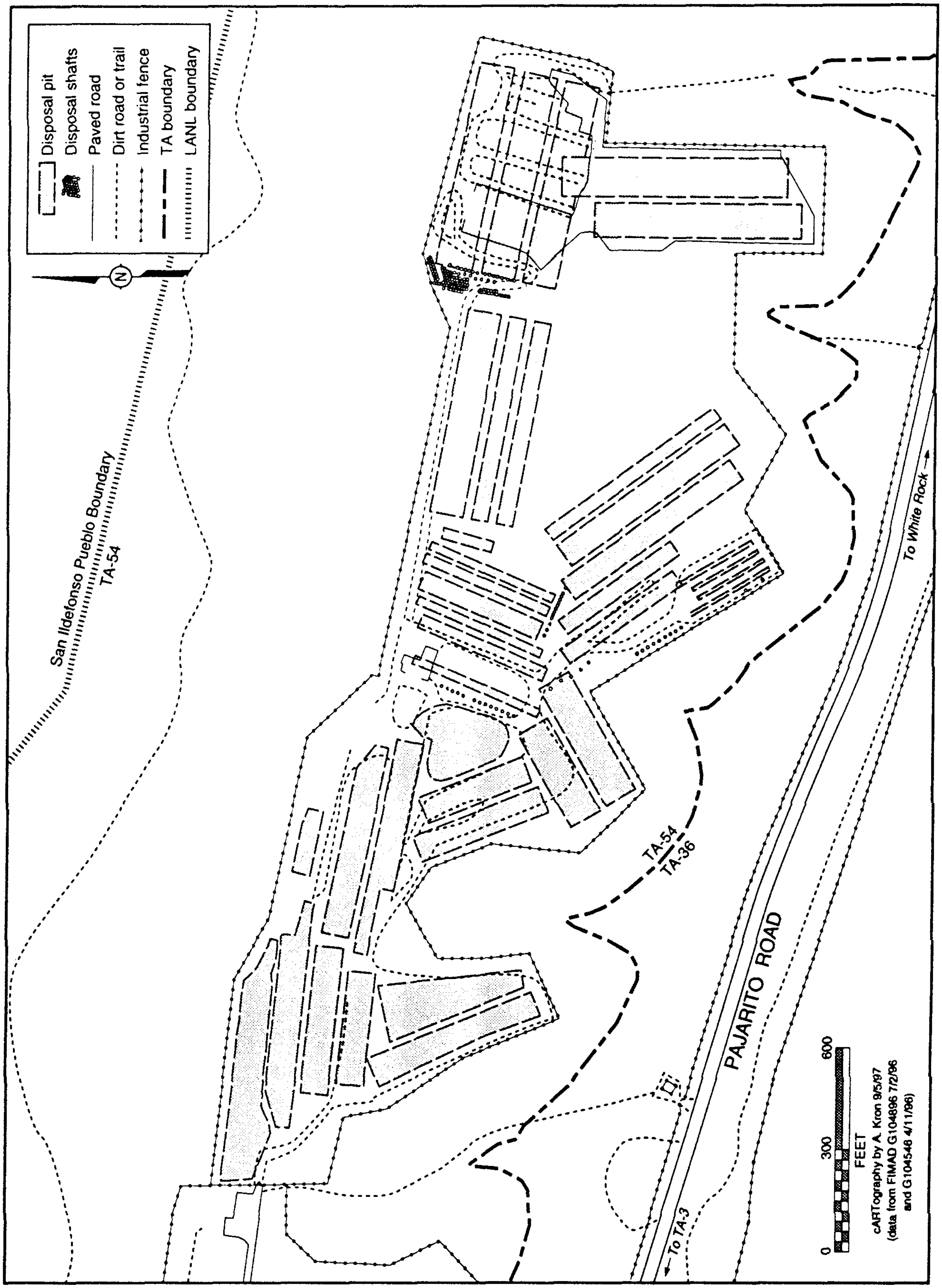


FIGURE 2.2.2.15–5.—*TA–54 Area G Disposal Cells.*

painting drums of TRU waste retrieved during TWISP, associated water sedimentation pits and collection tanks, a drum venting system to safely puncture and vent retrieved drums of TRU waste, and a general treatment bay with modular containment for size reduction of gloveboxes and similar large waste items, and for waste segregation.

Compactor Facility, Building 50–281. This building houses a waste compactor with 200 tons (180 metric tons) of compressive force, which can achieve volume reductions as great as 8 to 1. Compacting waste helps to conserve disposal space and minimizes soil subsidence at the disposal cell. A smaller compactor is used to crush items such as empty drums.

Waste storage facilities. Area G also includes:

- Tension Support Buildings 54–049 and 54–224 for solid LLMW
- Sheds 54–144, 145, 146, and 177 for mixed tritiated wastes
- Tension Support Buildings 54–048, 153, and 283 for newly generated TRU waste
- Storage Domes 54–229 and 230 (16,000 square feet [1,488 square meters] each) for legacy TRU waste retrieved during TWISP

Storage Pads 1, 2, and 4. These asphalt pads hold legacy TRU waste in drums and other containers. Pads and containers were covered with earth during the 1970's and 1980's. Wastes are to be retrieved and placed into above-surface storage domes so that RCRA inspection requirements can be met and so that wastes and containers are in a form suitable for disposal. A total of six storage domes will be required; two were constructed in 1995 and four more are planned. The domes are 280 feet (85 meters) long, 60 feet (18 meters) wide, and 40 feet (12 meters) high and can store about 3,000 drums of waste. (This action was categorically excluded from further NEPA review.)

An asphalt pad adjacent to Building 54–049 is used for the outdoor storage of pyrophoric uranium waste chips.

Other structures at TA–54 include:

- *54–002*—maintenance shop
- *54–011*—offices and a personnel decontamination shower facility
- *54–020, 54–079, and 54–092*—equipment shelter canopies

TA–50. TA–50 is the location of RLWTF for the treatment of radioactive liquid wastes as described in section 2.2.2.14. TRU wastes, however, are processed in two facilities in TA–50 and then transported to TA–54 for storage.

WCRR Facility, Building 50–069. This is a nuclear facility that is used to size reduce large TRU waste items such as gloveboxes. Waste items are stored outdoors, brought into the building through a vehicle air lock, then introduced into a cutting enclosure (glovebox). A plasma cutting torch is used to section large waste items and the smaller pieces are loaded into standard waste boxes. Clean-up liquids are piped to the RLWTF in Building 50–01 through a filter and storage system that allows characterization of the liquids prior to transfer. A second operation is the visual inspection of the contents of TRU waste drums that have already been characterized. This visual inspection is performed on a statistical percentage of drums and provides a quality assurance overcheck of the TRU waste characterization program.

RAMROD Facility, Building 50–037. An incinerator for PCBs and combustible hazardous wastes was formerly housed in this facility. Re-named the RAMROD Facility, Building 50–037 is a candidate Hazard

Category 2 nuclear facility. Equipment for the characterization of TRU waste has been installed and is expected to be operational by mid 1998. The RAMROD Facility is also a general host for any other process that requires the containment and controls of a nuclear facility.

Description of Capabilities

Capabilities required for the management of solid radioactive and chemical wastes include waste characterization, packaging, and labeling; waste transport, receipt, and acceptance; and waste storage and disposal. In addition, compaction, size reduction, waste retrieval, and other treatment operations are performed. Each of these activities is described below. (Additional information on waste management facilities and operations is included in *Waste Management Strategies for LANL* [LANL 1998b]). The manner in which they would vary among the alternatives is described in chapter 3.

The RAMROD Facility is being considered as an alternative for Lead Test Assembly and inspection operations in the *Surplus Plutonium Disposition Environmental Impact Statement* (DOE 1998a; section 1.5.8). This activity includes the receipt and inspection of MOX fuel rods that would be fabricated at the Plutonium Facility Complex (described in section 2.2.2.1), assembled into bundles, inspected, and shipped off site. Such operations would constitute a new capability at RAMROD. The impacts associated with implementing this proposal are described in chapter 5, section 5.6. This addition would change the amount of material in the facility (plutonium/uranium MOX) and increase shipments of nuclear materials to and from LANL, as compared to the SWEIS Expanded Operations Alternative.

Waste Characterization, Packaging, and Labeling. This is similar to the activities described under this heading in section 2.2.2.14. At TA–54, this activity includes characterizing and certifying that TRU wastes comply with waste acceptance criteria (WAC) for WIPP. Activities specific to WIPP WAC include drum venting, core sampling, and visual inspection.

Drum Venting. Drums containing TRU-contaminated hydrogenous materials such as plastic and cellulose could accumulate hydrogen gas through radiolytic decomposition of the waste matrix or packaging material. Accordingly, WIPP WAC specify that all waste packages be vented with one or more specified filters. Nondegraded drums retrieved during the TWISP are processed through the drum venting system at the Drum Preparation Facility, Building 54–33. The system safely vents containers up to 55 gallons (208 liters) in size and installs a filter vent in each.

Core Sampling. In a glovebox in the RAMROD Facility, samples will be cored from solidified TRU waste in order to analyze the chemical composition of wastes that have been solidified.

Visual Inspection. At the WCRR Facility, waste packages are opened, sampled, and examined, and the condition of the packages themselves is evaluated. Any items determined to be noncompliant are removed. A similar glovebox will be placed into operation in the RAMROD Facility. This characterization step is performed on a percentage of already-certified TRU waste packages to verify stated contents.

Compaction. Solid LLW is compacted in Building 54–281 at Area G. The compactor uses a hydraulic piston to generate 200 tons (180 metric tons) of compressive force, achieving waste volume reductions as great as 8-to-1. Compacting provides improved waste package integrity, minimizes soil subsidence at the disposal pit, and conserves disposal space. The process also confirms that there are no trapped or interstitial liquids within the waste package. Building 54–281 is also equipped with a smaller compactor that can be used to crush items such as empty drums.

Size Reduction. Size reduction operations occur within the WCRR Facility at TA–50 and the Drum Preparation Facility at TA–54. The WCRR Facility is operated for the purpose of sectioning (to reduce volume) and repackaging bulky TRU-contaminated metallic waste into containers approved for shipment to WIPP. The interior of the WCRR Facility consists of a large (6,790-cubic-foot [190-cubic-meter]) ventilated enclosure in which discarded gloveboxes and other TRU waste items are cut apart with a plasma torch. Waste items are staged in an outside storage area, brought into the building through an air lock, unpacked, and then moved into the main enclosure. At the Drum Preparation Facility, modular containment is used for size reduction operations.

Waste Transport, Receipt, and Acceptance. Containers for transport of solid wastes vary widely, and depend upon the waste, its destination, and transport regulations. Solid radioactive wastes, for example, are transported on site in drums, dumpsters, crates, or specially designed shielded packages. Periodically, containers other than DOT-specified containers may be used for some on-site shipments, provided the transport route is controlled (i.e., by road closure) during transport. Off-site transport of waste may require additional preparations. DOT-specified packages must be used for off-site transport, and waste must be certified to meet the WAC of the receiving facility.

Waste receipt and acceptance activities typically include visual inspection of the vehicle and the container, cross-checking container labels and shipment manifests, radiation surveys of the vehicle and containers, and weighing of vehicles and/or containers. These activities include receipt and acceptance of small quantities of off-site LLW and TRU waste.

Waste Storage. At TA–50, wastes are stored within the RAMROD Facility and adjacent to the WCRR Facility. At TA–54, chemical wastes are stored at Areas J and L until sufficient quantities are accumulated for a shipment to off-site treatment, storage, and disposal facilities. Because they are used only to store items prior to processing or shipping, however, these storage areas are small in comparison to those at TA–54 for storage of LLMW and TRU waste. LLMW and TRU waste represent the vast majority of wastes in storage and are stored in large fabric-covered domes within Area L (Dome 54–215) and Area G (seven domes). This activity includes the storage of small quantities of waste from off site.

Waste Retrieval. Between 1979 and 1991, LANL stored packages of TRU waste on three pads at the east end of Area G, then placed the containers under earthen cover. Because some of these packages contained mixed TRU waste, they are subject to RCRA and its requirements for periodic container inspection and response to emergency conditions. Accordingly, LANL has developed the facilities and capability to retrieve these wastes, repackage and characterize them, and place the wastes into new, aboveground storage domes.

The operation begins with the construction of the retrieval enclosure (Building 54–226) atop a storage pad. Containers are removed as earth is cleared away. Degraded containers will be overpacked, repaired, or secured by wrapping in plastic or by banding with metal straps. Nondegraded drums are transported to the adjacent Drum Preparation Facility (Building 54–33), where they will be vented using the drum vent system and then steam-cleaned, re-painted, and re-labeled as needed. Retrieved containers will then be characterized and certified to meet the WIPP WAC.

Other Waste Processing. Several treatment operations occur periodically or in small scale at LANL facilities for solid radioactive and chemical wastes. Solidification of TRU sludges is performed at the RLWTF (described in section 2.2.2.14). Sludges are mixed with cement in 55-gallon (208-liter) drums, allowed to cure, then transported to Area G for storage (prior to eventual shipment to WIPP).

Stabilization of pyrophoric uranium chips is periodically performed in a permacon on the asphalt pad adjacent to Building 54–049 in Area G. Chips, and the oil in which they are immersed, are mixed with a chemical agent to produce a gel. Thus stabilized, the uranium is then disposed of in disposal cells at Area G.

Electrochemical treatment of LLMW is performed at RAMROD. This is a demonstration project involving two pilot-scale treatment units. Solutions containing low levels of metals, nitrates, sulfides, and/or organics will be subjected to electric current. Metals will be electrochemically deposited on cathodes; sulfides will precipitate out of solution; and organics will oxidize to carbon dioxide and water. The remaining solution will contain low levels of radioactivity and be managed as a radioactive liquid waste. Other research and development on possible treatments for LLMW, including electrochemical and other currently undefined technologies, may also be performed at RAMROD as demonstration projects. Pilot-scale treatment units will be used, and small quantities of wastes will be processed.

Limited treatment of hazardous wastes is performed at Area L. This typically consists only of chemically treating characteristic hazardous wastes. Treatment of cylinders of gases has also been performed in the past.

As discussed under “Description of Facilities” earlier in this section, land farming of oil-contaminated soil is performed at Area J.

Disposal. Disposal operations are performed only at Area G and Area J. Solid LLW is disposed of at Area G in cells and shafts. Solid industrial wastes are disposed of at Area J.

At Area G, cells are generally rectangular excavations to a depth of 66 feet (20 meters), constructed in accordance with guidelines established by the U.S. Geological Survey and the Area G Performance Assessment (LANL 1998d). Each layer of waste is covered with a layer of backfill that is 6 to 12 inches (15 to 30 centimeters) thick. When nearly full, the upper 2 meters of each cell is filled with crushed tuff, mounded over with topsoil, and then re-vegetated. Approximately 20 to 25 percent of the pit volume is filled with LLW, and the remainder is either void space or tuff/soil backfill. Five cells are currently open and in use. Four of these receive solid LLW and one receives asbestos wastes that have radioactive contamination.

At Area G, shafts range from 1.0 to 8 feet (0.3 to 2.5 meters) in diameter and up to 66 feet (20 meters) in depth and are covered with a concrete plug. Shafts, readily capped until the next shipment of waste is received, are dedicated to specific types of waste such as solid LLW with activity greater than 1 rem per hour, tritiated wastes with activity greater than 20 microcuries per cubic meter, radioactive biological wastes, radioactive PCB wastes, radioactive beryllium wastes, and radioactive classified wastes.

Lesser volumes of administratively controlled industrial solid wastes and formerly characteristic wastes are disposed at the Area J landfill. The majority of these wastes are disposed in cells, where wastes are daily covered with backfill. Nonradioactive classified wastes are disposed in shafts in Area J.

Disposal activities include the disposal of small quantities of LLW from off-site locations (discussed further in section 4.9.3).

While LANL does not currently have any sites designated for disposal of LLMW, the WM PEIS (DOE 1997c) considers LANL as an alternative regional disposal site for this type of waste. If selected, LANL would have to establish a LLMW disposal capability, as well as WAC for LLMW and would identify candidate sites for disposal. The WM PEIS indicates that up to 2,263,000 cubic feet (64,100 cubic meters) of such waste could be designated for disposal at LANL over the next 20 years. The actual amount that would be disposed of at LANL, if selected, is highly dependent on the WAC, actual waste generation, and the sites identified that would ship such waste to LANL. As such, the siting and sizing of such a capability is highly uncertain and is not analyzed in the SWEIS.

2.2.3 Nuclear and Moderate Hazard Facilities Not Analyzed as Key Facilities

This section identifies LANL facilities that are designated as nuclear or moderate hazard facilities, but that do not meet the criteria for key facilities described in section 2.2.2 of the SWEIS. These facilities include those that are operating and several that are surplus and awaiting decontamination and decommissioning following removal of SNM and hazardous materials. No substantial change is anticipated in the future operations or impacts associated with these facilities.

As noted previously, there are no Hazard Category 1 nuclear facilities at LANL. Hazard Category 2 nuclear facilities (those for which a hazard analysis shows the potential for significant on-site consequences) that did not meet the criteria for key facilities are discussed in section 2.2.3.1. Hazard Category 3 nuclear facilities (those for which a hazard analysis shows the potential for only significant localized consequences) that did not meet the criteria for key facilities are discussed in section 2.2.3.2. Nonnuclear moderate hazard facilities that do not meet the criteria for key facilities are discussed in section 2.2.3.3

2.2.3.1 *Hazard Category 2 Nuclear Facilities*

The Source Storage Building (TA–3 Building 65) was given a Hazard Category 2 classification because of the presence of encapsulated radioactive materials and SNM used for research and measurement activities. All radioactive sources and SNM are sealed in steel containers that are never opened.

In addition, the Omega West Reactor (TA–2 Building 1) has been placed in permanent shutdown. All SNM and hazardous materials have been removed from the facility. The facility is surplus and was reclassified from a Category 2 nuclear facility to a low hazard radiological facility.

2.2.3.2 *Hazard Category 3 Nuclear Facilities*

The following are Hazard Category 3 nuclear facilities that do not meet the criteria for key facilities:

- *Calibration Building (TA–3 Building 130)*—The Calibration Facility is designated as a Hazard Category 3 nuclear facility due to the radioactive source inventories stored in the building. The primary functions of this facility are performing radiation evaluation studies involving sealed radiation sources; calibrating instrumentation; and evaluating the response of various detectors to x-ray, gamma, beta, and neutron emissions. Activities do not include processing of nuclear material because radioactive sources are sealed at all times.
- *Portion of Physics Building (TA–3 Building 40)*—The Health Physics Instrument Calibration facilities, located within the Physics Building, are designated a Hazard Category 3 nuclear facility because of the radioactive materials and SNM used in the laboratories for instrument calibration, as

well as the radioactive and SNM source inventories that are stored in the two storage vaults. The primary function of this facility is the calibration and evaluation of all types of radiation detection instrumentation used throughout the laboratory. The instrumentation includes alpha, beta-gamma, neutron, and tritium gas detectors.

- *High Pressure Tritium Facility (TA–33 Building 86)*—This building is an old high-pressure tritium handling facility that is currently in safe shutdown mode pending decontamination and decommissioning. Upon completion of decontamination and decommissioning activities, the facility is expected to have radionuclide inventories below threshold quantities, which, in turn, will result in the facility being downgraded from its current Hazard Category 3 classification.
- *Nuclear Safeguards Research Facilities (TA–35 Buildings 2 and 27)*—These facilities are classified as Hazard Category 3 nuclear facilities because each facility contains an SNM storage vault. All radioactive sources and SNM are encapsulated or in sealed containers that prevent contamination to the workers and facility. Uranium is singly contained, while plutonium is doubly contained within this facility. The primary mission of both facilities is to support nonproliferation and international security activities; however, other research and development activities include various studies of radiation effects on materials in support of fusion, ceramic science, and technology programs.

2.2.3.3 *Nonnuclear Moderate Hazard Facilities*

The following are nonnuclear moderate hazard facilities that do not meet the criteria for key facilities:

- *Various Chlorination Stations (TA–0 Buildings 1109, 1110, 1113, 1114; TA–16 Building 560; TA–54 Building 1008; TA–72 Building 3; TA–73 Building 9)*—These facilities are designated moderate chemical hazards because they are all gas chlorination stations where the potable water supply for the Los Alamos townsite and LANL is chlorinated.
- *Sewage Treatment Plants (TA–46, Building 340)*—The sewage plants are designated as moderate chemical hazard facilities because of the historical use of chlorine gas to disinfect plant effluent prior to its release to holding ponds. (Building 340 is a chlorine storage building.) These are being replaced currently by a new process not requiring the use of gaseous chlorine.
- *Liquid and Compressed Gas Facility (TA–3 Building 170)*—All toxic materials have been removed from this facility. A reclassification to a low chemical hazard status is pending.
- *Laboratory (TA–21 Buildings 3 and 4)*—Current activity at this facility includes radiochemistry operations in the laboratory areas of Buildings 3 and 4 North. Buildings 3 and 4 South had decontamination and decommissioning activities begin in 1994, with eventual decontamination and decommissioning activity to be performed at Building 3 North pending funding.
- *Laboratory Building (TA–41 Building 4)*—The facility is a laboratory called the Icehouse, where past operations included the handling and storage of materials such as uranium, tritium, deuterium, and liquid nitrogen. All nuclear materials were removed from this facility in 1995. The work currently performed in this facility consists of nonradiological work related to weapons engineering.

2.3 THE ROLE OF THE UNIVERSITY OF CALIFORNIA IN LANL ACTIVITIES

The U.S. Government, through DOE, owns all the land, buildings, and equipment at DOE facilities, including LANL. DOE contracts with commercial and academic entities for facility operations, a relationship referred to as government owned, contractor operated. The UC manages LANL for DOE and has continuously operated this facility since its creation during World War II. As LANL is managed by a nonprofit entity, UC, its operating budget is not subject to state or local gross receipts taxes.

The management and operating contract between DOE and UC has been renegotiated numerous times. The most recent 5-year contract was signed in October 1997.

The UC contract contains specific performance measures (i.e., criteria by which DOE evaluates the success of the operator). These performance criteria are reviewed and modified annually. Based on the results of performance appraisals for LANL and two other DOE sites (Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory), UC will receive a performance fee that can be used for any operating costs from these laboratories not otherwise reimbursed by the government or for discretionary research by or at these laboratories.

The UC contract is administered by DOE through the DOE Los Alamos Area Office and the Albuquerque Operations Office. Major subcontractors to UC under this contract include Johnson Controls World Services, Inc., Protection Technology Los Alamos, and Bechtel Nevada.

In response to DOE requests for information, UC has provided data projections and descriptive information that has been relied upon as source material for this SWEIS. This includes background information on the history of LANL, information regarding funding, information regarding the buildings at LANL and their hazards, and detailed information regarding the operations within each of the key facilities. UC has compiled such information in several documents that were published to correspond with the publication of the draft SWEIS. These documents are cited throughout the SWEIS (particularly in chapter 5) and are available in hard copy at the LANL Community Outreach Center in Los Alamos. The titles, LANL document numbers, and web site of those documents are:

- *Waste Management Strategies for Los Alamos National Laboratory - 1997*, LA-UR-97-4764, http://lib-www.lanl.gov/la-pubs/00412794.pdf (LANL 1998b)
- *Overview of Los Alamos National Laboratory - 1997*, LA-UR-97-4765, http://lib-www.lanl.gov/la-pubs/00412795.pdf (LANL 1998a)
- *Description of Technical Areas and Facilities at Los Alamos National Laboratory - 1997*, LA-UR-97-4275 (LANL 1998c)
  - — Part I: http://lib-www.lanl.gov/la-pubs/00412796.pdf
  - — Part II: http://lib-www.lanl.gov/la-pubs/00412797.pdf

A popular Los Alamos publication web site is http://lib-www.lanl.gov/pubs/la-pubs.htm.

2.4 RECENT LANL FUNDING LEVELS

Table 2.4–1 shows recent and projected funding levels for DOE and non-DOE activities by major budget category. This information, requested by commentors through the scoping process, is provided for context to indicate current sponsors and users of LANL facilities and expertise. While funding levels for programs may change, the expertise and types of operations are expected to remain relatively constant.

TABLE 2.4–1.—*LANL Consolidated Funding Summary (Fiscal Year 1994 to Fiscal Year 1998)*

PROJECTS	CONSOLIDATED FUNDING (MILLIONS)				
	ACTUAL COSTS				FUNDING PROJECTIONS
	1994 (9/30/94)	1995 (9/30/95)	1996 (9/30/96)	1997 (9/30/97)	1998 (3/04/98)
DOE OPERATING FUNDS					
Defense Activities	430	446	488	563	631
Nonproliferation/International Security	85	77	88	101	112
Materials Disposition[a]	0	0	10	21	28
Environmental Restoration and Waste Management	217	210	148	134	154
Energy Research	95	92	65	71	65
Nuclear Energy	13	17	18	18	14
Civilian Radioactive Waste[b]	17	10	0	0	0
Energy Efficiency	15	14	11	13	11
Science Education and Technology	1	1	1	0	0
Other DOE	9	14	12	8	10
Subtotal DOE	882	881	841	929	1,025
REIMBURSABLE OPERATING FUNDS					
DoD	82	71	52	54	44
U.S. Nuclear Regulatory Commission	3	2	2	3	1
Intelligence	18	14	10	12	10
Remaining Reimbursable Work[c]	70	113	103	108	108
Subtotal Reimbursable Work	173	200	167	177	163
Total Operating Funds[d]	1,055	1,081	1,008	1,106	1,188
CAPITAL/CONSTRUCTION FUNDS					
Total	109	102	102	143	149

[a] Prior to 1996, funding in this area was included in Defense Activities funding.
[b] Included in Remaining Reimbursable Work after 1995.
[c] Includes DOE Reimbursable Work.
[d] Operations that are capitalized are included in Capital/Construction Funds.

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REFERENCES

Allred and Talley 1987	*Los Alamos Meson Physics Facility* (currently known as the LANSCE). Brochure by J. C. Allred and B. Talley. Los Alamos National Laboratory. LA-UR-87-327. Los Alamos, New Mexico. January 1987.
Browne 1997	Memorandum (e-mail) from J. Browne, Director, Los Alamos National Laboratory, to LANL managers. Subject: "CMR Facility." December 19, 1997.
DOE 1991	*Environmental Assessment for the Materials Science Laboratory*. U.S. Department of Energy. DOE/EA-0493 and Finding of No Significant Impact. Los Alamos, New Mexico. 1991
DOE 1993	*Nonnuclear Consolidation Environmental Assessment, Nuclear Weapons Complex Reconfiguration Program.* U.S. Department of Energy. DOE/EA-0792. Washington, D.C.. June 1993.
DOE 1995a	*Environmental Assessment for Relocation of Neutron Tube Target Loading Operations,* Los Alamos National Laboratory. U.S. Department of Energy. DOE/EA-1131 and Finding of No Significant Impact. Los Alamos, New Mexico. December 1995.
DOE 1995b	*Relocation of the Weapons Components Testing Facility Environmental Assessment.* U.S. Department of Energy. DOE/EA-1035. Washington, D.C. January 1995.
DOE 1995c	*Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement*. U.S. Department of Energy, Albuquerque Operations Office and Los Alamos Area Office. DOE/EIS-0228. Albuquerque, New Mexico. August 1995.
DOE 1995d	*Environmental Assessment, High Explosive Wastewater Treatment Facility*. U.S. Department of Energy. DOE/EA-1100 and Finding of No Significant Impact. Los Alamos, New Mexico. August 1995
DOE 1996a	*Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*. U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. September 1996.
DOE 1996b	*Low-Energy Demonstration Accelerator Environmental Assessment*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1147. Los Alamos, New Mexico. April 1996.

DOE 1996c — *Environmental Assessment for Effluent Reduction*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1156. Los Alamos, New Mexico. July 3, 1996.

DOE 1996d — *Land Use and Facility Use Planning*. U.S. Department of Energy. p.430.1. Washington, D.C. July 9, 1996.

DOE 1997a — *Environmental Assessment for the Proposed CMR Building Upgrades at the Los Alamos National Laboratory*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1101. Los Alamos, New Mexico. February 4, 1997.

DOE 1997b — *Audit of the Radioactive Liquid Waste Treatment Facility Operations at the Los Alamos National Laboratory*. U.S. Department of Energy, Office of the Inspector General, Western Regional Audit Office. WR-B-98-01. Albuquerque, New Mexico. November 1997.

DOE 1997c — *Waste Management Final Programmatic Environmental Impact Statement.* U.S. Department of Energy, Office of Environmental Management. DOE/EIS-0200. Washington, D.C. May 1997.

DOE 1998a — *Surplus Plutonium Disposition Environmental Impact Statement.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/Draft EIS-0283. Washington, D.C. July 1998.

DOE 1998b — *Accelerating Cleanup: Paths to Closure*. DOE/EM-0362. U.S. Department of Energy, Office of Environmental Management. June 1998.

Gancarz 1997 — Memorandum from A. Gancarz, Los Alamos National Laboratory, to all CMR Building occupants. Subject: “Suspension of Normal Operations within CMR.” September 2, 1977.

Gurule 1998 — Memorandum from D. A. Gurule, U.S. Department of Energy, Los Alamos Area Office, to J. C. Browne, Los Alamos National Laboratory. Subject: “Make/Buy Analysis for the Radioactive Liquid Waste Treatment Facility.” July 24, 1998.

Krueger 1994 — *Overview of Area G, Technical Area 54, Los Alamos National Laboratory.* J. W. Krueger. Los Alamos National Laboratory. Los Alamos, New Mexico. March 11, 1994.

LANL 1992 — *RCRA Facility Investigation Work Plan for Operable Unit 1147.* Los Alamos National Laboratory, Environmental Restoration Program. Los Alamos, New Mexico. May 1992.

LANL 1996a — *Waste Minimization Activities for Pit Production at LANL*. Los Alamos National Laboratory. LA-UR-96-2704. Los Alamos, New Mexico. 1996.

LANL 1996b *Los Alamos National Laboratory Institutional Plan, FY 1997–FY 2002.* Los Alamos National Laboratory. LA-LP-96-77. Los Alamos, New Mexico. 1996.

LANL 1996c *Capital Asset Management Process for Fiscal Year 1998.* Los Alamos National Laboratory. LA-UR-96-3081. Los Alamos, New Mexico. 1996

LANL 1997a *Site Pollution Prevention Plan for Los Alamos National Laboratory*. Los Alamos National Laboratory. LA-UR-97-1726. Los Alamos, New Mexico. 1997.

LANL 1998a *Overview of LANL.* Los Alamos National Laboratory. LA-UR-97-4765. Los Alamos, New Mexico. March 1998.

LANL 1998b *Waste Management Strategies for LANL*. Los Alamos National Laboratory. LA-UR-97-4764. Los Alamos, New Mexico. April 1998.

LANL 1998c *Description of Technical Areas and Facilities at LANL.* Los Alamos National Laboratory. LA-UR-97-4275. Los Alamos, New Mexico. March 1998.

LANL 1998d *Performance Assessment and Composite Analysis for the Los Alamos National Laboratory Low-Level Waste Material Disposal Area G*. Los Alamos National Laboratory. LA-UR-97-85. Los Alamos, New Mexico. Submitted to the U.S. Department of Energy March 1997. Approved October 1998.

Whiteman 1997 Memorandum from A. E. Whiteman, DOE Albuquerque Operations, to P. Cunningham, LANL. Subject: "Chemistry and Metallurgical Research Upgrade Project, Los Alamos National Laboratory." May 5, 1997.

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CHAPTER 3.0
ALTERNATIVES FOR THE CONTINUED OPERATION OF THE LOS ALAMOS NATIONAL LABORATORY

This chapter describes the four alternatives DOE has analyzed in detail regarding the continued operation of LANL. Specifically, it describes the activities at LANL's key facilities that vary among the alternatives and the activities that are common to all alternatives. In addition, the chapter identifies the alternatives DOE considered, but has not analyzed in detail because they were not reasonable. The chapter concludes with a comparison of the environmental consequences of the four alternatives.

DOE is considering four alternatives for the continued operation of LANL to support its existing and potential future program assignments (described in SWEIS chapter 1, section 1.1). These alternatives are:

- No Action Alternative (section 3.1)
- Expanded Operations Alternative and Preferred Alternative (section 3.2)
- Reduced Operations Alternative (section 3.3)
- Greener Alternative (section 3.4)

The first three alternatives present differing operational levels of the same types of activities, with the No Action Alternative representing the currently planned levels of operation. The fourth (the Greener Alternative) emphasizes use of LANL capabilities in nonweapons missions, such as nonproliferation and nonweapons research. Some activities in the Greener Alternative are the same as in the No Action or Reduced Operations Alternatives. In other facilities, operations under the Greener Alternative are the same as those under the Expanded Operations Alternative, but they are conducted for nonproliferation, waste management, or other nonweapons purposes.

In the draft SWEIS, the DOE's Preferred Alternative was the Expanded Operations Alternative. In this final SWEIS, the Expanded Operations Alternative remains the Preferred

Alternatives Analyzed

No Action*—LANL operations would continue at their currently planned level.*

Expanded Operations*—implements all current DOE mission element assignments to LANL, including full implementation of those made in recent programmatic EIS (PEIS) Records of Decision, at the highest foreseeable levels of activity.*

Reduced Operations*—conducts the minimal levels of activities necessary to maintain the capabilities necessary to support DOE missions.*

Greener*—uses LANL capabilities to maximize support to DOE nonproliferation, basic science, and materials recovery/stabilization mission elements, and minimizes support to DOE defense and nuclear weapons mission elements.*

Preferred Alternative*—DOE has identified the Preferred Alternative as the Expanded Operations Alternative, with the exception that pit manufacturing would not be implemented at a 50 pits per year level, single shifts, but only at a level of 20 pits per year, in the near term.*

Alternative with one modification, as noted below. The modification to the Preferred Alternative involves the level at which pit manufacturing will be implemented at LANL. Under the Expanded Operations Alternative, DOE would expand operations at LANL, as the need arises, to increase the level of existing operations to the highest reasonably foreseeable levels, including the full implementation of pit manufacturing up to the capacity of 50 pits per year under single-shift operations (80 pits per year using multiple shifts). However, as a result of delays in the implementation of the Capability Maintenance and Improvement Project (CMIP) and recent additional controls and operational constraints in the Chemistry and Metallurgy (CMR) Building (instituted to ensure that the risks associated with the CMR Building operations are maintained at an acceptable level), DOE has determined that additional study of methods for implementing the 50 pits per year production capacity is warranted. In effect, because DOE has postponed any decision to expand pit manufacturing beyond a level of 20 pits per year in the near future, the revised Preferred Alternative would only implement pit manufacturing at this level. This postponement does not modify the long-term goal announced in the Record of Decision (ROD) for the Stockpile Stewardship and Management Programmatic EIS (SSM PEIS) (up to 80 pits per year using multiple shifts).

LANL's direct-funded and support activities are described in general terms in SWEIS chapter 2, sections 2.1.1 and 2.1.2, respectively. In addition, the operations of 15 key facilities are described in section 2.2.2. Those direct-funded and support activities that occur outside of the key facilities will not change among the alternatives (outside the expected variability due to the dynamic nature of research and development, as discussed in section 2.1). Thus, the alternatives for continued operations of LANL focus on four differing levels of operation at the key facilities.

Some Terminology Notes

Activities—*The specific research and development, experimentation, and studies conducted at LANL under assignment from DOE or through DOE by assignment from other government entities, industries, or organizations. This definition includes facility or technical area operations, as well as studies, monitoring, and other actions DOE may cause to be undertaken to manage and maintain LANL.*

Operations—*This term is used in two senses in this document. The first is the overall continuing use of the capabilities of LANL. The second sense is specific to facilities and technical areas (TAs), the subset of activities undertaken. Examples are accelerator operations or activities that are procedure-controlled such as movement of appreciable quantities of special materials, including special nuclear materials, through process lines such as gloveboxes resulting in one or more products and waste.*

Facility—*One or more buildings in a technical area of LANL that house specific activities.*

Capability—*The combination of equipment, facilities, infrastructure, and expertise required to undertake types or groups of activities and to implement assignments. Using a capability results in facility or technical area operations (see the second use of operations above).*

Many of these key facilities are primarily engaged in supporting the national security mission. Additionally, the key facilities include those that may be upgraded and modified to implement the ROD of the programmatic NEPA documents addressing stockpile stewardship and management, waste management, and disposition of weapons-usable fissile materials. Other key facilities are engaged in neutron science and research and development efforts such as materials research, radiochemistry, and health research. By using this approach, DOE has examined in the greatest detail the LANL facilities and activities that are critical to meeting mission element assignments at LANL, could result in the most significant health and/or environmental impacts, are of most interest or concern to the public, and are the most subject to change across the alternatives due to recent programmatic decisions.

For clarity and brevity, the descriptions of the alternatives in the text (sections 3.1, 3.2, 3.3, and 3.4) and in the tables (section 3.6) in this chapter focus on significant "markers" to characterize the variation of activities across alternatives. More complete descriptions of the activities at LANL are provided by facility in chapter 2 (section 2.2), and all of these activities were projected and used in evaluating the impacts of each alternative.

Key Facilities in the SWEIS

While the SWEIS analyzes the ongoing and future (reasonably foreseeable within the next 10 years) activities throughout LANL, DOE has identified 15 key facilities that account for a large majority of the issues and impacts addressed in the SWEIS. Alternatives analyzed for continued operations at LANL focus on differing levels of activities conducted in the key facilities. Alternative operating levels of key facilities are analyzed in detail because such operations are critical to meeting assignments at LANL, and: they could result in the most significant health or environmental impacts; or they are of most interest or concern to the public; or they are the most subject to change due to recent programmatic decisions. Descriptions of key facilities and their operations are presented in *section 2.2.2. However, a large amount of the research and development and experimental work conducted at LANL does not occur in the key facilities and, for the purposes of this analysis, is not expected to change outside of the variation that is typical of research and development activities.*

Where consolidation of operations is appropriate in a specific alternative, the cleanup of the excess facilities or space is reflected in the description of that alternative. At a minimum, estimates were made of consequences of activities undertaken to place such facilities in a "secure safe shutdown" condition. These facilities retain negligible inventories of radioactive or hazardous materials and await decontamination or renovation for other use of the space. A few of these are already scheduled for decommissioning as part of the LANL Environmental Restoration (ER) Project, described in chapter 2, section 2.1.2.5.

All of the alternatives include the activities or projects for which NEPA analysis and documentation already exist and on which DOE has already made a decision. DOE is not revisiting any programmatic decisions made through its NEPA process, such as those addressing weapons complex consolidation and reconfiguration, materials disposition, or waste management.

Although DOE is not addressing changes to LANL's mission element assignments, it does analyze the site-specific implementation of assignments that were analyzed in other programmatic NEPA documents. Specifically, the SWEIS evaluates the impacts of continuing and planned activities, representing a range of operational levels that could be reasonably implemented in the 10-year time frame of the SWEIS analysis. Inclusion of these activities in the SWEIS is intended to provide DOE, and the public, with a better understanding of the total consequences of the alternatives for continued operations of LANL.

For a variety of reasons (including the variability inherent in research and development activities), no one condition and time was simultaneously typical of all LANL activities. Therefore, an index was established for operations in each key facility and for each parameter used to evaluate impacts. The index contains the best data set from historical records that could be used to describe conditions associated with activities expected in the future. This index was used as a base to project levels of activity with associated impact parameters for the various alternatives.

As noted above, sections 3.1, 3.2, 3.3, and 3.4 present the four SWEIS alternatives. Section 3.5 describes other alternatives that DOE considered, but did not analyze in detail in the SWEIS. Section 3.6 provides a comparison of the changes across the alternatives and of the environmental impacts associated with each of the alternatives.

3.1 NO ACTION ALTERNATIVE

The Council on Environmental Quality (CEQ) NEPA implementing regulations (40 CFR 1500 through 1508) require analysis of the No Action Alternative to provide a benchmark against which the impacts of the other alternatives can be compared. In the SWEIS, the No Action Alternative is a projection over the next 10 years, from the index established for past operations, of a level of activity for facility operations that would implement current management plans for assigned programs.

These planned actions include: continued support of major DOE programs including defense programs, nuclear energy, fissile material disposition, environmental management, and energy research; projects to maintain existing facilities and capabilities; and projects previously receiving NEPA reviews resulting in decisions (e.g., the CMR Building Phase I and Phase II Upgrades). The plans utilized in preparing the description of the No Action Alternative include the Capital Assets Management Process, DOE Program Plans, Site Development Plans for LANL, interagency agreements between DOE and the U.S. Department of Defense (DoD), PEISs, Presidential Directives, and the DOE Work for Others proposals and guidance. The planned activities reflected in this alternative include an increase in some LANL operations and activities over the actions in previous years (e.g., the suspension of underground nuclear testing results in increased stockpile stewardship activities at LANL).

> ***Organization of SWEIS Chapter 3***
>
> ***Sections 3.1 through 3.4*** *describe the activities that would occur at each of the key facilities under each of the four alternatives.*
>
> ***Section 3.5*** *describes alternatives that DOE considered, but did not analyze in detail because they are unreasonable.*
>
> ***Section 3.6*** *compares the environmental consequences of the alternatives.*

The No Action Alternative also includes continued scientific, engineering, technology research and development, and support activities throughout LANL, including those at the SWEIS key facilities. By the very nature of research and development, specific activities are expected to vary and evolve through time. However, they can be sufficiently characterized to assure the analysis of their consequences in the SWEIS. (For the non-key facilities, chapter 2, section 2.1 provides this description.) This alternative includes foreseeable construction projects that are required to maintain facilities necessary for currently authorized activities, and this SWEIS is the entire NEPA review for these activities.

3.1.1 Plutonium Facility Complex

The Plutonium Facility (PF) Complex (TA–55) is described in chapter 2, section 2.2.2.1. Under the No Action Alternative, the following activities would occur at this complex.

Plutonium Stabilization. LANL would recover, process, and store its existing plutonium residue inventory in 8 years.

Manufacturing Plutonium Components. LANL would produce up to 14 plutonium pits per year (its existing capacity), as well as fabricate parts and samples for research and development activities (including parts for subcritical experiments).

Surveillance and Disassembly of Weapons Components. LANL would disassemble up to 40 plutonium pits per year (including up to 20 pits that would be destructively examined). In addition, up to 20 pits per year would be nondestructively examined.

Actinide Materials Science and Processing Research and Development. Research, as described in chapter 2 (section 2.2.2.1), would continue to be conducted on plutonium (and other actinide) materials, including metallurgical and other characterization of samples and measurements of mechanical and physical properties. This would include continued operation of the 40-millimeter Impact Test Facility and other apparatus. Research also would be conducted to develop new techniques useful for such research or for enhanced surveillance. In addition, LANL would perform research supporting development and assessment of technology for manufacturing and fabrication of components, including activities in areas such as welding bonding, fire resistance, and casting, machining, and other forming technologies.

LANL would demonstrate the disassembly/conversion of 1 to 2 pits per day (up to 40 pits total) using hydride-dehydride processes. Up to 1,000 curies of neutron sources (plutonium-239/beryllium and americium-241/beryllium) and up to 220 pounds (100 kilograms) of actinides would be processed each year. LANL would process up to 12 items per year (1 to 2 items per month) through tritium separation and would perform decontamination (to remove plutonium) of 15 to 20 uranium components per month.

Research on the physical and chemical characteristics of actinides and in support of DOE's actinide cleanup activities and on actinide processing and waste activities at DOE sites would be conducted. In addition, LANL would stabilize minor quantities of specialty items and residues from other DOE sites, fabricate and study small amounts of nuclear fuels used in terrestrial and space reactors, fabricate and study prototype fuel for lead test assemblies, develop safeguards instrumentation for plutonium assay, and analyze samples.

Fabrication of Ceramic-Based Reactor Fuels. LANL would make prototype mixed oxide (MOX) fuel and continue research and development on other fuels.

Plutonium-238 Research, Development, and Applications Processing. LANL would process, evaluate, and test up to 55 pounds (25 kilograms) of plutonium-238 per year in production of materials and parts to support space and terrestrial uses. In addition, up to 22 pounds (10 kilograms) of plutonium-238 per year would be processed to recover material from heat sources and milliwatt generators, research and development, and safety testing.

Storage, Shipping, and Receiving. As under all alternatives, the Nuclear Material Storage Facility (NMSF) is to be renovated to perform as originally intended: to serve as a centralized receiving area and vault for the interim storage of up to 7.3 tons (6.6 metric tons) of the LANL special nuclear material (SNM) inventory, mainly plutonium. This is expected to be an adequate capacity to allow the PF-4 vault to return to its intended use as a working vault and to accommodate the projected inventory growth at LANL (approximately 287 pounds [130 kilograms] per year under all alternatives—refer to volume III, appendix F, section F.5.3). The NMSF renovation is included in all alternatives. Once renovation is complete, nuclear materials will be moved to the NMSF from other LANL vaults and from other DOE facilities as necessary to support tasks assigned to LANL. Nondestructive assays would be conducted on SNM at the NMSF to verify and identify the content of stored containers. Material stored would be limited to nuclear material in metal or oxide forms. Nuclear material solutions and tritium would not be stored in NMSF, although some may be accepted at the receiving area and redirected to other facilities within the same day.

Under all alternatives, the Plutonium Facility would be renovated to ensure the continued availability of existing capabilities under all alternatives. Activities to be included in all alternatives as renovation that will ensure continued availability of the Plutonium Facility's existing capabilities are:

- Improvements to utilities that increase reliability
- Emergency lighting and interior improvements to meet fire and life safety code requirements
- Replacement of components in the process waste treatment systems
- Replacement of outdated laboratory equipment
- Improvements to communication and fire alarm systems
- Electrical system improvements

It is recognized that project plans can change over time. If this alternative is selected, the construction projects proposed under this alternative, as described above, would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.1.2 Tritium Facilities

The Tritium Facilities are described in chapter 2 (section 2.2.2.2). Under the No Action Alternative, the following activities would occur at these facilities.

High Pressure Gas Fills and Processing. LANL would handle and process tritium gas in quantities of up to 3.53 ounces (100 grams) at the Weapons Engineering Tritium Facility (WETF) approximately 25 times per year.

Gas Boost System Testing and Development. Approximately 20 times per year, LANL would conduct gas boost system research, development, and testing and gas processing operations at WETF involving quantities of up to 3.53 ounces (100 grams) of tritium.

Cryogenic Separation. At the Tritium Systems Test Assembly (TSTA), LANL would purify and process tritium gas in quantities of up to 7.06 ounces (200 grams) approximately 3 times per year using cryogenic separation.

Diffusion and Membrane Purification. LANL would conduct research on tritium movement and penetration through materials, including major experimental efforts, approximately 2 to 3 times per month.

Metallurgical and Material Research. LANL would also conduct metallurgical and materials research involving tritium, including research and application studies regarding tritium storage.

Thin Film Loading. LANL would use its thin film loading capability (involving chemically bonding tritium to a metallic surface) for tritium loading of neutron tube targets, processing approximately 800 units per year.

Gas Analysis. LANL's activities to measure the composition and quantities of gases used would continue in support of tritium operations under this alternative.

Calorimetry. LANL would also continue its calorimetry measurements (a nondestructive method of measuring the amount of tritium in a container) in support of tritium operations under this alternative.

Solid Material and Container Storage. Tritium would continue to be stored on site in WETF, TSTA, and the Tritium Science and Fabrication Facility (TSFF). Storage of tritium occurs in process systems, process samples, inventory for use, and waste.

Under all alternatives, LANL would remodel Building 16-450 and connect it to WETF in support of neutron tube target loading, as discussed in chapter 2 (section 2.2.2.2).

3.1.3 Chemistry and Metallurgy Research Building

The CMR Building is described in section 2.2.2.3. Under the No Action Alternative, the following activities would occur at this facility.

Analytical Chemistry. LANL would provide sample analysis in support of actinide research and processing activities, processing approximately 5,200 samples per year.

Uranium Processing. LANL would conduct activities to recover, process, and store LANL's highly enriched uranium inventory over the next 8 years.

Destructive and Nondestructive Analysis. Up to a total of 10 secondary assemblies over the next 10 years (an average of 1 each year) would be evaluated through destructive and nondestructive analysis and disassembly.

Nonproliferation Training. LANL would conduct nonproliferation training using SNM.

Actinide Research and Processing. LANL would process up to 3,600 curies of plutonium-238/beryllium neutron sources and up to 500 curies of americium-241/beryllium neutron sources per year. In addition, up to 1,000 plutonium-238/beryllium and americium-241/beryllium neutron sources would be staged in CMR Building Wing 9 floor holes. LANL would retain its capability for research and development activities on spent nuclear fuels. Further, LANL would characterize approximately 50 samples per year using metallurgical microstructural/chemical analysis and would conduct compatibility testing of actinides and other metals in order to study long-term aging and other material effects. LANL would also conduct analysis of transuranic (TRU) waste disposal related to the validation of Waste Isolation Pilot Plant (WIPP) performance assessment models, characterize TRU waste, and analyze gas generation such as that which could occur during transportation to WIPP. LANL would continue to develop, demonstrate, and test nondestructive assay and evaluation equipment.

Fabrication and Metallography. LANL would produce 1,080 targets per year for production of molybdenum-99, with each target containing approximately 0.71 ounces (20 grams) of uranium-235. In addition, LANL would support highly enriched uranium processing, research and development, pilot operations, and casting and fabrication of metal shapes using from 2.2 to 22 pounds (1 to 10 kilograms) of highly enriched uranium in each operation, with an annual throughput of approximately 2,200 pounds (1,000 kilograms) (which would remain in the LANL material inventory).

Four construction or facility modification projects are currently in development or implementation at the CMR Building and are included in all alternatives (all have previously been reviewed under NEPA), as discussed in section 2.2.2.3:

- CMR Building Phase I Upgrades (ongoing)
- CMR Building Phase II Upgrades (DOE 1997)
- Medical Radioisotope Target Fabrication (DOE 1996c)
- Radioactive Source Recovery Program (DOE 1995d)

3.1.4 Pajarito Site (Los Alamos Critical Experiments Facility)

The Pajarito Site is described in detail in section 2.2.2.4. Under the No Action Alternative, the following activities would occur at this facility.

LANL would continue to conduct experiments and tests in all areas described in chapter 2, section 2.2.2.4. In 1997, up to 570 experimental operations would be expected; annual growth of about 5 percent is anticipated over the next 10 years to meet the planned research and development needs of DOE and other sponsors.

In addition, LANL would develop safeguards instrumentation and research and development activities for SNM, light detection and ranging experiments, materials processing, interrogation techniques, and field systems.

3.1.5 Sigma Complex

The Sigma Complex is described in section 2.2.2.5. Under the No Action Alternative, the following activities would occur at this complex.

Research and Development on Materials Fabrication, Coating, Joining, and Processing. LANL would continue to fabricate items from metals, ceramics, salts, beryllium, enriched uranium, depleted uranium, and other uranium isotope mixtures. Activities include casting, forming, machining, polishing, coating, and joining.

Characterization of Materials. LANL would continue research and development activities on properties of ceramics, oxides, silicides, composites, and high-temperature materials; analyze up to 24 tritium reservoirs per year; and develop a library of aged non-SNM materials from stockpiled weapons and develop techniques to test and predict changes. Up to 250 non-SNM samples, including uranium, would be stored and characterized.

Fabrication of Metallic and Ceramic Items. LANL would, on an annual basis, fabricate stainless steel and beryllium components for approximately 50 plutonium pits, 50 to 100 reservoirs for tritium, components for up to 50 secondary assemblies (of depleted uranium, depleted uranium alloy, enriched uranium, deuterium, and lithium), nonnuclear components for research and development (30 major hydrotests and 20 to 40 joint test assemblies, beryllium targets, targets and other components for accelerator production of tritium research, test storage containers for nuclear materials stabilization, and nonnuclear (stainless steel and beryllium) components for up to 20 plutonium pit rebuilds.

In addition, all of the alternatives include construction, renovation, and modification projects that are underway and planned in the near term for the purpose of maintaining the availability and viability of the Sigma Complex:

- *Sigma Building Renovation.* These renovations, described further below, are required to keep the building in good operating condition for current missions.
- *Nonnuclear Consolidation/Pit Support and Beryllium Technology Support.* This was previously reviewed under NEPA (DOE 1993), as discussed in section 2.2.2.5.

Typical activities to be included for the Sigma Building (SM–66) in all alternatives to ensure continued availability of the existing capabilities are:

- Perform seismic upgrades including adding shear walls and reinforcements.
- Replace the roof.
- Replace and upgrade the graphite collection systems.
- Replace the cooling water pump and piping.

- Modify the industrial drain system.
- Replace and upgrade electrical components.
- Perform site work such as relocating a fire hydrant, repairing the dock area, and removing unneeded exterior equipment.

In addition, at one of the shops (SM–106), the baghouse on the ventilation system will be replaced with new ductwork and a high-efficiency particulate air (HEPA) filter system.

It is recognized that project plans can change over time. If this alternative is selected, the construction projects proposed under this alternative, as described above, would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.1.6 Materials Science Laboratory

The Materials Science Laboratory (MSL) is described in chapter 2 (section 2.2.2.6). Under the No Action Alternative, the following activities would occur at this facility.

Materials Processing. LANL would continue research at the MSL at current levels of operation, including synthesis and processing techniques, wet chemistry, thermomechanical processing, microwave processing, heavy equipment materials, single crystal growth, amorphous alloys, and powder processing.

Mechanical Behavior in Extreme Environments. LANL would continue mechanical testing, dynamic testing, and fabrication and assembly research at current levels of operation.

Advanced Materials Development. LANL would continue research in materials, synthesis and characterization, ceramics, and superconductors at current levels of operation.

Materials Characterization. LANL would also continue activities in these six areas at current levels of operation: surface science chemistry, corrosion characterization, electron microscopy, x-ray, optical metallography, and spectroscopy.

3.1.7 Target Fabrication Facility

The TFF described in section 2.2.2.7. Under the No Action Alternative, TFF materials research, development, effects studies, and characterization work would continue at current levels, along with the following activities.

Precision Machining and Target Fabrication. LANL would provide targets and specialized components for approximately 1,200 laser and physics tests per year, including a 10 percent annual growth in operations for the next 10 years.

Polymer Synthesis. LANL would produce polymers for targets and specialized components for approximately 1,200 laser and physics tests per year, including a 10 percent annual growth in operations for the next 10 years.

Chemical and Physical Vapor Deposition. LANL would coat targets and specialized components for approximately 1,200 laser and physics tests per year, including a 10 percent annual growth in operations for the next 10 years. This would also support plutonium pit manufacturing operations (as discussed in section 3.1.1).

3.1.8 Machine Shops

The Machine Shops are described in chapter 2 (section 2.2.2.8). Under the No Action Alternative, the following activities would occur at these facilities.

The Machine Shops would provide fabrication support for the dynamic experiments program and explosive research studies, support up to 30 hydrodynamic tests annually, manufacture 20 to

40 joint test assembly sets annually, and provide general laboratory fabrication support as requested. LANL would also continue its fabrication activities using unique and unusual materials and provide appropriate dimensional inspection of these activities.

3.1.9 High Explosives Processing Facilities

The High Explosives Processing Facilities are described in chapter 2 (section 2.2.2.9). The operations listed below are expected to require a total of 46,750 pounds (21,200 kilograms) of explosives annually and 1,590 pounds (720 kilograms) of mock explosives. (This is considered an appropriate indicator of overall activity levels for this key facility.) Under the No Action Alternative, the following activities would occur at these facilities.

High Explosives Synthesis and Production. LANL would continue its current level of high explosives synthesis and production research and development, produce new materials and formulate plastic-bonded explosives as needed. Process development would increase over current levels and materials would be produced for research and stockpile applications.

High Explosives and Plastics Development and Characterization. LANL would evaluate stockpile returns and increase efforts in development and characterization of new plastics and high explosives for stockpile improvement. LANL would also improve its predictive capabilities and conduct research into high explosives waste treatment methods.

High Explosives and Plastics Fabrication. LANL would continue its traditional stockpile surveillance and process development and would supply parts to Pantex for surveillance, war reserve (WR) rebuilds, and joint test assemblies. Fabrication for hydrodynamic and environmental testing would be increased over current levels.

Test Device Assembly. Operations would be increased over current levels to support stockpile related hydrodynamic tests, joint test assemblies, environmental and safety tests, and research and development activities. Approximately 30 major hydrodynamic test devices would be assembled annually.

Safety and Mechanical Testing. Safety and environmental testing related to stockpile assurance would be increased over current levels and predictive models would be improved. Approximately 12 safety and mechanical tests would be conducted annually.

Research, Development, and Fabrication of High-Power Detonators. LANL would increase efforts to support SSM activities, manufacture up to 20 major product lines per year, and support DOE-wide packaging and transportation of electro-explosive devices.

3.1.10 High Explosives Testing

High explosives testing is described in section 2.2.2.10. The No Action Alternative includes approximately 600 experiments per year of varying degrees and types at the high explosives testing firing sites. Up to 30 of these would be characterized as major hydrodynamic tests. Firing site activities would include expenditures of materials, which are considered to be useful indicators of overall test activity. Under this alternative, about 2,900 pounds (1,320 kilograms) of depleted uranium would be expended annually. This is considered to be the minimum level required for the maintenance of capabilities, including staff expertise and equipment, and the recertification of the safety and reliability of the nuclear weapons stockpile. The operation of the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility is included in all alternatives, using phased containment as described in the Final DARHT EIS (DOE 1995c).

Under the No Action Alternative, the following activities would occur.

Hydrodynamic Tests. LANL would conduct hydrodynamic tests, develop containment technology, and conduct tests of weapons configurations. Up to 30 of these per year would be characterized as major hydrodynamic tests.

Dynamic Experiments. LANL would conduct dynamic experiments to study properties and enhance understanding of the basic physics and equation of state and motion for materials used in nuclear weapons, including some experiments with SNMs.

Explosives Research and Testing. High explosives tests would be conducted to characterize explosive materials.

Munitions Experiments. LANL would continue to support the DoD with research and development on conventional munitions, conducting experiments with projectiles, and studying other effects of munitions.

High Explosives Pulsed-Power Experiments. LANL would conduct high explosives pulsed-power experiments and development tests.

Calibration, Development, and Maintenance Testing. LANL would conduct tests to provide calibration data, instrumentation development, and maintenance of image processing capability.

Other Explosives Testing. LANL would also conduct advanced high explosives or weapons evaluation studies.

3.1.11 Los Alamos Neutron Science Center

The Los Alamos Neutron Science Center (LANSCE) is described in chapter 2 (section 2.2.2.11). Under the No Action Alternative, the following activities would occur at this facility.

Accelerator Beam Delivery, Maintenance, and Development. LANSCE would deliver a linear accelerator beam to Areas A, B, and C; the Weapons Neutron Research (WNR) buildings; Manuel Lujan Center; radiography firing sites; and a new Isotope Production Facility (IPF) for 8 months each year (5,100 hours). The H^+ beam current would be 1,000 microamps, and the H^- beam current would be 200 microamps. The beam delivery and support equipment would be reconfigured to support new facilities, upgrades, and experiments.

A 40-million electron volt low-energy demonstration accelerator (LEDA) would be built and operated in an existing facility (TA–53–365) for 6 years, operating up to approximately 6,600 hours per year. LEDA would be used to demonstrate the practicality of using continuous-wave accelerator beam technology to produce tritium, as an alternative to the historical use of nuclear reactors. This facility would be located in existing Building 53–365, as described in section 2.2.2.11.

The LEDA building consists of two major parts: an underground, shielded beam tunnel (16,200 square feet [1,500 square meters]) and a four-story, steel-frame building (53,800 square feet [5,000 square meters]). The heating, ventilation, and air conditioning system would allow short-lived radioisotopes to decay in the beam tunnel prior to release via the 82-foot-high (25-meter-high) exhaust stack.

The construction and operation of LEDA was analyzed under NEPA in an environmental assessment that supported a finding of no significant impact (DOE 1996b).

Experimental Area Support. Support activities would continue to ensure availability of the beam lines, beam line components, handling and transportation systems, and shielding, as well as radiofrequency power sources (including technology development and application). Remote handling and packaging of radioactive materials and wastes at LANSCE would be maintained at fiscal year 1994 levels.

Neutron Research and Technology. LANL would conduct 500 to 1,000 different experiments annually, using neutrons from the Manuel Lujan Center and the WNR Facility. LANL would also conduct an accelerator production of tritium target neutronics experiment for 6 months. In addition, LANL would continue to support contained weapons-related experiments using small to moderate quantities of high explosives. These experiments would include:

- Experiments with nonhazardous materials and small quantities of high explosives (up to approximately 100 per year)
- Experiments with up to 10 pounds (4.54 kilograms) of high explosives and/or depleted uranium (up to approximately 30 per year)
- Experiments with small quantities of actinides, high explosives, and sources (up to approximately 40 per year)
- Shockwave experiments involving small amounts, up to nominally 0.18 ounces (5 grams), of plutonium

In addition, LANL would provide support for static stockpile surveillance technology research and development.

Accelerator-Driven Transmutation Technology. LANL would conduct lead target tests for 2 years at the Area A beam stop, establish a 1-megawatt target/blanket experimental area at one existing target area in Area A, and conduct low-power (less than 1 megawatt) experiments during the 8 months of accelerator operations per year for 4 years.

Subatomic Physics Research. LANL would conduct five to ten physics experiments annually at the Manuel Lujan Center and WNR and conduct proton radiography experiments. Proton radiography experiments would include contained experiments using small to moderate quantities of high explosives, similar to those discussed above under Neutron Research and Technology.

Medical Isotope Production. Up to approximately 40 targets per year would be irradiated for medical isotope production.

High-Power Microwaves and Advanced Accelerators. Research and development would be conducted for advanced accelerator concepts, high-power microwaves, room-temperature and superconducting linear accelerator structures, and in support of the Spallation Neutron Source Program. Research and development also would be conducted in microwave chemistry for industrial and environmental applications.

Under all alternatives, the following facilities would be constructed and operated based on previous NEPA reviews, as discussed in chapter 2 (section 2.2.2.11):

- The LEDA would be constructed.
- Proton radiography and neutron spectroscopy facilities (for neutron research and technology) would be constructed within existing buildings and would house photographic equipment and experiments contained within closed vessels.
- IPF (for medical isotope production) and equipment would be relocated to a new 100-million electron volt station, instead of using the full 800-million electron volt beam as is currently done.
- The short-pulse spallation source (SPSS) enhancement will result in higher neutron flux and greater beam availability for experimenters in WNR and the Manuel Lujan Center.

It is recognized that project plans can change over time. If this alternative is selected, the construction projects proposed under this alternative, as described above, would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.1.12 Health Research Laboratory

The Health Research Laboratory (HRL) is described in section 2.2.2.12. Under the No Action Alternative, the following activities would occur at this facility.

Genomic Studies. LANL would continue to conduct research at current levels using molecular and biochemical techniques to analyze the genes of animals, particularly humans. Specifically, personnel are developing strategies to analyze the nucleotide sequence of individual genes, especially those associated with genetic disorders, and to identify their map genes and/or genetic diseases to locations on individual chromosomes. Part of this work is to map each nucleotide, in sequence, of each gene in all 46 chromosomes of the human genome.

Cell Biology. LANL would continue to conduct research at current levels using whole cells and cellular systems, both in-vivo and in-vitro, to investigate the effects of natural and catastrophic cellular events such as response to aging, harmful chemical and physical agents, and cancer.

Cytometry. LANL would also conduct research utilizing laser imaging systems to analyze the structures and functions of subcellular systems.

DNA Damage and Repair. LANL would conduct research using isolated cells to investigate deoxyribonucleic acid (DNA) repair mechanisms.

Environmental Effects. LANL would conduct research that identifies specific changes in DNA and proteins in certain microorganisms that occur after events in the environment.

Structural Cell Biology. LANL would conduct research utilizing chemical and crystallographic techniques to isolate and characterize the three dimensional shapes and properties of DNA and protein molecules.

Neurobiology. LANL would conduct research using magnetic fields produced in active areas of the brain to map human brain locations associated with certain sensory and cognitive functions.

In-Vivo Monitoring. LANL would also continue to conduct 1,500 whole-body scans annually as a service that supports operations with radioactive materials conducted elsewhere at LANL.

3.1.13 Radiochemistry Facility

The Radiochemistry Facility is described in chapter 2 (section 2.2.2.13). Overall, levels of activity under this alternative would remain at current levels. Because much of the work here is research and development work, one indicator of activity levels is employment. This alternative would be expected to utilize about 170 full-time equivalent employees (FTEs) to perform the activity below. Under the No Action Alternative, the following activities would occur at this facility.

Radionuclide Transport. LANL would conduct 45 to 80 of these studies annually.

Environmental Remediation. Environmental remediation activities would continue to provide field support at current levels.

Ultra-Low-Level Measurements. These activities would continue at current levels.

Nuclear/Radiochemistry. These operations would also continue at current levels.

Isotope Production. LANL would conduct target preparation, irradiation, and processing to recover medical and industrial application isotopes at current levels.

Actinide/Transuranic Chemistry. LANL would perform radiochemical separations at the current level of operations.

Data Analysis. LANL would continue to re-examine archive data and measure nuclear process parameters of interest to weapons radiochemists at current levels.

Inorganic Chemistry. LANL would conduct these activities at current levels.

Structural Analysis. LANL would continue these activities at current levels of operation.

Sample Counting. LANL's sample counting activity to measure the quantity of radioactivity in samples would continue at current levels.

3.1.14 Radioactive Liquid Waste Treatment Facility

The Radioactive Liquid Waste Treatment Facility (RLWTF) is described in chapter 2 (section 2.2.2.14). Under the No Action Alternative, the following activities would occur at this facility.

Waste Characterization, Packaging, and Labeling. LANL would support, certify, and audit generator characterization programs and maintain the waste acceptance criteria (WAC) for the RLWTF.

Waste Transport, Receipt, and Acceptance. LANL would collect radioactive liquid waste from generators and transport it to the RLWTF in TA–50.

Radioactive Liquid Waste Pretreatment. LANL would pretreat 185,000 gallons (700,000 liters) of radioactive liquid waste per year at TA–21; 7,900 gallons (30,000 liters) of radioactive liquid waste per year at TA–50; and solidify, characterize, and package 71 cubic feet (2 cubic meters) of TRU waste sludge per year at TA–50.

Radioactive Liquid Waste Treatment. LANL would install equipment for nitrate reduction in mid 1999, treat 6,600,000 gallons (25 million liters) of radioactive liquid waste (RLW) per year; dewater, characterize, and package 247 cubic feet (7 cubic meters) of low-level radioactive waste (LLW) sludge per year; and solidify, characterize, and package 812 cubic feet (23 cubic meters) of TRU waste sludge per year.

Decontamination Operations. LANL would:

- Decontaminate personnel respirators for reuse (approximately 500 per month).
- Decontaminate air-proportional probes for reuse (approximately 200 per month).
- Decontaminate vehicles and portable instruments for re-use (as required).
- Decontaminate precious metals for resale (acid bath).
- Decontaminate scrap metals for resale (sand blast).
- Decontaminate 6,710 cubic feet (190 cubic meters) of lead for reuse (grit blast).

Three modifications were recently completed or are planned for the RLWTF: an upgrade to the influent tank system, installation of a new process for treatment of RLW, and installation of additional treatment steps for removal of nitrates. These have all been previously reviewed under NEPA and are included in all of the SWEIS alternatives (these are discussed further in section 2.2.2.14).

3.1.15 Solid Radioactive and Chemical Waste Facilities

The Solid Radioactive and Chemical Waste Facilities are described in chapter 2 (section 2.2.2.15). Under the No Action Alternative, the following activities would occur at these facilities.

Waste Characterization, Packaging, and Labeling. LANL would support, certify, and audit generator characterization programs and maintain the WAC for LANL waste management facilities. At the Solid Radioactive and Chemical Waste facilities, LANL would characterize 26,830 cubic feet (760 cubic meters) of legacy low-level radioactive mixed waste (LLMW); characterize 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste; verify characterization data at the Radioactive Assay and Nondestructive Test (RANT) Facility for unopened containers of LLW and TRU waste; maintain the WAC for off-site treatment, storage, and disposal facilities; and overpack and bulk waste containers.

LANL would also perform coring and visual inspection of a percentage of TRU waste packages, ventilate 16,700 drums of TRU waste retrieved during the TRU Waste Inspectable Storage Project (TWISP), and maintain the current version of the WIPP WAC and coordinate with WIPP operations.

Compaction. LANL would compact up to 614,000 cubic feet (17,400 cubic meters) of LLW.

Size Reduction. In addition, 91,800 cubic feet (2,600 cubic meters) of TRU waste would be reduced in size at the Waste Characterization, Reduction, and Repackaging (WCRR) Facility in TA–50 and the Drum Preparation Facility in TA–54.

Waste Transport, Receipt, and Acceptance. LANL would collect chemical and mixed wastes from LANL generators and transport them to TA–54. LANL would ship 31,960 tons (29,000 metric tons) of chemical wastes and 126,700 cubic feet (3,590 cubic meters) of LLMW for off-site treatment and disposal in accordance with EPA land disposal restrictions. In addition, LANL would ship 1,437,000 cubic feet (40,700 cubic meters) of LLW for off-site disposal. Beginning in 1999, 318,00 cubic feet (9,010 cubic meters) of legacy TRU waste would be shipped to WIPP. LANL would also ship 86,800 cubic feet (2,460 cubic meters) of TRU waste generated as a result of future operations and research to WIPP and 100,600 cubic feet (2,850 cubic meters) of LLMW in environmental restoration soils for off-site solidification and disposal.

Waste Storage. Prior to shipment to off-site treatment, storage, and disposal facilities, LANL would store chemical and mixed wastes. LANL would also continue to: store legacy TRU waste until WIPP is open for disposal; LLMW until treatment facilities are available; and LLW uranium chips until sufficient quantities were accumulated for stabilization campaigns.

Waste Retrieval. LANL would retrieve 165,900 cubic feet (4,700 cubic meters) of TRU waste from Pads 1, 2, and 4 by 2004.

Other Waste Processing. LANL would demonstrate treatment (e.g., electrochemical) of LLMW liquids, land farm oil-contaminated soils at Area J, stabilize 14,500 cubic feet (410 cubic meters) of uranium chips and provide special case treatment for 23,650 cubic feet (670 cubic meters) of TRU waste.

Disposal. LANL would dispose of 3,530 cubic feet (100 cubic meters) of LLW in shafts at Area G, 1,271,000 cubic feet (36,000 cubic meters) of LLW and small quantities of radioactively contaminated polychlorinated biphenyls (PCBs) in disposal cells at Area G, approximately 3,530 cubic feet (100 cubic meters) of administratively controlled industrial solid wastes in cells at Area J annually, and nonradiological classified wastes in shafts at Area J.

In addition, under all alternatives, LANL would construct TRU Waste Inspectable Storage Project storage domes for TRU wastes recovered from Pads 1, 2, and 4, as described in section 2.2.2.15. This proposal has been reviewed under NEPA and is included under all four alternatives.

3.2 EXPANDED OPERATIONS ALTERNATIVE

The Expanded Operations Alternative for the SWEIS reflects the implementation of assignments at higher levels of operations through much of LANL. This alternative includes full implementation of new mission element assignments as defined in RODs of DOE programmatic NEPA documents such as the SSM PEIS (DOE 1996a). This activity level is a projection from the index established for past operations and represents a level that is possible to attain within a 10-year period, given an increased level of funding for programs, consistent with current and newly assigned LANL missions. DOE's Preferred Alternative is the Expanded Operations Alternative, with the exception that pit manufacturing would not be implemented at a 50 pits per year level, single shifts, but only at a level of 20 pits per year in the near term.

New facilities and modifications to existing facilities that are necessary to support projected capabilities and operations levels considered in this alternative are also analyzed. Specifically, construction and/or modifications are analyzed that could be required to optimize facilities for increased levels of operations and to increase capabilities or capacities where necessary.

The construction and upgrade projects associated with the Expanded Operations Alternative are identified in the descriptions of activities under this alternative for each of the key facilities. This SWEIS constitutes the entire NEPA review for these projects.

In particular, the Expanded Operations Alternative includes the project-level analyses for the Expansion of TA–54/Area G and for the Enhancement of Pit Manufacturing (to implement the pit production mission element assignment at LANL), including the siting and construction analyses detailed in volume II of this SWEIS. While the full implementation of the pit production mission at LANL is expected to continue beyond the period of time covered in this SWEIS, the impacts are projected based on the best available information. The first phase of this proposed action (establishing pit production at a 20 pits per year rate, DOE's Preferred Alternative) is discussed in this alternative, and the impacts associated with that level of operation are presented in chapter 5 of this SWEIS, as are the impacts of full implementation of pit production at the 80 pits per year level (using multiple shifts).

The selection of the Preferred Alternative as the Expanded Operations Alternative, but only at pit manufacturing rate of 20 pits per year, is influenced by several factors, including:

- DOE's obligation to assure a safe and reliable nuclear weapons stockpile
- The unique capabilities (facilities, equipment, instrumentation, and expertise) at LANL that support DOE's obligation to assure a safe and reliable nuclear weapons stockpile
- The continued consolidation and downsizing of the DOE weapons complex, increasing demands on the remaining facilities and capabilities
- The U.S. policy decision to suspend underground nuclear testing, increasing dependence upon modeling and experimentation with enhanced diagnostics and instrumentation to provide for continued stockpile confidence
- The continued emphasis on applying the resources and technologies developed within DOE national laboratories to improve the U.S. technological position and competitiveness
- The unique capabilities at LANL to support DOE's basic science mission

These factors will continue to influence DOE budget requests, management practices, and decisions. While future budget allocations cannot be predicted with accuracy, DOE is preparing for the future based on expressed national policies and the factors noted above. Thus, DOE expects that future demands on the unique capabilities at LANL are best addressed by the levels of operations described in the Expanded Operations Alternative, but at the 20 pits per year level.

It should be noted that the implementation of the 50 to 80 pits per year production capacity is more than 10 years into the future. While this level is the long-term goal, DOE's proposed action in the near term (next 10 years) is to achieve the 20 pits per year production level.

3.2.1 Plutonium Facility Complex

The Plutonium Facility Complex (TA–55) is described in chapter 2 (section 2.2.2.1). Under the Expanded Operations Alternative, the following activities would occur at this complex.

Plutonium Stabilization. LANL would recover, process, and store its existing plutonium residue inventory in 8 years.

Manufacturing Plutonium Components. LANL would produce up to 80 plutonium pits per year in multiple shift operations (up to 50 pits per year in single-shift operations). This would be implemented in a phased manner, with the near-term objective of establishing this capability at a 20 pits per year rate (Preferred Alternative). Under longer-term objectives, the 80 pits per year (using multiple shifts) capability would be established. In addition, LANL would fabricate parts and samples for research and development at a higher level than under the No Action Alternative (within the existing capacity of TA–55–4).

Surveillance and Disassembly of Weapons Components. LANL would continue to examine and disassemble plutonium pits, but the existing equipment and the responsibility for this activity would be moved to the CMR Building to make room for the expanded pit production capability needed at the Plutonium Facility. (A detailed analysis of the alternatives considered to address the need for additional space for pit production is included in the project-specific siting and construction [PSSC] analysis in the SWEIS, volume II. To bound the impact analysis, PSSC "CMR Building Use" Alternative, relocation of some activities to the CMR Building is assumed because it does not create new nuclear space.) This relocation would result in increased transportation between the Plutonium Facility and the CMR Building, causing increases in road closures (and increased inconvenience to motorists) or in increased packaging costs and risks to the public if U.S. Department of Transportation (DOT)-approved packaging without road closures is used. The DOE has included the environmental impacts to establish a dedicated road for transport between the Plutonium Facility and the CMR Building in the Expanded Operations Alternative. However, the road would not be constructed to establish the 20 pits per year capability (Preferred Alternative). Also, under the Preferred Alternative, the pit manufacturing process activities would not be moved to the CMR Building.

Actinide Materials Science and Processing Research and Development. Research would continue to be conducted on plutonium (and other actinide) materials, as described in chapter 2 (section 2.2.2.1) at a higher level than under the No Action Alternative (but within the existing capacity of TA–55–4). LANL would demonstrate the disassembly/conversion of plutonium pits as under the No Action Alternative and would also develop expanded disassembly capacity, processing up to 200 pits per year (including a total of 250 pits over 4 years as part of disposition demonstration activities) (DOE 1998). Up to 5,000 curies of neutron sources (plutonium-239/beryllium and americium-241/beryllium) would be processed at TA–55. Up to 880 pounds (400 kilograms) of actinides would be processed each year between

TA–55 and the CMR Building. LANL would also process neutron sources other than sealed sources. Although LANL would continue to process items through the Special Recovery Line (tritium separation), that activity would also move to the CMR Building to make room for the expanded pit production at the Plutonium Facility. LANL would perform oralloy decontamination of 28 to 48 uranium components per month in the TA–55 Plutonium Facility.

Research in support of DOE's actinide clean-up activities and on actinide processing and waste activities at DOE sites would be conducted at a level higher than that under the No Action Alternative. In addition, LANL would stabilize larger quantities of specialty items and residues from other DOE sites (including plutonium salts from the Rocky Flats Environmental Technology Site [RFETS]); fabricate and study larger amounts of nuclear fuels used in terrestrial and space reactors; fabricate and study larger amounts of prototype fuel for lead test assemblies; develop safeguards instrumentation for plutonium assay at a level increased from that of the No Action Alternative; and analyze samples. Half of the sample analysis would be conducted at the Plutonium Facility, with the remainder moved to the CMR Building (again, to make room for expanded pit production at the TA–55 Plutonium Facility).

Fabrication of Ceramic-Based Reactor Fuels. LANL would make prototype MOX fuel and would build test reactor fuel assemblies. LANL also would continue research and development on other fuels.

Plutonium-238 Research, Development, and Applications. LANL would process, evaluate, and test up to 55 pounds (25 kilograms) of plutonium-238 per year in production of materials and parts to support space and terrestrial uses. In addition, LANL would recover, recycle, and blend up to 40 pounds (18 kilograms) per year of plutonium-238.

Storage, Shipping, and Receiving. NMSF is to be renovated to perform as originally intended: to serve as a vault for the interim storage of up to 7.3 tons (6.6 metric tons) of the LANL SNM inventory, mainly plutonium. Storage, shipping, and receiving activities would be similar to those under the No Action Alternative, with the differences in shipping activity, as presented in volume III (appendix F, section F.5), increasing the amount of shipping and receiving activity (but not requiring a change in the storage capacity for TA–55).

Under all alternatives, the Plutonium Facility would be renovated to ensure the continued availability of existing capabilities, as described under the No Action Alternative, section 3.1.1. Under the Expanded Operations Alternative, additional upgrades would be performed to support newly assigned missions. Additional upgrades to support newly assigned missions under the Expanded Operations Alternative could include reconfiguration of interior space and installation of new equipment (see volume II, part II, for additional information on these upgrades) in support of expanded activities, as described above.

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative as described above, would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.2.2 Tritium Facilities

The Tritium Facilities are described in chapter 2 (section 2.2.2.2). Under the Expanded Operations Alternative, the following activities would occur at these facilities.

High Pressure Gas Fills and Processing. LANL would handle and process tritium gas in quantities of up to 3.53 ounces (100 grams) at WETF approximately 65 times per year.

Gas Boost System Testing and Development. Approximately 35 times per year, LANL would conduct gas boost system research, development, and testing and gas processing operations at WETF involving quantities of up to 3.53 ounces (100 grams) of tritium.

Cryogenic Separation. At TSTA, LANL would purify and process tritium gas in quantities of up to 7.06 ounces (200 grams) approximately 5 to 6 times per year using cryogenic separation.

Diffusion and Membrane Purification. Significantly increasing from the No Action Alternative level, LANL would conduct research on tritium movement and penetration through materials including major experimental efforts approximately 6 to 8 times per month, accompanied by continuous use for effluent treatment.

Metallurgical and Material Research. LANL's metallurgical and materials research capability would be expanded above the No Action Alternative level, although the amount of tritium used would remain the same.

Thin Film Loading. LANL would use its thin film loading capability (involving chemically bonding tritium to a metallic surface) for tritium loading of neutron tube targets, processing approximately 3,000 units per year using small quantities of tritium.

Gas Analysis. LANL's activity to measure the composition and quantities of gases used would increase from the No Action Alternative level in support of increased tritium operations under this alternative.

Calorimetry. LANL's calorimetry measurements (a nondestructive method of measuring the amount of tritium in a container) would also increase from the No Action Alternative level in support of increased tritium operations under this alternative.

Solid Material and Container Storage. Tritium would continue to be stored on site in WETF, TSTA, and TSFF at approximately 10 times the amount to be stored under the No Action Alternative level.

Under all alternatives, LANL would remodel Building 16-450 and connect it to WETF in support of neutron tube target loading.

3.2.3 Chemistry and Metallurgy Research Building

The CMR Building is described in chapter 2 (section 2.2.2.3). Under the Expanded Operations Alternative, the following activities would occur at this facility.

Analytical Chemistry. LANL would provide expanded sample analysis in support of actinide research and processing activities, processing approximately 11,000 samples per year (including actinide sample analysis relocated from the Plutonium Facility).

Uranium Processing. LANL would conduct activities to recover, process, and store LANL's highly enriched uranium inventory over the next 8 years (same as No Action Alternative).

Destructive and Nondestructive Analysis. Up to 10 secondary assemblies per year would be evaluated through destructive and nondestructive analysis and disassembly.

Nonproliferation Training. LANL would also conduct more nonproliferation training using SNM than would be conducted under the No Action Alternative, and would possibly use different types of SNM in that training.

Actinide Research and Processing. LANL would process up to 5,000 curies of neutron sources (both plutonium-238/beryllium and americium-241/beryllium sources) per year at the CMR Building and would process neutron sources other than sealed sources. In addition, up to a total of 1,000 plutonium-238/beryllium and americium-241/beryllium neutron sources would be staged in CMR Building Wing 9 floor holes. LANL would begin a research and development effort on spent nuclear fuels related to long-term storage and would analyze materials from spent and partially spent fuels. Further, LANL would characterize approximately 100 samples per year using metallurgical microstructural/chemical analysis, would conduct compatibility testing of actinides and other metals in order to study long-term aging and other material effects, and would conduct research and development activities in hot cells on plutonium pits exposed to high temperatures. LANL would also conduct analysis of TRU waste disposal related to the validation of WIPP performance assessment models, characterize TRU waste, and analyze gas generation such as that which could occur during transportation to WIPP. Further, LANL would demonstrate decontamination technologies for actinide-contaminated soils and materials and develop an actinide precipitation method to reduce mixed wastes in LANL effluents.

Under the Expanded Operations Alternative, some actinide activities currently housed in the Plutonium Facility Complex (at TA–55) would move to the CMR Building to make room in TA–55–4 for increased plutonium pit production. Up to 400 kilograms of actinides would be processed per year between TA–55 and the CMR Building, and hydrodynamic testing and tritium separation activities would be supported at the CMR Building.

Fabrication and Metallography. LANL would produce 1,320 targets per year for production of molybdenum-99, with each target containing approximately 20 grams of uranium-235. LANL would separate fission products from the irradiated targets to provide molybdenum-99 (and other isotopes); this capability would produce up to 3,000 6-day curies of molybdenum-99 per week. (A 6-day curie is defined as the amount of product, in curies, remaining 6 days after the product is delivered to the radiopharmaceutical company.) In addition, LANL would retain the capability to fabricate metal shapes using highly enriched uranium (as well as the related uranium processing activities), with an annual throughput of approximately 2,200 pounds (1,000 kilograms).

Surveillance and Disassembly of Weapons Components. The CMR Building would also be used to disassemble approximately 65 plutonium pits per year (including 40 pits destructively examined). Up to 20 pits per year would be nondestructively examined, with additional testing conducted under the Expanded Operations Alternative (as compared to the No Action Alternative). This activity would move to the CMR Building from the TA–55 Plutonium Facility.

The Expanded Operations Alternative also includes the upgrades necessary to accommodate activities displaced from the Plutonium Facilities Complex to the CMR Building as a result of implementing enhanced pit fabrication. These upgrades are addressed in the PSSC analysis for the enhancement of plutonium pit manufacturing in this SWEIS, volume II.

In addition, under the Expanded Operations Alternative, modifications to CMR Building Wing 9 hot cells would be undertaken to provide for the safety testing of pits in a high-temperature environment (to assess the fire resistance of pits). These changes would place a glovebox and a furnace into one of the hot cells, as well as introduce additional instrumentation and equipment for controlling, monitoring and measuring such tests.

In addition, the four projects currently in development or implementation at the CMR Building are included in all alternatives as described under the No Action Alternative, section 3.1.3.

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.2.4 Pajarito Site (Los Alamos Critical Experiments Facility)

The Pajarito Site is described in chapter 2 (section 2.2.2.4). Under the Expanded Operations Alternative, the following activities would occur at this facility.

LANL would continue to conduct experiments and tests in all of the areas described in section 2.2.2.4. These activities would increase by about 25 percent from the No Action Alternative levels of operation, and the nuclear materials inventory would increase by about 20 percent over No Action Alternative levels. As under the No Action Alternative, LANL would also develop safeguards instrumentation and perform research and development activities for SNM, light detection and ranging experiments, materials processing, interrogation techniques, and field systems.

3.2.5 Sigma Complex

The Sigma Complex is described in chapter 2 (section 2.2.2.5). Under the Expanded Operations Alternative, the following activities would occur at this complex.

Research and Development on Materials Fabrication, Coating, Joining, and Processing. Under the Expanded Operations Alternative, as under the No Action Alternative, LANL would continue to fabricate items from metals, ceramics, salts, beryllium, enriched uranium, depleted uranium, and other uranium isotope mixtures. Activities include casting, forming, machining, polishing, coating, and joining.

Characterization of Materials. LANL would continue research and development activities on properties of ceramics, oxides, silicides, composites, and high-temperature materials at a level slightly increased over that for the No Action Alternative. In addition, LANL would analyze up to 36 tritium reservoirs per year; and develop a library of aged non-SNM materials from stockpiled weapons and develop techniques to test and predict changes. Up to 2,500 non-SNM samples, including uranium, would be stored and characterized.

Fabrication of Metallic and Ceramic Items. LANL would, on an annual basis, fabricate stainless steel and beryllium components for approximately 80 plutonium pits, 200 reservoirs for tritium, components for up to 50 secondary assemblies (of depleted uranium, depleted uranium alloy, enriched uranium, deuterium, and lithium), nonnuclear components for research and development (50 to 100 major hydrotests and 50 joint test assemblies, beryllium targets at a slightly increased level over the No Action Alternative, targets and other components for accelerator production of tritium research, test storage containers for nuclear materials stabilization, and nonnuclear (stainless steel and beryllium) components for up to 20 plutonium pit rebuilds.

In addition, all of the alternatives include construction, renovation, and modification projects that are underway and planned in the near term for the purpose of maintaining the availability and viability of the Sigma Complex, as described under the No Action Alternative, section 3.1.5.

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.2.6 Materials Science Laboratory

The MSL is described in chapter 2 (section 2.2.2.6). Under the Expanded Operations Alternative, the following activities would occur at this facility.

Materials Processing. LANL would maintain seven of eight materials processing activities at current levels of research; these activities are: wet chemistry, thermomechanical processing, microwave processing, heavy equipment materials, single crystal growth, amorphous alloys, and powder processing. LANL would expand its materials synthesis/processing activity to develop cold mock-up of weapons assembly and processing and to develop environmental and waste management technologies.

Mechanical Behavior in Extreme Environments. In addition, LANL would continue mechanical testing, fabrication, and assembly at current levels of research. Dynamic testing would be expanded to include research and development on the aging of weapons materials, and a new research capability in machining technology would be developed.

Advanced Materials Development. LANL would continue activities in materials, synthesis and characterization, ceramics, and superconductors at current levels of research.

Materials Characterization. LANL would also continue four of its six materials characterization activities at current levels of operation. These are: surface science chemistry, x-ray, optical metallography, and spectroscopy. Corrosion characterization would be expanded to develop surface modification technology and electron microscopy would be expanded to develop plasma source ion implantation.

3.2.7 Target Fabrication Facility

The Target Fabrication Facility is described in chapter 2 (section 2.2.2.7). Under the Expanded Operations Alternative, the following activities would occur at this facility.

Precision Machining and Target Fabrication. LANL would provide targets and specialized components for approximately 2,400 laser and physics tests per year, including a 10 to 20 percent annual growth in DoD and high explosives pulsed-power target operations for the next 10 years. This level of operations would include a 20 percent increase (over No Action Alternative levels) in high explosives pulsed-power target operations and approximately 100 high-energy density physics tests per year.

Polymer Synthesis. LANL would produce polymers for targets and specialized components for approximately 2,400 laser and physics tests per year, including a 10 to 20 percent annual growth in DoD and high explosives pulsed-power target operations for the next 10 years. This level of operations would include a 20 percent increase (over No Action Alternative levels) in high explosives pulsed-power target operations and approximately 100-high energy density physics tests per year.

Chemical and Physical Vapor Deposition. LANL would coat targets and specialized components for approximately 2,400 laser and physics tests per year, including a 10 to 20 percent annual growth in DoD and high explosives pulsed-power target operations for the next 10 years. This level of operations would include a 20 percent increase (over No Action Alternative levels) in high explosive pulsed-power target operations and approximately 100 high-energy density physics tests per year. This also would support plutonium pit manufacturing operations (as discussed in section 3.2.1).

3.2.8 Machine Shops

The Machine Shops are described in section 2.2.2.8. Under the Expanded Operations Alternative, the following activities would occur at these facilities.

The Machine Shops would provide fabrication support for the dynamic experiments program and explosive research studies, support up to 100 hydrodynamic tests annually, manufacture 50 joint test assembly sets annually, and provide general laboratory fabrication support as requested. LANL would also continue its fabrication activities using unique and unusual materials and provide appropriate dimensional inspection of these activities at a level up to 3 times that of the No Action Alternative. In addition, LANL would undertake additional types of measurements and inspections in its dimensional inspection of fabricated components.

3.2.9 High Explosives Processing Facilities

The High Explosives Processing Facilities are described in chapter 2 (section 2.2.2.9). Activities under this alternative would require an estimated 82,700 pounds (37,500 kilograms) of explosives and 2,910 pounds (1,320 kilograms) of mock explosives annually (this is an indicator of overall activity levels in this key facility). Under the Expanded Operations Alternative, the following activities would occur at these facilities.

High Explosives Synthesis and Production. LANL would increase by 50 percent over the No Action Alternative level of high explosives synthesis and production research and development, produce new materials, and formulate plastic-bonded explosives as needed. Process development would increase over the No Action Alternative level and materials would be produced for research and stockpile applications.

High Explosives and Plastics Development and Characterization. LANL would evaluate stockpile returns and increase by 40 percent (over No Action Alternative levels) efforts in development and characterization of new plastics and high explosives for stockpile improvement. LANL would also increase its efforts to improve its predictive capabilities and conduct research into high explosives waste treatment methods over No Action Alternative levels.

High Explosives and Plastics Fabrication. LANL would increase its stockpile surveillance and process development by 40 percent and double the supply of parts to Pantex for surveillance and WR rebuilds and joint test assemblies over No Action Alternative levels. Fabrication for hydrodynamic and environmental testing would be increased by 50 percent over No Action Alternative levels.

Test Device Assembly. Operations would be increased over current levels to support stockpile related hydrodynamic tests, joint test assemblies, environmental and safety tests, and research and development activities. Approximately 100 major hydrodynamic test device assemblies would be supported annually.

Safety and Mechanical Testing. Safety and environmental testing related to stockpile assurance would be increased by 50 percent over No Action Alternative levels and predictive models would be improved. Approximately 15 safety and mechanical tests would be conducted annually.

Research, Development, and Fabrication of High-Power Detonators. LANL would increase efforts to support SSM activities, manufacture up to 40 major product lines per year, and support DOE-wide packaging and transportation of electro-explosive devices.

3.2.10 High Explosives Testing

High explosives testing is described in section 2.2.2.10. This alternative includes about 1,800 experiments per year, 100 of which would be characterized as major hydrodynamic tests. In addition to smaller quantities of other materials, up to 6,900 pounds (3,130 kilograms) of depleted uranium would be expended in experiments annually. As these numbers indicate, overall high explosives test activity would be about three times that under the No Action Alternative. Under the Expanded Operations Alternative, the following activities would occur.

Hydrodynamic Tests. LANL would increase the number of hydrodynamic tests (over the No Action Alternative), develop containment technology, and conduct tests of weapons configurations. These would include up to 100 major hydrodynamic tests per year.

Dynamic Experiments. LANL would increase these experiments by approximately 50 percent (over No Action Alternative levels) the number of dynamic experiments to study properties and enhance understanding of the basic physics of state and motion for materials used in nuclear weapons, including some experiments with SNMs.

Explosives Research and Testing. Up to twice as many high explosives tests would be conducted as under the No Action Alternative to characterize explosive materials.

Munitions Experiments. As under the No Action Alternative, LANL would continue to support DoD in conventional munitions, conducting experiments with projectiles and studying other effects of munitions.

High Explosives Pulsed-Power Experiments. LANL would conduct up to twice as many high explosives pulsed-power experiments and development tests.

Calibration, Development, and Maintenance Testing. LANL would conduct up to twice as many tests to provide calibration data, instrumentation development, and maintenance of image processing capability.

Other Explosives Testing. LANL would conduct 50 percent more advanced high explosives or weapons evaluation studies than under the No Action Alternative.

The operation of the DARHT facility is included in all alternatives.

3.2.11 Los Alamos Neutron Science Center

LANSCE is described in chapter 2 (section 2.2.2.11). Under the Expanded Operations Alternative, the following activities would occur at this facility.

Accelerator Beam Delivery, Maintenance, and Development. LANSCE would deliver a linear accelerator beam to Areas A, B, and C; the WNR buildings; the Manuel Lujan Center; the dynamic test facility; and a new Isotope Production Facility for 10 months each year (6,400 hours). The H^+ beam current would be 1,250 microamps and the H^- beam current would be 200 microamps. The beam delivery and support equipment would be reconfigured to support new facilities, upgrades, and experiments.

A 40-million electron volt LEDA would be built and operated in an existing facility (TA–53–365) for 10 to 15 years, operating up to approximately 6,600 hours per year, as described under the No Action Alternative, section 3.1.11.

Experimental Area Support. Support activities would continue, consistent with the levels of operation under this alternative (same activities as those described under the No Action Alternative). Remote handling and packaging of radioactive materials and wastes at LANSCE would increase to handle waste generation that results from the facility construction and modifications at LANSCE under this alternative (as discussed later in this section).

Neutron Research and Technology. LANL would conduct 1,000 to 2,000 different experiments annually, using neutrons from the Manuel Lujan Center, WNR, and the Long-Pulse Spallation Source (LPSS). The LPSS would be a new experimental facility that would provide advanced capabilities for neutron scattering and subatomic physics using cold and ultracold neutrons. Together with the SPSS at the Manuel Lujan Center, the LPSS would provide U.S. scientists with a complementary pair of neutron sources for research in materials, biological, and nuclear science.

The LPSS neutron production system, which would be located in Area A, would consist of a tungsten target, moderators, and a reflector surrounded by a large iron and concrete biological shield. The Area A building has 100,000 square feet (9,300 square meters) of space and a usable height of 45 feet (14 meters). No modifications would be required to the building or floor of Area A, but existing experimental stations and other equipment in Area A would have to be dismantled and removed, including Area A experimental stations, the Neutrino Scintillation Detector Station, and Area A shielding. This removal of existing experimental stations, instrumentation, and related hardware would generate an estimated 118,000 cubic feet (3,300 cubic meters) of suspect contaminated concrete that would be disposed at TA–54/Area G (8,400 tons [7,620 metric tons], 420 shipments), and another 48,000 cubic feet (1,350 cubic meters) of activated metals and debris (for which 200 Type B cask shipments would be required, and 900 low specific activity and Type A shipments, all to TA–54).

As part of the LPSS project, the linear accelerator would be upgraded to deliver an average proton current of 1.25 milliampere (versus 1.0 at present), for a power of 1.0 megawatt (versus 0.8 at present). This upgrade would increase LANSCE electricity and cooling water requirements.

The LPSS design would use an evacuated target cell that would largely eliminate short-lived activation products. This newer design would decrease radioactive air emissions by an order of magnitude (per unit basis of microampere-hours of linear accelerator operation). This design would result in LPSS operations contributing no more than 1 millirem per year to the dose received by the maximally exposed individual defined for LANSCE. (The term "maximally exposed individual" is discussed in the Air Quality sections of chapters 4 and 5).

The LPSS target, moderators, and hot cell would be constructed inside Building 53–003M, and would thus require no additional land disturbance. There would be no change from the current industrial use of these disturbed areas.

LANL also would construct and operate a Dynamic Experiment Laboratory (DEL) to provide both neutron and proton radiography and resonance neutron spectroscopy of materials for the study of dynamic materials phenomena under a single roof. Such techniques are currently employed for experiments at LANSCE but in varying locations; they complement x-ray radiographic and other techniques for dynamic materials studies used at LANL and other DOE facilities. The DEL also would provide improved support for these experiments and some added capabilities. It would provide more effectively utilized physical space and dedicated infrastructure for these experiments; it would enable proton radiography experiments to use beam from the Proton Storage Ring, thereby reducing interference of these experiments with other LANSCE uses and increasing the beam intensity available for proton radiography; and it would incorporate gas guns to enable additional shock wave experiments and simplify some such experiments. The DEL would be constructed as a new facility adjacent to WNR. It would make use of existing LANSCE infrastructure, including the 800-million electron volt linear accelerator, the Proton Storage Ring, and existing personnel.

The proton radiography experimental program requires a containment vessel, beam tubes in the upstream and downstream lenses, three beam axes with two matching lenses and two downstream lenses on each axis, and a gas gun pointing at the center of the containment vessel. The resonance neutron spectroscopy and neutron radiography experiments require a neutron production target and moderator, a flight path about 66 feet (20 meters) in length, and a gas gun pointing at the center of the containment vessel.

A high explosives assembly area and magazine would be attached to the outside of DEL, with an explosion-proof door separating the two. Separate from DEL with its high explosives areas, a counting house and a building for support equipment (e.g., power supplies, deionized water system) would be needed. This laboratory would be established in a previously disturbed area. There would be no change from the current industrial use of these areas.

LANL would also conduct an accelerator production of tritium target neutronics experiment for 6 months. In addition, LANL would continue to support contained weapons-related experiments using small to moderate quantities of high explosives. These experiments would include:

- Experiments with nonhazardous materials and small quantities of high explosives (up to approximately 200 per year)
- Experiments with up to 10 pounds (4.54 kilograms) of high explosives and/or depleted uranium (up to approximately 60 per year)
- Experiments with small quantities of actinides, high explosives, and sources (up to approximately 80 per year)
- Shockwave experiments involving small amounts, up to nominally 1.8 ounces (50 grams), of plutonium

In addition, LANL would provide support for static stockpile surveillance technology research and development.

Accelerator-Driven Transmutation Technology. LANL would conduct lead target tests for 2 years at the Area A beam stop, as well as the 1 megawatt target/blanket experiments, as described in section 3.1.11. Once these experiments were completed, LANL would construct a 5-megawatt target/blanket experimental area (referred to as the Los Alamos International Facility for Transmutation [LIFT]) adjacent to Area A, and conduct 5-megawatt experiments for 10 months per year for 4 years.

LIFT would be used to demonstrate the practicality of using accelerator technology to transmute plutonium and high-level radioactive wastes into other elements or isotopes. LIFT would be constructed adjacent to Area A in a previously disturbed area. There would be no change from the current industrial use of these areas.

Subatomic Physics Research. LANL would conduct five to ten physics experiments annually at the Manuel Lujan Center, WNR, and LPSS and conduct proton radiography experiments. Proton radiography experiments would include contained experiments using small to moderate quantities of high explosives similar to those discussed above under Neutron Research and Technology.

Medical Isotope Production. Up to approximately 50 targets per year would be irradiated for medical isotope production and exotic and neutron rich/deficient isotopes would be produced.

In addition, LANL would establish the Exotic Isotope Production Facility in an existing facility, which would complement the 100-million electron volt IPF by using the 800-million electron volt proton beam available at the end of the half-mile-long linear accelerator to fabricate radioisotopes used by the medical community for diagnostic and other procedures. This facility would be established within an existing building and would not result in either land disturbance or a change from the current industrial land use of these areas.

Also under the Expanded Operations Alternative, Area A East would be stripped of existing contaminated and uncontaminated items so that it could be put to use as a staging area for shipments, receipts, equipment storage, and limited maintenance activities. (This portion of Experimental Area A currently houses a beam stop, shielding, and equipment related to isotope production and materials irradiation activities.) Removal of existing items would generate wastes for disposal, including an estimated 50,000 cubic feet (1,400 cubic meters) of suspect contaminated concrete, 20,000 cubic feet (560 cubic meters) of activated metal used for shielding, and another 14,000 cubic feet (400 cubic meters) of equipment and debris. Wastes would total an estimated 1,700 tons (1,540 metric tons), the disposal of which would require 200 Type B cask shipments, 530 Type A shipments, and 290 low specific activity shipments, all to TA–54.

High-Power Microwaves and Advanced Accelerators. Research and development in this area would be conducted at the same levels described under the No Action Alternative.

Under all alternatives, the following facilities (as described under the No Action Alternative, section 3.1.11 and in chapter 2, section 2.2.2.11) would be constructed and operated (based on previous NEPA reviews):

- LEDA
- Proton radiography and neutron spectroscopy facilities
- IPF relocation
- SPSS enhancement

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.2.12 Health Research Laboratory

The HRL is described in chapter 2 (section 2.2.2.12). Under the Expanded Operations Alternative, the following activities would occur at this facility.

Genomic Studies. LANL would increase genomic studies at HRL by approximately 25 percent over the No Action Alternative level.

Cell Biology. LANL would increase its research activities by approximately 40 percent above the No Action Alternative level.

Cytometry. LANL's research utilizing laser imaging systems to analyze the structures and functions of subcellular systems would increase by approximately 33 percent.

DNA Damage and Repair. Research using isolated cells to investigate DNA repair mechanisms would increase by approximately 40 percent above the No Action Alternative levels.

Environmental Effects. LANL would conduct research that identifies specific changes in DNA and proteins in certain microorganisms that occur after events in the environment at a level approximately 25 percent higher than the No Action Alternative.

Structural Cell Biology. LANL would conduct research utilizing chemical and crystallographic techniques to isolate and characterize the three-dimensional shapes and properties of DNA and protein molecules at a level approximately 50 percent higher than the No Action Alternative.

Neurobiology. LANL's activities in neurobiology, conducting research using magnetic fields produced in active areas of the brain to map human brain locations associated with certain sensory and cognitive functions, would be increased to three times that of the No Action Alternative.

In-Vivo Monitoring. LANL would conduct 3,000 whole-body scans annually as a service that supports operations with radioactive materials conducted elsewhere at LANL.

3.2.13 Radiochemistry Facility

The Radiochemistry Facility is described in chapter 2 (section 2.2.2.13). As an indicator of overall activity levels, these operations would be expected to require about 250 FTEs. Under the Expanded Operations Alternative, the following activities would occur at this facility.

Radionuclide Transport. LANL would conduct 80 to 160 of these studies annually.

Environmental Remediation. Environmental remediation activities would approximately double the No Action Alternative level of operations.

Ultra-Low-Level Measurements. These activities would be at approximately double the No Action Alternative level.

Nuclear/Radiochemistry. These operations would be slightly more than the No Action Alternative levels.

Isotope Production. LANL would conduct target preparation, irradiation, and processing to recover medical and industrial application isotopes at a level approximately double that of the No Action Alternative.

Actinide/Transuranic Chemistry. LANL would also perform radiochemical separations at approximately twice the No Action Alternative level of operations.

Data Analysis. LANL would reexamine archive data and measure nuclear process parameters of interest to weapons radiochemists at approximately twice the No Action Alternative level.

Inorganic Chemistry. LANL would conduct synthesis, catalysis, and actinide chemistry activities at a level approximately 50 percent higher than that of the No Action Alternative.

Structural Analysis. LANL would perform these activities at approximately twice the No Action Alternative level of operation.

Sample Counting. LANL's sample counting activity would be the same as the No Action Alternative.

3.2.14 Radioactive Liquid Waste Treatment Facility

The RLWTF is described in chapter 2 (section 2.2.2.14). Under the Expanded Operations Alternative, the following activities would occur at this facility.

Waste Characterization, Packaging, and Labeling. Under this alternative, as under the No Action Alternative, LANL would support, certify, and audit generator characterization programs and maintain the WAC for the RLWTF.

Waste Transport, Receipt, and Acceptance. LANL would also collect radioactive liquid waste from generators and transport it to the RLWTF in TA–50.

Radioactive Liquid Waste Pretreatment. LANL would pretreat 238,000 gallons (900,000 liters) of RLW per year at TA–21; 21,100 gallons (80,000 liters) of RLW per year at TA–50; and solidify, characterize, and package 106 cubic feet (3 cubic meters) of TRU waste sludge per year at TA–50.

Radioactive Liquid Waste Treatment. LANL would install equipment for nitrate reduction in mid 1999, treat 9.24 million gallons (35 million liters) of RLW per year; dewater, characterize, and package 353 cubic feet (10 cubic meters) of LLW sludge per year; and solidify, characterize, and package 1,130 cubic feet (32 cubic meters) of TRU waste sludge per year.

Decontamination Operations. LANL would:

- Decontaminate personnel respirators for reuse (approximately 700 per month).
- Decontaminate air-proportional probes for reuse (approximately 300 per month).
- Decontaminate vehicles and portable instruments for reuse (as required).
- Decontaminate precious metals for resale (acid bath).
- Decontaminate scrap metals for resale (sand blast).
- Decontaminate 7,060 cubic feet (200 cubic meters) of lead for reuse (grit blast).

Three modifications were recently completed or are planned for the RLWTF: an upgrade to the influent tank system, installation of a new process for treatment of RLW, and installation of additional treatment steps for removal of nitrates. These have all been previously reviewed under NEPA and are included in all of the SWEIS alternatives as described under the No Action Alternative, section 3.1.14, and in chapter 2, section 2.2.2.14.

3.2.15 Solid Radioactive and Chemical Waste Facilities

The Solid Radioactive and Chemical Waste Facilities are described in chapter 2 (section 2.2.2.15). Under the Expanded Operations Alternative, the following activities would occur at these facilities.

Waste Characterization, Packaging, and Labeling. Under this alternative, as under the No Action Alternative, LANL would support, certify, and audit generator characterization programs and maintain the WAC for LANL waste management facilities. At the Solid Radioactive and Chemical Waste Facilities, LANL would characterize 26,800 cubic feet (760 cubic meters) of legacy LLMW; characterize 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste; verify characterization data at the RANT Facility, for unopened containers of LLW and TRU waste; maintain the WAC for off-site treatment, storage, and disposal facilities; and overpack and bulk waste containers.

As under the No Action Alternative, LANL would also perform coring and visual inspection of a percentage of TRU waste packages, ventilate 16,700 drums of TRU waste retrieved during the TWISP, and maintain the current version of the WIPP WAC and coordinate with WIPP operations.

Compaction. LANL would compact up to 896,600 cubic feet (25,400 cubic meters) of LLW.

Size Reduction. In addition, 102,400 cubic feet (2,900 cubic meters) of TRU waste would be reduced in size at the WCRR Facility in TA–50 and the Drum Preparation Facility in TA–54.

Waste Transport, Receipt, and Acceptance. LANL would collect chemical and mixed wastes from LANL generators and transport them to TA–54. LANL would ship 35,260 tons (32,000 metric tons) of chemical wastes and

128,500 cubic feet (3,640 cubic meters) of LLMW for off-site treatment and disposal in accordance with EPA land disposal restrictions. Beginning in 1999, 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste would be shipped to WIPP. LANL would also ship 192,700 cubic feet (5,460 cubic meters) of TRU waste generated as a result of future operations and research to WIPP. LANL would not ship LLW or environmental restoration soils for off-site disposal.

Waste Storage. As under the No Action Alternative, prior to shipment to off-site treatment, storage, and disposal facilities, LANL would store chemical and mixed wastes. LANL would also store legacy TRU waste until WIPP is opened for disposal; LLMW until treatment facilities are available; and LLW uranium chips until sufficient quantities were accumulated for stabilization campaigns.

Waste Retrieval. LANL would retrieve 165,900 cubic feet (4,700 cubic meters) of TRU waste from Pads 1, 2, and 4 by 2004 (same level as the No Action Alternative).

Other Waste Processing. LANL would demonstrate treatment (e.g., electrochemical) of LLMW liquids, land farm oil-contaminated soils at Area J, stabilize 30,700 cubic feet (870 cubic meters) of uranium chips, provide special case treatment for 36,360 cubic feet (1,030 cubic meters) of TRU waste, and solidify 100,600 cubic feet (2,850 cubic meters) of LLMW (environmental restoration soils) for disposal at Area G.

Disposal. LANL would dispose of 14,830 cubic feet (420 cubic meters) of LLW in shafts at Area G, 4,060,000 cubic feet (115,000 cubic meters) of LLW and small quantities of radioactively contaminated PCBs in disposal cells at Area G, approximately 3,530 cubic feet (100 cubic meters) of administratively controlled industrial solid wastes in cells at Area J annually, and nonradiological classified wastes in shafts at Area J. In addition, LLW disposal operations in Area G would be expanded.

Existing disposal capacity is projected to be filled before 2000. Under the Expanded Operations Alternative, Area G would be expanded to allow continued disposal of LLW at LANL. Five siting and construction alternatives for expanded disposal operations are discussed in the PSSC analysis for Expansion of TA–54/Area G Low-Level Disposal Area in the SWEIS, volume II, part I. Expansion into Zones 4 and 6 in Area G is identified as DOE's preferred expansion alternative in that analysis.

In addition, under all alternatives, LANL would construct storage domes for TRU wastes recovered from Pads 1, 2, and 4. This is described under the No Action Alternative, section 3.1.15.

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.3 REDUCED OPERATIONS ALTERNATIVE

The Reduced Operations Alternative reflects minimum levels of activity to maintain the capabilities necessary to support LANL's assigned missions. This activity level is a projection from the index established for past operations and represents a level that is possible if funding is reduced. In some cases, the selected index was the best available for most operations at LANL, but could not reasonably be adjusted from the historical record to account for capabilities insufficiently exercised during that period. In those cases, the Reduced Operations activity may reflect an increase over the index (although no greater than that under the No Action Alternative).

This alternative does not eliminate assigned missions or programs, but results in reduced technology demonstration activities and/or a decline in technological capability. In the long term, implementation of the Reduced Operations Alternative could reduce LANL capabilities below those required to fully meet its existing assigned missions.

For this alternative, LANL operations would be reduced to the minimum necessary to maintain safety and security activities such as the maintenance of nuclear materials, high explosives, or other hazardous materials in storage or use at LANL. Under this alternative, for example, plutonium processing activities would be reduced, but would occur at a level that could still support the safe, secure maintenance of the plutonium inventory.

Construction (including facility modification) projects that are required to maintain LANL activities, even at a reduced level, are included in this alternative. Some construction projects also may be required to support consolidation of some operations to fewer facilities or within a currently used facility, resulting in a reduced "footprint." These construction and upgrade activities are identified in the descriptions of activities under this alternative for each of the key facilities. This SWEIS constitutes the entire NEPA review for these projects.

3.3.1 Plutonium Facility Complex

The Plutonium Facility Complex (TA–55) is described in chapter 2 (section 2.2.2.1). Under the Reduced Operations Alternative, the following activities would occur at this complex.

Plutonium Stabilization. LANL would recover, process, and store its existing plutonium residue inventory in 10 to 15 years.

Manufacturing Plutonium Components. LANL would produce 6 to 12 plutonium pits per year in order to maintain the technical capability to understand pit characteristics and behavior. In addition, it would fabricate other parts and samples for research and development at the same levels as under the No Action Alternative.

Surveillance and Disassembly of Weapons Components. As under the No Action Alternative, LANL would disassemble up to 40 plutonium pits per year (including up to 20 pits destructively examined). Up to 20 pits would be nondestructively examined.

Actinide Materials Science and Processing Research and Development. As under the No Action Alternative, LANL would continue to conduct research on plutonium (and other actinide) materials. The types and levels of these activities are the same under this alternative as under the No Action Alternative. LANL would demonstrate the disassembly/conversion of 1 to 2 pits per day (up to 40 pits total) using hydride-dehydride processes. Up to 500 curies of neutron sources (plutonium-239/beryllium and americium-241/beryllium) would be processed to maintain capability; LANL would retain the capability to process actinides and undertake tritium separation from metals, but would not use these capabilities. LANL would perform decontamination of 15 to 20 uranium components per month.

Research in support of DOE's actinide clean-up activities and on actinide processing and waste activities at DOE sites would be conducted, although support to other sites would be less than under the No Action Alternative. As under the No Action Alternative, LANL would stabilize minor quantities of specialty items and residues from other DOE sites; fabricate and study small amounts of nuclear fuels used in terrestrial and space reactors; fabricate and study prototype fuel for lead test assemblies; continue to develop safeguards instrumentation for plutonium assay; and analyze samples.

Fabrication of Ceramic-Based Reactor Fuels. LANL would conduct MOX and other fuel research and development.

Plutonium-238 Research, Development, and Applications. LANL would process, evaluate, and test up to 15.4 pounds (7 kilograms) of plutonium-238 per year in production of materials and parts to support space and terrestrial uses. In addition, up to 1.1 pounds (0.5 kilograms) of plutonium-238 per year would be processed to recover material from heat sources and milliwatt generators, research and development, and safety testing.

Storage, Shipping, and Receiving. The NMSF is to be renovated to perform as originally intended: to serve as a vault for the interim storage of up to 7.3 tons (6.6 metric tons) of the LANL SNM inventory, mainly plutonium. The NMSF renovation is included in all alternatives.

Under all alternatives, the Plutonium Facility would be renovated to ensure the continued availability of existing capabilities as described under the No Action Alternative, section 3.1.1.

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.3.2 Tritium Facilities

The Tritium Facilities are described in chapter 2 (section 2.2.2.2). Under the Reduced Operations Alternative, the following activities would occur at these facilities.

High-Pressure Gas Fills and Processing. LANL would handle and process tritium gas in quantities of up to 3.53 ounces (100 grams) at the WETF approximately 20 times per year.

Gas Boost System Testing and Development. Approximately 15 times per year, LANL would conduct gas boost system research, development, and testing and gas processing operations at WETF involving quantities of up to 100 grams of tritium.

Cryogenic Separation. At TSTA, LANL would purify and process tritium gas in quantities of up to 7.06 ounces (200 grams) once per year using cryogenic separation.

Diffusion and Membrane Purification. LANL would conduct research on tritium movement and penetration through materials including major experimental efforts approximately 2 to 3 times per month.

Metallurgical and Material Research. LANL would also conduct metallurgical and materials research involving tritium including research and application studies regarding tritium storage (same as the No Action Alternative).

Thin Film Loading. In addition, LANL would use its thin film loading capability (involving chemically bonding tritium to a metallic surface) for tritium loading of neutron tube targets, processing approximately 800 units per year (same as the No Action Alternative).

Gas Analysis. LANL's activities to measure the composition and quantities of gases used would continue in support of tritium operations.

Calorimetry. LANL's calorimetry measurements (a nondestructive method of measuring the amount of tritium in a container) would also continue in support of tritium operations.

Solid Material and Container Storage. Tritium would continue to be stored on site in WETF, TSTA, and TSFF.

Under all alternatives, LANL would remodel Building 16-450 and connect it to WETF in support of neutron tube target loading.

3.3.3 Chemistry and Metallurgy Research Building

The CMR Building is described in chapter 2 (section 2.2.2.3). Under the Reduced

Operations Alternative, the following activities would occur at this facility.

Analytical Chemistry. LANL would provide sample analysis in support of actinide research and processing activities, processing approximately 5,200 samples per year (same as the No Action Alternative).

Uranium Processing. LANL would conduct activities to recover, process, and store LANL's highly enriched uranium inventory over the next 10 to 15 years.

Destructive and Nondestructive Analysis. Up to a total of 10 secondary assemblies (1 per year) would be evaluated through destructive and nondestructive analysis and disassembly (same as the No Action Alternative).

Nonproliferation Training. Reducing from the No Action Alternative level, LANL would also conduct some nonproliferation training using the same quantities of SNM as under the No Action Alternative.

Actinide Research and Processing. LANL would maintain its capabilities for plutonium-238/beryllium and americium-241/beryllium neutron source processing, but annual throughput would not exceed a total of 2,000 curies at the CMR Building. In addition, up to a total of 1,000 plutonium-238/beryllium and neutron sources would be staged in CMR Building Wing 9 floor holes. LANL would retain its capability for research and development activities on spent nuclear fuels. Further, LANL would characterize approximately 25 samples per year using metallurgical microstructural/chemical analysis and would conduct compatibility testing of actinides and other metals in order to study long-term aging and other material effects. LANL would also conduct analysis of TRU waste disposal related to the validation of WIPP performance assessment models, characterize TRU waste, and analyze gas generation such as that which could occur during transportation to WIPP.

Fabrication and Metallography. LANL would produce 50 targets per year for production of molybdenum-99, with each target containing approximately 0.71 ounces (20 grams) of uranium-235. The targets would be stored. In addition, LANL would support highly enriched uranium processing, research and development, pilot operations, and casting and fabrication of metal shapes using from 2.2 to 22 pounds (1 to 10 kilograms) of highly enriched uranium in each operation, with an annual throughput of approximately 2,200 pounds (1,000 kilograms) (which would remain in the LANL material inventory).

In addition, the four projects currently in development or implementation at the CMR Building are included in all alternatives, as described under the No Action Alternative, section 3.1.3.

3.3.4 Pajarito Site (Los Alamos Critical Experiments Facility)

The Pajarito Site is described in chapter 2 (section 2.2.2.4). Under the Reduced Operations Alternative, the following activities would occur at this facility.

Under the Reduced Operations Alternative as under the No Action Alternative, LANL would continue to conduct experiments and tests in all of the areas described in section 2.2.2.4. In 1997, as with the No Action Alternative, up to 570 experimental operations would be expected, with a 5 percent annual growth after that. LANL would also develop safeguards instrumentation and perform research and development activities for SNM, light detection and ranging experiments, materials processing, interrogation techniques, and field systems.

3.3.5 Sigma Complex

The Sigma Complex is described in section 2.2.2.5. The Reduced Operations Alternative for the Sigma Complex is the same as the No Action Alternative, as described in section 3.1.5.

3.3.6 Materials Science Laboratory

The MSL is described in section 2.2.2.6. Under the Reduced Operations Alternative, the following activities would occur at this facility.

Materials Processing. LANL would continue materials processing research at the MSL; these capabilities are: synthesis and processing techniques, wet chemistry, thermomechanical processing, microwave processing, heavy equipment materials, single crystal growth, amorphous alloys, and powder processing. However, there would be a decrease in the number of experiments conducted in these research capabilities as compared to the No Action Alternative.

Mechanical Behavior in Extreme Environments. LANL would continue mechanical testing, dynamic testing, and fabrication and assembly research, although there would be a decrease in the number of experiments conducted, as compared to the No Action Alternative.

Advanced Materials Development. LANL would continue research into materials, synthesis and characterization, ceramics, and superconductors activities, although there would be a significant decrease in the number of experiments conducted, as compared to the No Action Alternative.

Materials Characterization. LANL would also continue two of its materials characterization activities (surface science chemistry and corrosion characterization), although there would be a decrease in the number of experiments conducted, as compared to the No Action Alternative. Electron microscopy, x-ray, optical metallography, and spectroscopy capabilities would be eliminated.

3.3.7 Target Fabrication Facility

The TFF is described in chapter 2 (section 2.2.2.7). Under the Reduced Operations Alternative, the following activities would occur at this facility.

Precision Machining and Target Fabrication. LANL would provide targets and specialized components for approximately 400 laser and high-energy density physics tests per year.

Polymer Synthesis. LANL would produce polymers for targets and specialized components for approximately 400 laser and high-energy density physics tests per year.

Chemical and Physical Vapor Deposition. LANL would coat targets and specialized components for approximately 400 laser and high-energy density physics tests per year. Support for pit manufacturing operations would be the same as under the No Action Alternative.

3.3.8 Machine Shops

The Machine Shops are described in section 2.2.2.8. Under the Reduced Operations Alternative, the following activities would occur at these facilities.

The Machine Shops would provide fabrication support for the dynamic experiments program and explosive research studies, support up to 30 hydrodynamic tests annually, manufacture 20 to 40 joint test assembly sets annually, and provide general laboratory fabrication support as requested. LANL would also continue its fabrication activities using unique and unusual materials and provide appropriate dimensional inspection of these activities. (These activity levels are about the same as under the No Action Alternative.)

3.3.9 High Explosives Processing Facilities

The High Explosives Processing Facilities are described in section 2.2.2.9. Under this alternative, 19,400 pounds (8,800 kilograms) of explosives and 1,150 pounds (520 kilograms) of mock explosives would be used annually (as an indicator of overall activity levels in this key facility). Under the Reduced Operations Alternative, the following activities would occur at these facilities.

High Explosives Synthesis and Production. LANL would reduce its current level of high explosives synthesis and production research and development, production of new materials and formulation of plastic-bonded explosives by approximately 60 percent. Process development would decrease from current levels, and materials production for research and stockpile applications would continue at a reduced level (approximately 60 percent of the No Action Alternative).

High Explosives and Plastics Development and Characterization. LANL would evaluate stockpile returns and decrease efforts in development and characterization of new plastics and high explosives for stockpile improvement. LANL would also conduct research into high explosives waste treatment methods, with the overall level of effort reduced to about 60 percent of the No Action Alternative.

High Explosives and Plastics Fabrication. LANL would reduce its traditional stockpile surveillance and process development from No Action Alternative levels by approximately 60 percent. Stockpile surveillance fabrication for hydrodynamic and environmental testing would be reduced to approximately 75 percent of the No Action Alternative levels.

Test Device Assembly. Operations would be the same as the No Action Alternative levels. Approximately 30 major hydrodynamic test devices would be assembled annually.

Safety and Mechanical Testing. Safety and environmental testing related to stockpile assurance would be reduced to approximately 80 percent of No Action Alternative levels, and predictive models would be improved. Approximately 12 safety and mechanical tests would be conducted annually.

Research, Development, and Fabrication of High-Power Detonators. As with the No Action Alternative, LANL would manufacture up to 20 major product lines per year and support DOE-wide packaging and transportation of electro-explosive devices.

3.3.10 High Explosives Testing

High explosives testing is described in chapter 2 (section 2.2.2.10). The Reduced Operations Alternative for LANL's high explosives testing facilities is the same as the No Action Alternative, as described in section 3.1.10.

3.3.11 Los Alamos Neutron Science Center

The LANSCE is described in section 2.2.2.11. Under the Reduced Operations Alternative, the following activities would occur at this facility.

Accelerator Beam Delivery, Maintenance, and Development. LANSCE would deliver a linear accelerator beam to Areas A, B, and C; WNR buildings; the Manuel Lujan Center; radiography firing sites; and a new IPF for 4 months each year (2,600 hours). The H^+ beam current would be 1,000 microamps and the H^- beam current would be 200 microamps. The beam delivery and support equipment would be reconfigured to support new facilities, upgrades, and experiments.

Under the Reduced Alternative, the LEDA would be operated at 12-million electron volts to demonstrate the practicality of using continuous-wave accelerator beam technology to produce tritium, as an alternative to the historical use of nuclear reactors. It would operate for 2 years, operating up to approximately 1,000 hours per year. This facility would be constructed as described under the No Action Alternative, section 3.1.11.

Experimental Area Support. The same support activities would continue at the same levels as described under the No Action Alternative. Remote handling and packaging of radioactive wastes at LANSCE would be maintained at fiscal year 1994 levels.

Neutron Research and Technology. LANL would conduct 100 to 500 different experiments annually, using neutrons from Manuel Lujan Center and WNR. LANL would continue to support contained weapons-related experiments using small to moderate quantities of high explosives. These experiments would include:

- Experiments with nonhazardous materials and small quantities of high explosives (up to approximately 50 per year)
- Experiments with up to 10 pounds (4.54 kilograms) of high explosives and/or depleted uranium (up to approximately 15 per year)
- Experiments with small quantities of actinides, high explosives, and sources (up to approximately 20 per year)

Accelerator-Driven Transmutation Technology. LANL would conduct basic research using existing LANSCE facilities.

Subatomic Physics Research. LANL would conduct 5 to 10 physics experiments annually at the Manuel Lujan Center and WNR and conduct proton radiography experiments. Proton radiography experiments would include contained experiments using small to moderate quantities of high explosives, similar to those discussed above under Neutron Research and Technology.

Medical Isotope Production. Up to approximately 20 targets per year would be irradiated for medical isotope production.

High-Power Microwaves and Advanced Accelerators. Research and development in this area would be conducted at reduced levels (about 50 percent) as compared to the No Action Alternative levels. Microwave chemistry research for industrial and environmental applications would not be conducted.

Under all alternatives, the following facilities (as described under the No Action Alternative, section 3.1.11, and in chapter 2, section 2.2.2.11) would be constructed and operated (based on previous NEPA reviews):

- LEDA
- Proton radiography and neutron spectroscopy facilities
- IPF relocation
- SPSS enhancement

3.3.12 Health Research Laboratory

The HRL is described in chapter 2 (section 2.2.2.12). Under the Reduced Operations Alternative, the following activities would occur at this facility.

Genomic Studies. LANL would reduce genomic studies at HRL to approximately 20 percent of the No Action Alternative level.

Cell Biology. LANL would decrease research activities to approximately 30 percent of the No Action Alternative level.

Cytometry. LANL's research utilizing laser imaging systems to analyze the structures and functions of subcellular systems would be reduced to approximately 25 percent of the No Action Alternative level.

DNA Damage and Repair. LANL's research using isolated cells to investigate DNA repair mechanisms would be reduced to approximately 30 percent of the No Action Alternative levels.

Environmental Effects. LANL would conduct research that identifies specific changes in DNA and proteins in certain microorganisms that occur after events in the environment to a level approximately 40 percent of than the No Action Alternative.

Structural Cell Biology. LANL would conduct research utilizing chemical and crystallographic techniques to isolate and characterize the three-dimensional shapes and properties of DNA and protein molecules to a level approximately 20 percent of that under the No Action Alternative.

Neurobiology. LANL's activities in neurobiology, conducting research using magnetic fields produced in active areas of the brain to map human brain locations associated with certain sensory and cognitive functions, would be the same as that of the No Action Alternative.

In-Vivo Monitoring. LANL would conduct 500 whole-body scans annually.

3.3.13 Radiochemistry Facility

The Radiochemistry Facility is described in section 2.2.2.13. As an indicator of overall activity levels, these operations would be expected to require about 130 FTEs. Under the Reduced Operations Alternative, the following activities would occur at this facility.

Radionuclide Transport. LANL would conduct 18 to 36 of these studies annually.

Environmental Remediation. Environmental remediation activities would be the same as the No Action Alternative level of operations.

Ultra-Low-Level Measurements. These activities would be slightly lower than the No Action Alternative level.

Nuclear/Radiochemistry. These operations would be approximately half of the No Action Alternative levels.

Isotope Production. LANL would conduct target preparation, irradiation, and processing to recover medical and industrial application isotopes at a level approximately half that of the No Action Alternative.

Actinide/Transuranic Chemistry. LANL also would perform radiochemical separations at half the No Action Alternative level of operations.

Data Analysis. LANL would reexamine archive data and measure nuclear process parameters of interest to weapons radiochemists at a level slightly lower than the No Action Alternative level.

Inorganic Chemistry. LANL would conduct synthesis, catalysis, and actinide chemistry activities the same level as the No Action Alternative.

Structural Analysis. LANL would perform these activities at the No Action Alternative level of operation.

Sample Counting. LANL's sample counting activity would also be the same as the No Action Alternative.

3.3.14 Radioactive Liquid Waste Treatment Facility

The RLWTF is described in chapter 2 (section 2.2.2.14). Under the Reduced Operations Alternative, the following activities would occur at this facility.

Waste Characterization, Packaging, and Labeling. Under the Reduced Operations Alternative, as under the No Action Alternative, LANL would support, certify, and audit generator characterization programs and maintain the WAC for the RLWTF.

Waste Transport, Receipt, and Acceptance. LANL would also collect radioactive liquid waste from generators and transport it to the RLWTF in TA–50.

Radioactive Liquid Waste Pretreatment. LANL would pretreat 158,400 gallons (600,000 liters) of RLW per year at TA–21; 5,280 gallons (20,000 liters) of RLW per year at TA–50; and solidify, characterize, and package 71 cubic feet (2 cubic meters) of TRU waste sludge per year at TA–50.

Radioactive Liquid Waste Treatment. LANL would install equipment for nitrate reduction in mid 1999, treat 5.28 million gallons (20 million liters) of RLW per year; dewater, characterize, and package 247 cubic feet (7 cubic meters) of LLW sludge per year; and solidify, characterize, and package 671 cubic feet (19 cubic meters) of TRU waste sludge per year.

Decontamination Operations. LANL would:

- Decontaminate personnel respirators for reuse (approximately 300 per month).
- Decontaminate air-proportional probes for reuse (approximately 200 per month).
- Decontaminate vehicles and portable instruments for reuse (as required).
- Decontaminate precious metals for resale (acid bath).
- Decontaminate scrap metals for resale (sand blast).
- Decontaminate 6,700 cubic feet (190 cubic meters) of lead for reuse (grit blast).

Three modifications were recently completed or are planned for the RLWTF: an upgrade to the influent tank system, installation of a new process for treatment of RLW, and installation of additional treatment steps for removal of nitrates. These have all been previously reviewed under NEPA and are included in all of the SWEIS alternatives, as described under the No Action Alternative, section 3.1.14 and in chapter 2 (section 2.2.2.14).

3.3.15 Solid Radioactive and Chemical Waste Facilities

The Solid Radioactive and Chemical Waste Facilities are described in section 2.2.2.15. Under the Reduced Operations Alternative, the following activities would occur at these facilities.

Waste Characterization, Packaging, and Labeling. Under the Reduced Operations Alternative, as under the No Action Alternative, LANL would support, certify, and audit generator characterization programs and maintain the WAC for LANL waste management facilities. At the Solid Radioactive and Chemical Waste Facilities, LANL would characterize 26,800 cubic feet (760 cubic meters) of legacy LLMW; characterize 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste; verify characterization data at the RANT Facility for unopened containers of LLW and TRU waste; maintain the WAC for off-site treatment, storage, and disposal facilities; and overpack and bulk waste containers.

As under the No Action Alternative, LANL would also perform coring and visual inspection of a percentage of TRU waste packages, ventilate 16,700 drums of TRU waste retrieved during the TWISP, and maintain the current version of the WIPP WAC and coordinate with WIPP operations.

Compaction. LANL would compact up to 590,000 cubic feet (16,700 cubic meters) of LLW.

Size Reduction. In addition, 91,800 cubic feet (2,600 cubic meters) of TRU waste would be reduced in size at the WCRR Facility in TA–50 and the Drum Preparation Facility in TA–54 (the same level as under the No Action Alternative).

Waste Transport, Receipt, and Acceptance. LANL would collect chemical and mixed wastes from LANL generators and transport them to TA–54. LANL would ship 31,960 tons (29,000 metric tons) of chemical wastes and 126,000 cubic feet (3,570 cubic meters) of LLMW for off-site treatment and disposal in accordance with EPA land disposal restrictions. In addition, LANL would ship 2,578,000 cubic feet (73,030 cubic meters) of LLW for off-site disposal. (This corresponds to shipment of LANL LLW to an off-site [e.g., regional] disposal facility to the extent practicable.) Beginning in 1999, 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste would be shipped to WIPP. LANL would also ship 67,100 cubic feet (1,900 cubic meters) of TRU waste generated as a result of future operations and research to WIPP and 100,600 cubic feet (2,850 cubic meters) of LLMW in environmental restoration soils for off-site solidification and disposal.

Waste Storage. As under the No Action Alternative, prior to shipment to off-site treatment, storage, and disposal facilities, LANL would store chemical and mixed wastes. LANL would also store: legacy TRU waste until WIPP is opened for disposal; LLMW until treatment facilities are available; and LLW uranium chips until sufficient quantities were accumulated for stabilization campaigns.

Waste Retrieval. LANL would retrieve 166,000 cubic feet (4,700 cubic meters) of TRU waste from Pads 1, 2, and 4 by 2004 (same level as the No Action Alternative).

Other Waste Processing. LANL would demonstrate treatment (e.g., electrochemical) of LLMW liquids, land farm oil-contaminated soils at Area J, stabilize 14,500 cubic feet (410 cubic meters) of uranium chips, and provide special case treatment for 23,650 cubic feet (670 cubic meters) of TRU waste. These activities would be the same as under the No Action Alternative.

Disposal. LANL would dispose of 3,530 cubic feet (100 cubic meters) of LLW in shafts at Area G, 98,800 cubic feet (2,800 cubic meters) of LLW and small quantities of radioactively contaminated PCBs in disposal cells at Area G (this is the LANL LLW for which LANL has a unique disposal capability, or for which there is no approved transportation configuration), approximately 3,530 cubic feet (100 cubic meters) of administratively controlled industrial solid wastes in cells at Area J annually, and nonradiological classified wastes in shafts at Area J.

In addition, under all alternatives, LANL would construct storage domes for TRU wastes recovered from Pads 1, 2, and 4. This is described under the No Action Alternative, section 3.1.15.

3.4 GREENER ALTERNATIVE

The name and general description for this alternative were provided by interested citizens as a result of the scoping process. The Greener Alternative uses existing LANL capabilities with an emphasis on basic science, waste minimization and treatment, dismantlement of nuclear weapons, nonproliferation, and other areas of national and international importance. Thus, while similar activities may occur under both the Expanded Operations and Greener Alternatives, the purpose for which the activities would be conducted under the Greener Alternative would focus on science, waste management, and nuclear weapons dismantlement.

This alternative does not change any LANL missions, nor add or eliminate LANL programs or projects. This alternative includes increased activities and operations in areas of emphasis including: neutron science, health and nuclear medicines research, basic science research (e.g., the fundamental nature of matter), waste minimization technologies, environmental restoration technologies, nuclear weapons dismantlement, international nuclear safety, and nonproliferation. These increased activities are combined with the Reduced Operations or No Action levels of defense mission activities at LANL to make up the Greener Alternative.

Construction projects required for LANL support operations are included in the Greener Alternative. Construction also may be necessary to support consolidation of various operations to a reduced "footprint," to optimize some facilities for increased levels of operations, and/or to increase LANL capabilities and capacities as required to accomplish assigned programs, projects, and activities. These construction or upgrade activities are identified insofar as they are associated with key facilities, as described below.

3.4.1 Plutonium Facility Complex

The Plutonium Facility Complex (TA–55) is described in chapter 2 (section 2.2.2.1). Under the Greener Alternative, the following activities would occur at this complex.

Plutonium Stabilization. LANL would recover, process, and store its existing plutonium residue inventory in 8 years.

Manufacturing Plutonium Components. As with the Reduced Operations Alternative, LANL would produce up to 12 plutonium pits per year in order to maintain the technical capability to understand pit characteristics and behavior. In addition, it would fabricate other parts and samples for research and development at the same levels as under the No Action Alternative.

Surveillance and Disassembly of Weapons Components. LANL would disassemble up to 65 pits per year (up to 40 pits would be destructively examined). Up to 20 pits would be nondestructively examined.

Actinide Materials Science and Processing Research and Development. As under the No Action Alternative, LANL would continue to conduct research on plutonium (and other actinide) materials. The types and levels of these activities are the same under this alternative as under the No Action Alternative. LANL would demonstrate the disassembly/conversion of 1 to 2 pits per day (up to 40 pits total) using hydride-dehydride processes. LANL would expand research in the material disposition technologies to support weapon disassembly. Up to 5,000 curies of neutron sources (plutonium-239/beryllium and americium-241/beryllium) and neutron sources other than sealed sources would be processed. LANL would not process actinides and would not use tritium separation, but would retain these capabilities. LANL would perform decontamination of 10 to 15 uranium components per month.

Research in support of DOE's actinide clean-up activities and on actinide processing and waste activities at DOE sites would be conducted at the same level as the Expanded Operations Alternative. In addition, as under the Expanded Operations Alternative, LANL would stabilize larger quantities of specialty items and residues from other DOE sites. As under the No Action Alternative, LANL would fabricate and study small amounts of nuclear fuels used in terrestrial and space reactors; fabricate and study prototype fuel for lead test assemblies; and analyze samples. As under the Expanded Operations Alternative, LANL would develop safeguards instrumentation for plutonium assay at a level increased from that of the No Action Alternative.

Fabrication of Ceramic-Based Reactor Fuels. LANL would make prototype MOX fuel and would continue research and development on other fuels.

Plutonium-238 Research, Development, and Applications. LANL would process, evaluate, and test up to 55 pounds (25 kilograms) of plutonium-238 per year in production of materials and parts to support space and terrestrial uses. In addition, LANL would recover, recycle, and blend up to 40 pounds (18 kilograms) per year of plutonium-238.

Storage, Shipping, and Receiving. The NMSF is to be renovated to perform as originally intended: to serve as a vault for the interim storage of up to 7.3 tons (6.6 metric tons) of the LANL SNM inventory, mainly plutonium. The NMSF renovation is included in all alternatives.

Under all alternatives, the Plutonium Facility would be renovated to ensure the continued availability of existing capabilities, as described under the No Action Alternative, section 3.1.1.

It is recognized that projects plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.4.2 Tritium Facilities

The Tritium Facilities are described in chapter 2 (section 2.2.2.2). Under the Greener Alternative, the following activities would occur at these facilities.

High-Pressure Gas Fills and Processing. LANL would handle and process tritium gas in quantities of up to 3.53 ounces (100 grams) at the WETF approximately 20 times per year.

Gas Boost System Testing and Development. Approximately 15 times per year, LANL would conduct gas boost system research, development, and testing and gas processing operations at WETF involving quantities of up to to 3.53 ounces (100 grams) of tritium.

Cyrogenic Separation. At TSTA, LANL would purify and process tritium gas in quantities of up to 7.06 ounces (200 grams) in five to six operations per year using cryogenic separation for the purpose of alternative energy development.

Diffusion and Membrane Purification. LANL would conduct research on tritium movement and penetration through materials in including major experimental efforts approximately six to eight experiments per month and continuous use for effluent treatment, with a focus on waste reduction.

Metallurgical and Material Research. LANL also would conduct metallurgical and materials research involving tritium, including research and application studies regarding tritium storage.

Thin Film Loading. In addition, LANL would use its thin film loading capability (involving chemically bonding tritium to a metallic surface) for tritium loading of neutron tube targets, processing approximately 800 units per year using small quantities of tritium (same as the No Action Alternative).

Gas Analysis. LANL's activities to measure the composition and quantities of gases used would increase from the No Action Alternative level in support of tritium operations under this alternative.

Calorimetry. LANL's calorimetry measurements (a nondestructive method of measuring the amount of tritium in a container) would increase (as compared to the No Action Alternative) under this alternative in support of tritium operations.

Solid Material and Container Storage. Tritium would continue to be stored on site in WETF, TSTA, and TSFF.

Under all alternatives, LANL would remodel Building 16–450 and connect it to WETF in support of neutron tube target loading.

3.4.3 Chemistry and Metallurgy Research Building

The CMR Building is described in chapter 2 (section 2.2.2.3). Under the Greener Alternative, the following activities would occur at this facility.

Analytical Chemistry. LANL would provide sample analysis in support of actinide research and processing activities, processing approximately 5,200 samples per year (same as the No Action Alternative).

Uranium Processing. LANL would conduct activities to recover, process, and store LANL's highly enriched uranium inventory over the next 8 years (same as the No Action Alternative).

Destructive and Nondestructive Analysis. Up to a total of 10 secondary assemblies (1 per year) would be evaluated through destructive and nondestructive analysis and disassembly (same as the No Action Alternative).

Nonproliferation Training. LANL would also conduct more nonproliferation training using quantities of SNM than under the No Action Alternative and would possibly use different types of SNM in that training.

Actinide Research and Processing. LANL would process up to 5,000 curies of neutron sources (both plutonium-238/beryllium and americium-241/beryllium sources) per year and would process neutron sources other than sealed sources. In addition, up to a total of 1,000 plutonium-238/beryllium and americium-241/ beryllium neutron sources would be staged in CMR Building Wing 9 floor holes. LANL would begin a research and development effort on spent nuclear fuels related to long-term storage and would analyze components in spent and partially spent fuels, including research and development into monitoring of spent reactor fuels. Further, LANL would characterize approximately 50 samples per year using metallurgical microstructural/chemical analysis and would conduct compatibility testing of actinides and other metals in order to study long-term aging and other material effects. LANL would also conduct analysis of TRU waste disposal related to the validation of WIPP performance assessment models, characterize TRU waste, and analyze gas generation such as that which could occur during transportation to WIPP. Further, LANL would demonstrate decontamination technologies for actinide-contaminated soils and materials and develop an actinide precipitation method to reduce mixed wastes in LANL effluents.

Fabrication and Metallography. LANL would produce 1,080 targets per year for production of molybdenum-99, with each target containing approximately 0.71 ounces (20 grams) of uranium-235. In addition, LANL would support highly enriched uranium processing research and development pilot operations and casting and fabricate metal shapes using from 2.2 to 22 pounds (1 to 10 kilograms) of highly enriched uranium in each operation, with an annual throughput of approximately 2,200 pounds (1,000 kilograms) (which would be retained in the LANL material inventory). (These activities are at the same levels as under the No Action Alternative.)

In addition, four projects currently in development or implementation at the CMR Building are included in all alternatives, as described under the No Action Alternative, section 3.1.3.

3.4.4 Pajarito Site (Los Alamos Critical Experiments Facility)

The Pajarito Site is described in chapter 2 (section 2.2.2.4). Under the Greener

Alternative, the following activities would occur at this facility.

LANL would continue to conduct experiments and tests in all of the areas described in section 2.2.2.4. The level of dosimeter assessment and calibration, skyshine, and vaporization experiments would be the same as the No Action Alternative; other experiments would increase by about 25 percent over the No Action Alternative level (the same as the Expanded Operations Alternative). In those areas where nuclear criticality experiments would increase, the nuclear materials inventory would increase by about 20 percent over the No Action Alternative level. As under the No Action Alternative, LANL would also develop safeguards instrumentation and perform research and development activities for SNM, light detection and ranging experiments, materials processing, interrogation techniques, and field systems.

3.4.5 Sigma Complex

The Sigma Complex is described in section 2.2.2.5. Under the Greener Alternative, the following activities would occur at this complex.

Research and Development on Materials Fabrication, Coating, Joining, and Processing. Under the Greener Alternative, as under the No Action Alternative, LANL would continue to fabricate items from metals, ceramics, salts, beryllium, enriched uranium, depleted uranium, and other uranium isotope mixtures. Activities include casting, forming, machining, polishing, coating, and joining.

Characterization of Materials. LANL would also continue research and development activities on properties of ceramics, oxides, slicides, composites, and high-temperature materials; analyze up to 24 tritium reservoirs per year; and develop a library of aged non-SNM materials from stockpiled weapons and develop techniques to test and predict changes. As under the Expanded Operations Alternative, up to 2,500 non-SNM samples, including uranium, would be stored and characterized.

Fabrication of Metallic and Ceramic Items. LANL would (as under the No Action Alternative), on an annual basis, fabricate stainless steel and beryllium components for approximately 50 plutonium pits, 50 to 100 reservoirs for tritium, components for up to 50 secondary assemblies (of depleted uranium, depleted uranium alloy, enriched uranium, deuterium, and lithium), nonnuclear components for research and development (30 major hydrotests and 20 to 40 joint test assemblies, beryllium targets, targets and other components for accelerator production of tritium research, test storage containers for nuclear materials stabilization, and nonnuclear (stainless steel and beryllium) components for up to 20 plutonium pit rebuilds.

In addition, all of the alternatives include construction, renovation, and modification projects that are underway and planned in the near term for the purpose of maintaining the availability and viability of the Sigma Complex, as described under the No Action Alternative, section 3.1.5.

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.4.6 Materials Science Laboratory

The MSL is described in chapter 2 (section 2.2.2.6). Under the Greener Alternative, the following activities would occur at this facility.

Materials Processing. LANL would continue research at current levels for six of its eight materials processing activities at the MSL; these capabilities are: thermomechanical processing, microwave processing, heavy equipment materials, single crystal growth, amorphous alloys, and powder processing. The materials synthesis/processing activities would be expanded for nonweapons applications and to develop environmental and waste management technologies; wet chemistry would be expanded to develop a remediation chemistry capability.

Mechanical Behavior in Extreme Environments. LANL would continue dynamic testing and fabrication and assembly research at current levels. Mechanical testing would be expanded for nonweapons applications.

Advanced Materials Development. LANL would continue activities in materials, synthesis and characterization, and ceramics capabilities at current levels of research; the research effort for high-temperature superconductors would be increased from the No Action Alternative level.

Materials Characterization. LANL would also expand activities in the six materials characterization areas: surface science chemistry, corrosion characterization, electron microscopy, x-ray, optical metallography, and spectroscopy. Research into environmental corrosives would also be conducted.

3.4.7 Target Fabrication Facility

The Target Fabrication Facility is described in section 2.2.2.7. Under the Greener Alternative, the following activities would occur at this facility. (These are the same as the No Action Alternative levels.)

Precision Machining and Target Fabrication. LANL would provide targets and specialized components for approximately 1,200 laser and physics tests per year, including a 10 percent annual growth in operations for the next 10 years.

Polymer Synthesis. LANL would produce polymers for targets and specialized components for approximately 1,200 laser and physics tests per year, including a 10 percent annual growth in operations for the next 10 years. Other activities at this facility would be redirected to advanced materials research and manufacturing, waste treatment, energy technologies, and environmental restoration technology, with the potential for a moderate increase in operations.

Chemical and Physical Vapor Deposition. LANL would coat targets and specialized components for approximately 1,200 laser and physics tests per year, including a 10 percent annual growth in operations for the next 10 years. Other activities at this facility would be redirected to advanced materials research and manufacturing, waste treatment, energy technologies, and environmental restoration technology, with the potential for a moderate increase in operations. Support for pit manufacturing operations would be the same as under the No Action Alternative.

3.4.8 Machine Shops

The Machine Shops are described in chapter 2 (section 2.2.2.8). Under the Greener Alternative, the following activities would occur at this facility. (These are at the same levels as under the No Action Alternative.)

The Machine Shops would provide fabrication support for the dynamic experiments program and explosive research studies, support up to 30 hydrodynamic tests annually, manufacture 20 to 40 joint test assembly sets annually, and provide general laboratory fabrication support as requested. LANL would also continue its fabrication activities using unique and unusual materials and provide appropriate dimensional inspection of these activities.

3.4.9 High Explosives Processing Facilities

The High Explosives Processing Facilities are described in section 2.2.2.9. Under this alternative, 19,400 pounds (8,800 kilograms) of explosives and 1,150 pounds (520 kilograms) of mock explosives would be used annually (as an indicator of overall activity levels in this key facility). Under the Greener Alternative, the following activities would occur at these facilities.

High Explosives Synthesis and Production. Under the Greener Alternative, as under the Reduced Operations Alternative, LANL would reduce its current level of high explosives synthesis and production research and development, production of new materials and formulation of plastic-bonded explosives by approximately 60 percent. Process development would decrease over current levels and materials and components for directed stockpile production would be produced at a reduced level (approximately 60 percent of the No Action Alternative).

High Explosives and Plastics Development and Characterization. LANL would evaluate stockpile returns and decrease efforts in development and characterization of new plastics and high explosives for stockpile improvement. LANL would also conduct research into high explosives waste treatment methods, with the overall level of effort reduced to about 60 percent of the No Action Alternative.

High Explosives and Plastics Fabrication. LANL would reduce its traditional stockpile surveillance and process development over No Action Alternative levels by approximately 60 percent. Stockpile surveillance fabrication for hydrodynamic and environmental testing would be reduced to approximately 75 percent of the No Action Alternative.

Test Device Assembly. Operations would be increased over current levels to support stockpile related hydrodynamic tests, joint test assemblies, environmental and safety tests, and slightly increased research and development activities. Approximately 30 major hydrodynamic test devices would be assembled annually.

Safety and Mechanical Testing. As under the Reduced Operations Alternative, safety and environmental testing related to stockpile assurance would be reduced to approximately 80 percent of No Action Alternative levels and predictive models would be improved. Approximately 12 safety and mechanical tests would be conducted annually.

Research, Development, and Fabrication of High-Power Detonators. As under the No Action Alternative, LANL would increase efforts to support SSM activities, manufacture up to 20 major product lines per year, and support DOE-wide packaging and transportation of electro-explosive devices.

3.4.10 High Explosives Testing

High explosives testing is described in chapter 2 (section 2.2.2.10). The Greener Alternative for LANL's high explosives testing facilities is the same as the No Action Alternative, section 3.1.10.

3.4.11 Los Alamos Neutron Science Center

LANSCE is described in section 2.2.2.11. Under the Greener Alternative, the following activities would occur at this facility.

Accelerator Beam Delivery, Maintenance, and Development. LANSCE would deliver a linear accelerator beam to Areas A, B, and C; the WNR buildings; the Manuel Lujan Center; the dynamic test facility; and a new IPF for 10 months each year (6,400 hours). The H^+

beam current would be 1,250 microamps and the H^- beam current would be 200 microamps. The beam delivery and support equipment would be reconfigured to support new facilities, upgrades, and experiments.

A 40-million electron volt LEDA would be built and operated in an existing facility (TA–53–365) for 10 to 15 years, operating up to approximately 6,600 hours per year. This facility would be constructed and operated as described under the Expanded Operations Alternative, section 3.1.11.

Experimental Area Support. Support activities would continue, consistent with the levels of operation under this alternative. Remote handling and packaging of radioactive materials and wastes at LANSCE would increase to handle waste generation that results from the facility construction and modifications at LANSCE for LPSS and for the decontamination of Area A East under this alternative.

Neutron Research and Technology. LANL would conduct 1,000 to 2,000 different experiments annually, using neutrons from the Manuel Lujan Center, WNR, and the LPSS. LANL would construct and operate the LPSS as described under the Expanded Operations Alternative, section 3.2.11.

LANL also would continue to support contained weapons-related experiments using small to moderate quantities of high explosives. These experiments would include:

- Experiments with nonhazardous materials and small quantities of high explosives (up to approximately 100 per year)
- Experiments with up to 10 pounds (4.54 kilograms) of high explosives and/or depleted uranium (up to approximately 30 per year)
- Experiments with small quantities of actinides, high explosives, and sources (up to approximately 40 per year)
- Shockwave experiments involving small amounts, up to nominally 0.18 ounce (5 grams), of plutonium

Accelerator-Driven Transmutation Technology. LANL would conduct lead target tests for 2 years at the Area A beam stop; construct and operate the 1-megawatt, and then the 5-megawatt target/blanket experiments, as described under the Expanded Operations Alternative, section 3.2.11.

Subatomic Physics Research. LANL would conduct 5 to 10 physics experiments annually at Manuel Lujan Center, WNR, and LPSS and conduct proton radiography experiments. Proton radiography experiments would include contained experiments using small to moderate quantities of high explosives, similar to those described above under Neutron Research and Technology.

Medical Isotope Production. Up to approximately 50 targets per year would be irradiated for medical isotope production and exotic and neutron rich/deficient isotopes would be produced. LANL would also construct and operate the Exotic Isotope Production Facility as described under the Expanded Operations Alternative, section 3.2.11.

LANL would decontaminate Area A East as described under the Expanded Operations Alternative, section 3.2.11.

High-Power Microwave and Advanced Accelerators. Research and development in this area would be conducted at the same levels described under the No Action Alternative.

Under all alternatives, the following facilities (as described under the No Action Alternative, section 3.1.11 and in chapter 2, section 2.2.2.11) would be constructed and operated (based on previous NEPA reviews):

- LEDA

- Proton radiography and neutron spectroscopy facilities
- IPF relocation
- SPSS enhancement

It is recognized that project plans change over time. If this alternative is selected, the construction projects proposed under this alternative (as described above), would be reviewed prior to construction to determine whether additional NEPA analysis is required.

3.4.12 Health Research Laboratory

The HRL is described in chapter 2 (section 2.2.2.12). With one exception, activities at HRL under the Greener Alternative would be the same as those described for the Expanded Operations Alternative in section 3.2.12. LANL's neurobiology research, using magnetic fields produced in active areas of the brain to map human brain locations associated with certain sensory and cognitive functions, would be increased to twice the level of the No Action Alternative.

3.4.13 Radiochemistry Facility

The Radiochemistry Facility is described in section 2.2.2.13. As an indicator of overall activity levels, these operations would be expected to require about 250 FTEs. Under the Greener Alternative, the following activities would occur at this facility.

Radionuclide Transport. Under the Greener Alternative, as under the Expanded Operations Alternative, LANL would conduct 80 to 160 of these studies annually, but the studies would support environmental remediation.

Environmental Remediation. Environmental remediation activities would be the same as the Expanded Operations Alternative (approximately double the No Action Alternative level of operations).

Ultra-Low-Level Measurements. These activities would also be at the same levels as the Expanded Operations Alternative (about double the No Action Alternative level).

Nuclear/Radiochemistry. These operations would be approximately the same as the No Action Alternative overall levels; however, weapons work would be reduced by half, and nonweapons work would be increased by 10 percent.

Isotope Production. LANL would conduct target preparation, irradiation, and processing to recover medical and industrial application isotopes at the same level as the No Action Alternative.

Actinide/Transuranic Chemistry. LANL also would perform radiochemical separations at the No Action Alternative level of operations; however, these activities would support nonweapons programs.

Data Analysis. LANL would re-examine archive data and measure nuclear process parameters of interest to weapons radiochemists at a level slightly lower than the No Action Alternative level (same as under the Reduced Operations Alternative).

Inorganic Chemistry. LANL would conduct synthesis, catalysis, and actinide chemistry activities at a level approximately 50 percent higher than that of the No Action Alternative.

Structural Analysis. As under the Expanded Operations Alternative, LANL would perform these activities at approximately twice the No Action Alternative level of operation.

Sample Counting. LANL's sample counting activity to measure the quantity of radioactivity in samples using alpha, beta, and gamma ray counting systems would be the same as the No Action Alternative.

3.4.14 Radioactive Liquid Waste Treatment Facility

The RLWTF is described in chapter 2 (section 2.2.2.14). Under the Greener Alternative, the following activities would occur at this facility.

Waste Characterization, Packaging, and Labeling. Under the Greener Alternative, as under the No Action Alternative, LANL would support, certify, and audit generator characterization programs and maintain the WAC for the RLWTF.

Waste Transport, Receipt, and Acceptance. LANL would also collect radioactive liquid waste from generators and transport it to the RLWTF in TA–50.

Radioactive Liquid Waste Pretreatment. LANL would pretreat 185,000 gallons (700,000 liters) of RLW per year at TA–21; 6,600 gallons (25,000 liters) of RLW per year at TA–50; and solidify, characterize, and package 71 cubic feet (2 cubic meters) of TRU waste sludge per year at TA–50.

Radioactive Liquid Waste Treatment. LANL would install equipment for nitrate reduction in mid 1999, treat 6.6 million gallons (25 million liters) of RLW per year; dewater, characterize, and package 247 cubic feet (7 cubic meters) of LLW sludge per year; and solidify, characterize, and package 812 cubic feet (23 cubic meters) of TRU waste sludge per year. This would be the same level of operations as the No Action Alternative.

Decontamination Operations. The decontamination operations at RLWTF under the Greener Alternative would be the same as those under the No Action Alternative described in section 3.1.14.

Three modifications were recently completed or are planned for the RLWTF: an upgrade to the influent tank system, installation of a new process for treatment of RLW, and installation of additional treatment steps for removal of nitrates. These have all been previously reviewed under NEPA and are included in all of the SWEIS alternatives, as described under the No Action Alternative, section 3.1.14 and in section 2.2.2.14.

3.4.15 Solid Radioactive and Chemical Waste Facilities

The Solid Radioactive and Chemical Waste Facilities are described in section 2.2.2.15. Under the Greener Alternative, the following activities would occur at these facilities.

Waste Characterization, Packaging, and Labeling. Under the Greener Alternative, as under the No Action Alternative, LANL would support, certify, and audit generator characterization programs and maintain the WAC for LANL waste management facilities. At the Solid Radioactive and Chemical Waste Facilities, LANL would characterize 26,800 cubic feet (760 cubic meters) of legacy LLMW; characterize 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste; verify characterization data at the RANT Facility for unopened containers of LLW and TRU waste; maintain the WAC for off-site treatment, storage, and disposal facilities; and overpack and bulk waste containers.

As under the No Action Alternative, LANL would also perform coring and visual inspection of a percentage of TRU waste packages, ventilate 16,700 drums of TRU waste retrieved during the TWISP, and maintain the current version of the WIPP WAC and coordinate with WIPP operations.

Compaction. LANL would compact up to 706,000 cubic feet (20,000 cubic meters) of LLW.

Size Reduction. In addition, 91,800 cubic feet (2,600 cubic meters) of TRU waste would be reduced in size at the WCRR Facility in TA–50 and the Drum Preparation Facility in TA–54 (the same level as under the No Action Alternative).

Waste Transport, Receipt, and Acceptance. LANL would collect chemical and mixed wastes from LANL generators and transport them to TA–54. LANL would ship 32,000 tons (29,000 metric tons) of chemical wastes and 127,400 cubic feet (3,610 cubic meters) of LLMW for off-site treatment and disposal is accordance with EPA land disposal restrictions. In addition, LANL would ship 2,587,500 cubic feet (73,300 cubic meters) of LLW for off-site disposal. (This corresponds to shipment of LANL LLW to an off-site [e.g., regional] disposal facility to the extent practicable.) Beginning in 1999, 318,000 cubic feet (9,010 cubic meters) of legacy TRU waste would be shipped to WIPP. LANL would also ship 87,900 cubic feet (2,490 cubic meters) of TRU waste generated as a result of future operations and research to WIPP and 100,600 cubic feet (2,850 cubic meters) of LLMW in environmental restoration soils for off-site solidification and disposal.

Waste Storage. As under the No Action Alternative, prior to shipment to off-site treatment, storage, and disposal facilities, LANL would store chemical and mixed wastes. LANL would also store: legacy TRU waste until WIPP is opened for disposal; LLMW until treatment facilities are available; and LLW uranium chips until sufficient quantities were accumulated for stabilization campaigns.

Waste Retrieval. LANL would retrieve 165,900 cubic feet (4,700 cubic meters) of TRU waste from Pads 1, 2, and 4 by 2004 (same level as the No Action Alternative).

Other Waste Processing. LANL would demonstrate treatment (e.g., electrochemical) of LLMW liquids, land farm oil-contaminated soils at Area J, stabilize 14,500 cubic feet (410 cubic meters) of uranium chips, and provide special case treatment for 23,650 cubic feet (670 cubic meters) of TRU waste. These activities would be the same as under the No Action Alternative.

Disposal. LANL would dispose of 14,500 cubic feet (410 cubic meters) of LLW in shafts at Area G, 423,600 cubic feet (12,000 cubic meters) of LLW and small quantities of radioactively contaminated PCBs in disposal cells at Area G (this is the LANL LLW for which LANL has a unique disposal capability, or for which there is no approved transportation configuration), approximately 3,530 cubic feet (100 cubic meters) of administratively controlled industrial solid wastes in cells at Area J annually, and nonradiological classified wastes in shafts at Area J.

In addition, under all alternatives, LANL would construct storage domes for TRU wastes recovered from Pads 1, 2, and 4. This is described under the No Action Alternative, section 3.1.15.

3.5 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL IN THE SWEIS

Comments received during prescoping and scoping were carefully considered by DOE. Several alternatives identified during scoping were examined by DOE but determined to be unreasonable because they could not be implemented within the 10-year time frame of the SWEIS analysis, or because they would not allow DOE to meet its core mission requirements. (LANL's support for DOE missions is described in chapter 1 [section 1.1].) These alternatives include: decommissioning of LANL, conversion to nondefense activities, privatization, and operating LANL exclusively as a National Environmental Research Park.

3.5.1 Decontamination and Decommissioning LANL

Under this alternative, LANL operations would be phased out and all facilities of LANL decontaminated and decommissioned as soon as practicable. The site is a government reservation, and therefore, would be transferred by the DOE property disposition process following decommissioning.

This alternative is not considered in detail in the SWEIS because it is unreasonable in the foreseeable future under the terms of the *National Defense Authorization Act of 1994* [Public Law (PL) 103–160] and presidential policy guidance on the future of the laboratories (DOE 1995a). Under this act, as well as national security policy, the maintenance of a safe and reliable nuclear weapons stockpile will remain a cornerstone of the U.S. nuclear deterrent for the foreseeable future and the continued vitality of all three DOE weapons laboratories (LANL, Lawrence Livermore National Laboratory, and Sandia National Laboratories) is essential to ensuring national security. Core intellectual and technical competencies and the facility capabilities and capacities housed in these weapons laboratories are essential to meeting DOE's technical responsibilities for development and maintenance of the U.S. nuclear weapon stockpile.

There is a clear national security requirement for continued operation of LANL for stockpile stewardship and management based on PL 103–160 and other statutes, the DoD Nuclear Posture Review, Presidential Decision Directives, and the Nuclear Weapon Stockpile Memorandum. It is also not economically feasible for certain specific work activities conducted at LANL to be reassigned to other DOE laboratories (see PL 103-160 and DOE 1996a, Volume I, Sections 2.2 and 2.3).

Therefore, because the continued operation of LANL is essential to DOE implementation of PL 103–160 and other statutes, as well as the Presidential Decision Directives and for U.S. compliance with treaties (including the first Strategic Arms Reduction Treaty [START I], START II, Nuclear Nonproliferation Treaty, and the Proposed comprehensive Test Ban Treaty), as well as extensive congressional guidance and national security policy implementation documents, decontamination and decommissioning of LANL is not a feasible alternative and is not considered in detail in the SWEIS.

3.5.2 Elimination of All Weapons-Related Work (Including Stockpile Stewardship and Management) from Continued Operation of LANL

Under this alternative, operations at LANL would continue, but all weapons work except currently authorized pit disassembly, stabilization, and storage would cease. This alternative is unreasonable because it would not allow DOE to meet its mission requirements under the terms of the *Atomic Energy Act of 1954* (42 U.S.C. §2011). This alternative is also unreasonable because of the unique expertise, capabilities, and responsibilities of DOE assigned under the *National Defense Authorization Act of 1994* (PL 103–160) as well as other acts and the 1995 presidential decision that declares that all three weapons laboratories are essential to meeting national security requirements (DOE 1995a). In fact, because of the proposed Comprehensive Test Ban Treaty and the moratorium on nuclear testing, the importance of operations at LANL supporting weapons safety and reliability has increased. LANL is the laboratory responsible for the design of the majority of nuclear weapons that are expected to continue to comprise the U.S. stockpile under the arms control agreements and treaties. With no new design weapons being produced, the U.S. will experience an increasingly aging nuclear stockpile. The average age of a stockpile weapon is currently 13 years. By the year 2005, the average age will be 20 years, which is the design basis for these weapons. The oldest weapons will be about 35 years old at that time. LANL is responsible for the safety and reliability of a substantial number of the weapons in the enduring stockpile.

The confidence in the performance of the nuclear explosives package has traditionally been based on underground nuclear detonation test data, aboveground experiments, computer simulations, surveillance data, and technical judgment. In a future without additional underground testing, the capabilities of LANL must be increasingly employed to assess and solve stockpile problems. The ability to assess nuclear components is more difficult without underground testing and with limited "aging" data; therefore, new facilities such as the DARHT Facility are critical to stockpile assurance (DOE 1995c). Repairs and replacements that are "certified" (that is, the weapon is assured to continue to be safe and reliable) will be needed to support even the most minimal stockpile projections (DOE 1996a, Volume I, Section 2.3.4). DOE must rely on improved experimental capabilities coupled with improved computational capability to address safety and reliance questions concerning the stockpile. These techniques are also essential to the nonproliferation, recovery, and disassembly of weapons and weapons components from outside the U.S.

For the foreseeable future, it is not reasonable to pursue a course that would eliminate weapons research and development, surveillance, computational analyses, components manufacturing, and experimentation from being undertaken at LANL because it would be counter to national security policy and congressional guidance. Further, moving these capabilities elsewhere would require expenditures that are unreasonable and significantly increase the risk of continued stockpile safety and reliability during the lengthy period required for relocation. (In any case, such a relocation could not reasonably be completed in the next 10 years.) Therefore, this alternative has been eliminated from further consideration in the SWEIS.

3.5.3 Operating LANL Exclusively as a National Environmental Research Park

In August 1977, LANL was dedicated as a National Environmental Research Park (NERP), a program managed by DOE in response to congressional legislation to set aside land for ecosystem preservation and study. In addition to LANL, six other NERPs are located at DOE sites and associated with national laboratories. The ultimate goal of programs associated with LANL is to encourage environmental research that will contribute to understanding how people can best live in balance with nature while enjoying the benefits of technology. Recent research at the NERP emphasizes understanding the fundamental processes governing the interaction of ecosystems and the hydrologic cycle on the Pajarito Plateau. The NERP remains a LANL program in accordance with legislation, but it was not intended to eliminate or to add missions or operations at a site.

An alternative to operate LANL exclusively as a NERP is not analyzed in the SWEIS because it is unfeasible in the foreseeable future and is not consistent with national security policy and LANL mission element assignments (chapter 1, section 1.1). DOE solicited potential new NERP projects during the scoping for the SWEIS. No specific projects were proposed by commentors as additional NERP projects for analysis in the SWEIS. Some activities that are closely related to the use of the LANL site as a NERP address DOE responsibilities as the Natural Resources Trustee. The Natural Resources Management Plan, initiated in part as a result of the SWEIS process, is being prepared to determine existing conditions management measures at LANL within the context of the Pajarito Plateau ecosystem (chapter 4, section 4.5.1.6).

3.5.4 Privatizing the Operations of LANL

Regardless of who operates LANL, the risks and potential consequences are functions of the specific activities assigned to LANL and the facilities, equipment, and procedures used to implement them. These facilities, equipment, and procedures would not be expected to change due to actions such as privatization. Therefore, this alternative is indistinct from the alternatives presented in sections 3.1 through 3.4.

There are restrictions on DOE privatization possibilities imposed under the terms of the *Atomic Energy Act of 1954* (42 U.S.C. §2015). Section 2015 governs the transfer of property and limits what DOE can do with real properties. Four subchapters govern what can be done with respect to government responsibilities over materials; Subchapter IV: Production of Special Nuclear Material; Chapter V: Special Nuclear Material; Subchapter VI: Source Material; and Subchapter VII: By-Product Materials. Furthermore, access to restricted data remains a responsibility of DOE (Subchapter XI).

For these reasons, this alternative was considered unreasonable and not considered in detail in the SWEIS. However, the risks posed by this alternative are not distinctly different from those of the No Action Alternative; the reader is referred to the description and consequences of that alternative.

3.6 COMPARISON OF POTENTIAL CONSEQUENCES AMONG ALTERNATIVES FOR CONTINUED OPERATION OF LANL

This section consists of four parts. The first part presents a summary of the differences across the SWEIS alternatives. The second part presents a summary comparison of the potential consequences of the four alternatives for continued operations of LANL. The detailed presentation of potential consequences of the four SWEIS alternatives is included in chapter 5. The third part presents a comparison of the potential consequences (of both construction and operations) of the alternatives for two specific projects, the Expansion of the TA–54/Area G Low-Level Waste Disposal Area and the Enhancement of Plutonium Pit Manufacturing. Details on the alternatives for siting and construction for these projects may be found in volume II of this SWEIS. The construction and operations for these projects are included in the SWEIS Expanded Operations Alternative, while the SWEIS No Action Alternative includes the alternative of not undertaking the construction (and maintaining operations at the level currently planned) for each of these projects. The fourth part summarizes the ER Project impacts and benefits; environmental restoration activities do not change across the SWEIS alternatives.

3.6.1 Summary of Differences in Activities Among the SWEIS Alternatives

The SWEIS alternatives for the continued operations of LANL are described in more detail in sections 3.1 through 3.4. The differences in activities at LANL among the alternatives are within the 15 SWEIS key facilities (each of which is described in chapter 2, section 2.2.2). Tables 3.6.1–1 through 3.6.1–30 (provided at the end of this chapter) summarize these differences. These tables are of two types and are intended to be complementary: (1) the Alternatives for Continued Operations tables reflect the activities (significant “markers” are reflected in the table; more complete descriptions are provided in sections 2.2, 3.1, 3.2, 3.3, and 3.4) within each of the key facilities and how these activities change across the SWEIS alternatives (the activity names on these tables match the capabilities discussed for each key facility in sections 2.2, 3.1, 3.2, 3.3, and 3.4); and (2) the Parameter Differences Among Alternatives for Continued Operations tables reflect facility-level emissions, waste generation, and other measures that are intended to clarify what the activity-by-activity descriptions mean (in total) for each SWEIS key facility. Table 3.6.1–31 is a parameter table for the LANL activities other than those at the key facilities. (These activities do not vary by alternative.)

3.6.2 Consequences of SWEIS Alternatives

Site-wide environmental consequences are summarized in two tables. Table 3.6.2–1 (provided at the end of this chapter) summarizes the potential consequences of normal operations of LANL under the four alternatives. Table 3.6.2–2 addresses the potential consequences of a range of transportation and operational accidents possible at LANL, including beyond design basis accidents. Accidents evaluated include: natural phenomena, process accidents, and accidents resulting from external human activities (such as airplane crashes and transportation accidents).

The major contributors to environmental impacts of operating LANL are wastewater discharges and radioactive air emissions.

- Historic discharges to Mortandad Canyon from the RLWFT have resulted in above background residual radionuclide (americium, plutonium, strontium-90, and

REFERENCES

DOE 1993 — *Nonnuclear Consolidation Environmental Assessment, Nuclear Weapons Complex Reconfiguration Program.* U.S. Department of Energy. DOE/EA-0792. Washington, D.C. June 1993.

DOE 1995a — Statement by the President: *Future of Major Federal Laboratories.* The White House, Office of the Press Secretary. 1995.

DOE 1995c — *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement.* U.S. Department of Energy, Albuquerque Operations Office and Los Alamos Area Office. DOE/EIS-0228. Albuquerque, New Mexico. August 1995.

DOE 1995d — *Radioactive Source Recovery Program Environmental Assessment.* U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1059. Los Alamos, New Mexico. December 1995.

DOE 1996a — *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management.* U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. September 1996.

DOE 1996b — *Low-Energy Demonstration Accelerator Environmental Assessment.* U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1147. Los Alamos, New Mexico. April 1996.

DOE 1996c — *Medical Isotope Production Project: Molybdenum-99 and Related Isotopes, Environmental Impact Statement.* U.S. Department of Energy, Office of Nuclear Energy, Science and Technology. DOE/EIS-0249. Washington, D.C. April 1996.

DOE 1997 — *Environmental Assessment for the Proposed CMR Building Upgrades at the Los Alamos National Laboratory*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1101. Los Alamos, New Mexico. February 4, 1997.

DOE 1998 — *Pit Disassembly and Conversion Demonstration Environmental Assessment and Research and Development Activities.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/EA-1207. Washington, D.C. August 1998.

ICRP 1991 — *Recommendations of the International Commission on Radiological Protection*. International Commission on Radiological Protection. ICRP Publication No. 60. Pergamon Press. New York. 1991.

LANL 1990 — *Nonradioactive Air Emissions Inventory* (Regulated Air Pollutants Reports). Los Alamos National Laboratory, Air Quality and Meteorology Section, Environmental Protection (EM–8), Environmental Management. Los Alamos, New Mexico. 1990.

LANL 1995a — *Installation Work Plan for Environmental Restoration*, Revision 5. Los Alamos National Laboratory. Los Alamos, New Mexico. November 1995.

LANL 1995b — *Automatic Chemical Inventory System.* Los Alamos National Laboratory. Los Alamos, New Mexico. January 1996.

LANL 1996 — *Final Report for the Expedited Cleanup of Material Disposal Area (MDA) M, TA–9.* Appendix F, "Asbestos and RCRA Metal Air Results." Prepared by NES, Inc. for Los Alamos National Laboratory. Los Alamos, New Mexico. April 1996.

LANL 1998 — *Performance Assessment and Composite Analysis for the Los Alamos National Laboratory Low-Level Waste Material Disposal Area G*. Los Alamos National Laboratory. LA-UR-97-85. Los Alamos, New Mexico. Submitted to the U.S. Department of Energy March 1997. Approved October 1998.

cesium-137) concentrations as well as nitrates in alluvial groundwater and sediments.

- Plutonium deposits have been detected along the Rio Grande between Otowi and Cochiti Lake.
- The principal contributors to radioactive air emissions have been and continue to be the Los Alamos Neutron Science Center and high explosives testing activities.

In addition, trace amounts of tritium have been detected in some samples from the main aquifer. (Isolated results have indicated the presence of other radionuclides. However, results have not been duplicated in previous or subsequent samples, making these results suspect.)

The analysis in the SWEIS indicates that there would be very little difference in the environmental impacts among the SWEIS alternatives analyzed. The major discriminators among alternatives would be collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand. The lack of notable differences arises from a number of factors. First, because there were very few specific new proposals of significant size, the alternatives describe a range of minimum to maximum operations within the constraints of existing facilities. Second, the lower limit for minimum operations in the major nuclear facilities is set by previous decisions (including those based on the SSM PEIS) regarding the assignment of mission and program elements. Third, when effects are not large to start with, the changes in resource parameters that arise from projected operations under the alternatives also do not result in large effects.

Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same. The following information highlights the similarities and differences between the consequences of alternatives.

3.6.2.1 *Land Resources*

There is little difference in the impacts to land resources between the No Action, Reduced Operations, and the Greener Alternatives. Differences among the alternatives are primarily associated with operations in existing facilities and very little new development is planned. Therefore, these impacts are essentially the same as currently experienced. The Expanded Operations Alternative has very similar land resources impacts to those of the other three alternatives, with the principal differences being attributable to the visual impacts of lighting along the proposed transportation corridor (a mitigation measure intended to reduce the number of road closures and the accident risk associated with transportation under this alternative) and the noise and vibration associated with increased frequency of high explosives testing (as compared to the other three alternatives).

3.6.2.2 *Geology, Geological Conditions, and Soils*

There is little difference in the impacts to these resources across the alternatives. Wastewater discharge volumes with associated contaminants do change across the alternatives, but not to a degree noticeable in terms of impacts (such as causing soil erosion, for example). Under all of the alternatives, small quantities (as compared to existing conditions) of contaminants would be deposited in soils due to continued LANL operations and the ER Project would continue to remove existing contaminants at sites to be remediated.

Geological mapping and fault trenching studies at LANL are currently underway or recently completed to better define the rates of fault movement, specifically for the Pajarito Fault, and the location and possible southern termination of the Rendija Canyon Fault. Appendix I (in volume III) of the SWEIS presents a detailed status of the ongoing and recently completed seismic hazard studies, as well as the implications of these studies for LANL and DOE. That report indicates that slip rates (recurrence intervals for earthquakes) are within the parameters assumed in the 1995 seismic hazards study at LANL (chapter 4, section 4.2.2.2).

3.6.2.3 *Water Resources*

Water demand under all alternatives (section 3.6.2.9, below) is within existing DOE rights to water, and would result in average drops of 10 to 15 feet (3.1 to 4.6 meters) in the water levels in DOE well fields over the next 10 years. Except for cooling water used for the TA–53 accelerator facilities, there are not predominant industrial water users at LANL. Usage, therefore, will remain within a fairly tight range among the alternatives. The related aspect of wastewater discharges is also within a narrow range for that reason. Outfall flows range from 218 to 278 million gallons (825 to 1,052 million liters) per year across the alternatives, and these flows are not expected to result in substantial changes to existing surface or groundwater quantities. Outfall flows are not expected to result in substantial surface contaminant transport under any of the alternatives. Although mechanisms for recharge to groundwater are highly uncertain, it is possible that discharges under any of the alternatives could result in contaminant transport in groundwater, particularly beneath Los Alamos Canyon and Sandia Canyon and off site. (The outfall flows associated with the Expanded Operations and Greener Alternatives would reflect the largest potential for such contaminant transport, and the flows associated with the Reduced Operations Alternative would have the least potential for such transport.)

3.6.2.4 *Air Quality*

Nonradioactive hazardous air pollutants would not be expected to degrade air quality or affect human health under any of the alternatives. The differences across the alternatives do not result in large changes in chemical usage. The activities at LANL are such that large amounts are not typically used in any industrial process (as may be found in manufacturing facilities); but research and development activities involving many users dispersed throughout the site are the norm. Air emissions are therefore not expected to change by a magnitude that would, for example, trigger more stringent regulatory requirements or warrant continuous monitoring. Radioactive air emissions change slightly, but are within a narrow range due to the controls placed on these types of emissions and the need to assure compliance with regulatory standards. The collective population radiation doses from these emissions range from about

11 person-rem per year to 33 person-rem per year across the alternatives (primarily from LANSCE and high explosives testing activities), and the radiation dose to the maximally exposed individual ranges from 1.9 millirem per year to 5.4 millirem per year across the alternatives (primarily from the operations at the LANSCE facility). These doses are considered in the human health impact analysis.

3.6.2.5 *Ecological and Biological Resources*

No significant adverse impact to these resources is projected under any of the alternatives. The separate analyses of impacts to air and water resources constitute some of the source information for analysis of impacts in this area; as can be seen from those presentations, the variation across the alternatives are not of a sufficient magnitude to cause large differences in effects. The impacts of the Expanded Operations Alternative differ from those of the other alternatives in that there is some projected loss of habitat; however, this habitat loss is small (due to limited new construction) compared to available similar habitat in the immediate vicinity, and no significant adverse effects to ecological or biological resources are expected.

3.6.2.6 *Human Health*

The total radiological doses over the next 10 years to the public under any of the SWEIS alternatives are relatively small, as compared to doses due to background radiation in the area (about 0.3 rem per year) and would not be expected to result in any excess latent cancer fatalities (LCFs) to members of the public. Additionally, exposure to chemicals due to LANL operations under any of the SWEIS alternatives are not expected to result in significant effects to either workers or the public. Exposure pathways associated with the traditional practices of communities in the LANL area (special pathways) would not be expected to result in human health effects under any of the alternatives. The annual collective radiation dose to workers at LANL ranges from 170 person-rem per year to 830 person-rem per year across the SWEIS alternatives (the difference is primarily attributable to the differences in LANSCE accelerator operations and TA–55–4 actinide processing and pit fabrication activities); these dose levels would be expected to result in from 0.07 to 0.33 excess LCFs per year of operation, respectively, among the exposed workforce. These impacts, in terms of excess LCFs per year of operation, reflect the numbers of excess fatal cancers estimated to occur among exposed members of the workforce over their lifetimes, per year of LANL operations. The reader should recognize that these estimates are intended to provide a conservative measure of the potential impacts to be used in the decision-making process and do not necessarily portray an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated impacts form an upper bound, and that actual consequences could be less but probably would not be worse. Refer to appendix D, section D.1 (in volume III), for a discussion on the determination and application of risk factors for excess LCFs.

Worker exposures to physical safety hazards are expected to result in from 417 (Reduced Operations) to 507 (Expanded Operations) reportable cases each year; typically, such cases would result in minor or short-term effects to workers, but some of these incidents could result in long-term health effects or even death.

3.6.2.7 *Environmental Justice*

Executive Order 12898 (*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*) requires every federal agency to analyze whether its proposed action and alternatives would have disproportionately high and adverse impacts on minority or low-income populations. Based on the analysis of other impact areas, DOE expects few high and adverse impacts from the continued operation of LANL under any of the alternatives, and, to the extent impacts may be high and adverse, DOE expects the impact to affect all populations in the area equally. DOE also analyzed human health impacts from exposure through special pathways, including ingestion of game animals, fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of plant materials. The special pathways have the potential to be important to the environmental justice analysis because some of these pathways may be more important or viable for the traditional or cultural practices of minority populations in the area. However, human health impacts associated with these special pathways also would not present disproportionately high and adverse impacts to minority or low-income populations.

3.6.2.8 *Cultural Resources*

Under all of the SWEIS alternatives there is a negligible to low potential for impacts to archaeological and historic resources due to shrapnel and vibration caused by explosives testing and contamination from emissions. Logically, potential impacts would vary in intensity in accordance with the frequency of explosives tests and the operational levels that generate emissions (e.g., Reduced Operations would reflect the lowest potential, and Expanded Operations would reflect the highest potential). Recent assessments of prehistoric resources indicate a low potential compared to the effects of natural conditions (wind, rain, etc.). In addition to these potential impacts, the Expanded Operations Alternative includes the expansion of the LLW disposal site at TA–54, which contains several National Register of Historic Places (NRHP) sites; it is anticipated that a determination of no adverse effect to these resources would be achieved based on a data recovery plan.

The potential impacts to specific traditional cultural properties (TCPs) would depend on their number, characteristics, and location. Such resources could be adversely affected by changes in water quality and quantity, erosion, shrapnel from explosives testing, noise and vibration from explosives testing, and contamination from ongoing operations. Such impacts would vary in intensity in accordance with the frequency of explosives tests and the operational levels that generate emissions (e.g., Reduced Operations would reflect the lowest intensity, and Expanded Operations would reflect the highest intensity). The current practice of consultation with the four Pueblos nearest to LANL would continue to be used to provide opportunities to avoid or minimize adverse impacts to any TCPs located at LANL.

3.6.2.9 *Socioeconomics, Infrastructure, and Waste Management*

LANL employment (including employees of the University of California, Johnson Controls, Inc., and Protection Technology of Los Alamos) ranges from 9,347 (Reduced Operations) to 11,351 (Expanded Operations) FTEs across the alternatives, as compared to 9,375 LANL FTEs in 1996. These changes in employment would result in changes in the Tri-County population, employment, personal income, and other socioeconomic measures. These secondary effects would change existing conditions in the Tri-County area by less than 5 percent.

Peak electrical demand under the Reduced Operations Alternative exceeds supply during the winter months and may result in periodic brownouts. Peak electrical demand under the No Action, Expanded Operations, and Greener Alternatives exceeds the power supply in winter and summer; this may result in periodic brownouts. (Power supply to the Los Alamos area has been a concern for a number of years, and DOE continues to work with other users in the area and power suppliers to increase this supply.) Natural gas demand is not projected to change across the alternatives, and this demand is within the existing supply of natural gas to the area; however, the age and condition of the existing supply and distribution system will continue to be a reliability issue for LANL and for residents and other businesses in the area. Water demand for LANL ranges from 602 million gallons (2,279 million liters) per year to 759 million gallons (2,873 million liters) per year across the alternatives; the total water demand (including LANL and the residences and other businesses and agencies in the area) is within the existing DOE rights to water.

LANL chemical waste generation ranges from 3,173 to 3,582 tons (2,878,000 to 3,249,300 kilograms) per year across the alternatives. LANL LLW generation, including LLMW, ranges from 338,210 to 456,530 cubic feet (9,581 to 12,873 cubic meters) per year across the alternatives. LANL TRU waste generation, including mixed TRU waste, ranges from 6,710 to 19,270 cubic feet (190 to 547 cubic meters) across the alternatives. Disposal of these wastes at on-site or off-site locations is projected to constitute a relatively small portion of the existing capacity for disposal sites; disposal of all LANL LLW on site would require expansion of the LLW disposal capacity beyond the existing footprint of TA–54 Area G under all alternatives (although this is only included in the Expanded Operations Alternative).

Contaminated space in LANL facilities would increase by about 63,000 square feet (5,853 square meters) under the No Action, Reduced Operations, and Greener Alternatives (due primarily to actions previously reviewed under NEPA but not fully implemented at the time the existing contaminated space estimate was established [May 1996]). The Expanded Operations Alternative would increase contaminated space in LANL facilities by about 73,000 square feet (6,782 square meters). The creation of new contaminated space implies a cleanup burden in the future, including the generation of radioactive waste for treatment and disposal; the actual impacts of such cleanups are highly uncertain because they are dependent on the actual characteristics of the facility, the technologies available, and the applicable requirements at the time of the clean-up actions.

3.6.2.10 *Transportation*

Incident-free transportation associated with LANL activities over the next 10 years would be conservatively expected to cause radiation doses that would result in about one excess LCF to a member of the public and two excess LCFs to members of the LANL workforce over their lifetimes under each of the SWEIS alternatives. (Refer to the discussion of the limitations on quantitative estimates of excess LCF risks in volume III, appendix D.) There is little variation in impacts because effects are small, and the increased transport of radioactive materials is not enough to make a significant change in these small effects.

Transportation accidents without an associated cargo release over the next 10 years of LANL operations are conservatively projected to result in from 33 to 76 injuries and 3 to 8 fatalities (including workers and the public) across the alternatives. The bounding off-site and on-site transportation accidents over the next 10 years involving a release of cargo would not be expected to result in any injuries or fatalities to members of the public for any of the alternatives. Accidents were analyzed by type of material, and the maximum quantities were selected for analysis. These parameters do not change across the alternatives. Total risk also does not change appreciably across the alternatives, because the frequency of shipments dose not vary enough to substantially influence the result.

3.6.2.11 *Accidents (Other Than Transportation Accidents and Worker Physical Safety Incidents/Accidents)*

Accidents were analyzed by creating scenarios, ranging from probable to highly improbable, that would demonstrate the effects of abnormal circumstance on existing and proposed operations. Such scenarios were selected based on screening steps that would select for demonstration those scenarios that involved the greatest quantities of hazardous material and the most severe circumstances, or that might involve a typical operation with a hazardous material. The purpose of analyzing a variety of scenarios was to provide some perspective on risks associated with operating LANL, and not to provide a list of all the possible things that could reasonably be expected to go wrong. Variations in operations across the alternatives did not change these scenarios because there are few changes in factors that would influence this type of analysis, such as significant changes in quantities of materials involved in an operation, toxicity of material, or new physical hazard.

The operational accident analysis included four scenarios that would result in multiple source releases of hazardous materials: three due to a site-wide earthquake and one due to a wildfire. (Three different earthquake magnitudes were analyzed [labeled SITE–01, SITE–02, and SITE–03], resulting in three different degrees of damage and consequences and one wildfire scenario [labeled SITE–04].) These four scenarios dominate the radiological risk due to accidents at LANL because they involve radiological releases at multiple facilities and are considered credible (that is, they would be expected to occur more often than once in a million years), with the wildfire considered likely. Another earthquake-initiated accident, labelled RAD–12, is facility-specific (to Building TA–16–411) and is dominated by the site-wide earthquake accidents due to its very low frequency (about 1.5 x 10^{-6} per year). It is noteworthy that the consequences of such earthquakes are dependent on the frequency of the earthquake event, the facility design, and the amount of material that could be released due to the earthquake; such features do not change across the SWEIS alternatives, so the impacts of these accidents are the same for all four alternatives. Similarly, the site-wide wildfire risks do not change significantly among the alternatives because the alternatives do not affect the probability (frequency) of the wildfire. The risks were estimated conservatively in terms of both the frequency of the events and the consequences of such events. (In particular, it is noteworthy that the analysis assumes that any building that would sustain structural or systems damage in an earthquake scenario does so in a manner that creates a path for release of material outside of the building.) Similarly, the wildfire analysis assumes that any building that is vulnerable to wildfire and in the path of the wildfire will burn. The total societal risk of an accident is the product of the accident frequency and the consequences to the total population within 50 miles (80 kilometers). This risk as presented in chapter 5 and appendix G (in volume III), ranges from 0.046 (SITE–01) and 0.034 (SITE–04) excess LCF per year of operation, to extremely small numbers for most of the radiological accidents.[1] The societal risk for release of chemicals, such as chlorine, is calculated similarly as the product of the frequency and numbers of people exposed to greater than the selected guideline concentration, Emergency Response Planning

[1] As an example, for SITE–01 the societal risk of 0.046 excess LCF per year was calculated by multiplying the event frequency of 0.0029 per year by the consequence to the population of 16 excess LCFs (Table 3.6.2–2). The excess LCFs resulting from public exposure are calculated by an approved model, such as the MELCOR Accident Consequences Code System (MACCS) code, or alternatively by multiplying the public exposure of 27,726 person-rem (from accident analysis) by the conversion factor of 5 x 10^{-4} excess LCFs per person-rem (ICRP 1991).

Guideline (ERPG–2)[2]. The risks for chemical releases range from 6.4 (SITE–01) people exposed per year of operation to vanishingly small numbers for some chemical releases. In general, such earthquakes would be expected to cause fatalities due to falling structures or equipment; this also would be true for LANL facilities. Thus, worker fatalities due to the direct effects of the earthquakes would be expected. Worker injuries or fatalities due to the release of radioactive or other hazardous materials would be expected to be small or modest increments to the injuries and fatalities due to the direct effects of the earthquakes.

Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same.

Plutonium accident risks to the public (other than those associated with the site-wide earthquake scenarios) are dominated by the puncture of a "typical" TRU waste drum (typical refers to the radioactivity of the drum contents), which is the highest frequency plutonium accident analyzed, and the release of plutonium from a fire in a TRU waste container storage area, which had one of the highest population doses from a plutonium accident. These accidents, labeled as RAD–09 and RAD–07, have societal risks of 0.0008 and 0.00011 excess LCF per year, respectively, under the No Action Alternative. While other accident scenarios were considered and analyzed (including process risks in TA–55 and the CMR Building), their risks to the public are at least an order of magnitude lower because either they are associated with relatively infrequent initiating events (e.g., aircraft crashes), or because the event occurs within facilities that are designed with multiple features (referred to as defense in depth) that prevent or minimize releases to the public. The risks associated with plutonium accidents change slightly (less than an order of magnitude) across the SWEIS alternatives. (Frequency or consequence increases [up to double that of No Action] for some accidents under the Expanded Operations Alternative, and frequency decreases [by up to 25 percent] from some accidents under the Reduced Operations Alternative.) RAD–07 and RAD–09 remain the dominant plutonium accidents under all alternatives.

Worker risk due to plutonium accidents is highly dependent on the number of workers present at the time of the event, on the type of protective measures taken at the time of the accident, on the speed with which these measures are taken, and on the effectiveness of

2. ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without irreversible or serious health effects or symptoms that could impair their abilities to take protective action.

medical treatment after exposure; as such, worker risks cannot be predicted quantitatively or reliably. In general, worker risks due to plutonium released in an accident would be limited to those workers in the immediate vicinity of the accident, and the consequences would be an increased risk of excess LCFs due to inhalation of plutonium; any acute fatalities would only be expected due to the initiating event (e.g., an aircraft crash), not due to the plutonium release. Worker risks change across alternatives only to the extent that frequencies of the events change (as discussed above for public risk from plutonium accidents).

An overview of the 1969 plutonium pit fire at the Rocky Flats site and a comparison of the design and operational differences between Rocky Flats and TA–55–4 are presented in appendix G, section G.4.1.2. Substantial differences exist between the nuclear facility and operations being conducted in TA–55–4 today and those that were present at the Rocky Flats Plant in 1969. TA–55–4 was designed to correct the deficiencies detected in older facilities such as the Rocky Flats Plant and is being upgraded to meet the even more stringent requirements of the 1990's, including enhanced seismic resistance and fire containment.

The risks to the public associated with highly enriched uranium (labeled as RAD–03) and tritium (RAD–05) releases due to accidents, other than the site-wide earthquakes, are several orders of magnitude lower than those for the earthquake or for the plutonium accidents. Similarly, worker risks in such accidents are also substantially lower for these types of accidents (as compared to the worker risks for site-wide earthquake or plutonium accident events). The risks to the public and to the workers associated with highly enriched uranium and tritium releases do not change across the alternatives because the frequencies of the initiating events and the amounts of material involved in the accident do not change across the alternatives.

The risk to the public from accidents that result in chemical releases (due to events other than the site-wide earthquakes and wildfire) at LANL dominate all other accident risks. In particular, the release of chlorine gas from TA–55 (labeled as CHEM–06) has a relatively high frequency and substantial consequences. The societal risk for this accident is about six people per year who would be exposed to greater than ERPG–2 concentrations of chlorine. The site-wide wildfire also can release some chemicals that would be released by earthquakes. Because the frequency of the wildfire is much greater than that of earthquakes, SITE–04 has a societal risk of 1.1 people per year exposed to greater than ERPG–2 concentrations of formaldehyde. Three other accidents that result in chemical releases (CHEM–01, CHEM–02, and CHEM–03) have societal risks that are very similar to the risks associated with hazardous chemical releases from the site-wide earthquakes (up to 0.066 people per year exposed to greater than ERPG–2 concentrations of chlorine gas for CHEM–01). It is noteworthy that the scenario for CHEM–01 is associated with potable water treatment activities; such activities are typical of municipal water supply operations throughout the U.S. It is also noteworthy that the LANL potable water treatment process is being changed to a process that does not require that quantities of chlorine gas be stored for use. The risk associated with CHEM–06 would not be expected to change across the SWEIS alternatives; CHEM–01 and CHEM–02 have slight changes in risk across the alternatives (up to a 14 percent increase and an 8 percent decrease for CHEM–02) due to the operational changes (which change the frequencies of these accidents) associated with the Expanded Operations Alternative and the Reduced Operations Alternative.

As with other worker accidents discussed above, the risk of worker injury or fatality due to these chemical release accidents is highly dependent on whether workers are present at the time of the accident, the protective measures taken, how quickly protective measures are taken, and the effectiveness of medical treatment after the event. For CHEM–01, CHEM–03, and CHEM–06, it is unlikely that workers would be in the area at the time of the event (if workers were present, there is potential for worker injury or fatality). For CHEM–02, the fire and the chlorine release would be visible, and escape is likely for any workers present; if workers present do not escape, injury or fatality is possible. For CHEM–04 and CHEM–05, four or five workers are typically in the area during working hours; workers present could be injured or killed by missiles from the cylinder rupture or from exposure to the toxic gas. Workers risks change across alternatives only to the extent that frequencies of the events change (as discussed above for public risk from chemical release accidents).

In addition to the discussions of worker risks for the accidents discussed above, four other accidents were analyzed specifically for potential risk to workers (these would not be expected to result in substantial risks to the public). Of the worker accidents analyzed (recalling that transportation and physical safety hazards are discussed separately in sections 3.6.2.10 and 3.6.2.6, respectively), the highest frequency worker accidents would be associated with a biohazard contamination (WORK–02) or with an inadvertent exposure to nonionizing radiation (WORK–04); these would be expected to result in injury or fatality to one worker. Multiple worker injuries or fatalities are possible from either an inadvertent high-explosives detonation (WORK–01) or from an inadvertent nuclear criticality event (WORK–03). Risks to workers under any of these scenarios would not be expected to change across the SWEIS alternatives.

3.6.3 Project-Specific Consequences

This section summarizes the impacts of the proposed expansion of LLW disposal in Area G (included in both the Preferred Alternative and the Expanded Operations Alternative) and the proposed enhancement of plutonium pit manufacturing operations (included only in the Expanded Operations Alternative), including siting and construction, as well as operational impacts, once construction is completed. The impacts reflected here are a portion of the impacts associated with the Expanded Operations Alternative (DOE’s Preferred Alternative, with the exception that pit manufacturing would not be implemented at a 50 pits per year level, single shifts, but only at a level of 20 pits per year).

3.6.3.1 *Expansion of TA–54/Area G Low-Level Radioactive Waste Disposal Area*

The disposal of LLW in excavated disposal cells at LANL has been ongoing at Area G for a number of years. At this time, it appears that the disposal space remaining in the existing footprint at Area G will be exhausted within the next 10 years. The SWEIS examines the potential solutions to disposal of LLW through shipment off the site to the extent possible, use of the existing space to maximum capacity and shipment of the remaining waste to off-site locations, and expansion of LLW disposal space at LANL to accommodate on-site disposal for the foreseeable future.

As discussed in volume II, part I, expansion could be achieved by expansion of the existing disposal site at TA–54 (different TA–54 expansion options are considered), or by expansion into a new disposal site (TA–67 is examined as representative of such sites because it is the best characterized “new” site for such purposes). Expansion into Zones 4 and 6 at TA–54 is DOE's PSSC Preferred Alternative.

Land Resources

Alternatives for the development of additional disposal capacity on site involve from approximately 40 to 72 acres (16 to 29 hectares) depending on location. Locations on Mesita del Buey involve areas that have historically been designated for waste management activities, while use of the TA–67 site would be a new land use designation. All sites present physical constraints on development of some type, such as required set backs from canyon rims and location of power lines, although the sites closest to existing disposal areas must also avoid monitoring exclusion zones established for investigations under the ER Project. Sites in the Zones 4 and 6 locations are closest to existing waste disposal activities. There would be no changes in visibility of any new site from current operations for any location other than TA–67. In that case, there would be increased visibility from Pajarito Road. As is currently the case, disposal cell excavation activities could slightly exceed background noise levels at the nearest residential area (White Rock) for all sites except the one at TA–67.

Geology and Soils

All new sites involve the same types of surface soils and the same underlying Bandelier Tuff as the current disposal site. There is evidence that TA–67 may have a geologic fault. Disposal activities would not be expected to cause seismic activity or change soil erosion or geology in the area; this is due in part to the practice of revegetating the land after a disposal cell is filled and closed. These activities are not expected to contribute substantially to soil contamination in the area; this is due in part to the geology in the area and disposal and closure practices intended to isolate the buried waste from interacting with the environment.

Water Resources

There are no differences among on-site disposal alternatives in this resource area. Activities are not expected to use large quantities of water. Additionally, current and planned disposal practices (e.g., isolation of the closed disposal cells) minimize the potential for water to run across the site and to transport contaminants. The geology in the area is also expected to contribute to the minimal transport of contaminants to either the surface or groundwater bodies in the area.

Air Quality

Short duration dust from excavation and diffuse emissions (mostly from open disposal cells) will be similar to recent historical experiences (which have not had any substantive effect on air quality), although road development for the TA–67 site would cause additional short-term dust and vehicle exhaust emissions. Additionally, if cleared trees are burned, the smoke would have a temporary effect on air quality. Finally, it is possible that excavation in Zone 4 could disturb a volatile organic compound plume from Area L, resulting in low concentration releases; it is expected that this plume would be avoided during excavation.

Ecological Resources

Total acreage disturbed is greatest for the TA–67 alternative because of the need for new road and infrastructure development, while the Zone 4 and 6 alternatives involve the least disturbance. Because the habitat is similar for all the on-site development alternatives, the extent of habitat loss is also greatest at the TA–67 site, and least at the Zone 4 and 6 locations. The habitat change is expected to be relatively small under any of the PSSC alternatives, and similar habitat is available in the immediate area at both TA–54 and TA–67. This loss of habitat is not likely to affect species in the area. Loss of foraging habitat for peregrine falcons is less than 0.1 percent of the area's potential for all alternatives, except for the TA–67 alternative (where it would be about 1.3 percent). Loss of roosting area for the Mexican spotted owl is also identified for the TA–67 alternative.

Human Health

There are no significant differences in this area among the PSSC alternatives, but effects on human health do potentially arise from operating the expanded waste disposal area. Worker health risks associated with LLW disposal range from radiation exposure (much less for individuals than the DOE radiation exposure standard) to occupational safety and health incidents and accidents related to excavation of disposal cells and equipment operations. These are similar in nature to existing worker health risks; however, the projected waste generation across LANL is higher under the Expanded Operations Alternative, so these worker impacts are slightly greater than have been experienced in recent history and greater than would be expected under the SWEIS No Action Alternative.

In general, public health impacts in the near term would be similar to those experienced in recent years due to effects on soil, water, and air quality; as discussed above, these are minimal (LANL 1998). The Area G Performance Assessment indicates that over the next 1,000 years the maximum health impacts to the public would be minimal (e.g., exposure from all pathways in White Rock and Pajarito Canyon is less than 0.1 millirem per year; exposure from all pathways in Cañada del Buey is less than 6 millirem per year).

Environmental Justice

Expansion of LLW disposal is not likely to result in disproportionately high nor adverse impacts to minority and low-income populations.

Cultural Resources

Up to 15 known archeological sites could be affected by excavation activities at the Zone 4 and 6 locations, with the fewest known sites (4) potentially affected at the North Site location. Data recovery plans and consultations would be needed under all PSSC alternatives. (These have been completed for Zone 4.) It is expected that existing policies and procedures at LANL would minimize impacts by avoiding these sites, where possible. Where sites cannot be avoided, existing procedures call for data recovery in consultation with the New Mexico State Historic Resources Office(r) and others, where appropriate. If TCPs are present in areas of excavation, they would either be destroyed by construction or diminished in value.

Socioeconomics, Infrastructure, and Waste Management

All alternatives for developing additional waste disposal areas require minimal additional workers (30 more, or about a 15 percent increase above the No Action Alternative levels for solid waste management operations). Additionally, these activities do not demand substantial amounts of water, electricity, or gas. Finally, the generation of secondary waste is attributed primarily to treatment, storage, and repackaging operations, not to waste disposal; thus, secondary waste generation would not be expected to change substantially.

Transportation

The SWEIS Expanded Operations Alternative (with on-site disposal) would increase on-site shipments substantially—to almost double the approximately 1,300 shipments per year under the No Action Alternative (due to greater waste generation under the Expanded Operations Alternative and the shipment of LLW off the site under the No Action Alternative). However, due to the low radionuclide concentrations in LLW, the relatively short distances travelled on site, and the low rate of accidents experienced for on site shipments, this large difference in shipments does not equate to large differences in on-site transportation impacts (on-site transportation impacts under either the Expanded Operations or No Action Alternatives result in far less than one fatality or injury over the next 10 years due to traffic accidents and radiation doses related to such shipments), and waste shipments do not influence the bounding cargo accident risks.

In contrast, development and use of additional disposal capacity on site would reduce the off-site shipments of waste, as compared to the No Action Alternative (410 off-site LLW shipments per year under No Action Alternative, as compared to 33 under Expanded Operations). Again, the low concentrations of radionuclides in LLW would mean that these shipments contribute very little to incident-free radiation doses, and they do not bound the off-site cargo accident risk. While the longer off-site transportation mileage results in greater risks of vehicle accidents, injuries, and deaths, these are similar to the risks of increasing any vehicular traffic and are not unique to the fact that these are radioactive waste shipments. The off-site LLW shipments are a relatively small percentage of the total off-site shipment mileage under either the SWEIS No Action Alternative or the Expanded Operations Alternative.

Accidents

Accident risk associated with waste disposal operations for all alternatives are essentially the same. This is because the accident frequencies are relatively insensitive to the differences in waste volumes across the alternatives and because the consequences of an accident are dependent on the amount of material involved in the accident (which changes very little across the alternatives), not the total amount of generated or disposed waste. An additional factor is that waste disposal requires comparable packaging, handling, and certification in accordance with WAC whether it is disposed of on or off the site.

3.6.3.2 *Enhancement of Plutonium Pit Manufacturing*

The implementation of the plutonium pit production mission is examined in the SWEIS at varying levels. The No Action Alternative for operations includes the manufacturing of pits at a maximum rate of about 14 pits per year under the Expanded Operations Alternative, and as discussed in volume II, part II, DOE is considering the enhancement of the existing capability to optimize processes and remove process "choke" points to allow for production of up to 50 pits per year under single shift operations (80 pits per year under multiple-shift operations). However, the DOE does not propose to implement pit manufacturing capability beyond a level of 20 pits per year in the time frame of analyses for the SWEIS. The Preferred Alternative would only implement pit manufacturing at the 20 pits per year level in the near term. This postponement does not modify the long-term goal announced in the ROD for the SSM PEIS (up to 80 pits per year using multiple shifts). Nevertheless, the impacts of full implementation of the enhancement of plutonium pit manufacturing PSSC is included in the Expanded Operations Alternative. The DOE used the "CMR Building Use" Alternative to bound the impact analysis. Because other activities in TA–55 cannot be discontinued to make space available for the enhancement and operation, TA–55 does not have enough plutonium laboratory space available to undertake this and all other TA–55 activities described under the Expanded Operations Alternative. Options (alternatives) for providing the additional space required to accommodate Expanded Operations, including pit production, are discussed in detail in volume II, part II. Under the PSSC "CMR Building Use" Alternative for providing this additional space, some existing activities at TA–55–4 would be moved over to available space in the CMR Building, thus freeing space in TA–55–4 to accommodate pit production. This would take place in a phased manner.

First, the existing capability would be increased to capacity of 20 pits per year; after that, the additional modifications would be made to achieve the 80 pits per year capacity (using multiple shifts).

The increased pit production will require additional transportation of materials between TA–55 and the CMR Building (at least an increase in transportation of samples, but potentially, the additional transportation of plutonium for CMR activities transferred from TA–55–4); DOE is proposing to construct a dedicated road to minimize impacts (road closures and accidents) to the public. Under the Preferred Alternative, these processes would not be moved to the CMR Building nor would the transportation corridor be built.

Land Resources

All project alternatives other than the No Action Alternative require the use of additional land, including land that would be used for an optional dedicated transportation corridor between TA–55 and TA–3. While the land disturbed under the "CMR Building Use" Alternative would be limited to that associated with the transportation corridor, the Brownfield and TA–55–4 Add-On Alternatives would each require about one additional acre, both of which are in developed areas of TA–55. The 7 acres (2.8 hectares) required for the optional transportation corridor have been disturbed previously but not developed. Fencing and security lighting along the road could result in visual impacts. There would be some short-duration increase in noise during construction of the road; once the road is constructed, traffic noise would not be substantially different from the existing traffic noise in the area. (Under the Preferred Alternative, the road would not be constructed to establish the 20 pits per year capability, and the impacts associated with construction of that road would not be incurred.) Increased noise levels due to construction activity at TA–55 would occur under any of the PSSC alternatives. In addition, the "CMR Building Use" Alternative would result in increased construction noise at TA–3.

Geology and Soils

No changes in geology or soils are anticipated for either construction or operations under any PSSC alternative.

Water Resources

Minimal increase in water use is anticipated for either construction or operations under any of the PSSC alternatives. Some increases in RLW generation (associated with all activities under this alternative; pit production activities are not substantial contributors to this waste stream) would also be anticipated (a maximum increase of 2.6 million gallons [10 million liters] per year above the No Action Alternative level of about 6.6 million gallons [25 million liters] per year) under any of the PSSC alternatives. The location for wastewater discharge does not change from that under the SWEIS No Action Alternative.

Air Quality

The only potential construction air quality impacts are related to the emissions from construction equipment; these emissions would not exceed regulatory standards for criteria pollutants and would not be expected to affect air quality beyond the immediate vicinity of the construction work.

Operations under the "CMR Building Use" PSSC alternative in TA–55–4 and the CMR Building directly related to the implementation of pit production at LANL would result in minor increases in radioactive air emissions. For the CMR Building, an increase of 38 microcuries per year is attributable to pit production activities. (The total difference between the No Action and Expanded Operations radioactive air emissions at the CMR Building is about 340 microcuries per year.) For TA–55, a net increase (considering pit manufacturing increases and decreases due to activities moved to the CMR Building) of about 9 microcuries per year is attributable to pit production activities. (The total difference between the No Action and Expanded Operations radioactive air emissions at TA–55 is about 11 microcuries per year.) Under the other PSSC alternatives, the radioactive air emissions would not increase as much at the CMR Building, but most of the total 47 microcuries in increased annual air emissions attributed to pit production in both facilities would occur at TA–55. At the 20 pits per year production rate (Preferred Alternative), radioactive air emissions for TA–55 and the CMR Building together would result in about a 20 microcuries per year increase due to pit production activities; the radioactive air emissions impacts under the Expanded Operations Alternative at this rate would be essentially the same as those presented under the "CMR Building Use" Alternative. No substantive changes in nonradioactive air emissions are expected due to these activities under any of the PSSC alternatives.

Ecological Resources

Construction of the dedicated access road under any of the PSSC alternatives would disturb about 7 acres (2.8 hectares) and would reduce peregrine falcon foraging and meadow jumping mouse habitats by this amount. Other potential effects include:

- Large mammals (bear, elk, deer, mountain lion, coyotes) could be restricted from accessing the land in the transportation corridor and transversing to lands beyond the corridor; this access restriction could also alter predator-prey associations, food use, and habitat use in the project area.
- Potential for increases in automobile/ animal collisions could result from elk and deer movement into areas these animals do not usually inhabit.

Only minimal changes in potential habitat would be associated with alternatives requiring construction at TA–55 or TA–3. The total loss of 7 (for the "CMR Building Use" Alternative) to 8 (for the other two alternatives) acres (2.8 to 3.2 hectares) of habitat is small compared to that available on the entire LANL site. (Under the Preferred Alternative, at the 20 pits per year rate, these impacts would not be incurred because the road would not be constructed.) No other ecological impacts from operations are anticipated.

Human Health

Occupational exposure to radioactive material during the construction and modification of existing nuclear facility space for the "CMR Building Use" PSSC alternative is expected to result in up to 45 person-rem (0.018 excess LCF) to the involved workers. The other alternatives would have lower doses due to the reduced need for modification of existing nuclear facility spaces to accomplish the construction. Radiation doses to workers during operations that are directly related to pit production would constitute an increase of about 150 person-rem per year. (The total difference in collective dose associated with all activities at LANL between No Action and Expanded Operations is about 387 person-rem per year.) These occupational doses would not be expected to vary between the PSSC alternatives because the total work load would be the same, and the design criteria of the facilities would be the same regardless of implementation. This change in collective worker dose constitutes an incremental increase of about 0.06 excess LCF per year to the worker population involved in these activities. At the 20 pits per year rate (Preferred Alternative), worker exposures associated with pit production would be lower (about 130 person-rem per year lower than presented at the 80 pits per year rate). Thus, the worker population exposure and the estimated LCF risk associated with that exposure would be about 15 percent less than reflected for the Expanded Operations Alternative at the 80 pits per year rate.

Impacts to public health would not be expected to change substantially due to routine pit manufacturing operations. Except for transportation impacts (discussed below) and the contribution to public health impacts due to radiological air emissions, the remaining contributors to public health impacts do not change across the alternatives. As reflected in appendix B in volume III, (Table B.1.2.3–1), the radiological air emissions from TA–55 and CMR Building operations together contribute 1.005 person-rem per year and 1.853 person-rem per year under the No Action and Expanded Operations Alteratives, respectively. (The total collective public doses under these alteratives are about 14 and about 33 person-rem per year, respectively.) Of the total TA–55 and CMR Building air emissions, which lead to these collective public doses, about 1 percent of the curies emitted (under either the No Action or Expanded Operations Alternatives) are attributable to pit manufacturing, analytical chemistry support for pit manufacturing, actinide processing, and pit surveillance and disassembly activities (the activities that would be involved in the implementation of pit production at LANL under the Expanded Operations Alternative). Any variation to public health impacts between the PSSC alternatives would only be due to the differences in physical location of the air emission release points with relation to the publicly occupied areas, as discussed above in the air quality section.

Environmental Justice

Expansion of pit manufacturing is not likely to result in disproportionately high or adverse impacts to minority and low-income populations.

Cultural Resources

No impacts are anticipated under any of the PSSC alternatives due to construction or operations (prehistoric and historic sites are avoidable, and there are no known TCPs in the area).

Socioeconomics, Infrastructure, and Waste Management

Building modifications under the "CMR Building Use" PSSC alternative would employ about 221 construction workers over about a 3- or 4-year period (with peak employment for construction at 140 workers). The number of construction workers and project duration would be somewhat greater, but not substantially different for the other PSSC alternatives. Operations would increase employment by about 170 workers. (The total difference between employment under No Action and Expanded Operations is about 1,374 workers.) At the 20 pits per year rate (Preferred Alternative), construction and operations employment would be somewhat lower than reflected for the "CMR Building Use" Alternative. The employment differences are small compared to the total employment changes under the Expanded Operations Alternative. Thus, the impacts presented for the Expanded Operations Alternative are relatively insensitive to the PSSC alternatives and to the 20 pits per year phasing of pit production at LANL.

Utility use and contaminated space would not change substantially under the "CMR Building Use" PSSC alternative. The other two PSSC alternatives would require slightly more electrical power and would create about 15,000 square feet (1,400 square meters) of nuclear facility space that would be presumed as contaminated space.

Construction for the "CMR Building Use" PSSC alternative would generate about 15,100 cubic feet (426 cubic meters) of TRU waste, 10,200 cubic feet (288 cubic meters) of TRU mixed waste, 46,200 cubic feet (1,306 cubic meters) of LLW, and 1,100 cubic feet (31 cubic meters) of LLMW. The other PSSC alternatives would be expected to generate little, if any, radioactive waste (it could only be generated in equipment transfer to the new space). Pit manufacturing operations under the SWEIS Expanded Operations Alternative are not expected to generate substantial quantities of waste (as presented in the final SSM PEIS, this activity is expected to result in waste generation increases of less than 5 percent over current levels), except for TRU waste generation, which will increase from this activity by about 3,535 cubic feet (100 cubic meters) per year. (The total difference between No Action and Expanded Operations TRU waste generation is about 10,600 cubic feet [300 cubic meters] per year.) At the 20 pits per year level (Preferred Alternative), TRU waste generation would be about 530 cubic feet (15 cubic meters) per year.

Transportation

The Expanded Operations Alternative activities related to pit production would be expected to increase on-site shipments between TA–55 and the CMR Building by about 500 shipments per year (of plutonium sample solutions and plutonium metal, including components). Additionally, off-site shipments to and from Oak Ridge and Pantex are expected to increase by a total of about 50 shipments per year due to implementation of pit manufacturing at LANL. Even though the total risk is small (see Tables 3.6.2–1 and 3.6.2–2, Transportation Risks), these types of plutonium shipments are among those that bound both on-site and off-site transportation risk; additionally, such shipments are the main contributors to driver and public incident-free radiation doses. Because the portion of these shipments attributable to pit production operations is a small percentage of the total on-site (about 5 percent) and off-site (about 1 percent) shipments, transportation risks from pit production operations under the Expanded Operations Alternative are very small. Differences in shipment quantities are important contributors to the differences in transportation risk between the No Action and Expanded Operations Alternatives, although the absolute risk presented by these shipments is small. The construction of a dedicated transportation corridor between TA–55 and the CMR Building at TA–3 would further reduce risk associated with on-site shipments. At the 20 pits per year rate (Preferred Alternative), there would be somewhat fewer on- and off-site shipments in support of pit production; thus, the transportation impacts at that production rate would be slightly lower than presented for the Expanded Operations Alternative at 80 pits per year. Under the Preferred Alternative, the dedicated transportation route would not be constructed for implementation of the 20 pits per year rate.

Accidents

Accident risk associated with pit manufacturing operations (and those operations moved to the CMR Building to make space in TA–55 for pit production) are essentially the same under the No Action and Expanded Operations Alternatives. The reasons that there are such minor differences, given the differences in the number of pits manufactured, are that: accidents involving pit manufacturing activities themselves do not bound the risks associated with plutonium operations (section 3.6.2.11), although some of the support operations (e.g., waste handling and plutonium processing and recovery) are included in the set of bounding accidents analyzed; the frequencies of the bounding accidents are relatively insensitive to the number of pits manufactured (pit manufacturing activities are relatively small contributors to support operations throughputs); and, the consequences of accidents are dependent on the amount of material involved in the accident, which is relatively insensitive to the quantities of pits manufactured over a year. (That is, the difference in the number of pits produced over a year is dependent on process or room and does not change limits for the amount of material allowed to be in process at one time.) Any variation to accident risk between the PSSC alternatives would only be due to the differences in physical location of the release points with relation to the publicly occupied areas, similar to the discussion above in the air quality section.

3.6.4 Consequences of Environmental Restoration Activities

Environmental restoration activities, which include decontamination and decommissioning activities, are undertaken with the intent of reducing the long-term public and worker health and safety risks associated with contaminated sites or with surplus facilities and to reduce risk posed to ecosystems. Decisions regarding whether and how to undertake an environmental restoration action are made after a detailed assessment of the short-term and long-term risks and benefits for options specific to the site in question, and, at LANL, they are made primarily within the framework of the RCRA.

Because there are no individual or specific environmental restoration actions proposed within the scope of the SWEIS (such actions are proposed and undertaken on a time scale that is not compatible with the preparation of this SWEIS), the impact analyses regarding such actions are presented in general terms based on the experiences of the program, to date. As noted in the ecological resources and human health impact analyses in chapter 5, LANL's influence on ecological and human health risk arises primarily from the legacy of past operations in the form of contaminants that were historically deposited on land and in water. An improvement in the risk posed by the LANL site is therefore expected from the removal of some of this legacy contamination. A principal impact from restoration actions is related to the generation of waste during the cleanup or decontamination and decommissioning. The waste generated must be stored, treated, or disposed. Waste generation from the totality of future environmental restoration actions is estimated in the SWEIS, and the risks associated with the transport, treatment, storage, and disposal of this waste are included in the analyses (in particular, refer to sections 3.1.14, 3.1.15, 3.2.14, 3.2.15, 3.3.14, 3.3.15, 3.4.14, 3.4.15, 5.2.9, 5.3.9, 5.4.9, 5.5.9, and the discussion regarding the expansion of Area G in section 3.6.3.1).

The short-term risks and controls associated with the environmental restoration activities include:

- *Fugitive Dust*. This is the suspension of soil, including contaminated soil, in the air, resulting in the potential for exposure or dispersal of this material. At LANL, this potential risk is typically controlled by frequently wetting the ground at the clean-up site; this reduces the amounts of material suspended in air, and thus, the risk to human health and the environment (LANL 1996).
- *Surface Runoff*. This is the transport of contaminants from the clean-up site by surface water flow across the site. At LANL, surface runoff is controlled by flow barriers, collection of surface water, or contouring the ground such that flow off the site is precluded (LANL 1995a).
- *Soil and Sediment Erosion*. This is the transport of soil and sediment due to the force of wind and the intensity and frequency of precipitation. This potential risk is mitigated by covering clean-up sites with tarps during storm events to minimize the infiltration of water (LANL 1995a).
- *Worker Health and Safety Risks.* Environmental restoration actions have similar risks to those discussed in the human health impact analyses in chapter 5. Activities can involve heavy equipment, uneven ground (e.g., trenches), solvents and other chemicals, and other hazards of this nature. Worker health and safety risks are mitigated with work plans, safety programs, protective equipment, and similar administrative, education, and physical protection measures.

TABLE 3.6.1–1.—*Alternatives for Continued Operation of TA–55 Plutonium Facility Complex*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Plutonium Stabilization	Recover, process, and store the existing plutonium inventory in 8 years.	Same as No Action Alternative.	Decrease processing rate of residue and place metal and plutonium oxide in interim storage without further processing. Material inventory will be processed in 10 to 15 years.	Same as No Action Alternative.
Manufacturing Plutonium Components	Production of up to 14 pits/yr.	Produce 50 to 80 pits/yr (long-term goal requires major facility modifications). Produce 20 pits/yr in initial phase (requires minor facility modifications).	Maintain technical capability to understand pit characteristics and behavior. 6 to 12 pits produced per year.	Same as Reduced Operations Alternative.
Surveillance and Disassembly of Weapons Components	Pit surveillance: Up to 20 pits/yr destructively examined and 20 pits/yr nondestructively examined.	This activity moves to the CMR Building, with up to 65 pits/yr disassembled, including up to 40 pits/yr destructively examined. 20 pits/yr would be nondestructively examined.	Same as No Action Alternative.	Disassemble up to 65 pits/yr including 40 pits/yr destructively examined; 20 pits/yr nondestructively examined.
Actinide Materials and Science Processing, Research, and Development	Demonstrate disassembly/conversion of 1 to 2 pits/day for up to 40 pits total.	Develop production disassembly capacity. Process up to 200 pits/yr, including a total of 250 pits (over 4 years) as part of disposition demonstration activities.	Same as No Action Alternative.	Expand some areas of technology development for weapon dismantlement support. Otherwise, this alternative is the same as the No Action Alternative.
	Process up to 1,000 Ci/yr plutonium-239/beryllium and americium/beryllium neutron sources.	Process neutron sources up to 5,000 curies (Ci)/yr. Process neutron sources other than sealed sources.	Process up to 500 Ci/yr neutron source materials. Maintain capabilities for neutron source processing.	Same as Expanded Operations Alternative, including processing a greater variety of sources.
	Process up to 220 pounds (100 kilograms)/yr of actinides. Process 1 to 2 pits/month (up to 12 pits/yr) through tritium separation.	Process up to 880 pounds (400 kilograms)/yr of actinides[a]. Support for hydrodynamic testing and tritium separation activities move to the CMR Building[b] at the same level of activity as the No Action Alternative.	Maintain activity in standby mode; no processing of actinides; no use of routine tritium separation.	Same as Reduced Operations Alternative.

TABLE 3.6.1–1.—*Alternatives for Continued Operation of TA–55 Plutonium Facility Complex*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Actinide Materials and Science Processing, Research, and Development (continued)	Perform decontamination of 15 to 20 uranium components per month.	Perform decontamination of 28 to 48 uranium components per month.	Perform decontamination of 10 to 15 uranium components per month.	Same as Reduced Operations Alternative.
	Research in support of DOE actinide clean-up activities. Stabilize minor quantities of specialty items. Research and development on actinide processing and waste activities at DOE sites.	Increase research efforts, stabilize larger quantities of specialty materials, and increase technical support to other sites, including processing up to 310 pounds (140 kilograms) of plutonium as chloride salts from the Rocky Flats Environmental Technology Site (RFETS).	Maintain shelf-life efforts; decrease support to other sites.	Same as Expanded Operations Alternative.
	Prepare, measure, and characterize samples for fundamental research and development in areas such as aging, welding and bonding, coatings, and fire resistance.	Conduct plutonium research and development and support.	Same as No Action Alternative.	Same as No Action Alternative.
	Fabricate and study small amounts of nuclear fuels used in terrestrial and space reactors. Fabricate and study prototype fuel for lead test assemblies.	Fabricate and study more types and larger quantities of fuels.	Same as No Action Alternative.	Same as No Action Alternative.
	Develop safeguards instrumentation for plutonium assay.	Increase the level of safeguard instrumentation development.	Maintain safeguards instrumentation.	Same as Expanded Operations Alternative.
	Analyze samples in support of actinide reprocessing, research, and development activities.	Analyze half as many samples at TA–55. Remaining analyses move to the CMR Building.[b]	Analyze samples in support of actinide reprocessing, research, and development activities.	Analyze samples in support of actinide reprocessing, research, and development activities.
Fabrication of Ceramic-Based Reactor Fuels	Make prototype MOX fuel. Research and development on fuels.	Build MOX test reactor fuel assemblies and continue research and development on fuels.	Conduct fuel research and development.	Same as No Action Alternative.
Plutonium-238 Research, Development, and Applications	Process, evaluate, and test up to 25 kg/yr plutonium-238 to support space and terrestrial uses. Process up to 10 kg plutonium-238 from heat source and milliwatt recovery, research and development, and safety testing.	Process, evaluate, and test up to 25 kg/yr plutonium-238. Recycle residues and blend up to 18 kg/yr plutonium-238.	Process, evaluate, and test up to 7 kg/yr plutonium-238. Process up to 0.5 kg of plutonium-238 from heat source recovery.	Same as Expanded Operations Alternative.

TABLE 3.6.1–1.—*Alternatives for Continued Operation of TA–55 Plutonium Facility Complex*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
SNM Storage, Shipping and Receiving	Store up to 7.3 tons (6.6 metric tons) SNM in NMSF; continue to store working inventory in the PF–4 vault; ship and receive as needed to support LANL activities.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
	Conduct nondestructive assay on SNM at NMSF to verify identify and content of stored containers.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

Note: All alternatives include refurbishment of TA–55 and renovation of the NMSF, as discussed in chapter 2 (section 2.2.2.1).

[a] The actinide activities at the CMR Building and at TA–55 are expected to total 880 pounds (400 kilograms)/yr. The future split between these two facilities is not known, so the facility-specific impacts at each facility are conservatively analyzed at this maximum amount. Waste projections that are not specific to the facility (but are related directly to the activities themselves) are only projected for the total of 880 pounds (400 kilograms)/yr.

[b] Activities assumed to transfer to the CMR Building in Expanded Operations (as discussed in volume II, part II) include:

- Pit disassembly (noted in Table 3.6.1–5 under Surveillance and Disassembly of Weapons Components)
- Pit surveillance (noted in Table 3.6.1–5 under Surveillance and Disassembly of Weapons Components)
- Actinide research and development and processing activities (noted in Table 3.6.1–5 under Actinide Research and Processing)
- Hydrodynamic testing support and tritium separations (noted in Table 3.6.1–5 under Actinide Research and Processing)

TABLE 3.6.1–2.—*Parameter Differences Among Alternatives for Continued Operation of the Plutonium Facility Complex (TA–55)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions						
Plutonium-239[b]	Ci/yr	1.7×10^{-5} [c]	1.7×10^{-5}	2.7×10^{-5}	9.2×10^{-6}	1.7×10^{-5}
Tritium in Water Vapor[n]	Ci/yr	8.2×10^{2} [d]	7.5×10^{2}	7.5×10^{1}	7.5×10^{1}	7.5×10^{1}
Tritium as a Gas[n]	Ci/yr	2.7×10^{2} [d]	2.5×10^{2}	2.5×10^{1}	2.5×10^{1}	2.5×10^{1}
NPDES Discharge[e] 03A–181	MGY (MLY)	14 (53)	14 (53)	14 (53)	14 (53)	14 (53)
Chemical Waste	lb\yr (kg/yr)	9,260[f] (4,200)	11,580 (5,250)	18,390 (8,340)	11,580 (5,250)	11,580 (5,250)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	20,800[g] (590)	24,300 (688)	26,200[h] (741)	24,300 (688)	24,300 (688)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	388[i] (11)	424 (12)	459 (13)	424 (12)	424 (12)
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	3,850[j] (109)	5,650 (160)	14,500[h] (411)	3,810 (108)	5,720 (162)
Contaminated Space[k]	ft^2 (m^2)	59,600[m] (5,540)	+ 17,500 (NMSF) (1,630)	+ 17,500 (NMSF) (1,630)	+ 17,500 (NMSF) (1,630)	+ 17,500 (NMSF) (1,630)
Number of Workers	FTEs	640[l]	735	1,111	552	712

[a] Index was used as a point of reference for projecting data for the alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index emissions data are based upon process knowledge and gross alpha counting; analysis of emissions for specific radionuclides was not determined. Projections for the alternatives were reported as plutonium or plutonium-239, the primary material at TA–55.
[c] Index for plutonium-239 is from 1988 to 1989.
[d] Index for tritiated water and tritium gas is from 1986.
[e] Outfall contains one process source and no storm water sources. Index is 1990 to 1995.
[f] Index is 1990 to 1991 average.
[g] Index is 1990, 1994, and 1995 average.
[h] Includes estimates of waste generated by the facility upgrades associated with Pit Fabrication.
[i] Index is average of 1990, 1994, and 1995.
[j] Index is average of 1988 to 1990.
[k] Index is Fiscal Year 1995. Data represent increments or decrements to the index.
[l] Index is Fiscal Year 1995.
[m] In addition, there are approximately 1,100 cubic feet (31 cubic meters) of contaminated ducts (see chapter 4, Table 4.9.10–1).
[n] As stated in Table 3.6.1–1 under the No Action Alternative, tritium separation activities will be carried out in TA–55; but under the Expanded Operations, Reduced Operations, and Greener Alternatives, the tritium separation activities will be moved to the CMR Building, and the operations parameters will be reduced from the No Action Alternative and remain constant in the Expanded Operations, Reduced Operations, and Greener Alternatives.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–3.—*Alternatives for Continued Operation of Tritium Facilities*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
High-Pressure Gas Fills and Processing: WETF	Handling and processing of tritium gas in quantities of up to 3.53 oz (100 g) at WETF with no limit on number of operations per year. Capability is used approximately 25 times/yr.	Capability used approximately 65 times/yr.	Capability used approximately 20 times/yr.	Same as Reduced Operations Alternative.
Gas Boost System Testing and Development: WETF	System testing and gas processing operations involving quantities of up to 3.53 oz (100 g) at WETF. Capability is used 20 times/yr.	Capability used approximately 35 times/yr.	Capability used approximately 15 times/yr.	Same as Reduced Operations Alternative.
Cryogenic Separation: TSTA	Tritium gas purification and processing in quantities up to 7.06 oz (200 g) at TSTA. Capability used approximately 3 times/yr.	Capability used 5 to 6 times/yr.	Capability used 1 time/yr.	Same as Expanded Operations Alternative if focused on alternative energy development.
Diffusion and Membrane Purification: TSTA, TSFF, WETF	Research on tritium movement and penetration through materials. Used 2 to 3 times/ month.	Capability use increases significantly, accompanied by continuous use for effluent treatment and 6 to 8 experiments/ month.	Same as No Action Alternative.	Same as Expanded Operations Alternative, focused on waste reduction.
Metallurgical and Material Research: TSTA, TSFF, WETF	Capability involves materials research including metal getter research and application studies. Small quantities of tritium supports tritium effects and properties research and development. Contributes < 2% of LANL's tritium emissions to the environment.	This capability could be expanded, but the use of tritium would remain < 2% of LANL's tritium emissions to the environment.	Same as No Action Alternative.	Same as No Action Alternative

TABLE 3.6.1–3.—*Alternatives for Continued Operation of Tritium Facilities*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Thin Film Loading: TSFF (WETF by 1998)	Chemical bonding of tritium to metal surfaces. Current application is for tritium loading of neutron tube targets; approximately 800 units/yr with small quantities of tritium.	Increase number of required target loading operations up to 3,000 units/yr. However, the tritium at risk quantities will not change.	Same as No Action Alternative.	Same as No Action Alternative.
Gas Analysis: TSTA, TSFF, WETF	Analytical support current capabilities. Operations estimated to contribute < 5% of LANL's tritium emissions to the environment.	Increase to support the tritium operations under this alternative. Material at risk, emissions, and other parameters are not expected to change in this measurement support activity.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Calorimetry: TSTA, TSFF, WETF	This capability provides a measurement method for tritium material accountability. Contained tritium is placed in the calorimeter for quantity measurements. This capability is used frequently, but contributes < 2% of LANL's tritium emissions to the environment.	Increase to support the tritium operations under this alternative. Material at risk, emissions, and other parameters are not expected to change in this measurement support activity.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Solid Material and Container Storage: TSTA, TSFF, WETF	Storage of tritium occurs in process systems, process samples, inventory for use and as waste.	On-site storage could increase by about a factor of 10, with most of increase occurring at WETF.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.1–4.—*Parameter Differences Among Alternatives for Continued Operation of the Tritium Facilities (TA–16 and TA–21)*

PARAMETER	UNITS	INDEX[1]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions						
TA–16/WETF, Tritium Gas (HT/T2)	Ci/yr	1.73×10^{1} [b]	1.00×10^{2}	3.00×10^{2}	1.00×10^{2}	1.00×10^{2}
TA–16/WETF, Tritium Water (HTO)	Ci/yr	4.29×10^{1}	3.00×10^{2}	5.00×10^{2}	3.00×10^{2}	3.00×10^{2}
TA–21/TSTA, Tritium Gas (HT/T2)	Ci/yr	1.23×10^{1} [b]	1.00×10^{2}	1.00×10^{2}	1.00×10^{2}	1.00×10^{2}
TA–21/TSTA, Tritium Water (HTO)	Ci/yr	4.25×10^{1}	1.00×10^{2}	1.00×10^{2}	1.00×10^{2}	1.00×10^{2}
TA–21/TSFF, Tritium Gas (HT/T2)	Ci/yr	2.00×10^{2} [b]				
10-year average:	Ci/yr	NA	4.36×10^{2}	4.36×10^{2}	4.36×10^{2}	4.36×10^{2}
1996	Ci/yr	NA	3.00×10^{2}	3.00×10^{2}	3.00×10^{2}	3.00×10^{2}
1997 to 2000	Ci/yr	NA	6.40×10^{2}	6.40×10^{2}	6.40×10^{2}	6.40×10^{2}
2001 to 2005	Ci/yr	NA	3.00×10^{2}	3.00×10^{2}	3.00×10^{2}	3.00×10^{2}
TA–21/TSFF, Tritium Water (HTO)	Ci/yr	2.13×10^{2} [b]				
10-year average:	Ci/yr	NA	5.84×10^{2}	5.84×10^{2}	5.84×10^{2}	5.84×10^{2}
1996	Ci/yr	NA	4.00×10^{2}	4.00×10^{2}	4.00×10^{2}	4.00×10^{2}
1997 to 2000	Ci/yr	NA	8.60×10^{2}	8.60×10^{2}	8.60×10^{2}	8.60×10^{2}
2001 to 2005	Ci/yr	NA	4.00×10^{2}	4.00×10^{2}	4.00×10^{2}	4.00×10^{2}
NPDES Discharge[c]						
Total Discharges	MGY (MLY)	1.3 (4.92)	0.33 (1.25)	0.33 (1.25)	0.22 (0.83)	0.22 (0.83)
05S (Sewage Treatment Plant)	MGY (MLY)	0.77 (2.91)	0.00	0.00	0.00	0.00
02A-129	MGY (MLY)	0.11[d] (0.42)	0.11 (0.42)	0.11 (0.42)	0.11 (0.42)	0.11 (0.42)
03A-036	MGY (MLY)	0.02[e] (0.08)	0.00	0.00	0.00	0.00
03A-158	MGY (MLY)	0.22[d] (0.83)	0.22 (0.83)	0.22 (0.83)	0.11 (0.42)	0.11 (0.42)
04A-091	MGY (MLY)	0.22[d] (0.83)	0.00	0.00	0.00	0.00
Chemical Waste	lb/yr (kg/yr)	2,430[f] (1,100)	2,430 (1,100)	3,750 (1,700)	2,200 (1,000)	2,870 (1,300)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	1,410[f] (40)	15,900 (450)	16,900 (480)	15,500 (440)	15,900 (450)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	71[f] (2)	71 (2)	106 (3)	71 (2)	71 (2)
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	0	0	0	0
Contaminated Space[g]	ft^2 (m^2)	19,770 (1,840)	+ 10,000 (930)	+ 10,000 (930)	+ 10,000 (930)	+ 10,000 (930)
Number of Workers	FTEs	112[h]	112	123	90	90

TABLE 3.6.1–4.—*Parameter Differences Among Alternatives for Continued Operation of the Tritium Facilities (TA–16 and TA–21)*-Continued

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index data are either emission rates for 1996 or the average of emissions over the period 1992 to 1996, whichever is higher. For WETF and TSTA, 1996 estimates are used; for TSFF, the 5-year average is used.
[c] Outfalls consist of process sources only. Index is 1990 to 1995.
[d] Index is from ESH–18 measurements for NPDES permit application and from estimates based on facility operations. No specific dates for these data were provided.
[e] Index provided as representative data by facility operations personnel. No specific dates were available.
[f] Index is 1990 to 1995 average.
[g] Index Fiscal Year 1995. Data are increments or decrements to the index.
[h] Index is from Fiscal Year 1994.
NA = Not applicable; MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–5.—*Alternatives for Continued Operation of the Chemistry and Metallurgy Research Building (TA–3)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Analytical Chemistry	Sample analysis in support of a wide range of actinide research and processing activities. Approximately 5,200 samples/yr.	Provide expanded general sample analysis. Approximately 11,000 samples/yr. Includes actinide sample analysis relocated from TA–55.[a]	Same as No Action Alternative.	Same as No Action Alternative.
Uranium Processing	Activities to recover, process, and store LANL highly enriched uranium inventory by 2005.	Same as No Action Alternative, except for possible recovery of materials resulting from manufacturing operations.	Residue processing rate will decrease and highly enriched uranium will be placed in interim storage. Material inventory will be processed in 10 to 15 years.	Same as No Action Alternative.
Destructive and Nondestructive Analysis	Evaluate up to a total of 10 secondaries (an average of 1/yr) through destructive/ nondestructive analysis and disassembly.	Evaluate 6 to 10 secondaries/yr.	Same as No Action Alternative.	Same as No Action Alternative.
Nonproliferation Training	Nonproliferation training involving SNM.	Increased training, but no additional quantities of SNM. May work with more types of SNM.	Decreased training, but capability and inventory still remain.	Same as Expanded Operations Alternative.
Actinide Research and Processing	Process plutonium-238/beryllium neutron source at up to approximately 3,600 Ci/yr. Process americium-241/beryllium neutron source at up to approximately 500 Ci/yr. Stage up to 1,000 plutonium-238/ beryllium and americium-241/ beryllium sources in Wing 9 floor holes.	Process plutonium-238/beryllium and americium-241/beryllium neutron sources up to 5,000 Ci/yr at the CMR Building. Process neutron sources other than sealed sources. Stage up to 1,000 plutonium-238/beryllium and americium-241/beryllium sources in Wing 9 floor holes.	Maintain capabilities for americium-241/beryllium and plutonium-238/beryllium neutron source processing. Throughput would not exceed 2,000 Ci/yr. Stage up to 1,000 plutonium-238/ beryllium and americium-241/ beryllium sources in Wing 9 floor holes.	Same as Expanded Operations Alternative.
	Retain technical capability for research and development activities of spent nuclear reactor fuels.	Introduce research and development effort on spent nuclear fuel related to long-term storage and analyze components in spent and partially spent fuels.	Same as No Action Alternative.	Same as Expanded Operations Alternative.

TABLE 3.6.1–5.—*Alternatives for Continued Operation of the Chemistry and Metallurgy Research Building (TA–3)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Actinide Research and Processing (continued)	Metallurgical microstructural/ chemical analysis and compatibility testing of actinides and other metals. Primary mission to study long-term aging and other material effects. Characterize about 50 samples/yr.	Increased number of samples, with no changes in type of analyses performed. Characterize about 100 samples/yr. Conduct research and development in hot cells on pits exposed to high temperatures.	Maintain capability, characterize 25 samples/yr.	Same as No Action Alternative.
	Analysis of TRU disposal related to validation of WIPP performance assessment models. TRU waste characterization. Analysis of gas generation such as could occur in TRU waste during transportation to WIPP. Performance Demonstration Program to test nondestructive analysis/nondestructive examination equipment.	In addition to No Action activities: • Demonstrate actinide decontamination technology for soils and materials. • Develop actinide precipitation method to reduce mixed wastes in LANL effluents.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Actinide Activities Relocated from TA–55 (Expanded Operations Alternative only)		Process up to 880 lb (400 kg)/yr actinides.[a] Support to hydrodynamic testing and tritium separation activities move to the CMR Building[b] (requires facility modifications to make standby wings operational).		

TABLE 3.6.1–5.—*Alternatives for Continued Operation of the Chemistry and Metallurgy Research Building (TA–3)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Fabrication and Metallography	Produce 1,080 targets/yr containing approximately 0.71 oz (20 g) uranium-235 target for molybdenum-99.	Produce 1,080 targets/yr plus additional 20 targets/wk for 12 wks. Separate fission products from irradiated targets to provide molybdenum-99. Ability to produce 3,000 6-day curies of molybdenum-99/wk.	Produce 50 targets/yr and store them.	Same as No Action Alternative.
	Support complete highly enriched uranium processing research and development pilot operations and casting. Fabricate metal shapes, including up to 50 sets of highly enriched uranium components, using 2.2 to 22 lb (1 to 10 kg) highly enriched uranium/ operation. Material recovered and retained in inventory. Up to 2,200 lb (1,000 kg) annual throughput.	Same as No Action Alternative	Same as No Action Alternative.	Same as No Action Alternative.
Disassembly of Weapons Components (Relocated from TA–55, Expanded Operations Alternative only)		Disassemble approximately 65 pits/yr, including 40 pits/yr destructively examined for surveillance. More testing on the 20 pits/yr nondestructively examined[b] (requires facility modifications to make standby wings operational).		

Note: All alternatives include completion of Phase I and II Upgrades, as discussed in chapter 2 (section 2.2.2.3).

[a] The actinide activities at the CMR Building and at TA–55 are expected to total 880 lb (400 kg)/yr. The future split between these two facilities is not known, so the facility-specific impacts at each facility are conservatively analyzed at this maximum amount. Waste projections, which are not specific to the facility (but are related directly to the activities themselves), are only projected for the total of 880 lb (400 kg)/yr.

[b] Activities to be moved to the CMR Building from TA–55 in Expanded Operations Alternative include:

- Pit disassembly (noted in Table 3.6.1–1 under Surveillance and Disassembly of Weapons Components).
- Pit surveillance, which is also a disassembly operation (noted in Table 3.6.1–1 under Surveillance and Disassembly of Weapons Components).
- Actinide research and development and processing activities (noted in Table 3.6.1–1 under Actinide Reprocessing, Research, and Development).
- Hydrodynamic testing support and tritium separation activities (noted in Table 3.6.1–1 under Actinide Reprocessing, Research, and Development).

TABLE 3.6.1–6.—*Parameter Differences Among Alternatives for Continued Operation of the Chemistry and Metallurgy Research Building (TA–3)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions						
Total Actinides	Ci/yr	2.0×10^{-4} [b]	4.20×10^{-4}	7.60×10^{-4}	3.80×10^{-4}	4.20×10^{-4}
Krypton-85[c]	Ci/yr	None	None	1.00×10^{2}	None	None
Xenon-131m	Ci/yr	None	None	4.50×10^{1}	None	None
Xenon-133	Ci/yr	None	None	1.50×10^{3}	None	None
Tritium Water (HTO)[d]	Ci/yr	Negligible	Negligible	7.50×10^{2}	Negligible	Negligible
Tritium Gas (HT)[d]	Ci/yr	Negligible	Negligible	2.50×10^{2}	Negligible	Negligible
NPDES Discharge 03A–021[e]	MGY (MLY)	0.53 (2.01)	0.53 (2.01)	0.53 (2.01)	0.53 (2.01)	0.53 (2.01)
Chemical Waste	lb/yr (kg/yr)	10,500[f] (4,760)	17,600 (7,970)	24,700 (11,200)	13,000 (5,890)	18,200 (8,270)
Low-Level Radioactive Waste[g]	ft^3/yr (m^3/yr)	27,600[f] (781)	48,700 (1,380)	65,700 (1,860)	45,200 (1,280)	49,800 (1,410)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	180[f] (5.1)	580 (16.4)	690 (19.6)	570 (16.2)	580 (16.5)
TRU/Mixed TRU Waste[g]	ft^3/yr (m^3/yr)	760[f] (21.4)	950 (26.8)	2,370 (67.0)	800 (22.8)	1,000 (28.2)
Contaminated Space[h]	ft^2 (m^2)	40,320[j] (3,750)	No change	No change	No change	No change
Number of Workers	FTEs	221[i]	329	527	299	324

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index for the actinides is 1990 to 1994 average.
c Mixed fission products are only applicable for the Expanded Operations Alternative for medical isotope production.
[d] Tritium phase calculation of 75% water and 25% gas based upon 1997 data for TA–55 process to move to the CMR Building under the Expanded Operations Alternative. See Table 3.5.2.1–1.
[e] Outfall 03A–021 consists of one process source and five storm drain sources. Index is 1990 to 1995.
[f] Index is 1990 to 1995 average.
[g] Waste from the Phase II CMR Upgrades are included (e.g. 141,000 ft^3 [4,000 m^3]) in all alternatives during 1997 to 2000 (DOE 1997). Estimates in the tables are annual averages; the 141,000 ft^3 (4,000 m^3) is a total included in these averages.
[h] Index Fiscal Year 1995. Data are increments or decrements to the index.
[i] Provided as representative data by the facility subject matter expert. No specific index date available.
[j] In addition, there are approximately 760 ft^3 (21.5 m^3) of contaminated ducts (see chapter 4, Table 4.9.10–1).
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–7.—*Alternatives for Continued Operations of Pajarito Site (TA–18)*

ACTIVITIES	NO ACTION[a]	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Dosimeter Assessment and Calibration	Perform criticality experiments.	Criticality experiments increase 25% above No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Detector Development	Develop safeguards instrumentation and perform research and development for nuclear materials, LIDAR[b] experiments, and materials processing.	Same activities as under No Action, with increased alternative nuclear materials inventory by 20% and replace portable linear accelerator.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Materials Testing	Perform criticality experiments. Develop safeguards instrumentation and perform research and development for nuclear materials, LIDAR[b] experiments, and materials processing.	Criticality experiments increase 25% above No Action Alternative.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Subcritical Measurements	Perform criticality experiments. Develop safeguards instrumentation and perform research and development for nuclear materials, LIDAR[b] experiments, and materials processing.	Criticality experiments increase 25% above No Action Alternative. Increase alternative nuclear materials inventory by 20%.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Fast-Neutron Spectrum	Perform criticality experiments. Develop safeguards instrumentation and perform research and development for nuclear materials, LIDAR[b] experiments, and materials processing.	Criticality experiments increase 25% above No Action Alternative. Increase alternative nuclear materials inventory by 20%. Increase nuclear weapons components and materials.	Same as No Action Alternative.	Same as Expanded Operations Alternative.

TABLE 3.6.1–7.—*Alternatives for Continued Operations of Pajarito Site (TA–18)*-Continued

ACTIVITIES	NO ACTION[a]	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Dynamic Measurements	Perform criticality experiments. Develop safeguards instrumentation and perform research and development for nuclear materials, LIDAR[b] experiments, and materials processing.	Criticality experiments increase 25% above No Action Alternative. Increase alternative nuclear materials inventory by 20%.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Skyshine Measurements	Perform criticality experiments.	Criticality experiments increase 25% above No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Vaporization	Perform criticality experiments.	Criticality experiments increase 25% above No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Irradiation	Perform criticality experiments. Develop safeguards instrumentation and perform research and development for nuclear materials, interrogation techniques, and field systems.	Criticality experiments increase 25% above No Action Alternative. Increase alternative nuclear materials inventory by 20%.	Same as No Action Alternative.	Same as Expanded Operations Alternative.

[a] The total number of experiments under the No Action Alternative were 570 in 1997 and projected to have an annual growth of about 5% for the next 10 years.
[b] Light detection and ranging.

TABLE 3.6.1–8.—*Parameter Differences Among Alternatives for Continued Operation of the Pajarito Site, (TA–18)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions Argon-41[b]	Ci/yr	1.16×10[c]	8.17×10^1	1.02×10^2	8.17×10^1	8.17×10^1
NPDES Discharge	MGY	No outfalls	No outfalls	No outfalls	No outfalls	No outfalls
Chemical Waste	lb/yr (kg/yr)	4,400[d] (2,000)	8,800 (4,000)	8,800 (4,000)	8,800 (4,000)	8,800 (4,000)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	2,470[d] (70)	5,120 (145)	5,120 (145)	5,120 (145)	5,120 (145)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	25[d] (0.7)	53 (1.5)	53 (1.5)	53 (1.5)	53 (1.5)
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	0	0	0	0
Contaminated Space[e]	ft^2 (m^2)	< 500 (46)	No change	No change	No change	No change
Number of Workers	FTEs	68[f]	95	95	95	113

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] These values are not stack emissions. They are projections from Gaussian plume dispersion modeling. Values are from the first 394-foot (120-meter) radius. Other isotopes (nitrogen-13 and oxygen-15) are not shown due to very short half-lives.
[c] Index data for Argon-41 is from 1995
[d] Index is 1990 to 1995 average.
[e] Index is Fiscal Year 1995. Data are increments or decrements to the existing conditions.
[f] Index is Fiscal Year 1994.

TABLE 3.6.1–9.—*Alternatives for Continued Operation of Sigma Complex*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Research and Development on Materials Fabrication, Coating, Joining, and Processing	Maintain and enhance capability to fabricate items from metals, ceramics, salts, beryllium, enriched uranium, depleted uranium, and other uranium isotope mixtures including casting, forming, machining, polishing, coating, and joining.	Same as the No Action Alternative.	Same as the No Action Alternative.	Same as the No Action Alternative.
Characterization of Materials	Maintain and enhance research and development activities on properties of ceramics, oxides, silicides, composites, and high-temperature materials	Modest increase over No Action Alternative, characterize accelerator production of tritium components	Same as the No Action Alternative.	Same as the No Action Alternative.
	Analyze up to 24 tritium reservoirs/yr.	Analyze up to 36 tritium reservoirs/yr.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Develop library of aged non-SNM materials from stockpiled weapons and develop techniques to test and predict changes. Store and characterize up to 250 samples including uranium.	Store and characterize up to 2,500 non-SNM component samples, including uranium.	Same as the No Action Alternative.	Same as Expanded Operations Alternative.

TABLE 3.6.1–9.—*Alternatives for Continued Operation of Sigma Complex*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Fabrication of Metallic and Ceramic Items	Fabricate stainless steel and beryllium components for about 50 pits/yr.	Fabricate stainless steel and beryllium components for about 80 pits/yr.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate 50 to 100 reservoirs for tritium/yr.	Fabricate up to 200 reservoirs for tritium/yr.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate components for up to 50 secondaries (of depleted uranium, depleted uranium alloy, enriched uranium, lithium hydride, and lithium deuteride) /yr.	Same as No Action Alternative.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate nonnuclear components for research and development: 30 major hydrotests and 20 to 40 joint test assemblies/yr.	Fabricate nonnuclear components for research and development: 100 major hydrotests and 50 joint test assemblies/yr.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate beryllium targets.	Modest increase over the No Action Alternative.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate targets and other components for accelerator production of tritium research.	Same as the No Action Alternative.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate test storage containers for nuclear materials stabilization.	Same as the No Action Alternative.	Same as the No Action Alternative.	Same as the No Action Alternative.
	Fabricate nonnuclear (stainless steel and beryllium) components for up to 20 pit rebuilds/yr.	Same as the No Action Alternative.	Same as the No Action Alternative.	Same as the No Action Alternative.

Note: All alternatives include Sigma Building renovation and facility modifications for pit support and beryllium technology support, as discussed in chapter 2 (section 2.2.2.5).

TABLE 3.6.1–10.—*Parameter Differences Among Alternatives for Continued Operation of the Sigma Complex (TA–3)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions	Ci/yr					
Uranium-234		2.20×10^{-6} [b]	2.20×10^{-5}	6.6×10^{-5}	2.20×10^{-5}	2.20×10^{-5}
Uranium-238		6.10×10^{-5}	6.10×10^{-4}	1.8×10^{-3}	6.10×10^{-4}	6.10×10^{-4}
NPDES Discharge						
Total Discharges	MGY (MLY)	7.3 (27.6)	7.3 (27.6)	7.3 (27.6)	7.3 (27.6)	7.3 (27.6)
03A–022[c]	MGY (MLY)	4.4[e] (16.7)	4.4 (16.7)	4.4 (16.7)	4.4 (16.7)	4.4 (16.7)
03A–024[d]	MGY (MLY)	2.9[f] (11.0)	2.9 (11.0)	2.9 (11.0)	2.9 (11.0)	2.9 (11.0)
Chemical Waste	lb/yr (kg/yr)	6,170[g] (2,800)	12,100 (5,500)	22,050 (10,000)	12,100 (5,500)	12,100 (5,500)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	7,770[h] (220)	14,830 (420)	33,890 (960)	14,830 (420)	14,830 (420)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	35[i] (1)	71 (2)	141 (4)	71 (2)	71 (2)
TRU/Mixed TRU Waste	m^3/yr	0	0	0	0	0
Contaminated Space[j]	ft^2	Not estimated	No change	No change	No change	No change
Number of Workers	FTEs	142[k]	178	284	178	178

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index data for uranium isotopes is from 1990 to 1994.
[c] Outfall 03A–022 consists of one process source and some storm water drain sources.
[d] Outfall 03A–024 consists of process source only.
[e] Index is representative data provided by facility operations based on approximate water usage. No specific dates available.
[f] Index is representative data provided by Engineering Department based on frequency of blowdown. No specific dates available.
[g] Index is 1993 to 1995.
[h] Index is 1994 to 1995.
[i] Index is 1991 to 1995.
[j] This facility is expected (based on process knowledge) to have little or no contaminated space from past operations, so no estimate of the index was made (assumed to be none). Data are increments or decrements from the index.
[k] Index is Fiscal Year 1995.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–11.—*Alternatives for Continued Operation of the Materials Science Laboratory (TA–3–1698)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Materials Processing	Maintain eight capabilities at current levels of operation: • Synthesis/processing • Wet chemistry • Thermomechanical processing • Microwave processing • Heavy equipment materials • Single crystal growth • Amorphous alloys • Powder processing	No change to seven capabilities. Expand materials synthesis/ processing to develop cold mock-up of weapons assembly and processing. Expand materials synthesis/ processing to develop environmental and waste technologies.	Maintain capabilities and personnel. Significant decrease in the number of experiments for the eight research capabilities. Expand materials synthesis/processing to develop environmental and waste technologies.	No change to six capabilities. Expand wet chemistry to develop remediation chemistry capability. Expand materials synthesis/ processing research for nonweapons applications. Expand materials synthesis/ processing to develop environmental and waste technologies.
Mechanical Behavior in Extreme Environment	Maintain three capabilities at current levels of operation: • Mechanical testing • Dynamic testing • Fabrication and assembly	No change to two capabilities. Expand dynamic testing to include research and development for the aging of weapons materials. Develop a new research capability (machining technology).	Maintain capabilities and personnel. Significant decrease in the number of experiments for the three research capabilities.	No change to two capabilities. Expand mechanical testing research for nonweapons applications.
Advanced Materials Development	Maintain four capabilities at current levels of operation: • New materials • Synthesis and characterization • Ceramics • Superconductors	Same as No Action Alternative.	Maintain capabilities and personnel. Significant decrease in the number of experiments for three research capabilities. Reduce research effort for high-temperature superconductors.	No change to three capabilities. Increase research effort for high-temperature superconductors.
Materials Characterization	Maintain six capabilities at current levels of operation: • Surface science chemistry • Corrosion characterization • Electron microscopy • X-ray • Optical metallography • Spectroscopy	No change to four capabilities. Expand corrosion characterization to develop surface modification technology. Expand electron microscopy to develop plasma source ion implantation.	Significant decrease in the number of experiments for surface science chemistry and corrosion characterization. Eliminate capabilities for electron microscopy, x-ray, optical metallography, and spectroscopy.	Expand research in all six areas. Perform research into environmental corrosives.

TABLE 3.6.1–12.—*Parameter Differences Among Alternatives for Continued Operation of the Material Science Laboratory (TA–3)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions	Ci/yr	negligible	negligible	negligible	negligible	negligible
NPDES Discharge Volume	MGY	no outfalls	no outfalls	no outfalls	no outfalls	no outfalls
Chemical Waste	lb\yr (kg/yr)	660[b] (300)	1,320 (600)	1,320 (600)	1,320 (600)	1,320 (600)
Low-Level Radioactive Waste	m^3/yr	negligible	0	0	0	0
Low-Level Radioactive Mixed Waste	m^3/yr	0	0	0	0	0
TRU/Mixed TRU Waste	m^3/yr	0	0	0	0	0
Contaminated Space[c]	ft^2	Not estimated	No change	No change	No change	No change
Number of Workers	FTEs	82[d]	82	82	82	82

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index value is the average of 1994 and 1995 data.
[c] This facility is expected (based on process knowledge) to have little or no contaminated space from past operations, so no estimate of the index was made (assumed to be none). Data are increments or decrements from the index.
[d] Index is Fiscal Year 1995.

TABLE 3.6.1–13.—*Alternatives for Continued Operation of the Target Fabrication Facility (TA–35)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Precision Machining and Target Fabrication	Provide targets and specialized components for about 1,200 tests/yr. Expect 10% growth in these operations/yr for the next 10 yrs.	Operations at about twice No Action Alternative including 20% increase in high explosives pulsed-power and increase for 100 high-energy density physics /yr.	Operations reduced to about one-third of No Action Alternative levels.	Same as No Action Alternative.
Polymer Synthesis	Produce polymers for targets and specialized components for about 1,200 tests/yr. Expect 10% growth in these operations/yr for the next 10 yrs.	Operations supporting laser and physics tests increase to twice No Action Alternative level, with 10 to 20% growth in DoD and high explosives pulsed-power target operations. Increased operations to support 100 high-energy density physics tests/yr.	Laser and physics test operations reduced to about one-third of No Action Alternative levels.	Laser and physics test operations remain at No Action Alternative level. Other operations redirected to advanced materials research and manufacturing, waste treatment, energy technologies, and environmental restoration technology.
Chemical and Physical Vapor Deposition	Coat targets and specialized components for about 1,200 tests/yr. Expect 10% growth in these operations/yr for the next 10 yrs.	Operations supporting laser and physics tests increase to twice No Action Alternative level, with 10 to 20% growth in DoD and high explosives pulsed-power target operations. Increase operations to support 100 high-energy density physics tests/yr. Support for pit rebuild operations double over 10-yr period. Other operations have low increase over No Action Alterative levels.	Laser and physics test operations reduced to about one-third of No Action Alternative levels.	Laser and physics test operations remain at No Action Alternative level. Other operations redirected to advanced materials research and manufacturing, waste treatment, energy technologies, and environmental restoration technologies with potential for moderate increase in operations.

TABLE 3.6.1–14.—*Parameter Differences Among Alteratives for Continued Operation of the Target Fabrication Facility (TA–35)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radiological Air Emissions	Ci/yr	negligible	negligible	negligible	negligible	negligible
NPDES Discharge 04A–127[b]	MGY (MLY)	2.0[c] (7.6)	0	0	0	0
Chemical Waste	lb/yr (kg/yr)	4,170[d] (1,890)	8,380 (3,800)	8,380 (3,800)	8,380 (3,800)	8,380 (3,800)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	180[e] (5)	350 (10)	350 (10)	350 (10)	350 (10)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	7[f] (0.2)	14 (0.4)	14 (0.4)	14 (0.4)	14 (0.4)
TRU/Mixed TRU Waste	m^3/yr	0	0	0	0	0
Contaminated Space[g]	ft^2	Not estimated	No change	No change	No change	No change
Number of Workers	FTEs	71[h]	71	98	38	71

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Outfall 04A–127 consists of three process sources and four storm drains. Index is 1990 to 1995.
[c] Index is representative data; no specific index date available.
[d] Index is 1990 to 1995 average.
[e] Index is 1990 to 1993 average.
[f] Index is 1990 to 1991 average.
[g] This facility is expected (based on process knowledge) to have little or no contaminated space from past operations, so no estimate of the index was made (assumed to be none). Data are increments or decrements from the index.
[h] Index is representative data; no specific index date available.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–15.—*Alternatives for Continued Operation of the Machine Shops, TA–3*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Fabrication of Specialty Components	Provide fabrication support for the dynamic experiments program and explosives research studies, support up to 30 hydrodynamic tests/yr, manufacture 20 to 40 joint test assemblies sets per yr and provide general laboratory fabrication support as requested.	Increase operations to support up to 100 hydrodynamic tests/yr., manufacture up to 50 joint test assemblies sets per yr, and provide general laboratory fabrication support as requested.	Same as No Action Alternative.	Same as No Action Alternative.
Fabrication Utilizing Unique Materials	Continue fabrication utilizing unique and unusual materials.	Up to three times No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Dimensional Inspection of Fabricated Components	Provide appropriate dimensional inspection of above fabrication activities.	Provide appropriate dimensional inspection of above fabrication activities, and undertake additional types of measurements/inspections.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.1–16.—*Parameter Differences Among Alteratives for Continued Operation of the Machine Shops (TA–3)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions Uranium-238	Ci/yr	5.00×10^{-6} [b]	5.00×10^{-5}	1.50×10^{-4}	5.00×10^{-5}	5.00×10^{-5}
NPDES Discharge	MGY	No outfalls	No outfalls	No outfalls	No outfalls	No outfalls
Chemical Waste	lb/yr (kg/yr)	52,300[c] (23,700)	313,000 (142,000)	1,045,000 (474,000)	313,000 (142,000)	313,000 (142,000)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	710[c] (20)	9,880 (280)	21,390 (606)	9,880 (280)	9,880 (280)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	120[c] (3.3)	0	0	0	0
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	0	0	0	0
Contaminated Space[d]	ft^2 (m^2)	Not estimated	+ 5,000 (460)	+ 10,000 (930)	+ 5,000 (460)	+ 5,000 (460)
Number of Workers	FTEs	60[e]	123	289	123	123

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index data for uranium-238 is from 1993.
[c] Index is 1993 to 1995 average. Nonnuclear workload will increase substantially from the index.
[d] This facility is expected (based on process knowledge) to have little or no contaminated space from past operations, so no estimate of the index was made (assumed to be none). Data are increments or decrements from the index.
[e] Index is Fiscal Year 1996 as adjusted by the facility subject matter expert.

TABLE 3.6.1–17.—*Alternatives for the Continued Operation of the High Explosives Processing Facilities (TA–8, TA–9, TA–11, TA–16, TA–22, TA–29, and TA–37)*[a]

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
High Explosives Synthesis and Production	Continue low-level synthesis research and development, produce new materials and formulate explosives as needed. Increase process development. Produce material and components for directed stockpile production.	50% increase in synthesis research and development and formulation of explosives. Increase production of materials for evaluation and process development.	Activities reduced to approximately 60% of No Action Alternative.	Same as Reduced Operations Alternative.
High Explosives and Plastics Development and Characterization	Evaluate stockpile returns. Increase efforts in development and characterization of new plastics and high explosives for stockpile improvement. Improve predictive capabilities. Research high explosives waste treatment methods.	40% increase in developing and characterizing substitute materials for stockpile application. More efforts in predictive models, process development, and high explosives waste treatment.	Overall level of effort reduced to less than 60% of No Action Alternative.	Same as Reduced Operations Alternative.
High Explosives and Plastics Fabrication	Continue traditional stockpile surveillance and process development. Supply parts to Pantex for surveillance, stockpile rebuilds, and joint test assemblies. Increase fabrication for hydrodynamic and environmental testing.	Fabrication support increased: surveillance rebuild, + 40%; stockpile rebuilds, + 100%; surety and above ground test, + 50%.	Reduced efforts in fabrication as compared to No Action Alternative; War reserve refurbishment and weapons research and development, approximately 60% of No Action Alternative. Stockpile surveillance and above ground tests reduced to approximately 75% of No Action Alternative.	Same as Reduced Operations Alternative.
Test Device Assembly	Increase test device assembly to support stockpile related hydrodynamic tests, joint test assemblies, environmental and safety tests, and somewhat increased research and development. Approximately 30 major assembles/yr.	Increase operation to support approximately 100 major assemblies/yr.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.1–17.—*Alternatives for the Continued Operation of the High Explosives Processing Facilities (TA–8, TA–9, TA–11, TA–16, TA–22, TA–29, and TA–37)*[a]-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Safety and Mechanical Testing	Increase safety and environmental test related to stockpile assurance. Improve predictive models, approximately 12 safety and mechanical tests/yr.	50% increase in safety and environmental tests to support stockpile needs. Approximately 15 safety and mechanical tests/yr.	Testing activities reduced to approximately 80% of No Action Alternative.	Same as Reduced Operations Alternative.
Research, Development, and Fabrication of High-Power Detonators	Increase efforts to support assigned SSM activities; manufacture up to 20 major product lines per year. Support DOE complex for packaging and transportation of electro-explosive devices.	Increase operations to support 40 major product lines per year.	Same as No Action Alternative.	Same as No Action Alternative.

[a] The total amount of explosives and mock explosives used across all activities is an indicator of overall activity levels for this key facility. These amounts under each alternative are:

- No Action: 46,750 pounds (21,200 kilograms) of explosives and 1,590 pounds (720 kilograms) of mock explosives.
- Expanded Operations: 82,700 pounds (37,500 kilograms) of explosives and 2,910 pounds (1,320 kilograms) of mock explosives.
- Reduced Operations: 19,400 pounds (8,800 kilograms) of explosives and 1,150 pounds (520 kilograms) of mock explosives.
- Greener: 19,400 pounds (8,800 kilograms) of explosives and 1,150 pounds (520 kilograms) of mock explosives.

TABLE 3.6.1–18.—*Parameter Differences Among Alternatives for Continued Operation of High Explosives Processing (TA–8, TA–9, TA–11, TA–16, TA–22, TA–28, and TA–37)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions (TA–11)						
Uranium-238	Ci/yr	1.53×10^{-7} [b]	3.98×10^{-7}	9.96×10^{-7}	2.32×10^{-7}	2.32×10^{-7}
Uranium-235	Ci/yr	2.90×10^{-9}	7.56×10^{-9}	1.89×10^{-8}	4.41×10^{-9}	4.41×10^{-9}
Uranium-234	Ci/yr	5.69×10^{-8}	1.49×10^{-7}	3.71×10^{-7}	8.67×10^{-8}	8.67×10^{-8}
NPDES Discharge						
Total Discharges	MGY (MLY)	34 (129)	12.4 (47.0)	12.4 (47.0)	12.3 (46.6)	12.3 (46.6)
02A–007[c]	MGY (MLY)	10.5[d] (40)	7.4 (28.0)	7.4 (28.0)	7.4 (28.0)	7.4 (28.0)
03A–130	MGY (MLY)	0.037[e] (0.14)	0.037 (0.14)	0.037 (0.14)	0.037 (0.14)	0.037 (0.14)
04A–070	MGY (MLY)	0.22[f] (0.83)	0.0	0.0	0.0	0.0
04A–083[c]	MGY (MLY)	0.20[g] (0.76)	0.0	0.0	0.0	0.0
04A–092[c]	MGY (MLY)	1.57[f] (5.94)	0.0	0.0	0.0	0.0
04A–115[c]	MGY (MLY)	0.53[g] (2.01)	0.0	0.0	0.0	0.0
04A–157	MGY (MLY)	7.31[g] (27.7)	0.0	0.0	0.0	0.0
05A–053[c]	MGY (MLY)	0.124[d] (0.47)	0.0	0.0	0.0	0.0
05A–054	MGY (MLY)	3.57[d] (13.5)	3.6 (13.6)	3.6 (13.6)	3.6 (13.6)	3.6 (13.6)
05A–055	MGY (MLY)	0.036[d] (0.14)	0.13 (0.49)	0.13 (0.65)	0.10 (0.38)	0.10 (0.38)
05A–056	MGY (MLY)	2.53[d] (9.58)	0.0	0.0	0.0	0.0
05A–066[c]	MGY (MLY)	4.36[d] (16.5)	0.74 (2.80)	0.74 (2.80)	0.74 (2.80)	0.74 (2.80)
05A–067[c]	MGY (MLY)	0.33[d] (1.25)	0.33 (1.25)	0.33 (1.25)	0.33 (1.25)	0.33 (1.25)
05A–068[c]	MGY (MLY)	1.16[d] (4.39)	0.06 (0.23)	0.06 (0.23)	0.06 (0.23)	0.06 (0.23)
05A–069	MGY (MLY)	0.007[d] (0.03)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)
05A–071	MGY (MLY)	0.036[d] (0.14)	0.04 (0.15)	0.04 (0.15)	0.04 (0.15)	0.04 (0.15)
05A–072[c]	MGY (MLY)	0.0219[f] (0.08)	0.0	0.0	0.0	0.0
05A–096	MGY (MLY)	0.007[d] (0.03)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)
05A–097	MGY (MLY)	0.007[d] (0.03)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)
06A–073	MGY (MLY)	0.084[f] (0.32)	0.0	0.0	0.0	0.0
06A–074	MGY (MLY)	0.25[g] (0.95)	0.0	0.0	0.0	0.0
06A–075	MGY (MLY)	1.0[f] (3.79)	0.0	0.0	0.0	0.0
Chemical Waste	lb/yr (kg/yr)	20,300[h] (9,200)	24,300 (11,000)	28,700 (13,000)	15,400 (7,000)	15,400 (7,000)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	210[i] (6)	390 (11)	560 (16)	280 (8)	280 (8)

TABLE 3.6.1–18.—*Parameter Differences Among Alternatives for Continued Operation of High Explosives Processing (TA–8, TA–9, TA–11, TA–16, TA–22, TA–28, and TA–37)*-Continued

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	7[j] (0.2)	7 (0.2)	7 (0.2)	7 (0.2)	7 (0.2)
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	0	0	0	0
Contaminated Space[k]	ft^2 (m^2)	Not estimated	No change	No change	No change	No change
Number of Workers	FTEs	148[l]	242	335	170	170

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index is Fiscal Year 1995.
[c] Footnoted outfalls contain both process sources and storm water sources; otherwise, outfalls contain only process sources.
[d] Index is 1990 to 1995.
[e] Index is representative data; no specific index date available.
[f] Index data from ESH–18 measurements for NPDES permit application and from estimates based on facility operations. No specific dates available.
[g] Index estimated by facility operations based on approximate water usage. No specific index date available.
[h] Index is 1990 to 1995 average.
[i] Index is 1993 to 1995 average.
[j] Index is 1994 to 1995 average.
[k] This facility is expected (based on process knowledge) to have little or no contaminated space from past operations, so no estimate of the index was made (assumed to be none). Data are increments or decrements from the index.
[l] Provided as representative data by the facility subject matter expert. Index date not available.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–19.—*Alternatives for the Continued Operation of High Explosives Testing: TA–14 (Q-Site), TA–15 (R-Site), TA–36 (Kappa-Site), TA–39 (Ancho Canyon Site), and TA–40 (DF-Site)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Hydrodynamic Tests	Conduct up to 30 hydrodynamic tests/yr. Develop containment technology. Conduct baseline and code development tests of weapons configuration. Depleted uranium use of 2,900 lb/yr (over all activities).	Increase number of hydrodynamic tests to up to 100/yr. Depleted uranium use of about 6,900 lb/yr (over all activities).	Same as No Action Alternative.	Same as No Action Alternative.
Dynamic Experiments	Conduct dynamic experiments to study properties and enhance understanding of the basic physics of state and motion for materials used in nuclear weapons including some experiments with SNM.	Increase number of dynamic experiments by about 50%.	Same as No Action Alternative.	Same as No Action Alternative.
Explosives Research and Testing	Conduct high explosives tests to characterize explosive materials.	Up to twice No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Munitions Experiments	Continued support of DoD in conventional munitions. Conduct experiments with projectiles and study other effects on munitions.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
High Explosives Pulsed-Power (HEPP) Experiments	Conduct HEPP experiments and development tests.	Up to twice the number of HEPP experiments and development tests.	Same as No Action Alternative.	Same as No Action Alternative.
Calibration, Development, and Maintenance Testing	Conduct tests to provide calibration data, instrumentation development, and maintenance of image processing capability, etc.	Up to twice the number of tests.	Same as No Action Alternative.	Same as No Action Alternative.
Other Explosives Testing	Develop advanced high explosives or weapons evaluation techniques.	Increase the number of explosives studies by 50%.	Same as No Action Alternative.	Same as No Action Alternative.

Note: All alternatives include completion of construction for the DARHT Facility and its operation, as discussed in chapter 2 (section 2.2.2.10).

TABLE 3.6.1–20.—*Parameter Differences Among Alternatives for Continued Operation of High Explosives Testing, TA–14 (Q-Site) TA–15 (R-Site) TA–36 (Kappa Site), and TA–40 (DF-Site)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions[b]						
Depleted Uranium	Ci/yr	Not Available	5.0×10^{-2}	1.5×10^{-1}	5.0×10^{-2}	5.0×10^{-2}
Chemical Usage[c]						
TA–14						
Depleted Uranium	lb/yr (kg/yr)	6.6 (3)	22 (10)	66 (30)	22 (10)	22 (10)
Lead	lb/yr (kg/yr)	22 (10)	22 (10)	66 (30)	22 (10)	22 (10)
TA–15[d]						
Depleted Uranium	lb/yr (kg/yr)	730 (330)	1,980 (900)	5,950[e] (2,700)	1,980 (900)	1,980 (900)
Lead	lb/yr (kg/yr)	44 (20)	110 (50)	330 (150)	110 (50)	110 (50)
Beryllium	lb/yr (kg/yr)	22 (< 10)	22 (10)	66 (30)	22 (10)	22 (10)
Aluminum	lb/yr (kg/yr)	150 (70)	330 (150)	990 (450)	330 (150)	330 (150)
Copper	lb/yr (kg/yr)	44 (20)	220 (100)	660 (300)	220 (100)	220 (100)
Tantalum	lb/yr (kg/yr)	22 (< 10)	220 (100)	660 (300)	220 (100)	220 (100)
Tungsten	lb/yr (kg/yr)	22 (10)	220 (100)	660 (300)	220 (100)	220 (100)
TA–36						
Depleted Uranium	lb/yr (kg/yr)	330 (150)	880 (400)	2,650 (1,200)	880 (400)	880 (400)
Lead	lb/yr (kg/yr)	22 (< 10)	22 (10)	66 (30)	22 (10)	22 (10)
Beryllium	lb/yr (kg/yr)	0	22 (10)	66 (30)	22 (10)	22 (10)
Copper	lb/yr (kg/yr)	22 (10)	22 (10)	66 (30)	22 (10)	22 (10)
TA–39						
Lead	lb/yr (kg/yr)	0	22 (10)	66 (30)	22 (10)	22 (10)
Beryllium	lb/yr (kg/yr)	0	22 (10)	66 (30)	22 (10)	22 (10)
Aluminum[n]	lb/yr (kg/yr)	1,410 (640)	33,100 (15,000)	99,200 (45,000)	33,100 (15,000)	33,100 (15,000)
Copper[n]	lb/yr (kg/yr)	2,510 (1,140)	33,100 (15,000)	99,200 (45,000)	33,100 (15,000)	33,100 (15,000)
TA–40						
Copper	lb/yr (kg/yr)	44 (20)	220 (100)	660 (300)	220 (100)	220 (100)

TABLE 3.6.1–20.—*Parameter Differences Among Alternatives for Continued Operation of High Explosives Testing, TA–14 (Q-Site) TA–15 (R-Site) TA–36 (Kappa Site), and TA–40 (DF-Site)*-Continued

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
NPDES Discharge						
Total Discharges	MGY (MLY)	3.95 (15.0)	3.6 (13.6)	3.6 (13.6)	3.6 (13.6)	3.6 (13.6)
03A–028	MGY (MLY)	2.2[g] (8.33)	2.2 (8.33)	2.2 (8.33)	2.2 (8.33)	2.2 (8.33)
03A–185	MGY (MLY)	0.73[h] (2.76)	0.73 (2.76)	0.73 (2.76)	0.73 (2.76)	0.73 (2.76)
04A–101[f]	MGY (MLY)	< 0.05[i] (0.19)	0	0	0	0
04A–139	MGY (MLY)	None	None	None	None	None
04A–141	MGY (MLY)	0.031[h] (0.12)	0.0	0.0	0.0	0.0
04A–143	MGY (MLY)	0.018[h] (0.07)	0.018 (0.07)	0.018 (0.07)	0.018 (0.07)	0.018 (0.07)
04A–156	MGY (MLY)	0.091[h] (0.34)	0.0	0.0	0.0	0.0
06A–079	MGY (MLY)	0.54 (2.04)	0.54 (2.04)	0.54 (2.04)	0.54 (2.04)	0.54 (2.04)
06A–080	MGY (MLY)	0.027[h] (0.10)	0.03 (0.11)	0.03 (0.11)	0.03 (0.11)	0.03 (0.11)
06A–081	MGY (MLY)	0.027[h] (0.10)	0.03 (0.11)	0.03 (0.11)	0.03 (0.11)	0.03 (0.11)
06A–082	MGY (MLY)	0.027[h] (0.10)	0.0	0.0	0.0	0.0
06A–099[f]	MGY (MLY)	0.027[h] (0.10)	0.0	0.0	0.0	0.0
06A–100	MGY (MLY)	0.037[h] (0.14)	0.04 (0.15)	0.04 (0.15)	0.04 (0.15)	0.04 (0.15)
06A–123	MGY (MLY)	0.13[g] (0.49)	0.0	0.0	0.0	0.0
Chemical Waste	lb/yr (kg/yr)	52,700[j] (23,900)	55,600 (25,200)	77,800 (35,300)	55,600 (25,200)	55,600 (25,200)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	2,800[j] (80)	10,600 (300)	33,200 (940)	10,600 (300)	10,600 (300)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	3.5[j] (0.1)	10.6 (0.3)	31.8 (0.9)	10.6 (0.3)	10.6 (0.3)
TRU/Mixed TRU Waste[k]	ft^3/yr (m^3/yr)	0	7.1 (0.2)	7.1 (0.2)	7.1 (0.2)	7.1 (0.2)
Contaminated Space[l]	ft^2 (m^2)	Not estimated	No change	No change	No change	No change
Number of Workers	FTEs	341[m]	411	619	411	411

TABLE 3.6.1–20.—*Parameter Differences Among Alternatives for Continued Operation of High Explosives Testing, TA–14 (Q-Site) TA–15 (R-Site) TA–36 (Kappa Site), and TA–40 (DF-Site)*-Continued

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.

[b] The isotopic composition of depleted uranium is approximately 99.7% uranium-238, approximately 0.3% uranium-235, and approximately 0.002% uranium-234. Because there are no historic measurements of emissions from these sites, projections are based on estimated release fractions of the materials used in tests.

[c] Index from 1990 and 1995 chemical inventory data (LANL 1990 and LANL 1995b).

[d] Usage for TA–15 includes operations at DARHT and other TA–15 firing sites. The usage at DARHT for the No Action Alternative is the same as analyzed in the DARHT EIS (DOE 1995c). Conservatively, no credit was taken for the phased containment to be implemented at DARHT because the full benefits of phased containment would not be realized until late in the period examined in this SWEIS.

[e] Usage listed for the Expanded Operations Alternative includes projections for expanded operations at DARHT as well as the other TA–15 firing sites, consistent with the Expanded Operations Alternative description (the highest foreseeable level of such activities that could be supported by the LANL infrastructure). No proposals are currently before DOE to exceed the material expenditures at DARHT that are evaluated in the DARHT EIS (DOE 1995c).

[f] Outfall contains both process sources and storm water sources.

[g] Index provided as representative data by facility operations personnel. No specific dates available.

[h] Index data is from ESH–18 measurements for NPDES permit application and from estimates based on facility operations. No specific dates available.

[i] Index is representative data provided by facility operations based on approximate water usage. No specific dates available.

[j] Index is 1990 to 1995 average.

[k] TRU waste (steel) will be generated as a result of DARHT's Phased Containment Option (see DARHT EIS [DOE 1995c]).

[l] Most of these activities occur outdoors and, in general, such activities do not have the potential to result in contamination within facilities; thus, no estimate of the index was made. Environmental contamination from such test activities is addressed in chapter 4 (sections 4.2, 4.3, and 4.5). Data are increments or decrements from the index.

[m] Data provided as representative data by the facility subject matter expert. No specific index date available.

[n] The quantities of copper and aluminum involved in these tests are used primarily in the construction of support structures. These structures are not expended in the explosive tests, and thus, do not contribute to air emissions.

MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–21.—*Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS[c]	REDUCED OPERATIONS	GREENER[c]
Accelerator Beam Delivery, Maintenance, and Development	Deliver LANSCE linac beam to Areas A, B, C, WNR, Manuel Lujan Center, radiography sites, and new IPF for 8 months/yr (5,100 hrs). Positive ion current 1.00 milliampere and negative ion current of 200 microampere.	Deliver LANSCE linac beam to Areas A, B, C, WNR, Manuel Lujan Center, Dynamic Experiment Facility, and new IPF for 10 months/yr (6,400 hrs). Positive ion current 1.25 milliampere and negative ion current of 200 microampere.	Deliver LANSCE linac beam to Areas A, B, C, WNR, Manuel Lujan Center, radiography firing sites, and new IPF for 4 months/yr (2,600 hrs). Positive ion current 1.00 milliampere and negative ion current of 200 microampere.	Same as Expanded Operations Alternative.
	Reconfigure beam delivery and support equipment to support new facilities, upgrades, and experiments.[a]	Reconfigure beam delivery and support equipment to support new facilities, upgrades, and experiments.	Reconfigure beam delivery and support equipment to support new facilities, upgrades, and experiments.	
	Commission/operate/maintain LEDA for 6 yrs; operate up to approximately 6,600 hrs/yr.	Commission/operate/maintain LEDA for 10 to 15 yrs; operate up to approximately 6,600 hrs/yr.	Commission/operate/maintain 12-million electron volts LEDA for 2 yrs; operate up to approximately 1,000 hrs/yr.	
Experimental Area Support	Remote handling and radioactive waste disposal capability maintained.	Full-time remote handling and radioactive waste disposal capability required during Area A interior modifications, Area A East renovation.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
	Support of experiments, facility upgrades, and modifications.	Support of experiments, facility upgrades, and modifications.		
	Increased power demand for LEDA radiofrequency operation.	Increased power demand for LANSCE linac and LEDA radiofrequency operation.	Same as No Action Alternative.	Same as Expanded Operations Alternative.

TABLE 3.6.1–21.—*Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS[c]	REDUCED OPERATIONS	GREENER[c]
Neutron Research and Technology[b]	Conduct 500 to 1,000 experiments/yr using Manuel Lujan Center and WNR. Conduct accelerator production of tritium (APT) target neutronics experiment for 6 months. Support contained weapons-related experiments: • With small quantities of actinides, high explosives, and sources (up to approximately 40/yr) • With nonhazardous materials and small quantities of high explosives (up to approximately 100/yr) • With up to 10 lbs (4.5 kg) high explosives and/or depleted uranium (up to approximately 30/yr) • Shockwave experiments involving small amounts, up to (nominally) 0.18 oz (5 g) plutonium Provide support for static stockpile surveillance technology research and development.	Conduct 1,000 to 2,000 experiments/yr using Manuel Lujan Center, WNR, and LPSS. Establish LPSS in Area A (requires modification). Conduct APT target neutronics experiment for 6 months. Construct dynamic experiment laboratory adjacent to WNR. Support contained weapons-related experiments: • With small quantities of actinides, high explosives, and sources (up to approximately 80/yr) • With nonhazardous materials and small quantities of high explosives (up to approximately 200/yr) • With up to 10 lbs (4.5 kg) high explosives and/or depleted uranium (up to approximately 60/yr) • Shockwave experiments involving small amounts, up to (nominally) 1.8 oz (50 g) plutonium Provide support for static stockpile surveillance technology research and development.	Conduct 100 to 500 experiments/yr using Manuel Lujan Center and WNR. Support weapons-related experiments: • With small quantities of actinides, high explosives, and sources (up to approximately 20/yr) • With nonhazardous materials and small quantities of high explosives (up to approximately 50/yr) • With up to 10 lbs (4.5 kg) high explosives and/or depleted uranium (up to approximately 15/yr)	Conduct 1,000 to 2,000 experiments/yr using Manuel Lujan Center, WNR, and LPSS. Support weapons-related experiments: • With small quantities of actinides, high explosives, and sources (up to approximately 40/yr) • With nonhazardous materials and small quantities of high explosives (up to approximately 100/yr) • With up to 10 lbs (4.5 kg) high explosives and/or depleted uranium (up to approximately 30/yr) • Shockwave experiments involving small amounts, up to (nominally) 0.18 oz (5 g) plutonium

TABLE 3.6.1–21.—*Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS[c]	REDUCED OPERATIONS	GREENER[c]
Accelerator-Driven Transmutation Technology (ADTT)	Conduct lead target tests for 2 yrs at Area A beam stop. Establish 1-megawatt ADTT target/blanket experiment area in Area A. Conduct low-power experiments (< 1 megawatt) for 8 months/yr for 4 yrs.	Conduct lead target tests for 2 yrs at Area A beam stop. Implement LIFT (establish 1-megawatt, then 5-megawatt ADTT target/blanket experiment areas) adjacent to Area A. Conduct 5-megawatt experiments for 10 months/yr for 4 yrs (using about 6.6 lbs (3 kg) of actinides).	Conduct basic research using existing LANSCE facilities.	Same as Expanded Operations Alternative.
Subatomic Physics Research	Conduct 5 to 10 physics experiments/yr at Manuel Lujan Center and WNR. Continue neutrino experiment through Fiscal Year 1997. Conduct proton radiography experiments, including contained experiments with high explosives.	Conduct 5 to 10 physics experiments/yr at Manuel Lujan Center, WNR, and LPSS. Continue neutrino experiment through Fiscal Year 1997. Conduct proton radiography experiments, including contained experiments with high explosives.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Medical Isotope Production	Irradiate up to approximately 40 targets/yr for medical isotope production.	Irradiate up to approximately 50 targets/yr. Added production of exotic and neutron-rich/neutron-deficient isotopes (requires modification of an existing target area).	Irradiate up to approximately 20 targets/yr.	Same as Expanded Operations Alternative.
High-Power Microwaves and Advanced Accelerators	Conduct research and development in these areas, including microwave chemistry research for industrial and environmental applications.	Same as No Action Alternative.	Research reduced to about 50 percent of the No Action Alternative levels. No research in microwave chemistry for industrial and environmental applications.	Same as No Action Alternative.

TABLE 3.6.1–21.—*Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*-Continued

[a] **Note:** All alternatives include the completion of proton and neutron radiography facilities, the LEDA, the IPF relocation, and the SPSS enhancement, as discussed in chapter 2 (section 2.2.2.11).

[b] Numbers of neutron experiments represent plausible levels of activity for each alternative. Bounding conditions for the consequences of operations are primarily determined by: (a) length and power of beam operation and (b) maintenance and construction activities.

[c] The Expanded Operations and Greener Alternatives at TA–53 include the facility construction or modification activities and the operations associated with the LPSS, the 5-megawatt target/blanket experimental area (also referred to as LIFT), the DEL, and the Exotic Isotope Production Facility (in addition to TA–53 activities previously reviewed under NEPA). The parameters presented in Table 3.6.1–22, and the impacts presented in section 3.6 (and in chapter 5, sections 5.3 and 5.5) include the construction and the operation impacts associated with these projects. There are no meaningful siting and construction alternatives for these projects because they are dependent on the delivery of an accelerator beam that is not provided at other LANL facilities. (Construction of a new accelerator solely to provide for these activities is not considered reasonable.)

H^+ = proton (positively charged ion), H^- = negatively charged hydrogen ion

TABLE 3.6.1–22.—*Parameter Differences Among Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions[b]						
Argon-41 (10-yr average)	Ci/yr	2.4×10^{2}	4.81×10^{2}	7.68×10^{2}	2.46×10^{2}	7.68×10^{2}
1996 to 1997 average	Ci/yr		1.13×10^{3}	1.38×10^{3}	5.90×10^{2}	1.38×10^{3}
1998 to 1999 average	Ci/yr		6.01×10^{1}	7.44×10^{1}	3.12×10^{1}	7.44×10^{1}
2000 to 2001 average	Ci/yr		4.05×10^{2}	5.05×10^{2}	2.03×10^{2}	5.05×10^{2}
2002 to 2005 average	Ci/yr		4.05×10^{2}	9.37×10^{2}	2.03×10^{2}	9.37×10^{2}
Carbon-10 (10-yr average)	Ci/yr	2.08×10^{3}	1.35×10^{2}	1.53×10^{2}	1.05×10^{2}	1.53×10^{2}
1996 to 1997 average	Ci/yr		6.69×10^{2}	7.55×10^{2}	5.20×10^{2}	7.55×10^{2}
1998 to 2005 average	Ci/yr		2.12×10^{0}	2.65×10^{0}	1.06×10^{-0}	2.65×10^{0}
Carbon-11 (10-yr average)	Ci/yr	1.13×10^{4}	7.56×10^{3}	1.08×10^{4}	4.16×10^{3}	1.08×10^{4}
1996 to 1997 average	Ci/yr		1.90×10^{4}	2.30×10^{4}	1.14×10^{4}	2.30×10^{4}
1998 to 1999 average	Ci/yr		2.37×10^{3}	2.96×10^{3}	1.19×10^{3}	2.96×10^{3}
2000 to 2001 average	Ci/yr		5.47×10^{3}	6.84×10^{3}	2.74×10^{3}	6.84×10^{3}
2002 to 2005 average	Ci/yr		5.47×10^{3}	1.07×10^{4}	2.74×10^{3}	1.07×10^{4}
Nitrogen-13 (10-yr average)	Ci/yr	7.18×10^{3}	1.34×10^{3}	1.59×10^{3}	8.67×10^{2}	1.59×10^{3}
1996 to 1997 average	Ci/yr		4.98×10^{3}	5.81×10^{3}	3.48×10^{3}	5.81×10^{3}
1998 to 2005 average	Ci/yr		4.28×10^{2}	5.35×10^{2}	2.14×10^{2}	5.35×10^{2}
Nitrogen-16 (10-yr average)	Ci/yr	1.08×10^{3}	1.80×10^{2}	2.10×10^{2}	1.19×10^{2}	2.10×10^{2}
1996 to 1997 average	Ci/yr		8.98×10^{2}	1.05×10^{3}	5.95×10^{2}	1.05×10^{3}
1998 to 2005 average	Ci/yr		2.85×10^{-2}	2.85×10^{-2}	2.85×10^{-2}	2.85×10^{-2}
Oxygen-14 (10-yr average)	Ci/yr	7.5×10^{2}	7.32×10^{1}	8.33×10^{1}	5.63×10^{1}	8.33×10^{1}
1996 to 1997 average	Ci/yr		3.45×10^{2}	3.90×10^{2}	2.71×10^{2}	3.90×10^{2}
1998 to 2005 average	Ci/yr		5.29×10^{0}	6.61×10^{0}	2.65×10^{-0}	6.61×10^{0}
Oxygen-15 (10-yr average)	Ci/yr	2.84×10^{4}	2.79×10^{3}	3.18×10^{3}	2.09×10^{3}	3.18×10^{3}
1996 to 1997 average	Ci/yr		1.20×10^{4}	1.35×10^{4}	9.55×10^{3}	1.35×10^{4}
1998 to 2005 average	Ci/yr		4.84×10^{2}	6.06×10^{2}	2.32×10^{2}	6.06×10^{2}

TABLE 3.6.1–22.—*Parameter Differences Among Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*-Continued

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
LEDA Projections						
Oxygen-19 (8-yr average)	Ci/yr	Not Operating	2.16×10^{-3}	2.16×10^{-3}	2.16×10^{-3} [c]	2.16×10^{-3}
Sulfur-37 (8-yr average)	Ci/yr	Not Operating	1.81×10^{-3}	1.81×10^{-3}	1.81×10^{-3}	1.81×10^{-3}
Chlorine-39 (8-yr average)	Ci/yr	Not Operating	4.70×10^{-4}	4.70×10^{-4}	4.70×10^{-4}	4.70×10^{-4}
Chlorine-40 (8-yr average)	Ci/yr	Not Operating	2.19×10^{-3}	2.19×10^{-3}	2.19×10^{-3}	2.19×10^{-3}
Krypton-83m (8-yr average)	Ci/yr	Not Operating	2.21×10^{-3}	2.21×10^{-3}	2.21×10^{-3}	2.21×10^{-3}
Others (8-yr average)	Ci/yr	Not Operating	1.11×10^{-3}	1.11×10^{-3}	1.11×10^{-3}	1.11×10^{-3}
NPDES Discharge						
Total Discharges[d,e]	MGY (MLY)	16.8 (63.6)	67.7[f] (256)	81.8[f] (310)	26.2[f] (99.2)	81.8[f] (310)
03A–047	MGY (MLY)	2.64 (9.99)	4.7 (17.8)	7.1 (26.9)	2.3 (8.71)	7.1 (26.9)
03A–048	MGY (MLY)	8.56 (32.4)	15.6 (59.0)	23.4 (88.6)	7.7 (29.1)	23.4 (88.6)
03A–049	MGY (MLY)	4.15 (15.7)	7.5 (28.4)	11.3 (42.8)	3.7 (14.0)	11.3 (42.8)
03A–113	MGY (MLY)	0.9 (3.41)	39.7 (150)	39.8 (151)	12.3 (46.6)	39.8 (151)
03A–125	MGY (MLY)	0.18 (0.68)	0.18 (0.68)	0.18 (0.68)	0.18 (0.68)	0.18 (0.68)
03A–145	MGY (MLY)	0.37 (1.40)	0.0	0.0	0.0	0.0
Chemical Waste	lb/yr (kg/yr)	36,600[g] (16,600)	36,600 (16,600)	36,600 (16,600)	36,600 (16,600)	36,600 (16,600)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	3,530[h] (100)	5,510 (156)	38,300[i] (1,085)	5,510 (156)	38,300[i] (1,085)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	35[j] (1)	35 (1)	35 (1)	35 (1)	35 (1)
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	0	0	0	0
Electric Power	megawatts	29[k]	58	63	38	63
Electricity	gigawatt-hours	104[k]	372	437	163	437
Water	MGY (MLY)	78[l] (295)	218 (825)	265 (1,000)	108 (409)	265 (1,000)
Contaminated Space[m]	ft^3/ft^2 (m^3/m^2)	380,000 (10,750)	+19,000 (1,770)	+24,000 (2,230)	+19,000 (1,770)	+19,000 (1,770)
Number of Workers	FTEs	741[n]	856	856	731	856

TABLE 3.6.1–22.—*Parameter Differences Among Alternatives for Continued Operation of the Los Alamos Neutron Science Center (TA–53)*-Continued

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] 8-year average (1990 to 1997) is used as the basis for projected emissions for isotopes associated with the LEDA project. 5-year average (1991 to 1995) is used for the index for all other air emissions.
[c] For the Reduced Operations Alternative, power would be reduced from 40-million electron volts to 12-million electron volts. This would result in somewhat lower emissions; however, the relation is not linear. Therefore, no difference was shown in the Reduced Operations Alternative to remain conservative.
[d] Index is 1990 to 1995.
[e] All outfalls consist of process sources only.
[f] Values given across the alternatives are peak values for the 10 years. For most years, total discharges will be less.
[g] Index is 1990 to 1995.
[h] Index is 1992 to 1995.
[i] LLW volumes increase significantly in the Expanded Operations Alternative and Greener Alternative due to the LPSS project, which requires the decontamination and renovation of Experimental Area A (Building 53–03M).
[j] Assumed index value of 1. LLMW moratorium in mid 1990's caused changes in operations such that no more than 35 ft^3 (1 m^3) is expected.
[k] The index is the 6-year period 1990 to 1995.
[l] The index is 3-year average 1993 to 1995.
[m] Data are increments or decrements to the index. Index is May 1996. The index value is in ft^3 (m^3) because existing contamination is in materials in target areas that are best described in terms of volumes. The projections by alternative are in ft^2 (m^2) to recognize new areas that would have/handle irradiated or contaminated materials.
[n] Index is Fiscal Year 1995.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–23.—*Alternatives for the Continued Operation of the Health Research Laboratory (TA–43)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Genomic Studies	Conduct research utilizing molecular and biochemical techniques to analyze the genes of animals, particularly humans. Develop strategies at current levels to analyze the nucleotide sequence of individual genes, especially those associated with genetic disorders, and to identify their map genes and/or genetic diseases to locations on individual chromosomes. Part of this work is to map each nucleotide, in sequence, of each gene in all 46 chromosomes of the human genome.	Activities increased 25% above No Action Alternative.	Activities reduced to 20% of No Action Alternative.	Same as Expanded Operations Alternative.
Cell Biology	Conduct research at current levels utilizing whole cells and cellular systems, both in-vivo and in-vitro, to investigate the effects of natural and catastrophic cellular events like response to aging, harmful chemical and physical agents, and cancer.	Activities increased 40% above No Action Alternative.	Activities reduced to 30% of No Action Alternative.	Same as Expanded Operations Alternative.[a]
Cytometry	Conduct research utilizing laser imaging systems to analyze the structures and functions of subcellular systems.	Activities increased 33% above No Action Alternative.	Activities reduced to 25% of No Action Alternative.	Same as Expanded Operations Alternative.[a]
DNA Damage and Repair	Research using isolated cells to investigate DNA repair mechanisms.	Activities increased 40% above No Action Alternative.	Activities reduced to 30% of No Action Alternative.	Same as Expanded Operations Alternative.[a]

TABLE 3.6.1–23.—*Alternatives for the Continued Operation of the Health Research Laboratory (TA–43)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Environmental Effects	Research identifies specific changes that occur in DNA and proteins in certain microorganisms after events in the environment.	Activities increased 25% above No Action Alternative.	Activities reduced to 40% of No Action Alternative.	Same as Expanded Operations Alternative.[a]
Structural Cell Biology	Conduct research utilizing chemical and crystallographic techniques to isolate and characterize the three-dimensional shapes and properties of DNA and protein molecules.	Activities increased 50% above No Action Alternative.	Activities reduced to 20% of No Action Alternative.	Same as Expanded Operations Alternative.
Neurobiology	Conduct research using magnetic fields produced in active areas of the brain to map human brain locations associated with certain sensory and cognitive functions. Instrumentation is sensitive magnetic detection devices.	Activities increased to three times the level of the No Action Alternative.	Same activities as No Action Alternative.	Activities increased to two times the level of the No Action Alternative.
In-Vivo Monitoring	Continue 1,500 whole-body scans/yr as a service, a part of the LANL personnel monitoring program, which supports operations with radioactive materials conducted elsewhere at LANL.	Activities increased to 3,000 scans/yr.	Activities decreased to 500 scans/yr.	Same activities as Expanded Operations Alternative.

[a] Activity level is the same as Expanded Operations Alternative but FTE level is only slightly increased above the No Action Alternative. This is possible through use of more automated analytical apparatus.

TABLE 3.6.1–24.—*Parameter Differences in Alternatives for Continued Operation of the Health Research Laboratory (TA–43)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions	Ci/yr	Negligible	Not estimated	Not estimated	Not estimated	Not estimated
NPDES Discharge 03A–040[b]	MGY (MLY)	2.7[c] (10.2)	2.5[d] (9.46)	2.5 (9.46)	2.5 (9.46)	2.5 (9.46)
Chemical Waste	lb/yr (kg/yr)	10,800[e] (4,900)	15,400 (7,000)	28,700 (13,000)	11,000 (5,000)	28,700 (13,000)
Biomedical Waste	lb/yr (kg/yr)	290[e] (130)	110[f] (50)	620[g] (280)	110[f] (50)	620[f] (280)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	810[e] (23)	490 (14)	1,200 (34)	490 (14)	1,200 (34)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	14[e] (0.4)	95 (2.7)	120 (3.4)	88 (2.5)	120 (3.4)
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	0	0	0	0
Electric Power[j]	MW	0.445[i]	0.5	0.7	0.2	0.5
Water[j]	MGY (MLY)	10.5[j] (39.7)	12 (45.4)	15 (56.8)	4 (15.1)	12 (45.4)
Contaminated Space[k]			No change	No change	No change	No change
Total	ft^2 (m^2)	93,000 (8,640)				
Radiation Wing	ft^2 (m^2)	1,730 (160)				
Irradiator Suite	ft^2 (m^2)	840 (80)				
Number of Workers	FTEs	180[l]	190	250	70	200

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Outfall 03A–040 consists of one process outfall and nine storm drains. The process outfall is scheduled for elimination.
[c] Index is data from ESH–18 measurements for NPDES permit application and from estimates based on facility operations. No specific dates available.
[d] Storm water only. Estimated as the difference between total volume and process cooling water volume. An expected roof area increase of 10% is factored in as well.
[e] Index is 1994 to 1995 average.
[f] Waste comes from the animal colony. The animal colony was downsized substantially in the 1996 to 1997 period; waste in 1997 (calendar) was 165 lbs (75 kg). A future change in animal colony size is projected only for the Expanded Operations Alternative.
[g] Animal colony and the associated waste are projected to double.
[h] Facility-specific data are available for HRL, which is metered.
[i] The index is the average of 1994 (0.44 megawatts) and 1995 (0.45 megawatts) usage.
[j] The index is the average of 1993 (10 MGY [38 MLY]) and 1994 (11 MGY [42 MLY]) usage.
[k] Data are increments or decrements to the index. Index is May 1996.
[l] Index is Fiscal Year 1994, as adjusted by the facility subject matter expert.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–25.—*Alternatives for Continued Operation of the Radiochemistry Facility (TA–48)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radionuclide Transport Studies	Actinide transport, sorption, and bacterial interaction studies. Development of models for evolution of groundwater. Assessment of performance or risk of release for radionuclide sources at proposed waste disposal sites. 45 to 80 studies/yr.	Increased level of operations, approximately twice No Action Alternative. 80 to 160 studies/yr.	Reduced level of operations, approximately half No Action Alternative. 18 to 36 studies/yr.	Same level of activities as Expanded Operations Alternative, but activities are in support of environmental remediation.
Environmental Remediation Support	Background contamination characterization pilot studies. Performance assessments, soil remediation research and development, and field support at current levels.	Increased level of operations, approximately twice No Action Alternative.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Ultra-Low-Level Measurements	Isotope separation and mass spectrometry at current levels.	Increased level of operations, more than twice No Action Alternative.	Level of operations slightly reduced from No Action Alternative.	Same as Expanded Operations Alternative.
Nuclear/ Radiochemistry	Radiochemical operations involving quantities of alpha-, beta-, and gamma-emitting radionuclides at current levels for nonweapons and weapons work.	Slightly increased level of operations.	Reduced level of operations, approximately half of No Action Alternative.	About same activity level as No Action Alternative, but weapons work reduced by half, and nonweapons work increased by 10%.
Isotope Production	Target preparation. High-level beta/ gamma chemistry and target processing to recover isotopes for medical and industrial application.	Increased level of operations, approximately twice No Action Alternative.	Reduced level of operations, approximately half of No Action Alternative.	Same as No Action Alternative.
Actinide/ Transuranic Chemistry	Radiochemical operations involving significant quantities of alpha-emitting radionuclides at current level.	Increased level of operations, approximately twice No Action Alternative.	Reduced level of operations, approximately half of No Action Alternative.	Same level of activity as No Action Alternative, but activities are in support of nonweapons programs.

TABLE 3.6.1–25.—*Alternatives for Continued Operation of the Radiochemistry Facility (TA–48)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Data Analysis	Re-examination of archive data and measurement of nuclear process parameters of interest to weapons radiochemists at current levels.	Increased level of operations, approximately twice No Action Alternative.	Slightly reduced level of operations from No Action Alternative.	Same as Reduced Operations Alternative.
Inorganic Chemistry	Synthesis, catalysis, actinide chemistry (all activities at current level): • Chemical synthesis of new organo-metallic complexes • Structural and reactivity analysis, organic product analysis, and reactivity and mechanistic studies • Synthesis of new ligands for radiopharmaceuticals Environmental technology development (all activities at current level): • Ligand design and synthesis for selective extraction of metals • Soil washing • Membrane separator development • Ultra-filtration	Increased level of operations by 50% from No Action Alternative.	Same No Action Alternative.	Same as Expanded Operations Alternative.
Structural Analysis	Synthesis and structural analysis of actinide complexes at current levels. X-ray diffraction analysis of powders and single crystals at current levels.	Increased level of operations, almost twice No Action Alternative.	Same as No Action Alternative.	Same as Expanded Operations Alternative.
Sample Counting	Measurement of the quantity of radioactivity in samples using alpha-, beta-, and gamma-ray counting systems at current levels.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.1–26.—*Parameter Differences Among Alternatives for Continued Operation of the Radiochemistry Site (TA–48)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions						
Mixed Fission Products	Ci/yr	2.95×10^{-5}	1.1×10^{-4}	1.4×10^{-4}	6.9×10^{-5}	1.3×10^{-4}
Plutonium-239	Ci/yr	5.15×10^{-6}	5.5×10^{-6}	1.1×10^{-5}	5.2×10^{-6}	1.1×10^{-5}
Uranium-235[4]	Ci/yr	3.97×10^{-7}	4.0×10^{-7}	4.4×10^{-7}	2.0×10^{-7}	4.0×10^{-7}
Mixed Activation Products	Ci/yr	2.81×10^{-4}	1.6×10^{-6}	3.1×10^{-6}	7.8×10^{-7}	1.6×10^{-6}
Arsenic-72	Ci/yr	1.11×10^{-2}	5.6×10^{-5}	1.1×10^{-4}	2.8×10^{-5}	5.6×10^{-5}
Arsenic-73	Ci/yr	1.90×10^{-2}	9.5×10^{-5}	1.9×10^{-4}	4.8×10^{-5}	9.5×10^{-5}
Arsenic-74	Ci/yr	3.75×10^{-3}	2.0×10^{-5}	4.0×10^{-5}	9.8×10^{-6}	2.0×10^{-5}
Beryllium-7	Ci/yr	1.94×10^{-5}	7.4×10^{-6}	1.5×10^{-5}	3.6×10^{-6}	7.4×10^{-6}
Bromine-77	Ci/yr	2.37×10^{-2}	4.3×10^{-4}	8.5×10^{-4}	2.2×10^{-4}	4.3×10^{-4}
Germanium-68	Ci/yr	1.70×10^{-3}	8.5×10^{-6}	1.7×10^{-5}	4.3×10^{-6}	8.5×10^{-6}
Gallium-68	Ci/yr	1.70×10^{-3}	8.5×10^{-6}	1.7×10^{-5}	4.3×10^{-6}	8.5×10^{-6}
Rubidium-86	Ci/yr	2.76×10^{-5}	1.4×10^{-7}	2.8×10^{-7}	6.9×10^{-8}	1.4×10^{-7}
Selenium-75	Ci/yr	2.45×10^{-2}	1.6×10^{-4}	3.4×10^{-4}	8.3×10^{-5}	1.6×10^{-4}
NPDES Discharge						
Total Discharges	MGY (MLY)	15.6 (59.0)	4.1 (15.5)	4.1 (15.5)	4.1 (15.5)	4.1 (15.5)
03A–045[d]	MGY (MLY)	1.1[f] (4.16)	0.87[g] (3.29)	0.87 (3.29)	0.87 (3.29)	0.87 (3.29)
04A–016[e]	MGY (MLY)	6.3[f] (23.8)	No outfall[h]	No outfall	No outfall	No outfall
04A–131[e]	MGY (MLY)	0.95[f] (3.60)	No outfall[h]	No outfall	No outfall	No outfall
04A–152[e]	MGY (MLY)	4.0[f] (15.1)	No outfall[h]	No outfall	No outfall	No outfall
04A–153[d]	MGY (MLY)	3.2[f] (12.1)	3.2[g] (12.1)	3.2 (12.1)	3.2 (12.1)	3.2 (12.1)
Chemical Waste	lb/yr (kg/yr)	4,400 (2,000[i])	4,400 (2,000)	7,300 (3,300)	3,500 (1,600)	6,400 (2,900)
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	5,300 (150[i])	6,000 (170)	9,500 (270)	4,200 (120)	8,500 (240)
Low-Level Radioactive Mixed Waste	ft^3/yr (m^3/yr)	71 (2.0[i])	71 (2.0)	130 (3.8)	46 (1.3)	120 (3.4)
TRU/Mixed TRU Waste[j]	ft^3/yr (m^3/yr)	0	0	0	0	0
Contaminated Space[k]	ft^2 (m^2)	39,300 (3,600)	No change	No change	No change	No change
Number of Workers	FTEs	141[l]	171	248	132	248

TABLE 3.6.1–26.—*Parameter Differences Among Alternatives for Continued Operation of the Radiochemistry Site (TA–48)*-Continued

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Index data is the higher of stack emissions for 1994 or 1995.
[c] Uranium-235 index value is for 1994.
[d] Outfall consists of one process source and several storm water sources (roof drains).
[e] Outfall consists of one process source only.
[f] Index values from ESH–18 measurements for NPDES permit application and from estimates based on facility operations. No specific dates available.
[g] Estimates across the alternatives for outfalls 03A–045 and 04A–153 represent storm water only.
[h] Outfalls 04A–016 and 04A–152 were eliminated in August 1997, and these outfalls do not exist in any of the alternatives.
[i] Index 1990 to 1995 average.
[j] TRU waste is returned to the generating facility.
[k] Data are increments or decrements to the index. Index is May 1996.
[l] Index is February 1997 value.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–27.—*Alternatives for Continued Operation of the Radioactive Liquid Waste Treatment Facility (TA–50)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Waste Characterization, Packaging, Labeling	Support, certify, and audit generator characterization programs. Maintain waste acceptance criteria for RLW treatment facilities.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Waste Transport, Receipt, and Acceptance	Collect RLW from generators and transport to TA–50.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Radioactive Liquid Waste Pretreatment	Pretreat 185,000 gal/yr (700,000 l/yr) of RLW at TA–21. Pretreat 7,900 gal/yr (30,000 l/yr) of RLW from TA–55 in Room 60. Solidify, characterize, and package 71 ft^3/yr (2 m^3/yr) of TRU waste sludge in Room 60.	Pretreat 238,000 gal/yr (900,000 l/yr) of RLW at TA–21. Pretreat 21,100 gal/yr (80,000 l/yr) of RLW from TA–55 in Room 60. Solidify, characterize, and package 106 ft^3/yr (3 m^3/yr) of TRU waste sludge in Room 60.	Pretreat 158,000 gal/yr (600,000 l/yr) of RLW at TA–21. Pretreat 5,300 gal/yr (20,000 l/yr) of RLW from TA–55 in Room 60. Solidify, characterize, and package 71 ft^3/yr (2 m^3/yr) of TRU waste sludge in Room 60.	Pretreat 185,000 gal/yr (700,000 l/yr) of RLW at TA–21. Pretreat 6,600 gal/yr (25,000 l/yr) of RLW from TA–55 in Room 60. Solidify, characterize, and package 71 ft^3/yr (2 m^3/yr) of TRU waste sludge in Room 60.
Radioactive Liquid Waste Treatment	Install ultrafiltration and reverse osmosis equipment in 1997. Install equipment for nitrate reduction in 1999. Treat 6.6 MGY (25 MLY) of RLW. Dewater, characterize, and package 247 ft^3/yr (7 m^3/yr) of LLW sludge. Solidify, characterize, and package 812 ft^3/yr (23 m^3/yr) of TRU waste sludge.	Same as No Action Alternative except: • Treat 9.2 MGY (35 MLY) of RLW. • Dewater, characterize, and package 353 ft^3/yr (10 m^3/yr) of LLW sludge. • Solidify, characterize, and package 1,130 ft^3/yr (32 m^3/yr) of TRU waste sludge.	Same as No Action Alternative except: • Treat 5.3 MGY (20 MLY) of RLW. • Solidify, characterize, and package 671 ft^3/yr (19 m^3/yr) of TRU waste sludge.	Same as No Action Alternative.

TABLE 3.6.1–27.—*Alternatives for Continued Operation of the Radioactive Liquid Waste Treatment Facility (TA–50)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Decontamination Operations	Decontaminate personnel respirators for reuse (approximately 500/month). Decontaminate air-proportional probes for reuse (approximately 200/month). Decontaminate vehicles and portable instruments for reuse (as required). Decontaminate precious metals for resale (acid bath). Decontaminate scrap metals for resale (sand blast). Decontaminate 6,700 ft^3 (190 m^3) of lead for reuse (grit blast).	Same as No Action Alternative except: • Decontaminate LANL personnel respirators for reuse (approximately 700/month). • Decontaminate air-proportional probes for reuse (approximately 300/month). • Decontaminate 7,100 ft^3 (200 m^3) of lead for reuse (grit blast).	Same as No Action Alternative except: • Decontaminate LANL personnel respirators for reuse (approximately 300/month).	Same as No Action Alternative.

Note: Under all alternatives, influent storage tank upgrade, installation of a new process for treatment of radioactive liquid waste (RLW), and installation of additional treatment steps for removal of nitrates are all completed, as discussed in chapter 2 (section 2.2.2.14).

TABLE 3.6.1–28.—*Parameter Differences Among Alternatives for Continued Operations of the Radioactive Liquid Waste Treatment Facility (TA–50)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions[b]	Ci/yr	Negligible	Negligible	Negligible	Negligible	Negligible
Radioactive Liquid Waste Influent[c]	MGY (MLY)	5.3 (20.0)	6.6 (25.0)	9.3 (35.0)	5.3 (20.0)	6.6 (35.0)
NPDES Discharge Process[c]	MGY (MLY)	5.5[d] (20.8)	6.6 (25.0)	9.3 (35.0)	5.3 (20.0)	6.6 (25.0)
Radioactive Liquid Waste[d,e]	gal/yr (l/yr)	1,100 (4,000)	2,500 (9,500)	2,600 (10,000)	2,500 (9,500)	2,500 (9,500)
Chemical Waste[f]	lb/yr (kg/yr)	4,900 (2,200)	4,900 (2,200)	4,900 (2,200)	4,900 (2,200)	4,900 (2,200)
Low-Level Radioactive Waste[f]	ft^3/yr (m^3/yr)	5,300 (150)	5,300 (150)	5,600 (160)	5,300 (150)	5,300 (150)
Low-Level Radioactive Mixed Waste[g]	ft^3/yr (m^3/yr)	1,300 (38)	0	0	0	0
TRU/Mixed TRU Waste[f]	ft^3/yr (m^3/yr)	110 (3)	740 (21)	1,060 (30)	740 (21)	740 (21)
Contaminated Space[h]	ft^2 (m^2)	37,000 (3,400)	No change	No change	No change	No change
Number of Workers	FTEs	90[8]	98	110	96	98

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Radiological air emissions from this facility are minimal and would not vary across the alternatives.
[c] Outfall consists of process sources only.
[d] Index is 1994.
[e] Secondary wastes are generated during the treatment of RLW and as a result of decontamination operations. Examples include decontamination acid bath solutions and rinse waters, HEPA filters, personnel protective clothing and equipment, and sludges from the pretreatment and main RLW treatment processes.
[f] RCRA-listed hazardous chemicals are not used in RLWTF, and secondary mixed wastes are therefore not generated.
[g] Data are increments or decrements to the index. Index is May 1996. The index is the footprint of the facility; even though the entire facility is not contaminated, no other method of estimating contaminated space was devised.
[h] Index is Fiscal Year 1995.
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.1–29.—*Alternatives for Continued Operation of the Solid Radioactive and Chemical Waste Facilities (TA–54 and TA–50)*

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Waste Characterization, Packaging, and Labeling	Support, certify, and audit generator characterization programs. Maintain WAC for LANL waste management facilities. Characterize 26,800 ft^3 (760 m^3) of legacy LLMW. Characterize 318,000 ft^3 (9,010 m^3) of legacy TRU waste. Verify characterization data at the Radioactive Assay and Nondestructive Test Facility for unopened containers of LLW and TRU waste. Maintain WAC for off-site treatment, storage, and disposal facilities. Overpack and bulk waste as required. Perform coring and visual inspection of a percentage of TRU waste packages. Ventilate 16,700 drums of TRU waste retrieved during TWISP. Maintain current version of WIPP WAC and liaison with WIPP operations.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Compaction	Compact up to 614,000 ft^3 (17,400 m^3) of LLW.	Compact up to 897,000 ft^3 (25,400 m^3) of LLW.	Compact up to 590,000 ft^3 (16,700 m^3) of LLW.	Compact up to 706,000 ft^3 (20,000 m^3) of LLW.

TABLE 3.6.1–29.—*Alternatives for Continued Operation of the Solid Radioactive and Chemical Waste Facilities (TA–54 and TA–50)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Size Reduction	Size reduce 91,800 ft^3 (2,600 m^3) of TRU waste at WCRR Facility and the Drum Preparation Facility.	Size reduce 102,000 ft^3 (2,900 m^3) of TRU waste at WCRR Facility and the Drum Preparation Facility.	Same as No Action Alternative.	Same as No Action Alternative.
Waste Transport, Receipt, and Acceptance	Collect chemical and mixed wastes from LANL generators, and transport to TA–54. Begin shipments to WIPP in 1999. Over the next 10 years: • Ship 32,000 tons (29,000 metric tons) of chemical wastes and 127,000 ft^3 (3,590 m^3) of LLMW, for off-site land disposal restrictions (LDR) treatment and disposal. • Ship 1,437,000 ft^3 (40,700 m^3) of LLW for off-site disposal. • Ship 318,000 ft^3 (9,010 m^3) of legacy TRU waste to WIPP. • Ship 86,800 ft^3 (2,460 m^3) of operational and environmental restoration TRU waste to WIPP. • Ship 101,000 ft^3 (2,850 m^3) of LLMW (environmental restoration soils) for off-site solidification and disposal. Annually receive, on average, 177 ft^3 (5 m^3) of LLW and TRU waste from off-site locations in 5 to 10 shipments.	Same as No Action Alternative, except over next 10 years: • Ship 35,300 tons (32,000 metric tons) of chemical wastes and 128,000 ft^3 (3,640 m^3) of LLMW, for off-site LDR treatment and disposal. • Ship no LLW or environmental restoration soils for off-site disposal. • Ship 193,000 ft^3 (5,460 m^3) of operational and environmental restoration TRU waste to WIPP.	Same as No Action Alternative, except over next 10 years: • Ship 32,000 tons (29,000 metric tons) of chemical wastes and 126,000 ft^3 (3,570 m^3) of LLMW for off-site LDR treatment and disposal. • Ship 2,578,000 ft^3 (73,030 m^3) of LLW for off- site disposal. • Ship 67,100 ft^3 (1,900 m^3) of operational and environmental restoration TRU waste to WIPP.	Same as No Action Alternative, except over next 10 years: • Ship 32,000 tons (29,000 metric tons) of chemical wastes and 127,000 ft^3 (3,610 m^3) of LLMW, for off-site LDR treatment and disposal. • Ship 2,587,000 ft^3 (73,300 m^3) of LLW for off-site disposal. • Ship 88,000 ft^3 (2,490 m^3) of operational and environmental restoration TRU waste to WIPP.

TABLE 3.6.1–29.—*Alternatives for Continued Operation of the Solid Radioactive and Chemical Waste Facilities (TA–54 and TA–50)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Waste Storage	Stage chemical and mixed wastes prior to shipment for off-site treatment, storage, and disposal. Store legacy TRU waste and LLMW. Store LLW uranium chips until sufficient quantities have accumulated for stabilization.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Waste Retrieval	Begin retrieval operations in 1997. Retrieve 166,000 ft^3 (4,700 m^3) of TRU waste from Pads 1, 2, 4 by 2004.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Other Waste Processing	Demonstrate treatment (e.g., electrochemical) of LLMW liquids. Land farm oil-contaminated soils at Area J. Stabilize 14,500 ft^3 (410 m^3) of uranium chips. Provide special-case treatment for 23,700 ft^3 (670 m^3) of TRU waste.	Same as No Action Alternative except: Stabilize 30,700 ft^3 (870 m^3) of uranium chips. Provide special-case treatment for 36,400 ft^3 (1,030 m^3) of TRU waste. Solidify 101,000 ft^3 (2,850 m^3) of LLMW (environmental restoration soils) for disposal at Area G.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.1–29.—*Alternatives for Continued Operation of the Solid Radioactive and Chemical Waste Facilities (TA–54 and TA–50)*-Continued

ACTIVITY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Disposal	Over next 10 years: Dispose 3,530 ft^3 (100 m^3) of LLW in shafts at Area G. Dispose 1,271,000 ft^3 (36,000 m^3) of LLW in disposal cells at Area G. Dispose 3,530 ft^3/yr (100 m^3/yr) of administratively controlled industrial solid wastes in pits at Area J. Dispose nonradioactive classified wastes in shafts at Area J.	Same as No Action Alternative, except over next 10 years: • Dispose 14,800 ft^3 (420 m^3) of LLW in shafts at Area G. • Dispose 4,060,000 ft^3 (115,000 m^3) of LLW in disposal cells at Area G. • Expand on-site LLW disposal operations beyond existing Area G footprint.	Same as No Action Alternative, except over next 10 years: • Dispose 98,800 ft^3 (2,800 m^3) of LLW in disposal cells at Area G.	Same as No Action Alternative, except over next 10 years: • Dispose 14,500 ft^3 (410 m^3) of LLW in shafts at Area G. • Dispose 424,000 ft^3 (12,000 m^3) of LLW in disposal cells at Area G.

Note: Under all alternatives, the TRU waste Inspectable Storage Project storage domes for TRU wastes would be constructed, as discussed in chapter 2 (section 2.2.2.15).

TABLE 3.6.1–30.—*Parameter Differences Among Alternatives for Continued Operation of the Solid Radioactive and Chemical Waste Facilities (TA–54 and TA–50)*

PARAMETER	UNITS	INDEX[a]	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Radioactive Air Emissions[b]						
Tritium	Ci/yr	2.10×10^{1} [c]	4.83×10^{1}	6.09×10^{1}	4.83×10^{1}	5.46×10^{1}
Americium-241	Ci/yr	6.60×10^{-7}	6.60×10^{-7}	6.60×10^{-7}	6.60×10^{-7}	6.60×10^{-7}
Plutonium-238	Ci/yr	4.80×10^{-6}	4.80×10^{-6}	4.80×10^{-6}	4.80×10^{-6}	4.80×10^{-6}
Plutonium-239	Ci/yr	6.80×10^{-7}	6.80×10^{-7}	6.80×10^{-7}	6.80×10^{-7}	6.80×10^{-7}
Uranium-234	Ci/yr	8.00×10^{-6}	8.00×10^{-6}	8.00×10^{-6}	8.00×10^{-6}	8.00×10^{-6}
Uranium-235	Ci/yr	4.10×10^{-7}	4.10×10^{-7}	4.10×10^{-7}	4.10×10^{-7}	4.10×10^{-7}
Uranium-238	Ci/yr	4.00×10^{-6}	4.00×10^{-6}	4.00×10^{-6}	4.00×10^{-6}	4.00×10^{-6}
NPDES Discharge	MGY	No outfalls	No outfalls	No outfalls	No outfalls	No outfalls
Chemical Waste[d]	lb/yr (kg/yr)	243,000[e] (110,000)	2,030 (920)	2,030 (920)	2,030 (920)	2,030 (920)
Radioactive Liquid Waste	gal/yr (l/yr)	2,100[e] (8,000)	2,600 (10,000)	2,600 (10,000)	2,600 (10,000)	2,600 (10,000)
Low-Level Radioactive Waste[d]	ft^3/yr (m^3/yr)	3,100[e] (88)	6,100 (174)	6,100 (174)	6,100 (174)	6,100 (174)
Low-Level Mixed Waste[d]	ft^3/yr (m^3/yr)	110[e] (3)	140 (4)	140 (4)	140 (4)	140 (4)
TRU/Mixed TRU Waste[d]	ft^3/yr (m^3/yr)	950[e] (27)	950 (27)	950 (27)	950 (27)	950 (27)
Contaminated Space[f]	ft^2 (m^2)	Not estimated	+ 11,500 (1,100)	+ 11,500 (1,100)	+ 11,500 (1,100)	+ 11,500 (1,100)
Number of Workers	FTEs	144[g]	195	225	192	198

[a] Index was used as a point of reference for projecting data for alternatives (as discussed on page 3–3). Index is NOT a consistent time period across parameters or facilities. Each parameter is footnoted with the index used.
[b] Values for tritium were determined from the emission estimates for the index and the differences in waste volumes by alternative.
[c] Index for the emissions is 1990 to 1994.
[d] Secondary wastes are generated during the treatment, storage, and disposal of chemical and radioactive wastes. Examples include repackaging wastes from the visual inspection of TRU waste, HEPA filters, personnel protective clothing and equipment, and process wastes from size reduction and compaction. The large difference between the index and projections for chemical waste generation are due to a change in operations. The generation of barium-contaminated sands, formerly treated at Area L and disposed at Area J, was ended in 1995.
[e] Index is 1990 to 1995.
[f] This facility is expected (based on process knowledge) to have little or no contaminated space from past operations, so no estimate of the index was made (assumed to be none.) Data are increments or decrements from the index. The contaminated space projections are for activities in TA–50 (RAMROD and WCRR) that were previously reviewed under NEPA.
[g] Index is Fiscal Year 1995.
MGY = million gallons per year.

TABLE 3.6.1–31.—*Parameters for LANL Activities Other Than Those at the Key Facilities*

PARAMETER	UNITS	ONGOING	INDEX YEAR
Radioactive Air Emissions[a]			
Tritium	Ci/y	9.1×10^{2}	1994
Plutonium	Ci/y	3.3×10^{-6}	1994
Uranium	Ci/y	1.8×10^{-4}	1994
NPDES Discharge	MGY (MLY)	142 (537)	1996
Chemical Waste	lb/yr (kg/yr)	1,435,000 (651,000)	1990 to 1994
Low-Level Radioactive Waste	ft^3/yr (m^3/yr)	18,400 (520)	1990 to 1994
Low-Level Mixed Radioactive Waste	ft^3/yr (m^3/yr)	1,060 (30)	1990 to 1994
TRU/Mixed TRU Waste	ft^3/yr (m^3/yr)	0	
Contaminated Space[b]	ft^2 (m^2)	222,930 (20,700)	
	ft^3 (m^3)	224,060 (6,300)	1996
	tons (metric tons)	350 (320)	
Number of Workers	FTEs	6579	1996

[a] Stack emissions from previously active facilities (TA–33, TA–21, and TA–41); these are not projected as continuing emissions in the future. Does not include nonpoint sources.
[b] As discussed further in chapter 4, section 4.9.4, contaminated space is estimated by square footage where feasible. However, ductwork in some facilities, rubble from cleanup actions, and activated materials from accelerator target areas are better estimated on the basis of cubic footage (or in the case of lead shielding, in tonnage).
MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
LAND RESOURCES				
Land Use	No changes projected, except where specific environmental restoration actions change use from waste disposal back to research and development or explosives land uses (none specifically known at this time).	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Visual Resources	Temporary and minor changes due to equipment associated with construction and environmental restoration activities.	Same as No Action Alternative, plus effects of lighting for the transportation corridor constructed under this alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Noise	Continued ambient noise at existing levels, temporary and minor noise associated with construction, and explosives noise and vibration at increased frequencies and at the same amplitudes as compared to recent experience.	Individual activities similar to those under No Action Alternative. Additional construction would result in additional temporary and minor noise. Noise and vibration associated with explosives testing is more frequent under this alternative, but the amplitude is the same as compared to No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
GEOLOGY AND SOILS				
Geology	LANL activities are not expected to change geology in the area, trigger seismic events, or substantively change slope stability.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Soils	Minimal deposition of contaminants to soils and continued removal of existing contaminants under the Environmental Restoration Project.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
WATER RESOURCES				
Water Use	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 13 feet (4.0 meters).	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 15 feet (4.6 meters).	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 10 feet (3.1 meters).	Effect of water use over the next 10 years (extracted from main aquifer) is an average drop in DOE well fields of up to 14 feet (4.3 meters).
NPDES Outfall Volumes	261 MGY (988 MLY) discharged from outfalls (an increase of about 28 MGY (106 MLY) from recent discharges).	278 MGY (1,052 MLY) discharged from outfalls (an increase of about 45 MGY (170 MLY) from recent discharges).	218 MGY (825 MLY) discharged from outfalls (a decrease of about 15 MGY (57 MLY) from recent discharges).	275 MGY (1,041 MLY) discharged from outfalls (an increase of about 42 MGY (160 MLY) from recent discharges).
Effect of Outfall Flows on Groundwater Quantities	No substantial changes to groundwater quantities are expected, as compared to recent experience, due to outfall flows.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Surface Water Quality	Outfall water quality should be similar to or better than in recent experience, so surface water quality on the site is not expected to change substantially as compared to existing quality.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Surface Contaminant Transport	Continued outfall flows are not expected to result in substantial contaminant transport off the site.	Similar to No Action Alternative; the small increase in outfall flows (as compared to No Action) are not expected to result in substantial contaminant transport off site.	Same as No Action Alternative.	Same as Expanded Operations Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Groundwater Quality	Mechanisms for recharge to groundwater are highly uncertain; thus, the potential for LANL operations to contaminate groundwater is highly uncertain. It is possible that increased discharges could increase contaminant transport beneath Los Alamos Canyon and Sandia Canyon and off site due to increased recharge to intermediate perched groundwater. No other effects can be projected based on existing information.	Same as No Action Alternative.	Although NPDES outfall flows are lower than in the other alternatives, it is still possible that the flows under this alternative could transport contaminants beneath Los Alamos Canyon and Sandia Canyon and off site.	Same as No Action Alternative.
AIR QUALITY				
Criteria Pollutants	Criteria pollutant emissions are not expected to exceed ambient air quality standards and are not expected to approach levels that could affect human health.	Same as No Action Alternative. Construction activities associated with the expansion of Area G and the enhancement of pit manufacturing would be transitory and would not be expected to degrade air quality substantially.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Toxic Pollutants	Toxic air pollutants, including carcinogenic pollutants, are not expected to approach levels that could affect human health.	Firing site toxic emissions and the total of carcinogenic pollutant emissions exceeded screening values; but, more detailed analysis does not indicate that these emissions would have a significant effect on ecological resources or human health (see comments under those resource areas). Construction activities associated with the expansion of Area G and the enhancement of pit manufacturing would be transitory and would not be expected to degrade air quality substantially.	Same as No Action Alternative.	Same as No Action Alternative.
Radioactive Emissions Dose to the Public Maximally Exposed Individual (MEI)	3.1 millirem (mrem)/year to the LANL MEI (see human health effects below).	5.4 mrem/year to the LANL MEI (see human health effects below).	1.9 mrem/year to the LANL MEI (see human health effects below).	4.5 mrem/year to the LANL MEI (see human health effects below).
Radioactive Emissions Population Dose	About 14 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).	About 33 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).	About 11 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).	About 14 person-rem/year to the population within 50 miles (80 kilometers) of LANL (see human health effects below).
ECOLOGICAL AND BIOLOGICAL RESOURCES				
Biological Resources, Ecological Processes, and Biodiversity	No significant adverse impacts projected for biological resources, ecological processes, or biodiversity, including threatened and endangered species.	Same as the No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Habitat Reduction	No reduction in habitat projected.	Removal of about 7 acres (2.8 hectares) of habitat for small mammals and birds, plus fencing that could alter large mammal movement, are associated with the proposed dedicated road between TA–55 and TA–3. Gradual removal of up to approximately 41 acres (17 hectares) of pinyon-juniper woodland associated with the Area G expansion; corresponds to small wildlife habitat loss and disturbance.	Same as No Action Alternative.	Same as No Action Alternative.
Ecological Risk	No significant risk to biotic communities due to LANL legacy contamination or contamination due to ongoing operations.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
HUMAN HEALTH				
Public Health —Radiological (inhalation, ingestion, and external radiation pathways)[a]	Average total ingestion dose to: • Los Alamos County resident: 3.9 mrem/year of operation (2.0×10^{-6} excess LCFs/year of operation). • Non-Los Alamos County resident: 7.5 mrem/year of operation (3.8×10^{-6} excess LCFs/year of operation). • Nonresident recreational user: 0.2 mrem/year of operation (1.0×10^{-7} excess LCFs/year of operation). • Resident recreational user: 0.6 mrem/year of operation (2.8×10^{-7} excess LCFs/year of operation). Air pathway dose to: • LANL MEI: 3.11 mrem/year of operation (1.6×10^{-6} excess LCFs/year of operation). • Total population: 14 person-rem/year of operation (0.007 excess LCF/year of operation).	Average total ingestion doses are the same as under the No Action Alternative. Air pathway dose to: • LANL MEI: 5.44 mrem/year of operation (2.7×10^{-6} excess LCFs/year of operation). • Total population: 33 person-rem/year of operation (0.017 excess LCF/year of operation).	Average total ingestion doses are the same as under the No Action Alternative. Air pathway dose to: • LANL MEI: 1.88 mrem/year of operation (9.4×10^{-7} excess LCFs/year of operation). • Total population: 11 person-rem/year of operation (0.005 excess LCF/year of operation).	Average total ingestion doses are the same as under the No Action Alternative. Air pathway dose to: • LANL MEI: 4.52 mrem/year of operation (2.3×10^{-6}excess LCFs/year of operation). • Total population: 14 person-rem/year of operation (0.007 excess LCF/year of operation).
Public Health —Chemical	No significant effect to off-site residents or to the recreational user.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Special Pathways	No significant effect through special pathways (< 1×10^{-6} excess LCFs/year of operation).	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Worker Health—Radiological[a]	• Collective worker dose: 446 person-rem/year of operation (0.18 excess LCF/year of operation). • Average (non-zero) worker dose: 0.14 rem/year of operation (0.00005 excess LCF/year of operation).	• Collective worker dose: 833 person-rem/year of operation (0.33 excess LCF/year of operation). • Average (non-zero) worker dose: 0.24 rem/year of operation (0.000096 excess LCF/year of operation).	• Collective worker dose: 170 person-rem/year of operation (0.07 excess LCF/year of operation). • Average (non-zero) worker dose: 0.08 rem/year of operation (0.00003 excess LCF/year of operation).	• Collective worker dose: 472 person-rem/year of operation (0.19 excess LCF/year of operation). • Average (non-zero) worker dose: 0.14 rem/year of operation (0.00005 excess LCF/year of operation).
Worker Health—Chemical	1 to 3 reportable chemical exposures per year (none expected to result in serious injury or in fatalities).	2 to 5 reportable chemical exposures per year (none expected to result in serious injury or in fatalities).	Same as No Action Alternative.	Same as No Action Alternative.
Worker Health—Physical Safety Hazards	About 445 reportable cases per year.	About 507 reportable cases per year.	About 417 reportable cases per year.	Same as No Action Alternative.
ENVIRONMENTAL JUSTICE				
Environmental Justice Impacts	No disproportionately high or adverse impacts to minority or low-income populations identified.	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
CULTURAL RESOURCES				
Prehistoric Resources	Negligible to minor potential for effects to some prehistoric resources due to shrapnel or vibrations from explosives testing. However, inspection of resources does not indicate that past operations have caused such effects. Other effects of ongoing operations are negligible or small compared to legacy contamination and natural effects.	Similar to the impacts under No Action, except that Expanded Operations would mean increased frequency of explosives testing (potentially accelerating any damage due to shrapnel and ground vibration). In addition, the expansion of Area G could affect 15 NRHP sites; it is anticipated that a determination of no adverse effect would be achieved based on a data recovery plan.	Same as No Action Alternative.	Same as No Action Alternative.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Historic Resources	Negligible potential for future operations to add contaminants that may limit preservation options. Other effects of ongoing operations are negligible or small compared to legacy contamination and natural effects.	Similar to the impacts under No Action, except that Expanded Operations would mean increased frequency of explosives testing (potentially accelerating damage due to shrapnel and ground vibration).	Same as No Action Alternative.	Same as No Action Alternative.
Traditional Cultural Properties	Unknown due to a lack of information on specific TCPs. Potential for effects to all types of TCPs due to changes in water quality and quantity, erosion, explosives testing shrapnel, noise and vibrations from explosives testing, and contamination from ongoing operations. Security at LANL can prevent access by traditional communities to some TCPs.	Highly uncertain due to a lack of information on specific TCPs. Similar to the impacts under No Action, except that Expanded Operations would mean increased frequency of explosives testing (potentially accelerating damage due to shrapnel, ground vibration, and noise). Additionally, TCPs could be affected by the expansion of Area G; coordination with the four Accord Pueblos would be pursued to identify and mitigate any potential adverse effects.	Same as No Action Alternative.	Same as No Action Alternative.
SOCIOECONOMICS, INFRASTRUCTURE, AND WASTE MANAGEMENT				
LANL Employment	9,977 full-time equivalents	11,351 full-time equivalents	9,347 full-time equivalents	9,968 full-time equivalents
Tri-County Employment	Increase of 691 full-time equivalents, as compared to the 1995 regional employment, about 85,720.	Increase of 2,186 full-time equivalents, as compared to 1995 regional employment.	Decrease of 33 full-time equivalents, as compared to 1995 regional employment.	Increase of 680 full-time equivalents, as compared to 1995 regional employment.
Tri-County Population	Increase of 1,337 people, as compared to the estimated 1996 Tri-County population of 165,938.	Increase of 4,230 people, as compared to the 1996 estimated population.	Decrease of 64 people, as compared to the 1996 estimated population.	Increase of 1,316 people, as compared to the 1996 estimated population.

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Tri-County Personal Income	Increase of about $53 million, as compared to the 1994 estimate of $3.5 billion.	Increase of $172 million, as compared to the 1994 estimate.	Decrease of $6 million, as compared to the 1994 estimate.	Increase of $55 million, as compared to the 1994 estimate.
Maximum Annual Electrical Demand	717 gigawatt-hours	782 gigawatt-hours	508 gigawatt-hours	782 gigawatt-hours
Peak Electrical Demand	108 megawatts (exceeds supply during winter and summer months). May result in brownouts.	113 megawatts (exceeds supply during winter and summer months). May result in brownouts.	88 megawatts (exceeds supply during winter and within the existing supply throughout the rest of the year). May result in brownouts.	113 megawatts (exceeds supply during winter and summer months). May result in brownouts.
Maximum Annual Natural Gas Demand	1,840,000 decatherms (well within existing supply capacity).	Same as No Action Alternative.	Same as No Action Alternative.	Same as No Action Alternative.
Maximum Annual Water Demand	712 MGY (2,700 MLY) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water).	759 MGY (2,900 MLY) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water).	602 MGY (2,300 MLY) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water).	759 MGY (2,900 MLY) (DOE rights to water from main aquifer are adequate to meet this demand and other demands that draw from this right to water).
Annual Chemical Waste Generation	6,364,000 pounds (2,886,000 kilograms)	7,164,000 pounds (3,249,000 kilograms)	6,346,000 pounds (2,878,000 kilograms)	6,372,000 pounds (2,890,000 kilograms)
Annual LLW Generation (includes LLMW)	344,000 cubic feet (9,752 cubic meters)	454,000 cubic feet (12,873 cubic meters)	338,000 cubic feet (9,581 cubic meters)	382,000 cubic feet (10,825 cubic meters)
Annual TRU Waste Generation (includes Mixed TRU)	19,000 cubic feet (537 cubic meters)	19,300 cubic feet (546 cubic meters)	6,700 cubic feet (190 cubic meters)	8,800 cubic feet (250 cubic meters)

TABLE 3.6.2–1.—*Comparison of Potential Consequences of Continued Operations of LANL: Normal Operations*-Continued

RESOURCE AREA	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Increase in Contaminated Space	Increase of 63,000 square feet (5,900 square meter), as compared to the index.	Increase of 73,000 square feet (6,800 square meter), as compared to the index.	Same as No Action Alternative.	Same as No Action Alternative.
TRANSPORTATION (INCIDENT FREE)				
Public Radiation Exposure (Off-Site Shipments)[a]	• Along route: 3.3 person-rem/year of operation (0.0017 excess LCF/year of operation). • Sharing route: 30 person-rem/year of operation (0.015 excess LCF/year of operation). • At rest stops: 210 person-rem/year of operation (0.11 excess LCF/year of operation). • MEI: 0.0003 rem/year of operation (1.5×10^{-7} excess LCFs/year of operation).	• Along route: 4.2 person-rem/year of operation (0.0021 excess LCF/year of operation). • Sharing route: 37 person-rem/year of operation (0.019 excess LCF/year of operation). • At rest stops: 270 person-rem/year of operation (0.14 excess LCF/year of operation). • MEI: 0.0004 rem/year of operation (1.9×10^{-7} excess LCFs/year of operation).	• Along route: 3.5 person-rem/year of operation (0.0017 excess LCF/year of operation). • Sharing route: 31 person-rem/year of operation (0.015 excess LCF/year of operation). • At rest stops: 230 person-rem/year of operation (0.12 excess LCF/year of operation). • MEI: 0.0003 rem/year of operation (1.6×10^{-7} excess LCFs/year of operation).	• Along route: 3.6 person-rem/year of operation (0.0018 excess LCF/year of operation). • Sharing route: 33 person-rem/year of operation (0.015 excess LCF/year of operation). • At rest stops: 250 person-rem/year of operation (0.12 excess LCF/year of operation). • MEI: 0.0003 rem/year of operation (1.7×10^{-7} excess LCFs/year of operation).
Worker (Drivers) Radiation Exposure[a]	• Off-site: 470 person-rem/year of operation (0.19 excess LCF/year of operation). • On-site: 4.2 person-rem/year of operation (0.0018 excess LCF/year of operation).	• Off-site: 580 person-rem/year of operation (0.23 excess LCF/year of operation). • On-site: 10.3 person-rem/year of operation (0.0041 excess LCF/year of operation).	• Off-site: 510 person-rem/year of operation (0.21 excess LCF/year of operation). • On-site: 4.3 person-rem/year of operation (0.0017 excess LCF/year of operation).	• Off-site: 530 person-rem/year of operation (0.21 excess LCF/year of operation). • On-site: 4.5 person-rem/year of operation (0.0018 excess LCF/year of operation).

[a] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., a maximally exposed individual [MEI]), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

Note: The impacts of implementing the proposed actions in the Surplus Plutonium Disposition EIS; Lead Test Assembly (chapter 1, section 1.5.8); Siting and Construction, and Operation of the Spallation Neutron Source (chapter 1, section 1.5.9); and Conveyance and Transfer of Certain Land Tracts Located Within Los Alamos County and Los Alamos National Laboratory EIS (chapter 1, section 1.5.10) are summarized in chapter 5, section 5.6.

MGY = million gallons per year; MLY = million liters per year.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
TRANSPORTATION ACCIDENTS[c,f]					
Vehicle Accidents (No Cargo Release)	Accidents per year	4.5	9.0	4.9	5.2
	Resulting injuries per year	3.8	7.6	3.3	3.8
	Resulting fatalities per year	0.38	0.78	0.33	0.44
Release of Radioactive Cargo (Bounding Off-Site Accidents)	Radiation dose (person-rem/year)	2.8	3.0	2.8	3.0
	Resulting excess LCF per year of operation (total along entire route)	0.0014	0.0016	0.0014	0.0016
Release of Radioactive Cargo (Bounding On-Site Accidents)	Plutonium-238: Accidents per year MEI dose (rem) Resulting MEI risk	8.8×10^{-8} 8.7 7.7×10^{-7} rem/yr (3.1×10^{-10} excess LCFs/yr)	1.7×10^{-7} 8.7 1.4×10^{-6} rem/yr (5.8×10^{-10} excess LCFs/yr)	8.8×10^{-8} 8.7 7.7×10^{-7} rem/yr (3.1×10^{-10} excess LCFs/yr)	8.8×10^{-8} 8.7 7.7×10^{-7} rem/yr (3.1×10^{-10} excess LCFs/yr)
	Irradiated targets: Accident frequency MEI consequence Resulting MEI risk	3.1×10^{-6} Acute fatality 3.1×10^{-6} fatalities/yr	3.2×10^{-6} Acute fatality 3.2×10^{-6} fatalities/yr	2.9×10^{-6} Acute fatality 2.9×10^{-6} fatalities/yr	3.2×10^{-6} Acute fatality 3.2×10^{-6} fatalities/yr
Release of Chemical Cargo	Chlorine: Injuries per year (total)	0.006	0.013	0.0056	0.006
	Chlorine: Fatalities per year (total)	0.0016	0.0036	0.0015	0.0016
	Propane: Injuries per year (total)	0.0014	0.0031	0.0014	0.0014
	Propane: Fatalities per year (total)	0.00035	0.00076	0.00032	0.00035
ACCIDENTS (OTHER THAN TRANSPORTATION ACCIDENTS AND WORKER PHYSICAL SAFETY INCIDENTS/ACCIDENTS)[c]					
SITE–01: Site-Wide Earthquake with Severe Damage to Multiple Low-Capacity Facilities[a]	Event frequency (per year)	0.0029	0.0029	0.0029	0.0029
	MEI dose (rem)	20	20	20	20
	Public exposure (person-rem) excess LCF	27,726 16	27,726 16	27,726 16	27,726 16

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
SITE–02: Site-Wide Earthquake with Severe Damage to Multiple Moderate-Capacity Facilities[a]	Event frequency (per year)	0.00044	0.00044	0.00044	0.00044
	MEI dose (rem)	34	34	34	34
	Public exposure (person-rem) excess LCF	41,340 24	41,340 24	41,340 24	41,340 24
SITE–03: Site-Wide Earthquake with Severe Damage to Essentially All Facilities[a,d]	Event frequency (per year)	0.000071	0.000071	0.000071	0.000071
	MEI dose (rem)	247	247	247	247
	Public exposure (person-rem) excess LCF	210,758 134	210,758 134	210,758 134	210,758 134
SITE–04: Site-Wide Wildfire Consuming Combustible Structures and Vegetation	Event frequency (per year)	0.1	0.1	0.1	0.1
	MEI dose (rem)	< 25	< 25	< 25	< 25
	Public exposure (person-rem) excess LCF	675 0.34	675 0.34	669 0.33	675 0.34
RAD–12: Plutonium Release from a Seismically Initiated Event	Event frequency (per year)	approximately 1.5×10^{-6}	approximately 1.5×10^{-6}	approximately 1.5×10^{-6}	approximately 1.5×10^{-6}
	MEI dose (rem)	138	138	138	138
	Public exposure (person-rem) excess LCF	approximately 35,800 18	approximately 35,800 18	approximately 35,800 18	approximately 35,800 18
	Worker Consequences	Any in the facility would be killed by explosion or falling debris	Any in the facility would be killed by explosion or falling debris	Any in the facility would be killed by explosion or falling debris	Any in the facility would be killed by explosion or falling debris

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
CHEM–01: Single Cylinder Chlorine Release from Potable Water Treatment Station (TA–0)	Event frequency (per year)	0.0012	0.0013	0.0011	0.0012
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2[b]	 12 43	 12 43	 12 43	 12 43
	Worker consequences	If workers are present, there is potential for worker injury or fatality.	If workers are present, there is potential for worker injury or fatality.	If workers are present, there is potential for worker injury or fatality.	If workers are present, there is potential for worker injury or fatality.
CHEM–02: Multiple Cylinder Chlorine Release from Toxic Gas Storage Facility (TA–3)	Event frequency (per year)	0.00013	0.00015	0.00012	0.00013
	MEI	NA	NA	NA	NA
	Public exposed to > ERPG–3 or > ERPG–2	292	292	292	292
	Worker consequences	Possible injuries or fatalities to workers present at time of accident or responding to accident.	Possible injuries or fatalities to workers present at time of accident or responding to accident.	Possible injuries or fatalities to workers present at time of accident or responding to accident.	Possible injuries or fatalities to workers present at time of accident or responding to accident.
CHEM–03: Single Cylinder Chlorine Release from Toxic Gas Storage Facility (TA–3)	Event frequency (per year)	0.00012	0.00012	0.00012	0.00012
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 239 263	 239 263	 239 263	 239 263
	Worker consequences	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.	Unlikely that workers are present; but if present, there is potential for worker injury or fatality.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
CHEM–04: Bounding Single Container Release of Toxic Gas (Selenium Hexaflouride) from Toxic Gas Cylinder Storage (TA–54)	Event frequency (per year)	0.004	0.004	0.004	0.004
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 0 0	 0 0	 0 0	 0 0
	Worker consequences	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.
CHEM–05: Bounding Multiple Cylinder Release of Toxic Gas (Sulfur Dioxide) from Toxic Gas Cylinder Storage (TA–54)	Event frequency (per year)	0.00051	0.00051	0.00051	0.00051
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 0 0	 0 0	 0 0	 0 0
	Worker consequences	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.	Possible injuries or fatalities to up to 5 workers present at time of accident.
CHEM–06: Chlorine Gas Release from Plutonium Facility (TA–55) Process Line	Event frequency (per year)	0.063	0.063	0.063	0.063
	MEI	NA	NA	NA	NA
	Public exposed to: > ERPG–3 > ERPG–2	 7 102	 7 102	 7 102	 7 102
	Worker consequences	Unlikely that workers are present; but if present, there is potential for worker injury.	Unlikely that workers are present; but if present, there is potential for worker injury.	Unlikely that workers are present; but if present, there is potential for worker injury.	Unlikely that workers are present; but if present, there is potential for worker injury.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–01: Plutonium Release from Container Storage Area Fire Involving TRU Waste Drums (TA–54)	Event frequency (per year)	0.0016	0.0016	0.0016	0.0016
	MEI dose (rem)	46	46	46	46
	Public exposure (person-rem) excess LCF	72 0.04	72 0.04	72 0.04	72 0.04
	Worker consequences	Potential for plutonium inhalation, but no fatalities would be expected.	Potential for plutonium inhalation, but no fatalities would be expected.	Potential for plutonium inhalation, but no fatalities would be expected.	Potential for plutonium inhalation, but no fatalities would be expected.
RAD–03: Reactivity Excursion at Pajarito Site (TA–18) Kiva #3, Vaporizing Some Enriched Uranium Fuel and Melting the Remainder	Event frequency (per year)	3.4×10^{-6}	3.4×10^{-6}	3.4×10^{-6}	3.4×10^{-6}
	MEI dose rem[e]	150	150	150	150
	Public exposure (person-rem) excess LCF	110 0.06	110 0.06	110 0.06	110 0.06
	Worker consequences	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.
RAD–05: Aircraft Crash with Explosion and/or Fire at TA–21 Resulting in Tritium Oxide Release	Event frequency (per year)	5.3×10^{-6}	5.3×10^{-6}	5.3×10^{-6}	5.3×10^{-6}
	MEI dose (rem)	0.01	0.01	0.01	0.01
	Public exposure (person-rem) excess LCF	24 0.01	24 0.01	24 0.01	24 0.01
	Worker consequences	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.	Aircraft crash could cause injuries and accidents to workers present; workers not affected by crash could be exposed to tritium oxide released by crash.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–07: Plutonium Release due to Container Storage Area Fire Involving TRU Waste Drums (TA–50)	Event frequency (per year)	0.00015	0.0003	0.00011	0.00015
	MEI dose (rem)	74	74	74	74
	Public exposure (person-rem) excess LCF	1,300 0.69	1,300 0.69	1,300 0.69	1,300 0.69
	Worker consequences	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.
RAD–08: Aircraft Crash with Explosion and/or Fire at the TRU Waste Area at TA–54	Event frequency (per year)	4.3×10^{-6}	4.3×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
	MEI dose (rem)	22	22	22	22
	Public exposure (person-rem) excess LCF	400 0.2	400 0.2	400 0.2	400 0.2
	Worker consequences	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and fatalities to workers present; workers not affected by crash could be exposed to plutonium released by crash.
RAD–09: Transuranic Waste Drum Failure or Puncture at TA–54, Area G (results are for typical drum)	Event frequency (per year)	0.4	0.49	0.4	0.4
	MEI dose (rem)	0.41	0.41	0.41	0.41
	Public exposure (person-rem) excess LCF	4.3 0.002	4.3 0.002	4.3 0.002	4.3 0.002
	Worker consequences	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.	Some workers could inhale plutonium (dose would depend on protective measures taken), but no acute fatalities would be expected.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–13: Plutonium Melting and Release Accident at Pajarito Site (TA–18) Kiva #3	Event frequency (per year)	0.000016	0.000016	0.000016	0.000016
	MEI dose (rem)	120	120	120	120
	Public exposure (person-rem) excess LCF	160 0.08	160 0.08	160 0.08	160 0.08
	Worker consequences	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.	No acute fatalities would be expected.
RAD–15: Plutonium Release from a Wing Fire at the CMR Building (in TA–3)	Event frequency (per year)	0.000032	0.000032	0.000032	0.000032
	MEI dose (rem)	40	91	40	40
	Public exposure (person-rem) excess LCF	1,700 0.85	3,400 1.7	1,700 0.85	1,700 0.85
	Worker consequences	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.	1 to 3 workers present in accident location could be injured or killed due to fire; if not killed, could inhale plutonium. Other workers in the area could be affected by smoke inhalation.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
RAD–16: Aircraft Crash with Explosion and/or Fire at the CMR Building (in TA–3) Resulting in a Plutonium Release	Event frequency (per year)	3.5×10^{-6}	3.5×10^{-6}	3.5×10^{-6}	3.5×10^{-6}
	MEI dose (rem)	3	3	3	3
	Public exposure (person-rem) excess LCF	56 0.03	56 0.03	56 0.03	56 0.03
	Worker consequences	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.	Aircraft crash could cause injuries and accidents to nearly all workers in the building; workers not affected by crash could be exposed to plutonium released by crash.
WORK–01: Worker Fatality Due to Inadvertent High Explosives Detonation	Event frequency (per year)	0.001 to 0.01	0.0015 to 0.015	0.0008 to 0.008	0.0006 to 0.006
	Worker injuries or fatalities	1 to 10 injuries or fatalities.	1 to 10 injuries or fatalities.	1 to 10 injuries or fatalities.	1 to 10 injuries or fatalities.
WORK–02: Worker Illness or Fatality Due to Inadvertent Biohazard Contamination	Event frequency (per year)	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1
	Worker injuries or fatalities	1 injury or fatality.	1 injury or fatality.	1 injury or fatality.	1 injury or fatality.
WORK–03: Multiple Worker Fatality Due to Inadvertent Nuclear Criticality Event	Event frequency (per year)	< 0.00001	< 0.00001	< 0.00001	< 0.00001
	Worker exposures or fatalities	Substantial doses and possible fatalities.	Substantial doses and possible fatalities.	Substantial doses and possible fatalities.	Substantial doses and possible fatalities.
WORK–04: Worker Injury or Fatality Due to Inadvertent Nonionizing Radiation Exposure	Event frequency (per year)	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1
	Worker injuries or fatalities	Typically 1, rarely several, injuries or fatalities.	Typically 1, rarely several, injuries or fatalities.	Typically 1, rarely several, injuries or fatalities.	Typically 1, rarely several, injuries or fatalities.

TABLE 3.6.2–2.—*Comparison of Potential Consequences of Continued Operations of LANL: Accidents*-Continued

ACCIDENT	MEASURE	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
WORK–05: Worker Exposure to Plutonium Released from a Degraded Storage Container at TA–55	Event frequency (per year)	0.23	0.23	0.23	0.23
	Worker injuries or fatalities	1 or 2 workers potentially exposed to plutonium inhalation.	1 or 2 workers potentially exposed to plutonium inhalation.	1 or 2 workers potentially exposed to plutonium inhalation.	1 or 2 workers potentially exposed to plutonium inhalation.

[a] Workers in buildings that are structurally damaged or collapse could be injured or killed, but the number of workers injured or killed cannot be predicted a priori. Worker excess latent cancer fatalities due to radiological releases in an earthquake and worker injuries or fatalities due to chemical releases in an earthquake are expected to be small or modest increments to the impacts directly attributable to the earthquake (e.g., the collapse of structures). The estimates of event frequencies and impacts are conservative.

[b] ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without irreversible or serious health effects or symptoms that could impair their abilities to take protective action. ERPG–3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without life-threatening health effects.

[c] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., a maximally exposed individual [MEI]), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

[d] There is a potential for fault rupturing to occur at the CMR Building (TA–3–29) at a somewhat lower frequency than the SITE–03 earthquake (estimated at 1 to 3 x 10^{-5} per year). Should this occur in association with the SITE–03 earthquake, a conservative estimate results in an additional 133,833 person-rem population exposure (increasing LCFs by 99), and an increase to the MEI of 134 rem.

[e] The MEI dose is provided, under this accident scenario, for an individual located on Pajarito Road at a distance of 50 meters from the facility, even though Pajarito Road would be closed to the public during outdoor operations.

[f] Transportation accidents are typically calculated using computer codes, considering varying accident rates for route types, varying populations along the routes, and other factors. The calculated risks are presented as the product of the accident frequency and the accident consequence; for such calculations, the frequency and consequence terms are not readily accessible from the calculational results. As such, this table reflects the risks associated with transportation accidents, but generally does not separately present the consequence and frequency terms. The on-site radioactive transportation analyses were done by hand calculations, and for these accidents, frequency, consequence, and risk are all presented separately in the table.

Note: Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same.

CHAPTER 4.0
AFFECTED ENVIRONMENT

LANL is located in north-central New Mexico, 60 miles (97 kilometers) north-northeast of Albuquerque, 25 miles (40 kilometers) northwest of Santa Fe, and 20 miles (32 kilometers) southwest of Española in Los Alamos and Santa Fe Counties (Figure 4.0–1). LANL and the surrounding region are characterized by forested areas with mountains, canyons, and valleys, as well as diverse cultures and ecosystems.

The area is dominated by the Jemez Mountains to the west and the Sangre de Cristo Mountains to the east. These two mountain ranges and the State of New Mexico are divided north to south by the Rio Grande. LANL is located on the Pajarito Plateau, a volcanic shelf on the eastern slope of the Jemez Mountains at an approximate elevation of 7,000 feet (2,135 meters). The Pajarito Plateau is cut by 13 steeply sloped and deeply eroded canyons that have formed isolated finger-like mesas running west to east. The Santa Fe National Forest, which includes the Dome Wilderness Area, lies to the north, west, and south of LANL. The American Indian Pueblo of San Ildefonso and the Rio Grande border the site on the east, and the Bandelier National Monument (BNM) and Bandelier Wilderness Area lie directly south.

A large variety of natural, cultural, and scientific resources lie within the LANL region. The Pajarito Plateau is one of the longest continually occupied areas in the U.S. The archaeological and historical resources of the LANL site reflect the length of temporal occupation as well as the diversity in the cultures of its occupants. American Indian and Hispanic communities—where traditional ceremonies and customs are still honored—and the ruins of prehistoric cultures surround LANL. The County of Los Alamos has developed a unique science-support community culture of its own since the creation of Los Alamos townsite as a LANL "company town." LANL has played a leading role in scientific research in this country since 1943, including the design and development of nuclear weapons, and continues to offer support to the world's scientific community.

The ecosystems in the region are diverse due to the 5,000-foot (1,525-meter) gradient that extends between the Rio Grande Valley on the eastern edge of LANL and the top of Pajarito Mountain on its western border. Variations in precipitation and temperature and differences in the amount of sunlight that reach the north-facing and south-facing canyon slopes have resulted in a diversity of plant life, wildlife, and soils. The mosaic of mesa tops, mountains, canyon bottoms, cliffs, and steep slopes within this region support the habitats of several threatened and endangered species including the Mexican spotted owl, peregrine falcon, and bald eagle.

This chapter describes the environmental setting and existing conditions associated with LANL and DOE's operations at LANL. The information presented in this chapter forms a baseline description for use in evaluating the environmental impacts of the four identified SWEIS alternatives. Much of the information presented in this chapter is drawn from LANL's Environmental Surveillance and Compliance Program, which is described below.

Environmental Surveillance and Compliance at LANL

DOE requires monitoring of LANL and the surrounding region for radiation, radioactive materials, and hazardous chemicals. The LANL Environmental Surveillance and Compliance Program (in previous years, this program was referred to as the Environmental Surveillance Program) is intended to meet this requirement,

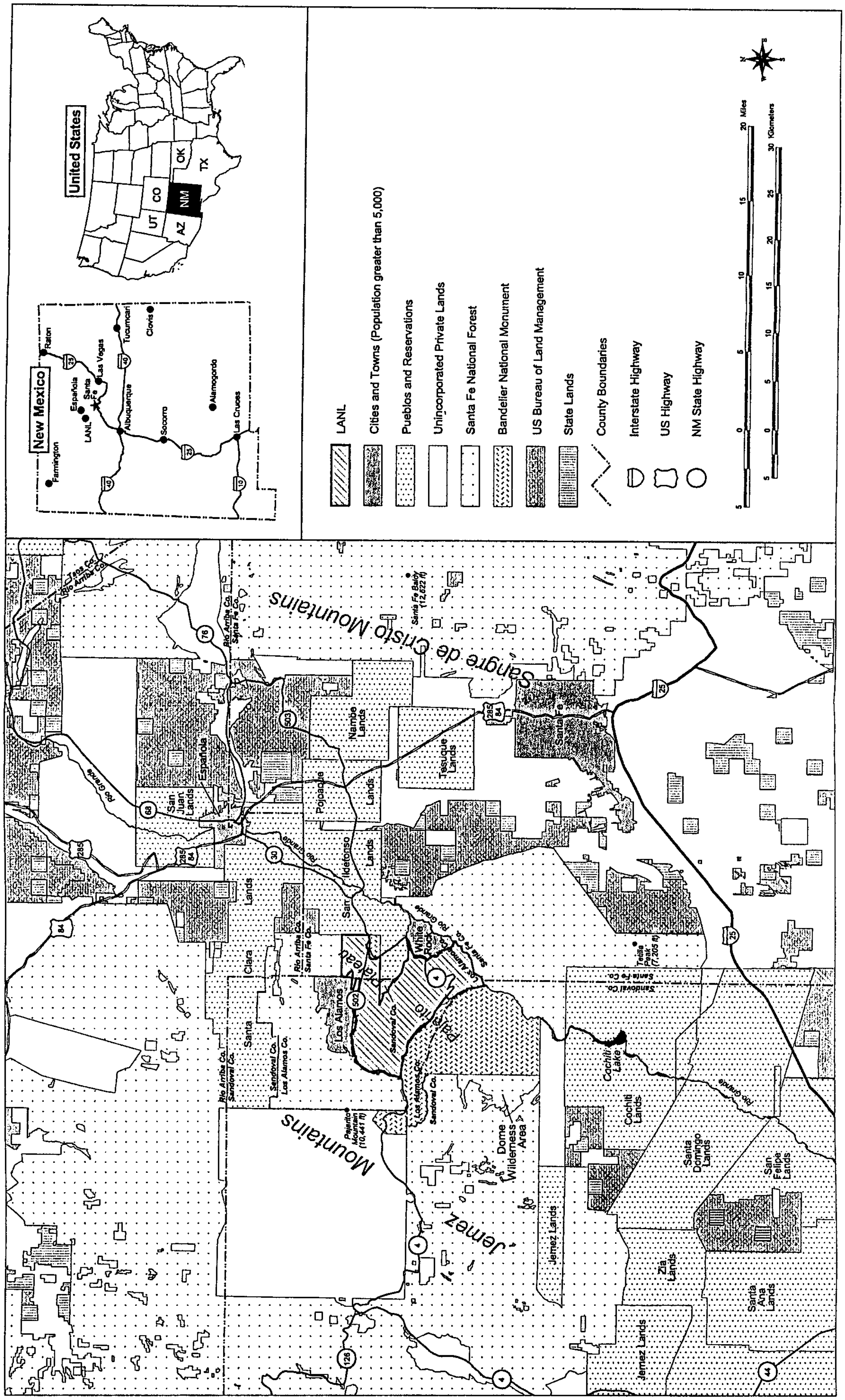


FIGURE 4.0–1.—*Location of LANL.*

> ***A Look Back in Time—***
> ***U.S. Army Corps of Engineers' Criteria for a Secret Laboratory***
>
> 1. *Adequate housing for 30 scientists.*
> 2. *Must be owned by the government or easily acquired in secrecy.*
> 3. *Large enough and uninhabited enough so as to permit safe separation of sites for experiments.*
> 4. *Easy control of access for security and safety reasons.*
> 5. *Enough cleared land free of timber to locate the main buildings at once.*
>
> *Source: LAHS nd*

as well as to determine compliance with appropriate standards and to identify undesirable trends. Data collected and analyzed under this program include: external penetrating radiation; airborne radioactive materials; the radioactive and hazardous chemical content of soils, sediments, and water; and radioactive and hazardous chemicals in foodstuffs and biological resources. Biological studies also are conducted on all major levels of the food chain.

This program provides more than 11,000 environmental samples each year from more than 450 sampling stations in and around LANL. These samples are subjected to more than 200,000 analyses to identify the chemical constituents in the samples collected. The sampling and analysis results are made publicly available annually, once analyses are complete (e.g., *Environmental Surveillance at Los Alamos During 1995* [LANL 1996i] was published in October 1996, and *Environmental Surveillance and Compliance at Los Alamos During 1996* [LANL 1997c] was published in 1997).

4.1 LAND RESOURCES

The relative isolation of north-central New Mexico was considered ideal for a secret nuclear weapons research laboratory when the site was selected during World War II. Today the area surrounding LANL, Los Alamos County, and much of Sandoval, Santa Fe, and Rio Arriba Counties is still undeveloped (LANL 1996d). This predominantly undeveloped area supports a wide variety of land uses that range from the protected wilderness areas in BNM and the Santa Fe National Forest to research and development activities.

4.1.1 Land Use

Land use in this region is linked to the economy of northern New Mexico, which depends heavily on tourism, recreation (e.g., skiing, fishing), agriculture, and the state and federal governments for its economic base. Area communities are generally small, such as Los Alamos townsite with under 12,000 residents, and primarily support urban uses including residential, commercial, light industrial, and recreational facilities. The region also includes American Indian communities; lands of the Pueblo of San Ildefonso share LANL's eastern border, and six other pueblos are clustered nearby.

LANL occupies an area of approximately 27,832 acres (11,272 hectares), or approximately 43 square miles (111 square kilometers), of the DOE land, of which 86 percent (23,951 acres [9,700 hectares]) lies within Los Alamos County.

The remaining 14 percent of LANL acreage lies within Santa Fe County, which also borders portions of LANL boundaries along the east and southeast. In this western portion of Santa Fe County, development is very limited, occurring primarily on American Indian lands within the Rio Grande Valley. A small isolated portion of

Sandoval County borders LANL on the east and is composed entirely of undeveloped lands belonging to the Pueblo of San Ildefonso. Additionally, a small portion of Sandoval County borders LANL on its southwest boundary, with the remainder of the county being located (noncontiguously) to the south, west, and north. In the LANL area, Sandoval County is generally undeveloped, being primarily U.S. Forest Service (USFS) and U.S. National Park Service (NPS) lands.

The Fenton Hill site (TA–57) occupies 15 acres (6 hectares) in Sandoval County, on land leased from the USFS. The use of this land is governed by a Memorandum of Understanding with the USFS.

Rio Arriba County is located approximately 2.5 miles (4.0 kilometers) north of LANL. The southern part of Rio Arriba County includes the town of Española and large areas of undeveloped American Indian land (see Figure 4.1.1–1), together with portions of the Santa Fe National Forest.

4.1.1.1 *Stewardship and Land Use Authority*

Los Alamos County (LAC), New Mexico's smallest county in size (approximately 110 square miles [285 square kilometers]), was created in 1963 from Sandoval and Santa Fe Counties (PC 1997a). Four major governmental bodies serve as land stewards and determine land uses within Los Alamos County (Figure 4.1.1–1).

- *DOE*—primarily the land that LANL occupies.
- *Los Alamos County*—all county and privately held land within the communities of Los Alamos and White Rock (LAC 1987). (There are no incorporated cities in Los Alamos County.)
- *U.S. Forest Service*—the Santa Fe National Forest.
- *National Park Service*—the BNM and Wilderness Area and Tsankawi Ruins.

Land area ratios distributed among these land stewards are presented in Table 4.1.1.1–1.

Land stewards and land use authorities in the western portion of Santa Fe County include the USFS, the State of New Mexico, the U.S. Bureau of Land Management (BLM), and American Indian Pueblos. Land use decisions for the BLM lands are made in agreement with the adjacent American Indian Pueblos.

All Sandoval County lands adjacent to or near LANL are controlled by one of three stewards: the NPS (BNM), the USFS (Santa Fe National Forest, including the Dome Wilderness), and the Pueblo of San Ildefonso (the small isolated parcel east of LANL). The nearest Rio Arriba

TABLE 4.1.1.1–1.—*Land Stewards Within Los Alamos County*

STEWARD	PERCENT OF LAND	AREA IN SQUARE MILES	AREA IN SQUARE KILOMETERS	AREA IN ACRES	AREA IN HECTARES
DOE (LANL)	35	37[a]	96	23,951	9,700
Private or Los Alamos County	12	13	34	8,613	3,488
U.S. Forest Service	43	46	119	29,593	11,985
National Park Service	10	10	26	6,482	2,625

Source: LAC 1987
[a] 6 square miles (16 square kilometers) of LANL lie within Santa Fe County.

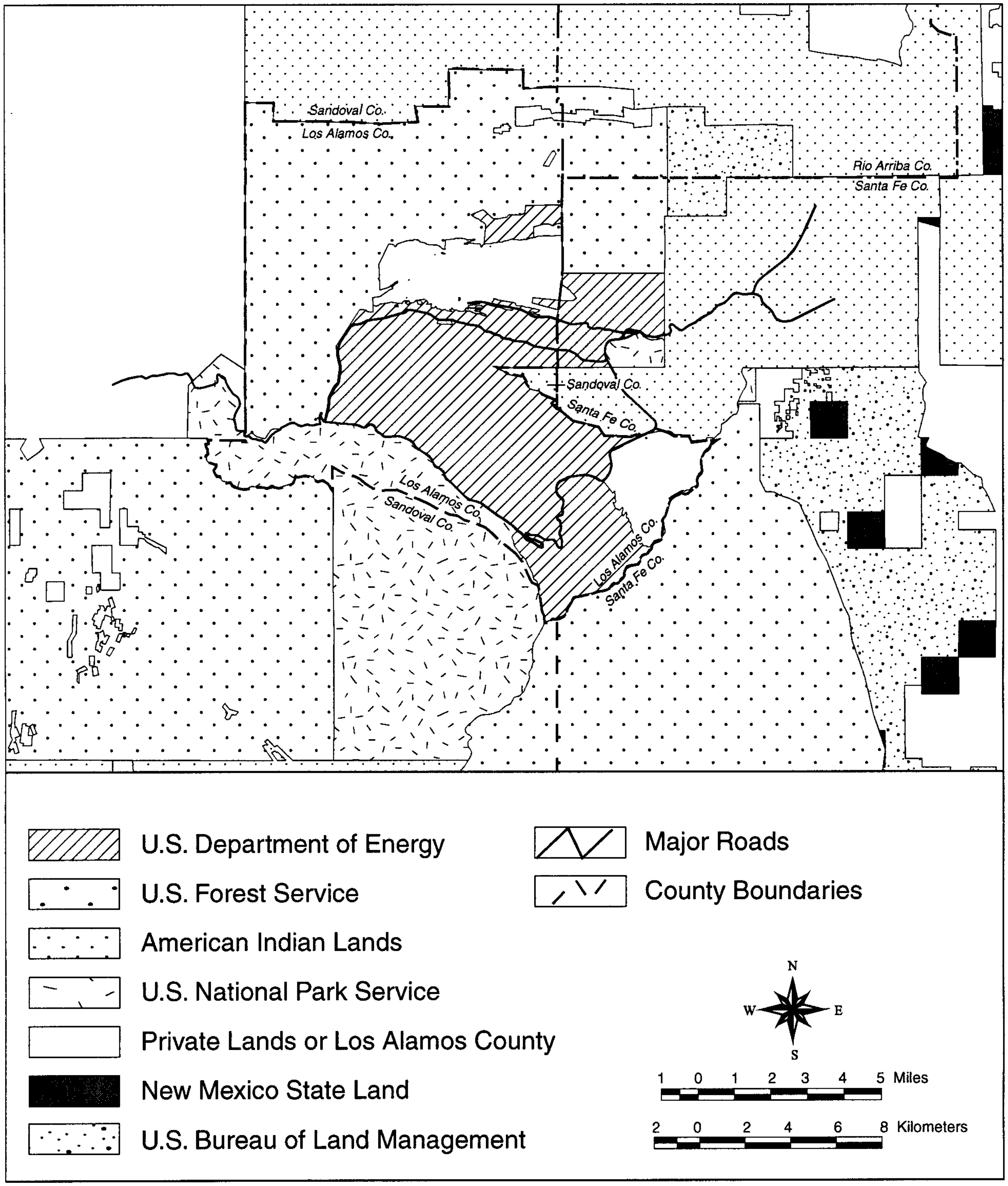


FIGURE 4.1.1–1.—*Land Stewardship in the LANL Area.*

County land is either USFS property or American Indian land.

Resource management involving land use planning, especially that incorporating an integrated approach that is implemented across land management boundaries, has only recently begun to be considered and employed by land stewards within Los Alamos County and surrounding areas.

4.1.1.2 *LANL Land Use*

LANL is divided into 49 separate technical areas (TAs) with location and spacing that reflect the site's historical development patterns, regional topography, and functional relationships. While the number of structures changes slightly with time (in particular, there is frequent addition or removal of temporary structures and miscellaneous buildings), a recent publication reflected the following breakdown of structures at LANL: there are approximately 944 permanent structures (including 93 plant and utility structures); 512 temporary structures (e.g., trailers, transportable buildings); and 806 miscellaneous buildings (e.g., sheds) with approximately 5,000,000 square feet (465,000 square meters) that could be occupied. However, only 1,316,000 square feet (122,400 square meters) of space, in 599 buildings, is designed to house personnel in an office environment. In addition to on-site office space, 213,262 square feet (19,833 square meters) of space is leased within the Los Alamos townsite and White Rock community to provide work space for an additional 806 people (LANL 1995d). These rented or leased spaces are considered part of TA–0.

Overall, 30 percent of the LANL structures (not including leased or rented space) are more than 40 years old, and 50 percent are more than 30 years old. A recent DOE assessment survey reflected the condition of LANL facilities as follows: 1 percent are in excellent condition; 8 percent are in good condition; 37 percent are adequate; 44 percent are fair; 9 percent are poor; and 1 percent fail condition review requirements (LANL 1995e). Condition review requirements cover a wide range of criteria and standards (e.g., safety, severity, seismic, etc.).

In addition to the buildings at LANL, there are over 80 miles (130 kilometers) of asphalt roads and parking areas at LANL. Unpaved roads and remote high explosives testing or firing sites are estimated to include up to an additional 200 acres (81 hectares). The majority of the land associated with the high explosives firing sites is open to most wildlife. Less than 5 percent (approximately 1,375 acres [557 hectares]) of the LANL total area is estimated to be unavailable to most wildlife because of security fencing.

Over the years, land on LANL has been developed in response to the specific needs of a variety of users. Many of the structures have changed uses. New programs have often been placed in existing facilities. New facilities have been constructed in the few areas of readily developable land (relatively flat land supported by the appropriate infrastructure, without other physical or environmental constraints). This has led to a pattern of mixed land uses throughout the property. For example, a support use such as an administrative office may be located near, or even in the same building with, a research and development use requiring a high level of security. This makes "absolute" classification of land use on LANL difficult.

In the following discussions, land use characterization is based on the most hazardous activities in each TA. For the purposes of the SWEIS, land use within LANL boundaries is organized into six categories:

- *Support*—includes TAs with support facilities only, without research and development activities, that are generally free from chemical, radiological, or explosive hazards; also includes undeveloped TAs (other than those that serve as buffers).

- *Research and Development*—includes TAs where research and development occur, with associated chemical and radiological hazards, but that are generally free of explosives hazards; does not include waste disposal sites.
- *Research and Development/Waste Disposal*—the remaining research and development areas (that is, those areas generally free of explosives hazards and that have existing waste disposal sites).
- *Explosives*—includes TAs where explosives are tested or stored, but does not include waste disposal sites.
- *Explosives/Waste Disposal*—the remaining sites where explosives are tested or stored (that is, those with existing waste disposal sites).
- *Buffer*—land identified in each of the usage types described above also may serve as buffers. This last land use category, therefore, includes areas that only serve as buffers for the safety or security of other TAs, usually explosives areas.

Figure 4.1.1.2–1 shows LANL land sorted into these categories (while Fenton Hill is not reflected in this figure, it is designated for research and development). Table 4.1.1.2–1 presents the number of acres associated with each of these six categories of LANL land use.

Any actual future consideration of changing land use within a particular LANL land use category location would be subject to DOE's Land Use and Facility Use Planning Process (DOE 1996b). The planning process allows for the holistic management of DOE's land and facilities through an integration of missions, ecology, economics, and regional cultural and social factors. LANL's 1990 Site Development Plan, which was last updated in 1995, guides land use decision-making at LANL (LANL et al. 1990 and LANL 1995e). The Site Development Plan contains policies, specific recommendations, and mapping of land use, as well as other information. This plan is periodically updated.

4.1.1.3 *Los Alamos County Land Use*

The Los Alamos County Comprehensive Plan, which established land planning issues and objectives, addresses private and county lands comprising 8,613 acres (3,488 hectares) (LAC 1987). Twenty-nine percent of this land is located within the Los Alamos townsite and 26 percent is located in the community of White Rock (LAC 1987). The remaining 45 percent of the land is undeveloped and is used for recreational activities and open space. Table 4.1.1.3–1 presents the amount of land used for the various land uses as defined by Los Alamos County.

Although it may appear that there is sufficient land within Los Alamos County for future expansion by private citizens, business owners, and the county, the majority of this land is very difficult to develop due to the many severe physical constraints of the topography and excessive associated development costs. Fifty-four percent of county land consists of slopes that exceed 20 percent and cannot be reasonably built upon. Therefore, the county's comprehensive plan establishes direction for urban development to occur in compact and contiguous areas where public services can be most efficiently provided and adverse environmental impacts can be minimized. By necessity, much of this development would occur by building in between existing structures or reuse of land. Outlying development areas are designated along West Jemez Road (northwest of LANL); on the northern edge of the townsite on DOE land, which is designated for transfer; and north of the White Rock community, which is the Pueblo of San Ildefonso's land. Recommendations in the Los Alamos County Comprehensive Plan are for the county to work with the Pueblo of San Ildefonso

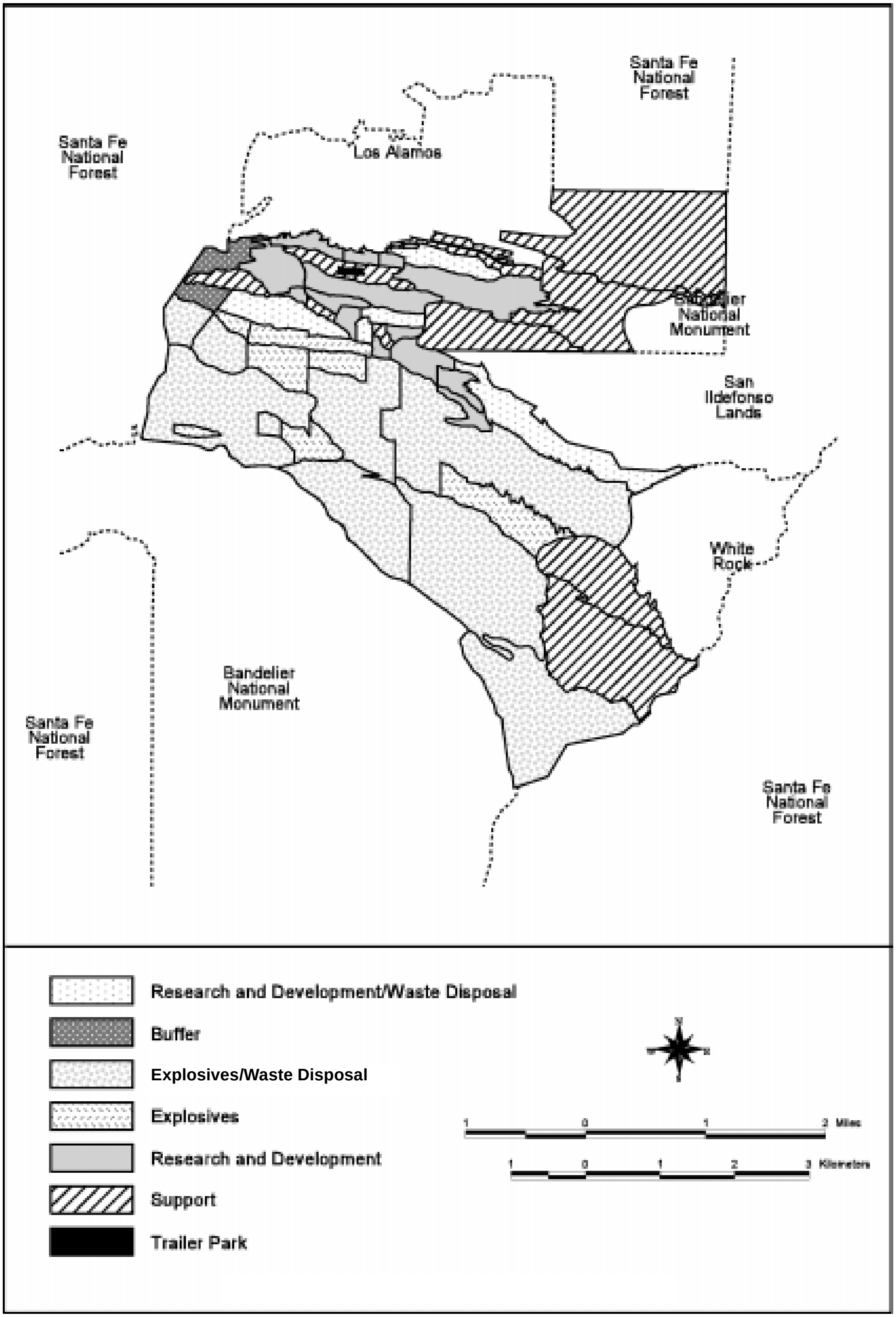


FIGURE 4.1.1.2–1.—*Land Use Within LANL Boundaries.*

TABLE 4.1.1.2–1.—*LANL General Land Use*

LAND USE	ACREAGE	HECTARES	PERCENT[a]
Support	8,457	3,422	30
Research and Development	2,745	1,111	10
Research and Development/Waste Disposal	1,966	796	7
Explosives	1,947	788	7
Explosives/Waste Disposal	12,285	4,972	44
Buffer	404	163	2

[a] Percentages may not total 100 due to rounding.
Source: LANL 1998a

TABLE 4.1.1.3–1.—*Los Alamos County (Excluding LANL) Land Use Definitions*

LAND USE	ACREAGE	HECTARES	PERCENT[a]
Residential	2,919	1,182	34
Commercial	157	64	2
Public (Governmental)	1,699	688	20
Streets/Undeveloped Land	3,838	1,554	45
Total	8,613	3,488	100

[a] Percentages may not total 100 due to rounding.
Source: LAC 1987

to encourage growth in this area (LAC 1987). Los Alamos townsite borders LANL's TA–2, TA–21, TA–41, TA–43, TA–62, TA–72, TA–73, and TA–74. The community of White Rock borders TA–36, TA–54, TA–70, and TA–71.

4.1.1.4 *Potential Land Transfers and Related Land Use Issues*

DOE has entered into discussions with several entities, including Los Alamos County, regarding the potential transfer or lease of DOE-managed land that is part of LANL. DOE has recently examined the proposal to lease a tract of land containing about 60 acres (24 hectares) to the County of Los Alamos for their development and use as a research park. An environmental assessment (EA) was prepared, entitled *Environmental Assessment for Lease of Land for the Development of a Research Park at Los Alamos National Laboratory* (DOE 1997a), that resulted in a Finding of No Significant Impact (FONSI), signed on October 8, 1997. This research park would be located within TA–3 of LANL and would be consistent in use with the current land use designation for TA–3. A lease for this land is expected to be negotiated in 1998. It would not result in a change in the LANL boundary. Another recent proposal considered by DOE to transfer a 28-acre (11-hectare) tract of land along DP Road within TA–21 to the county, would, however, result in a change of land use designation and in the redefinition of LANL's boundary. An EA, entitled *Environmental Assessment for the Transfer of the DP Road Tract to the County of Los Alamos* (DOE 1997b) was prepared that supported a FONSI, signed on January 23, 1997. This transfer of land would change the land use designation of research and development/waste disposal to the county's land use designation of light commercial and professional (C–1), civic center business and professional (C–2), heavy commercial (C–3), or light industrial (M–1), in keeping with the current zoning of the land use in the nearby Los Alamos townsite area. It is likely that the transfer of this tract could occur in 1998.

The *Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriations Act for Fiscal Year 1998*, passed by Congress in the fall of 1997 and signed into law by the President, directs the Secretary of Energy to convey parcels of land that are identified by DOE as being suitable for conveyance or transfer. These parcels would be those that are not now required to meet the national security mission of DOE or would not be required for that purpose before the end of the next 10-year period, and which are suitable for use for the purposes of historic, cultural, or environmental preservation, economic diversification, or community self-sufficiency. The act further directs the Secretary of Energy to "carry out any review of the environmental impact of the conveyance or transfer of each such parcel that is required under the provisions of NEPA." The disbursement of this land by lease or transfer will be to the Incorporated County of Los Alamos and the Secretary of the Interior, in trust for the Pueblo of San Ildefonso. A DOE decision on this matter is expected by late 1999. Complex-wide DOE initiatives affecting present and future land use are interwoven with this issue. This SWEIS does not include analysis of these potential land transfer(s). While any land transfer(s) could result in changes to land use, the total potential land transfer of this potentially large amount of acreage and the potential changes in land use were not well enough defined to include in the SWEIS to allow for meaningful analysis. On May 6, 1998, DOE published a Notice of Intent to prepare an EIS for the Proposed Conveyance and Transfer of Certain Land Tracts in the *Federal Register* (63 FR 25022). A draft EIS is expected to be released for public review and comment in early 1999.

4.1.1.5 *Santa Fe National Forest Land Use*

The Santa Fe National Forest encompasses 1,567,181 acres (634,708 hectares) and is separated into two divisions: the Pecos Division in the Sangre de Cristo Mountains to the east of LANL and the Jemez Mountains Division to the west. Both divisions of the Santa Fe National Forest support tourism; logging; cattle grazing; and recreational activities such as hiking, fishing, hunting, camping, and skiing. The Jemez Division also contains the Dome Wilderness Area and is a designated habitat for federal and state protected species, including the Mexican spotted owl (section 4.5, Biodiversity and Ecological Resources) (USFS 1987).

The USFS has classified land use on its property surrounding LANL into forest management areas (Figure 4.1.1.5–1) (USFS 1987). These management areas are described in Table 4.1.1.5–1. The 1987 Santa Fe National Forest Plan (USFS 1987) presents the most current land management directions for forest lands within the Jemez Division. Eight forest management policies have been adopted by the USFS for the Santa Fe National Forest. Each of these forest management areas emphasizes activities for the enhancement, development, or preservation of a natural resource. The portions of land within the Santa Fe National Forest that border LANL are within designated management Area C (TA–8, TA–16, TA–62, and TA–69), Area L (TA–33, TA–70, and TA–71), and Area N (TA–74).

4.1.1.6 *Bandelier National Monument Land Use*

BNM consists of two units: the primary unit is located immediately south of LANL, and the Tsankawi unit (secondary unit) is located to the northeast of LANL. It has been a popular tourist attraction since 1916, when a Presidential Proclamation established it as a National Monument offering natural beauty, American

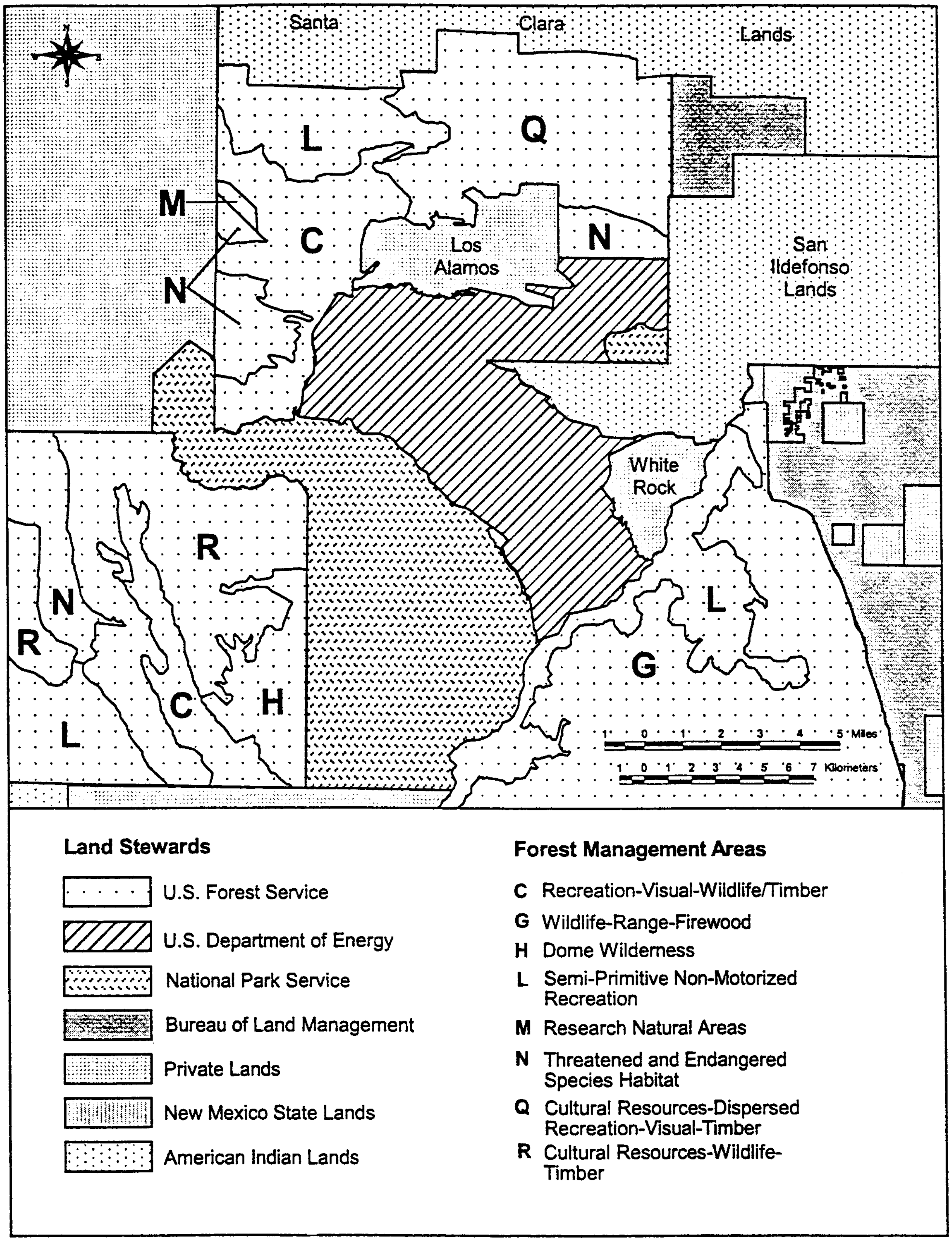


FIGURE 4.1.1.5–1.—*Santa Fe National Forest Management Areas.*

TABLE 4.1.1.5–1.—*Santa Fe National Forest Management Areas*

MANAGEMENT AREA	GENERAL USES	LAND USE MANAGEMENT EMPHASIS
C	Recreation—Visual—Wildlife—Timber	Emphasis is on enhancing visual quality and developing recreation opportunities while protecting essential wildlife habitat and riparian zones. Grazing and timber activities occur where compatible with primary emphasis.
G	Wildlife—Range—Firewood	Emphasis is on key wildlife habitat protection, habitat improvement, and forage and firewood protection. Recreational opportunities are dispersed and consist of firewood and pinyon nut gathering, hunting, and recreational driving.
H	Wilderness	Emphasis is on preserving wilderness character and values. Managed to retain the primeval, wild character and influence without permanent improvements or habitation and to preserve the natural conditions. Primitive recreation opportunities, wildlife habitat management, grazing, and fire management will occur only when consistent with these values and where historically established.
L	Semi-Primitive Nonmotorized Recreation	Emphasis is on providing semi-primitive nonmotorized recreation opportunities. Wildlife, range, and fuels management may occur where consistent with this emphasis. Timber harvest and road building are not consistent with this emphasis.
M	Research—Nature Areas	Emphasis is on providing opportunities for nondisruptive research and education. This allows natural processes to occur and the protection of natural features. Use restrictions are imposed as necessary to keep areas in their natural and unmodified condition. There is no harvest of timber or firewood nor any grazing.
N	Threatened and Endangered Species Habitat	Emphasis is on management that protects and enhances essential wildlife habitat. Not included in the suitable timber base. Certain timber management activities, grazing, firewood harvesting, and fire management may occur when compatible with protection emphasis.
Q	Cultural Resources—Dispersed Recreation—Visual—Timber	Emphasis is on cultural resource site location, inventory, nomination, and protection; also on providing dispersed recreation opportunities while maintaining visual quality, timber, and firewood production. Grazing activities vary. Emphasis is also on maintenance or enhancement of wildlife habitat diversity.
R	Cultural Resources—Wildlife—Timber	Emphasis is on cultural resource site location, inventory, nomination, and protection; also on wildlife habitat improvement and essential habitat protection and enhancement. Grazing and timber harvest activities occur where compatible with the primary emphasis. Firewood provided as a byproduct of timber harvest.

Source: USFS 1987

Indian ruins, abundant wildlife, and structures of historical importance (DOI 1995). The two monument units border along LANL TA–16, TA–18, TA–33, TA–39, TA–49, and TA–72.

The primary unit of BNM contains the ruins of nearby American Indian communities. Only a small portion of this unit has been developed for visitors: the area in and around Frijoles Canyon, just south of LANL. This developed area contains a visitors' center, concession facilities, administrative facilities, maintenance facilities, housing facilities, picnic areas, campgrounds, parking areas, trails, and roadways. The remainder of BNM has been left relatively undisturbed within the Historic era, with only a few trails and unpaved roads crossing the property. The majority of this unit of BNM has been designated as a Wilderness Area, where protection of the environment is the highest priority (DOI 1995).

Nearby Tsankawi ruins are ancestral to several nearby Pueblos. The 826-acre (335-hectare) Tsankawi unit, located adjacent to LANL to the northeast, is a large, unexcavated ruin with many small caves in the canyon walls. Few visitor facilities are available. There is a 1.5-mile (2.4-kilometer) trail providing access to the ruin (DOI 1995).

The number of visitors arriving at BNM is increasing annually. The attendance for 1997 was 410,143, which represents an increase of 42,665 over the 1993 attendance of 367,478. Approximately 586,860 visitors are projected to visit BNM annually by 2003 (DOI 1995).

The NPS has developed numerous plans and public documents that address the management of BNM. The *Final Master Plan* for the monument was approved in 1977, identifying broad objectives for the area (DOI 1977). However, this plan is now out of date and is no longer a reasonable guide. *The Bandelier National Monument Draft Development Concept Plans: Frijoles Canyon and Tsankawi* (DOI 1995) is a development concept plan to manage visitor use and facilities in the main headquarters area of the park and in a small portion of Tsankawi. These plans focus on reducing the impacts of visitors on the limited resources within BNM and preserving the natural and cultural setting to the greatest extent possible. The NPS has never developed a general management plan for BNM.

4.1.1.7 *American Indian Pueblo Land Use*

The lands of the Pueblo of San Ildefonso are located immediately east of LANL (Figure 4.1.1.2–1), bordering LANL's TA–5, TA–46, TA–54, and TA–72. The Pueblo traces its origins north of Colorado's Mesa Verde area. The Pueblo of San Ildefonso's traditional history holds that the Pueblo people migrated south to the Pajarito Plateau. The villages of Otowi (located in the northeast portion of LANL) and Tsankawi (now part of BNM) were established there around the year 1300 A.D.

The Pueblo of San Ildefonso owns or has use of 28,136 acres (11,395 hectares) of land. The Pueblo of San Ildefonso is bounded by LANL to the west, the Santa Fe National Forest to the south, the Tsankawi ruins of BNM to the west, the Pueblo of Santa Clara to the north, and the community of White Rock to the south. Most of the Pueblo land is within the boundaries of Santa Fe County, although a small portion lies in an isolated section of Sandoval County as mentioned earlier (Figure 4.1.1.2–1).

The U.S. Bureau of Indian Affairs (BIA) reports the current population of the Pueblo of San Ildefonso at 580 (BIA 1996). Most of the inhabitants of San Ildefonso live in the developed area located along New Mexico State Road 30 (NM 30) in Santa Fe County, approximately 2.75 miles (4.43 kilometers) northeast of LANL. The remainder of the Pueblo lands are largely undeveloped. Land use by the Pueblo is a mixture of residential use, gardening and farming, cattle grazing, hunting, fishing, food and medicinal plant gathering, and firewood production along with general cultural and resource preservation. The Pueblo of San Ildefonso has not adopted a formal land use plan yet.

Other American Indian lands are located in Santa Fe, Sandoval, and Rio Arriba Counties with similar land uses, together with the addition of some commercial and light industrial land use. However, the land uses on these other lands are not directly affected by activities on LANL. (Section 4.8, Cultural Resources; Section 4.9, Socioeconomics; Section 4.7, Environmental Justice; and in volume III, appendix E, Cultural Resources, provide additional information on American Indian pueblos and reservations.)

4.1.2 Visual Environment

The natural setting of the Los Alamos area is very panoramic and scenic. The mountain landscape, unusual geology, varied plant communities, and archeological heritage of the area create a diverse visual environment.

4.1.2.1 *Physical Characteristics Within the Visual Environment*

Modern inhabitants of the Los Alamos region have altered the natural physical environment to a greater extent over the past 100 years than the early inhabitants due to larger populations and enhanced use of machinery. For the most part, this alteration of the environment takes three forms: terrain alteration (cutting and filling), land cover changes (e.g., forestry, farming, fire suppression), and development. Terrain alteration has been relatively limited in the region. For the most part, disturbance has occurred on the level areas. The most obvious terrain alterations in this area are the side-hill cuts sometimes necessary for roadways. However, these steep cuts are not as out of character with the surrounding sharply angled terrain as they would be in more gentle topography.

The topography in this part of northern New Mexico is rugged, especially in the vicinity of Los Alamos. Mesa tops are cut by deep canyons, creating sharp angles in the land forms. In some cases, slopes are nearly vertical. Often little vegetation grows on these steep slopes, exposing the geology, which is equally striking with contrasting horizontal planes varying from fairly bright orange-red to almost white in color.

A variety of vegetation occurs in the region (section 4.5.1.1). The density of vegetation and height of vegetation may change over time, both of which can affect the visibility of an area within the LANL viewshed (the area from which an observer can potentially view LANL). In some areas the only vegetation is low-lying meadows (grasslands and recent burn areas). At the other end of the scale, portions of LANL are covered with mixed conifer evergreen forests, which have increased in density over the past decades due to the suppression of natural fires. The height and density of mature trees in this forest type may obscure many views and partially screen others. Mixed grass, shrub and savannah lands, which have varying densities of trees, are between these extremes. Over the years, the clearing of vegetation within the LANL viewshed has occurred through timber harvests or to make room for farming or development. It is sometimes difficult, if not impossible, to recognize these cleared areas, due to the high variability in vegetation type. The opposite has also occurred. Very generally, portions of LANL located along mesa tops at the lower elevations of the facility toward the eastern site boundary are covered with grasslands, mixed shrubs or short trees with sparsely distributed taller trees, allowing greater visibility from within the viewshed. In contrast, the portions of LANL located at the upper elevations toward the western boundary are

A Look Back In Time

[Prior to the development of LANL], an incident occurred that had great portent for the future. A visitor rode over the mesas on a pack trip. His summer home was across the valley, in the high mountains at the headwaters of the Pecos River, east of Santa Fe. His name was J. Robert Oppenheimer.

He admired the setting, and thereafter often visited the [Los Alamos Ranch] school. He remembered the place upon being confronted with a momentous decision a few years later, when he was asked to advise the Corps of Engineers on the selection of a secret laboratory site.

Source: LAHS nd

more densely covered by tall mixed conifer forests that lessen the visibility of these areas.

The most obvious modern alteration of the natural environment is development. Within LANL and Los Alamos townsite, much of this development is austere and utilitarian in appearance, contrasting greatly with nature (LANL et al. 1990). Because both LANL and the townsite were established in response to a national emergency, many buildings were built as temporary structures. Overcrowded conditions, due to the limited amount of developable land, have often resulted in an unplanned, visually discordant assembly of structures and functions, equipment, parking, and outside storage. More recent development, however, includes many facilities with designs and materials that are more visually appropriate and compatible with the natural environment. Many LANL planning documents, such as the *Capital Assets Management Process, Fiscal Year 1997* (LANL 1995d), target improving the quality of building design at LANL, creating more attractive work environments, and providing clear signage and an easy-to-navigate road system.

For security reasons, much of the development within LANL has occurred out of the public's view. Passing motorists or nearby residents can only see a small fraction of what is actually there. The view of most of LANL property from many stretches of the area roadways is that of woodlands and brushy areas. The most visible developments are a limited number of very tall structures; facilities at relatively high, exposed locations; or those beside well-traveled, publicly accessible roads within the core part of LANL, the TA–3 area. Designed structures that blend in with other features include the Los Alamos Canyon Bridge, the Otowi Building, the Oppenheimer Study Center, and the entry sign on East Jemez Road.

However, there are examples of existing facilities that cause adverse visual impacts:

- The National Radio Astronomy Observatory Very Long Baseline Array telescope, which is a large, white, dish-type antenna located at a high elevation, clearly visible from surrounding sensitive land use areas such as BNM.
- The extremely dense and mixed development in areas such as TA–3, combined with the parking lots and little room for screening elements such as landscaping.
- Very tall structures such as the radio towers or the Rack Assembly and Alignment Complex.

At the lower elevations, at a distance of several miles away from LANL, the facility is primarily distinguishable among the trees in the daytime by views of its water storage towers, emission stacks, and occasional glimpses of older buildings that are very austere and industrial in appearance. Similarly, the Los Alamos townsite appears mostly residential in character with the water storage towers being very visible against the forested backdrop of the Jemez Mountains. The most readily visible LANL and Los Alamos townsite landmarks at very distant vantage points are the water storage towers that are painted white. These show up against the evergreen forests and cause the developed areas to appear to be spread over a broad distance along the Pajarito Plateau. At elevations above LANL, along the upper reaches of the Pajarito Plateau rim, the view of LANL is primarily of scattered austere-appearing buildings among heavily forested areas and the nested several-storied buildings of the TA–3 area. Similarly, the residential character of the Los Alamos townsite is predominately visible from higher elevation viewpoints.

4.1.2.2 *Air Quality and Light Pollution Within the Visual Environment*

Visibility related to air quality is an important facet of the visual environment within the Los Alamos viewshed. (Section 4.4.3, Air Quality Visibility, includes additional discussion on this subject.) In addition to smoke produced by wood burning in nearby residential areas, smoke is produced within the viewshed area both at LANL, where there is periodic burning of high explosives waste material, and at the neighboring Santa Fe National Forest, where there is periodic, controlled forest burning as a wildfire management tool. Permitted waste fires at LANL can last for hours at a time, while under certain weather conditions, forest burning can last for several days. As is true throughout the region, fugitive dust can also be generated within the viewshed on windy days if soil moisture levels are inadequate to prevent this from occurring. These types of temporary air pollutions by particulate suspension can be easily noticed in the relatively clear air in northern New Mexico and can negatively affect visibility.

Similarly, light pollution from various sources within the Los Alamos viewshed is an important facet of the nighttime visual environment with regards to the visibility of LANL and the visibility of celestial features within the natural environment, such as the planets and the stars. Two types of light impacts typically occur around development: direct impacts related to views of the light source itself and indirect impacts related to the cumulative and reflected light that creates an unnatural glow in the sky and reduces the visibility of stars. The lights of LANL, Los Alamos townsite, and White Rock are directly visible from various locations across the viewshed as far away as the towns of Española and Santa Fe. Because there is little nighttime activity at LANL, light sources are generally security lighting rather than personnel safety lighting. The sodium vapor lights used for this purpose can be distinguished from the lights of the nearby communities at White Rock and the Los Alamos townsite by their slightly yellow color. At a distance across the viewshed, however, the color variation in light sources become unrecognizable and any nighttime distinction between LANL and the two communities is lost to the casual observer. There are relatively few of the LANL security light sources compared to the greater number of safety light sources coming from the nearby communities. Indirect (reflected) light impacts from LANL sources are very limited for three reasons: first, there are relatively few sources, compared to the nearby communities; second, the designs of these light sources direct light downward only; third, most of these sources are located at the perimeter of security areas, in areas that are not paved. Because of this, very little light is reflected upward. By contrast, lights in parking lots in the surrounding communities are more likely to be reflected off asphalt and concrete.

4.1.3 Noise, Air Blasts, and Vibration Environment

Noise (considered to be unpleasant, loud, annoying or confusing sounds to humans), air blasts (also known as air pressure waves or over pressures) and ground vibrations are intermittent aspects of the LANL area environment. Although the receptor most often considered for these environmental conditions is human, sound and vibrations may also be perceived by animals and birds in the LANL vicinity. Little is known about how different wildlife species may process these sensations, or how certain species may react to them. The vigor and well being of area wildlife and sensitive, federally protected bird populations suggests that these environmental conditions are present at levels within an acceptable tolerance range for most wildlife species and sensitive nesting birds found along the Pajarito Plateau. (Biological resources are discussed in more detail in section 4.5.)

"Public noise" is the noise present outside the LANL site boundaries. It is from the combined effect of the existing LANL traffic and site activities and the noise generated by activities around the Los Alamos and White Rock communities. "Worker noise" is the noise generated by LANL activities within LANL boundaries. Air blasts consist of a higher frequency portion of air pressure waves that are audible and that accompany an explosives detonation. This noise can be heard by both workers and the area public. The lower frequency portion of air pressure waves is not audible but may cause a secondary and audible noise within a testing structure that may be heard by workers. Air blasts and most LANL-generated ground vibrations result from testing activities involving above-ground explosives research.

The forested condition of much of LANL (especially where explosives testing areas are located), the prevailing area atmospheric conditions, and the regional topography that consists of widely varied elevations and rock formations all influence how noise and vibrations can be both attenuated (lessened) and channeled away from receptors. These regional features are jointly responsible for there being little environmental noise pollution or ground vibration concerns to the area resulting from LANL operations. Sudden loud "booming" noises associated with explosives testing are similar to the sound of thunder and may occasionally startle members of the public and LANL workers alike. The human startle response is usually related to the total amounts of explosives used in the test, the prevailing atmospheric conditions, and the receptor's relative location to the source location and to channeling valleys. Although these noises are sporadic or episodic in nature, they contribute to the perception of noise pollution in the area.

Concerns for damage that may be caused by ground vibrations as a result of explosives testing are primarily related to sensitive architectural receptors, such as the many archeological sites and historic building near the LANL firing ranges. The low masonry adobe or rock walls at prehistoric sites, and the nonrobust walls of what were expected to be temporary or short-term use buildings when originally constructed, may be speculated to suffer from subtle structural deterioration (fatigue damage) over time. However, field observations of eight prehistoric archeological sites in the vicinity of the firing ranges determined that none of the sites exhibited deterioration other than natural weathering.

Limited data currently exist on the levels of routine background ambient noise levels, air blasts, or ground vibrations produced by LANL operations that include explosives detonations. The following discussions of noise level limitations are provided to identify applicable regulatory limits or administrative controls regarding LANL's noise, air blast, and vibration environment; there are no regulatory, worker health protective, or maximum permissible level limitations for air blasts or ground vibrations. Available LANL noise and vibration information from specific activities is also summarized and presented.

4.1.3.1 *Noise Level Regulatory Limits and LANL Administrative Requirements*

Noise generated by LANL operations, together with the audible portions of explosives air blasts, is regulated by county ordinance and worker protection standards. The standard unit used to report sound pressure levels is the decibel (dB); the A-weighted frequency scale (db[A] or dBA) is an expression of adjusted pressure levels by frequency that accounts for human perception of loudness. Los Alamos County has promulgated a local noise ordinance that establishes noise level limits for residential land uses. Noise levels that affect residential receptors are limited to a maximum of 65 dBA during daytime hours and 53 dBA during nighttime hours between 9 p.m. and 7 a.m. Between 7 a.m. and 9 p.m., the permissible noise level can be increased to 75 dBA in residential areas, provided the noise is limited to 10 minutes in any 1 hour. Activities that do not meet the noise ordinance limits require a permit (LANL 1994a).

Noise standards related to protecting worker hearing are contained in LANL's Administrative Requirements, *Hearing Conservation*, which is part of the electronic Environmental, Safety, and Health Manual (LANL 1993c). LANL hearing conservation policy and noise level limits are based on:

- U.S. Air Force Regulation 161-35, *Hazardous Noise Exposure*
- DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*
- 29 Code of Federal Regulations (CFR) 1910.95, *Occupational Noise Exposure*
- American Conference of Governmental Industrial Hygienists' (ACGIH) publication (ACGIH 1993) entitled, *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1992–1993)*

The occupational exposure limit for steady-state noise, defined in terms of accumulated daily (8-hour) noise exposure dose that allows for both exposure level and duration, is 84 dBA (29 CFR 1910.95). When a worker is exposed for a shorter duration, the permitted noise level is increased (Table 4.1.3.1–1). LANL Administrative Requirements also limit worker impulse/impact noise exposures that consist of a sharp rise in sound pressure level (high peak) followed by a rapid decay less than 1 second in duration and greater than 1 second apart. These limits are based on noise level and number of impacts allowed per day (Table 4.1.3.1–2).

To meet the limits presented above, managers at LANL are required to minimize excessive worker noise exposure through measures such as worker hearing protection, control of noise using alternative operating conditions, and engineering designs or modifications to reduce operating noise levels.

There are no regulatory, worker health protective LANL administrative controls or other maximum permissible levels regarding

TABLE 4.1.3.1–1.—*Limiting Values for Average Daily Noise Exposure*

DURATION OF TOTAL DAILY EXPOSURES HOURS	OCCUPATIONAL EXPOSURE LIMITS NOISE LEVEL dBA
16	80
8	84
6	86
4	88
2	92
1	96
0.5	100
0.033 (2 minutes)	115[a]

[a] Exposure above 115 dBA is not permitted.
Source: LANL 1993c

TABLE 4.1.3.1–2.—*Occupational Exposure Limits for Impulse/Impact Noise*

SOUND LEVEL dBA	NUMBER OF IMPULSES OR IMPACTS PERMITTED DAILY
140[a]	100
130	1,000
120	10,000

[a] Exposure above 140 dBA is not permitted.
Source: LANL 1993c

property damage resulting from vibrations such as those generated through LANL operations.

Vibration criteria for ancient monuments have been recommended as low as 2 millimeters per second amplitude; a few European countries have established standards for ground vibrations levels allowed at their historic monuments of 2 millimeters per second. The vibration limit recommended at Mesa Verde and Chaco Canyon for one-of-a-kind, irreplaceable structures was not to exceed 2 millimeters per second in the 2 to 20 hertz frequency bandwidth. Given the lack of vibration damage attributable to vibrations from 50 years of explosives testing (as discussed in section 4.1.3.2), and given the environmental setting of the firing site areas (additional information regarding these sites is presented in section 4.8), it appears unnecessary to adopt such a limit for the types of resources present at LANL.

4.1.3.2 *Existing LANL Noise Air Blast and Vibration Environment*

Existing LANL-related publicly detectable noise levels are generated by a variety of sources, including truck and automobile movements to and from the LANL TAs, high explosives testing, and security guards' firearms practice activities. Noise levels within Los Alamos County unrelated to LANL are generated predominately by traffic movements and, to a much lesser degree, other residential-, commercial-, and industrial-related activities within the county communities and the surrounding areas.

Traffic noise from truck and automobile movements around the LANL TAs is excepted under Los Alamos County noise regulations, as is the traffic noise generated along public thoroughfares within the county. This type of noise contributes heavily to the background noise heard by humans over most of the county. Although some measurements of sound specifically targeting traffic-generated noise have been made at various county locations in recent studies, these sound levels are found to be highly dependent upon the exact measuring location, time of day, and meteorological conditions. There is, therefore, no single representative measurement of ambient traffic noise for the LANL site. Noise generated by traffic has been computer modeled to estimate the impact of incremental traffic for various studies, including recent NEPA analyses, without demonstrating meaningful change from current levels due to any new activities. While very few measurements of nonspecific background ambient noise in the LANL area have been made, two such measurements have been taken at a couple of locations near the LANL boundaries next to public roadways. Background noise levels were found to range from 31 to 35 dBA at the vicinity of the entrance to BNM and NM 4. At White Rock, background noise levels range from 38 to 51 dBA; this is slightly higher than was found near BNM, probably due to higher levels of traffic and the presence of a residential neighborhood (DOE 1995b) as well as the different physical setting.

The detonation of high explosives represents the peak noise levels generated by LANL operations. The results of these detonations are air blasts and ground vibrations. LANL has instituted stringent administrative controls to protect site workers from potential physical damages that could result from these detonations. These protective measures include the employment of TA perimeter fencing, badge exchange programs at manned access points, and gated personnel exclusion zones located at varying distances from the firing site detonation points determined by site safety requirements. Personal protective hearing devices are also made available for use by personnel as necessary as part of the standard operating procedures established for these sites. Exclusion zones are provided both for hearing protection and to keep workers from potentially being struck with high speed detonation debris or being adversely affected by air blasts. The perimeter fencing is also provided both for the protection of co-located workers and for members of the public. The primary source of these activities is the high explosives experiments conducted at the LANL Pulsed High-Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility and surrounding TAs with active firing sites. Within the foreseeable future, the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility will begin operation (followed by a corresponding reduction of PHERMEX operations) and will become a source of high explosives testing. Explosives detonations were performed in March 1995 for the DARHT EIS analysis and measurements of air blasts and ground vibrations were obtained for representative PHERMEX explosives tests. The sound measurements recorded the following:

- *70 dBA* at a distance from the source of 4 miles (6 kilometers) using 150 pounds (68 kilograms) of TNT
- *71 dBA* at a distance from the source of 1 mile (2 kilometers) using 150 pounds (68 kilograms) of TNT (the closest public access point next to TA–49 at NM 4)
- *60 dBA to 63 dBA* at a distance from the source of 3 miles (5 kilometers) using 150 pounds (68 kilograms) of TNT (BNM entrance near NM 4) (DOE 1995b)

Based on such findings, the Los Alamos County Community Development Department has determined that LANL does not need a special permit under the Los Alamos County Code because noise related to explosives testing is not prolonged, nor is it considered unusual to the Los Alamos community (Los Alamos County Code, August 8, 1996).

The DARHT EIS analysis performed to determine vibratory ground motion from detonation of high explosives indicated that the peak ground motion for the energy transmitted through the ground was less than the ground motion caused by the air wave pulse when it arrived at a measurement point. This is understandable because of the above ground placement of the explosives used in testing activities. Ground motion (particle velocity) amplitudes slightly above 2 millimeters per second were estimated by derivative calculations to occur within 1 mile (1.61 kilometers) of a 500-pound (227-kilogram) TNT explosives test (GRAM 1997). In general, structures within 2,000 feet (610 meters) are estimated to be exposed to ground vibration in excess of 5 millimeters per second. For explosive tests in the range of 10 pounds (4.5 kilograms) to 150 pounds (68 kilograms), ground vibrations in excess of 5 millimeters per second are not expected to be exceeded at locations of 1,000 feet (305 meters) or more from the firing site (GRAM 1997). For architectural sites near the firing site, but separated from them by an intervening canyon(s), the effects would be greatly lessened to absent from ground transmitted vibrations. Detonations of up to 500 pounds (227 kilograms) of TNT or its equivalent are not expected to generate vibrations sufficient to result in any damage to either sensitive historical or prehistoric structures at BNM or to residences in the White Rock or Los Alamos communities. Measurement of the air blast associated with a 150-pound (68-kilogram) detonation of TNT indicated that the maximum air blast over pressure was 5.05 millibar (0.073 pounds per square inch [psi] or 143 dB at 1,200 feet [366 meters]) to the blast site. The effect of a 500-pound (227-kilogram) detonation of TNT is estimated to be in excess of the 7 millibar (0.1 psi or 150 dB) that would be required to occur at that distance from the blast site before cracking of building windows and walls would be expected to occur. Given the distance of buildings from existing LANL blast site locations, it is unlikely that any cracks to building walls or windows would result due to air blasts from explosives testing.

Field observations were made in 1997 to determine the existing condition of eight sensitive prehistoric resource sites within an 800-foot (244-meter) radius of 13 active explosives firing sites at LANL. The survey did not identify any significant structural deterioration to these sites that could conclusively be associated with ground vibrations. Rather, they appeared to be deteriorating due to natural weathering processes (LANL 1997e).

4.2 GEOLOGY AND SOILS

This section describes the geology, geologic conditions, soils, and mineral and geothermal resources present at LANL and the surrounding area. As presented in Figure 4.2–1, the area includes LANL, extends to the northernmost point of the Jemez Mountains and Española Valley in the north, to the Cerros del Rio Volcanic Field in the east, to Cochiti Lake in the south, and to the Valles Caldera in the west.

Information on the Fenton Hill site is provided in section 4.3.

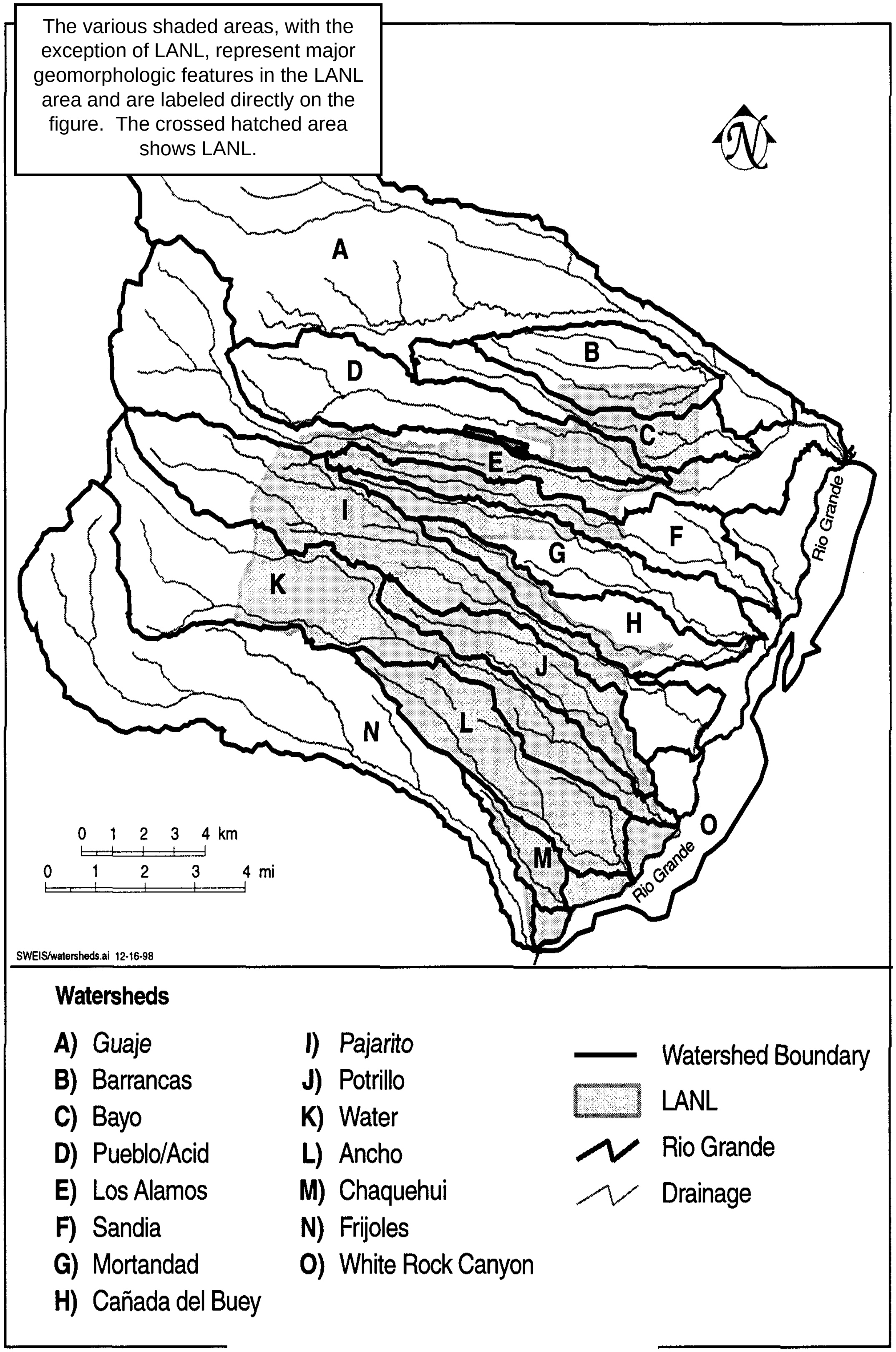
> ***A Look Back In Time***
>
> *Early map makers, looking at the rectangular block of the Jemez Mountain range in northern New Mexico, apparently noted with only a passing interest the circular shape formed by a series of peaks near the center.*
>
> *It was not until sometime in the 1920's that the idea that this unusual geographic feature might actually be the rim of an ancient and extinct volcano began to gain acceptance. There never was any question of the volcanic origin of the Jemez range. Even to the untrained eye thick layers of volcanic ash, heaps of burned rock, cone-shaped hills and fumeroles, and bubbling hot sulfur springs, all give unmistakable evidence of an open passage to the underworld in the not-too-distant past.*
>
> *Source: LAHS nd*

4.2.1 Geology

LANL and the communities of Los Alamos and White Rock are located on the Pajarito Plateau (Figure 4.2–1). The Pajarito Plateau is 8 to 16 miles (13 to 26 kilometers) wide and 30 to 40 miles (48 to 64 kilometers) long, lying between the Sierra de los Valles to the west and the Rio Grande to the east (Purtymun et al. 1995). The Sierra de los Valles lies between the Jemez Mountains and the Pajarito Plateau. The crest of this north-south range of peaks and ridges forms a surface water divide. The surface of the Pajarito Plateau is divided into numerous narrow, finger-like mesas separated by deep east-to-west oriented canyons that drain toward the Rio Grande.

A primary geologic feature in the region is the Rio Grande Rift, which begins in northern Mexico, trends northward across central New Mexico, and ends in central Colorado (Figure 4.2–1). The rift is a complex system of north-trending basins that have formed by downfaulting of large blocks of the Earth's crust (Dransfield and Gardner 1985). Faults are breaks in the Earth's crust involving horizontal or vertical movement, or both, along a zone of weakness called a fault plane. In the Los Alamos area, the Rio Grande Rift is about 35 miles (56 kilometers) wide and encompasses the Española Basin. The Sangre de Cristo Mountains border the Rio Grande Rift on the east, and the Jemez Mountains lie over the western fault margin of the rift. The north-trending Pajarito Fault system is part of the Rio Grande Rift and consists of a group of interconnecting faults that are nearly parallel. Information regarding these faults is presented in section 4.2.2.2.

The rocks present in the LANL region were predominantly produced by volcanic and sedimentary processes. Geologists classify rock types by the processes or events that formed them and the approximate time when the rocks were formed. The classification of rocks by type and geologic history is referred to as stratigraphy. The broadest classification of different rocks is referred to as a group, formations may be subdivisions of a group or a major category alone without an associated group, and members are subdivisions of a formation. The characteristics of the major stratigraphic units in the LANL region are summarized in Table 4.2.1–1. A generalized



SOURCE: DOE 1979

FIGURE 4.2–1.—*Geology of the LANL Region.*

TABLE 4.2.1–1.—*Characteristics of the Major Stratigraphic Units in the LANL Region*

GROUP	FORMATION	AGE OF DEPOSITION[a]	ROCK TYPES	THICKNESS IN LANL REGION[b]	COMMENTS
Tewa[c]					
	Bandelier Tuff	1.61 to 1.22	Rhyolitic tuff and pumice	0 to 700 feet (0 to 213 meters)	Ash-flow deposits formed by catastrophic eruption of the Valles and Toledo calderas west of LANL. Formation is composed of Otowi and Tshirege members.
	Cerro Toledo “Interval”	1.61 to 1.22	Volcaniclastic sediments	10 to 130 feet (3 to 40 meters)	Informal name. Not considered part of the Bandelier Tuff because of unique petrologic features and different eruptive style.
Polvadera[d]					
	Puye	4 to 1.7	Clays, gravel, volcanic debris	0 to 600 feet (0 to 183 meters)	Shed from eastern Jemez Mountains. Interwoven with Cerro del Rio basalts in some locations. Top of the main aquifer is usually within this formation. The basal Totavi Lentil consists of channel deposits of the ancestral Rio Grande and is sometimes given its own formation by some authors.
	Tschicoma[e]	7 to 3	Andesite, rhyolite, and dacite	0 to 5,000 feet (0 to 1,524 meters)	Originated from volcanic vents in the central to northeastern Jemez Mountains.
Basalt Fields[d]					
	Cerros del Rio	4.6 to 2.0	Basalts, breccia, and scoria	0 to 600 feet (0 to 183 meters)	Many source vents beneath the plateau and to the east. The top of the main aquifer is in this formation in some locations.
Keres[d]					
	Paliza Canyon	13 to 6	Volcanic andesite and basalt	0 to ?	Erupted from St. Peter’s Dome area 3 miles (5 kilometers) south of LANL. Possibly found in southern part of LANL (e.g., TA–49 wells).
	Cochiti	13 to 6	Vent breccias and gravels of dacite and andesite	0 to ?	Laterally equivalent to some rocks in the Santa Fe Group. Transition between Cochiti, Santa Fe, and Puye formations probably occurs beneath Los Alamos County but is poorly defined.

TABLE 4.2.1–1.—*Characteristics of the Major Stratigraphic Units in the LANL Region*-Continued

GROUP	FORMATION	AGE OF DEPOSITION[a]	ROCK TYPES	THICKNESS IN LANL REGION[b]	COMMENTS
Santa Fe[f]		18 to 4.5			Most extensive rock units filling the Rio Grande Rift and most productive in terms of water.
	Chamita		Terrestrial conglomerates, sandstones, mudstones, minor limestones, evaporites, tuff and intercalated basalts	0 to 30 feet (0 to 9 meters)	Localized deposits only. Shallow stream or deltaic deposits.
	Tesuque		Same as Chamita	> 1,300 feet (> 396 meters)	Shallow stream or deltaic deposits. Underlain by Precambrian crystalline rock. Contact between the two rock types can be at depths up to 7,500 feet (2,300 meters) below ground surface.

[a] Million Years
[b] Where question marks appear, the thickness of the formation is unknown.
[c] Broxton and Reneau 1995
[d] Gardner et al. 1986
[e] Tschicoma—The spelling of the word "Tschicoma" may be a derivative of the Native American spelling "Tsichomo," which refers to a lake and a mountain peak within the Santa Clara Pueblo Indian Reservation. The U.S. Geological Survey (USGS) reference to "Chicoma Peak" may also be a derivative of the Native American spelling.
[f] LANL 1996a

cross-section of the geology in the region is illustrated in Figure 4.2.1–1.

4.2.2 Geologic Conditions

This subsection describes the geologic conditions that could affect the stability of buildings and infrastructure at LANL and includes volcanic activity, seismic activity (earthquakes), slope stability, surface subsidence, and soil liquefaction.

4.2.2.1 *Volcanism*

Volcanism in the Jemez Mountains volcanic field, west of LANL, has a 13-million-year history. An understanding of the area's volcanic history is important when evaluating the potential volcanic hazards that may occur at LANL. Seismic activity and volcanic activity are being tracked and studied by LANL.

The first 11 million years of activity in the Jemez Mountains volcanic field resulted in the formation of a large volcanic ridge on the western margin of the Rio Grande Rift. This activity was followed by the formation of the Valles Caldera. The volcanic history of the Valles Caldera includes two major eruptive episodes (Izett and Obradovich 1994). The first major episode of caldera formation occurred 1.6 million years ago and produced the Otowi member of the Bandelier Tuff. Subsequent activity produced domes within the caldera and associated tuffs. The eruption that occurred 1.22 million years ago produced the Tshirege member of the Bandelier Tuff (Self et al. 1986). The Bandelier Tuff is the material upon which most LANL facilities are constructed

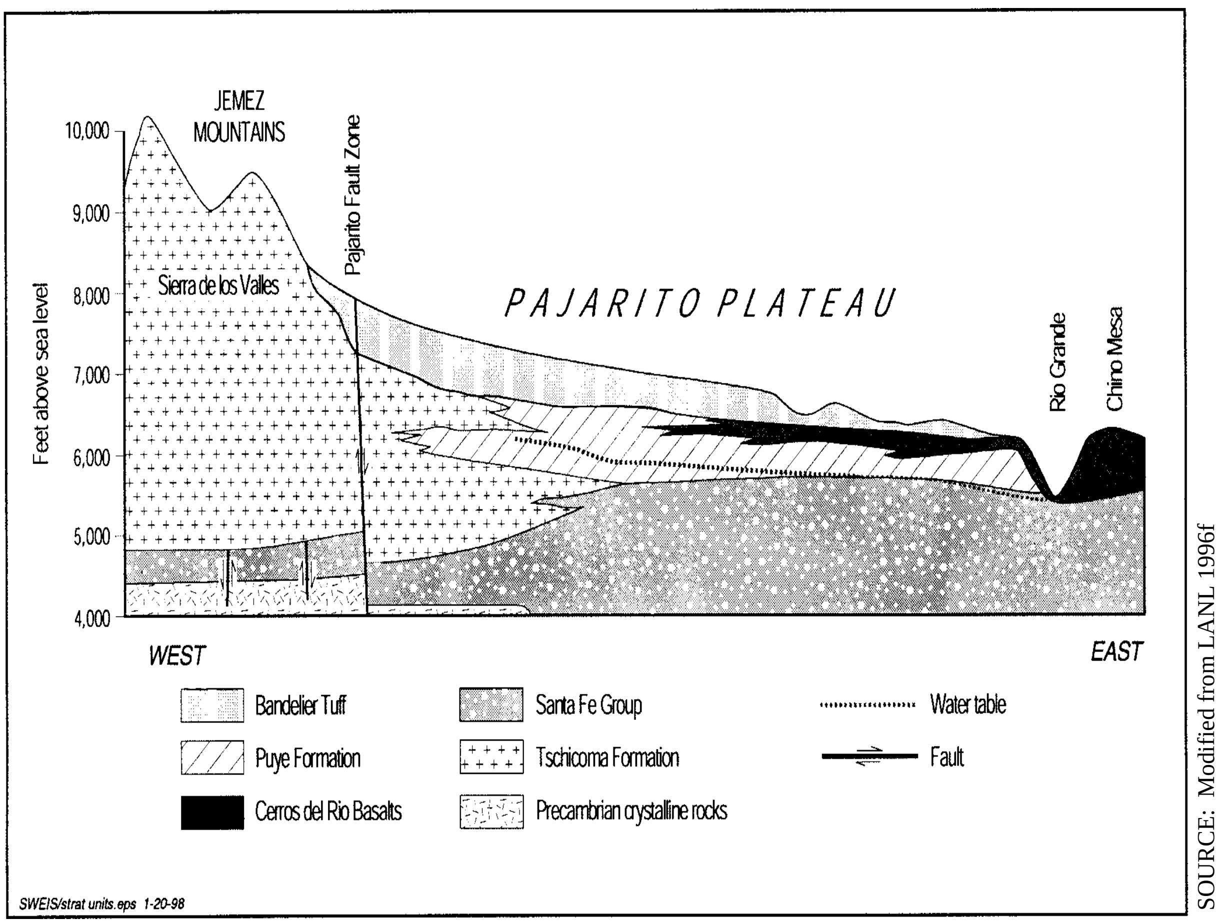


FIGURE 4.2.1–1.—*Stratigraphic Units and Structure of the LANL Area.*

(Purtymun 1995 and Broxton and Reneau 1995). The Bandelier Tuff is generally thickest to the west of LANL near its source, and thins eastward across the Pajarito Plateau, due to increasing distance from the source and erosion.

Volcanic eruptions continued from 1.22 million to 520,000 years ago, followed by a 460,000-year period of dormancy. Following this period of dormancy, the most recent volcanic activity produced several rock units including the El Cajete pumice, a member of the Valles Rhyolite Formation of the Tewa Group. Although present in the LANL area, the El Cajete does not constitute a major stratigraphic unit. The El Cajete pumice is a widespread stratigraphic marker (used for denoting rocks of similar age) in areas east, southeast, and south of the caldera. Therefore, determining the age of the El Cajete pumice is important to understanding potential for volcanic activity in the region (Wolff and Gardner 1995). Recent analysis of the El Cajete dates the pumice at 50,000 to 60,000 years old (Reneau et al. 1996). Additionally, the chemical composition of the rocks resulting from the most recent volcanic activity is dissimilar to the earlier caldera-related units.

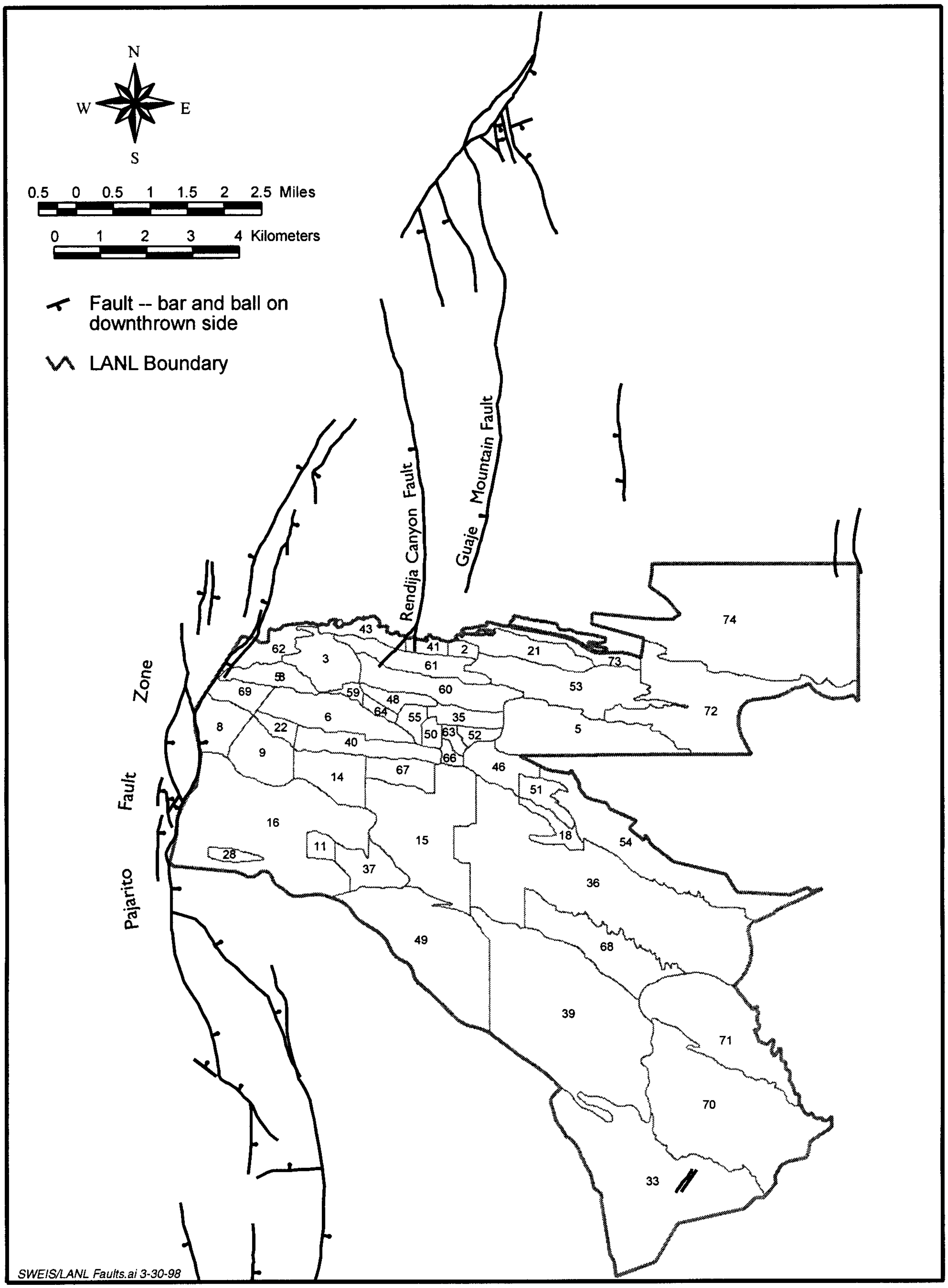
Volcanic activity is difficult to predict, and the accuracy of a prediction may depend on the type of eruption. Increasing seismic activity deep below the Earth's surface is often an indication that magma is migrating toward the surface. The Jemez Mountains show an unusually low amount of seismic activity, which suggests that no magma migration is occurring. However, it is also possible that seismic signals are partially absorbed deep in the subsurface due to elevated temperatures and high heat flow. Such masking of seismic signals would add to the difficulty of predicting volcanism in the LANL area. However, a large Bandelier Tuff-type eruption would give years of warning as regional uplift and doming occurred. A smaller, El Cajete-type eruption may only be detectable by the existing LANL seismographic network within weeks or days of the eruption, and may result in ashfall at LANL depending on the location of the eruption and prevailing wind direction. There are plans to install additional seismograph stations in the vicinity of the Valles Caldera to improve predictive capabilities (Wolff and Gardner 1995 and PC 1996i).

4.2.2.2 *Seismic Activity*

A comprehensive seismic hazards study was completed in 1995 at LANL (Wong et al. 1995). This study provided estimates of the ground shaking hazards by considering the location and rates of movement of earthquakes on a variety of seismic sources and the resulting ground motions that may be caused by these earthquake sources. This study included a detailed assessment of uncertainties, including those associated with the rates of movement for earthquake faults near LANL. The earthquake faults included in the study included all faults within 10 miles (16 kilometers) that met the definition of the term capable fault used by the U.S. Nuclear Regulatory Commission to assess the seismic safety of nuclear power reactors (10 CFR 100, Appendix A).

The nearby north-trending Pajarito Fault system dominates the geologic structure of the LANL area (Figure 4.2.2.2–1). The Pajarito Fault system forms the structural boundary along the western edge of the Española Basin, which is a part of the Rio Grande Rift and the eastern edge of the Valles volcanic province (Wong et al. 1995).

The Pajarito Fault system consists of three major faults and numerous secondary faults. The major faults in Los Alamos County are the Pajarito, Rendija Canyon, and Guaje Mountain. A summary of the characteristics of these faults is presented in Table 4.2.2.2–1. Estimates of the most recent movements along the faults are based on trench studies where the faults are not buried. Therefore, it is possible that the most recent movements along the faults are younger than those presented in Table 4.2.2.2–1 (Wong et al. 1995). As discussed above, these



SOURCE: Gardner and House 1987

FIGURE 4.2.2.2–1.—*Major Surface Faults at LANL.*

TABLE 4.2.2.2–1.—*Summary of Major Faults*

NAME	APPROXIMATE LENGTH miles (kilometers)	TYPE	MOST RECENT MOVEMENT	MAXIMUM POTENTIAL EARTHQUAKE[a]
Pajarito	26 miles (42 kilometers)	Normal, down-to-the-east[b]	Approximately 45,000 to 55,000 years ago	7
Rendija Canyon	6 miles (10 kilometers)	Normal, down-to-the-west	8,000 to 9,000 or 23,000 years ago	6.5
Guaje Mountain	8 miles (14 kilometers)	Normal, down-to-the-west	4,000 to 6,000 years ago	6.5

[a] Richter magnitude
[b] The crustal block on the east side of the fault slips downward toward the east when fault movement occurs. This results in a fault plane for the Pajarito Fault, for example, which runs under LANL toward the east. A normal west fault involves the crustal block on the west side of the fault slipping downward toward the west.
Source: Wong et al. 1995

uncertainties were factored into the seismic hazards study (Wong et al. 1995).

Geologic mapping and fault trenching studies at LANL are currently underway or were recently completed to better define the rates of fault movement, specifically for the Pajarito Fault, and the location and possible southern termination of the Rendija Canyon Fault. A summary of these studies is provided in Table 4.2.2.2–2, including the date or expected date of publication for each study's final report. Results of these studies have been and will continue to be reviewed to determine if the seismic hazards study (Wong et al. 1995) needs to be updated. To account for the results and potential results of this work, selection of earthquake scenarios for evaluation of risk-dominant accidents has considered the uncertainties that exist related to the frequency and location of earthquakes, including the possibility that Rendija Canyon Fault intersects TA–3 (see volume III, appendix G, section G.4.1.1). Locations of active faults, such as the Rendija Canyon Fault, may also need to be addressed as part of any new facility siting decisions.

In volume III, appendix I presents a detailed status of the ongoing and recently completed seismic hazard studies as well as the implications of these studies for LANL and DOE. The Status and Implications of Seismic Hazard Studies at LANL Report (this report, appendix I, has been reviewed and accepted by DOE) indicates that TA–3 does have faults with vertical displacements in the range of 1 to 10 feet (0.3 to 30 meters). The faults found include one under the Chemistry and Metallurgy Research (CMR) Building in TA–3 with a vertical offset of approximately 8 feet (2.4 meters). While surface rupture can cause significant structural damage, surface rupturing earthquakes are low probability events. As discussed in the report, the probability of an earthquake causing significant surface displacement at this site in the future is small. From the probabilistic assessment of surface rupture, earthquakes that might result in permanent ground displacements capable of causing structures to collapse are estimated to be 33,000 to 100,000 year events. The displacement threshold for collapse was taken as about 20 inches (50 centimeters). For the CMR Building, a nuclear facility, the probability of damaging ground displacement is at or beyond the performance goal for the facility (10,000 year recurrence interval). In its current condition, the probability of damaging ground motion is at least 20 times greater than the probability of damage caused by surface

TABLE 4.2.2.2–2.—*Summary of Ongoing Geologic Field Studies*

GEOLOGIC FIELD TASK	SUMMARY AND PURPOSE OF FIELD WORK	SCHEDULE FOR COMPLETION
Stratigraphic Survey for TA–55[a]	High precision geologic mapping effort in the vicinity of TA–55 to identify and locate faults with the potential for seismic surface rupture. The technique used identifies faults with as little as 0.5 meters of offset in 1.2-million-year-old Bandelier Tuff.	6/98 Final Report
Probabilistic Surface Rupture Assessment for TA–3[b]	Provide bounding estimates on the probability of surface rupture and expected displacement at TA–3. Upper bound will assume the Rendija Canyon Fault runs adjacent to TA–3.	7/98 Final Report
Core Holes (Facility-Specific) Study: SCC/NISC Site and CMR Site[c,d]	To investigate individual sites for evidence of primary faults with the potential for seismic surface rupture. The location at which a stratigraphic marker is found in a series of holes cored across an individual site would indicate the presence/absence of primary faulting.	Final Reports 9/98 SCC/NISC Site 10/98 CMR Site
Fiscal Year 1997 Pajarito Trench Study[e]	Complete data analysis and report writing of investigation started in fiscal year 1997 to help establish the recurrence interval and latest event of the major fault affecting the LANL seismic hazard. This effort focuses on seven trenches cut immediately to the south of Los Alamos Canyon to the west and north of the LANL site.	8/98 Final Report
Stratigraphic Survey for TA–3	High precision geologic mapping effort in the vicinity of TA–3 to identify and locate faults with the potential for seismic surface rupture. The technique used identifies faults with as little as 0.5 meters of offset in 1.2-million-year-old Bandelier Tuff.	12/98 Field Work 3/99 Final Report
Fiscal Year 1998 Pajarito Trench Study	Initiate seven new trenches on the Pajarito Fault to continue the investigation into the recurrence interval and latest event on the major fault affecting the LANL seismic hazard. These trenches are located roughly 1 mile (1.6 kilometer) or greater to the south of those in the fiscal year 1997 effort and are near the western boundary of the LANL site.	8/98 Field Work 3/99 Final Report

SCC = Strategic Computing Complex, NISC = Nonproliferation and International Security Center

Sources:

[a] Gardner and WoldeGabriel 1998
[b] Olig et al. 1998
[c] Krier et al. 1998a
[d] Krier et al. 1998b
[e] McCalpin 1998

rupture. Therefore, the discovery of the fault under the CMR Building does not increase the seismic risk. However, the discovery of a fault under the CMR Building has an impact on decisions concerning upgrades and future uses for the facility.

The report, presented as appendix I (in volume III), indicates that slip rates (recurrence intervals for earthquakes) are within the parameters assumed in the 1995 seismic hazards study at LANL (Wong et al. 1995). The 1995 study (Wong et al. 1995) was used for the LANL facility design basis for ground motion. The report also indicates that TA–55 has no evidence of existing faults and is not susceptible to surface rupture from earthquakes.

A historical catalog has been compiled of earthquakes that have occurred in the LANL area from 1873 to 1991 (Wong et al. 1995). A review of these earthquakes indicates that only six, having an estimated magnitude of 5 or greater on the Richter scale, have occurred in the LANL region. The most significant seismic event in this period was the 1918 Cerrillos earthquake. This earthquake had an estimated Richter magnitude of 5.5 and was centered approximately 31 miles (50 kilometers) southeast of LANL. Near the epicenter, an earthquake of this magnitude may cause damage to buildings, depending on their design, and cause chimneys and factory stacks to collapse.

It is possible to relate Richter magnitudes to ground acceleration values (the change of rate in ground movement during an earthquake) and to observed effects of earthquakes. However, it is important to note that these relationships are approximate. The observed effects can vary with ground motion and Richter magnitude, depending upon the distance to the epicenter, the type of ground on which the observer is standing, the type and orientation of the fault with respect to the observer, and many other variables. Table 4.2.2.2–3 was prepared to provide the reader with a frame of reference that is important in understanding earthquakes and the impacts of earthquakes on structures. Table 4.2.2.2–3 was developed based on general correlations between observed earthquake effects and earthquake magnitudes and the correlations between earthquake magnitudes and ground acceleration from the comprehensive LANL seismic hazard study.

The seismic hazards results indicate that the Pajarito Fault system represents the greatest potential seismic risk to LANL, with an estimated maximum earthquake magnitude of about 7. Although large uncertainties exist, an earthquake with a Richter magnitude greater than or equal to 6 is estimated to occur once every 4,000 years; an earthquake with a magnitude greater than or equal to 7 is estimated to occur once every 100,000 years along the Pajarito Fault system. Earthquakes of this magnitude may cause considerable damage to structures and underground pipes.

Modern earthquake design standards for DOE are based on criteria defined in DOE Standard 1020–94 (DOE 1996c). Four levels of design earthquake ground motions are defined for structures corresponding to return periods of 500, 1,000, 2,000, and 10,000 years, depending on the off-site hazard posed by failure of the facility. These standards were promulgated in 1993 through 1995. The seismic hazards study of facilities in eight LANL TAs found that earthquakes representative of frequency of 1 in 10,000 per year would cause the horizontal peak ground acceleration ranging from 0.53 ground acceleration to 0.57 ground acceleration (Table 4.2.2.2–4) (Wong et al. 1995). Some of the maintenance and refurbishment activities at LANL (chapter 3, section 3.4) are specifically intended to upgrade the seismic performance of older structures.

TABLE 4.2.2.2–3.—*Correlations Among Observed Effects of Earthquakes, Richter Magnitudes, and Peak Ground Acceleration*

OBSERVED EFFECTS OF EARTHQUAKES	APPROXIMATE RICHTER MAGNITUDE[a]	APPROXIMATE PEAK GROUND ACCELERATION (*g*) WITHIN 0 TO 10 mi (0 TO 16 km)[b]
Usually not felt	2	
Felt by persons at rest, on upper floors, or favorably placed		
Felt indoors; hanging objects swing; vibration like passing of light truck occurs; might not be recognized as earthquake	3	
Felt noticeably by persons indoors, especially on upper floors; vibration occurs like passing of heavy truck; jolting sensation; standing automobiles rock; windows, dishes, and doors rattle; wooden walls and frames may creak		
Felt by nearly everyone; sleepers awaken; liquids disturbed and may spill; some dishes break; small unstable objects are displaced or upset; doors swing; shutters and pictures move; pendulum clocks stop or start	4	
Felt by all; persons walk unsteadily; windows and dishes break; objects fall off shelves and pictures fall off walls; furniture moves or overturns; weak masonry cracks; small bells ring; trees and bushes shake	5	0.05 to 0.20
Difficult to stand; noticed by car drivers; furniture breaks; damage moderate in well-built ordinary structures; poor quality masonry cracks and breaks; chimneys break at roof line; loose bricks, stones, and tiles fall; waves appear on ponds and water is turbid with mud; small earthslides; large bells ring	6	0.15 to 0.30
Automobile steering affected; some walls fall; twisting and falling of chimneys, stacks, and towers; frame houses shift if on unsecured foundations; damage slight in specially designed structures, considerable in ordinary substantial buildings; changes in flow of wells or springs; cracks appear in wet ground and steep slopes		
Masonry heavily damaged or destroyed; foundations damaged; serious damage to frame structures, dams, and reservoirs; underground pipes break; conspicuous ground cracks	7	0.35 to 0.70
Most masonry and frame structures destroyed; some well-built wooden structures and bridges destroyed; serious damage to dams and dikes, large landslides; rails bent		
Rails bent greatly; underground pipelines completely out of service	8	0.50 to 1.0
Damage nearly total; large rock masses displaced; objects thrown into air; lines of sight distorted		

Sources: [a] Richter 1958 and [b] Wong et al. 1995.

TABLE 4.2.2.2–4.—*Peak Horizontal Ground Accelerations Corresponding to Return Periods from 500 to 10,000 Years for Eight LANL Technical Areas*

SITE	GROUND ACCELERATION 500-YEAR RETURN PERIOD	GROUND ACCELERATION 1,000-YEAR RETURN PERIOD	GROUND ACCELERATION 2,000-YEAR RETURN PERIOD	GROUND ACCELERATION 10,000-YEAR RETURN PERIOD	GROUND ACCELERATION 100,000-YEAR RETURN PERIOD (EST.)
TA–2	0.14	0.22	0.31	0.57	> 1.0
TA–3	0.14	0.21	0.30	0.56	> 1.0
TA–16	0.14	0.21	0.29	0.53	1.0
TA–18	0.14	0.22	0.31	0.57	0.98
TA–21	0.15	0.22	0.31	0.55	1.0
TA–41	0.14	0.22	0.31	0.57	> 1.0
TA–46	0.15	0.22	0.30	0.55	0.99
TA–55	0.15	0.22	0.30	0.56	> 1.0

> = greater than

Source: Wong et al. 1995

4.2.2.3 *Slope Stability, Subsidence, and Soil Liquefaction*

Rockfalls and landslides are two geologic processes related to slope stability at LANL. The historic downward cutting or erosion of surface water streams in the LANL region results in steep canyon walls. The primary risk factors most likely to affect slope stability are wall steepness, canyon depth, and stratigraphy. Because of this, the LANL facilities near a cliff edge (e.g., TA–33) or in a canyon bottom (e.g., TA–2, Omega West reactor) are potentially susceptible to slope instability. The largest slope instability may be triggered by any process that might destabilize supporting rocks. These processes include, but are not limited to, excessive rainfalls, erosion, and seismic activity.

Although no LANL-wide slope stability studies have been performed, several site-specific studies have been published. Slope stability studies have been performed for Los Alamos Canyon (in the vicinity of TA–2, the Omega West reactor), TA–33, TA–21, and Pajarito Mesa (Kelley 1970, Reneau et al. 1995, Reneau 1995, and Reneau 1994). Generally, the proximity of these sites to canyon edges prompted these reports, and these may represent worst-case scenarios for LANL.

A rock catcher was installed in TA–2 in the Los Alamos Canyon in 1944 to protect the Omega West reactor (which is no longer operational) from rockfalls. Additionally, a rock catcher was installed at TA–41 in 1978, and periodic inspections are performed at both sites. Twenty-four separate rockfalls were recorded at both sites between 1944 and 1993. The rocks caught range in size from 300 to 21,000 pounds (136 to 9,525 kilograms) (McLin 1993).

Subsidence (lowering of the ground surface) and soil liquefaction are two geologic processes that are less likely to affect LANL than rockfalls or landslides. The potential for subsidence is minimal due to the firm rock beneath LANL. Soil liquefaction is a process where saturated (or nearly saturated soils) and unconsolidated sediments become fluid during an earthquake, to the extent that the ground may be unable to support structures. Bedrock, soils, and unconsolidated deposits that are unsaturated, such as those that occur beneath LANL, are unlikely to undergo liquefaction.

4.2.3 Soils

Several distinct soils have developed in Los Alamos County as a result of interactions between the bedrock, topography, and local climate. Soils that formed on mesa tops of the Pajarito Plateau include the Carjo, Frijoles, Hackroy, Nyjack, Pogna, Prieta, Seaby, and Tocal soil series (Reneau 1994). All of the soils in the aforementioned soil series are well-drained and range from very shallow (0 to 10 inches [0 to 25 centimeters]) to moderately deep (20 to 40 inches [51 to 102 centimeters]), with the greatest depth to the underlying Bandelier Tuff being 40 inches (102 centimeters) (Nyhan et al. 1978). The geochemistry, geomorphology, and formation of soils in the LANL area have been characterized (Longmire et al. 1996).

4.2.3.1 *Soil Monitoring*

Soils on and surrounding LANL are sampled annually as a part of the Environmental Surveillance and Compliance Program to determine if they have been affected by LANL operations (LANL 1992b, LANL 1993b, LANL 1994b, LANL 1995f, LANL 1996e, LANL 1996i, and LANL 1997c). Sediments, which occur along most segments of LANL canyons as narrow bands of canyon-bottom deposits that can be transported by surface water during runoff events or by LANL outfall effluent flows, are not part of the soil monitoring program and are discussed under section 4.3.1.4. A soil sampling and analysis program, as mandated by DOE Orders 5400.1

and 5400.5, provides information on the concentration and distribution of radionuclides in soils near LANL. Soil samples are collected from on-site, perimeter, and off-site locations shown in Figure 4.2.3.1–1. Additionally, background soil samples are collected from regional stations that are located in three major drainages surrounding LANL (Rio Chama and Embudo, Cochiti and Bernalillo, and Jemez) and one regional station located near Santa Cruz Lake, across the Rio Grande Valley to the northeast of LANL (Figure 4.2.3.1–2). These background stations are located over 9 miles (15 kilometers) from LANL, which is considered beyond the range of potential influence from normal LANL operations (DOE 1991).

On-site areas sampled at LANL are not from potential release sites (PRSs) or wastewater outfalls. Instead, the majority of on-site sampling stations are located close to and downwind from major facilities and/or operations at LANL in an effort to assess radionuclide, radioactivity, and heavy metals in soils that may have been contaminated as a result of air stack emissions and fugitive dust (e.g., the resuspension of dust from PRSs). A rough estimate, based on information from LANL's database, FIMAD, which has areal estimates of the PRSs, indicates that the areal extent of the PRS are less than 3 percent of LANL's approximately 43 square miles (111 square kilometers). The areal extent of this 3 percent does not include the canyons because they are not classified under the FIMAD database as PRSs.

The soil radionuclide and radioactivity samples collected from 1974 through 1995 have been analyzed for tritium; cesium-137; plutonium-238, -239, and -240; americium-241; strontium-90; total uranium; gross alpha; gross beta; and gross gamma activities.

Sources of radionuclides in soil may include natural minerals, atmospheric fallout from nuclear weapons testing (Klement 1965), burn-up of nuclear-powered satellites (Perkins and Thomas 1980), and planned or unplanned releases of radioactive gases, liquids, and/or solids by LANL. Naturally occurring uranium is present in relatively high concentrations in soil and rocks due to the regional geologic setting (Purtymun et al. 1987). Sources of plutonium include LANL operations and atmospheric fallout. Metals in soil may be naturally occurring or may result from LANL releases.

LANL on-site and perimeter soil samples (Figure 4.2.3.1–1) are collected and analyzed for radiological and nonradiological constituents, and compared to the regional (background) locations (Figure 4.2.3.1–2). In general, the average concentrations of tritium, strontium-90, cesium-137, plutonium-239, plutonium-240, americium-241, and gross alpha and beta activity in soils collected from perimeter stations were not significantly different than radionuclide concentrations and activity in soil samples collected from regional background locations. In contrast, the average levels of uranium (3.12 micrograms per gram), plutonium-238 (0.015 picocurie per gram), and gross gamma activity (4.1 picocuries per gram) were significantly higher than uranium (1.84 micrograms per gram), plutonium-238 (0.004 picocurie per gram), and gross gamma (3.4 picocuries per gram) in background soils. Although the average levels of uranium and gross gamma activity in perimeter soils were significantly higher than background, they were still within the regional statistical reference level (RSRL) of 4.05 micrograms per gram and 7.3 picocuries per gram, respectively. The RSRL is the average background concentration plus twice the standard deviation of the mean from data collected over a 21-year period (Fresquez et al. 1996a). Plutonium-238 average concentrations, on the other hand, were just above the RSRL (0.008 picocurie per gram); however, these levels were far below LANL screening action levels (SALs) of 27 picocuries per gram. LANL SALs, developed by the

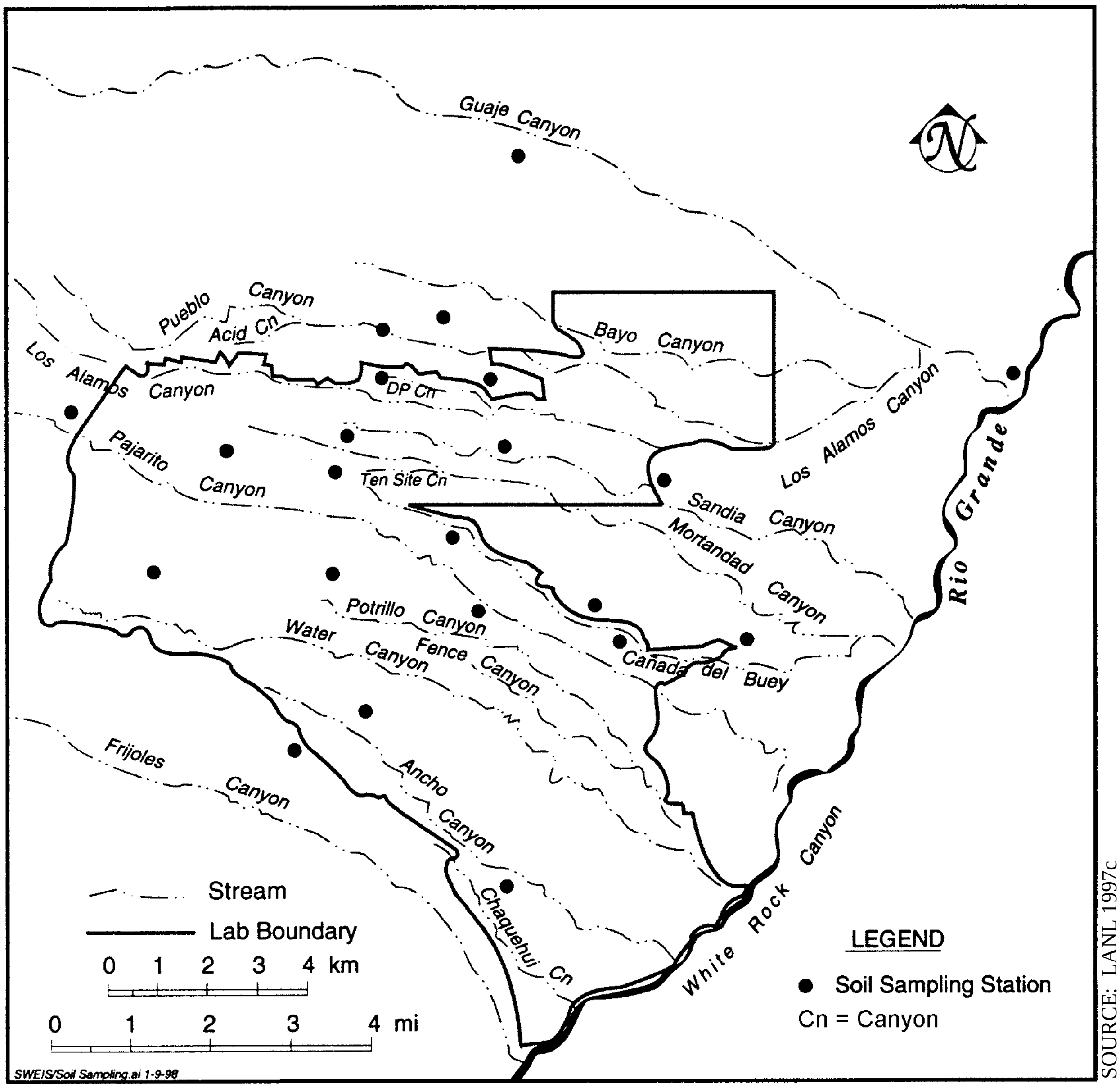
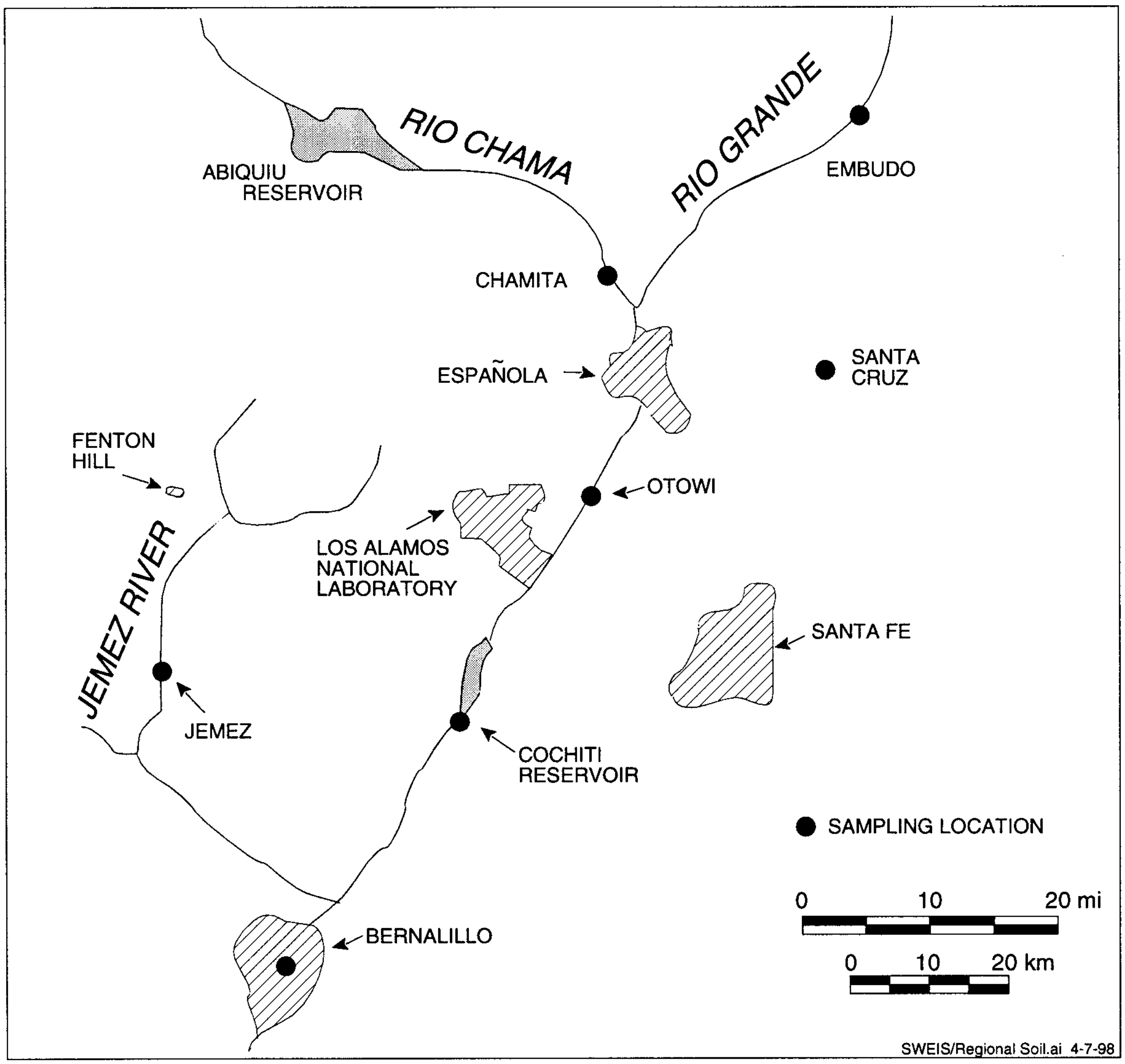


FIGURE 4.2.3.1–1.—*On-Site and Off-Site Perimeter Soil Sampling Locations.*
(**Note:** Perimeter stations are located within 2.5 miles [4 kilometers] of LANL.)



SOURCE: LANL 1997c

FIGURE 4.2.3.1–2.—*Regional Soil Sampling Locations.*

Environmental Restoration (ER) Project at LANL, are used to identify the presence of contaminants of concern and are derived from a risk assessment pathway using a 10 millirem per year dose limit. SALs are used by the ER Project at LANL to identify "hot spots" that will require additional sampling and may require remediation. Table 4.2.3.1–1 shows the RSRL and the LANL SAL values for several radionuclides. The SALs shown in Table 4.2.3.1–1 provide an indication of how far below RSRLs are to the 10 millirem per year standard.

For 1995 on-site soil samples, only plutonium-239, plutonium-240 (both 0.059 picocurie per gram) and total uranium (3.57 micrograms per gram) were detected in significantly higher concentrations as compared to off-site background soils. However, the levels were still within the RSRL and/or were far below LANL SALs. In general, the higher concentration of radionuclides, particularly uranium and plutonium isotopes, in perimeter soils as compared to background soils may be due in part to LANL operations but are mostly due to worldwide fallout and to naturally occurring radioactivity in Bandelier Tuff soils; whereas, higher radioactivity in soils from on-site areas may be due to worldwide fallout, natural radioactivity, and to LANL operations. (Fresquez et al. 1995d.)

Trend analyses show that most radionuclides and radioactivity, with the exception of plutonium-238 and gross alpha, in soils from on-site and perimeter areas have been decreasing over time (Fresquez et al. 1996a). These trends were especially apparent (i.e., significant at the 0.05 probability level

TABLE 4.2.3.1–1.—*Regional Statistical Reference Level and LANL Screening Action Levels for Radionuclides*[a]

	RSRL[b] (AVERAGE FROM 1974 TO 1994)	LANL SCREENING ACTION LEVEL (SAL)[c]
Tritium	6.34 nCi/l	1,900 nCi/l
Cesium-137	1.13 pCi/g	5.10 pCi/g
Plutonium-238	0.008 pCi/g	27 pCi/g
Plutonium-239, -240	0.028 pCi/g	24 pCi/g
Americium-241	0.208 pCi/g	22 pCi/g
Strontium 90	0.82 pCi/g	4.40 pCi/g
Total Uranium	4.05 µg/g	29 µg/g
Gross Alpha	35.24 pCi/g	Not Available
Beta	13.62 pCi/g	Not Available
Gamma	7.33 pCi/g	Not Available

nCi/l = nanocuries per liter, pCi/g = picocuries per gram, µg/g = microcuries per gram.

[a] Fresquez et al. 1996a

[b] Regional Statistical Reference Level; this is the upper limit background concentration (mean plus two standard deviations) (Fresquez et al. 1996a).

[c] SALs are a benchmark for the potential for human health risk and are derived from toxicity data using a risk assessment approach that requires information regarding the contaminant toxicity, the uptake rate of the medium in which the contaminant is found, the body weight of the receptor, and the biological availability of the contaminant after uptake. Because all of this information is rarely known, assumptions and/or extrapolations from other data usually are required. These assumptions and extrapolations result in some degree of uncertainty associated with the resultant SALs. Also, SALs may change over time as studies that result in new toxicological data or new information regarding other parameters that are used in calculating the SALs are obtained.

[probability less than 0.05]) for tritium and uranium in soils from on-site areas. Their decrease may be due in part to reductions in LANL operations, air stack emissions, and to better engineering controls employed by LANL (LANL 1996i), but is more probably due to: (1) the cessation of aboveground nuclear weapon testing in the early 1960's, (2) weathering (wind, water erosion, and leaching), and (3) radioactive decay (half-life) (Whicker and Schultz 1982). Tritium, which has a half-life of about 12 years, exhibited the greatest decrease in activity over the 21 years in almost all of the soil sites studied, including regional locations. Plutonium-238 and gross alpha activity generally increased over time in most on-site, perimeter, and even regional background sites; all sites, however, were far from being statistically significant (probability less than 0.05). The source of most plutonium-238 detected in the environment is from nuclear weapons testing in the atmosphere (Klement 1965) and from the re-entry burn-up of satellites containing a plutonium-238 power source (Perkins and Thomas 1980). Only a few gross alpha readings and a few gross beta readings showed significantly increasing trends (probability less than 0.05) over time. In these cases, however, the measurement period was both early and very short (1978 to 1981).

Soils were also analyzed for trace and heavy metals, and most metals were within RSRLs and were well below LANL SALs (LANL 1996i). Only beryllium and lead, both products of firing site activities, exhibited any kind of trend; that is, both were consistently higher in perimeter and on-site soils than in background soils. Concentrations over time show that average beryllium in perimeter soils decreased from 0.97 microgram per gram in 1992 to 0.62 microgram per gram in 1995. Lead decreased from 32 micrograms per gram in 1992 to 22.7 micrograms per gram in 1995. Similarly, beryllium in on-site soils averaged 1.17 micrograms per gram in 1992, and decreased to 0.63 microgram per gram in 1995. Lead in on-site soils, on the other hand, increased slightly in concentration from an average of 16 micrograms per gram in 1992 to 20 micrograms per gram in 1995. The RSRL for beryllium and lead is 0.90 and 21.8 micrograms per gram, respectively.

The EPA studied radionuclides and radioactivity in soils at the Pueblo of San Ildefonso in 1994 (EPA 1995). Samples were collected from 16 locations east of the Rio Grande; 9 locations west of the Rio Grande in Los Alamos Canyon, Mortandad Canyon, and Cañada del Buey; and 5 regional background locations at Embudo Station, Santa Fe, Rio Chama above and below Abiquiu Reservoir, and Albuquerque. The EPA analyzed the soil samples for tritium; cesium-137; plutonium-238, -239, and -240; americium-241; strontium-90; uranium isotopes (uranium-234, -235, and -238); thorium isotopes (thorium-227, -228, -230, and -232); and gamma-emitting radionuclides. Analyses of the various isotopes of uranium and thorium were performed to evaluate whether these radionuclides were from natural sources or a result of human activities. The EPA concluded that, with the exception of cesium-137 and cobalt-56, the radionuclides detected were of natural origin and had concentrations typical of southwestern soils. The source of cesium-137 was interpreted to be from atmospheric fallout from nuclear weapons testing. Cobalt-56 is not normally detected in the environment due to its short half-life (79 days) and was found in only one sample. The EPA concluded that the origin of this radionuclide was unknown (EPA 1995).

4.2.3.2 *Soil Erosion*

Soil erosion can have serious consequences to the maintenance of biological communities and may also be a mechanism for moving contaminants across LANL and off site. Soil erosion rates vary considerably on the mesa tops at LANL, with the highest rates occurring in drainage channels and areas of steep slopes and the lowest rates occurring on gently sloping portions of the mesa tops away from the channels (LANL 1993a). A recent study performed in BNM suggests that erosion rates are high across widespread portions of local pinyon-juniper woodlands, which are found on the eastern portion of LANL (Wilcox et al. 1996a).

Another study found that light summer rain storms in 1993 resulted in erosion of more than 12 tons per acre (26,900 kilograms per hectare) of soil (Wilcox et al. 1996b). It is estimated that the current annual rate of soil erosion in BNM is 36 tons per acre (80,700 kilograms per hectare).

Areas where runoff is concentrated by roads and other structures are especially prone to high erosion rates. High erosion rates appear to be relatively recent, most likely resulting from loss of vegetative cover, decreased precipitation, past logging practices, and past livestock grazing (Wilcox et al. 1996b).

4.2.4 Mineral Resources

There are no active mines, mills, pits, or quarries in Los Alamos County or on DOE land at LANL. Sand, gravel, and pumice are mined throughout the surrounding counties. For example, there is a pumice mine in Guaje Canyon on USFS land.

The major sand and gravel deposit in the area is located in the lower member of the Puye Conglomerate (DOE 1979). The Totavi Gravel Pit, located approximately 4 miles east (6.4 kilometers) of Los Alamos County on NM 502, is an active operation that extracts sand and gravel from this deposit. The deposit is approximately 50 feet (15 meters) thick and is overlain by 20 to 50 feet (6 to 15 meters) of overburden (Griggs and Hein 1954). Sand and gravel are used for construction purposes such as aggregate for concrete, asphalt paving, and road base.

Sand and gravel have also been taken from terrace deposits in Los Alamos Canyon, from the floors of Pajarito and Water Canyons, and from river deposits near the slopes of the Jemez Mountains (DOE 1979). The terrace and river deposits have been exhausted. However, small sand and gravel deposits may exist west of the previously worked areas in Pajarito and Water Canyons (DOE 1979).

Commercial deposits of pumice are actively mined to the northeast, east, south, and southwest of Los Alamos County (NMNRD 1994). Pumice is used in textile laundries to soften material, for building blocks and landscaping, and as an abrasive (NMNRD 1994). Although pumice deposits of potential commercial value lie within Los Alamos County, no active mines exist. The deposit of Guaje Flats has been estimated to contain 7 million cubic yards (about 5 million cubic meters) of pumice (Kelley 1948).

The moderately welded and welded units of the Bandelier Tuff are suitable as foundation rocks, structural building stone, ornamental stone, or insulating material (Purtymun and Koopman 1965). Volcanic tuff has been used successfully by the Zia Company as the aggregate in soil-cement sub-bases for roads (Pettitt 1969).

4.2.5 Paleontological Resources

No paleontological sites are reported to occur within LANL boundaries, and the near-surface stratigraphy is not conducive to preserving plant and animal remains. These near-surface materials are volcanic ash and pumice that were extremely hot when deposited. Occasionally, some charcoal is found at the base of an ashfall (DOE 1995b).

4.3 WATER RESOURCES

Only a small percentage of the world's total water supply is available to humans as fresh water, and more than 98 percent of the available fresh water is groundwater (Fetter 1988). Water is scarce in the semi-arid climate of northern New Mexico where precipitation is variable and stems primarily from summer thunderstorms and winter snowfall. During most of the year in the LANL region, surface water is present only in the Rio Grande and Rito de los Frijoles and in reservoirs. Naturally perennial surface water reaches also are located in Ancho, Pajarito, and Chaquehui Canyons.[1] The canyon-bottom streams within LANL boundaries are mostly dry and only portions of some streams contain water year-round. Flash floods can occur from the Sierra de Los Valles to the Rio Grande. Sediments moved by stormwater events from upstream, hill sides, or mesa tops occur along most of LANL canyons. Flash floods move the sediments from the canyon bottoms to downstream locations such as Cochiti Lake. Springs and the 87 National Pollutant Discharge Elimination System (NPDES)-permitted industrial and sanitary wastewater outfalls from LANL operations are additional sources of water to watersheds in the region. The 87 index NPDES flows were estimated using data provided by the surface water data team reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997).

A Look Back in Time

The autumn colours of America are famous and some of the mountain-sides, where aspens grew, turned an unbelievable butter-cup yellow in the autumn, such as I have never seen anywhere else, in brilliant contrast to the dark green of the pine woods. Below us in the valley was the Rio Grande in its early course, a quiet trickle of water during much of the year (and of course frozen in winter) but a torrent of tomato soup in the spring when it was fed by the melting snow of the Rocky Mountains and carried millions of tons of red soil. The ground in the valley had been cut up by ages of erosion into table mountains, some of those mesas almost unclimbable, with steep rocky walls like the Lost World which Conan Doyle so vividly described.

Source: Frisch 1979

The geology of the region has set the stage for the locations of groundwater. Bodies of groundwater can occur near the surface of the earth in the canyon bottom alluvium, perched or trapped above the less-permeable rocks below, or at deeper levels, forming groundwater bodies referred to as intermediate perched groundwater (Purtymun 1995). Where these perched groundwater bodies occur or how large they are, is still under investigation and is not fully characterized.

The main aquifer is the only body of groundwater in the region that is sufficiently saturated and permeable to transmit economic quantities of water to wells for public use. All drinking water for LAC, LANL, and BNM comes from the main aquifer (Purtymun et al. 1995). Depth to water in the main aquifer from the ground surface varies from approximately 1,200 feet (366 meters) along the western boundary to approximately 600 feet (183 meters) along the eastern edge below the surface of the Pajarito Plateau. This groundwater body is relatively insulated from the alluvial and intermediate perched groundwater bodies by geologic formations. To better understand the hydrology of the Pajarito Plateau, LANL personnel have prepared a Hydrogeologic Workplan (LANL 1998b). The workplan proposes the installation of new wells that will further investigate the recharge and cross-connection mechanisms to the main aquifer (sections 4.3.2.1 and 4.3.2.3). The main

1. This does not include LANL effluent supported discharges.

aquifer exists regionally in the sedimentary and volcanic rock of the Española Basin, which extends from the Jemez Mountains in the west to the Sangre de Cristo Mountains in the east, and from the village of Abiquiu in the north to the village of La Bajada in the south. The main aquifer takes residence in interconnected geologic units of the Puye Formation and the Tesuque Formation. The latter unit is a member of the Santa Fe Group. Data on water levels and groundwater ages suggest that the main aquifer of the Española Basin is not strongly interconnected across its extent. There are significant differences in water chemistry at various locations in the Española Basin, further indicating that the regions are not connected. These observations may result from variations in permeability and from different directions of water movement in the aquifer (LANL 1998b). For information on the hydraulic parameters for the unsaturated zone, alluvium, and intermediate and main aquifer, see volume III, appendix A.

Water in the main aquifer is under artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen 1974). The source of recharge to the aquifer is presently uncertain. Early research studies concluded that major recharge to the main aquifer is probably from the Jemez Mountains to the west, because the piezometric surface slopes downward to the east, suggesting easterly groundwater flow beneath the Pajarito Plateau. The small amount of recharge available from the Jemez Mountains relative to water supply pumping quantities, along with differences in isotopic and trace element composition, appear to rule this out. Further, isotopic and chemical composition of some waters from wells near the Rio Grande suggest that the source of water underlying the eastern part of the Pajarito Plateau may be the Sangre de Cristo Mountains (Blake et al. 1995). Groundwater flow along the Rio Grande rift from the north is another possible recharge source. The main aquifer discharges into the Rio Grande through springs in White Rock Canyon (LANL 1996i).

A conceptual drawing of groundwater flow paths in the Española portion of the northern Rio Grande Basin is presented in Figure 4.3–1. The question marks indicate uncertainties in the groundwater flow.

A conceptual drawing of the surface and groundwater bodies as they occur beneath the Pajarito Plateau (the geohydrologic setting) is presented in Figure 4.3–2. A description of the types of water resources in the LANL region and where they occur is presented in Table 4.3–1. The surface and groundwater resources present in the LANL region are described further in this section. Information and data regarding surface water and groundwater quality, NPDES outfalls, sediments, and stormwater monitoring are presented by watershed. It should be noted that the grouping of groundwaters by watershed is applicable to alluvial groundwater, but may not reflect flow pathways to intermediate perched groundwater bodies. The main aquifer is present beneath all watersheds, but is generally considered to receive negligible recharge from surface water streams in the watersheds (Purtymun et al. 1995). The Hydrogeologic Workplan proposes the installation of new wells that will further investigate recharge to the main aquifer (section 4.3.2.3).

Monitoring data presented in this section are primarily from the LANL Environmental Surveillance and Compliance Program (previously called the Environmental Surveillance Program) for the period 1990 through 1996. This program is described in more detail on page 4–1. Summary water quality data tables derived from the 1991 to 1996 LANL Environmental Surveillance and Compliance reports are presented in volume III, appendix C (Tables C–1 through C–7). Additional information regarding water use projections and the groundwater model are presented in appendix A.

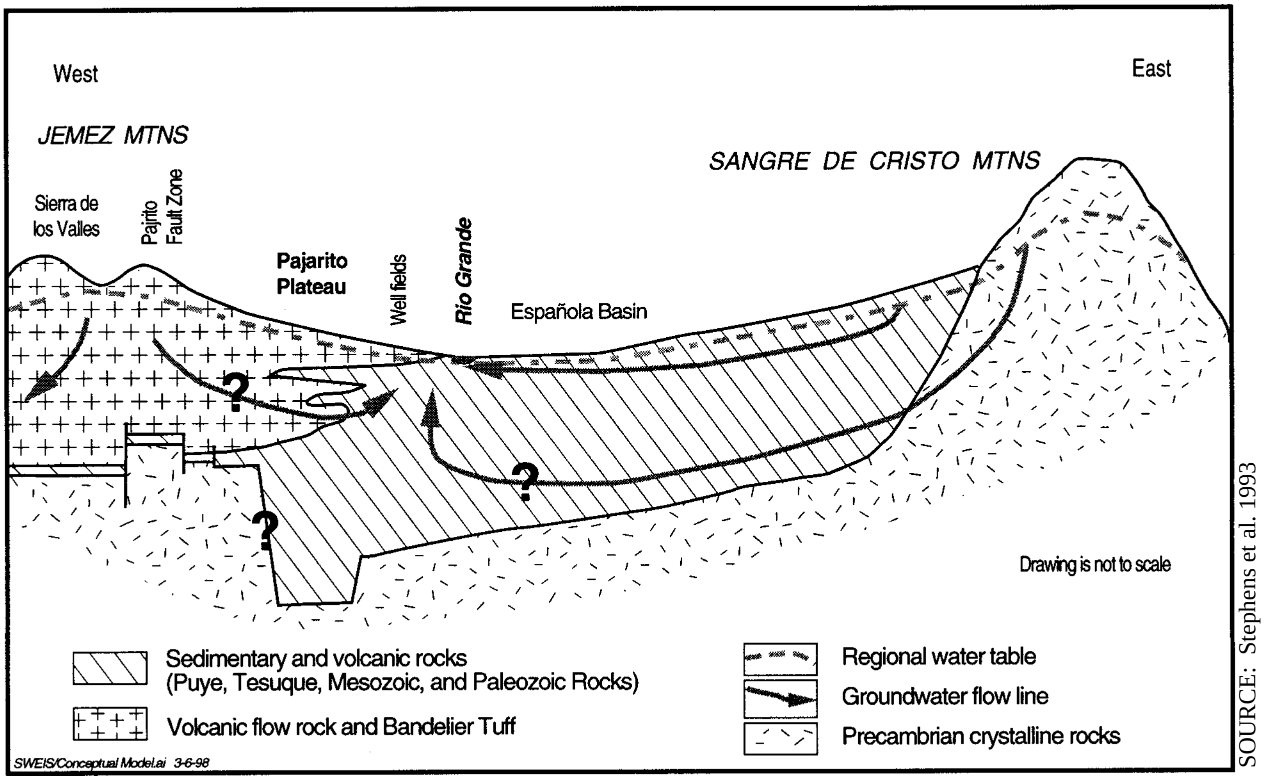


FIGURE 4.3–1.—*Conceptual Sketch of Groundwater Flow Paths in the Española Portion of the Northern Rio Grande Basin.*

Fenton Hill Site

The Fenton Hill site (TA–57) is located about 20 miles (32 kilometers) west of Los Alamos on the southwestern edge of the Valles Caldera in the Jemez Mountains and was the location of LANL's now decommissioned Hot Dry Rock Geothermal Project (chapter 1, Figure 1–1). From the early 1970's until the 1990's, LANL carried out geothermal research at this facility. The main LANL site lies on the eastern side of the caldera, known as the Pajarito Plateau; whereas, the Fenton Hill site is on the western side, known as the Jemez Plateau. The drainage from the main LANL site is eastward toward the Rio Grande; whereas, the drainage from the Fenton Hill site is westward toward the Jemez River. Liquid waste discharges were governed by NPDES Permit No. NM0028576. During the time of operation there were no NPDES permit violations at the Fenton Hill site. No discharges have been made from the Fenton Hill site outfall since fiscal year 1990, and the NPDES permit was discontinued at the request of DOE and LANL on December 29, 1997. Additional information on this facility is available in the *Resource Conservation and Recovery Act* (RCRA) Facility Investigation (RFI) Work Plan for Operable Unit 1154 at the LANL (LANL 1994c).

4.3.1 Surface Water

Surface water in the Los Alamos area occurs primarily as short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the LANL site before they are depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande, the major

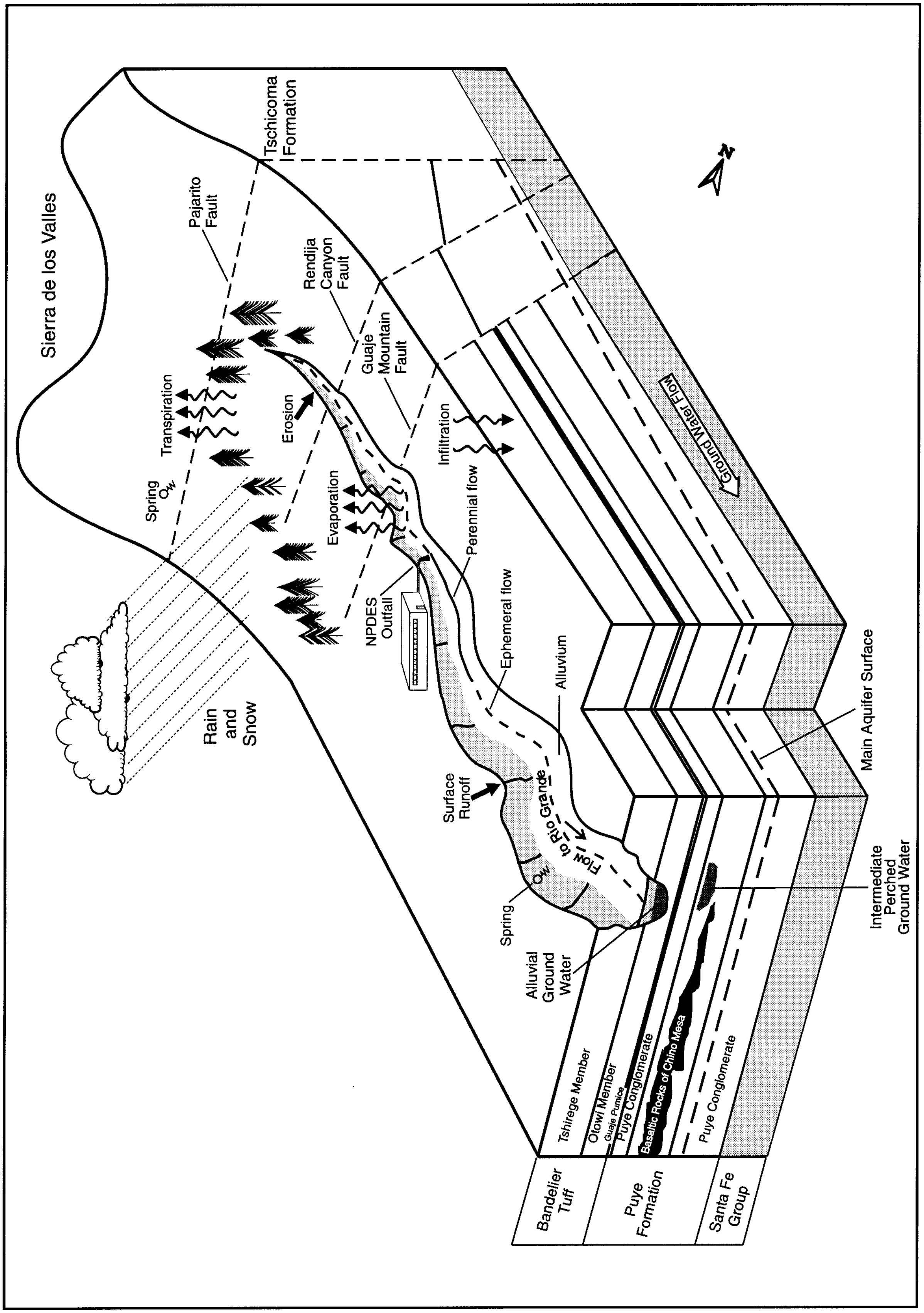


FIGURE 4.3–2.—Conceptual Geohydrological Drawing of the Pajarito Plateau.

TABLE 4.3–1.—*Summary of Water Resources and Sampling Locations by Watershed*

		GUAJE	BARRANCAS	BAYO	PUEBLO	LOS ALAMOS	SANDIA	MORTANDAD	CAÑADA DEL BUEY	PAJARITO	POTRILLO	WATER	ANCHO	CHAQUEHUI	FRIJOLES	WHITE ROCK CANYON[a]
LANL Technical Areas Within Watershed			74	74	72, 73, 74	2, 3, 21, 41, 43, 53, 61, 62, 72, 73, 74	3, 5, 53, 60, 61, 72	3, 5, 35, 48, 50, 52, 55, 59, 60, 63	36, 46, 51, 52, 54, 63, 66	3, 6, 8, 9, 14, 15, 18, 22, 36, 40, 46, 48, 50, 51, 54, 55, 58, 59, 62, 63, 64, 66, 67, 69	15, 36, 68, 71	8, 9, 11, 14, 15, 16, 28, 36, 37, 39, 49, 68, 70, 71	39, 49, 70, 33	33		33, 70
1) Surface Water Flow Category		P/E	E	E	P/E[g]	P/E	P/E[g]	P/E[g]	E	P/E	E	P/E	P/E	P/E	P	P
	Number of Gaging Stations	0	0	0	1	3	1	2[f]	2	3	1	4	1	0	0	0
	Days with Flow[b] (10-1-94 to 9-30-95)	NM	NM	NM	365	247	6	83	15	239	3	74	5	NM	NM	NM
	Number of Sampling Locations[c]	1	0	0	4	4	3	2[f]	1	2	0	1	1	0	2	0
	Number of NPDES Outfalls	7	0	0	1	12	11	12	3	17	0	21	2	1	0	0
2) Sediment Sampling Locations[c]		1	0	1	6	12	2	13	5	8	0	10	8	1	2	2
3) Presence of Alluvial Ground Water		unknown	unknown	unknown	yes	yes	unknown	yes	unknown	yes	unknown	unknown	unknown	unknown	unknown	yes
	Number of Wells Sampled[c]	0	0	0	1	7	2	5	6	3	1	4	0	0	0	0
	Number of Springs Sampled[c]	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
4) Presence of Intermediate Ground Water		unknown	unknown	unknown	yes	yes	yes	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
	Number of Wells Sampled[c]	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Number of Springs Sampled[c]	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5) Presence of Main Aquifer		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Number of Wells Sampled[c, d]	6[e]	0	0	4	5	2	1	2	1	0	2	1	0	0	0
	Number of Springs Sampled[c]	1	0	0	0	0	1	0	0	2	0	1	1	2	0	20

E = Ephemeral (flow is not continuous throughout the year for the entire reach of the canyon); P = Perennial (flow is continuous throughout the year for the entire reach of the canyon); P/E = Drainage contains both ephemeral and perennial reaches; NM = Not measured

[a] Sampling points located at the confluence of a specific watershed and White Rock Canyon (e.g., Los Alamos and the Rio Grande) are included as part of the specific watershed.

[b] Represents local flow at the stream gage only. Does not represent entire canyon.

[c] Number of samples collected by LANL's Environmental Surveillance and Compliance Program. Other Samples collected by LANL's Environmental Restoration Project are not included here.

[d] The number of main aquifer wells is grouped by watershed for consistency. However, the main aquifer is relatively isolated from recharge from the watersheds. Thus, water quality in the main aquifer wells does not necessarily correlate to surface water quality in watersheds.

[e] Only six of the seven wells in Guaje Canyon are sampled. Well G–3 is off-line and has not been sampled during the evaluation period of the SWEIS.

[f] Gaging station GS–1 in Mortandad Canyon is also a surface water sampling location.

[g] Perennial flow in Pueblo, Sandia, and Mortandad Canyons is strictly the result of effluent discharge. Perennial flow in Los Alamos Canyon is partially the result of effluent discharge.

[h] Perennial flow recorded at GS–E060 in Pueblo Canyon is strictly the result of effluent discharge from the Los Alamos County Sewage Treatment Plant.

river in north-central New Mexico, several times a year in some drainages. Effluents from sanitary sewage, industrial water treatment plants, and cooling-tower blowdown enter some canyons at rates sufficient to maintain surface flows for varying distances. Fifteen watersheds in the LANL region are shown in Figure 4.3.1–1 (watersheds A through O). Only 12 of these watersheds (watersheds B through M in Figure 4.3.1–1), with a total area of 82 square miles (212 square kilometers), pass through the boundary of LANL. All of these watersheds are tributaries to an 11-mile (18-kilometer) segment of the Rio Grande between Otowi Bridge and Frijoles Canyon. The Rio Grande passes through Cochiti Lake, approximately 11 miles (18 kilometers) below Frijoles Canyon. The Los Alamos Reservoir, in upper Los Alamos Canyon, has a capacity of 41 acre-feet (51,000 cubic meters). The reservoir water is used for recreation, swimming, fishing, and landscape irrigation in the Los Alamos townsite (LANL 1996i).

The Pajarito Plateau canyons, which serve as collection points for the regional watersheds, originate either along the eastern rim of the Sierra de Los Valles or on the Pajarito Plateau. Within LANL boundaries, only Los Alamos, Pajarito, Water, Ancho, Sandia, Pueblo, and Chaquehui Canyons contain reaches or streams with sections that have continuous flow. Surface water within LANL boundaries is not a source of municipal, industrial, or irrigation water, but is used by wildlife that live within, or migrate through, the region.

To better understand LANL's influence to surface water in the Los Alamos area, the following surface water sections will first present information on surface water monitoring (section 4.3.1.1) and surface water quality standards (section 4.3.1.2). The text will then focus on the two primary potential sources of contamination to surface water quality: the NPDES-permitted outfalls at LANL (section 4.3.1.3.) and the sediments in the LANL area (section 4.3.1.4). Surface water quality is discussed in section 4.3.1.5, and floodplain information is discussed in section 4.3.1.6.

4.3.1.1 *Surface Water Monitoring*

Surface waters in the region are monitored by LANL and the New Mexico Environment Department (NMED) to survey the environmental effects of LANL operations. LANL's Environmental Surveillance and Compliance Program is one of the ways LANL determines whether its operations are adversely affecting the public health or the environment, and that LANL conforms with applicable regulatory requirements. This program is described in more detail on page 4–1. As a part of this program, surface water samples from off-site and on-site locations are collected (Figures 4.3.1.1–1 and 4.3.1.1–2, respectively) (LANL 1996i); the monitoring results are published annually in Environmental Surveillance and Compliance Reports. There are several locations at which surface water samples are taken; however, which locations are selected for sampling may vary from year to year. Figures 4.3.1.1–1 and 4.3.1.1–2 reflect the locations where surface water samples were collected in 1995 (LANL 1996i). Beginning 1996, some environmental surveillance runoff samples were collected using automated samplers. The samplers are activated when a significant precipitation event causes flow in a drainage crossing LANL's eastern or western boundaries. The 1996 analysis results for the surface water program were consistent with past findings (LANL 1997c). Surface water samples are not collected from Barrancas and Bayo Canyons due to the lack of surface water in these drainages. Surface water samples are analyzed annually for surface water chemistry, radionuclides, and metals. Samples from one-third of the surface water sampling locations are analyzed annually for organics, with the samples from all of the surface water locations being analyzed for organics at least once every three years. Surface water at the Pueblo of San

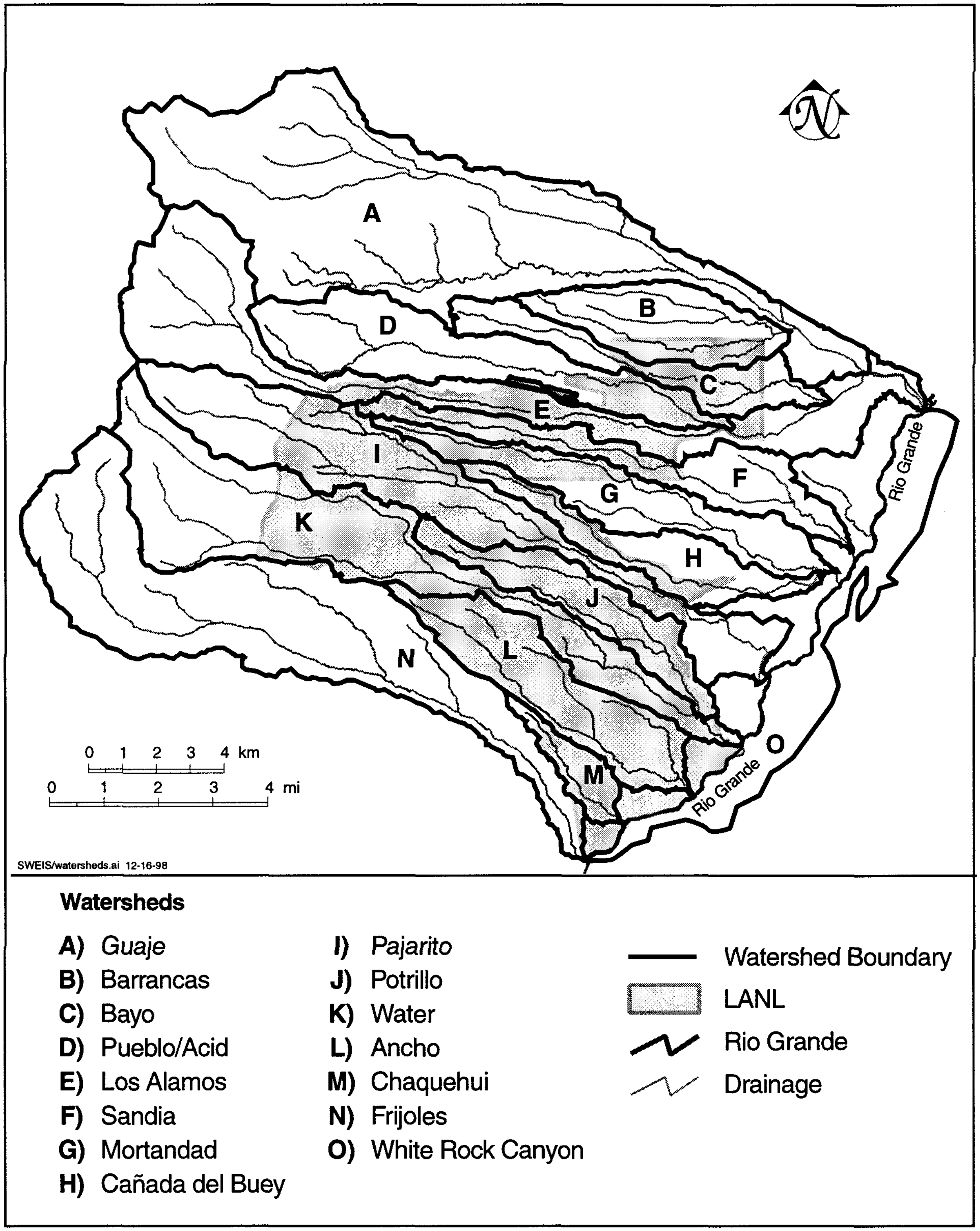


FIGURE 4.3.1–1.—*Watersheds in the LANL Region.*

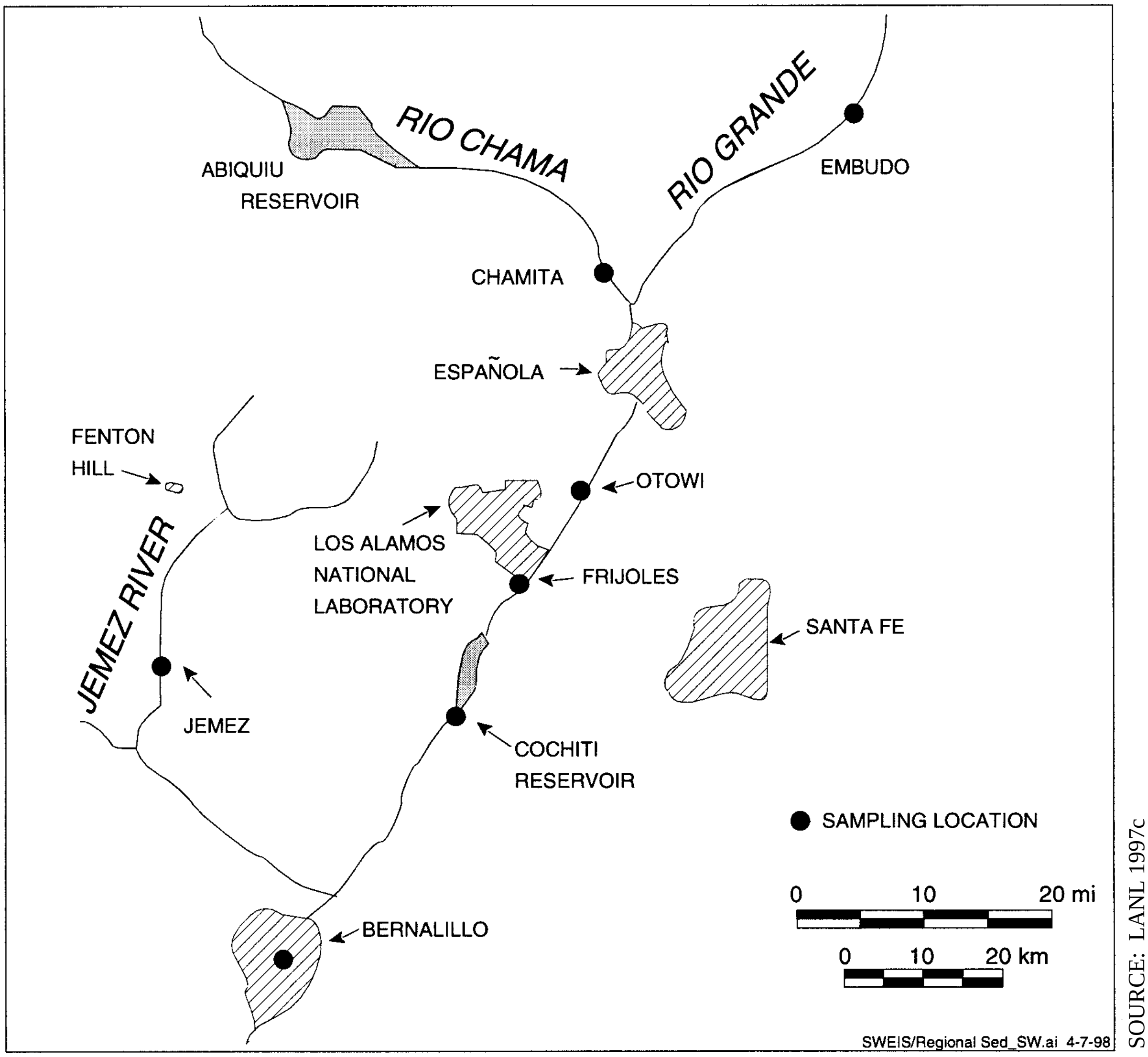


FIGURE 4.3.1.1–1.—*Regional Surface Water and Sediment Sampling Locations.*

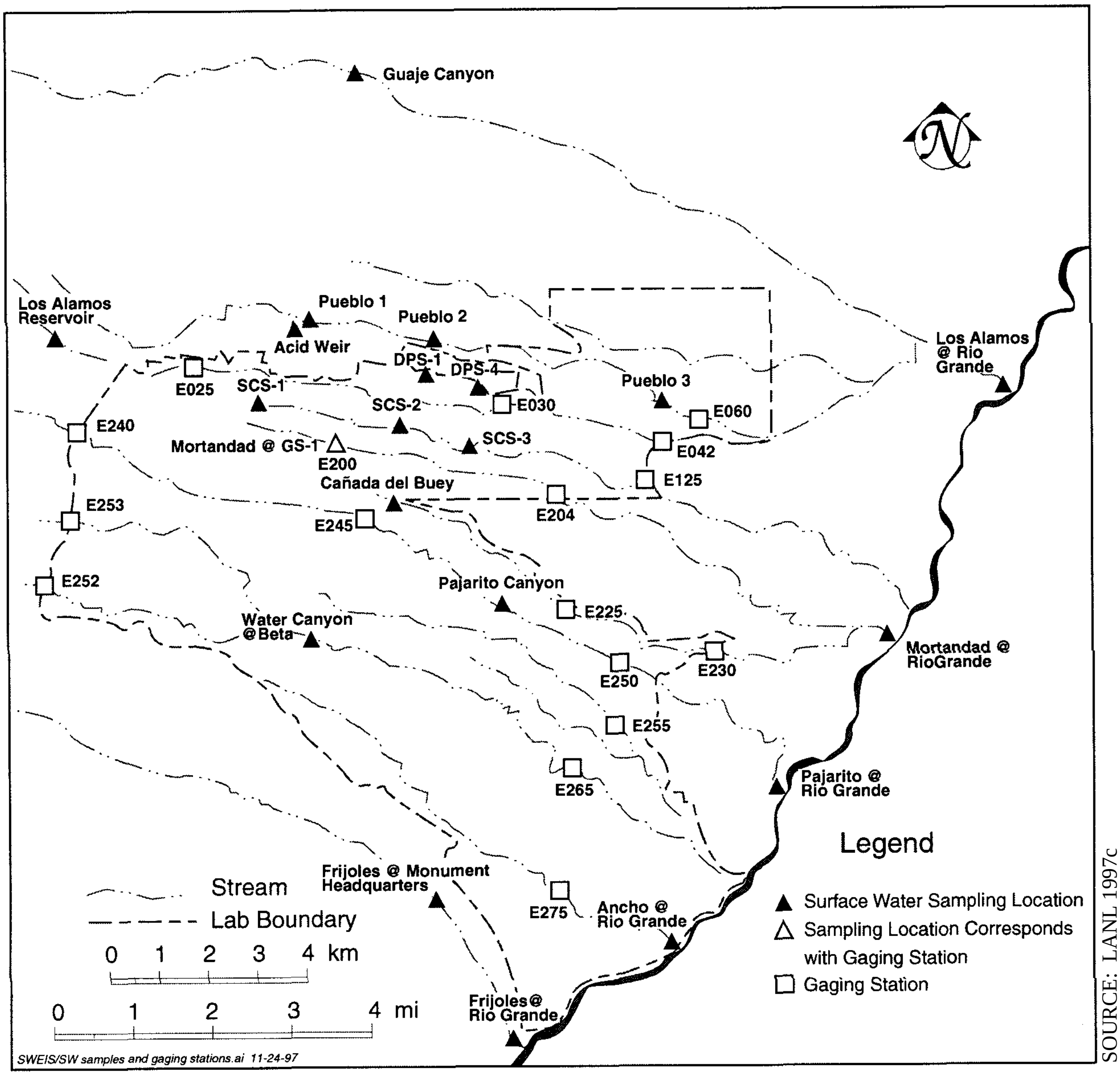


FIGURE 4.3.1.1–2.—*On-Site and Perimeter Surface Water Sampling Locations.*

Ildefonso is also sampled in accordance with a Memorandum of Understanding (MOU) among the Pueblo, U.S. Bureau of Indian Affairs (BIA), and DOE (BIA 1987). Pueblo of San Ildefonso or U.S. Bureau of Indian Affairs representatives may observe sampling and collect samples from the same surface water locations.

The NMED also collects surface water within the LANL region in accordance with the Agreement in Principle between DOE and the State of New Mexico (DOE 1995e). When LANL collects surface water samples, NMED will often (though not always) take split samples to verify the sampling data. NMED recently performed a comparison of LANL and NMED split-sampling data. The statistical analyses for general water chemistry parameters compared favorably, and for the majority of the samples there was no statistically significant difference between LANL and NMED analytical data (PC 1996f). Only LANL analytical data are presented in this SWEIS. Information is also collected from stream monitoring stations. Table 4.3.1.1–1 provides information (days with flow, volume of water, etc.) for various canyon reaches monitored in 1995. These canyon site locations (gaging stations) are further identified in Figure 4.3.1.1–2.

TABLE 4.3.1.1–1.—*Summary of Discharges from Stream Monitoring Stations at LANL, Water Year 1995 (October 1, 1994 Through September 30, 1995)*

CANYON SITES	DAYS W/ FLOW	TOTAL VOLUME OF WATER		INSTANTANEOUS MAX		COMMENTS
		acre-feet	gallons	ft^3/s	gpm	
E025 Upper Los Alamos	247	465	151,520,715	10	4,488	
E030 Middle Los Alamos	169	492	160,318,692	12	5,386	
E042 Lower Los Alamos[a]	110	328	106,879,128	54	24,235	USGS Operated
E060 Pueblo[a]	365	874	284,810,380	5.8	2,621	USGS Operated
E125 Sandia[a]	6	5	1,629,255	13	5,834	
E204 Lower Mortandad[a]	0	--	--	--	--	
E200 Middle Mortandad	83	18	5,865,318	9.7	4,353	Record began 5/10/95
E225 Upper Cañada del Buey	1	0.4	130,340	17	7,630	
E230 Lower Cañada del Buey[a]	15	14	4,561,914	75	33,660	
E240 Upper Pajarito	239	106	34,540,206	1.9	853	
E245 Middle Pajarito	211	250	81,462,750	24	10,771	
E250 Lower Pajarito[a]	210	30	9,775,530	4.6	2,064	
E255 Potrillo[a]	3	3.5	1,140,479	63	28,274	
E252 Upper Water	74	9.5	3,095,585	0.21	94	
E253 Canyon de Valle	0	--	--	--	--	
E265 Lower Water[a,b]	2	--	--	21	9,425	Gage rating to be established
E275 Ancho[a,b]	5	--	--	--	--	Gage rating to be established

ft^3/s = cubic feet per second, USGS = U.S. Geological Survey
[a] Station at downstream LANL boundary
[b] Daily values table not published this year
gpm = gallons per minute

4.3.1.2 Surface Water Quality Standards

Streams within LANL property are nonclassified, and therefore, according to 20 NMAC 6.1, 1105.A, are protected for the uses of livestock watering and wildlife habitat. Most of LANL effluent is discharged into normally dry arroyos (Table 4.3–1), and LANL is required to meet effluent limitations under the NPDES permit program (as discussed in section 4.3.1.3). As discussed in section 4.3.1.1, surface waters from the regional and Pajarito Plateau stations are monitored to evaluate the environmental effects of LANL operations. A study is being performed at LANL to determine if uses in addition to livestock watering and wildlife habitat can be attained for selected reaches on streams present on LANL. The U.S. Fish and Wildlife Service (FWS) is performing the study and will present the results to a Use Selection Committee consisting of NMED, DOE, and University of California members. The results should be available by early 1999.

Concentrations of radionuclides in surface water samples may be compared to either the DOE-Derived Concentration Guide (DCG) for estimation of potential exposure to members of the public from ingested water[2] or the New Mexico Water Quality Control Commission (NMWQCC) stream standards, which reference the New Mexico Health and Environment Department Environmental Improvement Division's New Mexico Radiation Protection Regulations (part 4, appendix A). New Mexico radiation standards are in general two orders of magnitude greater than DOE's DCG for the public (i.e., DCGs are more restrictive than New Mexico standards). Accordingly, only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with NMWQCC Standards for Interstate and Intrastate Streams, Livestock Watering, and Wildlife Habitat Stream Provisions. NMWQCC groundwater standards can also be applied in cases where groundwater discharge may affect stream water quality.

LANL conducts a variety of construction, maintenance, and environmental activities that result in excavation or fill within water courses, which are waters of the U.S. under Section 404 of the *Clean Water Act*. These activities are done pursuant to 404 permits issued by the Army Corps of Engineers and certified per Section 401 by NMED. Each permit is issued pursuant to one or more specific nationwide permits. These include relevant permit conditions to protect water quality and wildlife that must be complied with by LANL and its construction contractors. The NMED also adds conditions as a part of its 401 certification that require application of "best management practices" to ensure compliance with New Mexico stream standards. The following are some examples of currently active 404/401 permits at LANL:

- *LADP3 Culvert Removal Project*— Removal of access road culvert and channel restoration in Los Alamos Canyon
- *Sandia Wetland Restoration Project*— Erosion control, contaminated sediment trapping, and wetland restoration in Sandia Canyon
- *Otowi 1 Well Erosion Control Project*— Arroyo erosion control for well discharge tributary to Pueblo Canyon (PC 1998)

4.3.1.3 National Pollutant Discharge Elimination System Permitted Outfalls

Planned releases from industrial and sanitary wastewater facilities within LANL boundaries are controlled by NPDES permits. These permits require routine monitoring of point

2. The DOE-DCG for water is the concentration that would deliver a 100-millirem dose to an adult who ingests 772 quarts (730 liters) of water in 1 year.

source discharges and reporting of results. In 1995, there were 10 NPDES permits: one for effluent discharges from LANL operations; one for effluent discharges at the Fenton Hill Hot Dry Rock Geothermal Facility (now decommissioned) located 20 miles (32 kilometers) west of Los Alamos; and eight for stormwater discharges (LANL 1996i).

An analysis of data was completed for the 87 currently active NPDES industrial outfalls. Index NPDES flows were estimated using data provided by the surface water data team reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Approximately 233 million gallons (882 million liters) per year of effluent are discharged from NPDES outfalls into 10 of the 15 watersheds in the LANL region. There are no LANL NPDES-permitted effluents discharging directly into Barrancas, Bayo, Potrillo, Frijoles, or White Rock Canyon watersheds. The total number of gallons that were discharged into each canyon are presented in Table 4.3.1.3–1. Of the 233 million gallons (882 million liters) per year, the key facilities contributed about 103 million gallons (390 million liters) per year. The non-key facilities contributed about 130 million gallons (492 million liters) per year. Figure 4.3.1.3–1 shows the locations of the NPDES outfalls identified by legend number as listed in Table 4.3.1.3–1 and identifies eliminated outfalls that are discussed in chapter 5. Figure 4.3.1.3–1 also shows areas in the canyons that support perennial flows, ephemeral and intermittent flows, and NPDES effluent-supported flow. The primary sources of outfall effluent and the approximate volume of effluents that are discharged are presented below.

- Treated sanitary wastewater accounts for approximately 13 percent of the discharge volume.
- Treated cooling water and noncontact cooling water account for 50 percent of the discharge volume.
- Photo waste and demineralizer and boiler discharges account for 11 percent of the discharge volume.
- Power plant outfall and high-explosives wastewater account for 26 percent of the discharge volume (Bradford 1996 and Garvey 1997).

The LAC Bayo Wastewater Treatment Plant Facility discharges treated sanitary effluent into Pueblo Canyon. In 1990, the plant increased its sanitary effluent discharge resulting in a nearly continual flow in the lower portions of Pueblo Canyon. This flow extended into the lower, off-site segments of Los Alamos Canyon and onto Pueblo of San Ildefonso land. These flows generally extend to a location between Totavi (just east of the LANL and Pueblo of San Ildefonso boundary) and the confluence of Guaje and Los Alamos Canyons. There is continual flow in this drainage except during the months of June and July (LANL 1995f). The Radioactive Liquid Waste Treatment Facility (RLWTF) discharges treated effluents into Mortandad Canyon at an average rate of 5.51 million gallons (21 million liters) per year. Surface water flow in Mortandad Canyon has not reached the LANL boundary since the RLWTF began operating in 1963 (LANL 1996e). The Los Alamos County Treatment Plant discharges into Cañada del Buey and provides nearly continual flow in the lower portions of Cañada de Buey. Table 4.3.1.3–1 does not include the Los Alamos County treatment plants that flow into Pueblo Canyon and Cañada de Buey because they are not owned and operated by LANL. Their locations, however, are shown on Figure 4.3.1.3–1. Cooling tower water from the power plant and treated effluents from the sanitary wastewater systems consolidation (SWSC) treatment plant in TA–46 are discharged into Sandia Canyon at outfall 01A-001. These effluents support a continuous flow in a short segment of upper Sandia Canyon. During summer thunderstorms, stream flow in this canyon reaches the LANL boundary

TABLE 4.3.1.3–1.—*NPDES Outfalls by Watershed*[a]

WATER-SHED	OUTFALL[b]	LEGEND[c]	FACILITY[d]	TA[e]	BUILDINGS	DESCRIPTION[h]	FLOW (MGY)[f]
Ancho	04A-141*	85	HE Testing	39	69	Light Gas Gun Fac.	0.03
	04A-156*	86	HE Testing	39	89	Gas Gun Shop	0.09
	Sum					2 Outfalls	0.1
Cañada del Buey	03A-042	44	S&T	46	01	Laboratory	5.30
	04A-118	46	S&T	54	1013	Pajarito #4 Well	1.10
	04A-166	43	S&T	05	26	Pajarito #5 Well	0.01
	Sum					3 Outfalls	6.4
Chaquehui	03A-038	87	S&T	33	114	Support Bldg.	5.80
	Sum					1 Outfall	5.8
Guaje	04A-171	07	S&T	NF	01	Guaje #1 Well	0.00
	04A-172	06	S&T	NF	01A	Guaje #1A Well	0.00
	04A-173	05	S&T	NF	02	Guaje #2 Well	0.00
	04A-174	04	S&T	NF	04	Guaje #4 Well	0.00
	04A-175	02	S&T	NF	05	Guaje #5 Well	0.00
	04A-176	01	S&T	NF	06	Guaje #6 Well	0.66
	04A-177	03	S&T	NF	B1	Guaje Booster #1 Well	0.06
	Sum					7 Outfalls	0.7
Los Alamos	02A-129*	11	Tritium	21	155N,357	Steam Plant	0.11
	03A-034	13	S&T	21	166	Equipment Bldg.	0.26
	03A-035	10	S&T	21	210	Research Bldg.	0.04
	03A-036*	12	Tritium	21	152, 155, 155N, 220	Laboratory, TSTA, C-Tower	0.02
	03A-040*	08	HRL	43	01	HRL	2.70
	03A-047*	18	LANSCE	53	60	Linac C-Tower	2.64
	03A-048*	19	LANSCE	53	62	Linac C-Tower	8.56
	03A-049*	20	LANSCE	53	64	Linac C-Tower	4.15
	03A-158*	14	Tritium	21	209	TSFF	0.22
	04A-182	09	S&T	21	1003	Backflow Preventer	0.00
	04A-186	16	S&T	21	452	Otowi #4 Well	0.18
	05S(STP)*	15	Tritium	21	227	Sewage treatment	0.77
	Sum					12 Outfalls	19.7

TABLE 4.3.1.3–1.—*NPDES Outfalls by Watershed*[a]-Continued

WATER-SHED	OUTFALL[b]	LEGEND[c]	FACILITY[d]	TA[e]	BUILDINGS	DESCRIPTION[h]	FLOW (MGY)[f]
Mortandad	03A-021*	31	CMR	03	29	CMR	0.53
	03A-022*	32	Sigma	03	66,127,141	Sigma Complex	4.40
	03A-045*	37	Radiochemistry	48	01	RC-1	1.10
	03A-160	41	S&T	35	124	Antares Target Hall	5.10
	03A-181*	38	Plutonium	55	06	Utility Bldg.	14.00
	04A-016*	34	Radiochemistry	48	01	RC-1	6.30
	04A-127*	40	TFF	35	213	TFF	2.00
	04A-131*	33	Radiochemistry	48	01	RC-1	0.95
	04A-152*	36	Radiochemistry	48	28	RC-1	4.00
	04A-153*	35	Radiochemistry	48	01	RC-1	3.20
	06A-132	42	S&T	35	87	Laboratory	5.80
	EPA051*	39	RLWTF	50	01	RLWTF	5.51
	Sum					12 Outfalls	52.9
Pajarito	03A-025	47	S&T	03	208	Equipment Bldg.	0.18
	04A-101*	58	HE Testing	40	09	Firing Site	0.05
	04A-115*	49	HE Processing	08	70	NDT Facility	0.53
	04A-143*	61	HE Testing	15	306	Hydrotest Bldg.	0.02
	04A-164	63	S&T	18	252	Pajarito #2 Well	0.01
	05A-066*	53	HE Processing	09	A,21,28	Lab., Shop	4.36
	05A-067*	51	HE Processing	09	B,41,42	Laboratory	0.33
	05A-068*	52	HE Processing	09	48	Machining Bldg.	1.16
	06A-074*	48	HE Processing	08	22	X-ray Bldg.	0.25
	06A-075*	50	HE Processing	08	21	Laboratory	1.00
	06A-079*	54	HE Testing	40	04	Firing Site	0.54
	06A-080*	55	HE Testing	40	05	Firing Site	0.03
	06A-081*	56	HE Testing	40	08	Firing Site	0.03
	06A-082*	59	HE Testing	40	12	Prep. Room	0.03
	06A-099*	57	HE Testing	40	23	Laboratory	0.03
	06A-100*	60	HE Testing	40	15	Firing Site	0.04
	06A-106	62	S&T	36	01	Laboratory	0.58
	Sum					17 Outfalls	9.2
Pueblo	04A-161	17	S&T	72	01	Otowi #1 Well	1.00
	Sum					1 Outfall	1.0

TABLE 4.3.1.3–1.—*NPDES Outfalls by Watershed*[a]-Continued

WATER-SHED	OUTFALL[b]	LEGEND[c]	FACILITY[d]	TA[e]	BUILDINGS	DESCRIPTION[h]	FLOW (MGY)[f]
Sandia	01A-001[7]	27	S&T	03	22	Power Plant	77.9
	03A-024*	30	Sigma	03	35,187	Press Bldg./ C. Tower	2.90
	03A-027	28	S&T	03	285	Cooling Tower	5.80
	03A-113*	21	LANSCE	53	293,294,1032	LEDA C-Towers	0.90
	03A-125*	23	LANSCE	53	28	Proton Storage Ring	0.18
	03A-145*	22	LANSCE	53	06	Orange Box Offices	0.37
	03A-148	26	S&T	03	1498	Data Center	6.30
	04A-094	29	S&T	03	170	Gas Facility	5.30
	04A-163	25	S&T	72	04	Pajarito #1 Well	6.20
	04A-165	24	S&T	72	07	Pajarito #3 Well	2.00
	Sum					11 Outfalls[g]	107.9
Water	02A-007*	64	HE Processing	16	540	Steam Plant	10.50
	03A-028*	72	HE Testing	15	184,185,202	Cooling Tower	2.20
	03A-130*	81	HE Processing	11	30	Laboratory	0.04
	03A-185*	70	HE Testing	15	184,202	Cooling Tower	0.73
	04A-070*	65	HE Processing	16	220	X-ray Bldg.	0.22
	04A-083*	73	HE Processing	16	202	Shops	0.20
	04A-091*	76	Tritium	16	450	Process Bldg.	0.22
	04A-092*	80	HE Processing	16	370	Metal Forming	1.57
	04A-139*	71	HE Testing	15	184	PHERMEX	0.00
	04A-157*	75	HE Processing	16	460	Laboratory	7.31
	05A-053*	79	HE Processing	16	410	Assay Bldg.	0.12
	05A-054*	68	HE Processing	16	340	HE Synthesis	3.57
	05A-055*	78	HE Processing	16	401,406	Pressure Tanks	0.04
	05A-056*	67	HE Processing	16	260	Process Bldg.	2.53
	05A-069*	82	HE Processing	11	50	Drop Tower Sump	0.01
	05A-071*	77	HE Processing	16	430	HE Pressing	0.04
	05A-072*	74	HE Processing	16	460	Laboratory	0.02
	05A-096*	83	HE Processing	11	51	Drop Tower Sump	0.01
	05A-097*	84	HE Processing	11	52	Drop Tower Sump	0.01
	06A-073*	66	HE Processing	16	222	Dark Room	0.08
	06A-123*	69	HE Testing	15	183	Laboratory	0.13
	Sum					21 Outfalls	29.5

TABLE 4.3.1.3–1.—*NPDES Outfalls by Watershed*[a]-Continued

WATER-SHED	OUTFALL[b]	LEGEND[c]	FACILITY[d]	TA[e]	BUILDINGS	DESCRIPTION[h]	FLOW (MGY)[f]
Grand Totals	10 Watersheds					87 Outfalls	233

[a] Index NPDES flows were estimated using data provided by the surface water data team reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997).
[b] * Indicates a key facility
[c] Legend numbers correspond to NPDES locations shown in Figure 4.3.1.3–1.
[d] HE = High Explosives, S&T = Science and Technology, HRL = Health Research Laboratory, LANSCE = Los Alamos Neutron Science Center, CMR = Chemistry and Metallurgy Research, TFF = Target Fabrication Facility
[e] NF = National Forest.
[f] Watershed totals have been rounded to one decimal place, and grand total to two. MGY = million gallons per year
[g] All effluent from the TA–46 Sanitary Wastewater Systems Consolidation (SWSC) Facility is pumped to a re-use tank adjacent to the TA–3 Power Plant. When the Power Plant is in operation, water is drawn from the tank as make-up for the power plant cooling towers, where it is either lost to the air through evaporation or discharged to Sandia Canyon via the power plant outfall 01A-001. Of the total 77.9 million gallons per year (MGY) flow for outfall 01A-001, approximately 29 MGY are contributed by SWSC as make-up water. Outfall 135 is located at the TA–46 SWSC facility but is not used. Outfall 13S, although not listed in table, is added to the number of outfalls, making a total of 11 outfalls in Sandia Canyon.
[h] NDT = Nondestructive Testing

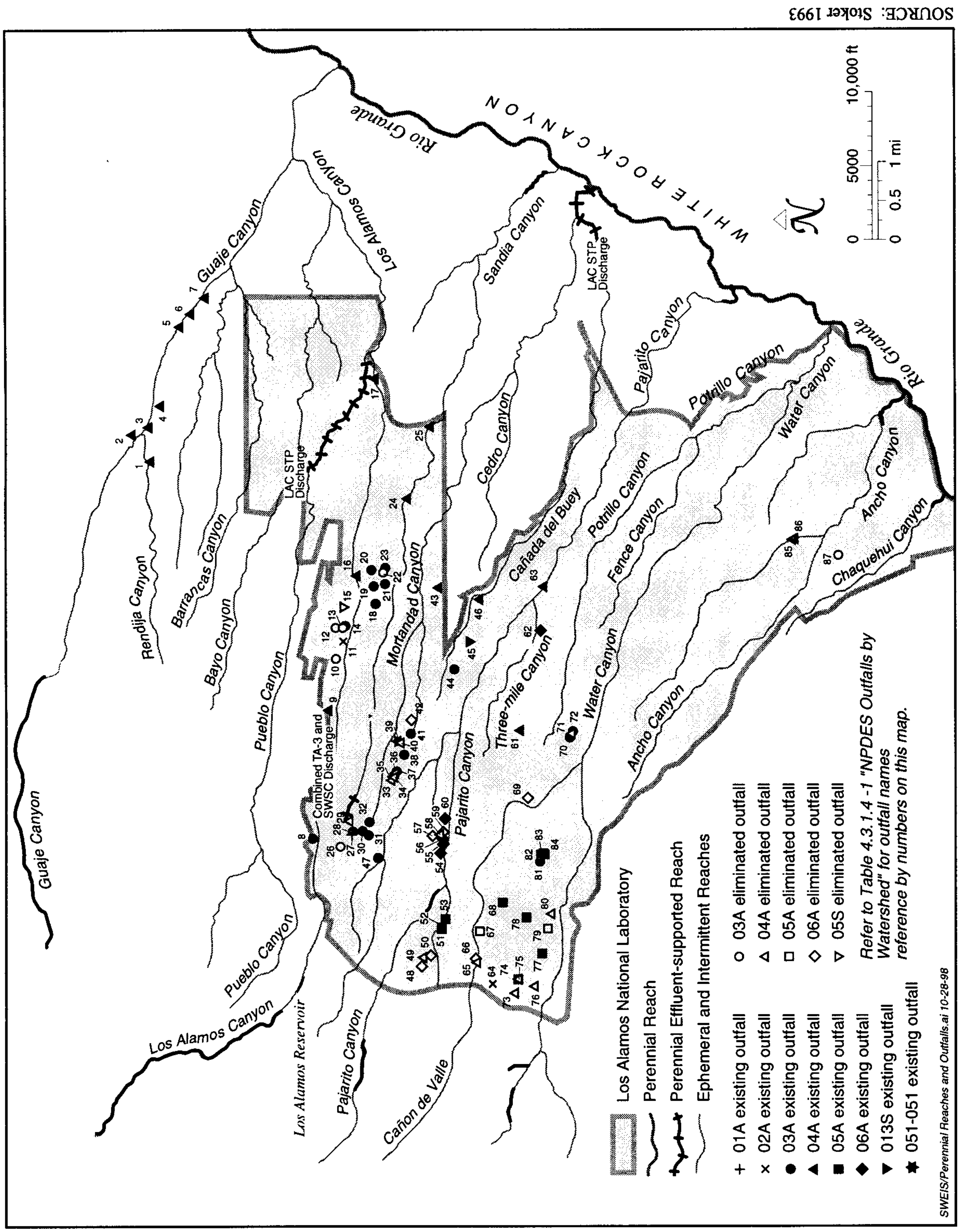


FIGURE 4.3.1.3–1.—*Stream Reaches and NPDES Outfall Locations.*

at NM 4; and during periods of heavy thunderstorms or snowmelt, the surface water flow extends beyond LANL boundaries and reaches the Rio Grande (LANL 1996e).

National Pollutant Discharge Elimination System Regulatory Compliance

The goal of the *Clean Water Act* is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The regulations specify water quality standards and effluent limitations. To comply with the *Clean Water Act*, LANL has two primary programs: the NPDES permit program and the Spill Prevention Control and Countermeasure Program. The University of California (UC) and DOE are co-operators on a site-wide NPDES permit covering the industrial and sanitary effluent discharges at Los Alamos. The permits are issued and enforced by EPA Region 6 in Dallas, Texas. However, NMED performs some compliance evaluation inspections and monitoring for EPA through a water quality grant issued under Section 106 of the act. The NPDES permits specify the parameters measured and the sampling frequency for the outfalls. The LANL NPDES industrial outfalls are identified by numbers and by types of industrial outfalls. Table 4.3.1.3–2 provides information on the industrial NPDES outfalls by number-type and NPDES permit limits. The NPDES numbers presented in Table 4.3.1.3–2 correspond to the first three numbers and/or characters identified for each outfall presented in Table 4.3.1.3–1. Concentrations limits are indicative of the overall quality of effluent discharges. Sampling frequency is dependent on the type of discharge and varies from once a week to annually. The chemical and biological constituents measured in outfall effluent samples and sampling results are presented in LANL's annual Environmental Surveillance and Compliance Reports. In 1995, effluent limits for the sanitary waste facilities were not exceeded. Analyses of 1,751 industrial outfall samples indicate that the NPDES permit limits for industrial outfalls were exceeded 21 times during 1995 (LANL 1996i). Table 4.3.1.3–3 presents information on the number of NPDES violations from 1991 through 1995. NPDES industrial discharge water quality data over the 24-month period of August 1994 (when the most recent NPDES permit and its new discharge limits became effective) through July 1996 is presented in summary NPDES water quality data tables in volume III, appendix C (Table C–1). Examples of types of exceedances are described later on in this section.

During the early 1990's, LANL was listed as a "Significant Non-Compliant Federal Facility" by EPA Region 6 for NPDES violations. DOE and LANL have had several Federal Facility Compliance Agreements and parallel administrative orders in effect to correct NPDES deficiencies. The current DOE compliance agreement (Docket No. VI-96-1237, December 12, 1996) (EPA 1996c) and the current LANL administrative order (AO Docket No. VI-96-1236, December 10, 1996) (EPA 1996b) include schedules for coming into full compliance with the *Clean Water Act* by completing the High Explosives Wastewater Treatment Facility and Waste Stream Characterization projects. These corrective actions required by compliance agreement and administrative order are continuing.

Examples of the materials that have been involved in NPDES exceedances at outfalls include arsenic, chlorine, total suspended solids, acidity, chemical oxygen demand (COD), biochemical/biological oxygen demand (BOD), cyanide, vanadium, copper, iron, oil and grease, silver, phosphorus, and radium. In 1995, most of the industrial outfall exceedances were for chlorine and arsenic; the NPDES permit for chlorine was exceeded four times, with the largest exceedance of 9.2 milligrams per liter as compared to the permit limit of 0.5 milligrams per liter for the daily maximum. The permitted levels for arsenic were exceeded nine times with the largest exceedance of 0.211 milligrams per liter as compared to the permit limit of

TABLE 4.3.1.3–2.—*LANL NPDES Discharge Limits (Daily Average/Daily Maximum)*

NPDES CHARACTERISTIC		POWER PLANT	DEMINERALIZED AND BOILER BLOWDOWN	COOLING TOWER BLOWDOWN	NONCONTACT COOLING WATER	HE WATER DISCHARGE	PHOTO WASTE	ASPHALT PLANT	RLWTF	SEWAGE	SEWAGE
NPDES NO.		**001**	**02A**	**03A**	**04A**	**05A**	**06A**	**07A**	**051**	**05S**	**13S**
PART I LIMITS											
Flow	MGD	*	*	*	*	*	*	*	*	*	*
TSS	mg/l	30/100	30/100	30/100	—	30/45	—	100/100	—	30/45	30/45
BOD	mg/l	—	—	—	—	—	—	—	—	30/45	30/45
COD	mg/l	—	—	—	—	125/125	—	125/125	125/125	125/125	—
O&G	mg/l	—	—	—	—	15/15	—	15/15	—	—	—
Fecal Coliform	(#/100 ml)	—	—	—	—	—	—	—	—	500/500	500/500
Ammonia (as N)	mg/l	—	—	—	—	—	—	—	*	—	—
Free Chlorine	mg/l	0.2/0.5	—	0.2/0.5	—	—	—	—	—	—	—
Residual Chlorine	mg/l	—	—	—	*	—	—	—	—	—	—
Iron	mg/l	—	10/40	—	—	—	—	—	—	—	—
Nickel	mg/l	—	—	—	—	—	—	—	*	—	—
Nitrate/Nitrite (as N)	mg/l	—	—	—	—	—	—	—	*	—	—
Nitrogen	mg/l	—	—	—	—	—	—	—	*	—	—
Phosphorous	mg/l	—	20/40	20/40	—	—	—	—	—	—	—
Silver	mg/l	—	—	—	—	—	0.5/1.0	—	—	—	—
Sulfite	mg/l	—	35/70	—	—	—	—	—	—	—	—
Toxic Organics	mg/l	—	—	—	—	—	—	—	1.0/1.0	—	—
PART II LIMITS											
Aluminum	mg/l	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0
Arsenic	mg/l	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04	0.04/0.04
Boron	mg/l	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0
Cadmium	mg/l	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2

TABLE 4.3.1.3–2.—*LANL NPDES Discharge Limits (Daily Average/Daily Maximum)*-Continued

NPDES CHARACTERISTIC		POWER PLANT	DEMINERALIZED AND BOILER BLOWDOWN	COOLING TOWER BLOWDOWN	NONCONTACT COOLING WATER	HE WATER DISCHARGE	PHOTO WASTE	ASPHALT PLANT	RLWTF	SEWAGE	SEWAGE
NPDES NO.		**001**	**02A**	**03A**	**04A**	**05A**	**06A**	**07A**	**051**	**05S**	**13S**
Chromium	mg/l	5.1/5.1	**1.0/1.0**	5.1/5.1	5.1/5.1	5.1/5.1	5.1/5.1	5.1/5.1	5.1/5.1	5.1/5.1	5.1/5.1
Cobalt	mg/l	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0
Copper	mg/l	1.6/1.6	**1.0/1.0**	1.6/1.6	1.6/1.6	1.6/1.6	1.6/1.6	1.6/1.6	1.6/1.6	1.6/1.6	1.6/1.6
Lead	mg/l	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4
Mercury	mg/l	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01
Selenium	mg/l	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05
Vanadium	mg/l	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1
Zinc	mg/l	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4	95.4/95.4
Radium-226, Radium-228	pCi/l	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0	30.0/30.0
Tritium	µCi/l	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3

* = Report only
— = No limit specified

001—Power plant discharge (Outfall 001)
02A—Neutralized demineralizer regeneration brine and boiler blowdown
03A—Cooling tower blowdown, evaporative coolers, chillers, condensers, and air washer blowdown
04A—Noncontact cooling water, nondestructive testing discharge, and water production facilities
05A—High explosives waste discharges
06A—Photo waste discharges
07A—Asphalt batch plants nonprocess wastewater (scrubber air wash)
051—RLWTF discharge
05S—Treated sanitary sewage effluent (Outfall 05S)
13S—Treated sanitary sewage effluent (Outfall 13S)
Other notes are as follows: TSS = total suspended solids; BOD = biological oxygen demand; COD = chemical oxygen demand; O&G = oil and grease; MGD = million gallons per day; mg/l = milligrams per liter; ml = milliliter; pCi/l = picocuries per liter; µCi/l = microcures per liter
Limits are set forth as "Daily Average/Daily Maximum."

TABLE 4.3.1.3–3.—*Number of NPDES Violations (1991 Through 1995)*[a,b]

YEAR	SANITARY OUTFALLS			INDUSTRIAL OUTFALLS		
	SAMPLES	VIOLATIONS	% VIOLATIONS	SAMPLES	VIOLATIONS	% VIOLATIONS
1991	297	3	1.0%	1,799	21	1.2%
1992	266	1	0.4%	2,028	20	1.0%
1993	147	0	0.0%	2,120	19	0.9%
1994	154	0	0.0%	2,045	28	1.4%
1995	166	0	0.0%	1,751	21	1.3%
Totals	1,030	4	0.4%	9,743	109	1.1%

[a] When summarizing LANL environmental programs, NPDES outfalls are grouped as either "domestic waste," which is sewage, or as "industrial waste," which is all other NPDES discharges (noncontact cooling water, power plant discharges, cooling tower blowdown, photo rinse waters, etc.). Compliance with LANL's NPDES Permit (NM0028355) is then reported as "number of violations for a year" versus "number of NPDES samples collected."

[b] Information as to which quality limits were exceeded can be found in the annual Los Alamos surveillance reports.

0.04 milligrams per liter for the daily maximum. Actions to improve compliance with permit conditions are continually being taken including, elimination of outfalls, improvements and corrective actions at specific outfalls, and implementation of the Waste Stream Characterization Program and Corrections Project (see also chapter 7, section 7.5).

Radioactive liquid effluent discharges are regulated by DOE Order 5400.5. One NPDES permitted outfall at TA–50, the RLWTF, began operations in 1963. This outfall had continued to discharge residual radionuclides to Mortandad Canyon in liquid effluents to the present time. DOE Order 5400.5 specifies DCGs for liquid radioactive effluents, which provide a reference for determining dose to various exposure pathways. For liquid radioactive effluents, the "as low as reasonably achievable" (ALARA) and the "best available technology" (BAT) processes are adopted to determine the appropriate level of treatment. If discharges are below DCG reference values at the point of discharge to a surface waterway, generally no further treatment is required due to cost/benefit considerations. Historic discharges to Mortandad Canyon have resulted in above background residual radionuclide concentrations in alluvial groundwater and sediments. For calendar year 1996, two DCGs were exceeded in TA–50 effluents (for americium-241 and plutonium-238). The TA–50 discharge also contains nitrates that have caused the alluvial groundwater to exceed the state groundwater standard of 10 milligrams per liter. LANL is working to continue to upgrade the treatment process at TA–50 to correct these problems. A treatment system will be operational by early 1999 that will reduce concentrations of americium-241, cesium-137, plutonium-238, plutonium-239, and strontium-90 and will result in concentrations of these radionuclides in effluent that will meet the DOE-DCG for the public. A treatment system to comply with nitrate levels within the new groundwater discharge limits established by NMED will be operational by mid 1999. Tritium concentrations, which are well below the DOE-DCG, will not be reduced by the new treatment system. There is currently no practical treatment technology for tritium for the dilute concentrations present in the RLWTF effluent. Investigation and cleanup, if required, are conducted through the ER Project, and interim controls (sediment traps) have been implemented to control movement of contaminants off the site.

Stormwater Effluents

In 1995, there were eight NPDES General Permits for LANL stormwater discharges (LANL 1996i): one permit is for LANL industrial activities; one permit is for the remediation of an environmental restoration site off of DOE property; and the other six permits are for construction activities disturbing more than 5 acres (2 hectares). As conditions of the General Permit, UC must develop and implement Stormwater Pollution Prevention Plans (SWPPs) and conduct monitoring activities (LANL 1996i). In 1993, 76 industrial facilities were identified that required SWPPs. There were 14 SWPPs developed and implemented in 1994 to cover these 76 facilities. In addition, several individual SWPPS were developed to address specific solid waste management units (SWMUs) and PRSs. LANL plans in 1999 to consolidate all the SWPPs into approximately 24 plans that will address all the 76 industrial facilities, as well as all the SWMUs.

UC monitors stormwater at TA–54, Areas G and J, and TA–50 as a requirement of the LANL NPDES general stormwater permit. Twenty-nine locations in 8 watersheds were sampled a total of 55 times between August 1991 and August 1995.

The largest amount of monitoring occurs in the Pajarito Canyon watershed where the stormwater from TA–54 drains. It is difficult to obtain stormwater samples repeatedly from the same location due to the inherently sporadic nature of stormwater. Therefore, it is difficult to identify trends in the stormwater quality or to perform confirmatory analyses. This problem should be corrected in the future by using U.S. Geological Survey (USGS) stream gage stations as consistent monitoring points and increasing the number of overall stormwater samples that are collected (PC 1997c). Also beginning 1996, environmental surveillance runoff samples were collected using automated samplers. The samplers are actuated when a significant precipitation event causes flow in a drainage crossing LANL boundaries.

4.3.1.4 *Sediments*

Sediments occur along most segments of LANL canyons as narrow bands of canyon-bottom deposits that can be transported by surface water during runoff events or by LANL outfall effluent flows. The 12 watersheds that cross LANL boundaries are watersheds B through M (Figure 4.3.1–1) and vary in their drainage area, peak flow volumes, and sediment-carrying capacity. Nearly every on-site LANL drainage has historically received LANL liquid industrial or sanitary effluents that contribute to the flow and water quality characteristics in the drainage area. As LANL effluents move downstream, some of the metals and radionuclides from LANL outfalls bind (or adsorb) to the sediments.

Sediment Monitoring

Samples of sediment are collected in the LANL region for DOE and NMED to monitor the environmental effects of LANL operations and activities on the environment. Sediment samples are analyzed for the presence of radionuclides, metals, and organics as a part of the LANL Environmental Surveillance and Compliance Program (described on page 4–1) (DOE Order 5400.1). Sediment samples are collected from off-site (regional and perimeter) and on-site locations (Figures 4.3.1.1–1 and 4.3.1.4–1). The locations at which sediment samples are collected may vary from year to year. Figure 4.3.1.4–1 shows locations where sediment samples were collected in 1995. Sediment samples are also collected at the Pueblo of San Ildefonso. Representatives of the Pueblo of San Ildefonso or U.S. Bureau of Indian Affairs may monitor or collect splits when LANL sediment samples are collected. NMED recently performed comparisons of LANL and NMED sediment and soil data. The statistical analysis of soils and sediments, which

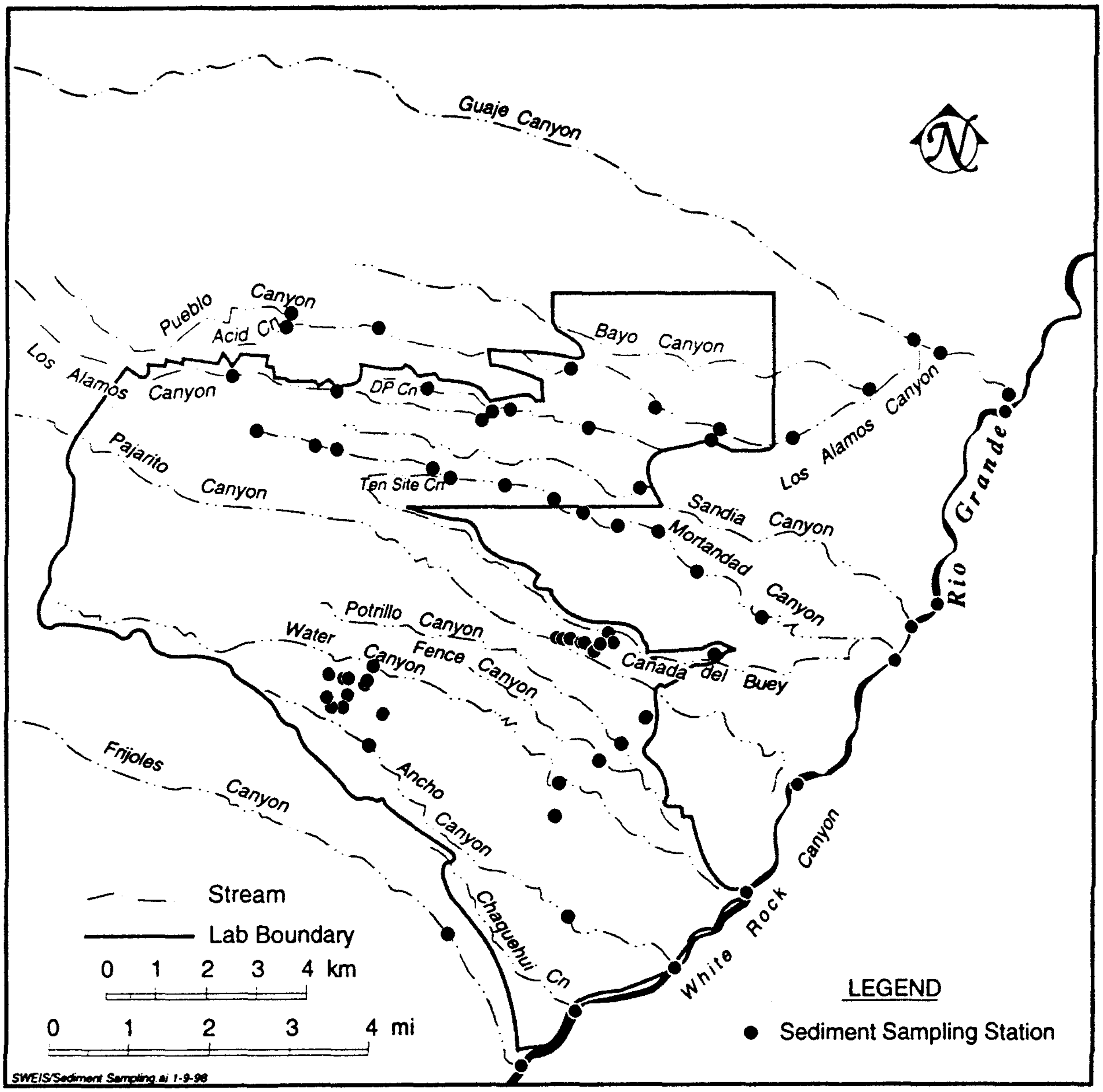


FIGURE 4.3.1.4–1.—*On-Site and Off-Site Perimeter Sediment Sampling Locations.*
(**Note:** Perimeter stations are located within 2.5 miles [4 kilometers] of LANL.)

included radionuclides (i.e., plutonium, uranium, cesium, gross alpha) and metals (i.e., lead, beryllium, arsenic), compared favorably, and for the majority of samples there was no statistically significant difference (PC 1997g).

Sediment Quality

Sediments in the LANL region naturally contain minerals and metals, and may also contain radionuclides from worldwide fallout. Nuclear weapon atmospheric testing (Klement 1965) and the re-entry and burn-up of satellites (Perkins and Thomas 1980) containing plutonium power sources have resulted in worldwide fallout of strontium-90; cesium-137; and plutonium-238, -239, and -240. Therefore, these radionuclides can be found in sediments in very small but measurable concentrations.

There are no standards for radionuclides or metals in sediments; therefore, regional comparison levels were developed for the purposes of the SWEIS. These comparison levels were established by taking the average of 1990 to 1994 existing data for the following six stations: Chamita, Embudo, Otowi, Los Alamos Reservoir, Jemez, and Bernalillo (Figure 4.3.1.1–1). These locations were selected to provide a broad overall coverage for comparison purposes in the LANL region. These values may differ from background values used in various remedial action cleanups. Background values used for remedial action cleanup are based on the local geologic formation in the area being remediated. Because the SWEIS covers a very large area, these six locations were used instead and are within the accuracy necessary for providing relative useful information for the SWEIS.

Sediment samples from individual LANL locations are analyzed every 3 years for organic contaminants (PC 1996h). It should be noted that sediment samples were not collected from the Barrancas watershed from 1990 through 1994, and there are no sediment sampling data for organics for 1991 and 1992 (LANL 1993b and LANL 1994b). In 1993 LANL's Environmental Surveillance and Compliance Program started analyzing sediments for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and polychlorinated biphenyls (PCBs). Starting in 1995, selected sediment samples were also analyzed for high explosives (HE) residues. In 1996, sediment samples were analyzed for VOCs, SVOCs, PCBs, and HE residues from about one-sixth of the regional and local stations (approximately 75 stations). The analytical results showed that there were no VOC, SVOC, PCBs or HE residues detected in any of the sediment samples collected during 1996 (LANL 1997c). Details on contaminants in sediments can be found in the annual LANL Environmental Surveillance and Compliance Reports. Summary sediment data tables derived from the 1991 to 1996 LANL Environmental Surveillance and Compliance Reports are presented in volume III, appendix C (Tables C–4 and C–5). To provide a general understanding of the contaminants in sediments, additional information is presented below.

- Samples from all sediment sampling locations for the period 1990 to 1994 exceeded the regional comparison value for at least one metal. Most of the metals that were above the regional comparison value occur naturally in the environment as a constituent of the sediments. The exception may be a 1994 sediment sample from Los Alamos Canyon, which contained 68 milligrams per gram selenium. The regional comparison value for selenium is 0.2 micrograms per gram. The source of this contaminant is unknown (LANL 1996e).
- The regional comparison levels for at least one radionuclide were exceeded at nearly all sediment sampling locations in the sediment monitoring network for the period 1990 to 1994. Plutonium-239 and -240 (regional comparison level of 0.003 picocuries per gram) have been

detected in sediments at 11.8 picocuries per gram in Acid Canyon, at 9.71 picocuries per gram in Pueblo Canyon, and at 0.329 picocuries per gram in Los Alamos Canyon). The source of this contamination is believed to be historic releases from LANL operations that occurred in Acid Canyon (a tributary to Pueblo Canyon) from 1945 to 1952. Natural stream processes have moved the contaminated materials out of Acid Canyon, down through Pueblo Canyon, and into lower Los Alamos Canyon to the Rio Grande (Graf 1995). This natural pathway crosses down-slope of San Ildefonso lands and meets the Rio Grande down-gradient from a nearby San Ildefonso well field.

Values of plutonium-239 and -240 at monitoring stations downstream at TA–50 and upstream of the sediment traps in Mortandad Canyon are above regional comparison levels. However, values of plutonium at monitoring stations downstream of the sediment traps and upstream of the Pueblo of San Ildefonso boundary are at or near atmospheric fallout levels. These results suggest that there has been little or no transport of plutonium from TA–50 below the sediment traps in Mortandad Canyon (LANL 1997c).

The distribution of plutonium-contaminated sediments is a result of several factors that control the ability of the stream to trap sediments. These factors include stream gradient, canyon width, the presence or lack of boulders, and vegetation. The locations, amounts, and likely sources of plutonium (in picocuries) that are found in the sediments of the Los Alamos region are illustrated in Figure 4.3.1.4–2.

Off-Site Sediment Sampling

A study that evaluated the deposition of plutonium in sediments in the northern portion of the Rio Grande estimated LANL contribution to the contamination (Graf 1993). The study found that, when averaged over several decades, 90 percent of the plutonium in the sediment moving into the northern Rio Grande system could be attributed to atmospheric fallout (Graf 1993). The remaining 10 percent of the plutonium in the sediments in the Rio Grande system can be attributed to releases from LANL operations. The sediment deposits along the Rio Grande between Otowi and Cochiti Lake are most likely to contain the plutonium that can be attributed to LANL operations (Graf 1993).

DOE continues to monitor and characterize the movement of sediments across LANL and into the Rio Grande. The LANL ER Project is currently evaluating the extent of the contamination (and the associated risks) in the canyon sediments. These sediment studies have found that off-site transport of sediments with elevated plutonium-239 and -240 levels has taken place. The study found the following:

- For sediments collected at Cochiti Lake during the period of 1982 through 1988, the mean plutonium-239 and -240 concentration was 0.189 picocuries per gram, compared to a mean plutonium-239 and -240 value of 0.0081 picocuries per gram that was found in sediments from a background monitoring station at Abiquiu Reservoir (Graf 1993).
- For sediments collected at Embudo Station during the period of 1974 to 1986, the mean plutonium-239 and -240 value was 0.0033 picocuries per gram, and at Cochiti Lake was 0.0092 picocuries per gram (Graf 1993).

Sediment samples have also been collected at the Pueblo of San Ildefonso and analyzed for radionuclides and trace metals. Tritium and plutonium-238, -239, and -240 were found at levels above regional comparison level at sampling locations. The plutonium-239 and plutonium-240 values were obtained at the boundary of Pueblo land with LANL. Strontium-90, cesium-137, total uranium, americium-241, gross alpha, gross beta, and

SOURCE: Gallaher 1997

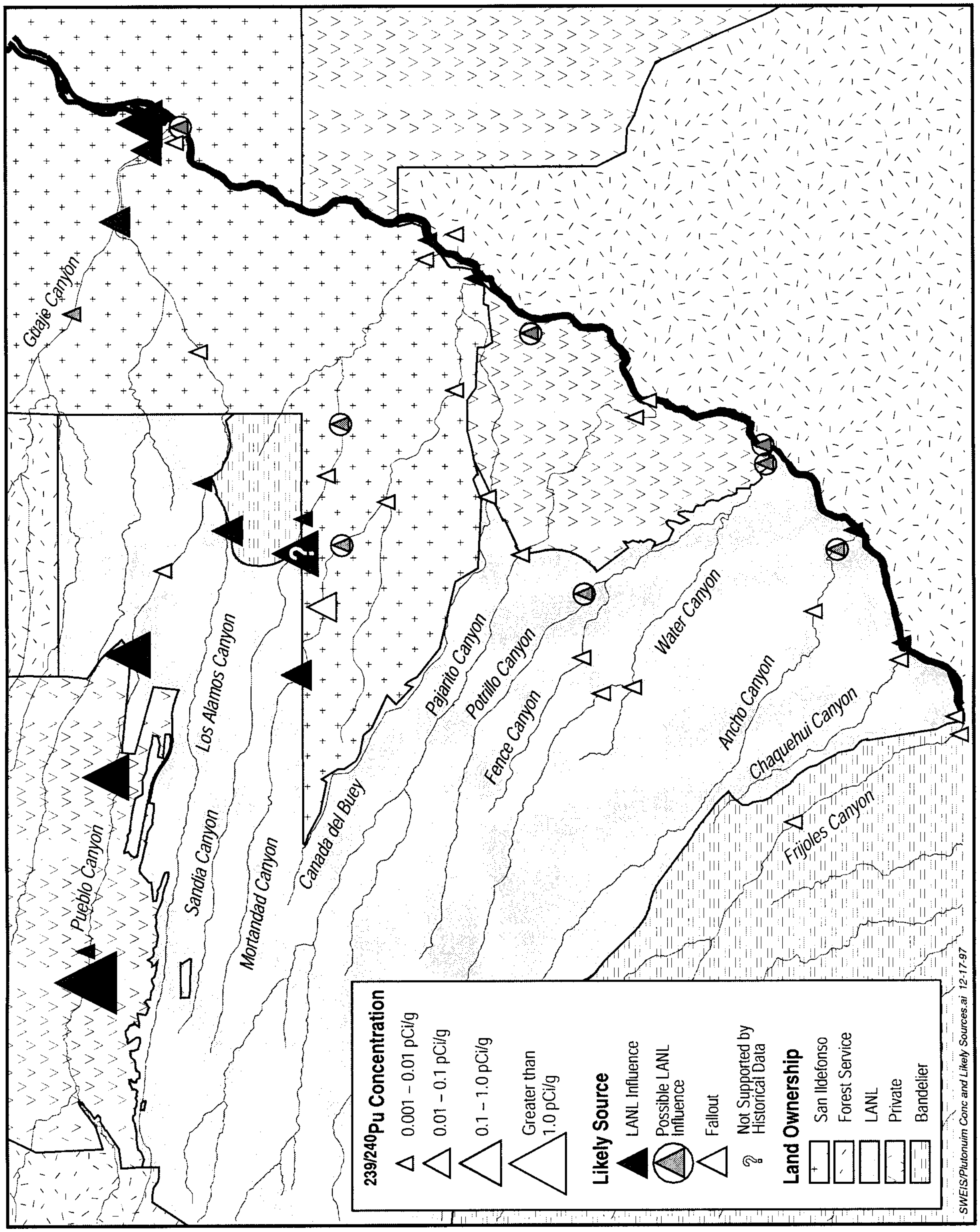


FIGURE 4.3.1.4–2.—*Plutonium Concentrations and Likely Sources.*

gross gamma were not found to be elevated above the regional comparison levels for sediment sampling stations located in Mortandad Canyon or on Pueblo land. The levels of radionuclides found in sediment samples from Bayo and Sandia Canyons on San Ildefonso Pueblo land were found to be at or below the regional comparison levels. Trace metals were all found to be within the range expected for natural background geologic materials (LANL 1996i).

4.3.1.5 *Surface Water Quality*

Analysis of LANL surface water sampling data indicates that LANL operations have affected the surface water within LANL boundaries. Data from the Environmental Surveillance and Compliance Program indicate that the greatest effects to surface water are attributable to historic LANL activities and radiological releases that occurred in Acid, Pueblo, Los Alamos, and Mortandad Canyons. Historical activities and releases that have contributed to the contamination in these canyons include:

- Nuclear materials research activities that occurred during the Manhattan Project
- An industrial liquid waste treatment plant, operated from 1952 to 1986, at TA–21
- Discharges from former TA–45 (operated from 1951 to 1964)
- Discharges from the Los Alamos Neutron Science Center (LANSCE) sanitary sewage lagoon system
- Discharges from the RLWTF
- NPDES-permitted effluent discharges (LANL 1996i)

Details on surface water quality can be found in the annual LANL Environmental Surveillance and Compliance Reports. Summary water quality data tables derived from the 1991 to 1996 LANL Environmental Surveillance and Compliance Reports are presented in volume III, appendix C (Tables C–2 and C–3). However, in order to provide a general understanding of the surface water quality at LANL, information from the 1996 Environmental Surveillance and Compliance Report is summarized in the following text. This information is, in most cases, consistent with past findings (LANL 1997c).

In 1996, the radiochemical analyses results for surface water samples were below DOE-DCGs for the public, and the majority of the results were near or below the detection limits of the analytical methods used and also were below DOE-DCGs for drinking water systems (except for samples from Mortandad Canyon). This was consistent with past findings. Long-term trends in the activity of tritium and total plutonium in surface water in Mortandad Canyon are depicted in Figure 4.3.1.5–1. These measurements were made from samples collected a short distance downstream of the TA–50 effluent discharge into Mortandad Canyon.

The measurements in waters from areas receiving effluents show the effects of these effluents; however, none of the results exceeded standards except for some pH measurements above 8.5. EPA drinking standards are only directly applicable to a public water supply. In particular, they would only apply to the supply wells in the main aquifer, which are the source of the Los Alamos water supply. EPA drinking water standards are useful for comparison purposes. Aluminum, iron, and manganese concentrations exceeded EPA secondary drinking water standards at most locations. The results reflect the presence of suspended solids in the water samples. Because the metals analyses are performed on unfiltered water samples, the results are influenced by naturally occurring metals (e.g., aluminum, iron, and manganese) that comprise the suspended solids. In 1996, barium and silver concentrations were within the NMWQCC groundwater limits. In 1996, mercury was not observed above the detection limit (0.2 microgram per liter) at any location, with the exception of a measurement

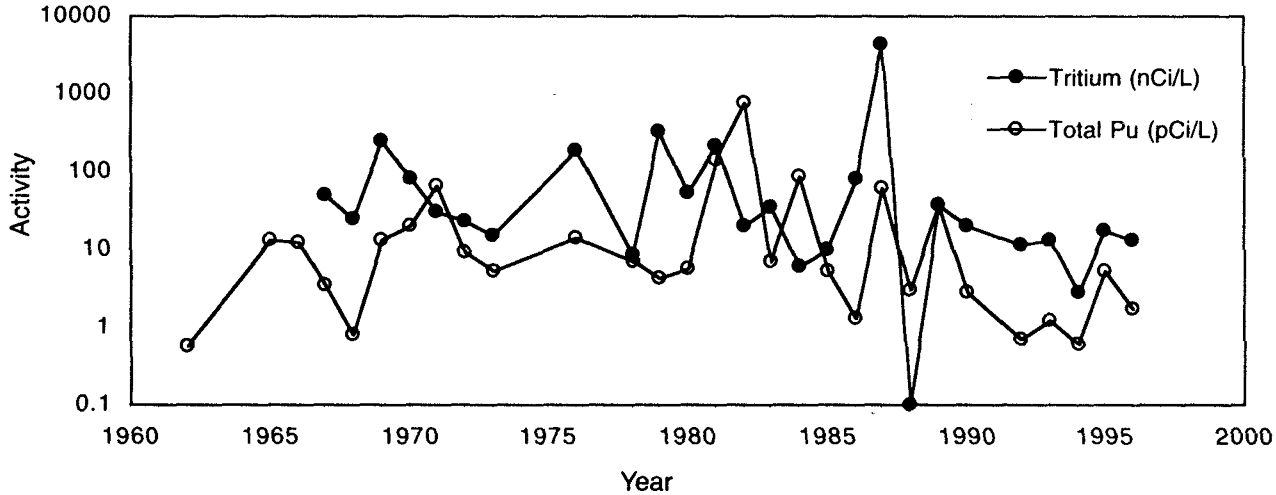


FIGURE 4.3.1.5–1.—*Tritium and Plutonium Activity at Mortandad Canyon at Gaging Station 1.*[a]

[a] This figure shows long-term trends of the activity of tritium and total plutonium in surface water in Mortandad Canyon. These measurements were made on samples collected at the station GS-1 at Mortandad, which is a short distance downstream of the TA–50 effluent discharge into Mortandad Canyon. Samples collected before 1996 were preserved in the field and filtered through a 0.45-micron filter in the laboratory. The 1996 measurements represented the total (unfiltered) activity. Plutonium values for 1962 to 1966 are for plutonium-239 and plutonium-240 only. Plutonium-238 was not recorded for those years. If more than one sample is collected in a year, the average value for the year is plotted. The DOE-DCG for the public for tritium is 2 x 10^6 picocuries per liter; for plutonium-238 it is 40 picocuries per liter, and for plutonium-239 and plutonium-240 it is 30 picocuries per liter. This figure shows the total plutonium values (LANL 1997c).

of 0.3 microgram per liter for one of two measurements in DP Canyon. The other measurement found the concentration to be below the detection limit. Selenium values exceeded the New Mexico Wildlife Habit Stream Standard (2 micrograms per liter) at numerous locations around LANL. The highest selenium value (18 micrograms per liter) was reported below the Bayo Wastewater Treatment Plant Facility discharge. Low levels of HE were detected at Water Canyon, Beta, and Frijoles Canyons near the BNM headquarters.

4.3.1.6 *Floodplains*

DOE has delineated all 100-year floodplain elevations within LANL boundaries in accordance with requirements presented in RCRA (40 CFR 270.14[b]) and Executive Order 11988—Floodplain Management (McLin 1992). There are a number of structures within the 100-year floodplain. Most may be characterized as small storage buildings, guard stations, well heads, water treatment stations, and some light laboratory buildings. There are no waste management facilities in the 100-year floodplain. Some facilities are characterized as moderate hazard due to the presence of sealed sources or x-ray equipment, but most are low hazard or with no hazard designation. The Solution High-Energy Burst Assembly (SHEBA) Building at TA–18 is within the 100-year floodplain, but the assembly is located there only during an experiment.

The 500-year flood plain has been designated only for Los Alamos Canyon. The Omega West reactor (inactive) is located with this floodplain, but was reclassified as a low hazard radiological facility. The remainder of the structures are of the type described for the 100-year floodplain. Overall, most laboratory development is on mesa tops, and development within canyons is light.

4.3.2 Groundwater Resources

The nature and extent of groundwater bodies in this region have not been fully characterized. The LANL Hydrogeologic Workplan (LANL 1998b) proposes the installation of new wells that will provide further characterization (section 4.3.2.3). Current data indicate that groundwater bodies occur near the surface of the Earth in the canyon bottom alluvium, perched at deeper levels (intermediate perched groundwater), and at deeper levels in the main aquifer (Purtymun 1995). Data about the groundwater resources, including springs and groundwater quality, will be presented in this subsection.

Alluvial groundwater bodies within LANL boundaries have been primarily characterized by drilling wells in locations where impacts from LANL operations are most likely to occur. Generally, only wells in Mortandad, Los Alamos, Pueblo, and Pajarito Canyons and in Cañada del Buey indicate the continually saturated alluvial groundwater bodies (Purtymun 1995). More information on the canyon-bottom alluvium and groundwater bodies for Mortandad, Los Alamos, Pueblo, and Pajarito Canyons and for Cañada del Buey is presented in Table 4.3–1.

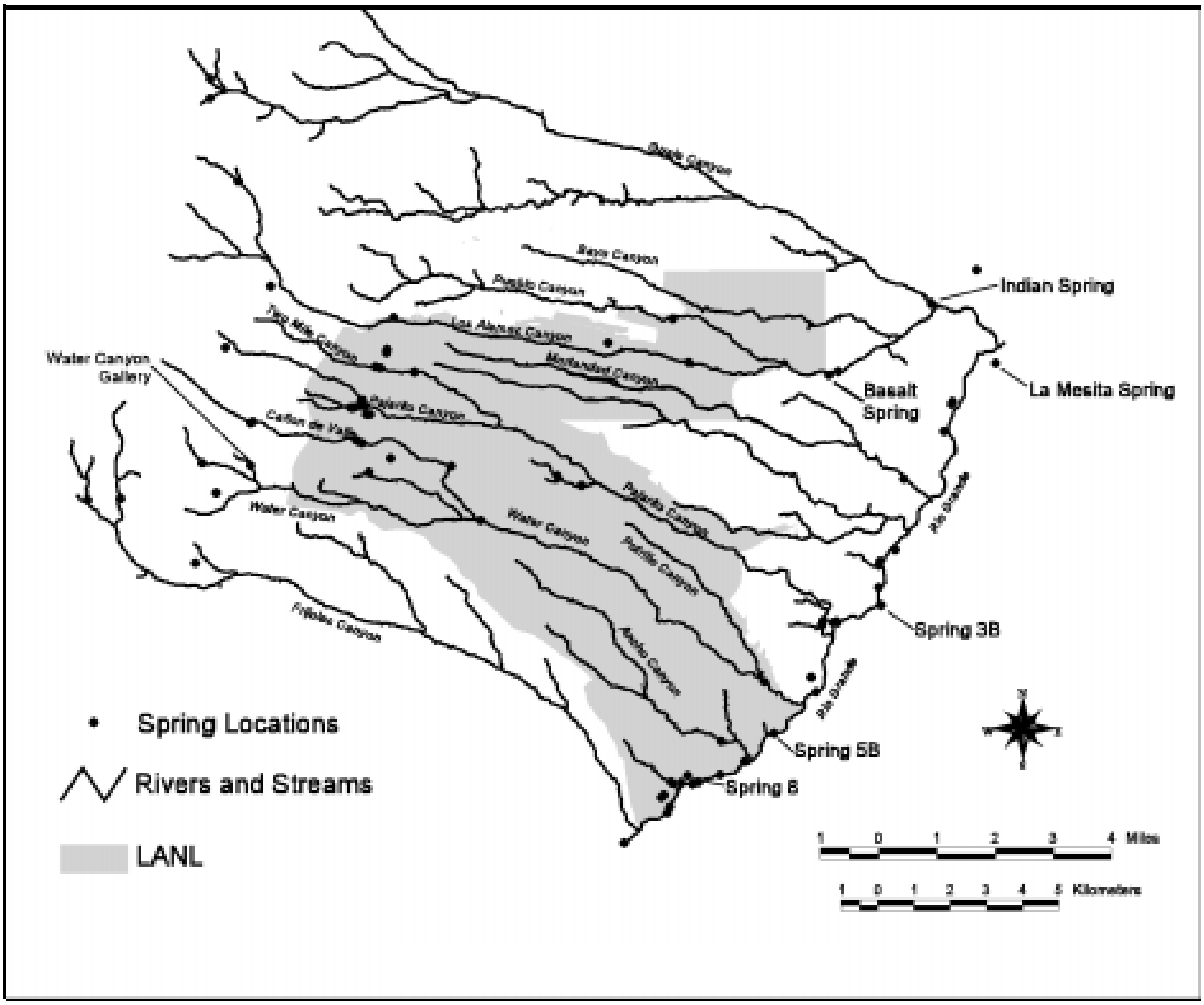
Intermediate perched groundwater bodies of limited extent occur beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons; in volcanic rocks on the sides of the Jemez Mountains to the west of LANL; and on the western portion of the Pajarito Plateau (LANL 1996i, LANL 1993a, and Purtymun 1995). Undiscovered intermediate perched groundwater bodies may exist, as the drilling coverage for these groundwater bodies has been relatively limited. The depth to perched water from the surface ranges from approximately 90 feet (27 meters) in the middle of Pueblo Canyon to 450 feet (137 meters) in lower Sandia Canyon (LANL 1993a).

The main aquifer is separated from alluvial and intermediate perched zone groundwater bodies by 350 to 620 feet (107 to 189 meters) of unsaturated volcanic tuff and sediments (Purtymun 1995). Recharge of the main aquifer is not fully understood nor characterized. Recent investigations suggest that the majority of water pumped to date has been from storage, with minimal recharge of the main aquifer (Rogers et al. 1996). Groundwater in the main aquifer to the west of the Rio Grande generally flows from the northwest to the southeast toward the Rio Grande. Groundwater in the main aquifer to the east of the Rio Grande generally flows westward from the Sangre de Cristo Mountains toward the Rio Grande. Groundwater flowing from these opposite directions converges in the approximate vicinity of the Rio Grande, then flows southwest.

As a result, shallow groundwater in the main aquifer does not flow across the Rio Grande from either side (Frenzel 1995). Groundwater may flow beneath the Rio Grande deeper in the basin, but conditions at lower depths have not been characterized.

Springs in the LANL area flow from alluvial and intermediate perched groundwater bodies and the main aquifer (Figure 4.3.2–1). Springs can be found in Guaje, Pueblo, Los Alamos, Pajarito, Frijoles, and White Rock Canyon watersheds (LANL 1996i). Information regarding these springs is presented below.

- The Water Canyon Gallery was previously a source of potable water for LANL. Since 1989, Water Canyon Gallery has not been used as a potable water supply due to the high sediment content of its water (Purtymun et al. 1995).
- Contaminants that appear to be from LANL NPDES-permitted discharges at TA–16 have been detected in the recently discovered springs in Pajarito and Water



SOURCE: LANL 1997c

FIGURE 4.3.2–1.—*Springs in the LANL Area.*

Canyon watersheds, indicating a hydrogeological connection. However, the source of these springs has not been determined.

- Twenty-seven springs discharge from the main aquifer into White Rock Canyon. White Rock Canyon springs and main aquifer discharges contribute an estimated 6 to 7 cubic feet (0.17 to 0.20 cubic meters) per second to the Rio Grande (LANL 1993a).

4.3.2.1 *Groundwater Monitoring*

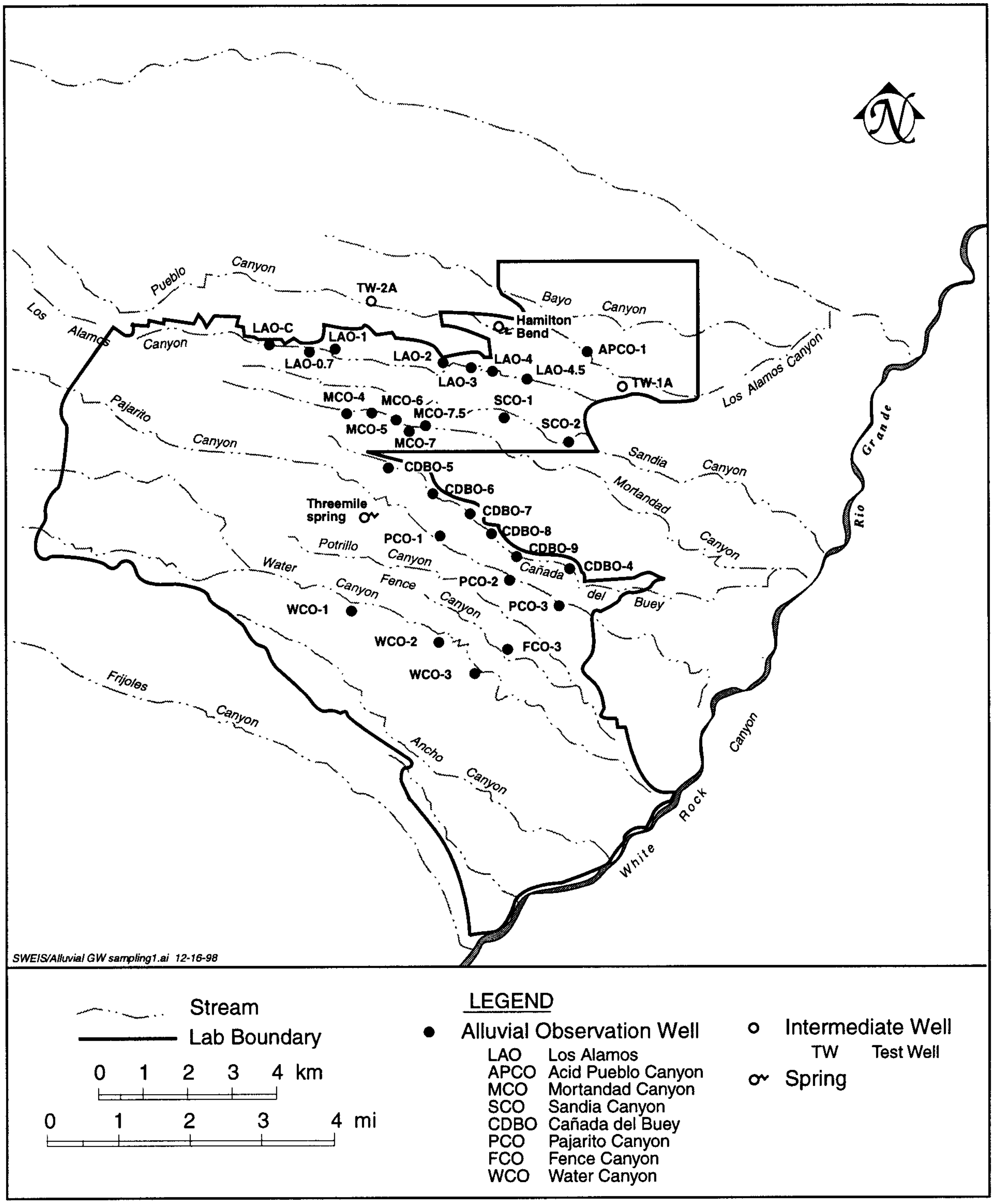
Groundwater monitoring is conducted within and near LANL. One of the objectives of LANL's groundwater monitoring program is to provide indications of the potential for human and environmental exposure from contaminated groundwater sources. Groundwater may accumulate contaminants from discharges to surface water or from leakage of liquid effluent storage systems. Though hydrogeologic conditions around LANL greatly protect the main aquifer from near-surface activities, groundwater monitoring is conducted to detect any threats to the resource. Groundwater monitoring and protection requirements are included in DOE Order 5400.1, General Environmental Protection Program. The order requires LANL to prepare a Groundwater Protection Management Program Plan (GWPMPP) and to implement the program outlined by that plan. The plan also requires development of a groundwater monitoring plan. The groundwater monitoring plan identifies all DOE requirements and regulations applicable to groundwater protection and includes strategies for sampling, analysis, and data management. LANL's GWPMPP was approved by DOE on March 15, 1996 (LANL 1996f).

DOE Order 5400.1 requires that groundwater monitoring needs be determined by site-specific characteristics and, where appropriate, that groundwater monitoring programs be designated and implemented in accordance with RCRA regulations. The section also requires that monitoring for radionuclides be in accordance with DOE Order 5400.5, Radiation Protection of the Public and the Environment.

In addition to DOE Order 5400.1, Module VIII of the LANL RCRA permit requires LANL to collect information to supplement and verify existing information on the environmental setting at the facility and collect analytical data on groundwater contamination. Under Task III, LANL is required to conduct a program to evaluate hydrogeological conditions and is required to conduct a groundwater investigation to characterize any plumes of contamination at the facility.

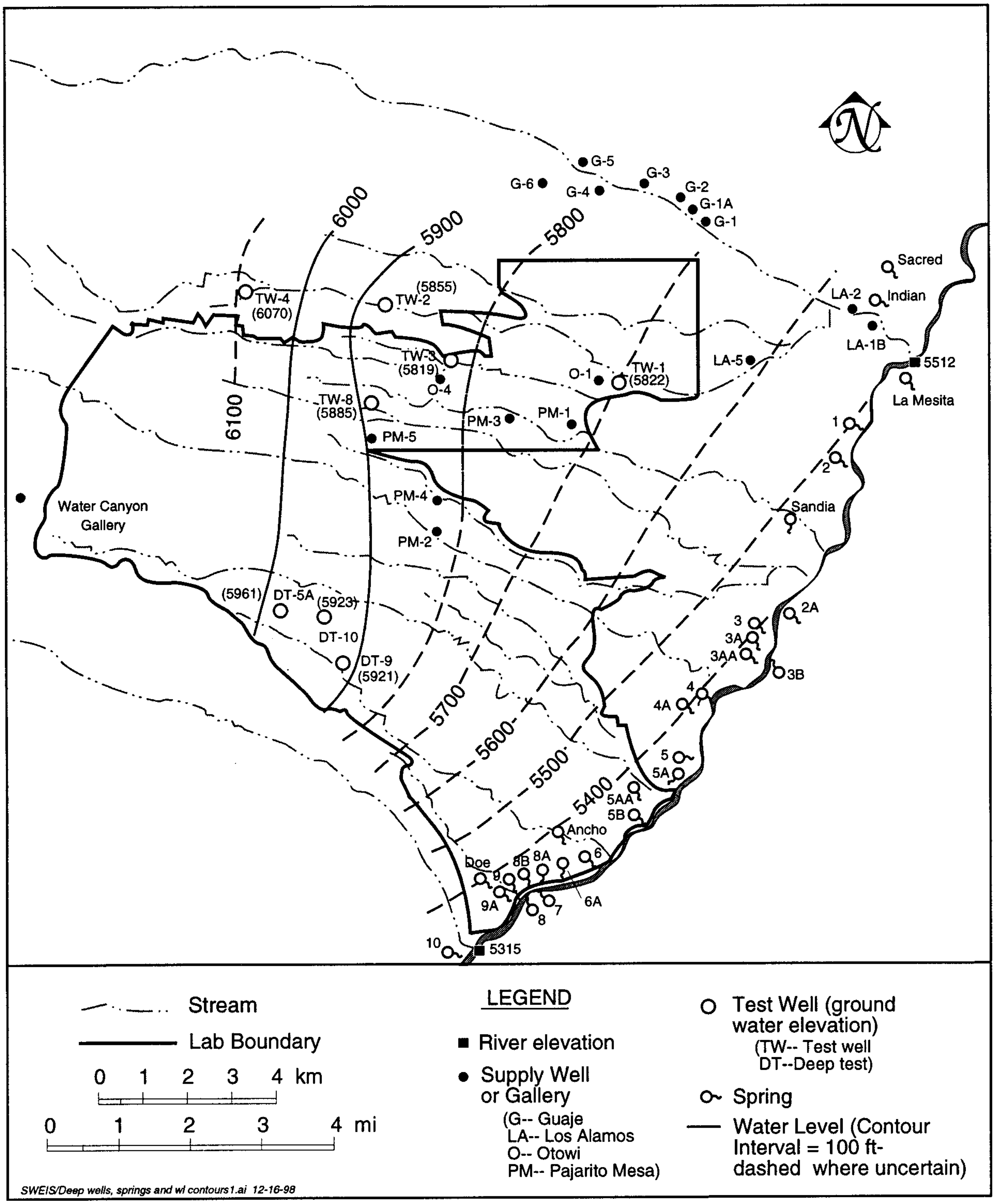
In 1995, the NMED requested DOE develop a comprehensive groundwater monitoring program plan that addresses both site-specific and LANL-wide groundwater monitoring objectives. This was in part satisfied with submittal of the GWPMPP. In August 1995, NMED requested a Hydrogeologic Workplan. This workplan was submitted to NMED for review in December 1996. The Hydrogeologic Workplan was approved by NMED on March 25, 1998, and finalized on May 22, 1998 (LANL 1998b).

Through the LANL Environmental Surveillance and Compliance Program, samples are collected annually from alluvial groundwater, intermediate perched groundwater, main aquifer test and supply wells, and springs. Module VIII of LANL RCRA permit specifically requires monitoring of the canyon alluvial groundwater system in Pueblo, Los Alamos, Sandia, Mortandad, Potrillo, Fence (a tributary of Potrillo), and Water Canyons. Figures 4.3.2.1–1 and 4.3.2.1–2 show groundwater sampling locations for (1) alluvial and intermediate observation wells and (2) springs and deep wells, respectively. Groundwater samples are analyzed annually to evaluate compliance with applicable standards for radionuclides, water quality chemistry parameters, and metals. One-third of the



SOURCE: LANL 1997c

FIGURE 4.3.2.1–1.—*Observation Wells and Springs Used for Alluvial and Intermediate Groundwater Sampling.*



SOURCE: Rogers et al. 1996

FIGURE 4.3.2.1–2.—*Regional Aquifer Test Wells, Supply Wells, Springs, and Water Level Contours*

(**Note:** Contours are Based on 1993 Data from Test Wells.)

groundwater samples collected from the well and spring locations are analyzed for organic compounds annually, with the samples from all locations analyzed for organics at least once every 3 years. The quality of water in the regional aquifer is tested at various locations. There are 8 deep test wells and 14 supply wells that belong to DOE. There also are several regional aquifer wells near the Rio Grande that do not belong to DOE. These wells are on San Ildefonso Pueblo land and are sampled under the Memorandum of Understanding (MOU) between the U.S. Bureau of Indian Affairs and DOE. In addition, there are many springs along the Rio Grande that are sampled. Since 1987, groundwater has been sampled annually from 13 wells and 4 springs on Pueblo of San Ildefonso land in accordance with the MOU (BIA 1987).

4.3.2.2 *Groundwater Quality*

Groundwater Quality Standards

There are numerous federal, state and DOE requirements related to groundwater protection and management. The State of New Mexico protects groundwater via NMWQCC regulations, which address liquid discharges onto or below ground surface. Under these regulations, a groundwater discharge plan must be submitted to and approved by the NMED for a discharging facility. Subsequent discharges must be consistent with the terms and conditions of the discharge plan. In 1996, LANL had three Groundwater Discharge Plans in effect. The NMWQCC regulations were significantly expanded in 1995 with the adoption of comprehensive abatement regulations. The purpose of these regulations is to abate surface and subsurface contamination for designated or future uses. Of particular importance to DOE is the contamination that may be present in the main aquifer.

Concentrations of radionuclides in environmental water samples from the main aquifer, the alluvial perched water in the canyons, and the intermediate depth perched systems, whether collected within the LANL boundaries or off the site, may be evaluated by comparison with DCGs for ingested water calculated from DOE's public dose limits. Concentrations of radioactivity in samples of water supply wells completed in the Los Alamos main aquifer are also compared to the NMED, New Mexico Environmental Improvement Board (NMEIB), and EPA safe drinking water standards or to the DOE-DCGs applicable to radioactivity in DOE drinking water systems, which are more restrictive in a few cases. EPA has given NMED authority to administer and enforce federal drinking water regulations and standards in New Mexico.

EPA drinking water standards are only directly applicable to a public water supply. In particular they would only apply to the supply wells in the main aquifer that are the source of the Los Alamos public water supply. EPA drinking water standards may be useful for comparison purposes in some cases. For example, because LANL shallow alluvial groundwater is not a source of municipal or industrial water but may feed surface water springs and seeps used by livestock and wildlife, shallow alluvial groundwater must meet the Standards for Groundwater or Livestock and Wildlife Watering established by the NMWQCC. However, for many elements there are no established livestock and wildlife standards. When this is the case, although generally much more conservative than the livestock and wildlife standards, EPA drinking water standards are used herein for comparison purposes.

Alluvial and Perched Water Quality

Data derived from groundwater samples taken from test wells indicate that LANL operations and activities have influenced some of the alluvial and intermediate perched zone groundwater quality in the LANL region. Primary LANL sources of contamination include historic discharges of treated and untreated wastes, discharges from the RLWTF (Mortandad Canyon) and leaks from the Omega West Reactor (Los Alamos Canyon). Other sources of contamination are from past and present LAC sanitary treatment plant releases (Pueblo Canyon). Details on alluvial and perched water quality can be found in the annual LANL Environmental Surveillance and Compliance Reports. Summary alluvial and perched water quality data tables derived from the 1991 to 1996 LANL Environmental Surveillance and Compliance Reports are presented in volume III, appendix C (Tables C–6 and C–7). However, in order to provide a general understanding of the alluvial and perched water quality at LANL, information from the 1990 to 1994 Environmental Surveillance Reports are summarized in the following text.

- EPA *Safe Drinking Water Act* (SDWA) (40 CFR 141) standard for strontium-90 (8 picocuries per liter) was exceeded in at least 50 percent of the alluvial groundwater samples collected from Los Alamos and Mortandad Canyons from 1990 through 1994, and EPA SDWA standard for tritium (20 nanocuries per liter) was exceeded in 20 of 22 of the alluvial groundwater samples collected in Mortandad Canyon during this same period. The more applicable New Mexico livestock and wildlife standard for tritium is the same as the SDWA standard of 20 nanocuries per liter and there are no livestock and wildlife comparison values for strontium-90. Standards for americium-241, cesium-137, plutonium-238 and plutonium-239, and nitrates also were exceeded during the period 1990 through 1994 in Mortandad Canyon.
- Standards for some water quality parameters and metals were exceeded in samples from the alluvial groundwater in Pueblo and Pajarito Canyons and Cañada del Buey from 1990 through 1994. These water quality parameters and metals occur naturally in the groundwater system within the LANL region and are also released through some of LANL's NPDES-permitted discharges (LANL 1994b, LANL 1995f, and LANL 1996e).
- Tritium and nitrates were detected in samples collected from the intermediate perched groundwater in Pueblo and Los Alamos Canyons. The levels of tritium detected were below the EPA standard of 20 nanocuries per liter, but nitrate as nitrogen concentrations exceeded the EPA standard of 10 milligrams per liter in all samples taken in 1994 from the two wells in the Pueblo and Los Alamos Canyon watersheds and Basalt Spring. The nitrate concentrations in these wells ranged from less than 0.04 to 19.4 milligrams per liter (LANL 1994b, LANL 1995f, and LANL 1996e).
- HE, VOCs, and nitrates were found in samples collected from the recently discovered springs in Pajarito Canyon watershed. VOCs (tetrachloromethane) were detected at 15 micrograms per liter, which is above the EPA SDWA standard of 5 micrograms per liter. High explosives (Hexahydron-1,3,5-trinitron-1,3,5-triazine) were detected in samples at 100 micrograms per liter (EPA standard is 0.61 micrograms per liter) and nitrates (2-amino-[2,4]-6-dinitrotoluene) were detected at 3.31 micrograms per liter, which is above the EPA standard of 0.99 micrograms per liter (Yanicak 1996). The water quality in these springs may improve as a result of the new LANL industrial wastewater treatment plants coming on line in TA–16 in 1997 and a reduction of effluent volume from the NPDES-permitted outfalls (Purtymun 1995).

Although groundwater data have been collected and will continue to be collected as a part of the Environmental Surveillance and Compliance Program, many questions remain regarding where groundwater occurs, groundwater quality, and potential contaminant migration (section 4.3.2.3).

Main Aquifer Water Quality

As a part of the Environmental Surveillance and Compliance Program, samples are collected from main aquifer test wells to ensure the quality of this groundwater body that provides the drinking water for LAC, LANL, and BNM. SDWA standards for all radionuclides were met in all samples taken from the main aquifer from 1990 through 1994. However, trace amounts of tritium, plutonium-239 and plutonium-240, americium-241, and strontium-90 have been detected in samples collected from the main aquifer. The presence of plutonium-239 and plutonium-240, americium-241, and strontium-90 has not been duplicated in previous or subsequent samples (section 4.3.2.3). Radioactive and hazardous waste has been generated and disposed at LANL since LANL's inception in 1943. LANL materials disposal areas and the PRSs identified by the ER Project (chapter 2, section 2.1.2.5) are potential sources of contamination. An additional possible source of groundwater contamination is the historic and current practice of discharging treated effluents in canyons near the northern boundary of LANL. While all canyons have received some industrial and sanitary discharges, Los Alamos, Sandia, Mortandad, and Pueblo Canyons are particular areas of concern because of the NPDES outfalls that discharge into these canyons. Tritium was first detected using a special sensitive method at Los Alamos in 1992. This analytical method was more sensitive than the EPA method for drinking water compliance monitoring in use. The levels measured were less than 2 percent of EPA SDWA (Dale and Yanicak 1996, LANL 1994b, LANL 1995f, and LANL 1996e) (also see section 4.3.2.3). Radioactivity, sodium, and metals all occur naturally in groundwater, and the detected concentrations are similar to those observed elsewhere in the Española Basin (LANL 1994b, LANL 1995f, LANL 1996e, and NMED 1995).

Organic compounds have been detected in samples taken from main aquifer test wells at TA–49 (DT–5A, DT–10, and DT–9; Figure 4.3.2.1–2). The largest detection was for pentachlorophenol from the TA–49 test well DT–9 (Figure 4.3.2–1) of 110 parts per billion. The EPA SDWA standard for pentachlorophenol is 1 part per billion. The sources of the contaminants detected in the TA–49 test wells are not known (LANL 1993b, LANL 1994b, LANL 1995f, LANL 1996e, and LANL 1996i). Test well DT–9 was retested in 1996, and no organic compounds were detected. However, the LANL Hydrogeologic Workplan (LANL 1998b) proposes the installation of borehole R–27 to further characterize the source of these contaminants. The TA–49 test wells are approximately 2 miles (3.2 kilometers) away and cross-gradient of the nearest public water supply well (PM 2) (Figure 4.3.2.1–2), and no public supply wells exist down-gradient of the TA–49 test wells. Therefore, the presence of organic compounds in these samples does not suggest a danger to the existing public water supply (Purtymun 1995).

The SDWA standard for nitrate (10 milligrams per liter) was exceeded in TW–1 in 1994 and 1995 (23.0 milligrams per liter and 12.9 milligrams per liter, respectively). This test well has shown nitrate levels in the range of about 5 to 25 milligrams per liter since early 1980. The source of the nitrate could be infiltration from sewage treatment effluent in Pueblo Canyon (LANL 1996i).

Details on main aquifer water quality can be found in the annual LANL Environmental Surveillance and Compliance Reports. Summary main aquifer water quality data tables derived from the 1991 to 1996 LANL Environmental Surveillance and Compliance Reports are presented in volume III, appendix C (Table C–6 and C–7).

4.3.2.3 *Transport of Radionuclides and Chemicals*

In the LANL region, uncertainties exist about the nature and extent of contaminant migration from alluvial groundwaters to deeper groundwaters (intermediate perched groundwaters or the main aquifer) and from intermediate perched groundwaters to the main aquifer (LANL 1993b, LANL 1994b, LANL 1995f, LANL 1996e, and LANL 1996i). The intermediate perched groundwater bodies beneath mid-Pueblo and lower Pueblo and Los Alamos Canyons are known to be hydraulically connected to surface water and alluvial groundwater in Pueblo Canyon. Therefore, groundwater movement from alluvial groundwater bodies to deeper intermediate perched groundwater bodies or the main aquifer may be a contaminant transport pathway in specific locations (LANL 1993a).

Of all hydrogeologic settings at LANL, contaminant transport from dry mesa top material disposal areas (e.g., Area G where contaminated wastes are treated, stored, and disposed) through the rock matrix to the main aquifer potentially takes the longest time. Evaluation of existing data and modeling results indicates potential transport of some radionuclides requires thousands of years to reach the main aquifer, and many other radionuclides will decay completely before arrival (Birdsell et al. 1995, DOE 1995b, Rosenberg et al. 1993, and Devaurs 1989).

The potential exists for contaminants to migrate more quickly from alluvial groundwater bodies through the rock matrix below to the main aquifer. Due to the hydrogeologic complexity of the LANL area, these pathways are not fully understood and may vary substantially from one hydrogeologic setting to another. Tritium in the main aquifer was first reported in the 1992 LANL Environmental Surveillance Report. This is when several advanced techniques not commonly applied to groundwater samples were first used. The levels measured were less than 2 percent of the EPA SDWA.

Although the exact recharge mechanism(s) is not known, some additional possible transport pathways from those discussed previously could be: (1) contaminants infiltrating along well shafts or boreholes, (2) contaminants moving through the unsaturated (vadose) zone, and (3) contamination infiltrating areas of high fault or fracture density. The tritium detected in TW–3 and TW–8 in Los Alamos Canyon and Mortandad Canyon, respectively, suggests a continual presence of a small recharge contribution from the surface in the main aquifer from an unknown source. As mentioned previously, one of the possible transport pathways is along the well bore of inadequately constructed or inappropriately designed older wells. Many of the wells at LANL were constructed as early as the 1940's. Tritium has been detected in samples taken from observation wells LA–1A and Test Wells TW–1, TW–1A, TW–2, TW–2A, TW–4, and TW–8. In all of these cases, it is possible that tritiated waters from the surface have seeped along the well bore due to an inadequate seal. These wells, as well as borings and coreholes that might present a pathway for contamination, may need to be plugged and abandoned in accordance with the NMED and New Mexico State Engineers Office requirements to ensure that contaminant transport pathways to intermediate depth perched groundwater and the main aquifer are properly closed off (LANL 1996f).

The primary solution to understanding the extent of the effects of LANL activities on the main aquifer is to obtain more site characterization information (i.e., construct more monitoring wells). This new site characterization information should provide data for researchers to gain a better understanding of how contaminants are transported from discharge sites. Because of the many questions concerning the hydrogeologic characterization of the Pajarito Plateau, such as the recharge mechanisms for the main aquifer and the lack of hydrologic detail, LANL personnel have prepared a Hydrogeologic Workplan that was approved by NMED in March 1998. The workplan proposes the installation of new wells to address these uncertainties. Well placement and other characterization activities as presented in the proposed plan will focus on providing more information on the hydrogeologic and stratigraphic settings (specifically, vertical hydraulic gradients, saturated hydraulic conductivities, vertical stratification, depth and direction of groundwater flow, recharge to the main aquifer, and water quality in the main aquifer). The workplan also proposes the placement of additional wells between known contaminated sources and water supply wells in order to provide detection of approaching contaminants (LANL 1998b).

4.3.2.4 *Public Water Supply*

DOE water supply system supplies potable water from the main aquifer to LANL, the Los Alamos townsite, the community of White Rock and BNM. Three well fields (Pajarito, Guaje, and Otowi) constitute the current DOE water supply system. Other than chlorine disinfection of the water supply, no other water treatment is required.

DOE's water rights allow the withdrawal of about 5,540 acre feet or 1.8 billion gallons (6.83 billion liters) per year from the main aquifer (DOE 1995a). In addition, DOE has a contractual agreement for Rights to Water for 1,200 acre feet or 0.39 billion gallons (1.48 billion liters) per year from the San Juan-Chama Transmountain Diversion Project of the U.S. Bureau of Reclamation (DOE 1995a). DOE obtained these Rights to Water in 1976 based on a concern that future use would exceed DOE's water rights for the main aquifer. No infrastructure exists for conveyance of water from the San Juan-Chama to LAC. DOE has not used and currently has no plans to use the San Juan-Chama Rights to Water (PC 1996c).

For the period from 1947 through 1994, LAC's, BNM's, and LANL's combined water usage peaked at 96 percent of DOE water rights in 1976. From 1990 through 1994, total water rights usage ranged from 81 percent in 1993 to 91 percent in 1990. LANL's use has been approximately 500 million gallons (1.89 billion liters) per year since the late 1970's (PC 1996c). Additional information on drinking water supplies can be found in section 4.9, Socioeconomics.

Historic water level measurements in main aquifer wells have indicated water level declines in the area due to pumping and natural discharges exceeding recharge and inflow. From 1947 through 1991, average water level declines in the four DOE supply well fields ranged from 24 to 76 feet (7 to 23 meters) (Purtymun 1995). Aquifer water level declines are shown pictorially, as in Figure 4.3.2.4–1; however, the water level declines are speculative. As expected, water level declines are most evident around water supply wells in the middle and northern part of Los Alamos County. Dashed contour lines on Figure 4.3.2.4–1 show declines on the order of 100 feet in the areas around the Guaje water supply well field diminishing in all directions away from it. Since the Los Alamos well field has been almost shut down (i.e., with the exception of LA–5, which supplies San Ildefonso - Totavi), water levels are returning to near-normal levels toward the east in the vicinity of the Rio Grande (Purtymun et al. 1995).

Water storage calculations which were made (based on the USGS regional model [Frenzel 1995]) for the total 5,600-foot (1,707-meter) thickness of the main aquifer indicate that approximately 21.8 trillion gallons (82,513 million cubic meters) of water are contained in the LANL region beneath the Pajarito Plateau (Frenzel 1995). If DOE used its

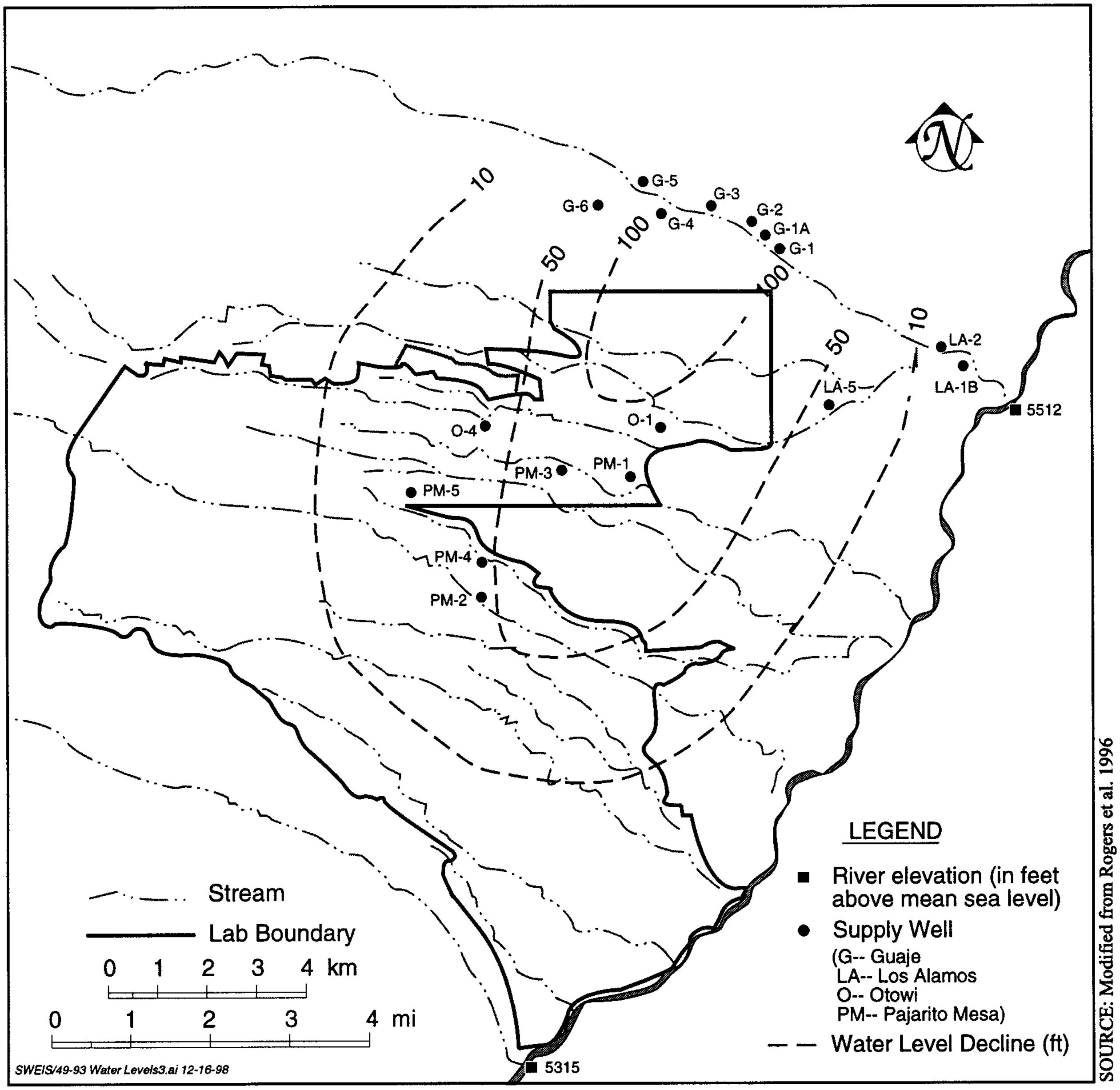


FIGURE 4.3.2.4–1.—*Approximate Aquifer Water Level Decline from 1949–1950 to 1993.*

full water rights at a rate of 1,805 million gallons (6.83 million cubic meters) per year, this storage volume represents a 12,109-year supply. However, because water quality will generally worsen with increasing depth, the volume of water suitable for drinking may be less. Available data are insufficient for modeling water quality degradation with depth, but water supply wells screened as deep as 1,830 feet (558 meters) into the main aquifer indicate that water at that level would meet SDWA standards. By comparison, storage calculations based on annual use at DOE water rights rate indicate a water supply for 2,839 years for the upper 1,275 feet (389 meters) of the main aquifer and 4,453 years for the upper 2,000 feet (610 meters) of the main aquifer.

A similar calculation for the water stored in the Española Basin (in which the main aquifer lies) indicates that 106 trillion gallons (401,210 billion liters) of water are stored in this aquifer. If the water rights of all major users (e.g., DOE, Santa Fe, and Española) were used at their capacity, the upper 1,275 feet (389 meters) of the Española Basin would be capable of supplying water for 2,982 years; and if the upper 2,000 feet (610 meters) of the water in the Española Basin were used, the basin would be capable of supplying water to current users for 4,637 years (PC 1996a). The calculations, assumptions, and data used for the Española Basin and main aquifer storage analyses are presented in volume III, appendix A.

Public Water Supply Quality

The DOE public water supply system is monitored to ensure compliance with the SDWA. Samples are collected from wellheads, the water distribution system, and residential taps. An evaluation of public water supply quality data indicates that all constituents analyzed were in compliance with applicable standards, with the exception of bacteria, which exceeded SDWA standards in August 1993. The bacteria were observed in samples taken from the distribution system for TA–33 and TA–39, which are both served by an infrequently used dead-end water main. The water was brought into compliance by flushing and disinfecting the water main. In response to this incident, LANL has increased minimum chlorination concentrations, sampling frequencies, and the frequency of flushing of dead-end water lines to prevent bacterial overgrowth (Dale and Yanicak 1995, LANL 1994b, LANL 1995f, LANL 1996e, LANL 1996i, and LANL 1993b).

DOE also monitors the drinking water wells for a number of radionuclides in order to assess whether LANL operations impact the quality of water in the main aquifer. Sample results for the radionuclides, which do not have limits under SDWA are compared to DOE-DCGs. All sample results from 1990 through 1994 indicate that radionuclide concentrations are well below the DCGs.

EPA has proposed standards for uranium (20 micrograms per liter) and radon (300 picocuries per liter) in groundwater (LANL 1995f). The movement of groundwater through uranium-rich rocks and sediments in the eastern portion of the Española Basin results in locally high concentrations of natural uranium and/or radon in the groundwater. During a study of residential wells in northern Santa Fe County, total uranium concentrations ranged from 0.1 to 930 micrograms per liter (PC 1997d). Analyses of water samples taken from the DOE water supply wells indicate that water from these wells exceed the proposed radon standard by 1.4 to 4.2 times (LANL 1995f). If the proposed EPA standard is adopted, treatment processes will need to be added to the DOE water supply system in order for the public water supply system for LAC to meet the radon standard. Uranium and radon in these wells is naturally occurring.

4.3.2.5 *Regional Groundwater*

In response to public and agency concerns about potential off-site groundwater contamination, data for the Buckman well fields and the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez were evaluated. Evaluations of groundwater quality, flow directions, and supply indicate that the Pueblos of Santa Clara, Cochiti, and Jemez are located outside of the hydrogeologic influence of LANL. Therefore, a baseline characterization of groundwater quality for these Pueblos is not included in this evaluation.

Buckman Well Field

The Buckman well field supplies approximately 41 percent of the city of Santa Fe's municipal drinking water supply. The Buckman well field is located east of LANL and the Rio Grande. An evaluation of NMED's Safe Drinking Water electronic database indicated that all samples collected were in compliance with the SDWA requirements for all constituents measured. Additionally, a joint study conducted by UC and NMED in 1990 found radionuclides in samples taken from the Buckman wells, nearby springs, and the Rio Grande to be below regulatory standards (Gallegos 1990 and Gunderson 1993).

Pueblo of San Ildefonso Groundwater Quality

During the period of 1990 through 1994, uranium was found in groundwater samples collected from 6 of the 18 Pueblo of San Ildefonso wells at concentrations that exceed the proposed EPA SDWA standard (20 micrograms per liter), and ranged from less than 1.0 to 55 micrograms per liter. Three of the six wells are located east of the Rio Grande and three wells are located west of the Rio Grande.

In May 1994, EPA sampled groundwater at all 18 Pueblo of San Ildefonso wells to investigate possible groundwater contamination and analyzed the samples for radionuclides. No plutonium or tritium was found in the groundwater. Uranium concentrations above background were detected in two of the wells. Based on uranium isotopic ratios in the samples, EPA stated, "These data indicate that the source of excess uranium present in these samples is probably natural" (EPA 1995). Regarding possible contamination of groundwater from LANL releases through surface water or sediments pathways, EPA made the following statement that was based on the uranium isotope ratios in surface water and sediment samples. "These data suggest that the elevated uranium concentrations are not a result of releases from the LANL operations and activities, but rather from a natural source that is different from that of the background samples. It is most likely from a geologic formation containing much higher than normal levels of uranium" (EPA 1995).

In 1994, SDWA standard for nitrate was exceeded in three of the Pueblo of San Ildefonso supply wells (LANL 1996e). Potential sources of nitrates in Pueblo of San Ildefonso groundwater include agricultural fertilizers, septic tanks, and sewage treatment plant discharges. Existing data do not allow the source(s) of nitrates detected in a sample to be identified. Therefore, the source of the nitrates in Pueblo of San Ildefonso groundwater is unknown. Analyses performed as a part of the groundwater sampling program in 1994 and 1995 did not find nitrate concentrations that exceeded the SWDA standard in the five main aquifer wells sampled on Pueblo of San Ildefonso land (Dale and Yanicak 1995).

4.4 AIR QUALITY AND CLIMATE

This section describes the air quality for LANL and the surrounding areas. The discussion includes the climatology and meteorology of the region, descriptions of radiological and nonradiological air emissions from recent operations, and a characterization of existing levels of air pollutants. Additional detail and information on the material in this section are presented in volume III, appendix B.

4.4.1 Climatology and Meteorology

Los Alamos has a semi-arid, temperate mountain climate. This climate is characterized by seasonable, variable rainfall with precipitation ranging from 10 to 20 inches (25 to 51 centimeters) per year. The climate of the Los Alamos townsite is not as dry (arid) as that part near the Rio Grande, which is arid continental (Nyhan et al. 1978). Meteorological conditions within Los Alamos are influenced by the elevation of the Pajarito Plateau. Climatological averages for atmospheric variables such as temperature, pressure, winds, and precipitation presented in this subsection are based on observations made at the official Los Alamos meteorological weather station from 1961 to 1990. The current official weather station, which has five sample heights (36 feet, 76 feet, 151 feet, 160 feet, and 302 feet [11 meters, 23 meters, 46 meters, 49 meters, and 92 meters]), is located at TA–6. Four other meteorological towers are also used by LANL. The locations of all five meteorological towers are shown on Figure 4.4.1–1 (LANL 1992a).

Normal (30-year mean) minimum and maximum temperatures for the communities of Los Alamos and White Rock are presented in Figure 4.4.1–2. Temperatures in Los Alamos vary with altitude, averaging 5 degrees Fahrenheit (°F) (3 degrees Celsius [°C]) higher in and near the Rio Grande Valley, which is 6,500 feet (1,981 meters) above sea level, and 5°F to 10°F (3°C to 5.5°C) lower in the Jemez Mountains, which are 8,500 to 10,000 feet (2,600 to 3,050 meters) above sea level. Los Alamos townsite temperatures have dropped as low as -18°F (-28°C) and have reached as high as 95°F (35°C) (LANL 1992a).

A Look Back in Time

During the winter I was usually at my breakfast table in time to watch the sun rise. There in front of the window was the rugged chain of the Rocky Mountains, a dark silhouette about thirty miles away. The sky above them grew lighter and lighter; the lightness began to contract to one particular point; and then suddenly, with blinking intensity, the first little segment of the sun. Within two minutes the breakfast room was filled with brilliant sunshine, every morning; all through the winter there was hardly ever a cloud to be seen, except for the occasional snowstorm which supplied what we needed for skiing. In the evening we would see the mountain chain turn red as the sun sank below the horizon, a lovely spectacle which had given the mountains the local name of el Sangre de Cristo. It was fascinating country, unlike anything I had ever seen.

Source: Frisch 1979

Normal (30-year mean) precipitation for the communities of Los Alamos and White Rock is presented in Figure 4.4.1–3. The normal annual precipitation for Los Alamos from 1961 to 1990 was approximately 19 inches (48 centimeters). Annual precipitation rates within the county decline toward the Rio Grande Valley, with the normal precipitation for White Rock at approximately 14 inches (34 centimeters). The Jemez Mountains receive over 25 inches (64 centimeters of precipitation) annually. The lowest recorded annual precipitation in Los Alamos townsite was 7 inches (17 centimeters) and the highest was 30 inches (1 meter) (LANL 1992a).

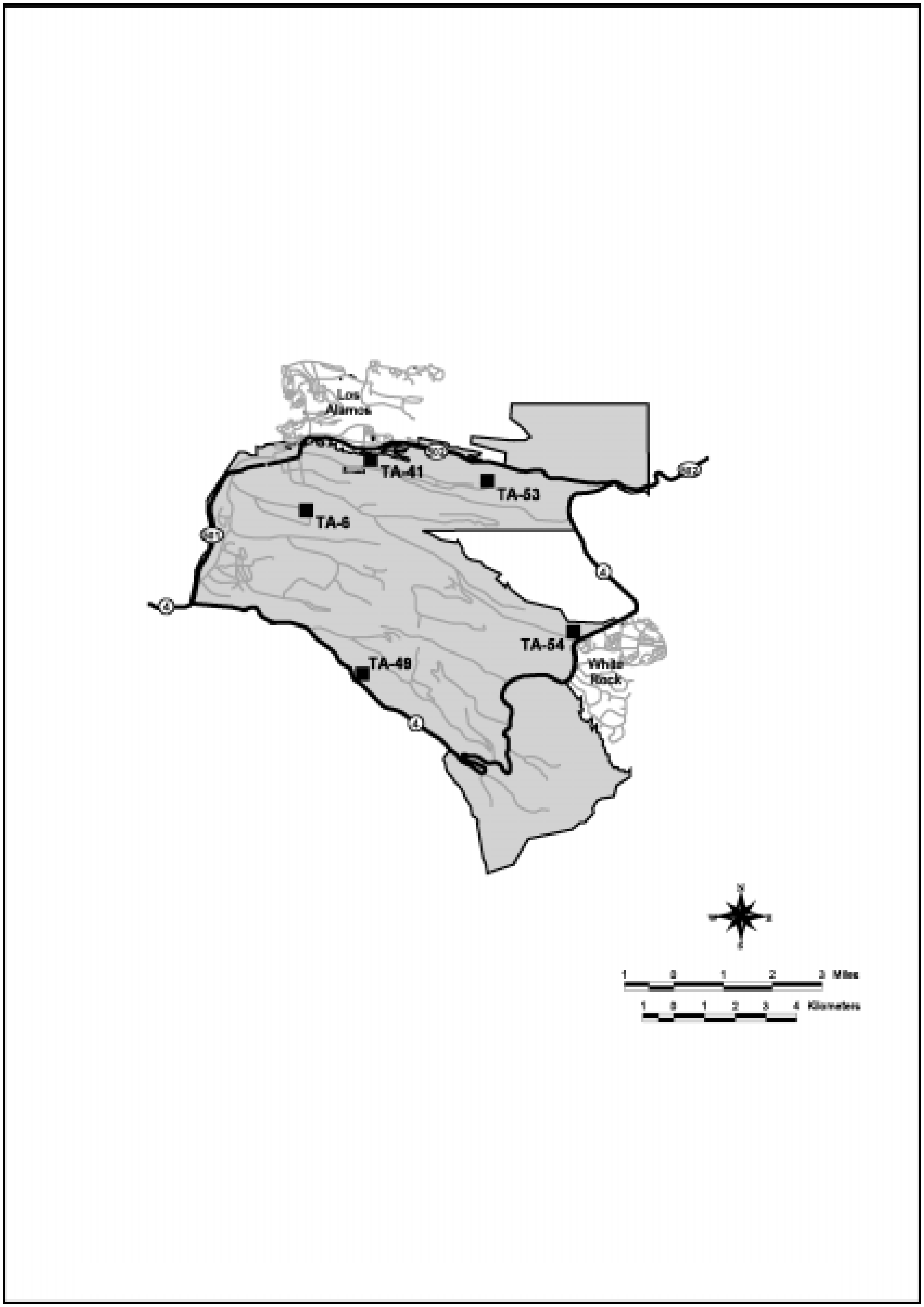
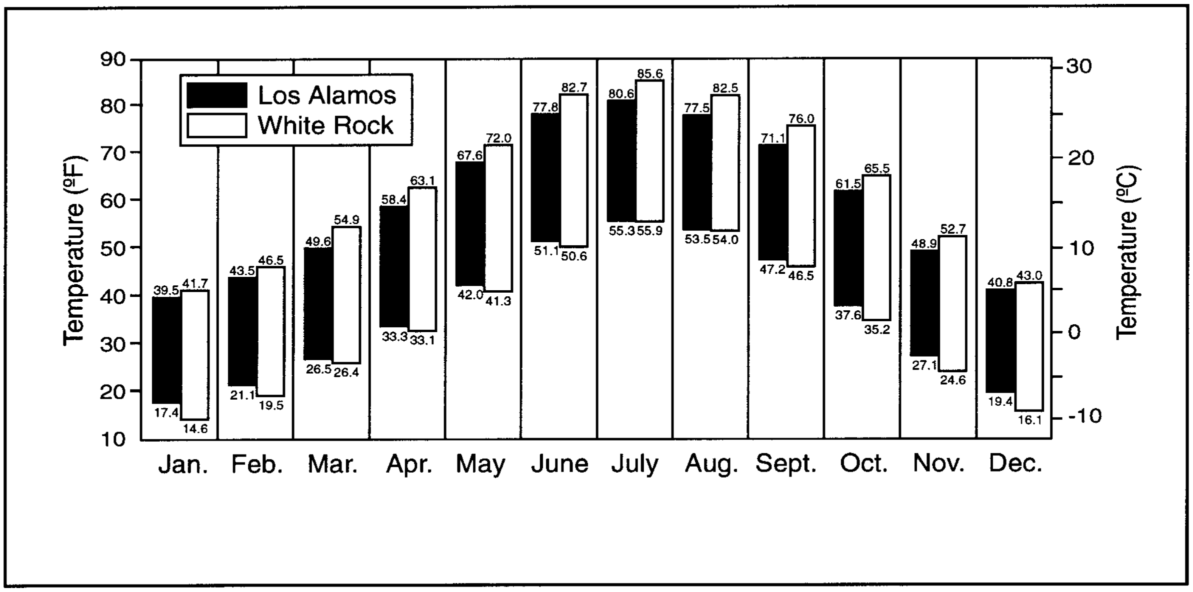
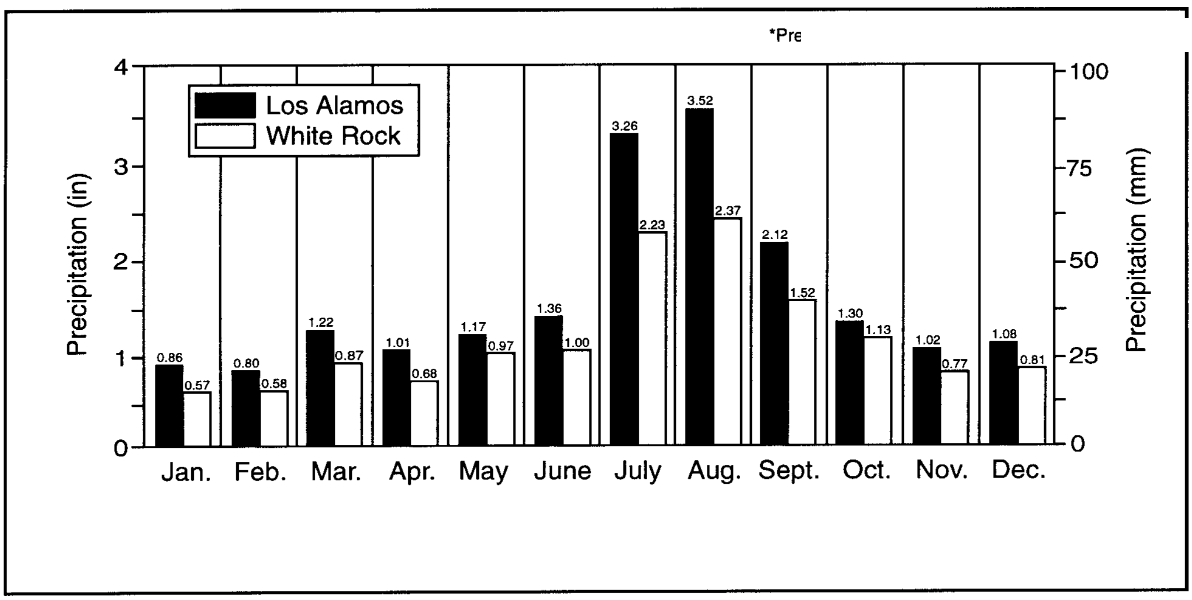


FIGURE 4.4.1–1.—*LANL Meteorological Stations.*



SOURCE: LANL 1992a

FIGURE 4.4.1–2.—*Mean High and Low Temperatures for Los Alamos (1961 to 1990) and White Rock (1965 to 1990).*



SOURCE: LANL 1992a

FIGURE 4.4.1–3.—*Mean Precipitation for Los Alamos (1961 to 1990) and White Rock (1965 to 1990).*

Approximately 36 percent of the annual precipitation for Los Alamos County and LANL results from thundershowers that occur in July and August. Winter precipitation falls primarily as snow. Average annual snowfall is approximately 59 inches (150 centimeters), but can vary considerably from year to year. Annual snowfall ranges from a minimum of 9 inches (24 centimeters) to a maximum of 153 inches (389 centimeters). The single-storm snowfall record is 4 feet (122 centimeters) (LANL 1992a).

4.4.1.1 *Wind Conditions*

Meteorological wind conditions are important with regard to air dispersion. The direction and strength of the wind are pertinent to air quality analysis. Los Alamos County winds average 7 miles per hour (3 meters per second). Wind speeds vary throughout the year, with the lowest wind speeds occurring in December and January. The highest winds occur in the spring (March through June) due to intense storms and cold fronts. The highest recorded wind in Los Alamos County was 77 miles per hour (34 meters per second). Surface winds often vary dramatically with the time of day, location, and elevation due to Los Alamos' complex terrain. Average wind direction and wind speed for the five measurement stations are plotted in wind roses and presented in Figure 4.4.1.1–1. A wind rose is a vector representation of wind velocity and duration. It appears as a circle with lines extending from the center representing the direction from which the wind blows. The length of each spoke is proportional to the frequency at which the wind blows from the direction indicated. The frequency of calm winds (less than 1 mile per hour [0.5 meter per second]) is presented in the center of the wind rose.

In addition to seasonal changes in wind conditions, surface winds often vary with the time of day. An up-slope air flow often develops over the Pajarito Plateau in the morning hours. By noon, winds from the south usually prevail over the entire plateau. The prevalent nighttime flow ranges from the west-southwest to northwest over the western portion of the plateau. These nighttime winds result from cold air drainage off the Jemez Mountains and the Pajarito Plateau.

Analyses of Los Alamos Canyon wind data indicate a difference between the atmospheric flow in the canyon and the atmospheric flow over the Pajarito Plateau. Cold air drainage flow is observed about 75 percent of the time during the night and continues for an hour or two after sunrise until an up-canyon flow forms. Nighttime canyon flows are predominantly weak drainage winds from the west. Because of the stability of these nighttime canyon flows and the relatively weak mesa winds, the development of rotors at night in the canyon is rare (LANL 1992a and LANL 1994b). This flow can develop into a turbulent longitudinal whirl or "rotor" that fills the canyon when the wind over the Pajarito Plateau has a strong cross-canyon component.

The irregular and complex terrain and rough forest surfaces in Los Alamos and surrounding areas also affect atmospheric dispersion. The terrain and forests increase horizontal and vertical turbulence and dispersion. The dispersion generally decreases at lower elevations where the terrain becomes smoother and less vegetated. The canyons surrounding LANL channel the air flow, which also limits dispersion. Clear skies and light winds, typical of the summer season, enhance daytime vertical air dispersion, thus lowering the concentrations at breathing height.

Light wind conditions under clear skies can create strong, shallow surface inversions that trap the air at lower elevations and severely restrict dispersion. These light wind conditions occur primarily during the autumn and winter months, with intense surface air inversions occasionally occurring during the winter. Air inversions are most severe during the night and

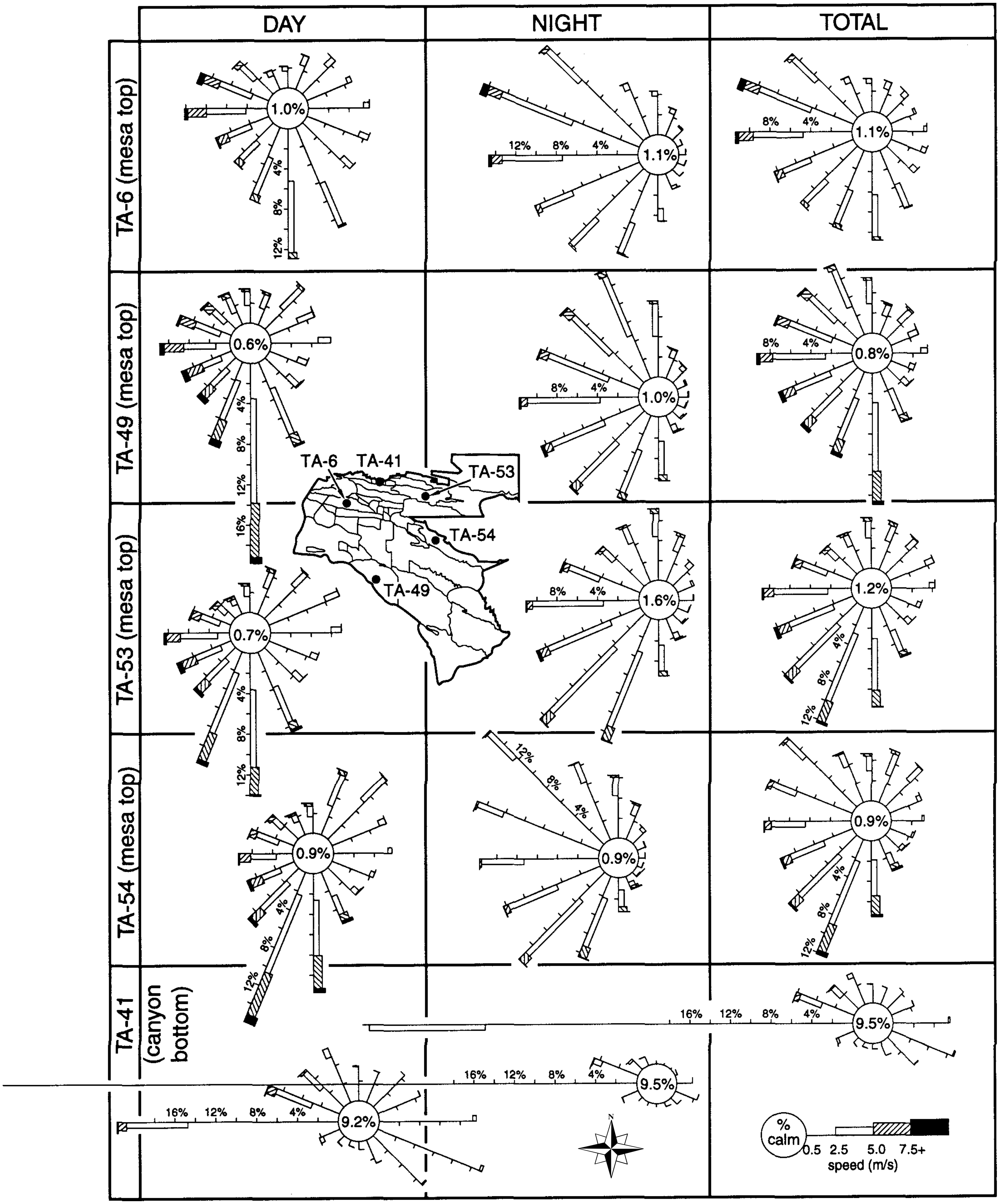


FIGURE 4.4.1.1–1.—*LANL Meteorological Stations with Associated Wind Rose Data.*

early morning. Overall dispersion is greater in the spring during strong winds. However, vertical dispersion is greatest during summer afternoons (LANL 1992a). Deep vertical mixing occurs in the summer afternoons, lowering concentrations at breathing height.

4.4.1.2 *Severe Weather*

Thunderstorms are common in Los Alamos County, with an average of 60 thunderstorms occurring in a year. Lightning can be frequent and intense. The average number of lightning-caused fires, for the years 1990 through 1994, in the 2,727 acres (1,104 hectares) of BNM, is 12 per year (BNM 1995). Because lightning can cause occasional power outages, lightning protection is an important design factor for most facilities at LANL and the surrounding area.

Frequent hailstorms occur in Los Alamos County that can produce measurable hail accumulations on the ground. Typically, hailstones have diameters of approximately 0.25 inch (0.63 centimeter) and do not cause heavy damage to property or plants. An extremely damaging hailstorm occurred in 1990 when golf ball- and baseball-sized hail pummeled the White Rock area (LANL 1992a).

Large-scale flooding is not common in New Mexico. There are no recorded instances of large-scale flooding in Los Alamos County. However, flash floods from heavy thunderstorms are possible in areas such as arroyos, canyons, and low-lying areas. For example, in 1991 a heavy downpour, combined with already saturated soil, caused flash flooding that washed out sewer lines in Pueblo Canyon, which is located between North Mesa and Los Alamos townsite. This incident caused extensive flooding of streets and basements in the Los Alamos townsite (LANL 1992a).

No tornadoes are known to have touched the ground in the Los Alamos area. However, funnel clouds have been observed in Santa Fe County (LANL 1992a).

Remnants of hurricanes and tropical storms originating in the Gulf of Mexico and the Pacific Ocean occasionally reach New Mexico during the summer and autumn. These storms are weak by the time they reach northern New Mexico and do not produce strong winds. However, these storms can produce widespread, strong thunderstorms and heavy rains (LANL 1992a).

4.4.2 Nonradiological Air Quality

LANL operations can result in the release of nonradiological air pollutants that may affect the air quality of the surrounding area. Information regarding the applicable air quality standards and guidelines and existing nonradiological air quality will be presented in this section.

4.4.2.1 *Applicable Requirements and Guidelines*

The *Clean Air Act* (CAA) mandated that EPA establish National Ambient Air Quality Standards (NAAQS) for pollutants of nationwide concern. These pollutants, known as criteria pollutants, are carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, lead, and particulate matter. As of September 16, 1997, in addition to the particulate matter (PM) equal to or less than 10 microns in aerodynamic diameter (PM_{10}) NAAQS, a new NAAQS became effective for particulate matter equal to or less than 2.5 microns (2.5 micrometers) in aerodynamic diameter ($PM_{2.5}$). These new standards will not require imposition of local area controls until 2005, and compliance determinations will not be required until 2008. The recently promulgated 8-hour 0.08 parts per million ozone standard now applies in those areas in which EPA has identified that the 1-hour 0.12 parts per million ozone standard does not apply (63 FR 31014). Los Alamos

County has been identified by EPA as an area where the new 8-hour 0.08 parts per million standard now applies. A primary NAAQS has been established for carbon monoxide and both primary and secondary standards have been established for the remaining criteria pollutants. National primary air quality standards define levels of air quality judged necessary, with an adequate margin of safety, to protect public health. National secondary ambient air quality standards define levels of air quality judged necessary to protect public welfare from any known or anticipated adverse effects of a pollutant. There are only three nonattainment areas in New Mexico, and the area encompassing LANL and Los Alamos County is classified as an attainment area for all six criteria pollutants.

The State of New Mexico has also established ambient air quality standards for carbon monoxide, sulfur dioxide, nitrogen dioxide, total suspended particulates (which is not PM_{10}), hydrogen sulfide, and total reduced sulfur. Additionally, New Mexico established guidelines for toxic air pollutants. Toxic air pollutants are chemicals that are generally found in trace amounts in the atmosphere, but that can result in chronic health effects or increase the risk of cancer when they are present in amounts that exceed established occupational exposure limits. Because of the financial constraints and the unavailability of sufficient information on the effects of toxic air pollutants, New Mexico has yet to establish ambient standards for toxic chemicals. To approach this issue, New Mexico has developed guidelines that are used by the NMED for determining if a new or modified source emitting a toxic pollutant would be issued a permit (20 New Mexico Administrative Code [NMAC] 2.72.402). Additionally, the EPA has established exposure levels for toxic air pollutants, which are known or suspected human carcinogens.

Almost all operations at LANL were in existence before August 31, 1972. Therefore, air quality permits were not required. Air quality permits were obtained from the State Air Quality Bureau for beryllium operations that were modified or constructed after August 31, 1972. In accordance with Title V of the CAA, as amended, and 20 NMAC 2.72.402, UC and DOE submitted a CAA operating permit application to NMED in December 1995. The primary purpose of this permit program is to identify all state and federal air quality requirements applicable to LANL operations so that a single site-wide permit can be granted. Under this permit, UC would track pollutant emissions by reporting annual emissions, based on chemical purchase data, knowledge of operations, and suitable emission factors. NMED has conducted an initial review of this application and issued a Notice of Completeness, but has yet to issue an operating permit.

The New Mexico ambient air pollutant guideline values were used to evaluate toxic air pollutants in the SWEIS. Additional information pertaining to applicable federal and state air quality regulations is presented in chapter 7.

4.4.2.2 *Sources of Nonradiological Emissions*

Criteria pollutants released from LANL operations are emitted primarily from combustion sources such as boilers, emergency generators, and motor vehicles. Table 4.4.2.2–1 presents information regarding the major existing combustion sources that were analyzed for the SWEIS. Toxic air pollutant emissions from LANL activities are released primarily from laboratory, maintenance, and waste management operations. Unlike a production facility with well-defined operational processes and schedules, LANL is a research and development facility with great fluctuations in both the types of chemicals emitted and their emission rates. DOE has a program to review all new operations for their potential to emit

TABLE 4.4.2.2–1.—*Combustion Sources at LANL*

MAJOR SOURCES[a]	LOCATION	FUEL	POLLUTANTS OF INTEREST
Steam Plant	TA–3–22–1	Natural gas/oil #2	Nitrogen dioxide Sulfur dioxide PM_{10} Total suspended particulates
Steam Plant	TA–21–257–1	Natural gas/oil #2	Nitrogen dioxide Sulfur dioxide PM_{10} Total suspended particulates
Boiler	TA–16–4	Natural gas	Nitrogen dioxide
Boiler	TA–16–5	Natural gas	Nitrogen dioxide
Boiler	TA–16–6	Natural gas	Nitrogen dioxide
Boiler	TA–16–13	Natural gas	Nitrogen dioxide
Asphalt Heater	TA–3–73–2	Oil #2	Nitrogen dioxide Sulfur dioxide PM_{10} Total suspended particulates
Water Pump	TA–54–1013	Natural gas	Nitrogen dioxide

PM_{10} = Particulate matter less than 10 microns in aerodynamic diameter
[a] Emissions from the following smaller combustion sources were also considered:

- 62 miscellaneous boilers at various technical areas (residential size);
- 149 standby emergency generators (7 natural gas, 50 diesel, and 92 gasoline-fueled).

toxic air pollutants. Because past reviews demonstrate that LANL's toxic air pollutant emissions are below the state's permitting threshold limits, DOE is not required to monitor LANL's toxic air pollutant emissions. However, air toxic estimates were made based on chemical use at LANL and assumed stack and building parameters as discussed in chapter 5, section 5.1.4.1.

4.4.2.3 *Existing Ambient Air Conditions*

Only a limited amount of monitoring of the ambient air has been performed for nonradiological air pollutants within the LANL region. NMED operated a DOE-owned ambient air quality monitoring station adjacent to BNM between 1990 and 1994 to record sulfur dioxide, nitrogen dioxide, ozone, and PM_{10} levels (Table 4.4.2.3–1). LANL and NMED discontinued operation of this station in fiscal year 1995 because recorded values were well below applicable standards. New Mexico State had ambient air quality control standards for beryllium, which were repealed in 1995. To ensure that LANL's beryllium emissions did not exceed those standards, ambient air monitoring of beryllium was performed at LANL from 1989 to December 1995. This monitoring was performed at four on-site stations, four perimeter performed at four on-site stations, four perimeter stations, and one regional station. The recorded beryllium levels were low, and as a result, beryllium monitoring was discontinued after December 1995.

4.4.3 Radiological Air Quality

Individuals are continuously exposed to airborne radioactive materials. These materials come primarily from natural sources such as

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TABLE 4.4.2.3–1.—*Nonradiological Ambient Air Monitoring Results at TA–49 (1991 Through 1994)*

CONTAMINANT	AVERAGING TIME	UNIT	NEW MEXICO STANDARD	NAAQ STANDARD		1991	1992	1993	1994
				PRIMARY	SECONDARY				
Sulfur Dioxide	Annual	ppm	0.02	0.03		0.001	0.0005	0.002	0.001
	24 hours	ppm	0.10	0.14					0.009
	3 hours	ppm			0.05				
	1 hour	ppm				0.008	0.009	0.006	0.011
Nitrogen Dioxide	Annual	ppm	0.05	0.053	0.053	0.003	0.002	0.003	0.003
	24 hours	ppm	0.10						0.006
	1 hour	ppm				0.01	0.02	0.027	0.013
Ozone	1 hour	ppm		0.12	0.12	0.087	0.076	0.077	0.09
PM_{10}	Annual	$\mu g/m^3$		50	50	7	8	8	8
	24 hours	$\mu g/m^3$		150	150	15	21	30	29

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
PM_{10} = Particulate matter less than 10 microns in aerodynamic diameter
NAAQ = National Ambient Air Quality
Sources: LANL 1994b, LANL 1995f, LANL 1996e, and LANL 1993b

radium and its daughters, including radon. However, airborne radioactive materials can also be emitted by manmade operations. For example, in 1993 the average Los Alamos resident received a radiation dose of 200 millirems from exposure to naturally occurring radon gas and a radiation dose of 0.15 millirems from LANL nuclear operations (LANL 1995f). Descriptions of the radiation doses received by individuals within Los Alamos County from recent routine LANL operations are presented in this subsection.

Some LANL operations may result in the release of radioactive materials to the air from point sources such as stacks or vents or from nonpoint (or area) sources such as the radioactive materials in contaminated soils. The concentration of radionuclides in point-source releases is continuously sampled or estimated based on knowledge of the materials used and the activities performed. Nonpoint-source emissions are directly monitored or sampled or estimated from airborne concentrations outdoors. Radionuclide emissions from LANL point and nonpoint sources include several radioisotopes such as tritium, uranium, strontium-90, and plutonium.

4.4.3.1 *Radiological Emissions and Monitoring*

Manmade sources of airborne radiological emissions include radioactive materials or radiation-producing equipment. At LANL, radiation sources are used in operations, primarily to support nuclear weapons research and development. Many LANL organizations or work groups use radioactive materials. These work groups are located in TAs throughout LANL.

The number of stacks that are continuously monitored for radiological air emissions varies, and is dependent on DOE operational and EPA radiological air emission monitoring requirements. As of August 1996, 33 stacks were continuously monitored to measure the air emissions for radioactive materials. DOE also operates an ambient air monitoring program (AIRNET) at LANL to measure the level of radionuclides in the air. In 1994, there were 35 on-site monitoring stations, 15 site perimeter monitoring stations, and 3 off-site monitoring stations at the Pueblos of San Ildefonso, Taos, and Jemez. Three background monitoring stations are also operated in Española, Pojoaque, and Santa Fe (Fong 1995). As activities with potential for increased releases change, on-site, site perimeter, and off-site monitoring stations will be added to the ambient air monitoring program (AIRNET) consistent with the requirements of the operational changes.

Currently, the largest contributors to LANL radiological point-source emissions are LANSCE and the tritium operations. LANL nonpoint sources of radiological emissions include fugitive emissions from the LANSCE bay area and holding ponds, the PHERMEX facility at TA–15, the dynamic testing facility at TA–36, and low-level radioactive waste (LLW) disposal at Material Disposal Area (MDA) G. A list of radionuclides emitted from LANL operations during the period of 1990 through 1995 is presented in volume III, appendix B.

4.4.3.2 *Radiological Emission Standards*

Radiological air emission requirements are specified in 40 CFR 61, Subpart H, "National Emissions Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities." During 1991 and 1992, EPA cited DOE for exceeding the dose standard in 1990 and for LANL operations not being in full compliance with these requirements. Although there was a program for measuring emissions of radioactive materials, the program did not meet all of the provisions of Subpart H, including sample probe design criteria, placement, and quality assurance requirements. Upon enactment of Subpart H, LANL began assessing its existing air monitoring program in light of these new regulations (enacted in December 1989), and investigating the means to achieve compliance with those regulations. In June 1996, DOE and EPA signed a Federal Facility Compliance Agreement that specifies how UC will meet the requirements of 40 CFR 61, Subpart H (EPA 1996a). Since June 1996, DOE and UC have asserted that LANL operations are in full compliance.

4.4.3.3 *Radiation Doses from LANL Airborne Emissions*

EPA regulations for radionuclide air emissions (40 CFR 61, Subpart H) require that doses be modeled in order to demonstrate compliance with the standard. Doses are also directly monitored as part of routine environmental monitoring but do not include some of the modeled pathways. The measured and modeled radiological doses for the maximally exposed individual (MEI) are presented in Table 4.4.3.3–1 for the period of 1990 through 1995. The location of the LANL MEI is assumed to be 2,625 feet (800 meters) north-northeast from the LANSCE ES–3 stack, where the maximum dose from the air pathway is received. The CAA Assessment Package for 1988 (CAP–88), an EPA-approved model, was used to calculate the dose to MEI. Different assumptions are used to estimate the measured and modeled doses. The CAP–88 model assumes that the MEI is stationary throughout the year and does not account for shielding from clothing or buildings. This model also assumes that the MEI ingests some food, milk, vegetables, and fruits grown at that location; inhales radioactive materials; and receives external exposure to radiation. This model also uses conservative dose conversion factors. Therefore, the modeled dose is generally higher than the actual measured dose.

Measured doses are based on actual monitoring data taken from the monitoring station at the

TABLE 4.4.3.3–1.—*Dose to the MEI from Exposure to LANL Airborne Radionuclide Emissions (1990 Through 1995)*

YEAR	MEASURED DOSE[a]		MODELED DOSE[b]	
	DOSE (millirem/year)	PERCENT OF EPA STANDARD	DOSE (millirem/year)	PERCENT OF EPA STANDARD
1990	3.1	31	15.3[c]	153
1991	Not Above Background[d]	-	6.5	65
1992	Not Above Background[d]	-	7.9	79
1993	3.1	31	5.6	56
1994	3.5	35	7.6	76
1995	2.3	23	5.1	51

[a] *Sources*: LANL 1994b, LANL 1995f, LANL 1996e, LANL 1996i, LANL 1993b, and LANL 1992b
[b] No shielding and an occupancy factor of 1.0 were used for calculating the modeled dose.
[c] This modeled dose is based on an MEI location that is 800 meters north/northeast of the LANSCE ES–3 stack. In 1990, no one resided at this location.
[d] In 1991 and 1992, the monitoring devices at the MEI location did not show doses above the background levels. This was because the monitoring devices were not sensitive enough to pick up small doses.

MEI location. This includes thermoluminescent dosimeters (TLDs) and air sampling stations. The measured doses do not take into account the inhalation or ingestion (breathing in or eating) of radioactive materials that are accounted for in the modeled dose.

EPA requires that emissions of radioactive materials to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 millirem. DOE received a notice of noncompliance from EPA for its emissions during 1990. This notice was issued because DOE applied a shielding factor (a factor that reduces the calculated dose to take credit for materials, such as clothing or walls of a residence, that can shield the MEI from the effects of radioactive emissions) in calculating the MEI dose without prior EPA approval; the MEI dose without use of the shielding factor exceeded the 10 millirem limit for 1990.

4.4.4 Visibility

In accordance with CAA, as amended, and New Mexico regulations, the BNM and Wilderness Area have been designated as a Class I area (i.e., wilderness areas that exceed 10,000 acres (4,047 hectares) where visibility is considered to be an important value (40 CFR 81 and 20 NMAC 2.74) and requires protection. Visibility is measured according to a standard visual range, how far an image is transmitted through the atmosphere to an observer some distance away. Visibility has been officially monitored by the NPS at the BNM since 1988 (Table 4.4.4–1 reflects average visibility from 1991 through 1994). The view distance at BNM has been recorded from approximately 40 to 103 miles (77 to 166 kilometers). The visual range has not deteriorated during the period for which data are available (ARSI 1994).

TABLE 4.4.4–1.—*Average Visibility Measurements at Bandelier National Monument (1991 to 1994)*

SEASON	1991		1992		1993		1994	
	miles	**kilometers**	**miles**	**kilometers**	**miles**	**kilometers**	**miles**	**kilometers**
Winter	77	124	70	113	67	107	92	148
Spring	77	124	73	117	77	124	63	102
Summer	70	113	65	104	83	133	73	117
Fall	67	107	68	110	63	102	85	137

Source: ARSI 1994

4.5 ECOLOGICAL RESOURCES AND BIODIVERSITY

4.5.1 Ecological Resources

LANL is located in a region of diverse landform, elevation, and climate—features that have contributed to producing in New Mexico one of the world's most diversified plant and animal communities. The combination of these features, including past and present human use, has given rise to correspondingly diverse, and often unique, biological communities and ecological relationships in Los Alamos County and the region as a whole. Plant communities range from urban and suburban areas to grasslands, wetlands, shrublands, woodlands, and mountain forest, and provide habitat for a wealth of animal life. This richness of animal life includes herds of elk and deer, bear, mountain lions, coyotes, rodents, bats, reptiles, amphibians, invertebrates, and a myriad of resident, seasonal, and migratory bird life. In addition, numerous threatened, endangered, species of concern, and other sensitive species utilize LANL resources. Because of restricted access to LANL lands and management of contiguous BNM for natural biological systems, much of the region provides a refuge for wildlife.

The interfingering of deep, steep-sided canyons with narrow mesas that descend the east slopes of the Jemez Mountains and an inversion of the normal altitudinal distribution of vegetation communities along the canyon floors result in many transitional overlaps of plant and animal communities and increased biological diversity. It is this dominant feature of the Pajarito Plateau, in combination with an elevational descent of almost a mile from mountain ridges to the Rio Grande, that has made a major contribution to the species richness and diverse ecological relationships that characterize the Pajarito Plateau.

Since the turn of the century, logging has been an important industry on the Pajarito Plateau. Sawmills were small and easily portable, dragged from place to place to follow the loggers. The output, mostly poles and railroad ties, was hauled by wagon to lumber yards along the Denver and Rio Grande Western Railroad. One small mill site lies at the head of Alamitos mesa. This was McCurdy's mill, one of a number of logging camps that itinerant lumberman H.T. McCurdy established on the Pajarito Plateau in the 1920's. Now little remains to mark the location but a round clearing and some mill debris. Elk bed in the tall grass and western tanagers sing from the tree tops.Source: Los Alamos Outdoors (Hoard nd)

4.5.1.1 *A Regional Approach*

Administrative boundaries do not often coincide with ecological boundaries, which are frequently boundaries that vary in space and time and at multiple scales. LANL facilities, infrastructure, operations, and impacts (positive, negative, and undetermined) are immersed in the patterns and processes of a complex and fragile regional landscape. Weather, geomorphic and elevational variation, soils, plant, and animal communities, and major canyon systems are continuous across the jurisdictional boundaries of LANL, the NPS, the USFS, the regional Pueblos, and other regional land stewards. Seasonal migration routes for thousands of elk and deer in the region and foraging or hunting ranges of black bears and mountain lions ignore map boundaries such as fences that define these boundaries on the landscape. Migratory birds from as far away as Central and South America breed throughout the region during the spring and summer. Because of this ecological continuity and "interconnectedness" of patterns of vegetation and wildlife populations, along with the ecological processes that shape and sustain them, the "site" to be analyzed in this SWEIS is the larger regional ecosystem.

Two landscape-based organizational themes are used to present the data in this section from a regional ecosystem perspective: watershed units and major vegetation zones. The general area included for analysis is shown in Figure 4.5.1.1–1, LANL Technical Areas and Watersheds. Descriptions of specific vegetation ecosystem components such as air, soils and sediments, and surface and groundwater can be found in other subsections of this report and associated technical reports.

Watershed Unit

Traditionally, environmental impact assessments have considered air quality, water resources, wildlife, and human communities as separate entities for analysis. Recognition of the interconnectedness of land, water, and human resources has encouraged many federal and state agencies to undertake ecosystem or watershed approaches to environmental protection (CEQ 1997). For example, EPA is promoting multi-organizational, multi-objective, watershed management projects across the nation. This shift toward comprehensive watershed management has helped lead EPA toward a "place-based approach" to environmental problem solving (EPA 1994).

Watersheds are natural boundaries that provide a common template for integrating multiple tasks, including ecological resource description, analysis, and management, thereby enhancing efficiency and economy. The complex canyon/mesa topography and pronounced elevational gradients of LANL region are particularly well suited to this approach because regional watersheds:

- Are relatively discrete landscape units with a hierarchical structure.
- Are relatively closed systems in terms of many ecological components and processes such as hydrologic regime, nutrient cycling, contaminant transport, erosion, and sedimentation.
- Provide an ecologically consistent template for organizing information on ecosystem components, such as landscape-wide vegetation zones as well as resident and migratory wildlife populations (including threatened and endangered species, and wetlands).

The regional LANL ecosystem has been more precisely delineated by incorporating watershed boundaries as shown in Figure 4.5.1.1–1. As mapped, this area includes 14 regional watersheds bounded by Guaje Canyon on the north, Frijoles Canyon on the south, the crest of the Jemez Mountains on the west, and the Rio Grande on the east. Because of their downstream hydrologic connection to LANL and the function boundary of Cochiti Dam, the White Rock Canyon stretch of the Rio Grande and Cochiti Lake were also included in this analysis. Summary information is presented in Table 4.5.1.1–1.

Major Vegetation Zones

While watersheds traverse all or part of the elevational gradient, major vegetation zones are organized into elevation- and aspect-defined bands across this gradient. Increasing temperature and decreasing moisture along the approximately 12-mile (19-kilometer) wide, 5,000-foot (1,500-meter) elevational gradient from the peaks of the Jemez Mountains to the Rio Grande are primarily responsible for the formation of five broad bands, containing six major vegetation zones. These vegetation zones are defined by the dominant vegetation species. Plant and animal communities similar to those found throughout the southern Rocky Mountain region live within these vegetation zones (Bailey 1980).

From the western crest of the Pajarito Plateau to the Rio Grande, the six vegetation zones that characterize the LANL region consist of

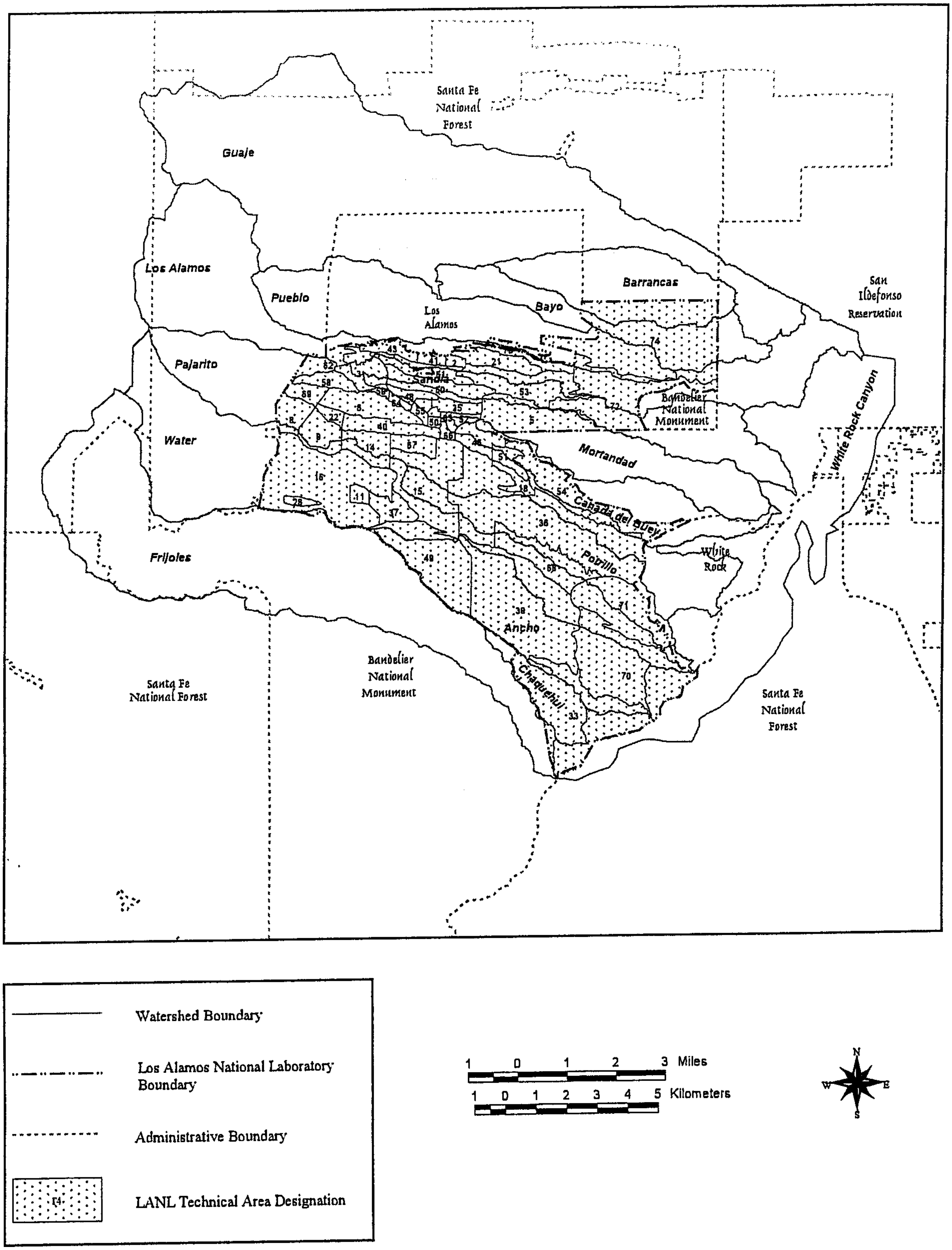


FIGURE 4.5.1.1–1.—*LANL Technical Areas and Watersheds.*

TABLE 4.5.1.1–1.—*Regional Watershed Summary*

WATERSHED	AREA (square feet)	AREA (acres)
Ancho	188,052,531	4,317
Barrancas	137,219,762	3,150
Bayo	110,280,543	2,532
Cañada del Buey	119,458,359	2,742
Chaquehui	43,866,574	1,007
Frijoles	532,030,496	12,214
Guaje	736,234,029	16,902
Los Alamos	391,865,822	8,996
Mortandad	168,145,908	3,860
Pajarito	357,109,578	8,198
Potrillo	125,618,752	2,884
Pueblo	232,544,591	5,338
Sandia	153,152,776	3,516
Water	402,236,668	9,234
White Rock Canyon	449,075,835	10,309
Total Area	4,146,892,223	95,200

montane grasslands, spruce-fir forest, mixed-conifer forest (with aspen forest), ponderosa pine forest, pinyon-juniper woodland, and juniper savannah. These vegetation zones are depicted on Figure 4.5.1.1–2. The major plant communities of each watershed and areal coverage are depicted in Table 4.5.1.1–2. The montane grassland, spruce-fir, and mixed conifer vegetation zones are located primarily west of LANL with little representation on the laboratory proper. The vegetation zones and associated ecotones provide habitat, including breeding and foraging territory, and migration routes for a diversity of permanent and seasonal wildlife species. This diversity is illustrated by the presence of over 900 species of vascular plants; 57 species of mammals; 200 species of birds, including 112 species known to breed in Los Alamos County; 28 species of reptiles; 9 species of amphibians; over 1,200 species of arthropods; and 12 species of fish (primarily found in the Rio Grande, Cochiti Lake and the Rito de los Frijoles). No fish species have been found within LANL boundaries.

Characteristics of each zone are presented in Table 4.5.1.1–3. The Fenton Hill site (TA–57) is on the southwestern side of the Valles Caldera, on a mesa top location (Lake Fork Mesa) on the Jemez Plateau. This site is at an elevation of 8,660 feet (2,640 meters), and its vegetation characteristics at this elevation are those described in Table 4.5.1.1–3. Table 4.5.1.1–4 is a summary of conditions for each vegetation zone that existed about 1850, human and natural disturbances that have altered these historic conditions, and current conditions resulting from these ecological perturbations.

4.5.1.2 *Wetlands*

Wetlands are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of the National Wetlands Inventory, conducted by the FWS, which included an inventory of wetlands in the LANL region, wetlands must have one or more of the following attributes:

- At least periodically, the land supports predominantly hydrophytes (plants adapted to abundant water such as cattails and willows).
- The substrate is predominantly undrained hydric soil (e.g., marshes, wet meadows).
- The substrate is nonsoil (e.g., gravel, stones) and is saturated with water or covered by shallow water at some time during the growing season of each year.

A 1990 survey (based on interpretation of aerial photographs) identified a total of 39 acres (16 hectares) of wetlands within LANL boundaries (FWS 1990). A 1996 field survey by LANL personnel identified an estimated 50 acres (20 hectares) of wetlands within

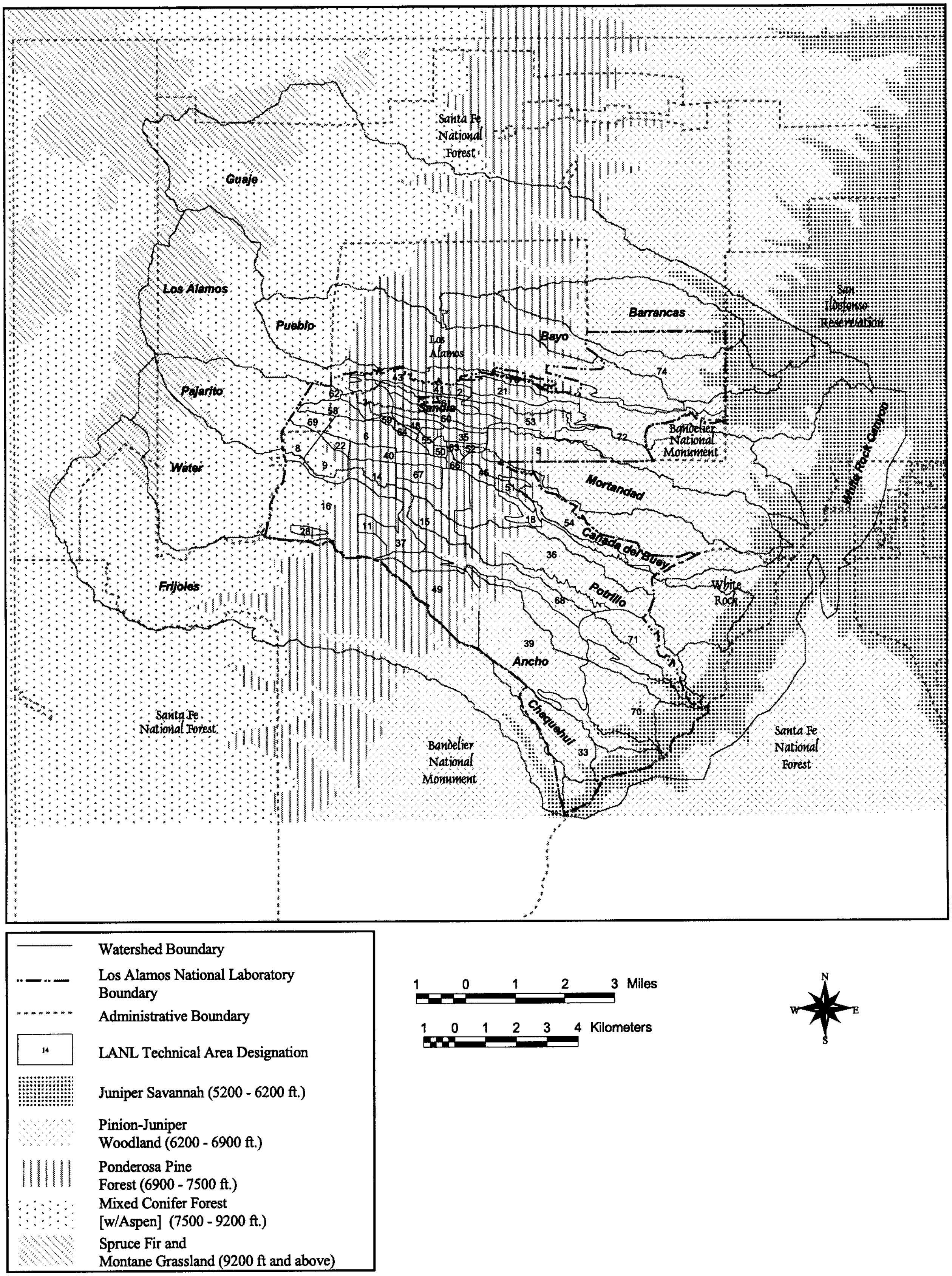


FIGURE 4.5.1.1–2.—*LANL Technical Areas and Watersheds with Vegetation Zones.*

TABLE 4.5.1.1–2.—*Areal Extent of Major Vegetation Zones by Watershed*

WATERSHED	VEGETATION RANGE (BASED ON ELEVATION)	AREA (square feet)	AREA (acres)
Ancho	Juniper Savannah	14,297,807	328
Ancho	Pinyon-Juniper Woodland	133,915,070	3,074
Ancho	Ponderosa Pine Forest	39,839,654	915
Barrancas	Juniper Savannah	10,073,560	231
Barrancas	Pinyon-Juniper Woodland	102,969,882	2,364
Barrancas	Ponderosa Pine Forest	24,176,321	555
Bayo	Juniper Savannah	22,090,862	507
Bayo	Pinyon-Juniper Woodland	52,558,313	1,207
Bayo	Ponderosa Pine Forest	35,631,368	818
Cañada del Buey	Juniper Savannah	2,692,403	62
Cañada del Buey	Pinyon-Juniper Woodland	96,741,792	2,221
Cañada del Buey	Ponderosa Pine Forest	20,024,164	460
Chaquehui	Juniper Savannah	2,092,897	48
Chaquehui	Pinyon-Juniper Woodland	41,773,677	959
Frijoles	Juniper Savannah	11,871,528	273
Frijoles	Mixed Conifer Forest (includes Aspen)	249,513,490	5,728
Frijoles	Pinyon-Juniper Woodland	79,998,306	1,837
Frijoles	Ponderosa Pine Forest	157,547,985	3,617
Frijoles	Spruce Fir Forest & Montane Grasslands	33,099,186	760
Guaje	Juniper Savannah	46,782,112	1,074
Guaje	Mixed Conifer Forest (includes Aspen)	325,620,902	7,475
Guaje	Pinyon-Juniper Woodland	68,220,346	1,566
Guaje	Ponderosa Pine Forest	181,335,133	4,163
Guaje	Spruce Fir Forest & Montane Grasslands	114,275,536	2,623
Los Alamos	Juniper Savannah	68,170,275	1,565
Los Alamos	Mixed Conifer Forest (includes Aspen)	99,349,119	2,281
Los Alamos	Pinyon-Juniper Woodland	70,685,022	1,623
Los Alamos	Ponderosa Pine Forest	57,650,780	1,323
Los Alamos	Spruce Fir Forest & Montane Grasslands	96,010,627	2,204
Mortandad	Juniper Savannah	8,610,636	198
Mortandad	Pinyon-Juniper Woodland	114,783,354	2,635
Mortandad	Ponderosa Pine Forest	44,751,918	1,027
Pajarito	Juniper Savannah	11,269,977	259
Pajarito	Mixed Conifer Forest (includes Aspen)	119,271,954	2,738
Pajarito	Pinyon-Juniper Woodland	82,916,322	1,903
Pajarito	Ponderosa Pine Forest	118,337,174	2,717
Pajarito	Spruce Fir Forest & Montane Grasslands	25,314,152	581

TABLE 4.5.1.1–2.—*Areal Extent of Major Vegetation Zones by Watershed*-Continued

WATERSHED	VEGETATION RANGE (BASED ON ELEVATION)	AREA (square feet)	AREA (acres)
Potrillo	Juniper Savannah	911,331	21
Potrillo	Pinyon-Juniper Woodland	95,475,889	2,192
Potrillo	Ponderosa Pine Forest	29,231,531	671
Pueblo	Mixed Conifer Forest (includes Aspen)	67,279,650	1,545
Pueblo	Pinyon-Juniper Woodland	56,892,435	1,306
Pueblo	Ponderosa Pine Forest	108,372,506	2,488
Sandia	Juniper Savannah	12,911,421	296
Sandia	Mixed Conifer Forest (includes Aspen)	63,567	1
Sandia	Pinyon-Juniper Woodland	95,838,989	2,200
Sandia	Ponderosa Pine Forest	44,338,799	1,018
Water	Juniper Savannah	8,447,744	194
Water	Mixed Conifer Forest (includes Aspen)	184,932,126	4,245
Water	Pinyon-Juniper Woodland	78,110,286	1,793
Water	Ponderosa Pine Forest	96,311,587	2,211
Water	Spruce Fir Forest & Montane Grasslands	34,434,926	791
White Rock Canyon	Juniper Savannah	316,447,111	7,265
White Rock Canyon	Pinyon-Juniper Woodland	132,628,723	3,045
Total Area		4,146,892,223	95,200

TABLE 4.5.1.1–3.—*Characteristics of the Major Vegetation Zones in the LANL Area*

MAJOR VEGETA-TION ZONE	ACRES AND PERCENT OF LANL	TYPICAL ELEVATION RANGE	AVERAGE PRECIPITATION	COMMON TREES	COMMON SHRUBS OR FLOWERS	COMMON GRASSES	COMMON ANIMALS	COMMON BIRDS	THREATENED AND ENDANGERED SPECIES POTENTIALLY PRESENT
Spruce-Fir Forest	None[a]	Above 9,500 ft[b] (2,895 m)	35 in. (90 cm)	• Engelmann spruce • Corkbark fir • White fir • Douglas fir	• Arizona peavine • Whortleberry • Creeping barberry • Western thimbleberry	• Pine dropseed • Timothy • Interior bluegrass	• Black bear • Elk • Mule deer • Mountain lion • Bobcat	• Warbling vireo • Blue grouse • Wild turkey • Clark's nutcracker	Yes
Montane Grassland	None[a]	Above 9,500 ft[b] (2,895 m)[c]	35 in. (90 cm)	• Ponderosa pine • Douglas fir	• Mariposa lily • Rocky Mountain iris • Gentiant	• Timber oatgrass • Thurber fescue • Orchard grass	• Black bear • Elk • Mule deer • Mountain lion • Bobcat	• Mountain bluebird • Golden-crowned kinglet • Northern flicker	Yes
Mixed-Conifer Forest (includes a minor amount of Aspen)	Approximately 367 ac (147 ha), 3.3 percent	7,500 to 9,500 ft (2,285 to 2,896 m)	18 to 30 in. (46 to 76 cm)	• Ponderosa pine • Douglas fir • White fir • Limber pine • Aspen	• Ninebark • Oceanspray • Cliffbush • Bracken fern • Mountain lover	• June grass • Arizona fesque • Fringed brome • Pine dropseed • Common timothy • Mountain brome	• Black bear • Elk • Mule deer • Mountain lion • Bobcat • Raccoon	• Dark-eyed junco • Yellow-rumped warbler • Olive-sided flycatcher	Yes
Ponderosa-Pine Forest	Approximately 8,092 ac (3,637 ha), 29.3 percent	6,900 to 7,500 ft (2,100 to 2,285 m)	16 to 18 in. (40 to 46 cm)	• Ponderosa pine • Gambel oak	• Kinnikinik • New Mexico locust	• Pine dropseed • Mountain muhly • Little bluestern	• Black bear • Elk • Mule deer • Mountain lion • Bobcat • Coyote • Skunk • Raccoon • Deer mouse • Abert's squirrel	• Western bluebird • Solitary vireo • Grace's warbler • Western tanager • Black-headed grosbeak	Yes

TABLE 4.5.1.1–3.—*Characteristics of the Major Vegetation Zones in the LANL Area*-Continued

MAJOR VEGETA-TION ZONE	ACRES AND PERCENT OF LANL	TYPICAL ELEVATION RANGE	AVERAGE PRECIPITATION	COMMON TREES	COMMON SHRUBS OR FLOWERS	COMMON GRASSES	COMMON ANIMALS	COMMON BIRDS	THREATENED AND ENDANGERED SPECIES POTENTIALLY PRESENT
Pinyon-Juniper Woodland	Approximately 12,770 ac (5,108 ha), 46.2 percent	6,200 to 6,900 ft (1,890 to 2,100 m)	12 to 16 in. (30 to 41 cm)	• One-seed juniper • Pinyon pine	• Wavy-leaved oak • Mountain mahogany • Chamisa • Yucca	• Blue grama • Galleta • Needle and thread	• Elk • Mule deer • Mountain lion • Bobcat • Coyote • Deer mouse	• Cassin's kingbird • Cliff swallow • Ash-throated flycatcher • Brown-headed cowbird	Yes
Juniper Savannah	Approximately 1,035 ac (414 ha), 3.7 percent	5,200 to 6,200 ft (1,585 to 1,890 m)	10 in. (25 cm)	• One-seeded juniper	• Big sagebrush • Perky sue • Yucca	• Blue grama • Side-oats grama • Indian rice grass • Black grama	• Elk • Mule deer • Mountain lion • Bobcat • Coyote • Ringtail	• Black-headed grosbeak • Rufous-sided towhee • Rock wren • Scrub jay	Yes

Nonvegetated: 2,432 acres (ac) (984 hectares [ha]), 8.8 percent
Water: 6 acres (2 hectares), 0 percent

[a] Although the spruce-fir forest and montane grassland vegetation zones do not occur within LANL boundaries, many of the region's watersheds originate from and are influenced by these communities.
[b] Spruce-fir forest and montane grassland share the same elevational band. Montane grasslands occur primarily on south-facing slopes.
Sources: Allen 1989, Jacobs 1989, Foxx and Tierney 1985, Travis 1992, Koch et al. 1997, BNM nd, NPS 1992, and NPS 1986

TABLE 4.5.1.1–4.—*Vegetation Zones—Disturbances and Current Ecological Conditions*

ECOSYSTEM CONDITIONS	MAJOR VEGETATION ZONES					
	SPRUCE-FIR FOREST	**MONTANE GRASSLAND**	**MIXED-CONIFER FOREST (INCLUDING ASPEN)**	**PONDEROSA-PINE FOREST**	**PINYON-JUNIPER WOODLAND**	**JUNIPER SAVANNAH**
Existing About 1850	• Greater number of corkbark fir • Fewer Engelmann spruce • Larger number of meadows on south-facing slopes and valleys • Intense fires occurred every 150 years • Diverse habitats and wildlife	• Zone was twice the size • Increased number of surface fires resulting in frequent tree thinning • Extensive summer range for elk • Diverse habitats and wildlife	• Existence of an open, old-growth forest (about 50 per ac [124 per ha]) with aspens and more grass and flowers • Low-intensity fires occurred about every 10 years • Diverse habitats and wildlife	• Open forests with lower tree density (about 40 per ac [99 per ha]) • Larger meadows with more grasses, shrubs, and flowers • Low-intensity surface fires occurred every 5 to 10 years • Diverse habitats and wildlife	• Open woodlands with low tree density and large grassy meadows • Low-intensity surface fires occurred every 15 to 40 years • Diverse habitats and wildlife	• Open woodlands with low tree density and large grassy meadows • Low-intensity surface fires occurred every 15 to 40 years
Human Disturbances	• Logging • Cattle and sheep grazing • Fire suppression • Land development • Increased recreational use • Elk overpopulation	• Cattle and sheep grazing • Fire suppression • Land development • Hunting • Increased recreational use	• Logging • Cattle and sheep grazing • Fire suppression • Land development • Hunting • Increased recreational use	• Logging • Cattle and sheep grazing • Fire suppression • Land development • Hunting • Increased recreational use	• Logging • Cattle and sheep grazing • Fire suppression • Land development • Hunting • Increased recreational use	• Logging • Cattle and sheep grazing • Fire suppression • Land development • Hunting • Increased recreational use
Natural Disturbances	• Climate variability • Flash flooding • Lightning-caused fires	• Climate variability • Flash flooding • Lightning resulting in fires • Insect outbreaks	• Climate variability • Flash flooding • Lightning resulting in fires • Insect outbreaks	• Climate variability • Flash flooding • Lightning resulting in fires • Insect outbreaks	• Climate variability • Flash flooding • Lightning resulting in fires • Insect outbreaks	• Climate variability • Flash flooding • Lightning resulting in fires • Insect outbreaks

TABLE 4.5.1.1–4.—*Vegetation Zones—Disturbances and Current Ecological Conditions*-Continued

ECOSYSTEM CONDITIONS	MAJOR VEGETATION ZONES					
	SPRUCE-FIR FOREST	MONTANE GRASSLAND	MIXED-CONIFER FOREST (INCLUDING ASPEN)	PONDEROSA-PINE FOREST	PINYON-JUNIPER WOODLAND	JUNIPER SAVANNAH
Current Condition Resulting from Ecological Disturbances	• Current condition more similar to previous than any other zone • Loss of old-growth forests and critical habitats • High-fuel loads • Shrinking meadows • Habitat fragmentation • Stressed habitats • Loss of grasslands • Higher soil erosion rates • Soil erosion and windthrow • Increased potential for fires • Death of trees and reduction of critical habitats	• Ingrowth of conifers, aspens, and woody shrubs are now the dominant species • On average, 55 percent reduction in grasslands size from 1920 to 1932 • High fuel loads and shrinking grasslands • Habitat fragmentation and altered wildlife use patterns • Species loss • Stressed habitats • Soil erosion and windthrow • Increased potential for fires • Death of trees and reduction of critical habitats	• Reduction of old-growth forests and critical habitats • Dense forests, smaller trees (up to about 5,000 per ac [12,350 per ha]), fewer aspen, more white fir and Douglas fir; grasses, shrubs, and flowers • Habitat fragmentation and altered wildlife use patterns • Species loss • Stressed habitats • Soil erosion and windthrow • Increased potential for fires • Death of trees and reduction of critical habitats	• Reduction of old-growth forests and critical habitats • Cessation of natural fires with dense forests with "dog hair thickets," 2,000 to 8,000 small-diameter trees per ac (4,940 to 19,750 per ha), little grass, shrubs, flowers; high fuel loads • Habitat fragmentation and altered wildlife use patterns • Species loss • Stressed habitats • Soil erosion and windthrow • Increased potential for fires • Death of trees and reduction of critical habitats	• Reduction of native grasses, loss of ground-cover vegetation • Cessation of natural fires resulting in high tree density expanding into former meadows • Habitat fragmentation and altered wildlife use patterns • Species loss • Stressed habitats • Soil erosion and windthrow • Increased potential for fires • Death of trees and reduction of critical habitats	• Reduction of native grasses, loss of ground-cover vegetation • Cessation of natural fire resulting in invasion of juniper trees and severe soil erosion • Habitat fragmentation and altered wildlife use patterns • Species loss • Stressed habitats • Canyons/Rio Grande sediment/ contaminant transport • Increased potential for fires • Death of trees and reduction of critical habitats

TABLE 4.5.1.1–4.—*Vegetation Zones—Disturbances and Current Ecological Conditions*-Continued

ECOSYSTEM CONDITIONS	MAJOR VEGETATION ZONES					
	SPRUCE-FIR FOREST	MONTANE GRASSLAND	MIXED-CONIFER FOREST (INCLUDING ASPEN)	PONDEROSA-PINE FOREST	PINYON-JUNIPER WOODLAND	JUNIPER SAVANNAH
Affected Management Jurisdictions	• Los Alamos County (LAC) • Santa Fe County • Santa Fe National Forest (SFNF) • Bandelier National Monument (BNM) • Pueblo of Santa Clara • Private lands	• SFNF • BNM • Pueblo of Santa Clara • Private lands	• DOE (LANL) • LAC • SFNF • BNM • Pueblo of Santa Clara • Private lands	• DOE (LANL) • LAC • SFNF • BNM • Pueblo of Santa Clara • Private lands	• DOE (LANL) • LAC • SFNF • BNM • Pueblos of Santa Clara, San Ildefonso, Cochiti, and Jemez • Private lands	• DOE (LANL) • LAC • SFNF • BNM • Pueblos of Santa Clara, San Ildefonso, Cochiti, and Jemez • Private lands

Sources: Allen 1989, Dunmire and Tierney 1995, Foxx and Tierney 1982, and Rothman nd

LANL boundaries, based on the presence of wetland vegetation (hydrophytes). The LANL survey determined that more than 95 percent of the identified wetlands are located in the Sandia, Mortandad, Pajarito, and Water Canyon watersheds (Bennett 1996). Wetland locations in the general area of LANL are shown on Figure 4.5.1.2–1.

Wetlands in the general LANL region provide habitat for reptiles, amphibians, and invertebrates (e.g., insects), and potentially contribute to the overall habitat requirements of the peregrine falcon, Mexican spotted owl, southwestern willow flycatcher, and spotted bat, all of which are federal- or state-listed species, or both. Wetlands also provide habitat, food, and water for many common species such as deer, elk, small mammals, and many migratory birds and bats. The majority of the wetlands in the LANL region are associated with canyon stream channels or are present on mountains or mesas as isolated meadows containing ponds or marshes, often in association with springs or seeps. Cochiti Lake and the area near the LANL Fenton Hill site (TA–57) support lake-associated wetlands. There are also some springs within White Rock Canyon.

Currently, about 13 acres (5 hectares) of wetlands within LANL boundaries are caused or enhanced by process effluent wastewater from 38 NPDES-permitted outfalls. These artificially created wetlands are afforded the same legal protection as wetlands that stem from natural sources. In 1996, the effluent from NPDES outfalls, both storm water and process water, contributed 108 million gallons (407 million liters) to wetlands within LANL boundaries (Garvey 1997). Nearly half of the NPDES outfalls at LANL are probable sources of drinking water for large mammals (Foxx and Edeskuty 1995). Data regarding the wetlands that occur within the LANL region are presented by watershed in Table 4.5.1.2–1. Information pertaining to wetlands in the general LANL area and their previous condition, current condition, and the human disturbances that have influenced and shaped them are presented in Table 4.5.1.2–2.

4.5.1.3 *Canyons*

The complex interactions of geology, water, climate, vegetation, and other living organisms are still carving the deep, vein-like canyon systems into the relatively soft Bandelier Tuff of the Pajarito Plateau. From their narrow, thickly forested beginnings on the flanks of the Jemez Mountains, to their confluence with the Rio Grande, major canyons are associated with the six major vegetation zones present in the LANL region. The plateau canyons range in depth from about 200 to 600 feet (60 to 180 meters). The steeply sloping, north-facing canyon walls and canyon bottoms are shadier and cooler and have higher levels of humidity and soil moisture than the often nearly vertical, south-facing canyon walls, which are sunnier, hotter, and more arid. These differences in slope, aspect, sunlight, temperature, and moisture cause a dramatic shift in major vegetation zones on canyon walls and in canyon bottoms beyond their typical range of elevation. This “canyon-effect” is responsible for the fingers of coniferous forest extending down regional canyons.

Canyons in this region reflect the effects of natural and human-caused disturbances on the surrounding environment. Data on the interactions of the disturbances within the region and some effects of these interactions on canyon ecosystems is presented in Table 4.5.1.3–1.

While the Rito de los Frijoles in BNM and the Rio Grande are the only truly perennial streams in the region, many canyon floors contain reaches of perennial surface water, such as the perennial streams draining LANL property from lower Pajarito and Ancho Canyons to the Rio Grande (Cross et al. 1996). Wetlands are common features of these isolated stretches of perennial water in the canyons where springs

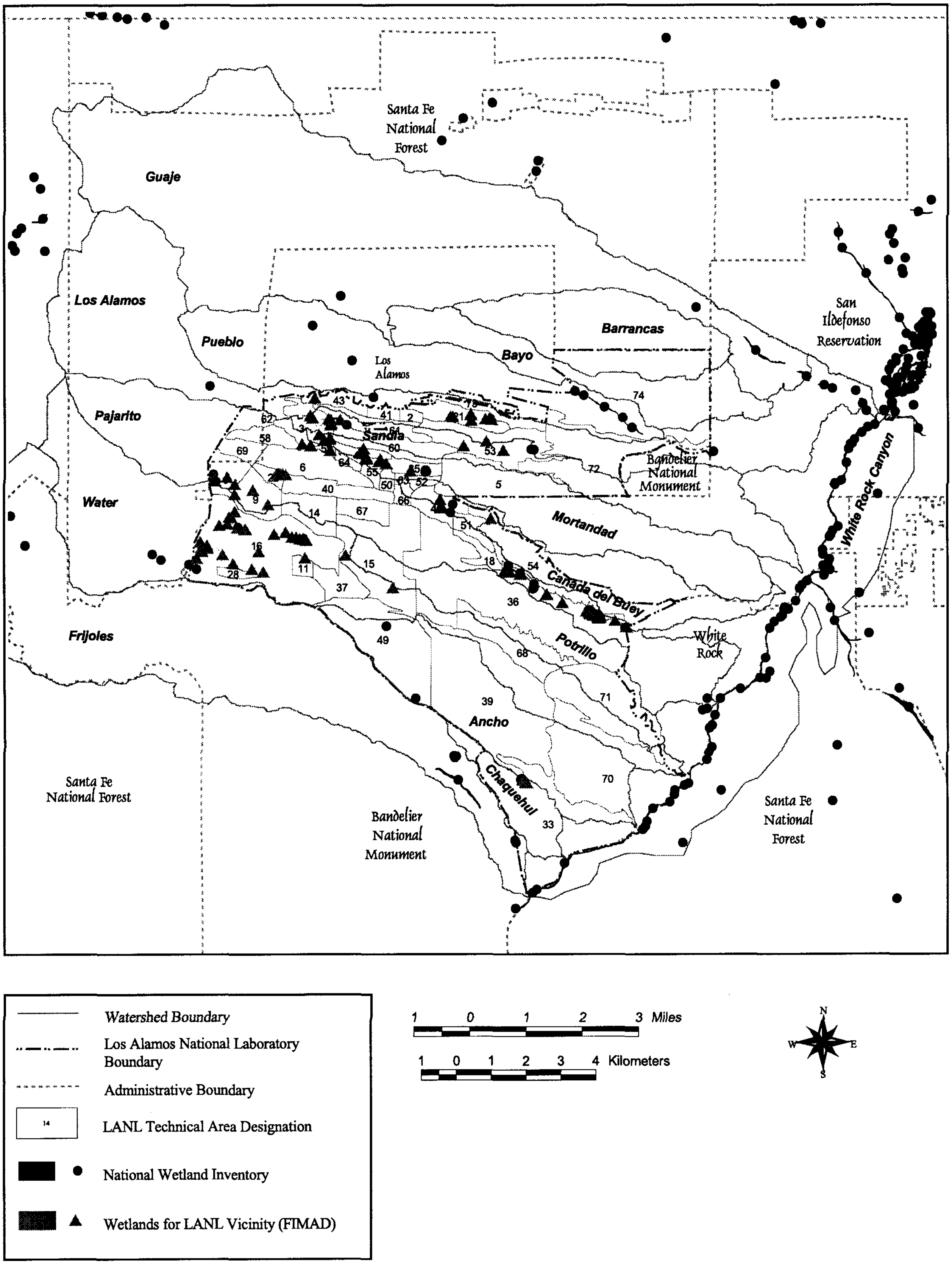


FIGURE 4.5.1.2–1.—*LANL Technical Areas and Watersheds with Wetland Locations.*

TABLE 4.5.1.2–1.—*Regional Watersheds and Wetlands in Association with Los Alamos National Laboratory Outfalls*

	WATERSHEDS WITHIN THE LANL REGION															
	GUAJE	BAR-RANCAS	BAYO	PUEBLO	LOS ALAMOS	SANDIA	MORTAN-DAD	CAÑADA DEL BUEY	PAJARITO	POTRILLO	WATER	ANCHO	CHAQUE-HUI	FRIJOLES	WHITE ROCK	TOTAL
Total watershed area	16,901	3,150	2,532	5,338	8,996	3,516	3,860	2,742	8,198	2,178	9,940	4,317	1,007	12,213		84,887
Watershed area[a] within LANL boundaries and percent of total watershed	0	742	1,020	999	2,186	1,588	1,249	1,122	4,667	2,029	5,881	4,316	864	132	1,016	27,810
	0	24%	40%	19%	24%	45%	32%	41%	57%	93%	59%	100%	86%	1%	0	
Total area of wetlands within watershed	16	0	0	.82	15	7	4	.01	30	0	10	0	.18	37		120
Wetlands area within LANL boundaries	0	0	0	0	.64	7	4	.01	29	0	9	0	.18	0	0	50
Total number of LANL outfalls	7	0	0	1	12	11	12	3	17	0	21	2	1	0	0	87
Number of LANL outfalls supporting wetlands	0	0	0	0	4	3	10	1	5	0	14	0	1	0	0	38
Estimated total flow from LANL outfalls (MGY)	1	0	0	1	20	108	53	6	9	0	30	0	6	0	0	233
LANL outfall flow supporting wetlands (MGY)	0	0	0	0	6.4	13	44	5.3	7.1	0	27	0	5.8	0	0	108
Percentage of LANL outfall flow supporting wetlands	0	0	0	0	32%	12%	83%	83%	77%	0	90%	0	100%	0	0	46%
Area of wetlands supported by outfalls	0	0	0	0	0.21	0.06	3.6	0.01	0.27	0	8.9	0	0.01	0	0	13
Dominant wetland vegetation	NA	NA	NA	NA	Cattails (Typha spp.)	Cattails (Typha spp.)	Cattails (Typha spp.)	Willows (Salix spp.)	Rushes & Sedges (Carex & Juncus spp.)	5	Cattails (Typha spp.)	NA	Cattails (Typha spp.)	NA	NA	—

[a] Area is presented in acres. Hectares = acres 0.405.
[b] Outfalls include NPDES-permitted outfalls.
[c] Flow is shown in million gallons per year (MGY). Liters = gallons 3.785
Sources: LANL ESH-20, National Wetlands Inventory database; Garvey 1997; National Wetlands Inventory; FIMAD (LANL 1996h); GRAM Team Geographic Information System
NA = Not applicable

TABLE 4.5.1.2–2.—*Wetlands—Disturbance and Current Ecological Conditions*

PREVIOUS CONDITION (ABOUT 1850)	HUMAN DISTURBANCES	CURRENT CONDITION RESULTING FROM HUMAN DISTURBANCES	AFFECTED MANAGEMENT JURISDICTIONS
• More streamside wetlands • Fewer mesa top wetlands	• Grazing by cattle and sheep • Fire suppression • Land development (e.g., roads, buildings) • NPDES outfall effluents • Contamination • Dams • Introduction of exotic plants and resulting reduction of native plants • Agriculture	• Destruction of wetlands by cattle and sheep • Increased number of trees in region reducing surface water available for wetlands within the canyons • Diverting of water away from historic channels • Of 87 LANL NPDES outfalls, 38 support 13 acres (5.3 hectares) of wetlands • Presence of Cochiti Lake resulting in development of large wetlands in White Rock Canyon and in Santa Fe River arm of lake	• DOE/LANL • LAC • BNM • Santa Fe National Forest • Corps of Engineers • Pueblo of Santa Clara • Pueblo of San Ildefonso • Pueblo of Cochiti • Pueblo of Jemez • Private lands

Sources: Allen 1989, Jacobs 1989, Durkin et al. 1995, Crawford et al. 1993, and Hink and Ohmart 1984

TABLE 4.5.1.3–1.—*Canyons—Disturbance and Current Ecological Conditions*

PREVIOUS CONDITION (ABOUT 1850)	HUMAN AND NATURAL DISTURBANCES	CURRENT CONDITION RESULTING FROM HUMAN AND NATURAL DISTURBANCES	AFFECTED MANAGEMENT JURISDICTIONS
• Lower tree density • Natural stream flow • Surface fires every 7 to 19 years • Floristically diverse vegetation in canyon mouth deltas near the Rio Grande (cottonwoods, willows, junipers, ponderosa pines) • Diverse aquatic and terrestrial habitats and wildlife	**Human** • Grazing by cattle and sheep and farming in canyon bottoms • Fire suppression • Land development (e.g., roads, buildings) • Increased recreational use • Contamination • Flood control in White Rock Canyon **Natural** • Climate variability • Flash floods • Lightning-caused fires • Occasional landslides	• Increased tree density in canyon bottoms • Ingrowth of nonnative trees • Increased tree density and decrease in habitat richness • Alteration of surface water flow and reduction of size of habitats • Increased stress on habitats and wildlife • Drought resulting in soil erosion and increased availability of sediments and concentrated wildlife use of canyons • Soil erosion, sedimentation of stream channels, and reduction of grasses • Large-scale fires • Soil erosion and altered stream flow	• DOE/LANL • LAC • BNM • Santa Fe National Forest • Pueblo of Santa Clara • Pueblo of San Ildefonso • Pueblo of Cochiti • Pueblo of Jemez • Private lands • Corps of Engineers

Sources: Allen 1989, Durkin et al. 1995, and Promislow and Fettig 1996 and seeps return groundwater to the surface throughout the year. As stated, many wetlands are caused or enhanced by process effluent water from 38 NPDES-permitted outfalls. Surface water flow occurs in canyon bottoms seasonally, or intermittently, as a result of spring snowmelt and summer rain. A few, short sections of riparian vegetation of cottonwood and willow and other water-loving plants are present in scattered locations on LANL as well as along the Rio Grande in White Rock Canyon. The relatively abundant moisture concentrated between the temperature moderating canyon walls allows a diverse array of plant and animal species to exist in these canyons at elevations that exceed the normal upper and lower elevational limits for these species.

Wildlife is abundant and diverse in the canyons. The canyons contain a more complex mix of habitats than the adjacent mesa tops and provide nest and den sites, food, water, and travel corridors. Mammals and birds are especially evident in these environments. Large mammals, such as black bears (*Ursus americanus*), mountain lions (*Felis concolor*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), raccoons (*Procyon lotor*), elk (*Cervus elaphus nelsoni*), and mule deer (*Odocoileus hemionus*) are known to use some portion of nearly all regional canyons.

Regional canyon systems also are essential to a variety of state-protected and federally protected species. The north-facing slopes of these canyons provide habitat for isolated populations of rare species, like the state-endangered yellow lady slipper orchid (*Cypripedium calceolus L.* var. *pubescens (Willd.) Correll)* as well as the Jemez Mountains salamander (*Plethodon neomexicanus*), a federal species of concern and state-threatened species (section 4.5.2). Mexican spotted owls (*Strix occidentalis lucida*) and American peregrine falcons (*Falco pereginus anatum*) are known to nest in the canyons of the region, and bald eagles (*Haliaeetus leucocephalus*) roost in canyon mouths along the Rio Grande during the winter. The southwestern willow flycatcher (*Empidonax traillii extimus*) is a likely migrant. Numerous bat species, including nine federal species of concern, use canyons in this region for roosting, breeding, and foraging.

4.5.1.4 *Rio Grande*

The watersheds draining the Jemez Mountains and the Pajarito Plateau are tributary to the Rio Grande, the fifth largest watershed in North America (Durkin et al. 1995). Approximately 11 miles (18 kilometers) of LANL's eastern boundary border on the rim of White Rock Canyon or descend to the Rio Grande. The riverine, lake, and canyon environment of the Rio Grande as it flows through White Rock Canyon makes a major contribution to the biological resources and significantly influences ecological processes of the LANL region.

The Rio Grande, like most rivers in North America, has been significantly altered throughout much of its length. The collective actions of humans, particularly since about 1850, have significantly altered, and continue to alter, its hydrogeologic regime and plant and animal communities as a consequence of water storage and flood control facilities, irrigated agriculture, watershed degradation, drainage, floodplain development, fragmentation, and the introduction of nonnative plants and animals. These consequences are particularly evident south of LANL in the middle Rio Grande Valley. The relatively recent construction of Cochiti Dam at the mouth of White Rock Canyon for flood and sediment control, recreation, and fish and wildlife purposes, has contributed to these changes and has significantly changed the features of White Rock Canyon and introduced new ecological components and processes. Water storage, particularly high floodwater storage during 1979 and 1985 to 1987, inundated riparian vegetation dominated by one-seeded juniper

(*Juniperus monosperma* Engelm. *Sarg.*) and isolated individuals and small stands of cottonwood (*Populus fremontii* var. *Wislizenii Wats.)*, willow (*Salix* spp.), boxelder (*Acer negundo L.*), and ponderosa pine (*Pinus ponderosa* Laws. var. *Scopulorum* Engelm.), and associated understory vegetation. Some of the denser concentrations of riparian vegetation were located at the mouths of tributary canyons. Sediment deposited along the banks of the river has been colonized by nonnative plants such as salt cedar (*Tamarix pentandra Pall.*), Russian olive (*Eleagnus angustifolia L.)*, and mullein (*Verbascum thapsus L.*).

Water storage in Cochiti Lake has greatly expanded aquatic communities and has fostered the development of two large wetlands, one on the Santa Fe River arm of the lake and the other at the expanding delta at the head of Cochiti Lake. The presence of these aquatic features has benefited a wide diversity of wildlife, including waterfowl, shorebirds, and threatened and endangered species such as the bald eagle and the peregrine falcon.

Summary information pertaining to the past and present conditions of the Rio Grande is presented in Table 4.5.1.4–1. This table generally focuses on the Rio Grande above Cochiti Dam.

4.5.1.5 *Protected and Sensitive Species*

The presence and use of LANL by protected and sensitive species is influenced not only by the actual presence and operation of the facility, but by management of contiguous lands and resources, and, importantly, by 150 years of human use.

TABLE 4.5.1.4–1.—*Rio Grande Disturbance and Current Ecological Conditions*

PREVIOUS CONDITION	HUMAN AND NATURAL DISTURBANCES	CURRENT CONDITION RESULTING FROM ECOLOGICAL DISTURBANCES	AFFECTED MANAGEMENT JURISDICTIONS
• Natural flow regime with spring floods of limited depth and duration • Several springs along lower canyon walls • Deeper channel through most of White Rock Canyon, numerous rapids • Streamside vegetation (cottonwoods, willows, junipers, grasslands) • Natural fire cycle • Diverse aquatic and terrestrial habitats and wildlife	**Human** • Dams and other structures for irrigation, flood and sediment control • Extensive upstream and downstream floodplain agriculture • Introduction of non-native plants and fish • Increased recreational use • Contamination **Natural** • Climate variability • Flash floods • Lightning-caused fires • Seasonal flooding	• Altered flow and flood regime, flood-kill of streamside and canyon mouth vegetation (cottonwoods, willows, junipers, ponderosa pines) • Expansion of habitat for threatened and endangered species • Sedimentation of channel and banks • Introduction of invasive nonnative plants and trees (e.g., salt cedar, Russian olive) • Reduction of native fish species • Transport of contaminants downstream of sources (e.g., fertilizers, LANL legacy contaminants) • Reduction of rapids • Creation of two large wetlands at Cochiti Lake that attract resident and migratory waterfowl and wintering bald eagles	• DOE/LANL • LAC • BNM • Santa Fe National Forest • Pueblo of Santa Clara • Pueblo of San Ildefonso • Pueblo of Cochiti • Private lands • Corps of Engineers

Sources: Allen 1989, Durkin et al. 1995, Jacobs 1989, and Promislow and Fettig 1996

A number of regionally protected and sensitive (rare or declining) species have been documented in the LANL region. These consist of 3 federally endangered species, 2 federally threatened species, and 18 species of concern (species that may be of concern to FWS but do not receive recognition under the *Endangered Species Act,* and that FWS encourages agencies to include in NEPA studies). Species listed as endangered, threatened, or rare or sensitive by the State of New Mexico are also included in this listing. The New Mexico "sensitive" taxa are those taxa that, in the opinion of a qualified New Mexico Department of Game and Fish (NMDGF) biologist, deserve special consideration in management and planning, and are not listed as threatened or endangered by the State of New Mexico. A summary of the available habitat and pertinent siting information for these species is presented in Table 4.5.1.5–1. DOE and LANL coordinate with the NMDGF and FWS to locate and conserve these species (LANL 1998c).

For the consultation procedures of the *Endangered Species Act of 1973* (42 U.S.C. §1531) and section 7(c) of the 1978 amendments, DOE has compiled information on five threatened and endangered species that are present, or potentially present, on LANL to assess possible effects that the proposed action, including the two project-specific proposals, would have on these species. None of these species have been found on or in the vicinity of Fenton Hill site (LANL 1995g). A biological assessment has been formally submitted to the FWS. The FWS provided comments on this biological assessment as part of its response to the draft SWEIS. These comments are being addressed and an amended biological assessment will be submitted to the FWS in continuation of the Section 7 consultation process.

Species Listed as Endangered or Threatened Under the *Endangered Species Act*

The species listed below utilize LANL as seasonal residents or during migration.

Endangered Species. American Peregrine Falcon (*Falco peregrinus anatum*). The peregrine falcon (state-listed as threatened) is a summer resident and migrant on the Pajarito Plateau. Peregrines do not nest within LANL boundaries but do nest on surrounding lands in the Jemez Mountains. Both adult and immature birds have been observed foraging on LANL, with the entire site providing suitable foraging habitat (LANL 1998c). The preferred prey of peregrine falcons includes doves, pigeons, and waterfowl, all captured in flight. Peregrine falcons also use the Rio Grande corridor during migration.

The southwestern willow flycatcher (*Empidonax traillii extimus*) (state-listed as endangered) occurs in riparian habitats along rivers, streams, or other wetlands, where dense growths of willows (*Salix* and *Baccharis* sp.), arrowweed (*Pluchea* sp.), tamarisk (*Tamarix* sp.), or other plants are present, often with a scattered overstory of cottonwood (*Populus* sp.). A possible migrant southwestern willow flycatcher was located on LANL during May 1997. Potential suitable nesting habitat is present on LANL but, in general, is limited. Southwestern willow flycatchers have been observed at higher elevations in the Jemez Mountains west of LANL and at lower elevations along the Rio Grande in the vicinity of Española.

Whooping cranes (*Grus americana*) in New Mexico (state-listed as endangered) are part of an experimental "cross-fostering" population that was established at Grays Lake National Wildlife Refuge, Idaho, in 1975. These birds migrate southward to winter in New Mexico in the autumn, and most winter in the middle Rio Grande Valley. Here, whooping cranes occupy the same habitats as their foster-parent sandhill

TABLE 4.5.1.5–1.—*Protected and Sensitive Species*

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
ANIMAL SPECIES				
American Peregrine Falcon (*Falco peregrinus anatum*)	Endangered	Threatened	• Uses the juniper savannah, pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Requires cliffs for nesting	• Forages on LANL. Nests and forages on adjacent lands.
Whooping Crane (*Grus americana*)	Endangered	Endangered	• Requires rivers and marshes • Roosts on sand bars	• Migratory visitor along the Rio Grande and Cochiti Lake
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Endangered	Endangered	• Requires riparian areas and vegetation • Requires dense riparian vegetation	• Potential presence on LANL and White Rock Canyon • Potential nesting area on LANL • Present in Jemez Mountains • Present in riparian zone near Española
Bald Eagle (*Haliaeetus leucocephalus*)	Threatened	Threatened	• Rivers and lakes	• Observed as a migratory and winter resident along the Rio Grande and on adjacent LANL lands
Mexican Spotted Owl (*Strix occidentalis lucida*)	Threatened	Sensitive (informal)	• Mixed conifer, ponderosa pine • Prefers tall, old-growth forest in canyons and moist areas for breeding • Forages in forests, woodlands, and rocky areas	• Breeding resident on LANL, LAC, BNM, and Santa Fe National Forest (SFNF) lands • Critical habitat designated on SFNF lands
Jemez Mountain Salamander (*Plethodon neomexicanus*)	Species of Concern	Threatened	• Uses the mixed-conifer forest vegetation zone • Requires north-facing, moist slopes	• Permanent resident on LANL, LAC, BNM, and SFNF lands
Baird's Sparrow (*Ammodramus bairdii*)	Species of Concern	Threatened	• Uses the pinyon-juniper woodland, ponderosa pine forest and mixed-conifer forest vegetation zones	• Observed on SFNF lands

TABLE 4.5.1.5–1.—*Protected and Sensitive Species*-Continued

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
Spotted Bat (*Euderma maculatum*)	Species of Concern	Threatened	• Uses the pinyon-juniper woodland, ponderosa pine forest, and spruce-fir forest vegetation zones • Requires riparian areas • Roosts in cliffs near water	• Permanent resident on BNM and SFNF lands • Seasonal resident on LANL
New Mexico Jumping Mouse (*Zapus hudsonius luteus*)	Species of Concern	Threatened	• Uses the mixed-conifer and spruce-fir forest vegetation zones • Requires riparian areas • Requires water nearby	• Permanent resident on LAC and SFNF lands • Overwinters by hibernating
Flathead Chub (*Platygobio gracilis*)	Species of Concern	Unlisted	• Requires access to perennial rivers	• Permanent resident of the Rio Grande between Española and the Cochiti Reservoir
Ferruginous Hawk (*Buteo regalis*)	Species of Concern	Unlisted	• Uses the juniper savannah and pinyon-juniper woodlands vegetation zones	• Observed as a breeding resident on LAC, LANL, BNM, and SFNF lands
Northern Goshawk (*Accipiter gentilis*)	Species of Concern	Sensitive (informal)	• Uses the mixed-conifer, ponderosa pine, spruce-fir forest vegetation zones	• Observed as a breeding resident on LAC, LANL, BNM, and SFNF lands
White-Faced Ibis (*Plegadis chihi*)	Species of Concern	Unlisted	• Requires perennial rivers and marshes	• Summer resident and migratory visitor on the Rio Grande and SFNF lands
Loggerhead Shrike (*Lanius ludovicianus*)	Species of Concern	Unlisted	• Uses the juniper savannah, pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones	• Observed on LAC, BNM, and SFNF lands
Big Free-Tailed Bat (*Nyctinomops macrotis*)	Species of Concern	Sensitive (informal)	• Uses the juniper savannah, pinyon-juniper woodland, and ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts on cliffs	• Migratory visitor on LAC, BNM, and SFNF lands
Fringed Myotis (*Myotis thysanodes*)	Species of Concern	Sensitive (informal)	• Uses the juniper savannah, pinyon juniper woodland, ponderosa pine forest vegetation zones • Roosts in caves and buildings	• Observed on LANL, BNM, and SFNF lands

TABLE 4.5.1.5–1.—*Protected and Sensitive Species*-Continued

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
Long-Eared Myotis (*Myotis evotis*)	Species of Concern	Sensitive (informal)	• Uses the ponderosa pine forest, mixed-conifer, and spruce-fir forests vegetation zones • Roosts in dead ponderosa pine trees	• Summer resident on LANL, BNM, and SFNF lands
Long-Legged Myotis (*Myotis volans*)	Species of Concern	Sensitive (informal)	• Uses the pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts in dead conifer trees	• Summer resident on LANL, LAC, BNM, and SFNF lands
Small-Footed Myotis (*Myotis ciliolabrum*)	Species of Concern	Sensitive (informal)	• Uses the juniper savannah, pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts in cliffs and caves	• Observed on LANL, BNM, and SFNF lands • Overwinters by hibernating
Yuma Myotis (*Myotis yumanensis*)	Species of Concern	Sensitive (informal)	• Uses the juniper savannah and pinyon-juniper woodland forest vegetation zones • Roosts in cliffs and caves near water	• Summer resident on LANL, LAC, and SFNF lands
Occult Little Brown Bat (*Myotis lucifugus occultus*)	Species of Concern	Sensitive (informal)	• Uses the pinyon-juniper woodland and ponderosa pine forest vegetation zones • Requires riparian areas • Forages over water	• Observed on SFNF lands
Pale Townsend's Big-Eared Bat *(Plecotus townsendii pallescens)*	Species of Concern	Sensitive (informal)	• Uses the pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts in caves	• Observed on LANL and BNM lands • Overwinters by hibernating
Goat Peak Pika (*Ochotona princeps nigrescens*)	Species of Concern	Sensitive (informal)	• Uses the mixed-conifer and spruce-fir forests vegetation zones • Requires boulder piles and rockslides	• Observed on LAC and BNM lands

TABLE 4.5.1.5–1.—*Protected and Sensitive Species*-Continued

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
Gray Vireo (*Vireo vicinior*)	Unlisted	Threatened	• Uses riparian areas in the juniper savannah and pinyon-juniper forests vegetation zones	• Observed on LAC, BNM, and SFNF lands
PLANT SPECIES				
Wood Lily (*Lilium philadelphicum L.* var. *andinum* (Nutt.) Ker)	Unlisted	Endangered	• Grows in the ponderosa pine forest, mixed-conifer, and spruce-fir forests vegetation zones • Requires riparian areas	• Observed on LAC, BNM, and SFNF lands
Yellow Lady's Slipper Orchid (*Cyprepedium calceolus L.* var. *Pubescens* (Willd.) Correll)	Unlisted	Endangered	• Requires riparian areas • Grows in the mixed-conifer forest vegetation zones • Requires moist soil	• Observed on BNM lands
Helleborine Orchid (*Epipactis gigantea* Dougl.)	Unlisted	Rare and sensitive	• Requires riparian areas • Grows in the juniper savannah and pinyon-juniper woodland forests vegetation zones • Requires springs, seeps, or other wet areas	• Observed on LAC lands

Note: This listing was developed with information and guidance provided by biologists from LANL; the FWS; the USFS; the NPS; the National Biological Service; the NMDGF; the New Mexico Energy, Minerals, and Natural Resources Department; and the New Mexico Natural Heritage Program, as well as consultations with independent consultants and reviews of the technical literature.

cranes. Foraging areas are generally agricultural fields and valley pastures, particularly where there is waste grain or sprouting crops. Both species of cranes roost together, typically on sand bars in the Rio Grande. The cross-fostering program was terminated in 1989 because the birds were not pairing and the mortality rate was too high to establish a self-sustaining population. Only three whooping cranes remain.

Three whooping cranes were led from Idaho to Bosque del Apache National Wildlife Refuge in New Mexico in 1997 as part of a research project to determine if captive-reared cranes can be taught to follow an ultralight aircraft along a migration route and, when released on a wintering area, will migrate north in spring to their natal area without human assistance. Survivors will be left in the wild.

The association of whooping cranes with LANL has been limited to overflights and possible occasional roosting (the latter on sandbars in White Rock Canyon). Limited night roosting at the Santa Fe River arm of Cochiti Lake has been observed during migration.

A proposal to designate the Rocky Mountain whooping cranes as "experimental nonessential" was published in the *Federal Register* (FR) in February 1996. A final ruling was published on July 21, 1997. For purposes of the Section 7(a)(2) consultation procedures under the *Endangered Species Act*, this designation will result in the treatment of the Rocky Mountain whooping cranes as a species proposed to be listed under Section 4 of the *Endangered Species Act*.

Threatened Species. Bald Eagle (*Haliaeetus leucocephalus*). In the general LANL area the bald eagle (state-listed as threatened) is a common late fall and late winter migrant and winter resident (November through March). The wintering bald eagle population in the general area has significantly increased since 1975 as a consequence of both the creation of nearby Cochiti Lake and a general increase in bald eagle populations. The Rio Grande in White Rock Canyon and connecting Cochiti Lake are focal use areas and are used by wintering bald eagles to forage for fish and waterfowl. Trees and rock cliffs that border the Rio Grande in White Rock Canyon are used as hunting and loafing perches, and canyons that dissect the Pajarito Plateau are used as night roosts. Bald eagles have been observed soaring over LANL, and some limited foraging for small mammals and carrion probably occurs over much of LANL. There is no evidence of historical or present nesting in the general region.

Critical Habitat

The specific areas within the geographic area occupied by a species on which are found those physical and biological features: (1) essential to the conservation of the species, (2) that may require special management considerations or protection, and (3) include specific areas outside the geographical area occupied by a species at the time it is listed, but are areas which are essential for the conservation of the species.

Mexican Spotted Owl (*Strix occidentalis lucida*). The Mexican spotted owl is a strictly nocturnal bird that prefers tall, old-growth forests in narrow, steep canyons where little light penetrates and cool temperatures and moist areas are present. Small mammals, especially wood rats, make up the bulk of the owl's diet. The Jemez Mountains, including areas within LANL and contiguous lands administered by the NPS, USFS, and the BLM provide habitat for the Mexican spotted owl. Nesting occurs on LANL as well as adjacent areas. Critical habitat has been designated on Santa Fe National Forest lands that are contiguous with LANL's western boundary.

4.5.1.6 *Management Plans*

There are two plans in progress or in the planning stage that are being developed for management of ecological resources and biodiversity at LANL. These plans consist of a Threatened and Endangered Species Habitat Management Plan and a Natural Resources Management Plan. Descriptions of these plans follows.

Threatened and Endangered Species Habitat Management Plan

The Record of Decision (ROD) for the *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement* (60 FR 53588) commits DOE to prepare a habitat management plan for federally listed endangered and threatened species within LANL boundaries. This plan has been completed and, in addition to federally listed species, also addresses species of concern and species listed by the State of New Mexico as threatened, endangered, and sensitive. Stated goals of the management plan are to: (1) develop a comprehensive management plan that protects undeveloped portions of LANL that are suitable, or potentially suitable habitat for threatened and endangered species, while allowing current operations to continue and future development to occur with a minimum of project or operational delays, or additional costs related to protecting species or their habitats; (2) facilitate DOE compliance with the *Endangered Species Act* and related federal regulations by protecting and aiding in the recovery of threatened and endangered species; and (3) promote good environmental stewardship by monitoring and managing threatened and endangered species and their habitats using sound scientific principles (LANL 1998c). This management plan is currently being reviewed by the FWS as part of the *Endangered Species Act*'s Section 7 consultation procedures.

Natural Resource Management Plan

A team has been established and is currently formulating a plan for development of a Natural Resource Management Plan. The purpose of natural resource management at LANL will be to determine conditions and to recommend management measures that will restore, sustain, and enhance the biological quality and ecosystem integrity at LANL within the context of a dynamic Pajarito Plateau ecosystem. The guiding principle of natural resource management will be to integrate the principles of ecosystem management into the critical missions of LANL to protect ecosystem processes and biodiversity. A Natural Resource Management Plan will provide policies, methods, and recommendations for long-term management of LANL facilities, infrastructure, and natural resources to ensure responsible stewardship of LANL resources that have been entrusted to DOE. Integral to natural resource management will be continuing guidance to operations managers with which to make management decisions based on a scientific understanding of the Pajarito Plateau ecosystem. The Threatened and Endangered Species Habitat Management Plan will be integrated into the Natural Resource Management Plan.

4.5.1.7 *Environmental Surveillance*

LANL's Environmental Surveillance and Compliance Program is described on page 4–1. As part of this program, biological studies are conducted at LANL on all major trophic levels. Contamination data analyzed under this program are also used for ecological risk assessments to evaluate the likelihood that adverse effects are occurring or may occur as a result of exposure to radioactive and nonradioactive materials. A qualitative discussion of ecological risk is presented later in this section as well as in chapter 5.

4.5.2 Biodiversity Considerations

Biodiversity is a new and more explicit expression of one of the fundamental concepts of ecology, popularly stated as "everything is connected to everything else" (CEQ 1993). Simply defined as "the variety of life and its processes," components of diversity consist of regional ecosystem diversity, local ecosystem or community diversity, and species diversity. The importance of biodiversity on local, regional, and global scales has been recognized in the U.S. by the Council on Environmental Quality (CEQ), resource management agencies, and the public. The heightened interest in biodiversity presents an opportunity to address environmental problems holistically, rather than the traditional and fragmentary species-by-species, stress-by-stress fashion (Noss 1990). "The biological world is not a series of unconnected elements, and the richness of the mix of elements and their connections are what maintains the system as a whole" (CEQ 1993).

Because knowledge of biodiversity as described above can be applied to improve decision-making in the areas of land use and resource management (Keystone 1991) and because it complements and informs the ecosystem approach, biodiversity considerations are an integral part of this impact analysis. For the purposes of this document, biodiversity considerations are intended to be synonymous with a healthy, functioning ecosystem.

The major human-caused disturbance factors identified by the CEQ (CEQ 1993) as responsible for the decline in biodiversity at multiple scales, including global, regional, and site-specific scales, are the following:

- Physical alteration of the landscape
- Over harvesting
- Disruption of natural processes, such as flooding and fires
- Introduction of nonnative (exotic) species
- Pollution
- Global climate change (which is considered outside the scope of this analysis) (CEQ 1993)

These human-caused disturbance factors provide a convenient framework for categorizing the causes of biodiversity loss, but these categories often overlap and are inevitably connected to each other in chains of ecological consequences.

The LANL regional area has also been affected by these major human-caused disturbance factors. Human occupation of the Jemez Mountains and the Pajarito Plateau (particularly since about the mid 19th Century) and accompanying disturbance actions, have worked in concert with one another and with natural disturbances to mold and continue to mold the environment in which LANL operates. These factors induce and perpetuate system-wide changes in the composition, structure, and function of plant and animal communities in all of the major vegetation zones.

As a consequence of historic and recent disturbances, several major issues affecting ecosystem sustainability and biodiversity currently confront DOE, LANL, and neighboring land administrators and owners such as the NPS, BNM, USFS, U.S. Army Corps of Engineers, and Native American Pueblos. The following discussions provide a summary of some issues of regional import and serve to describe ecosystem dynamics on a landscape scale and to illustrate the necessity of incorporating knowledge of these dynamics into the management and planning process.

4.5.2.1 *Physical Alteration of the Landscape*

Accelerated Soil Erosion

Historical overgrazing has been cited as the primary disturbance causing the continuing decline of local soils (Allen 1989 and

Rothman 1992). Extensive grazing by cattle and sheep in the pinyon-juniper woodland and juniper savanna vegetation zones has resulted in a decline in the fragile surface soils, which continues today (Allen 1989 and Potter 1977). Because of long-term restricted grazing on LANL, soil erosion is less of a concern than surrounding areas where continuing erosion represents an impediment to long-term stability and productivity.

Habitat Fragmentation

Fragmentation is the division of natural habitat areas into smaller segments or the destruction of animal access corridors between natural areas. It may reduce or enhance landscape productivity. Consideration of fragmentation is important in land use planning, because larger blocks of natural habitat are generally better for conserving biodiversity, and connected blocks of natural habitat are better than isolated ones. The edge to interior ratio of habitat patches is also an important consideration.

Developed areas, roads, and fenced areas either directly eliminate habitat, inhibit habitat use, or alter the dispersal and distribution patterns of wildlife, depending on the species being considered. Allen (Allen 1989) contrasts roadway development in the LANL regional area in 1935 with that present in 1989, demonstrating an appreciable increase in road expansion and accompanying habitat fragmentation. A comparison of disturbed (buffered to take into account the impact of features on their immediate surroundings) and nondisturbed areas within the 14 watersheds in which LANL is located demonstrated that of a total of 95,200 acres (38,080 hectares), 6,672 acres (2,669 hectares) have been disturbed. This represents about 7 percent of the land area analyzed. Most development is in pinyon-juniper woodland and ponderosa pine forest. Generally, many of the developed areas are concentrated in the flat lands formerly cleared for agricultural use, which has tended to limit fragmentation. However, there is some development in canyon areas, which has resulted in habitat loss and disturbance in areas with high biodiversity.

4.5.2.2 *Disruption of Natural Processes*

Natural processes can be disrupted even when many components of the ecosystem appear intact. Resource management activities may alter ecosystem dynamics through fire suppression, modification of surface water or groundwater flow, and alteration of predator-prey relationships (CEQ 1993). Natural fires helped to shape, structure, and sustain ecosystems throughout the Southwest (Allen et al. 1995). The tree-ring record for the Jemez Mountains reflects a virtual cessation of natural fire in about 1890. At higher elevations (i.e., the conifer forests, including ponderosa pine, mixed conifer, and spruce-fir forests), vigorous suppression of wildfire has had serious environmental consequences. In the absence of natural fires, ground-fuel loads and tree density have increased to high levels, favoring large-scale, high-intensity crown fires such as the 1954, 1977, and 1996 fires that occurred on or near LANL. Fires of this magnitude are recent phenomena.

DOE and LANL are members of the Los Alamos Wildfire Cooperators, an organization with representatives for the Santa Fe National Forest, American Red Cross, Cooperative Extension Service, LAC, BNM, and New Mexico Forestry Division. The goals of this organization are to develop a cooperative urban interface plan and to develop wildfire protection requirements for LAC. In response to the Dome Fire of 1996, an Interim Fire Management Team was formed with representatives from the DOE Los Alamos Area Office, Santa Fe National Forest, Los Alamos Fire Department, NMED, BNM, and LANL (PC 1996p). This team, drawing on regional expertise in fire management, is planning ways to reduce LANL's vulnerability to catastrophic wildfires.

The chair of this team has stated that wildfire is the number one threat to LANL (LAM 1996b).

4.5.2.3 *Overharvesting*

In addition to habitat loss and modification, physical alteration is linked to the disruption of natural wildlife patterns and processes and ensuing loss of biodiversity throughout the region. One increasingly troublesome result is the imbalance in the regional elk population. The current "elk problem" is due to excess numbers, which seems to suggest under harvesting. Although this is another example of an ecological cascade involving multiple disturbance regimes and intertwined ecological processes, the origins of the problem are grounded in the over harvest of multiple species.

The native population of Rocky Mountain elk was eliminated from the entire State of New Mexico by 1909. The current elk herds developed from 86 elk reintroduced into the Jemez Mountains in 1948 and 1964 through 1965. Since the 1970's, local elk populations have exhibited high growth rates (USFS 1996), and current estimates of herd size indicate that over 10,000 elk now inhabit the Jemez Mountains and the Pajarito Plateau (Allen 1994). A lack of predators such as the gray wolf (*Canis lupus*) and mountain lions has contributed to the abundance of the reintroduced herds. Hunting is not allowed within LANL nor in BNM, allowing them to be elk refuges.

The 1977 La Mesa Fire created about 15,000 acres (6,000 hectares) of grassy winter habitat adjacent to and extending into LANL property. Elk are expanding their range into lower elevation foraging areas and are using these areas throughout the year rather than migrating to summer pasture at higher elevations (USFS 1996). Existing information is inadequate to predict how elk numbers and distribution will respond to landscape changes resulting from the 16,500-acre (6,678-hectare) Dome Fire of 1996. An interagency work group consisting of representatives from the Jemez and Española Ranger Districts of the Santa Fe National Forest, BNM, LAC, and the NMDGF has been formed for the exploration of the problems and potential solutions related to elk overpopulation.

4.5.2.4 *Introduction of Nonnative (Exotic) Species*

Nonnative species of plants and animals are emerging worldwide as one of the leading threats to native species, ecosystem processes, and biodiversity. The introduction of nonnative species can result in the elimination of native species thorough predation, competition, genetic modification, and disease transmission (CEQ 1993). The botanical inventory of BNM, which is a reasonable representation of LANL flora, lists 150 plants as nonnative. These exotics comprise about 17 percent of the approximately 900 species inventoried (PC 1996r). LANL is currently developing a database, derived from the report *Status of the Flora of the Los Alamos National Environmental Research Park, Checklist of Vascular Plants of the Pajarito Plateau and Jemez Mountains* (Foxx and Tierney 1985) for exotic species and their distribution. Some of the exotic plant species of concern to local resource managers and LANL biologists are salt cedar (*Pall.*), tree of heaven (*Ailanthus altissima (Mill.) Swingle*), cheatgrass (*Bromus tectorum L.*), and Russian thistle *(Salsola kali L.* var. *tenui Folia Tausch*). Salt cedar may be of most concern for the future. Salt cedar, as well as Russian olive, possess certain phenological and reproductive characteristics that differ from those of the common native riparian species that gives them advantages in colonization of certain types of disturbed sites or during certain times of the year. In addition, salt cedar consumes prodigious amounts of groundwater, exudes salt from leaf glands that inhibits the growth of other plants, and has lower species density and diversity (e.g., birds) than native cottonwood or willow forests. It is present on LANL and BNM and in the mouths of canyons in White Rock Canyon.

4.5.2.5 *Pollution*

Pollution impacts on ecosystems include direct lethal, sub-lethal, and reproductive effects (including those resulting from bioaccumulation) and degradation of habitat (CEQ 1993). Sub-lethal effects of environmental contamination may indirectly cause mortality at widely varying temporal scales and on widely varying levels of ecological organization. Possible mechanisms include immunological effects enhancing susceptibility to disease, alteration of nutrient cycles through effects on bioavailability or uptake mechanisms, metabolic effects, and behavior modification affecting ability to feed, hunt, avoid predation, or breed (Hodgson and Leve 1987). The contribution of pollutants to environmental media by LANL operations is due primarily to past practices. Long-term monitoring of soils, sediment, water, and air and biomonitoring have not demonstrated levels of contaminants that would pose a health risk, nor have there been obvious toxic effects observed. Potential for ecological risk is discussed in greater detail in the following section. There is no evidence that would indicate any contaminant levels that would pose a risk to recreational fishing in the Rio Grande and downstream of Cochiti Lake.

Studies that have been completed to date or that have sufficient progress so as to report preliminary conclusions generally conclude (based on current levels of understanding) a lack of biological harm or lack of alterations to ecological processes. These studies include Lusk 1998, Ford-Schmid 1996, UNM 1998, Ferenbaugh et al. 1998, Gallegos et al. 1997a, Gallegos et al. 1997b, Gonzales et al. 1997, Gonzales et al. 1998a, Gonzales et al. 1998b, Haarmann 1997, Haarmann 1998a, Haarmann 1998b, Hansen 1997, Fresquez et al. 1996a, Fresquez et al. 1996b, LANL 1997c, Fresquez et al. 1995a, Fresquez et al. 1995b, Fresquez et al. 1995c, and Brooks 1989. Species, communities, and other areas that have been studied or are being studied include bees, rock squirrel, mule deer, elk, bald eagle, southwestern willow flycatcher, aquatic benthic invertebrates, plant communities, and foodstuffs.

4.5.3 Ecological Risk Considerations

Risk to biological communities and associated ecological processes have been assessed qualitatively, utilizing LANL Environmental Surveillance and Compliance Program Reports on the distribution and concentration of contaminants and biomonitoring data, existing ecological risk assessments, and general and species-specific knowledge of the presence, biology, and behavioral characteristics of biotic resources. Although no adverse effects to plants and animals have been observed (recognizing the absence of intensive, long-term research regarding such potential effects) from chemical and radioactive materials and populations appear healthy and thriving, more quantitative ecological risk analysis will be undertaken as part of the ER Project.

4.5.3.1 *Background on Contamination at LANL*

The following are parameters that are considered in an ecological risk assessment. Portions of this section have been summarized from more detailed discussions earlier in this chapter.

Soils

As discussed in section 4.2.3.1, soils in and adjacent to LANL contain chemicals and radioactive materials, including those that are naturally occurring as well as those due to past

LANL activities and worldwide fallout. Most of the contamination of concern at LANL is what is sometimes referred to as legacy waste or legacy contamination. This is residual waste or contamination that is found at certain locations throughout LANL as a result of historical processes. These past processes or practices were associated with surface impoundments and disposal areas; experimental reactors; inactive firing sites; above-ground and underground storage tanks; PCB transformers; incinerators; chemical processing; shop machining that resulted in radioactive waste; and operations to develop, fabricate, and test explosives components for nuclear weapons. Other sources of radionuclides in soil may include natural minerals, atmospheric fallout from nuclear weapons testing, burn-up of nuclear-powered satellites, and planned or unplanned releases or radioactive gases, liquids, or solids. Naturally occurring uranium is present in relatively high concentrations in soil due to the regional geologic setting. Sources of plutonium include LANL operations and atmospheric fallout. Metals in soil may be naturally occurring or may result from LANL releases or both.

A rough estimate, based on information from LANL's database, FIMAD, which has areal estimates of their priority release sites, demonstrated that less than 3 percent of LANL's approximately 43 square miles (111 square kilometers) is of potential concern. The areal extent of this 3 percent does not include the canyons because they are not classified under the FIMAD database as PRSs. However, recent cleanup activities for the PRSs have resulted in a smaller spacial area of cleanup than originally estimated. The exact areal extent of PRSs has yet to be determined. As discussed in chapter 2, section 2.1.2.5, the ER Project was instituted to assess and remediate potentially contaminated sites resulting from historical treatment, storage, and disposal practices. ER activities include identification of potentially contaminated sites, characterization of sites, risk assessment, and restoration actions, where appropriate.

LANL on-site and perimeter soil samples are collected and analyzed for radiological and nonradiological constituents, and compared to regional (background) locations. Soils monitoring data (detection statistics) for organics, inorganics, and radiochemistry by watershed are presented in volume III, appendix C, Tables C–8 and C–9. The concentration of most radionuclides sampled and activity levels in soils collected from perimeter stations were not significantly different from those collected from regional background concentrations. While the levels of uranium, plutonium-238, and gross gamma activity were higher than background soils, they were below the LANL SALs that are used to identify the presence of contaminants of concern.

For 1995 on-site soil samples, only plutonium-239, plutonium-240 and total uranium were detected in significantly higher concentrations as compared to off-site background soils. However, these levels were still far below LANL SALs. In general, the higher concentration of radionuclides, particularly uranium and plutonium isotopes, in perimeter soils (as compared to background soils) may be due in part to LANL operations, but are mostly due to worldwide fallout and to naturally occurring radioactivity in geologic formations; whereas, higher radioactivity in soils from on-site areas may be due to worldwide fallout, natural radioactivity, and to LANL operations (Fresquez et al. 1995d).

Trend analyses show that most radionuclides and radioactivity, with the exceptions of plutonium-238 and gross alpha, in soils from on-site and perimeter areas have been decreasing over time. This trend is likely due to: (1) the cessation of widespread, aboveground nuclear weapons testing, (2) weathering, and (3) radioactive decay (Whicker and Schultz 1982).

Soils were also analyzed for trace and heavy metals, and most metals were well below LANL SALs (LANL 1996i and LANL 1997c). Only beryllium and lead, both products of firing site activities, exhibited any kind of trend; that is, both were consistently higher in perimeter and on-site soils than in background soils. Average concentrations of beryllium and lead in perimeter soils decreased during the 1992 to 1995 time period. Similarly, beryllium in on-site soils decreased during this period; however, lead increased slightly.

Surface Water

The analysis of surface water quality in section 4.3.1.5 indicates that historic activities and radiological releases have had an effect on surface water within LANL boundaries, particularly in Acid, Pueblo, Los Alamos, and Mortandad Canyons. Stated historical activities and operational releases that have contributed to contamination in these canyons include historic nuclear materials research, a former industrial liquid waste treatment plant at TA–21, discharges from the LANSCE sanitary sewage lagoon system, discharges from the RLWTF, and NPDES-permitted effluent discharges. Surface water monitoring data (detection statistics) by location (on-site, perimeter, and regional) and analyte are presented in volume III, appendix C, Tables C–2 and C–3.

In 1996, radiochemical analyses results for surface water samples were below DOE-DCGs for the public, and the majority of the result were near or below detection limits. None of the nonradiochemical measurements in water from areas receiving effluents exceeded standards except for some pH measurements above 8.5. Aluminum, iron, and manganese concentrations (including naturally occurring metals) exceeded EPA secondary drinking water standards at most locations. Selenium values exceeded the New Mexico Wildlife Habitat stream standard at numerous locations around LANL.

National Pollutant Discharge Elimination System Outfalls

Primary sources of potential impact to surface water consist of the NPDES outfalls. With few exceptions, outfall discharges comply with NPDES permit limits. Examples of materials that have been involved in NPDES exceedances include arsenic, chlorine, total suspended solids, cyanide, vanadium, copper, iron, oil and grease, silver, phosphorus, and radium. TA–50, the RLWTF, has continued to discharge residual radionuclides into Mortandad Canyon. LANL is working to continue to upgrade the treatment process to correct these problems. Nearly every on-site drainage has historically received liquid industrial or sanitary effluents that contribute to the flow and water quality characteristics. NPDES detection statistics by watershed, 1994 to 1996, are presented in appendix C, Table C–1.

Sediments

As with soils, sediment in the LANL region contain naturally occurring chemical and radionuclides, chemical and radionuclides resulting from historic uses, and very small amounts of radionuclides resulting from worldwide fallout from atmospheric testing of nuclear weapons and re-entry burn-up of satellites containing plutonium power sources. Sediment detection statistics by location (on-site, perimeter, and regional) and analyte, 1991 to 1996 are presented in appendix C, Tables C–4 and C–5. As discussed in section 4.3.1.4, there are no standards for radionuclides or metals in sediments. Therefore, regional comparison levels were developed for the purposes of the SWEIS.

Sediment from all individual LANL sampling locations exceeded the regional comparison value for at least one metal. Most of the metals that were above the regional comparison value occur naturally in the environment as a constituent of the sediments. In 1996, three samples in Mortandad Canyon were in excess of

LANL's SALs for cesium; however, no other radiochemical analyses of sediment in 1996 samples showed any values that exceeded respective SAL values. Levels of plutonium-239 and -240 in sediments in Acid, Pueblo, and Los Alamos Canyons were found to be above regional comparison levels and are believed to result from historic releases from LANL operations and worldwide fallout from atomic testing. However, these levels are very low and no environmental risk is associated with them (Ferenbaugh et al. 1994). A study that evaluated the deposition of plutonium in sediments in the northern portion of the Rio Grande estimated LANL contribution to the contamination (Graf 1993). The study found that, when averaged over several decades, 90 percent of the plutonium in the sediment moving into the northern Rio Grande system could be attributed to atmospheric fallout. The remaining 10 percent could be attributed to historic releases from LANL operations.

Sediment transport studies by LANL have shown that off-site transport of sediments with elevated plutonium-239 and -240 levels has taken place. Sediments collected from Cochiti Lake contained mean plutonium-239 and -240 levels higher than levels found in sediment from background monitoring stations at Abiquiu Reservoir and Embudo station. However, these low levels are very small as compared to area background, and again, there is no associated environmental risk.

Biomonitoring

Biomonitoring to measure the amounts of contaminants in plants and animals and their effects on biological systems and processes is being accomplished as a component of the Environmental Surveillance and Monitoring Program. A limited amount of biomonitoring data has been obtained for produce, fish, honey, milk, elk, mule deer, pinyon pine, shrubs, grasses, and forbs. In volume III, appendix D presents many of these "foodstuffs," analytes detected, and their concentrations. These biomonitoring data indicate no immediate environmental concerns.

4.5.3.2 *Ecological Risk Assessments Performed for Threatened and Endangered Species*

Three preliminary, quantitative assessments have been conducted of the potential risk from legacy waste to the Mexican spotted owl (Gallegos et al. 1997a), the American peregrine falcon (Gallegos et al. 1997b), and the bald eagle (Gonzales et al. 1998a). Updates to these preliminary assessments are reflected in the *Second Annual Review Update Preliminary Risk Assessment of Federally Listed Species at the Los Alamos National Laboratory* (Gonzales et al. 1997). The objectives of the risk assessments were to: (1) quantitatively appraise the potential for contaminants (organic, inorganic, and radionuclide) to impact threatened and endangered species in or around LANL and (2) identify where further assessment is required. Potential habitats were evaluated for these species. Each consisted of a predetermined potential nesting/roosting zone and a calculated foraging area. Estimated doses were compared against toxicity reference values (benchmarks to which estimated intake rates of chemicals can be compared to determine whether a risk may exist) to generate hazard indices (the ratio of the estimated exposure to the estimated safe exposure) that included a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals). Data used in these assessments included various subsets of ER watershed data that is presented in appendix C. These assessments concluded that, on the average, there is a small potential for impact to the peregrine falcon from contaminants at LANL, but no appreciable impact is expected to the spotted owl nor the bald eagle.

4.5.3.3 *Ecological Risk*

A qualitative assessment of ecological risk based on findings of the Environmental Surveillance and Compliance Program (as discussed above in section 4.5.3.2) and assessment of risk to selected threatened and endangered species (4.5.3.3) is that there is little potential for risk, and this is primarily due to legacy contamination. Recent operations have little potential for contributing to ecological risk, and with recent programs, actions, and plans to clean up legacy waste (i.e., the ER program, reduced sources of operational contaminants, and institution of management measures to protect and manage natural resources), the overall potential for risk decreases over time.

4.6 HUMAN HEALTH: WORKER AND PUBLIC HEALTH IN THE REGION AFFECTED BY LANL OPERATIONS

The following sections summarize historical and current information on public and worker health in and around LANL. The information is presented in three major topics: (1) public health including the radiation and chemical exposures from LANL operations and summaries of health studies conducted in the area; (2) LANL worker health including recent accidents/incidents, the history of worker health at LANL and the dosimetry, radiation protection, hygiene and safety programs implemented at LANL; and (3) a description of the emergency preparedness, management, and response programs implemented at LANL to protect the public and workers.

4.6.1 Public Health in the LANL Vicinity

4.6.1.1 *Radiation in the Environment Around LANL*

Major sources of background radiation exposure to individuals in the vicinity of LANL are shown in Figure 4.6.1.1–1. Background doses will be accrued regardless of LANL operations. In 1996, the total effective dose equivalent (TEDE) to residents was 360 millirem at Los Alamos and 340 millirem at White Rock from all natural sources. The individual components of the background dose for Los Alamos and White Rock and the average effective dose equivalent (EDE) of 53 millirem per year to members of the U.S. population from medical and dental uses of radiation (NCRP 1987) are listed in Table 4.6.1.1–1.

Releases of radionuclides to the environment from LANL operations provide another source

Understanding Human Health Studies
Useful Terms

Absorbed Dose*. The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).*

Collective Effective Dose Equivalent*. The product of the effective dose equivalent (rem) to those exposed and the number of persons in the exposed population. The units are in person-rem.*

Committed Dose Equivalent (CDE)*. The dose equivalent calculated to be received by an organ or tissue over a 50-year period after the intake of a radionuclide into the body.*

Committed Effective Dose Equivalent (CEDE). *The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.*

Deep Dose Equivalent*. The dose equivalent derived from external radiation at a depth of 1 centimeter in tissue.*

Dose*. A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, or total dose equivalent.*

Dose Conversion Factor*. A factor used to convert radionuclide intake to the resultant dose (rem).*

Dose Equivalent*. The product of the absorbed dose in rad (or gray) in tissue, a quality factor, and all other modifying factors at the location of interest. The units of dose equivalent are the rem and the sievert (1 rem = 0.01 sievert).*

Effective Dose Equivalent (EDE)*. The sum of the products of the dose equivalent received by specified tissues of the body and the appropriate weighting factor. It includes the dose from radiation sources internal and/or external to the body. Effective dose equivalent is expressed in terms of rem or sievert.*

Hazard Index (HI). *An indicator of potential toxicological hazard from exposure to a specific chemical (ratio of intake/exposure divided by the chemical-specific reference dose, as determined by EPA).*

Maximally Exposed Individual (MEI)*. A hypothetical person placed and remaining where the greatest exposure can occur, who takes no protective actions, and who behaves in such a manner as to get the maximum possible dose at that location.*

Reference Dose*. The estimate of daily exposure to humans that is likely to occur without deleterious effects during a portion or all of a lifetime.*

Rem. *The common unit of dose equivalent, CEDE or TEDE.*

Total Effective Dose Equivalent (TEDE)*. The sum of the effective dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposure). Deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures.*

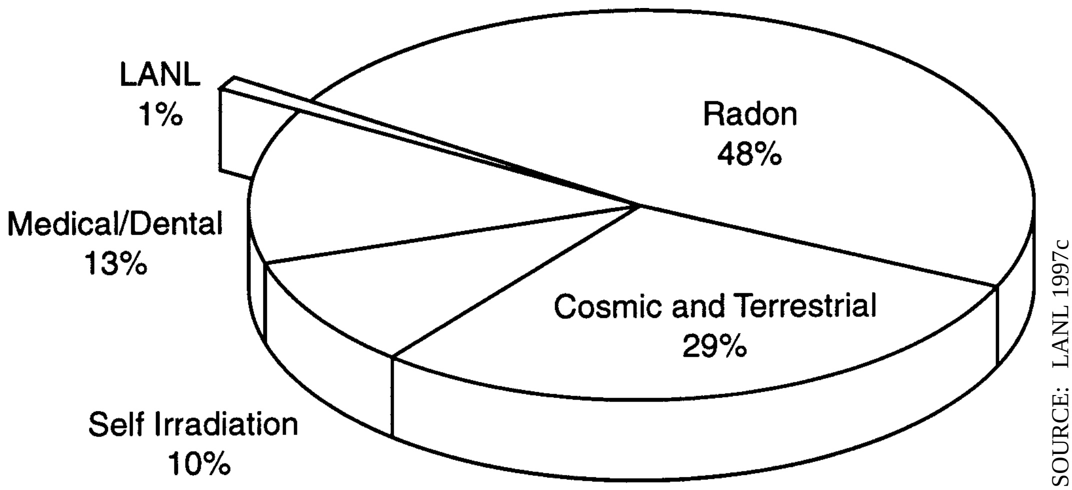


FIGURE 4.6.1.1–1.—*Total Contributions to 1996 Dose for LANL's Maximally Exposed Individual.*

TABLE 4.6.1.1–1.—*Total Effective Dose Equivalent (millirem/year) from Natural or Manmade Sources*

	LOS ALAMOS	WHITE ROCK
Radon	200	200
Self-Irradiation[a]	40	40
Total External[b] (cosmic and terrestrial)	120	100
Total Effective Background Dose	360	340
Medical and Dental	53	53

[a] Dose from radionuclides occurring naturally within the body, such as potassium-40.
[b] Includes correction for shielding.
Source: Adapted from LANL 1997c

of radiation exposure to individuals in the vicinity of LANL. Figure 4.6.1.1–2 summarizes LANL's contribution to dose by pathway for its hypothetical MEI (LANL 1997c).

The 1.93 millirem dose reported in the annual Environmental Surveillance and Compliance Report for 1996 (LANL 1997c) is similar to the following reported doses but is derived solely from an EPA-approved air transport model. The doses estimated below were based on actual measurements as well as transport modeling (CAP–88, an EPA-approved model for calculating collective public dose) (volume III, appendix B, section B.1.1.2 describes this model). Both methods of dose calculation are valid and are included here to provide a range for consideration.

Maximum Individual Dose—Off-Site Locations (1996)

The maximum EDE (or dose) was calculated at various locations to assess the maximum radiological impact from LANL to areas inhabited by the public. The East Gate area was found to be the location of the maximum off-site dose. This maximum EDE is the total dose from all potential routes of radiation exposure and is based on data gathered by both the Environmental Surveillance and Compliance Program and radiological effluent monitoring. The maximum dose, or the 95th percentile value, was 5.3 millirem, and the median value (50th percentile) for this estimate was 1.4 millirem (Table 4.6.1.1–2).

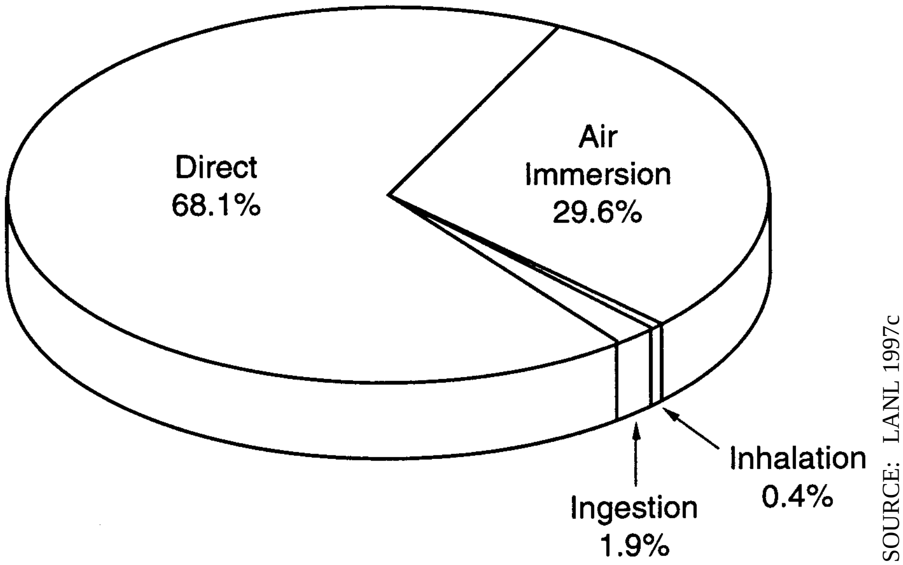


FIGURE 4.6.1.1–2.—*LANL's Contribution to Dose by Pathway for LANL's Maximally Exposed Individual.*

TABLE 4.6.1.1–2.—*Estimated Dose to Maximally Exposed Members of the Public from LANL Operations for 1996*

RECEPTOR	LOCATION	EDE (millirem/year) MEDIAN VALUE	EDE (millirem/year) 95TH PERCENTILE VALUE
Hypothetical Off-Site MEI	East Gate	1.4	5.3
Hypothetical On-Site MEI	Pajarito Road near TA–18	2.9	8.0

Source: LANL 1997c

Maximum Individual Dose—On-Site Locations (1996)

Potential doses that an individual who is not a LANL worker could have received while within the LANL boundary were calculated as 8.0 millirem for the maximum dose, or 95^{th} percentile value, and 2.9 millirem for the median dose, or 50^{th} percentile value. The location of the maximum potential exposure is a section of Pajarito Road near TA–18. The frequency and amount of time a member of the public may spend traveling this section of Pajarito Road, as well as the operational cycles of the TA–18 facility, were factored into the above dose calculations, which also used readings of external penetrating radiation measurements taken at TA–18 during the operation of criticality experiments. Potential doses to public members from TA–18 operations are limited using well-established principles of controlling exposure level, frequency, and duration. The section of Pajarito Road near TA–18 is closed during experiments when TA–18-generated doses to the public may exceed 1 millirem. For experiments involving lower dose levels, the road is controlled so that public members may pass by but not remain near TA–18. The 8.0 millirem maximum dose is a conservative estimate. An actual dose to an average public member who regularly commutes on Pajarito Road is estimated to be much lower.

External Radiation

The external penetrating radiation dose to Los Alamos and White Rock residents due to LANL operations in 1996 were estimated to be 0.2 millirem and 0.01 millirem, respectively. However, note the median EDE contribution estimated for a member of the public passing by on the road near TA–18 is 2.9 millirem for 1996 (see Table 4.6.1.1–2). In addition, one of the monitoring locations near TA–21 indicated a reading of 267±10 millirem in 1996. This value is consistent with values observed at this location in the past and is attributed to cesium-137 on the ground (due to past outfall effluents). Applying the occupancy factor for industrial settings of 0.01 (Robinson and Thomas 1991) to the annual exposure rate, the maximum (i.e., the 95th percentile value) external penetrating dose to an individual frequenting the access road north of TA–21 is estimated at 2.9 (2.67 + 0.2) millirem per year (LANL 1997c).

Inhalation

The net committed effective dose equivalent (CEDE) resulting from exposure, primarily through inhalation, to airborne emissions as measured by the LANL air monitoring network in 1996 for the town sites of Los Alamos and White Rock are 0.05 millirem and 0.04 millirem, respectively (LANL 1997c). These potential doses to the public are below the EPA standard of 10 millirem per year for airborne emissions (40 CFR 61.92).

Ingestion

Using the 1996 maximum consumption rate (LANL 1997c), the maximum difference between the total positive CEDE at sampling locations in the Los Alamos area and the regional background locations for each food group is as follows: fruits and vegetables, 0.77 millirem; milk, 0.083 millirem; honey, 0.036 millirem; eggs, 0.12 millirem; fish (bottom feeders), 0.083 millirem; fish (higher level feeders), 0.03 millirem; elk muscle, 0.011 millirem; elk bone, 1.4 millirem; deer muscle, 0.013 millirem; deer bone, 1.1 millirem; and tea, 0.24 millirem. Assuming one individual consumed the total quantity for each food group (except bone tissue), the total net positive difference for the CEDE in 1996 was 1.7 millirem.

The environmental surveillance data used in the analysis presented in chapter 5 for human health consequence analysis via ingestion are found in volume III, appendix C and appendix D, section D.3.5.

4.6.1.2 *Chemicals in the Environment Around LANL*

Environmental media and foodstuffs have been selectively analyzed for chemical contaminants since the early 1990's. Appendix C presents summaries of the numbers of analyses, numbers of samples with detectable concentrations, and average and 95th percentile concentrations of these chemicals. For those chemicals in the surveillance program, there are no significant differences in concentrations between media at the perimeter of the site and those of the general region (see appendix D, section D.3.4). In fish, concentrations of some metals are higher upgradient from LANL than downgradient (LANL 1997c).

Appendix C also contains summaries of contaminated site concentrations of inorganic and organic chemicals. These on-site data were developed to characterize the contaminated sites in order to determine whether remediation was needed. These media are not significant contributors to public exposures by any exposure pathways under the current circumstances.

Ingestion

Appendix D, section D.3.3 contains detailed analysis of ingestion risks to the hypothetical resident, recreational, and special pathways receptors. The risk of ingestion of metals by the public is expected to remain the same or be reduced by continued dilution and dispersion in the environment. The risk due to ingestion is believed to be that posed by ingestion in the general region of LANL and to be less than 1×10^{-6} excess latent cancer fatalities (LCFs) across all chemicals contributing to ingestion risk. Arsenic and beryllium may be regional ingestion risks. (That is, the background levels of these chemicals in the region may pose an incremental risk to human health.) The contribution to ingestion risk by current LANL operations is believed to be negligible. The beryllium and arsenic ingestion in the region of LANL is conservatively estimated (based on 95^{th} percentile) in appendix D and is highly uncertain (appendix D, section D.3.4)

Inhalation

Chemical emissions are sufficiently small from LANL operations so that they are not routinely measured. Emissions from high explosives (HE) testing are periodically monitored and included in the annual environmental surveillance reports (for example, for 1996, LANL 1997c, Table 4-13). In volume III, appendix B describes a series of screening steps used to identify chemical emissions (toxic and carcinogenic) of concern for the purpose of impact analysis for the operational alternatives. These screening steps also supply information related to potential impacts from current emissions and likely emissions from the recent past, since 1990 and 1995 chemical inventory and purchase information were used in the initial screening steps to identify chemicals of concern. No recent chemical usage was found to result in emissions of significance from the standpoint of potential human health effects.

4.6.1.3 *Cancer Incidence and Mortality in the Los Alamos Region*

During public scoping, a review of the current understanding of cancer incidence and mortality in the Los Alamos area was requested for inclusion in this SWEIS. DOE provided funding to the New Mexico Department of Health to conduct a study in response to citizen concerns about brain cancer in the area near LANL.

Detailed discussion of these studies and recent National Institutes of Health/National Cancer Institute studies under the Surveillance, Epidemiology and End Results (SEER) Program are presented in appendix D, section D.1.2. The SEER results, which provide a basis for comparison with the Los Alamos County studies, include a study population of New Mexico Native Americans. Rates of cancer mortality among white Hispanics (nationwide), white nonhispanics (nationwide), and New Mexican Native Americans are presented in appendix D, section D.1.2.3.

Los Alamos Cancer Rate Study

The Los Alamos Cancer Rate Study (Athas and Key 1993) was a study of cancer incidence among populations residing near LANL. The study was conducted in response to community concerns about an alleged recent large excess occurrence of brain cancer in Los Alamos County, particularly among residents of the Western Area neighborhood. Results presented in the report comprise the major findings of a descriptive epidemiologic study of cancer incidence in Los Alamos County for the time period 1970 through 1990. Incidence rates per 100,000 people for brain and nervous system cancer and 22 other major cancers were calculated for Los Alamos County using data of the population-based New Mexico Tumor Registry. The county rates were then compared to rates derived from a New Mexico reference population and a national reference population as represented by the National Cancer Institute's SEER Program (summary by county for all cancers, both sexes, incidence 1983 to 1987 and 1988 to 1991, Table 4.6.1.3–1).

Results of the incidence study showed that Los Alamos County experienced a 70 to 80 percent excess of brain cancer as compared with the New Mexico reference population and national statistics. The incidence of brain and nervous system cancer within different neighborhoods of Los Alamos County was examined by comparing incidence rates calculated for the five census tracts situated in the county. For the 11-year period from 1980 to 1991, all census tract rates were higher than the New Mexico reference rate. The highest incidence occurred in the census tract that corresponds to the Western Area neighborhood; however, there were only three cases, and they were confined to the 2-year period of 1986 to 1987. Additional descriptive studies showed that the brain cancer rates for Los Alamos County were within the rates observed across New Mexico counties from 1983 to 1986 and 1988 to 1991. A review of mortality statistics for benign or unspecified neoplasms of the brain and nervous system showed no deaths from these causes in Western Area residents during 1984 to 1990.

A review of incidence rates for 22 other major cancers and childhood cancers showed that the incidence of some cancers in Los Alamos County was greater than that observed in the reference populations, while the incidence of other cancers was lower than or comparable to that observed in the reference populations. Cancers with incidence rates consistently elevated in Los Alamos County during 1970 to 1990 included melanoma of the skin, prostate cancer, non-Hodgkin's lymphoma, ovarian cancer, and female breast cancer. Leukemia and major cancers of the respiratory and digestive systems occurred at or below the incidence levels observed in the reference populations. Several cancers showed distinct temporal patterns of increasing incidence. Most notable was the marked increase in thyroid cancer incidence observed in the mid 1980's. Thyroid cancer incidence in Los Alamos County during 1986 to 1990 was nearly four times higher than that observed in the New Mexico reference population. Based on the findings of the study, a study of the elevated thyroid cancer incidence in Los Alamos County was made (Athas 1996).

Investigation of Excess Cancer Incidence in Los Alamos County

The investigation was limited to a review of all causes of thyroid cancer diagnosed among Los Alamos County residents between 1970 and 1995 identified by the New Mexico Tumor Registry, a state-wide population-based cancer registry.

Results of the investigation showed the incidence of thyroid cancer in Los Alamos County fluctuated slightly above the statewide incidence between 1970 and the mid 1980's before rising to a statistically significant, four-fold elevated level during the late 1980's and early 1990's. Age-adjusted thyroid cancer incidence in Los Alamos County during 1988 to 1992 was 20.7 per 100,000 (n = 22, 95 percent CI = 12.6 to 30.9) compared to 4.5 per 100,000 in the state. Surveillance data collected from 1994 to 1995 indicated a decline in the number of cases diagnosed.

The higher than expected number of thyroid cancer cases could be accounted for by temporal changes in the diagnosis of thyroid cancer among Los Alamos County residents. The majority of all cases were detected following palpation of an asymptomatic neck mass by health care practitioners located at the local community hospital or LANL. None of the thyroid cancer cases had been detected by thyroid ultrasonography, nor was a temporal shift toward more incidental diagnoses of small occult thyroid cancers observed. A notably higher percentage of male cases had their tumor discovered at LANL compared to females, suggesting an impact from occupational

TABLE 4.6.1.3–1.—*All Cancer: All Races, Both Sexes, Age-Adjusted[a] Incidence Rates[b] (1983 Through 1987 and 1988 Through 1991)*

	CASES 1983–1987	RATE 1983–1987	LOWER 95% CI[c]	UPPER 95% CI	CASES 1988–1991	RATE 1988–1991	LOWER 95% CI	UPPER 95% CI
New Mexico	20,685	296.5	292.38	300.62	19,925	320.3	315.76	324.84
County								
Bernalillo	7,073	330.9	323.03	338.77	7,242	373.2	364.43	381.97
Catron	49	313.2	223.71	402.69	32	231.8	149.65	313.75
Chaves	1,140	324.6	305.37	343.83	914	311.1	290.52	331.68
Cibola	893	327.1	305.21	348.99	873	335.0	312.32	357.68
Colfax	214	236.1	205.55	270.65	188	268.8	229.59	308.01
Curry	568	276.1	252.93	299.27	501	289.9	264.00	315.80
De Baca	68	312.4	236.63	386.17	57	308.2	226.56	389.84
Doña Ana	1,403	282.5	267.42	297.58	1,436	298.3	282.56	314.04
Eddy	991	311.2	291.43	330.97	811	313.6	291.58	335.62
Grant	382	249.0	223.52	274.48	352	252.1	225.23	278.97
Guadalupe	70	276.9	210.71	343.09	62	305.4	227.83	382.97
Harding	24	281.9	166.81	396.99	14	165.4	76.99	253.81
Hidalgo	91	291.2	230.15	352.25	53	206.0	149.41	262.59
Lea	612	204.7	186.15	221.25	549	237.3	217.04	257.56
Lincoln	222	280.2	242.59	317.81	234	343.2	298.33	388.07
Los Alamos	293	347.9	307.25	388.55	302	408.5	361.49	455.51
Luna	414	313.3	282.50	344.10	370	307.4	275.44	339.36
McKinley	462	233.8	212.05	255.55	420	239.4	216.04	262.76
Mora	74	260.7	200.09	321.31	45	196.6	137.99	255.21
Otero	531	255.8	233.60	278.00	491	259.5	236.08	282.92
Quay	206	263.8	227.04	300.56	158	254.9	214.34	295.46
Rio Arriba	436	291.2	263.31	319.09	379	288.7	259.04	318.36

TABLE 4.6.1.3–1.—*All Cancer: All Races, Both Sexes, Age-Adjusted[a] Incidence Rates[b] (1983 Through 1987 and 1988 Through 1991)*-Continued

	CASES 1983–1987	RATE 1983–1987	LOWER 95% CI[c]	UPPER 95% CI	CASES 1988–1991	RATE 1988–1991	LOWER 95% CI	UPPER 95% CI
Roosevelt	255	270.8	236.88	304.72	202	264.5	227.28	301.72
Sandoval	775	355.3	329.77	380.83	810	340.4	316.48	364.32
San Juan	813	228.8	212.75	244.85	886	294.5	274.71	314.29
San Miguel	333	251.8	224.20	279.40	286	259.3	228.63	289.97
Santa Fe	1,292	306.3	289.26	323.34	1,264	312.5	294.92	330.08
Sierra	302	288.6	255.39	321.81	308	329.4	291.86	366.94
Socorro	219	322.7	279.09	366.31	174	295.4	250.61	340.19
Taos	289	250.5	221.03	279.97	302	298.5	264.15	332.85
Torrance	123	262.1	214.83	309.37	146	335.3	279.80	390.80
Union	91	250.1	197.66	302.54	64	289.5	217.13	361.88
Valencia	893	327.1	305.21	348.99	873	335.0	312.32	357.68

[a] 1970 U.S. Standard Population
[b] Rates are for 100,00 persons per year
[c] CI = Confidence interval
Source: Athas and Key 1993

medical surveillance. Additional analysis suggests that increased medical surveillance and greater access to medical care were responsible for the recent excess in Los Alamos County.

Results from this investigation showed that the 1988 to 1995 cases included people who had moved to Los Alamos County at different points in time and had lived in the county for varying lengths of time prior to diagnosis. Most of the cases had not lived in Los Alamos County prior to 1970; about half had resided in the county more than 20 years prior to diagnoses; about 20 percent had resided in the county 2 years or less prior to diagnosis; and four had resided in Los Alamos County during childhood.

The investigation described in this report did not identify a specific cause of the unusually high number of thyroid cancers diagnosed in Los Alamos County. The likelihood is that the excess had multiple causes. Potential risk factors for thyroid cancer include therapeutic irradiation, genetic susceptibility, occupational radiation exposure, and weight.

4.6.1.4 *LANL Environmental Surveillance and Compliance Program*

The LANL Environmental Surveillance and Compliance Program (described on page 4–1) monitors LANL and surrounding region foodstuffs, air, water, and soil for radiation, radioactive materials, and hazardous chemicals. This information is used for continually determining time trends and to assess potential risks to human health and the environment.

4.6.2 LANL Worker Health

This section summarizes operational health risk experience at LANL, including exposures of workers to radioactive materials and hazardous materials resulting in intakes and recordable incidents due to exposure or physical injuries from workplace hazards. The LANL Worker Health and Safety Program is summarized also.

4.6.2.1 *Summary of Radiological and Chemical Exposure and Physical Hazard Incidents Affecting Worker Health During the 1990's*

The working conditions at LANL have remained essentially the same during the 1990's. Few construction projects (e.g., DARHT) have been undertaken. More than half the work force is routinely engaged in activities that are typical of office and computing (analysis) industries. Much of the remainder of the work force is engaged in light industrial and bench-scale research activities. Approximately one-tenth of the general work force at LANL (UC; Johnson Controls, Inc.; and other UC subcontractors) is engaged in operations (including maintenance) and research and development within nuclear and moderate-hazard facilities (LANL 1998a). Uniform data have been reported since 1993 due to DOE requirements. Therefore, the information below addresses 1993 through 1996.

There have been five major (fatal, serious injury, or near miss) accidents affecting worker safety during this period. These were:

- *December 1994*—During a training exercise, a security officer (Protection Technology of Los Alamos) was accidentally shot and killed.
- *November 1995*—A forklift accident resulted in serious worker injury; the worker fully recovered.
- *January 1996*—An electrical accident resulted in near death; injured worker remains in coma.
- *July 1996*—An electrical accident resulted in serious worker injury; the worker fully recovered.

- *November 1996*—An explosion and fire in Chemistry and Metallurgy Research (CMR) Wing 9 (hot cell facility) resulted in property damage; this accident is considered a near-miss in terms of serious injuries or fatalities.

LANL's worker health and safety performance is reported and is a portion of UC's performance indicators within its contract with DOE.

The new DOE-UC contract contains objective standards of performance for environmental safety and health (modification number M440 Supplemental Agreement to Contract Number W-7405-ENG-36, Appendix F, Section B, Part II, Section II-2, F-10 to F-26) (October 1997). These provide specific performance objectives, criteria, and performance measures. These will continue to be used to evaluate LANL performance in the areas of safety, health, and environmental protection.

Table 4.6.2.1–1 presents representative examples of accidental radiological and chemical exposures and physical incidents resulting in worker injuries at LANL from 1993 to 1996. DOE required that dose estimates for radiological intakes be reported as CEDE starting in 1993. Three workers received doses above the regulatory limits of 5 rem due to intakes of plutonium isotopes in 1993. Two individuals were exposed while checking argon flow in an experimental metal preparation operation within a glovebox. The other individual was exposed following an incident involving the unbolting of a valve during a decommissioning operation. Physical accidents that resulted in hospitalization overnight or fatalities are listed, as are incidents that involved more than three workers. Chemical exposures at LANL between 1993 and 1996 are also listed in Table 4.6.2.1–1. These are potential exposures because it is difficult to confirm intake of many of the chemicals with which routine operations are conducted.

Table 4.6.2.1–2 presents the total recordable and lost work day (more than one-half day lost due to injury and treatment) cases rates per year at LANL (1990 through 1995). Recordable incidents are any occupational injuries or illnesses that result in: (1) fatalities, regardless of the time between the injury and death or the length of the illness; (2) or lost work day cases, other than fatalities, that result in lost work days; (3) or nonfatal cases without lost work days that result in transfer to another job, termination of employment, or require medical treatment (other than first aid), or involve loss of consciousness or restriction of work or motion. This category also includes any diagnosed occupational illnesses that are reported to the employer but are not classified as fatalities or lost work day cases (29 CFR 1904.12). Lost work days are a subset of recordable incidents. These comparisons were based on the LANL Occupational Safety and Health Administration (OSHA) 200 logs maintained by LANL's ESH-5, Industrial Hygiene Group, compared to eight other DOE facilities for the same time frame (LANL 1992b, LANL 1993a, LANL 1994b, LANL 1995f, LANL 1996e, and LANL 1996i). These logs allow comparisons of organizations performing similar activities by comparison of the recordable case rate (the number of fatalities, injuries, or illnesses per full-time equivalent worker, assuming 40 hours per week and 50 weeks per year worked). This methodology is standardized by the U.S. Department of Labor, Bureau of Labor Statistics, and is required reporting for employers with 11 or more employees in the previous year. The use of the total reportable injuries/illness case rates allows for comparisons to other DOE facilities.

LANL has experienced recordable and lost work day cases at a rate that is within the operational experience of DOE facilities (Table 4.6.2.1–2) and with that of research and development facilities in the U.S., both U.S. Nuclear Regulatory Commission (NRC) licensed and institutions such as Battelle

TABLE 4.6.2.1–1.—*Representative Examples of Recorded Radiological and Chemical Exposures and Physical Accidents Affecting Workers at LANL 1993 Through 1996*

DATE	LOCATION	DESCRIPTION OF INCIDENT/EXPOSURE
EXTERNAL RADIATION EXPOSURE		
1993 to 1996	LANL-wide	None to individual workers exceeding 5 rem/year.
RADIOLOGICAL INTAKE EXCEEDING 100 MREM		
January 19, 1993	TA–55, PF–4	11.3 rem CEDE plutonium-239 to one worker and 18.4 rem CEDE plutonium-239 to second during operation to clear reaction debris from line; continuous air monitor (CAM) alarm sounded, nasal smears confirmed potential exposure, CEDE quantified by bioassay.
August 30, 1993	TA–55, PF–4	1.2 rem CEDE plutonium-239 to one worker during a decontamination operation; CAM alarm sounded, nasal smears confirmed potential exposure, CEDE quantified by bioassay.
August 24, 1994	TA–3–29, CMR	3.5 rem CEDE plutonium-239 to one worker who received puncture wound in thumb through glovebox glove puncture; intake was quantified by bioassay.
April 30,1996	TA–55, PF–4	380 millirem CEDE plutonium-239 to one worker during a pump replacement operation; nasal smears confirmed potential exposure, CEDE quantified by bioassay.
July 5-11,1996	TA–55, PF–4	1.3 millirem CEDE plutonium-239 to one worker detected as a result of reviews of routine health physics survey of fixed head air sample data. Intake confirmed and quantified via bioassay.
POTENTIAL CHEMICAL EXPOSURES (NONE REQUIRED HOSPITALIZATION)		
March 8, 1995	TA–00	Six people confirmed to receive lead to blood 40 to 70 µg/dl as a result of removing paint from a water tank.[a]
April 12, 1995	TA–55, PF–4	Several employees exposed briefly to dilute acid fumes (hydrofluoric and nitric in water) during solution disposal down the acid drain line.
April 26, 1995	TA–3, SM–30 Warehouse	Four people became briefly ill due to release from chemical package containing 100 milliliters of ethyl mercaptan.
December 1, 1995	HRL, TA–43	Technician splashed 10% bleach being used for biological sterilization into his eyes.
December 7, 1995	TA–54, Area G	Personnel monitoring devices detected silica in three workers breathing zones exceeding the OSHA TLV-TWA[b] for crystalline silica during training.
February 23, 1996	TA–48	Two employees briefly exposed to HCL in excess of OSHA ceiling of 5 ppm during the failure of exhaust system in work station.
May 17, 1996	CMR	Disturbance of asbestos-containing material (ACM) on pipe during the installation of conduit for communications.
August 22, 1996	TA–3–40 Physics Complex	Elemental mercury identified on floor during remodeling, airborne concentrations exceeded OSHA Permissible Exposure Limits for ceiling level concentrations.
September 25, 1996	Cooling Tower CT–2	Nonfriable asbestos detected, improbable exposure, during the removal of filter media in cooling tower.

TABLE 4.6.2.1–1.—*Representative Examples of Recorded Radiological and Chemical Exposures and Physical Accidents Affecting Workers at LANL 1993 Through 1996*-Continued

DATE	LOCATION	DESCRIPTION OF INCIDENT/EXPOSURE
December 10, 1996	High Explosives Testing Site	Unknown puff of gas caused temporary discomfort, coughing to worker resulting from application of disinfectant and dechlorination operation.
PHYSICAL INJURIES (REQUIRING MINIMUM ONE NIGHT HOSPITALIZATION, RESULTING IN FATALITY OR AFFECTING 3 OR MORE WORKERS)		
April 9,1993	TA–33–114	Insect bite resulted in immuno-reaction requiring hospitalization.
April 19, 1993	TA–3	Employee kneeling on chair fell and struck adjacent pipe and was hospitalized overnight for observation.
May 24, 1993	TA–55	Injury sustained in basement when standing up and striking overhead obstruction.
August 24, 1993	TA–52 (HazMat Mobile Unit)	Sustained burns to right hand, face and neck while attempting to light the propane-fired water heater in mobile unit.
October 15, 1993	TA–3	Worker sustained broken hip in 5-foot fall from wooden pulpit ladder.
January 24, 1994	TA–59 Pajarito Road	LANL truck pulling trailer that came loose; trailer struck a privately owned vehicle causing it to veer off road; driver sustained hip injury and baby sustained concussion.
February 15, 1994	CMR, Wing 7	Worker broke arm in fall at floor level.
July 1, 1994	TA–54, Area L	Near miss lightning strike, worker hospitalized overnight for observation.
December 15, 1994	TA–48	Worker falls from ladder; the fall directly resulted in injury to the worker and subsequent hospitalization. Worker dies after surgery.
December 20, 1994	TA–72	Security guard fatally wounded by gunshot in training exercise.
May 20, 1995	East Jemez Road	Collision occurred between government-owned and private vehicle. Three of four individuals injured were hospitalized overnight.
June 13, 1995	TA–46	Injury to right foot from backhoe bucket hit during removal of earth from an excavation to expose a water line.
October 31, 1995	TA–55	Worker hospitalized overnight after fainting in the machine shop and hitting head on floor in the fall.
November 22, 1995	TA–35–128 Outside	Forklift wheel rolled off edge of concrete and rolled with driver into the adjacent ditch pinning worker's neck against overhead guard and foot beneath body of vehicle; 2 1/2 week hospitalization resulted but worker released to work without restrictions.
January 17, 1996	TA–21 TSFF	A mason tender (worker) was injured when he hit 13,200-volt buried electrical line with jack hammer while excavating through pavement; worker burned and rendered unconscious, sustained in comatose state.
February 8, 1996	TA–3–132	Worker broke finger on unguarded pinch point of a Tommy lift gate.
July 18, 1996	TA–53, MPF–14	Student worker injured by electrical shock while experimenting with commercial microwave oven; was rendered unconscious, regaining consciousness within a few hours; worker recovered fully.
October 21, 1996	Fenton Hill	Worker injured while inserting drill pipe into Well GT-2; worker fully recovered.

[a] 40 to 70 μg/dl means 40 to 70 micrograms of lead in any form in the blood of the person.
[b] TLV-TWA threshold limit value, time weighted average under OSHA.

TABLE 4.6.2.1–2.—*Total Recordable and Lost Workday Cases Rates[a] at LANL and at Other DOE Facilities (1990 Through 1995)[b]*

YEAR	LANL	LLNL	BNL	SNL	ORR	ANL	HS	RFS	INEEL
TOTAL RECORDABLE CASE RATE PER 100 WORKERS									
1990	6.6	2.9	5.8	4.4	5.8	2.7	3.5	6.7	4.5
1991	7.2	3.8	4.7	4.6	5.4	1.6	3.7	6.2	5.2
1992	9.4	5.1	5.2	4.4	5.5	2.4	4.3	6.0	3.7
1993	6.6	5.6	4.2	4.3	4.5	3.4	5.0	6.2	3.4
1994	5.9	4.7	5.6	4.0	4.3	2.4	5.2	5.1	3.3
1995	4.6[c]	4.7	4.2	3.4	4.2	1.6	4.7	4.6	3.6
LOST WORKDAY CASE RATE PER 100 WORKERS									
1990	2.8	2.2	3.2	1.9	1.8	1.0	1.3	4.2	2.2
1991	2.4	2.4	2.9	2.2	1.7	0.8	1.7	4.3	2.6
1992	3.3	2.6	3.6	2.0	2.1	1.1	2.0	3.8	1.7
1993	2.1	2.8	3.2	2.0	1.4	1.2	2.0	3.7	1.6
1994	2.3	2.2	3.7	1.9	1.6	0.9	2.2	3.0	1.4
1995	2.0	1.8	2.9	1.7	1.4	0.4	1.7	2.7	1.7

ANL = Argonne National Laboratory, BNL = Brookhaven National Laboratory, HS = Hanford Site, INEEL = Idaho National Engineering and Environmental Laboratory, LANL = Los Alamos National Laboratory, LLNL = Lawrence Livermore National Laboratory, ORR = Oak Ridge Reservation, RFS = Rocky Flats Environmental Technology Site, SNL = Sandia National Laboratories

Sources: LANL 1992b, LANL 1993b, LANL 1994b, LANL 1995f, LANL 1996e, and LANL 1995e

[a] Recordable occupational injuries or illnesses are any occupational injuries or illnesses that result in: (1) fatalities, regardless of the time between the injury and death, or the length of the illness; (2) or lost work day cases, other than fatalities, that result in lost work day; (3) or nonfatal cases without lost work days that result in transfer to another job, termination of employment, or require medical treatment (other than first aid), or involve loss of consciousness or restriction of work or motion. This category also includes any diagnosed occupational illnesses that are reported to the employer but are not classified as fatalities or lost work day cases (29 CFR 1904.12).

[b] The U.S. Department of Labor, Bureau of Labor Statistics, reported total reportable and lost work case rates of 8.5 and 3.8, respectively, for the period 1991 to 1995.

[c] Worker population in 1995 was 9,081.

Memorial Institute or Proctor and Gamble Corporation.

DOE is establishing a Chronic Beryllium Disease Prevention Program in response to the current prevalence of approximately 1 percent confirmed cases among DOE workers who have been included in a worker health surveillance program for chronic beryllium disease (CBD). CBD is a chronic, irreversible, and debilitating lung disease. In volume III, appendix D, section D.2.2.3, discusses beryllium exposure groups and contains more information about CBD. Worker health surveillance programs for CBD initiated in 1991 at DOE's Rocky Flats Environmental Technology Site (REFETS), the Oak Ridge Y–12 Plant, and Mound provide screening to current and former beryllium workers and employees who may have received incidental exposures. Data from these programs confirm that CBD remains an ongoing problem. Through December 1997, about 104 cases of CBD have been diagnosed (64 confirmed by bronchoscopy) and 40 probable cases of CBD (not confirmed by bronchoscopy [includes biopsy of lung tissue and Lymphocyte Proliferation Test of white blood cells washed from the lung]). This is from a population of 8,838 workers evaluated.

Anecdotally, an estimated eight cases of CBD have been diagnosed in former LANL site employees. Six cases are possibly the result of beryllium exposure at Los Alamos during the Manhattan Project; however, there are no records on site that support the diagnosis of CBD or level of beryllium exposure. Two cases were the result of exposure to beryllium at the University of Chicago in the early 1940's with no known subsequent beryllium exposure at LANL. There are no known cases of CBD in current LANL employees. There are two cases of beryllium sensitization in former Rocky Flats employees who are at LANL. No cases of confirmed beryllium sensitization have been found in LANL beryllium workers participating in a study of methods to improve the lymphocyte proliferation test.

The occupational health community does not have sufficient exposure and health outcome data to satisfy the majority of occupational health practitioners in either confirming that the current beryllium limit is adequate or establishing a lower limit. Peer-evaluated journal articles (Kreiss et al. 1996, Stange et al. 1996, and Banard et al. 1996) indicate a high prevalence of CBD where average exposures were reported to be below the 2 micrograms per cubic meter limit; but the reported exposure data have been challenged as not representing the true exposures that the CBD cases received. Adding to the uncertainty are unpublished data from the United Kingdom Atomic Weapons Establishment Cardiff Facility that suggest that controlling their facility to 2 micrograms per cubic meter resulted in no cases of CBD among their workers (UK et al. 1997).

Though workers having the highest levels of exposure are at greatest risk for CBD, individual susceptibility may play a role in who does or does not develop CBD. It has long been suspected that genetics plays a role in determining who will become ill, and recent research suggests that a genetic predisposition may play some role in determining who develops CBD (Richeldi et al. 1993). Currently, however, there is no reliable genetic test that identifies highly susceptible individuals.

At LANL, there have been ongoing operations using beryllium, primarily at Sigma (TA–3–141), but also at the Main Shops (TA–3–39 and TA–102), and the high explosives testing facilities (especially TA–15, TA–36, and TA–39). The Beryllium Technology Facility (TA–3–141) has been redesigned and upgraded as part of the DOE nonnuclear reconfiguration and is intended to be a state-of-the-art facility for these operations. It is expected to be in operation in 1998. (LANL 1998a and appendix D, section D.3.4, provide additional information on beryllium at LANL.)

Beryllium medical surveillance is part of the ongoing medical surveillance program at LANL as described in the laboratory requirements document "Occupational Medicine Program." All identified beryllium workers are required to participate in the beryllium medical surveillance program. The Occupational Medicine Group maintains beryllium-specific examination requirements and employee medical surveillance records.

4.6.2.2 *Ionizing Radiation Exposures of Workers*

Occupational radiation exposures for workers at LANL are summarized in Table 4.6.2.2–1. The collective dose, the sum of all measurable doses to workers, has fluctuated around 200 person-rem per year. LANL is one of seven major DOE sites that collectively contribute over 80 percent of DOE's total dose. The number of LANL workers with measurable dose has varied from about 1,400 to 2,600. The average measurable dose has been less than 150 millirem in recent years, which is considerably less than average doses in the nuclear power industry, for example.

For 1996, tritium produced measurable doses in 49 individuals for a collective dose of 0.305 person-rem, and an average CEDE of 0.006 rem. Plutonium produced measurable dose in two workers for a collective dose of 4.8 person-rem for an average of 2.4 rem. Uranium isotopes were measurable in 39 workers for a collective dose of 0.182 person-rem, averaging 0.005 rem per worker. As is generally the case at most DOE facilities, the collective dose to workers is almost entirely from external radiation.

4.6.2.3 *Nonionizing Radiation Exposure*

There are three types of nonionizing radiation within LANL operations that could affect workers. These are discussed below.

Electromagnetic Radiation

The incidence of exposure to electromagnetic radiation at LANL are very low, and therefore, are difficult to identify from historical records. There are no monitoring devices available such as those used for monitoring ionizing radiation. In-place monitoring devices interfere with or disrupt the nonionizing radiation field or beam resulting in inaccurate readings. Magnetic sources are normally controlled inside of buildings or behind fenced areas, thus limiting access to the field and limiting the size of the

TABLE 4.6.2.2–1.—*Baseline Radiological Exposure to LANL Workers*

YEAR	COLLECTIVE DOSE (person-rem) TEDE	NUMBER OF WORKERS WITH MEASURABLE DOSE	AVERAGE MEASURABLE DOSE (rem)
1992	230.4	1,724	0.134
1993	199.2	1,391	0.143
1994	190.0	2,448	0.078
1995	234.9	2,583	0.091
1996	184.1	1,984	0.093
1993 to 1995	208.0	2,141	0.097

Sources: Data from DOE Occupational Radiation Exposure reports for 1992 through 1994 (DOE nda), 1995 (DOE ndb), and 1996 (DOE ndc).

field (metal construction materials interfere with the magnetic field). No reported incidents of exposure to nonionizing radiation were found during the review of the OSHA 200 logs (LANL 1996c), Environmental Surveillance and Compliance Program Reports (LANL 1992b, LANL 1993b, LANL 1994b, LANL 1995f, LANL 1996e, and LANL 1996i) or of DOE's Occurrence Reporting and Processing System (ORPS) reports (DOE ORPS 1990–1996).

Laser Radiation

Most forms of nonionizing radiation are easily controlled. Light sources such as lasers are line-of-sight devices. Infrared and manmade ultraviolet light sources are normally contained or housed out of sight and without direct access in typical operating environments.

Microwave Radiation

In addition to the typical use of microwaves in cafeterias and lunchrooms, LANL is designated as an Experimental Operation Station for DOE by the U.S. Department of Commerce, National Telecommunications and Information Administration. As such, the operation of experimental microwave transmitters occurs within TA–49. In volume III, appendix D, section D.2.2.2 provides details of potential risk to human health from operating this transmitter. These risks are very low (i.e., resulting in less than measurable effects on human health).

4.6.2.4 *Summary of Worker Health Studies at LANL*

There have been several long-term studies of workers employed at LANL. A mortality study of 224 white males with internal depositions of plutonium (10 nanocuries or more) was conducted by Voelz (Voelz et al. 1985). All causes of death, and all malignant neoplasms were lower than expected when compared with death rates for U.S. white males. Cancers of interest for plutonium exposure, including cancers of the bone, lung, and liver, were infrequent or absent.

A cohort mortality study (Wiggs et al. 1994) examined the causes of death among 15,727 white males hired at LANL between 1943 and 1977. The study examined plutonium deposition and external ionizing radiation in relation to worker mortality. The LANL workforce experienced 37 percent fewer deaths from all causes, and 36 percent fewer deaths due to cancer than expected when compared with death rates for the U.S. population.

The researchers identified a subset of 3,775 workers who had been monitored for plutonium exposure; of these, 303 workers were categorized as "exposed" based on a urine bioassay; the remainder were "nonexposed." One case of rare bone cancer, osteogenic sarcoma, related to plutonium exposure in animal studies, was noted among the plutonium exposed group. The overall mortality and site-specific rates of cancer did not differ significantly between the two groups of workers.

Dose-response relationships were observed for cancers of the brain/central nervous system, the esophagus, and Hodgkin's disease among the 10,182 workers monitored for external ionizing radiation and tritium. When plutonium workers were excluded from the analyses, kidney cancer and chronic lymphocytic cancer also showed a dose response.

A lifetime medical study was conducted on 26 workers who received the largest internal depositions of plutonium (Voelz and Lawrence 1991) between the years 1944 and 1945. Seven deaths had occurred by 1990 compared with 16 expected based on death rates for U.S. white males, adjusted for age and calendar year. All cause mortality and all cancer mortality were similar to death rates among LANL workers. One of the seven reported deaths was due to bone sarcoma, as noted above. No additional deaths were reported in the cohort mortality study through 1995 (Voelz et al. 1997).

Wiggs (Wiggs 1987) conducted a mortality study among 6,970 women employed at LANL between 1943 and 1979. The mortality rates for all causes of death combined and all cancers combined were 24 percent and 22 percent below the rate for the U.S. population. Although the overall rates are low, women occupationally exposed to ionizing radiation had elevated rates for ovarian and pancreatic cancer relative to those not exposed. Unexpectedly, female radiation workers experienced a statistically significant excess of death from suicide. In an in-depth study, past employment as a radiation worker was significantly associated with death from suicide. No significant associations for duration of employment, plutonium exposure, or marital status were seen (Wiggs et al. 1988).

As result of a reported excess of malignant melanoma (a type of skin cancer) among workers at the Lawrence Livermore National Laboratory (LLNL) in California (Austin et al. 1981) and similarities with occupational exposures and prevailing sunshine conditions at Los Alamos, an investigation was undertaken to assess the risk of melanoma at LANL. Incidence data were obtained from the New Mexico Tumor Registry. No excess risk for melanoma was detected at LANL among 11,308 laboratory workers (Acquavella et al. 1982a). The rate for the total cohort, Hispanic males and females, non-Hispanic males and females were not significantly different from the corresponding New Mexico rates.

A study (Acquavella et al. 1982b) of 15 melanoma cases did not detect any associations between melanoma and exposure to any external radiation as measured by film badges, neutron exposures, plutonium body burden based on urine samples, or employment as a chemist or physicist. However, the melanoma cases were more educated than the comparison group; a finding consistent with other reports of malignant melanoma according to the authors. The numbers in this study were small, and therefore, could only detect large excesses.

4.6.2.5 *LANL Worker Health Programs*

Radiation Protection

The LANL radiation protection program has the objective of managing and controlling below applicable limits (ALARA) (10 CFR 835). To accomplish this objective, several preventative measures are applied, such as protective clothing, respirators, and use of shielding. Other technical requirements for the conduct of work, including construction, modifications, operations, maintenance, and decommissioning incorporate the radiological protection criteria in the early planning stages. The federal limit for personnel exposure is 5 rem (TEDE) per year.

The ALARA program uses administrative controls as one tool to monitor and control exposures. Administrative control levels (ACLs) for radiation doses have been established at a level below the regulatory limits. These ACLs provide a method by which increasing employee radiation doses are monitored, evaluated, and reviewed well before the regulatory limits are approached. Higher level management approval is required before an ACL can be exceeded.

The radiation protection services at LANL are provided by the Environment, Safety and Health (ES&H) Division. The mission of this division is to protect the workers, the public, and the environment from radiation associated with LANL operations. The Laboratory Assessment Office collects and publishes a quarterly report of performance indicators, which are parameters that indicate how well LANL has performed in areas of general importance. These performance indicators are used to identify trends, evaluate performance, allocate resources, assess conduct of operations, and facilitate continuous improvement. The radiation protection performance indicators for the various LANL activities include external dosimetry, internal dosimetry, radiation monitoring instruments, sample analysis, workplace radiological monitoring, nuclear criticality safety, radiological training, and maintaining radiological records.

Chemical Hygiene and Occupational Safety and Health Administration Safety Program

DOE implements OSHA requirements for employees at their facilities through DOE Order 440.1, *Worker Protection*. The order requires that contractors and contractor employees adhere to U.S. Department of Labor OSHA standards (29 CFR 1910). The applicable standards and requirements are included in the DOE-UC contract for LANL operations. LANL is required to furnish employees a place of employment free from recognized hazards that might cause injury or death. Routine and special medical examinations are used as surveillance tools to monitor worker health. LANL has a workplace monitoring program that collects more than 2,000 samples each year for analyses of more than 200 chemicals.

OSHA 200 Log—Recordable incidents in LANL workplaces are investigated and reported to DOE. A review of this log and of the ORPS database for the LANL facility for the period of 1993 through 1996 indicates that there were several potential exposures to chemicals—asbestos, crystalline silica, mercaptan (a gas), lead, elemental mercury, hydrochloric acid, and hydrofluoric acid vapor (Table 4.6.2.1–1).

Accident Investigating and Reporting Program

The LANL Accident/Occurrence Investigating and Reporting Program investigates accidents and incidents meeting defined criteria to determine appropriate corrective actions that may prevent future similar events or help in mitigating their consequences. These investigations also provide information required by programs external to LANL, such as data required by the state worker's compensation program, the OSHA 200 log, the DOE Computerized Accident/Incident Reporting System, the DOE Performance Indicator Program, and the DOE ORPS.

Chemical Hygiene Plan

The LANL Chemical Hygiene Plan is the LANL standard that helps to prevent overexposure of employees to hazardous substances. It includes necessary work practices, procedures, and policies to ensure the protection of employees. Additional requirements include employee training and information, medical consultation and examinations, hazard identification, the respirator protection program, and record-keeping. This plan is available on-line at LANL and allows personnel to tailor specific procedures and experimental plans to minimize risk.

Carcinogen Control

The Carcinogen Control Program involves the identification, evaluation, and control of occupational exposures to chemicals identified as known or suspected human carcinogens. The program encompasses the use, storage, or generation of carcinogens at LANL. Work areas where carcinogens are used, stored, or generated are governed by either the LANL Hazard Communication Standard or the Chemical Hygiene Plan. These areas are labeled, and controls for use of these materials are available at the work site or laboratory.

Lockout/Tagout (Red Lock Procedure)

The LANL Lockout/Tagout (Red Lock Procedure) Program describes the minimum requirements of the lockout/tagout procedures used for protecting personnel from accidental releases of hazardous energy while they are servicing, maintaining, or modifying machinery, equipment, or systems. Each facility may have facility-specific requirements for equipment operability checks, maintenance, and operability assurance.

Nonionizing Radiation

The Nonionizing Radiation Program helps to minimize the exposure of LANL workers to laser, radiofrequency/microwave, and subradiofrequency electric and magnetic fields, and establishes the frequency-dependent exposure limits at LANL. The program institutes requirements for anticipating, identifying, evaluating, and controlling the occupational exposure of workers to nonionizing radiation.

Occupational Medicine

The Occupational Medicine Program is maintained to provide continuing medical surveillance for workers to ensure the early detection and treatment of illnesses. It also applies early preventative medical measures. Activities include physical examinations, clinic visits, immunizations, drug testing, and counseling. For hazardous chemical and radiation workers, specific surveillances are often required.

Personal Protective Equipment

The Personal Protective Equipment Program is required in LANL work areas where hazards are not effectively controlled by other means (such as engineering controls) or are unknown (such as site characterization at waste management units) or are controlled, but require additional specific protection. Various types of personal protective equipment provide specialized protection for the respiratory system, eyes, face, feet, and head, as well as entire body.

Workplace Monitoring

The Workplace Monitoring Program helps to ensure that personnel exposures to radiological, chemical, physical, and biological hazards are kept ALARA and below the occupational exposure limit. Monitoring data are analyzed and evaluated to determine whether the control measures are effective, and then the data are documented.

Additional institutional health and safety program areas include biohazards, electrical safety, ergonomics, hearing conservation, ventilation systems, and safety and health training. Detailed information of each subprogram can be obtained from the Occupational Safety and Health Manual (LANL 1993c) and corresponding program requirement documents.

4.6.3 Emergency Response and Preparedness Program

DOE maintains equipment and procedures to respond to situations where human health or the environment are threatened. These include specialized training and equipment for the local fire department, local hospitals, state public safety organizations, and other government entities that may participate in response actions, as well as specialized response teams such as the Radiological Assistance Teams (DOE Order 151.1, *Comprehensive Emergency Management System*). These programs also provide for notification of local governments whose constituencies may be threatened. A broad range of exercises are run to ensure the systems are working properly, from facility-specific exercises (e.g., fire drills) to regional responses (major exercises involving several government organizations). Additionally, the emergency response procedures are periodically utilized in response to actual events, such as the Dome Fire in the spring of 1996.

4.6.3.1 *Emergency Management and Response*

LANL has an institutional emergency planning, preparedness, and response program as required by federal regulations. Emergency Management and Response (EM&R) personnel are responsible for the emergency planning, preparedness, and response necessary to minimize adverse operational impacts. They are available on a 24-hour basis for emergencies, and they provide a 24-hour notification service capable of contacting all LANL employees, even those on travel, should this assistance be needed. The EM&R Program also equips and trains both a Crisis Negotiations Team and a Hazardous Devices Team. It maintains an Emergency Operations Center 24 hours per day to coordinate emergency responses, and maintains an alternate emergency operations center as required by DOE. To effectively operate during an emergency, memoranda of understanding have been established among DOE, Los Alamos County, and the State of New Mexico to provide mutual assistance during emergencies and to provide open access to medical facilities. In addition, the EM&R Program supports development and deployment of a DOE-directed complex-wide data handling and display system.

To assist emergency responders, the EM&R Program maintains a database with facility-specific information such as building managers, phone numbers, building locations, chemicals of concern, etc. In addition, the EM&R Program has an Emergency Management Plan that contains all procedures for mitigating emergencies and collecting response data (LANL Emergency Preparedness).

4.6.3.2 *Emergency Response for Explosions*

LANL has procedures to be followed in case of an explosion. The procedures require a 911 call and a response by fire and medical personnel. EM&R personnel will respond to ensure that the situation is mediated prior to re-entry of the facility.

4.6.3.3 *Fire Protection*

LANL's fire protection program ensures that personnel and property are adequately protected against fire or related incidents. This involves all aspects of traditional fire protection, wildland fire prevention, and life safety as detailed in the National Fire Protection Association Code.

4.7 ENVIRONMENTAL JUSTICE

President Clinton, in Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, required federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental impacts of federal programs, policies, and activities on minority and low-income populations. The order also requires agencies to ensure greater public participation in their decision-making practices.

> ***Agency Responsibilities***
>
> *To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.*
>
> *Source: Executive Order 12898*

For the purpose of this assessment, minority refers to people who classified themselves in the 1990 U.S. Census as African Americans, Asian or Pacific Islanders, American Indians, Hispanics of any race or origin, or other non-White races. A minority population refers to an area where minority individuals comprise 25 percent or more of the population (DOC 1990b).

Low-income population refers to a community in which 25 percent or more of the population is characterized as living in poverty (50 FR 192). The U.S. Bureau of the Census uses statistical poverty thresholds to determine the number of individuals below the poverty level. The number of individuals below the poverty level is the sum of the number of persons in poor families and the number of unrelated individuals in poverty. The 1990 poverty threshold was a 1989 income of $12,674 for a family of four (DOC 1993).

4.7.1 Region and Population Considered

The area considered for the SWEIS environmental justice analysis was the area within a 50-mile (80-kilometer) radius of LANL. The center of the area is the emissions stack at the LANSCE in TA–53. The LANSCE stack was chosen because it is the primary source of LANL airborne radionuclide emissions. The use of a 50-mile (80-kilometer) radius circle was patterned after the methodology used by the NRC for assessing potential risks to populations from nuclear power plants and is intended to encompass the potential impacts from LANL operations across all areas of analyses (e.g., water, air, cultural resources).

The racial and ethnic diversity and geographic distribution of the populations within this region require the region be separated into smaller spatial portions (sectors) to assist DOE in identifying minority and low-income populations. To divide the region, four additional circles, centered on the LANSCE stack with radii at 10-mile (16-kilometer) intervals, were overlaid on the 1990 U.S. Census map for this region. The concentric circles were divided by 16 arcs, each 22.5 degrees in width (the resulting sectors are not of equal area). The minority and low-income population data for each sector were derived from U.S. Census Bureau data using Geographic Information System software.

This map will be used to overlay impacts to enable DOE to determine if any LANL operations result in disproportionately high and adverse human health or environmental impacts on minority and low-income populations. Figure 4.7.1–1 presents the area analyzed, the 1990 U.S. Bureau of Census-defined places within this area, and the resulting 80 sectors (discussed above). Eight counties, including all of Los Alamos County and parts of Rio Arriba, Taos, Mora, San Miguel, Santa Fe, Bernalillo, and Sandoval Counties are within the region. Many villages and other rural settlements (not depicted in this figure) are scattered throughout the area but were too small to have been defined as distinct places for the 1990 U.S. Census. Figure 4.7.1–2 presents the 80 sectors, highlighted with the low-income or minority populations greater than 25 percent of the total sector population (based on the information in Table 4.7.1–1). All minority population and income data used in this assessment are based on 1990 U.S. Census data (DOC 1993).

The 50-mile (80-kilometer) region includes at least portions of 15 American Indian Pueblos and 1 American Indian Reservation. These Pueblo and Tribal communities are presented in Figure 4.7.1–1. Only uninhabited or sparsely inhabited sectors of the Pueblo of Taos and Jicarilla Apache Indian Reservation fall within the 50-mile (80-kilometer) circle.

The Pueblo communities in closest proximity to LANL are the Pueblo of San Ildefonso, Pueblo of Santa Clara, Pueblo de Cochiti, and Pueblo of Jemez. DOE has signed intergovernmental agreements (accords) with these sovereign nations to improve cooperation and dialogue regarding LANL operations (section 4.8, Cultural Resources).

The total 1990 population within the 50-mile (80-kilometer) region is 212,771. This population was calculated by summing the populations of all the census tracts within the 50-mile (80-kilometer) radius. Census block data were used when the 50-mile (80-kilometer) radius split a census tract. Twenty-five of the sectors have populations of less than 200, while 3 sectors contain 57 percent of the regional population. The sectors containing 57 percent of the population are: (1) the Santa Fe metropolitan area (62,015); (2) the Rio Rancho, Pueblo of Sandia, and Sandia Heights areas (44,293); and (3) the Pueblo of Santa Clara, Española, and the Pueblo of San Juan (15,182). Table 4.7.1–1 presents the population, percentage of minorities, and percentage of the population living below the poverty level within each sector.

4.7.2 Minority Population

Nearly 54 percent of the population within the 50-mile (80-kilometer) radius area is minority. The area's largest minority group is the Hispanic population (97,378 or about 46 percent), followed by American Indians (14,308 or about 7 percent), African Americans (1,264 less than 1 percent), and Asians or Pacific Islanders (1,142 less than 1 percent). Within New Mexico, minorities make up 49.6 percent of the total state population. Minorities are about 15 percent of Los Alamos County's population, with Hispanics being the largest minority group (11 percent).

Hispanics reside throughout the 50-mile (80-kilometer) radius area, but most are located in the Española Valley and in the Santa Fe metropolitan area. Sixty-two percent of the Hispanics living within this area reside within a transportation corridor that extends north from Santa Fe, along U.S. 84/285 through its junction with NM 502, and north toward Española and its neighboring communities.

4.7.3 Low-Income Population

In 1989, the median household income for New Mexico was $24,087, while 21 percent of the population lived below the poverty threshold ($12,674 for a family of four). Los Alamos County had the highest median income

($54,801) within the state. Fifteen percent of the total population living within the 50-mile (80-kilometer) area had 1989 incomes below the poverty level. Los Alamos County had the lowest percentage (2.4 percent) of individuals living below the poverty level when compared to other census county divisions in the area.

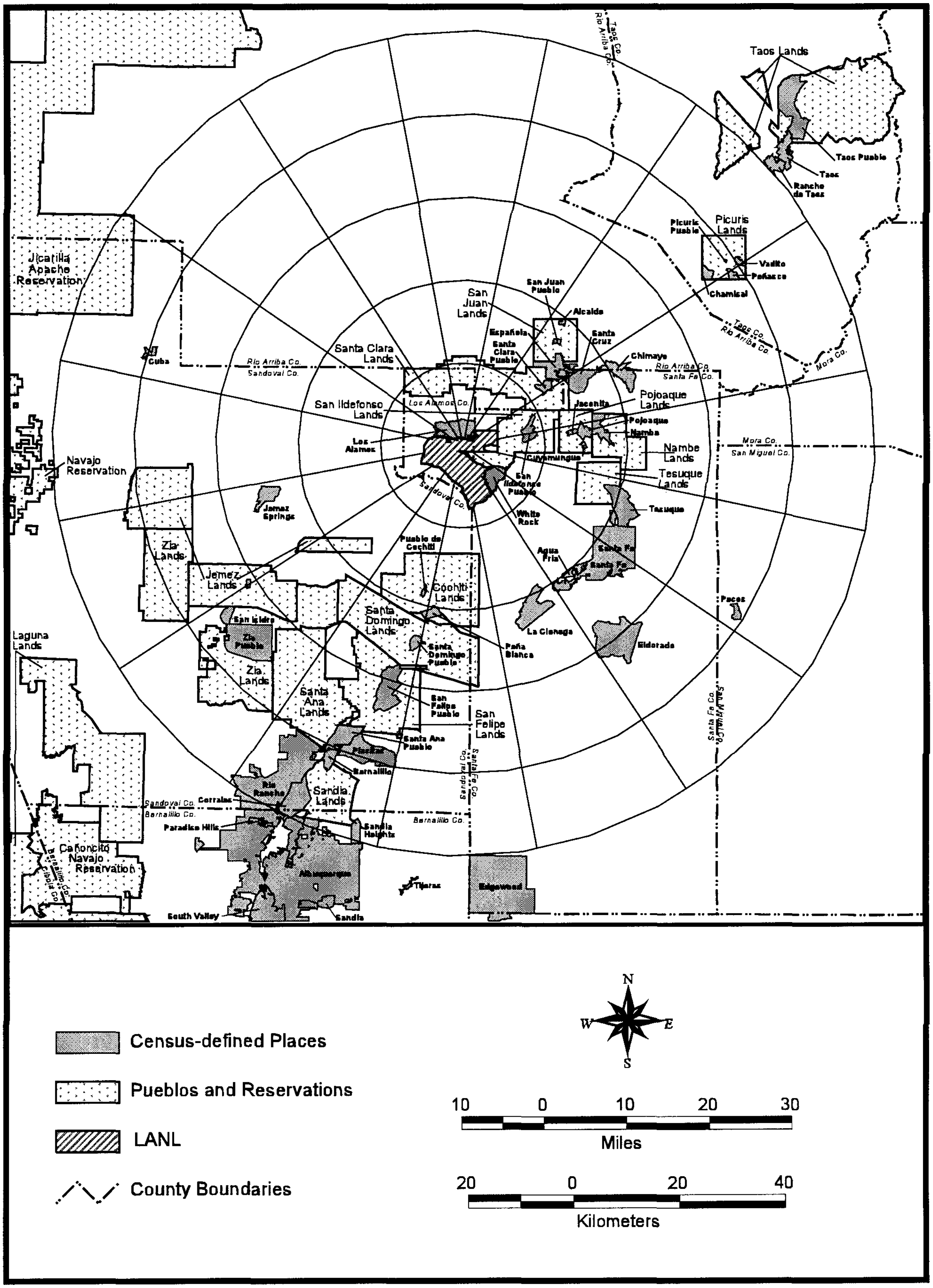


FIGURE 4.7.1–1.—*Sectors Used for Environmental Justice Analysis Within 50 Miles (80 Kilometers) of LANL.*

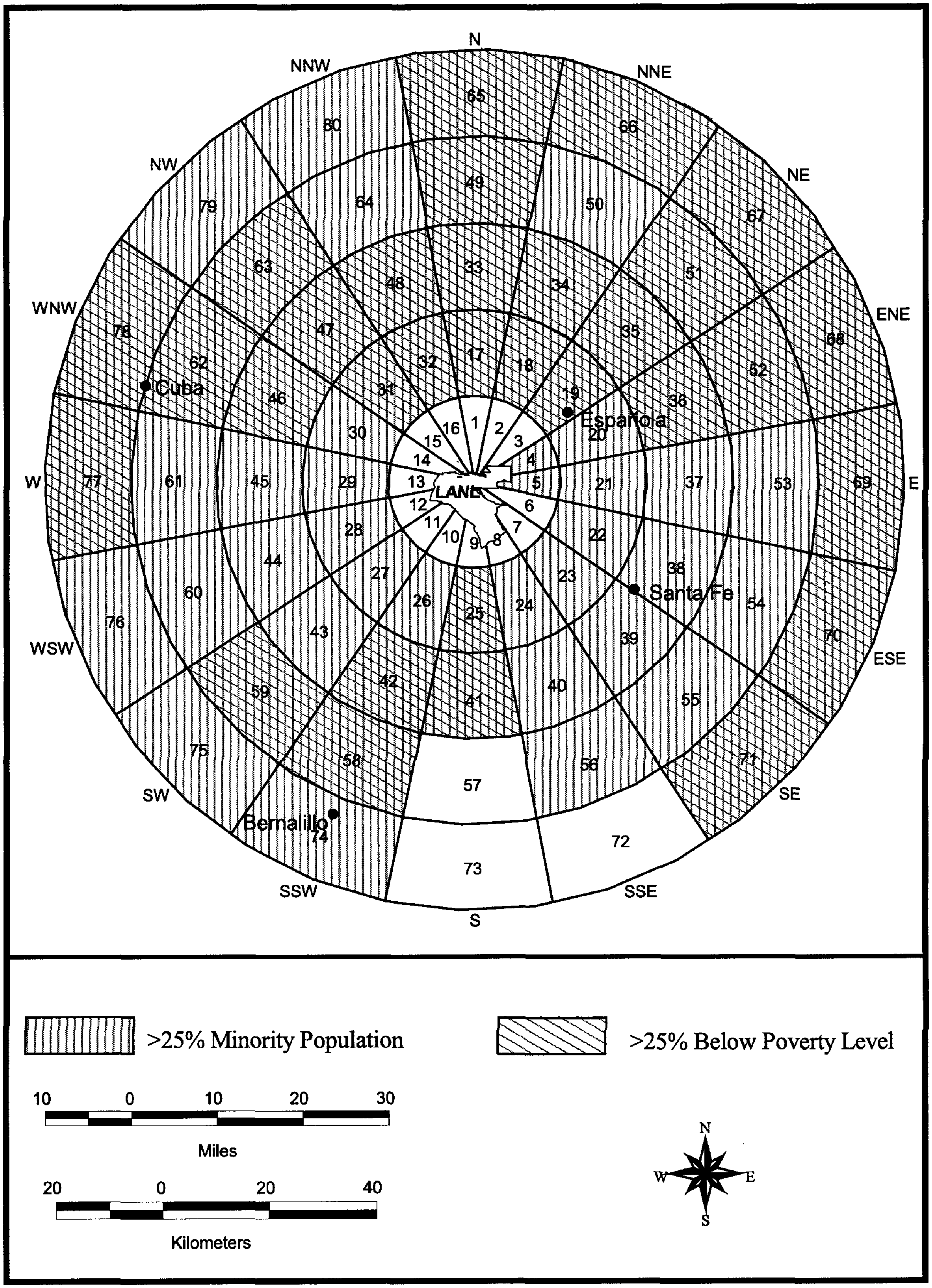


FIGURE 4.7.1–2.—*Sectors with Minority and Low-Income Populations Greater Than 25 Percent of the Sector Population.*

TABLE 4.7.1–1.—*Environmental Justice Areas Within a 50-Mile (80-Kilometer) Radius of LANL*

MAP SECTOR[a]	COMMUNITIES, LAND STATUS IN SECTOR	TOTAL POPULATION IN 1990	PERCENT MINORITIES	PERCENT PERSONS BELOW POVERTY LEVEL
1	Los Alamos townsite, Pueblo of Santa Clara, Santa Fe National Forest	799	8	1
2	Los Alamos townsite, Pueblo of Santa Clara, Santa Fe National Forest	422	8	1
3	Santa Fe National Forest, Pueblo of Santa Clara	132	12	2
4	LANL, Pueblo of San Ildefonso, and CDP	404	54	10
5	LANL, Pueblo of San Ildefonso and CDP	314	61	9
6	LANL, Bandelier National Monument, Pueblo of San Ildefonso, BLM	95	14	8
7	Pueblo of San Ildefonso, White Rock, Santa Fe National Forest	5,742	12	3
8	LANL, Bandelier National Monument, Santa Fe National Forest, edge of White Rock	358	7	0
9	LANL, Bandelier National Monument	63	8	0
10	LANL, Bandelier National Monument, Santa Fe National Forest	0	0	0
11	LANL, Bandelier National Monument	0	0	0
12	LANL, Bandelier National Monument, rural private	36	6	0
13	LANL, Los Alamos, Santa Fe National Forest	399	11	4
14	Los Alamos, Santa Fe National Forest	6,063	18	3
15	Los Alamos, Santa Fe National Forest, Pueblo of Santa Clara	2,912	17	2
16	Los Alamos townsite, Santa Fe National Forest, Pueblo of Santa Clara	1,196	11	1
17	Pueblo of Santa Clara, Santa Fe National Forest	123	83	31
18	Hernandez village, rural private, Santa Fe National Forest	1,920	90	26
19	Santa Clara CDP, Española, Pueblo of San Juan	15,182	89	27
20	Pueblos of San Ildefonso, Santa Clara, and Pojoaque; Española and Santa Cruz; rural private	6,755	82	19
21	LANL; Pueblos of San Ildefonso, Pojoaque, Nambe, and Tesuque; Jaconita, Pojoaque, Nambe CDPs	4,797	71	12
22	BLM, Pueblo of Tesuque, CDP, edge of Santa Fe metro	1,076	58	11
23	BLM, rural private	1,436	52	8
24	Santa Fe National Forest, La Cienega village	327	70	10
25	Cochiti Lake, Pueblo de Cochiti	66	91	26
26	Pueblo de Cochiti, Cochiti village	886	70	19
27	Santa Fe National Forest, Pueblo of Jemez	1	100	0
28	Santa Fe National Forest, Ponderosa village	226	32	15
29	Valle Grande scenic area, Santa Fe National Forest, rural private	71	42	11
30	Santa Fe National Forest, rural private	29	41	10
31	Santa Fe National Forest, rural private	36	94	50
32	Santa Fe National Forest, rural private	23	87	35
33	Abiquiu village, Santa Fe National Forest, rural private	879	82	33
34	Medanales village, rural private	451	87	29
35	Velarde village, rural private	2,470	89	26
36	Chimayo and Truchas villages, rural private	2, 832	93	27
37	Pueblo of Nambe, Santa Fe National Forest	166	49	8

TABLE 4.7.1–1.—*Environmental Justice Areas Within a 50-Mile (80-Kilometer) Radius of LANL*-Continued

MAP SECTOR[a]	COMMUNITIES, LAND STATUS IN SECTOR	TOTAL POPULATION IN 1990	PERCENT MINORITIES	PERCENT PERSONS BELOW POVERTY LEVEL
38	Santa Fe metro, Tesuque CDP, Santa Fe National Forest	7,932	30	8
39	Santa Fe metro	62,015	53	13
40	La Cienega village, rural private	5,204	69	15
41	Pueblo de Cochiti, Pueblo of Santo Domingo; Peña Blanca village	843	97	29
42	Pueblo de Cochiti, Pueblos of Santo Domingo and San Felipe	2,906	98	32
43	Pueblos of Jemez, Zia, and Santo Domingo	159	60	21
44	Jemez Springs, Santa Fe National Forest	747	34	14
45	Santa Fe National Forest, Fenton Lake State Park, rural private	190	33	12
46	Santa Fe National Forest, rural private	44	66	30
47	Coyote and Youngsville villages, Santa Fe National Forest	231	90	45
48	Abiquiu Reservoir, Santa Fe National Forest, rural private	331	84	37
49	El Rito village, Santa Fe National Forest, rural private	887	82	32
50	Ojo Caliente and La Madera villages, Santa Fe National Forest	432	73	24
51	Dixon, Chamisa, and Vadito villages; Pueblo of Picuris	2,538	88	36
52	Las Trampas and Peñasco villages, Carson National Forest	1,699	88	33
53	Santa Fe National Forest, rural private	32	84	22
54	Santa Fe National Forest, Pecos village	2,236	79	22
55	Lamy and Glorieta villages	2,420	32	8
56	Cerrillos, Madrid, and Galisteo villages	1,230	35	16
57	Pueblo of San Felipe, rural private	345	23	12
58	Pueblos of San Felipe and Santa Ana, Bernalillo, Placitas village	3,777	76	26
59	Pueblos of Jemez, Zia, and Santa Ana	2,614	98	34
60	Pueblo of Jemez	181	41	11
61	Pueblo of Jemez, rural private	63	71	24
62	Cuba village, San Pedro Wilderness Area	752	82	33
63	Santa Fe National Forest, rural private	505	75	27
64	Santa Fe National Forest, rural private	57	72	9
65	Santa Fe National Forest, rural private	399	85	25
66	Santa Fe National Forest, rural private	223	74	46
67	Pueblo of Picuris, Talpa village, Ranchos de Taos town	2,483	77	31
68	Carson National Forest, rural private	367	89	42
69	Santa Fe National Forest, Cowles and Tererro villages	391	78	29
70	Santa Fe National Forest, rural private	377	76	27
71	San Jose and San Miguel villages, Santa Fe National Forest	411	85	42
72	Stanley village, rural private	77	23	12
73	Sandia National Forest, Cedar Crest village, rural private	2,872	21	8
74	Rio Rancho, Pueblo of Sandia, Sandia Heights village, North Albuquerque	44,293	34	8
75	Pueblo of Zia	5	60	20
76	Pueblos of Jemez and Zia	5	80	20
77	Rural Private	55	80	42

TABLE 4.7.1–1.—*Environmental Justice Areas Within a 50-Mile (80-Kilometer) Radius of LANL*-Continued

MAP SECTOR[a]	COMMUNITIES, LAND STATUS IN SECTOR	TOTAL POPULATION IN 1990	PERCENT MINORITIES	PERCENT PERSONS BELOW POVERTY LEVEL
78	La Jara, Regina villages, Jicarilla Apache	1,233	75	32
79	Gallina village, Santa Fe National Forest	260	67	18
80	Cebolla and Canjilon villages, Santa Fe National Forest	263	86	8
Totals		212,771	54	15

[a] Map sector refers to the 80 subareas within a 50-mile (80-kilometer) radius of LANL shown in Figure 4.7.1–2. The center point of the circle is in TA–53 on LANL (DOE) property.

Sources: DOC 1993, standard tape files 1 and 3, and tiger line files; data and map lines compiled and analyzed with an atlas GIS by the Bureau of Business and Economic Research at the University of Nevada, Reno, Nevada, 1995.

CDP = Census Designated Place; GIS = geographic information system; BLM = Bureau of Land Management; Metro = Metropolitan Area.

4.8 CULTURAL RESOURCES

Cultural resources are any prehistoric or historic sites, buildings, structures, districts, or other places or objects (including biota of importance) considered to be important to a culture, subculture, or community for scientific, traditional, or religious purposes, or for any other reason. They combine to form the human legacy for a particular place. The cultural resources present within the LANL region are complex because of the great diversity in the culture of the inhabitants of this region. As the structure and physical environment of the Jemez Mountains and Pajarito Plateau changed over time, cultures changed in response, as reflected in the settlement patterns and technology that evolved over time.

The early hunter-gatherers maintained a mobile society that pursued the large game of the Pleistocene era and also used the vegetation present in the region. Archaic hunter-gatherers responded to a warmer and drier climate by increasing their gathering activities and hunting smaller game. The advent of agriculture permitted leisure time for the inhabitants within the region and also allowed the specialization of labor. Along the Rio Grande and the adjacent Pajarito Plateau, American Indian Pueblo cultures developed and moved through a succession of changes in where they settled, from the mesa tops and cliff faces to finally resting on the Rio Grande floodplain (Figure 4.8–1). After the Spanish conquest, the area remained agricultural until the Pajarito Plateau became home to a science and technology center, LANL.

While not all cultural resource elements need to be preserved, those with significance require identification and preservation so that future generations may be informed and enriched by the past. The standards and criteria used for evaluating impacts to cultural resources for the SWEIS are based on the system developed for the National Register of Historic Places (NRHP), which was established by the *National Historic Preservation Act*. The NRHP is a list of architectural, historical, archaeological, and cultural sites of local, state, or national importance.

> *Traditional cultural values are often central to the way a community or group defines itself, and maintaining such values is often vital to maintaining the group's sense of identity and self respect. Properties to which traditional cultural value is ascribed often take on this kind of vital significance, so that any damage to or infringement upon them is perceived to be deeply offensive to, and even destructive of, the group that values them. As a result, it is extremely important that traditional cultural properties be considered carefully in planning; hence it is important that such properties, when they are eligible for inclusion in the NRHP, be nominated to the NRHP, or otherwise identified in inventories for planning purposes.*
>
> *Source:* NPS 1990

The cultural resources present within the LANL boundaries and the region have been classified into three categories: prehistoric, historic, and traditional cultural properties (TCPs). Information pertaining to cultural resources that occur within the LANL site boundaries or the region is presented in this section.

Cultural resource data evaluated for the SWEIS are limited to information that is known about prehistoric resources present on the LANL site, historic evidence of cultures on the LANL site, and the TCPs of both American Indian and Hispanic communities on the LANL site and the surrounding areas that may be affected by LANL operations. Information pertaining to how ongoing cultural practices within the region are related to LANL and other land that could be affected by LANL operations is

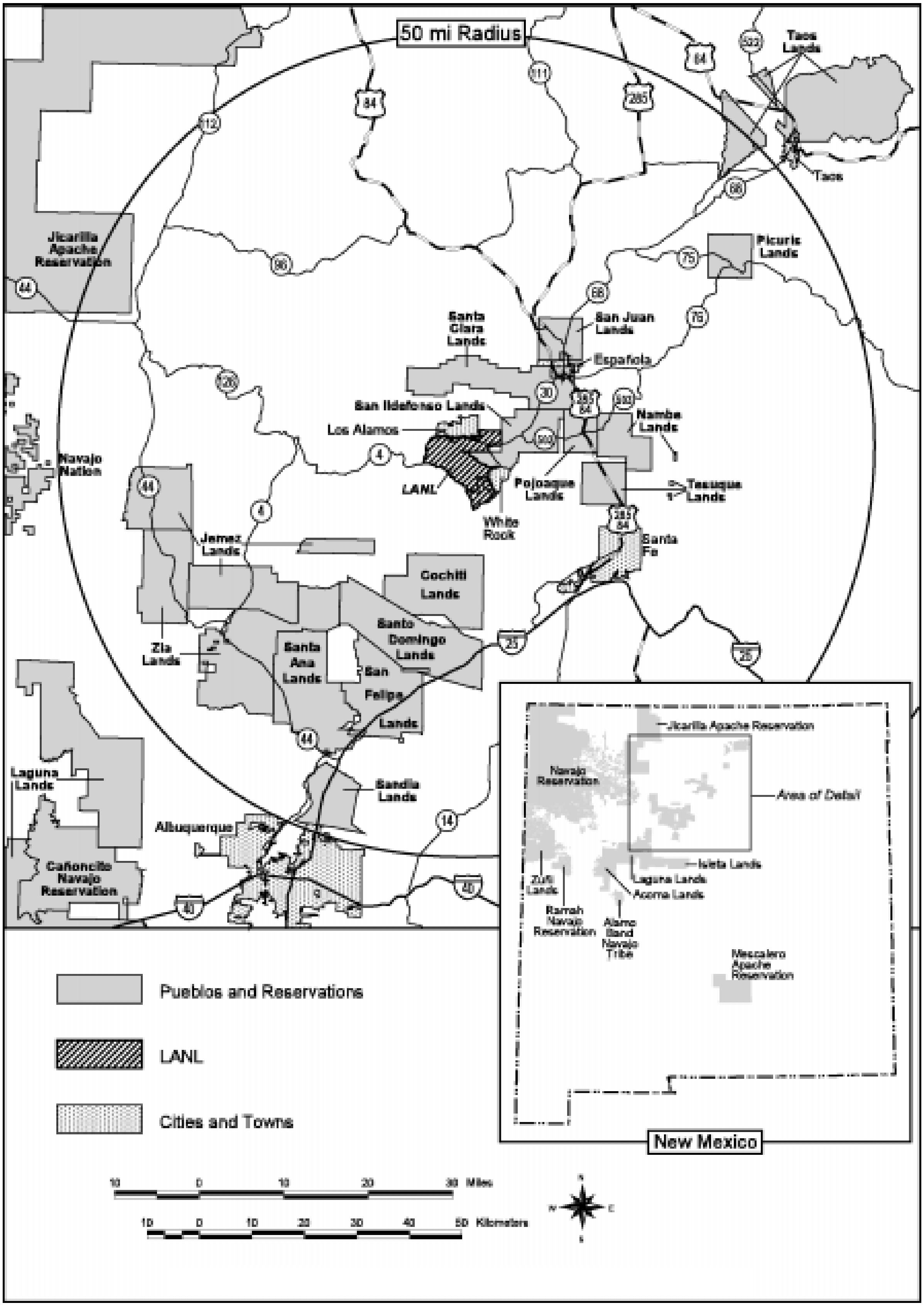


FIGURE 4.8–1.—*Pueblos and Reservations in the LANL Region*.

presented in subsection 4.8.3, Traditional Cultural Properties.

Sources used to assess the cultural resources present in the LANL region include systematic archeological surveys of cultural resources present on the LANL site that were conducted by or for DOE and recorded in the LANL cultural resource database, consultations with 23 American Indian tribal sovereign governments, consultations with Hispanic communities, and literature reviews of American Indian and Hispanic traditional cultural properties. In volume III, appendix E contains expanded discussions of previous studies of cultural resources in the LANL region, a cultural background of the LANL region, applicable regulations, methodologies used for acquiring cultural resource data and assessing impacts to cultural resources, and cultural resources management and resources within LANL boundaries.

4.8.1 Prehistoric Period

Prehistoric cultural resources refer to any material remains and items used or modified by people before the establishment of a European presence in the upper Rio Grande Valley in the early seventeenth century. Socio-historical time lines have been developed based on changes in how people lived and what they ate as reflected by the cultural material remains. Table 4.8.1–1 contains a typical classification scheme for sites in northern New Mexico.

Archeological surveys have been conducted of approximately 75 percent of the land within LANL boundaries (with 60 percent of the area surveyed receiving 100 percent coverage) to identify the cultural resources present. The majority of these surveys emphasized prehistoric American Indian cultural resources. Information on prehistoric cultural resources was obtained from the LANL cultural resources

TABLE 4.8.1–1.—*Archaeological Periods of Northern New Mexico*

PREHISTORIC PERIOD	10,000 B.C. TO A.D. 1600	CHARACTERISTIC CULTURAL EVIDENCE
Paleoindian	10,000 to 4,000 B.C.	• Bones of mammoth and bison • Stone butchering tools • Flakes and chips of stones from making stone tools • Distinctive lance-shaped projective points
Archaic	4,000 B.C. to A.D. 600	• Caves and rock shelters • Burned rock features • Scatters of tools and stone flakes and chips • Isolated hearths • End of the Archaic period (approximately A.D. 1 to 700) may have pottery, grinding stones, and charred corn
Developmental	A.D. 600 to 1100	• Ceramic storage and service vessels • Smaller projectile points reflecting the adoption of the bow and arrow • Grinding tools • Dwellings increased in size and complexity from semisubterranean pithouses to small adobe or crude masonry structures
Coalition	A.D. 1100 to 1325	• Early sites are rectangular structures of adobe and masonry with basin-shaped, adobe-lined fire pits, usually in the center of the room or against a wall • Comparatively small; pueblos average 28 rooms • Later Coalition sites contain plazas and room blocks of more than 100 rooms.
Classic	A.D. 1325 to 1600	• Large masonry structures of multiple-room blocks • For the Pajarito Plateau, three site clusters, one of which includes Navawi, Otowi, Tsankawi, and Tsirege • Associated one- or two-room isolated structures

Sources: Cordell 1979, Cordell 1984, Stuart and Gauthier 1981, Wolfman 1994, and Wendorf 1954 database, which is a listing of the cultural resources identified through surveys and excavations and recorded over the last decade. The database is organized primarily by site type and records 1,295 prehistoric sites (Table 4.8.1–2). Of the 1,295 prehistoric sites in the LANL database, 1,192 have been assessed for potential nomination to NRHP. Of these, 770 sites are eligible, 322 sites are potentially eligible, and 100 sites are ineligible. The remaining 103 sites, which have not been assessed for nomination to NRHP, are assumed to be potentially eligible until further assessment.

4.8.2 Historic Period

Historic cultural resources include all material remains and any other physical alteration of the landscape that has occurred since the arrival of Europeans in the region. The historic resources present within LANL boundaries and on the Pajarito Plateau can be attributed to three phases: Spanish Colonial, Early U.S. Territorial/Statehood, and the Nuclear Energy Period. Because of the very well-defined changes in the function of LANL, the Nuclear Energy Period is further broken into three periods: World War II/Early Nuclear Weapon Development, Early Cold War, and Late Cold War. No systematic survey has been conducted of the Historic Period resources present within LANL boundaries.

TABLE 4.8.1–2.—*Prehistoric Site Types and Number of Sites Recorded in the LANL Cultural Resources Database*

SITE TYPE	NUMBER OF SITES
Simple Pueblos	665
Complex Pueblos	62
Rock Shelters, Cavate (small cave) Pueblos	213
Rock Art	40
Water Control Features, Game Traps	56
Trails, Steps	20
Highly Eroded Pueblos, Rubble	29
Artifact Scatter, Lithic (made of stone) Scatter, Rock Rings	210
TOTAL	1,295

Sources: Cordell 1979, Cordell 1984, Stuart and Gauthier 1981, Wolfman 1994, and Wendorf 1954

Through LANL site surveys, 214 historical resources have been recorded; the remaining 2,105 resources were identified by reviewing the construction dates presented in the following LANL facility listings:

- Capital Asset Management Process Report for fiscal year 1997
- The Facility for Information Management, Analysis, and Display database
- As-built structure location maps
- The LANL ER Project decommissioning summary
- The LANL cultural resources database

The temporal phases of these historic periods, characteristic cultural evidence, number of known artifacts or sites, and eligibility for the NRHP are presented in Table 4.8.2–1, Historic Site Types and Number of Sites Recorded in the Los Alamos National Laboratory Cultural Resources Database. Numbers given are approximate because nonbuilding resources (e.g., barricades, fences, utility support structures, etc.) have not been identified and demolition actions are ongoing.

LANL is currently documenting Nuclear Energy period resources as part of a DOE-wide historic preservation program focusing on World War II and Cold War properties. This study was not completed in time for inclusion in the SWEIS.

4.8.3 Traditional Cultural Properties

A TCP is a significant place or object associated with historical and cultural practices or beliefs

TABLE 4.8.2–1.—*Historic Site Types and Number of Sites Recorded in the LANL Cultural Resources Database*

HISTORIC PERIOD	DATES	CHARACTERISTIC CULTURAL EVIDENCE	NUMBER OF KNOWN ARTIFACTS OR SITES	NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILITY
Spanish Colonial	A.D. 1600 to 1849	• Wagons • Iron hardware • Horse equipment • Pueblo V artifacts	0	
Early U.S. Territorial/ Statehood	A.D. 1850 to 1942	• European and Hispanic homesteads • Commercial ranching concerns/guest ranches: Pond Cabin, Anchor Ranch, and the Los Alamos Ranch School	87	22 sites are eligible for the NRHP. One site is also listed on the State Register of Cultural Properties.[a]
Nuclear Energy	A.D. 1943 to present			
a. World War II/ Early Nuclear Weapon Development Period	A.D. 1943 to 1948	• Original Los Alamos townsite • World War II Manhattan Project facilities where the design and manufacture of the “Trinity Site” bomb; Hiroshima bomb, “Little Boy,” and Nagasaki bomb, “Fat Man” occurred • LANL sites where all U.S. Nuclear Weapons were made from 1946 to 1950 • Common remains consist of buildings, security fences and stations, barricades, roads, and reinforced protective structures.	515	77 sites are eligible for the NRHP (1943–1956). One is also listed on the State Register of Cultural Properties.[a]
b. Early Cold War Period	A.D. 1949 to 1956	Pronounced expansion of facilities		
c. Late Cold War period	A.D. 1957 through 1989	Continued expansion of facilities	1,717	These LANL buildings have not been assessed for NRHP eligibility.
Total number of sites:			2,319	

Sources: LANL 1995a, LANL 1996h, LANL 1995c, McGehee 1995, and NMHPD 1995
[a] The Ashley Pond Cabin is listed twice because its occupation and use spans two historic periods.

of a living community that is rooted in that community's history and is important in maintaining the continuing cultural identity of the community (LAHS nd). TCPs are essential in preserving cultural identity through social, spiritual, political, and economic uses. Federal guidelines established by the NPS identify TCPs to include:

- Natural resources
- Prehistoric and historic archaeological sites
- Traditional-use areas in the cultural landscape that do not reveal evidence of human use
- A rural community whose organization, buildings and structures, or patterns of land use reflect the cultural traditions valued by its long-term residents
- An urban neighborhood that is the traditional home of a particular cultural group and that reflects its beliefs and practices
- A location where a community has traditionally carried out economic, artistic, or other cultural practices important in maintaining its historical identity (NPS 1990)

An area may have TCP significance depending upon a variety of factors such as if the site is remembered in prayers or tribal stories, if the traditional ritual knowledge of the place is passed on to other members of the community, or if traditional customs continue to be practiced by members of a community. TCPs that are considered culturally important by traditional communities include shrines, trails, springs, rivers, acequias, plant and mineral gathering areas (also referred to as ethnobotanical sites), traditional hunting areas, ancestral villages and grave sites, and petroglyphs (Harrington 1916 and Henderson and Harrington 1914). However, TCPs are not limited to ethnic minority groups. Americans of every ethnic origin have properties to which they ascribe traditional cultural value.

Within LANL's limited access boundaries, there are ancestral villages, shrines, petroglyphs, sacred springs, trails, and traditional use areas that could be identified by Pueblo and Athabascan communities as TCPs. DOE, together with the LANL Cultural Resource Management Team (CRMT), has a program in place to manage on-site cultural resources for compliance with the *Native American Graves Protection and Repatriation Act* and *American Indian Religious Freedom Act*. When an undertaking is proposed, DOE and LANL arrange site visits by tribal representatives with San Ildefonso, Santa Clara, Jemez, and Cochiti Pueblos to solicit their concerns and to comply with applicable requirements and agreements. Provisions for coordination among these four Pueblos and DOE is contained in formal agreements called Accords that were entered into in 1992 for the purpose of improving communication and cooperation among federal and tribal governments. According to the DOE compliance procedure, American Indian tribes may request permission for visits to sacred sites within LANL boundaries for ceremonies (PC 1997f).

American Indian TCPs located on lands outside LANL boundaries such as tribal lands, state lands, federally managed lands, and private lands, could potentially be affected by LANL operations. Other federal agencies that administer lands in the LANL vicinity that may have TCPs include the following:

- U.S. Forest Service—Santa Fe and Carson National Forests
- National Park Service—Bandelier National Monument
- Bureau of Land Management—Taos Resource Area

As part of the SWEIS process, a TCP study was conducted. This study involved consultations with 19 American Indian tribes and two Hispanic communities to identify cultural properties important to them in the LANL region. Contacts were made with 23 American Indian tribes; however, four chose not to participate in the consultations. All of the consulting groups stated that they had at least some TCPs present on or near LANL. Categories of TCPs identified and number of consultations identifying the presences of TCPs are summarized in Table 4.8.3–1. These resources are present throughout LANL and adjacent lands identified above. No specific features or locations were identified. A more expanded discussion of this study and its results are presented in volume III, appendix E, Cultural Resources.

Spiritual Concerns

In addition to physical cultural entities, concern has been expressed that "spiritual," "unseen," "undocumentable" or "beingness" aspects can be present at LANL that are an important part of Native American culture and may be adversely impacted by LANL's presence and operation.

4.8.4 Cultural Resource Management at LANL

Cultural resources management at LANL is handled by DOE and the LANL CRMT of the Environmental Assessments and Resource Evaluations Group of the ES&H Division. The CRMT follows the LANL compliance procedure outlined in the *LANL Cultural Resource Overview and Data Inventory 1995*. The procedure is designed to ensure DOE compliance with the *National Historic Preservation Act of 1966*; the *Archaeological Resources Protection Act of 1979*, Section 4(c); the *American Indian Religious Freedom Act*, Section 2*; Native American Graves Protection and Repatriation Act;* Executive Order 13007, Section 2(b)*; National Environmental Policy Act*; and DOE's *American Indian Tribal Government Policy* (DOE Order 1230.2). As stated, coordination of cultural resource issues with the four Accord tribes of San Ildefonso, Santa Clara, Jemez, and Cochiti is an integral part of this cultural resource compliance (chapter 7, section 7.2.4). In addition to the compliance procedure, measures are taken to provide American Indian tribes with access to information and input to the process of cultural resource management.

The DOE and LANL are active participants in the East Jemez Resource Council recently formed to foster conservation and preservation of the natural and cultural resources of the east Jemez Mountains.

A cultural resource management plan has not been prepared for LANL, although one is planned for the near future.

TABLE 4.8.3–1.—*Traditional Cultural Properties Identified by Consulting Communities on or near LANL Property*

	CEREMONIAL AND ARCHAEOLOGICAL SITES	NATURAL FEATURES	ETHNO-BOTANICAL SITES	ARTISAN MATERIAL SITES	SUBSISTENCE FEATURES
Number of Consultations Indicating the Presence of TCPs on or near LANL	15	14	10	7	8

4.9 SOCIOECONOMICS, INFRASTRUCTURE, AND WASTE MANAGEMENT

4.9.1 Socioeconomics

The geographic area most affected by changes at LANL is the region comprising Los Alamos, Rio Arriba, and Santa Fe Counties. Demographic, social, and economic conditions in these counties are described in this section, as are matters relating to local government finance, public services, and public utilities.

4.9.1.1 *Demographics*

Approximately 90 percent of LANL-affiliated employees reside in the counties of Los Alamos, Rio Arriba, and Santa Fe. This Tri-County region includes the following (LANL 1996g):

- The communities of Los Alamos and White Rock
- The cities of Santa Fe and Española
- The American Indian Pueblos of San Ildefonso, Santa Clara, San Juan, Nambe, Pojoaque, Tesuque, and part of the Jicarilla Apache Indian Reservation
- Several small villages, unincorporated communities, and widely dispersed farm and ranch holdings

The 1990 population of the region and the distribution by race and ethnicity are presented in Table 4.9.1.1–1. Projections for the region through the year 2006, based on the University of New Mexico's Bureau of Business and Economic Research estimates, are presented in Table 4.9.1.1–2 (UNM 1994).

4.9.1.2 *Regional Incomes*

In the year 1989, Los Alamos had the highest family and per capita incomes of all New Mexico counties. In fact, Los Alamos' median family income was the highest of all counties in the U.S. (DOC 1996). Income data for the LANL region are presented in Table 4.9.1.2–1.

> ***A Look Back in Time***
>
> *Around Los Alamos, the earliest known (historic) occupancy was by the summer bean farmers who came up from the valley. Bences Gonzales, who retired from his Laboratory employment in 1959 at the age of 66, recalls spending summers near Anchor Ranch (now GT site) where his father had been the first settler in 1891. His wife's grandfather, Antonio Sanchez, was the first homesteader on Pajarito Mesa (above present Pajarito site) in 1885, he recalls. Some scraggly peach trees and a tumbledown log cabin are all that are left of the old ranch. Because of unusually heavy snow the ranch was never occupied in the winter, Gonzales recalls.*
>
> *Source: LAHS nd*

In 1989, approximately 2 percent of Los Alamos County, 13 percent of Santa Fe County, and nearly 28 percent of Rio Arriba County populations lived below the poverty line. The 1989 poverty threshold was $12,674 for a family of four (DOC 1993). Since 1989, the percentage of those living below the poverty line is believed to have remained the same in Los Alamos and Santa Fe Counties and risen slightly in Rio Arriba County. The 1996 poverty threshold was $15,600 for a family of four and $7,740 for an unrelated individual (61 FR 42).

4.9.1.3 *Regional Labor Force and Educational Attainment*

The income and poverty rates for the Tri-County region are mirrored in unemployment rates, as illustrated in the regional data presented in Table 4.9.1.3–1. Unemployment rates for Rio Arriba County historically have been approximately double those for the U.S. at

TABLE 4.9.1.1–1.—*1990 Population by Race and Ethnicity for the Tri-County Region*

ALL PERSONS, RACE/ ETHNICITY	LOS ALAMOS COUNTY		RIO ARRIBA COUNTY		SANTA FE COUNTY		TOTAL	
	NUMBER	PERCENT[a]	NUMBER	PERCENT[a]	NUMBER	PERCENT[a]	NUMBER	PERCENT[a]
All Persons	18,115	100	34,365	100	98,928	100	151,408	100
Caucasian	15,467	85	4,375	13	46,450	47	66,292	44
African American	88	0.5	117	0.3	505	0.5	710	0.5
American Indian[b]	112	0.6	4,830	14	2,284	2	7,226	5
Asian/Pacific Islander	421	2	40	0.1	439	0.4	900	0.6
Hispanic of Any Race[c]	2,008	11	24,955	73	48,939	50	75,902	50
Other Races	19	0.1	48	0.1	311	0.3	378	0.3

[a] Percentages may not total to 100 due to rounding.
[b] Numbers for Aleuts and Eskimos were placed in the "other" category given their small number.
[c] In the 1990 Census, Hispanics classified themselves as White, Black, Asian/Pacific Islander, American Indian, Eskimo, or Aleut. To avoid double counting, the number of Hispanics was subtracted from each of the race categories.
Source: DOC 1991

TABLE 4.9.1.1–2.—*Tri-County Population Projections Through the Year 2006*

COUNTY	1990	1996	2001	2006	PERCENT OF CHANGE
Los Alamos	18,115	18,211	18,336	18,503	2
Rio Arriba	34,365	36,156	37,551	38,864	8
Santa Fe	98,928	111,571	122,556	134,546	21
Total Region	151,408	165,938	178,443	191,913	16

Source: UNM 1994, with linear projections for 1996, 2001, and 2006, based on prior years.

TABLE 4.9.1.2–1.—*Income Data for the LANL Region*

AREA	MEDIAN FAMILY INCOME		PER CAPITA INCOME	
	1989 $	1996 $	1989 $	1994 $
Los Alamos County	60,798	NA	24,473	29,762
Rio Arriba County	21,144	27,200	8,590	11,731
Santa Fe County	34,073	NA	16,679	22,531

NA = Not available
Sources: DOC 1993, DOC 1996, and HUD 1996

TABLE 4.9.1.3–1.—*Regional Civilian Labor Force, Employment, Unemployment, and Unemployment Rates (1995)*

COUNTY	CIVILIAN LABOR FORCE	EMPLOYED	UNEMPLOYED	UNEMPLOYMENT RATE
Los Alamos	11,005	10,792	213	1.9
Rio Arriba	17,434	15,364	2,070	11.9
Santa Fe	62,225	59,564	2,661	4.5
Tri-County Region	90,664	85,720	4,944	5.5
State of New Mexico	787,856	738,448	49,409	6.3

Source: NMDL 1996

5.6 percent and the State of New Mexico at 6.3 percent. During the past 6 years, Rio Arriba County's unemployment rates peaked in 1991 and 1992 at 14.6 percent, fell to 10.7 percent in 1994 because of new hires in the Native American casinos, and edged upward to 11.9 percent in 1995 (NMIGA 1996).

In 1990, of all counties in the nation, Los Alamos County had the highest percentage of adults 25 years and over with a bachelor's degree or higher (54 percent). The figure for the U. S. was 20 percent. Thirty-two percent of adults in Santa Fe County and 10 percent of the adults in Rio Arriba County had at least one degree. Approximately 34 percent of adults in Rio Arriba County did not have a high school diploma, compared to 17 percent of adults in Santa Fe County and 5 percent in Los Alamos County, which was the fourth lowest rate for counties in the country (DOC 1994).

4.9.1.4 *The Regional Economy*

In 1994, nearly 6,000 business establishments, government agencies, and government enterprises operated in Los Alamos, Santa Fe, and Rio Arriba Counties (OPM 1994). Collectively, these entities paid approximately $2.5 billion in wages and salaries, which was an increase of 47 percent over 1989. Of this amount, approximately $473 million, or 19 percent, was paid to the LANL work force residing in the Tri-County area. The LANL work force wage and salary data are for fiscal year (FY) 1995. The regional wage and salary data are for calendar year (CY) 1994. Detailed breakdowns of earnings are presented in Table 4.9.1.4–1 (OPM 1994).

Nearly 29 percent of the 6,000 enterprises were service businesses that employed less than 33 percent of the employed work force in the area and paid 30 percent of the earnings reported in 1993 (the principal components of earnings are proprietors' incomes and employee wages and salaries). Approximately 21 percent of the enterprises in the Tri-County area were farms and ranches, but these enterprises employed less than 2 percent of the employed work force and provided only 0.3 percent of the 1993 earnings in the area. Another 21 percent of the business and government operations in the area were retail trade establishments that employed slightly more than 17 percent of the employed work force and paid 12 percent of the earnings reported in 1993. Businesses in each of the other industry sectors were less than 10 percent of all establishments in the Tri-County area (DOC 1996).

Thirty-six percent of the nearly 6,000 sources of employment and earnings in the Tri-County area were government agencies and enterprises, including federal agencies and departments, state government, counties, cities, school districts, and tribal governments. Government

TABLE 4.9.1.4–1.—*Earnings for Tri-County Region (Thousands of Dollars)*

EARNINGS BY INDUSTRY	1989 DOLLARS	1994 DOLLARS	1989–1994 CHANGE IN DOLLARS	PERCENT CHANGE
Farm Earnings	NA	5,348	NA	NA
Private Earnings	980,135	1,571,619	591,484	60
Government Earnings	739,408	964,221	224,813	30
Federal Civilian	59,430	84,338	24,908	42
Military	5,590	6,042	452	8
State and Local	674,388	873,931	199,543	30
Subtotals	1,725,406	2,541,188	815,782	47
Earnings from Dividends, Interest, and Rents	502,429	725,709	223,280	44
Transfer Payments	293,909	464,484	170,575	58
Total Personal Income	2,349,069	3,506,728	1,157,659	49

NA = Not available
Source: DOC 1996

agencies and enterprises employed nearly 29 percent of the Tri-County workforce and paid nearly 40 percent of the total area earnings reported in 1993. Government operations and service sector businesses are clearly the dominant sectors of the economy in the region (DOC 1996).

4.9.1.5 *The LANL-Affiliated Workforce*

The LANL-affiliated work force includes employees of the prime contractor, UC, and its subcontractors, of which the major employers are Johnson Controls, Inc. (JCI), and Protection Technology Los Alamos (PTLA). LANL employs both technical and nontechnical subcontractors, as well as consultants from around the world on a temporary basis. A distribution of the LANL-affiliated work force, for which data were available by county of residence as of March 1996, is presented in Table 4.9.1.5–1. The addition of nontechnical contract labor and consultants brings the total LANL-affiliated work force to 12,837 at the end of March 1996. Race/ethnicity data for the same work force are presented in Table 4.9.1.5–2. Because student employment fluctuates greatly from month to month, students were separated from the total UC employees to better describe LANL's work force composition (LANL 1996g).

Organizational support staff and general support staff fulfill secretarial, computational, and other support functions. Race/ethnicity distribution varies greatly among the LANL UC employees' job categories, as illustrated in Table 4.9.1.5–3.

The LANL UC work force received approximately $421 million in wages and salaries in 1996. Over 97 percent of salaries were paid to employees residing in New Mexico. In the Tri-County area, approximately $267 million, or 63 percent, went to Los Alamos County; approximately $47 million, or 11 percent, went to Rio Arriba County; and approximately $77 million, or 18 percent, went to Santa Fe County. In fiscal year 1996, PTLA salaries totaled $15.5 million, and JCI salaries totaled $36.9 million. A comparison of work force to salary shares for UC employees at LANL by race/ethnicity is presented in Table 4.9.1.5–4 (OPM 1994).

TABLE 4.9.1.5–1.—*Employees of the LANL-Affiliated Work Force by County of Residence (March 1996)*

COUNTY OF RESIDENCE	NUMBER OF PERSONS EMPLOYED BY[a]:				TOTAL	PERCENT OF WORKFORCE[b]
	UC	TECHNICAL CONTRACTOR	JCI	PTLA		
Los Alamos	4,632	440	226	83	5,381	51
Rio Arriba	1,296	129	555	169	2,149	20
Santa Fe	1,443	134	300	90	1,967	19
Other NM	382	54	223	40	699	7
Total NM	7,753	757	1,304	382	10,196	96
Outside NM	366	23	8	0	397	4
Total	8,119	780	1,312	382	10,593	100
Percent of Total[b]	77	7	12	4	100	

[a] Data not available for nontechnical contractors or consultants.
[b] Percentages may not total to 100 due to rounding.
Source: LANL 1996g

TABLE 4.9.1.5–2.—*LANL-Affiliated Work Force by Race and Ethnicity*

	UC EMPLOYEES	UC STUDENT[a]	TECHNICAL CONTRACTORS	JCI EMPLOYEES	PTLA EMPLOYEES	PERCENT OF TOTAL LANL WORKFORCE[b]
Caucasian	4,734	670	418	377	102	60
Hispanic of Any Race[c]	1,746	372	176	878	269	33
African American	28	31	0	8	1	0.6
Asian/ Pacific Islander	232	75	1	4	0	3
American Indian	107	25	9	45	10	2
Unclassified	54	45	176	0	0	3
Total	6,901	1,218	780	1,312	382	100

[a] The number shown is a head count of students employed and does not reflect the number of hours worked per year.
[b] Percentages may not total 100 due to rounding.
[c] This term is used throughout section 4.9 to describe those who classify themselves as Hispanic for consistency with 1990 Census practices (see Table 4.9.1.1–1).
Source: LANL 1996g

TABLE 4.9.1.5–3.—*Percentage of University of California Employees by Race/Ethnicity (March 1996)*

CATEGORY	UNCLASSIFIED	WHITE	HISPANIC	AFRICAN-AMERICAN	ASIAN/ PACIFIC ISLANDER	AMERICAN INDIAN	TOTAL[a]
Technical Staff Members	1	86	6	0.4	6	1	100
Special Staff Members	0.5	68	29	0.4	1	1	100
Technical Support Personnel	0.4	51	45	0.5	0.06	3	100
Organizational Support	0.5	39	58	0.2	0.2	2	100
General Support	0	30	65	0.0	1	4	100
UC Total	1	67	26	0.7	1	4	100

[a] Percentages may not total 100 due to rounding.
Source: LANL 1996g

TABLE 4.9.1.5–4.—*Salary and Work Force Shares of University of California Employees by Race/Ethnicity (1986)*[a]

RACE/ETHNICITY	PERCENT OF UC WORK FORCE	PERCENT OF UC SALARIES
Unclassified	1	1
Caucasian	67	75
Hispanic of Any Race[b]	26	19
African-American	0.7	0.4
Asian/Pacific Islander	4	4
American Indian	2	1
Total[c]	100	100

[a] Work force figures are for March 1996, while salary figures are for the 1996 calendar year. The difference in the number of employees is minimal, with the maximum percentage difference by job category being 0.6 percent. Salary figures include terminated employees.
[b] This term is used throughout section 4.9 to describe those who classify themselves as Hispanic for consistency with 1990 Census practices (see Table 4.9.1.1–1).
[c] Percentages may not total 100 due to rounding.
Source: LANL 1996g

4.9.1.6 *University of California Procurement*

Data on purchase of goods and services from fiscal year 1993 to fiscal year 1995 are presented in Table 4.9.1.6–1. From a peak of $657.5 million in contracts during fiscal year 1993, overall procurement declined to $592.1 million in fiscal year 1995. New Mexico businesses and government agencies received approximately 62 percent of the dollar volume of UC purchase orders during the past three years, ranging from $406.8 million in fiscal year 1994 to $360.5 million in fiscal year 1995.

Distribution of UC procurement dollars within New Mexico counties during fiscal year 1995 is presented in Figure 4.9.1.6–1. UC spent $238 million, or 66 percent, of the contract dollars distributed within New Mexico in Los Alamos, Santa Fe, and Rio Arriba Counties; and Los Alamos County received 91 percent of that Tri-County total. Bernalillo County received the majority of the remaining 33 percent of in-state UC contract dollars.

Procurement data include temporary technical and nontechnical contract personnel. At the end of fiscal year 1995, there were 819 temporary technical contract staff and 331 temporary nontechnical contract staff working at LANL. Big business procurement data presented in Table 4.9.1.6–1 also includes the salaries of JCI and PTLA employees (LANL 1996g).

4.9.1.7 *Role of LANL in the Regional Economy*

A University of New Mexico, New Mexico State University, and DOE study of the impact of UC fiscal year 1995 operations on the economy of Los Alamos, Rio Arriba, and

TABLE 4.9.1.6–1.—*University of California Procurement for Fiscal Years 1993 Through 1995*

	FY 1993		FY 1994		FY 1995	
	DOLLAR AMOUNT	PERCENT[a]	DOLLAR AMOUNT	PERCENT[a]	DOLLAR AMOUNT	PERCENT[a]
NEW MEXICO ORDERS						
Big Business	237,883,405	59	234,988,709	58	218,234,176	61
Small Business[b]	151,657,164	38	159,236,526	40	132,763,856	37
Government and Educational Institutions	11,041,404	3	12,622,145	3	9,459,319	3
Total	400,581,973	100	406,847,380	100	360,457,351	100
OUTSIDE NEW MEXICO ORDERS						
Big Business	106,783,817	42	106,353,084	44	124,958,188	54
Small Business[b]	120,314,120	47	98,387,003	41	89,211,352	39
Government and Educational Institutions	29,778,157	12	36,040,517	15	17,476,520	8
Total	256,876,094	100	240,780,604	100	231,646,060	100
Total FY Procurement	657,458,067		647,627,984		592,103,411	

[a] Percentages may not total to 100 due to rounding.
[b] Businesses with 500 or fewer employees are classified as small businesses.
Source: PC 1995d

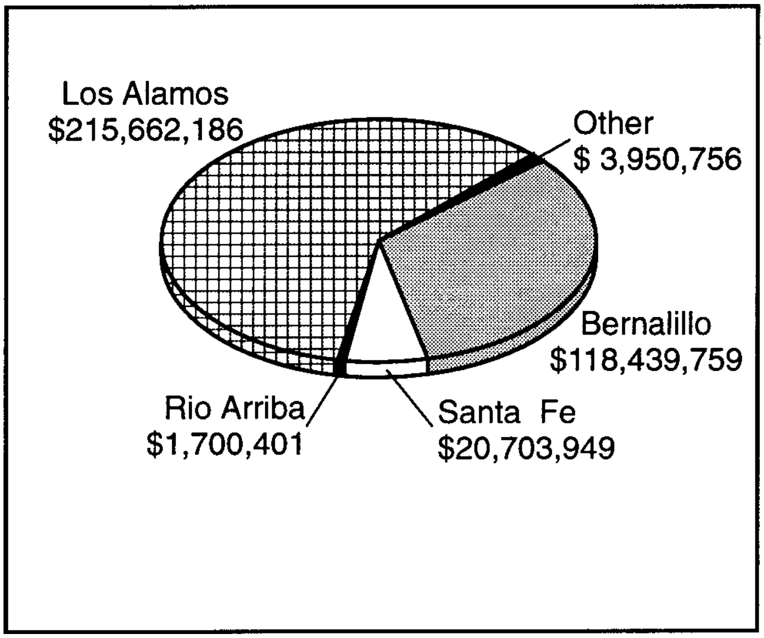


FIGURE 4.9.1.6–1.—*University of California Procurement in New Mexico Counties, Fiscal Year 1995.*

Santa Fe Counties resulted in the following conclusions (Lansford et al. 1996):

- Every 100 LANL jobs produce an additional 171 non-LANL jobs.
- $100 in LANL wages and salaries produce an additional $95 in non-LANL wages and salaries.
- $100 in LANL expenditures produce an additional $189 in non-LANL economic activity.

Multipliers are ratios of the indirect effects on the economy, for example, the number of jobs created or induced in the rest of the economy when jobs are created at LANL. Thus, if 100 jobs are created at LANL, 171 additional jobs will be created elsewhere in the economy, primarily in the Tri-County LANL region. The same logic applies to the multipliers for wages and salaries and expenditures. Using the multipliers described above, LANL directly and indirectly accounted for 27,282 jobs in these three counties, representing 32 percent of the total employment in the area during fiscal year 1995. A total of $1.03 billion in wages and salaries were directly and indirectly attributable to LANL during fiscal year 1995, representing 29 percent of total personal income in the three counties at the time. LANL's purchase of goods and services directly and indirectly accounted for a total of $3.4 billion in economic activity in the three counties, and 30 percent of the $11.35 billion total economic activity in the area during fiscal year 1995 (Lansford et al. 1996).

The new contract between the DOE and UC contains special provisions for performance over the first 2 years of the contract on regional involvement with particular emphasis on support of education, economic development, and community relations. The contract includes appendices enabling: (1) the establishment and funding of a nonprofit foundation to support education, economic development, and social services; (2) enhancing regional procurement; and (3) promoting commercialization of LANL technology.

4.9.1.8 *Community Resources and Social Services*

This subsection describes community resources and social services, primarily focusing on Los Alamos County. Discussions are centered on those resources and services that could be affected by LANL procurement policies and hiring practices, including the following:

- Local government finances
- Housing
- Public schools
- Health services
- Police protection
- Fire protection
- Utilities

Local Government Finance

LANL activities directly and indirectly account for more than a third of employment, wage and salary income, and business activity in the Tri-County LANL region. If there is a change in employment, employee incomes, or procurement at LANL, these changes will have an immediate and direct effect on city and county revenues, such as the gross receipts tax, in the Tri-County region (Lansford et al. 1996).

Municipal and county general fund revenues in the Tri-County area are presented in Table 4.9.1.8–1. The general funds of these communities support the ongoing operations of their governments as well as community services such as police protection and parks and recreation. In Los Alamos County, the fire department serving LANL and the community is funded through a separate fund derived from DOE contract payments. In addition to the general fund, most governments have separate enterprise funds for utilities and capital improvements. Enterprise funds are excluded from the tabulations in Table 4.9.1.8–2 from Los Alamos County and the cities of Española and Santa Fe, because the funds are not sensitive to changes in employment, incomes, and purchases and do not impact basic local government services (NMFMB 1996).

Revenue figures presented in Tables 4.9.1.8–1 and 4.9.1.8–3 demonstrate the heavy dependence of New Mexico communities on the gross receipts tax: a tax levied on most sales and service transactions, excluding automobiles and fuel. Gross receipts tax yields respond quickly to changes in employment, income, procurement, and construction contracting.

In recent years, retail and service sales in the Tri-County area have experienced little growth. In fact, in Los Alamos, gross receipts from retail and service sales decreased dramatically from 1993 to 1994. In the city of Santa Fe, the growth was lower than the rate of inflation. Because Santa Fe is a major regional retail trade and service center, a large state government employer, and a destination tourist location with a small industrial base, its dependence on gross receipts yield is unusually high.

Employment, salary payments, procurement, and contracting by UC are not compartmentalized by county. Therefore, a reduction in employment of LANL personnel who reside in Los Alamos and Rio Arriba Counties has an immediate effect on gross receipts tax proceeds in Santa Fe, where a high percentage of nonfood purchases are made by those employees.

Another source of general fund revenue is property taxes. This tax responds slowly to changes in regional economies, and then only in terms of delinquencies and diminished growth or expansion; effects that are felt over several years rather than immediately. Property taxes in New Mexico are limited by statute to a 5 percent annual increase on any single property.

Los Alamos County Finance

Historically, Los Alamos County and its school district have depended heavily on assistance payments from DOE for operational support.

TABLE 4.9.1.8–1.—*Municipal and County General Fund Revenues in the Tri-County Region (Fiscal Year 1995)*

REVENUE BY SOURCE	LOS ALAMOS COUNTY		RIO ARRIBA COUNTY		CITY OF ESPAÑOLA		SANTA FE COUNTY		CITY OF SANTA FE	
	$	PERCENT[a]	$	PERCENT[a]	$	PERCENT[a]	$	PERCENT[a]	$	PERCENT[a]
Property Tax	3,001,910	14	2,504,037	22	262,707	5	9,819,861	34	964,507	2
Gross Receipts Tax	10,361,829	50	663,626	6	3,930,810	72	4,233,441	15	46,986,752	79
Lodgers Tax	172,874	1	NA	NA	57,785	1	NA	NA	3,636,295	6
Others	921,854	4	205,451	2	671,746	13	1,325,943	4	3,244,930	5
Fees, Fines, Charges, Forfeits, Licenses, and Permits	2,427,527	12	132,857	1	373,620	7	1,458,675	5	3,853,266	7
Oil and Gas Taxes	NA	NA	3,319,900	30	NA	NA	NA	NA	NA	NA
Miscellaneous Income	4,033,998	19	1,306,555	12	153,686	3	1,428,134	5	1,185,088	2
Restricted Funds	NA	NA	3,091,129	28	NA	NA	10,822,381	37	NA	NA
Total Revenues	20,919,195	100	11,223,555	100	5,450,354	100	29,088,435	100	59,870,838	100

NA = Not available
[a] Percentages may not total 100 due to rounding.
Source: NMFMB 1996

TABLE 4.9.1.8–2.—*Municipal General Fund Revenues in Tri-County Region (Fiscal Year 1995)*

REVENUE BY SOURCE	LOS ALAMOS COUNTY		CITY OF ESPAÑOLA		CITY OF SANTA FE	
	ACTUAL	PERCENT[a]	ACTUAL	PERCENT[a]	ACTUAL	PERCENT[a]
Property Tax	3,001,910	14	262,707	5	964,507	2
Cigarette Tax	8,547	.04	46,811	1	136,504	.2
Franchise Tax	330,919	1	177,228	3	2,018,816	3
Gas Tax	380,737	2	362,883	7	817,992	1
Gross Receipts Tax	10,361,829	50	3,930,810	72	46,986,752	79
Lodgers Tax	172,874	1	57,785	1	3,636,295	6
Motor Vehicle Tax	200,851	1	84,824	2	271,618	.5
Total Taxes	14,457,667	69	4,923,048	90	54,832,484	92
Fee and Charges	2,113,272	10	135,315	3	2,697,675	5
Fines and Forfeits	99,939	.5	179,373	3	265,526	.4
Licenses and Permits	214,319	1	58,932	1	890,065	2
Misc. (Includes DOE Assistance to Los Alamos County)	4,033,998	19	153,686	3	1,185,088	2
Total General Fund Revenue	20,919,195	100	5,450,354	100	59,870,838	100

[a] Percentages may not total to 100 due to rounding.
Source: NMFMB 1996

TABLE 4.9.1.8–3.—*Rio Arriba and Santa Fe Counties Revenues (Fiscal Year 1995)*

REVENUE BY SOURCE	RIO ARRIBA COUNTY		SANTA FE COUNTY	
	$	PERCENT[a]	$	PERCENT[a]
Property Taxes	2,504,037	22	9,819,861	34
Oil, Gas and Mineral Taxes	3,319,900	30	NA	NA
Gross Receipts Taxes	663,626	6	4,233,441	15
Motor Vehicle Taxes	118,151	1	289,015	1
Other Taxes, Penalties and Interest	87,300	0.8	1,036,928	4
Licenses, Permits, Fees and Service Charges	132,857	1	1,458,675	5
Miscellaneous Income	1,306,555	12	1,428,134	5
Restricted Funds	3,091,129	28	10,822,381	37
Total Receipts	11,223,555	100	29,088,435	100

[a] Percentages may not total 100 due to rounding.
NA = Not available
Source: NMFMB 1996

DOE financial assistance payments to Los Alamos County and the Los Alamos School District are presented in Table 4.9.1.8–4.

DOE has agreed upon a one-time buyout from the DOE assistance programs for $22.6 million (as identified in the *Energy and Water Development Appropriations Act* of 1997). The agreement does not cover payments made to the Los Alamos School District (PC 1997a). Based upon this agreement, DOE's assistance payments to Los Alamos County ended on June 30, 1997. As of March 1998, $17.6 million of these buyout funds have been paid to Los Alamos County.

Public Schools

New Mexico is divided into 88 school districts, 4 of which are predominantly within the Tri-County area. The State Equalization Guarantee Distribution accounts for over 90 percent of operational revenue received by New Mexico's public schools (NMDE 1995a). Information regarding school district operations for the school districts within the Tri-County region is presented in Table 4.9.1.8–5.

The Los Alamos School District receives 36 percent of its funding from the federal government, over 56 percent from the State Equalization Guarantee Distribution, and 6.5 percent from local sources such as the property tax levy and surplus school space rental (PC 1995b). The district receives direct, formula-based funding from DOE in lieu of property taxes on nontaxable federal property in the district. The district also receives Public Law (PL) 874 funding in lieu of property taxes for children residing on federal land or having parents employed on federal property (PL 874). The total school budget for fiscal year 1997 is projected to be $24.5 million.

PL 874 funding for Los Alamos public schools will run through fiscal year 1998 (PL 874). The school district is not eligible for many of the federal programs that assist schools and students, because the majority of its student body is not low income. The school district is at the legal limit in its ability to raise local taxes for operational funds.

In the Los Alamos School District, enrollment increased 6.5 percent during the period of 1990 through 1995. However, enrollment for the 1996–1997 school year is projected to decrease 1.2 percent. The district owns four surplus school facilities: one it leases to DOE and the University of New Mexico at Los Alamos, and three it leases to LANL and LANL contractors. These four facilities could potentially accommodate approximately 1,275 students. Capacities differ at each school now in use, but as a whole, schools currently in use could accommodate approximately 1,560 more students in the coming years (PC 1995b and PC 1996n).

Enrollment at the Española Public School District has remained relatively stable over the past 5 years. Full-time equivalent enrollment

TABLE 4.9.1.8–4.—*DOE Payments to Los Alamos County (Fiscal Year 1997)*

RECIPIENT	DOE DOLLARS	TOTAL BUDGET DOLLARS	DOE PERCENT OF TOTAL
County Fire Department	8,349,934	8,625,965	97
County General Fund	2,600,000	19,956,702	13
School District	8,700,000	24,500,000	36
Total	19,649,934	53,082,667	37

Source: PC 1996n

TABLE 4.9.1.8–5.—*Public School Statistics in the LANL Region (1995–1996 School Year)*

DISTRICT	STUDENT ENROLLMENT[a]	TEACHERS[a]	TEACHER/ STUDENT RATIO	PER STUDENT OPERATIONAL EXPENDITURES
Los Alamos	3,606	253.8	1:14.2	$6,640
Santa Fe	12,789.5	706.1	1:18.1	$3,665
Española	5,130.0	283.5	1:18.1	$3,986
Pojoaque	1,852.5	103.5	1:17.9	$4,011
State Average			1:17.0	$4,009

[a] These are full-time equivalent figures.
Source: NMDE 1995b

for the 1996–1997 school year is projected to increase 0.6 percent. The district has the capacity to accommodate approximately 150 more students in the schools outside of the city of Española proper and 225 more students within Española. The district is planning to build a middle school in the next 5 to 10 years that will accommodate approximately 800 students (PC 1996o).

Enrollment in the Santa Fe Public School District from 1990 to the 1995–1996 school year has increased 4.1 percent. Full-time equivalent enrollment for the 1996–1997 school year is projected to increase 0.2 percent (PC 1995f).

At the Pojoaque Public School District from 1990 to the 1995–1996 school year, enrollment has increased 4.4 percent. Full-time equivalent enrollment for the 1996–1997 school year is projected to increase by 0.2 percent. The district is currently recruiting students from other districts to attend classes in Pojoaque (PC 1995f).

Housing

The 1990 housing statistics for the Tri-County region are presented in Table 4.9.1.8–6. In Los Alamos, between 1990 and the end of 1996, building permits were issued for 256 single-family units and a single rental property with 36 units. This brought the total housing inventory to 7,857 units, representing a 3.9 percent increase since 1990 (DOC 1990a). For information on land use in Los Alamos County, see section 4.1, Land Resources.

The American Chamber of Commerce Researchers Association estimated that housing costs for a middle-management household in Los Alamos were 47 percent above the national average during the third quarter of 1995 (LAEDC 1995). The median home price in Santa Fe was $179,000 in the first quarter of 1995, down from $181,062 in the first quarter of 1994. From the first quarter of 1993 to the first quarter of 1995, the number of active listings in Santa Fe County and Española increased from 947 to 1,305 (PC 1996j).

Health Services

Three hospitals serve the Tri-County region: Los Alamos Medical Center, Española Hospital, and St. Vincent Hospital in Santa Fe. These hospitals have a licensed bed capacity of 53, 81, and 268, respectively. St. Vincent Hospital is the second-busiest in the state and houses the only trauma center in the area (Ortiz 1995). The number of bed-days is a measure of the number of licensed beds at a hospital multiplied by the number of days in a year. If bed-days are compared to the number of people discharged at each hospital times the average number of days they stayed, the following use characteristics at each hospital are derived: Los Alamos,

TABLE 4.9.1.8–6.—*Regional Housing Summary for the Tri-County Region (1990)*

	LOS ALAMOS COUNTY		RIO ARRIBA COUNTY		SANTA FE COUNTY	
	NUMBER	PERCENT[a]	NUMBER	PERCENT[a]	NUMBER	PERCENT[a]
Total Housing Units	7,565	100	14,357	100	41,464	100
Occupied	7,213	95	11,461	80	37,840	91
Owner-Occupied	5,367	75	9,218	80	25,621	68
Renter Occupied	1,846	24	2,243	20	12,219	32
Vacant	352	5	2,896	20	3,624	9
For Sale Only	42	12	128	4	354	10
For Rent	101	29	326	11	927	26
Other	209	59	2,442	84	2,343	65
Median Home Value	$125,100	NA	$57,900	NA	$103,300	NA
Median Contract Rent	$403	NA	$189	NA	$422	NA

NA = Not available
[a] May not total 100 due to rounding
Source: DOC 1990a

26 percent bed-days used; Española, 32 percent bed-days used; and Santa Fe, 51 percent bed-days used. It appears that each hospital as a unit has the capacity to accommodate more patients; however, figures may differ for each section of hospital activity (PC 1995g).

The Los Alamos Medical Center and St. Vincent Hospital have signed agreements with DOE to provide facilities for treating patients from LANL in the event of an emergency or any type of accident that involves the release of radioactive materials and subsequent contamination of individuals. DOE has agreed to educate hospital personnel and provide contamination control supplies and equipment for use at the hospitals. The current agreements are reviewed annually (DOE 1994a and DOE 1994b).

Police Protection

The Los Alamos County Police Department has 39 officers and 4 detention staff with an approved fiscal year 1997 budget of $3.7 million. The police department responds to approximately 1,700 service calls monthly and is involved in various community programs. The ratio of commissioned police officers in Los Alamos County was 2.14 officers per 1,000 of population in January 1997. This is a higher level of police manpower than in Albuquerque (2.10) or Santa Fe (2.02) (Kirk 1995).

Fire Protection

The Los Alamos County Fire Department facilities and equipment are owned by DOE and operated through contract by Los Alamos County (fire department personnel are county employees). The fire department provides fire suppression, medical/rescue, wildland fire suppression and fire prevention services to both LANL and the Los Alamos County community. There are five continuously manned fire stations located on government property, including two at LANL, and a training facility at the Fire Department headquarters. An additional reserve station and training facility on DP Road may dispatch fire fighters when it is occupied.

Because of the potential severity of the consequences of a LANL emergency, the fire department has been specially trained to respond to a variety of incidents. Fire losses at LANL are reported as being far below industry expectations (BH&A 1995).

4.9.2 LANL Infrastructure and Central Services

LANL has about 8 million square feet (743,224 square meters) of structural space. Approximately 7.3 million square feet (678,192 square meters) of this total exist in 1,835 buildings, and about 0.7 million square feet (65,032 square meters) exist in 208 other structures such as meteorological towers, manhole covers, and small storage sheds. Approximately 30 percent of these buildings and structures are over 40 years old, and about 80 percent are over 20 years old. This means most structures are at the age where major building systems begin to fail and maintenance and operating costs increase.

According to the LANL's Needs and Institutional Plan (fiscal year 1997 to fiscal year 2002), administration occupies 25 percent of LANL space, and storage and services including power facilities occupy approximately 23 percent. Thus, central services and infrastructure account for almost half of LANL's structural space. These activities include:

- *Administrative/Technical Services*—facilities used for support functions that include the Director's Office, Business, Human Resources, Facilities, Security and Safeguards Division, Environment, Safety and Health Division, and communications.
- *Public/Corporate Interface*—facilities, both restricted and unrestricted, that allow public and corporate access and use. These include such facilities as the Oppenheimer Building, Bradbury Museum, and special research centers.
- *Physical Support and Infrastructure*—facilities used for physical support of other LANL facilities. These include warehouses, general storage, utilities, and wastewater treatment.

The other 52 percent of LANL space is occupied by a wide variety of laboratories, fabrication facilities, production and testing facilities, and other structures dedicated to research and development.

4.9.2.1 *Utilities*

Ownership and distribution of utility services are split between DOE and Los Alamos County. DOE owns and distributes most utility services to LANL facilities, and the county provides these services to the communities of White Rock and Los Alamos. DOE also owns and maintains several main lines for electrical, natural gas, and water distribution located throughout the town's residential areas. The County Department of Public Utilities taps into these main lines at a number of locations and owns and maintains the final distribution systems.

Utility systems at LANL include electrical service, natural gas, steam, water, sanitary wastewater, and refuse. Electrical service includes DOE ownership of a 115-kilovolt power transmission line from the Norton substation, a steam/power plant at TA–3 used on a as-needed basis. Secondary power consists of approximately 34 miles of 13.2-kilovolt distribution lines connecting to the input side of low-voltage transformers at LANL facilities. The natural gas system includes a DOE-owned high-pressure main and distribution system to Los Alamos County and pressure reducing stations at LANL buildings. Steam systems include generation and distribution at TA–3 and TA–21. The water system includes supply wells, water chlorination, pumping stations, storage tanks, and distribution systems. Sanitary wastewater systems include septic tanks and a new centralized sanitary wastewater collection system and treatment plant. Refuse collection and disposal is handled by the Support Services Subcontractor and combined with refuse from Los Alamos County in a DOE-owned, Los Alamos County managed landfill.

Gas

Los Alamos County purchases natural gas from Meridian Oil Company in the San Juan Basin of northwestern New Mexico. DOE independently purchases gas through a DOE–DoD Federal Defense Fuels Procurement. DOE currently owns the main gas supply line to Los Alamos and customers in Española, Taos, and Red River areas (PNM 1996). DOE has agreed to sell this line to Public Service Company of New Mexico (PNM). Figure 4.9.2.1–1 reflects the existing natural gas lines and distribution system in the region near LANL.

The county and LANL both have delivery points where gas is monitored and measured. In 1994, the county used approximately 946,000 decatherms of gas compared to the 1.682×10^6 decatherms used by LANL (DOE 1995f and JCUS 1996). About 80 percent of the gas used by LANL was used for heating (both steam and hot air). The remainder was used for electrical generation. The electrical generation was used to fill the difference between peak loads and the electric contractual import rights.

An increased demand for electricity could be accommodated by modifying (e.g., increasing the capacity) the electric power transmission system or by burning natural gas to generate additional electric power. Portions of the existing gas distribution system are 47 years old, and will require modification and upgrades in the future to support the latter option. For example, a second full-capacity border station and an upgrade to the existing 4-inch (10-centimeter) gas line on East Jemez Road would be needed. There is only one full-capacity border station at present on the distribution system.

As shown in Table 4.9.2.1–1, LANL burns natural gas to generate steam to heat buildings at three technical areas (TA–3, TA–16, and TA–21). The use of gas to produce steam remained relatively constant over the 5 years from 1991 to 1995. Peak use occurred in 1993 when the TA–3 steam/power plant used about 775,000 decatherms of gas to generate steam and about 412,000 decatherms of gas to generate electricity. The low-pressure steam is supplied to the TA–3 district heating system and the electricity is routed into the power grid. The TA–3 steam distribution system has about 5.3 miles (8.5 kilometers) of steam supply and condensate return lines. Most of the condensate return lines are old and corroded, resulting in the loss of up to 20 million gallons per year (7.5708×10^7 liters per year) of treated condensate. In addition, operation and maintenance costs for the district heating system (supplying steam heat) are three to four times that of natural gas at about $5 million per year. Without upgrades, these costs will increase dramatically.

The gas use at the TA–16 and TA–21 steam plants is smaller than that at the TA–3 power plant. In addition, the TA–16 district heating system has been replaced by small natural-gas-fired distributed heaters and boilers under a shared savings contract by JCI. Using 1993 data, gas consumption at the old TA–16 steam plant was about 336,500 decatherms, and gas consumption at the TA–21 steam plant was 81,500 decatherms.

Electricity

In the year 1985, DOE and Los Alamos County formally agreed to pool their electrical generating and transmission resources and to share bulk power costs based on usage. The Electric Resource Pool (the Pool) currently provides bulk electricity to LANL and customers within the communities of White Rock and Los Alamos, as well as BNM. Pool resources currently provide 72 to 94 megawatts (contractually limited to 72 megawatts during

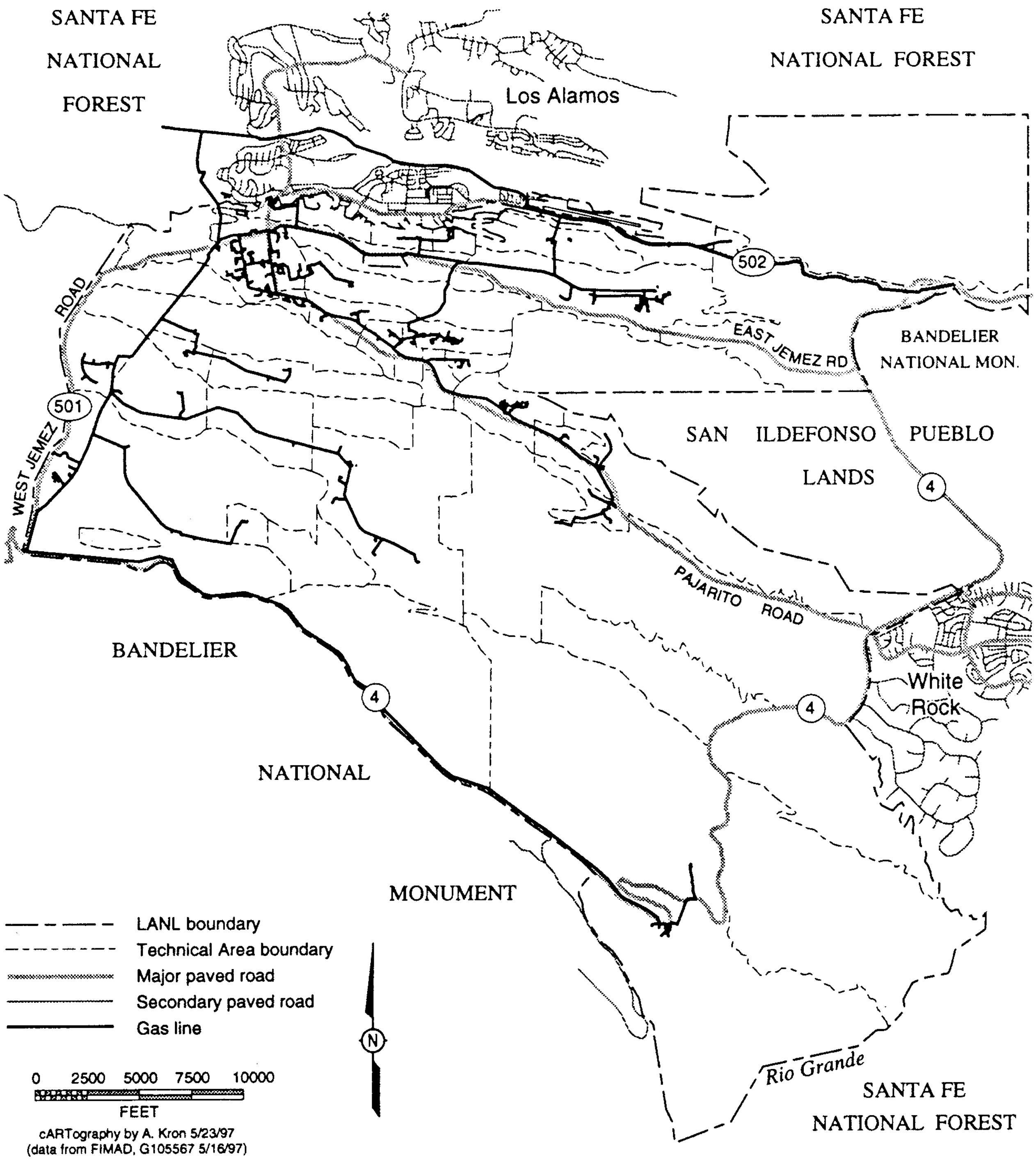


FIGURE 4.9.2.1–1.—*Los Alamos Area Natural Gas Distribution System.*

TABLE 4.9.2.1–1.—*Gas Consumption (Decatherms) at LANL (Fiscal Years 1991 to 1995)*

	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995
Total LANL Consumption	1,480,789	1,833,318	1,843,936	1,682,180	1,520,358
Total Used for Electric Production	64,891	447,427	411,822	242,792	111,908
Total Used for Heat Production	1,415,898	1,385,891	1,432,113	1,439,388	1,408,450
TA–3 Steam Production	471,631	387,421	774,750	719,769	583,229
TA–16 Steam Production	252,916	282,206	336,543	314,430	328,332
TA–21 Steam Production	78,621	74,673	81,510	60,613	65,026
Total Steam Production	803,168	744,300	1,192,803	1,094,812	976,587

Source: Rea 1997

winter months, when El Vado and Abiquiu hydroelectric output is negligible, and to about 94 megawatts during the spring and early summer months) from a number of hydroelectric, coal, and natural gas power generators throughout the western U.S. Excess power is sold by the Pool to other area power utilities. Power delivered to the Pool is limited by the two existing regional 115-kilovolt transmission lines owned by PNM and Plains Electric Generation and Transmission Cooperative. The two 115-kilovolt electric power transmission lines come to the Bernalillo-Algodones substation near Albuquerque and the Norton substation near White Rock. Many northern New Mexico communities, including Santa Fe and Española, also receive power from these substations (PNM nd). Figure 4.9.2.1–2 reflects the current electrical power distribution system in the LANL area. On-site electric generating capacity for the Pool is limited to the existing TA–3 steam/power plant, which has an operating capacity of 12 megawatts in the summer and 15 megawatts in the winter (LANL 1997d).

Table 4.9.2.1–2 and Table 4.9.2.1–3 show peak demand and annual use of electricity for fiscal years 1991 to 1995. Usage by LANL ranged from about 352,000 megawatt-hours (fiscal year 1994) to about 382,000 megawatt-hours (fiscal year 1992). Most of this fluctuation was a result of power consumption by LANSCE. Peak demand declined from about 76,000 kilowatts in fiscal year 1991 to about 66,000 kilowatts in fiscal year 1995. Again, this reduction is attributable to the decline in power demand at LANSCE.

The existing electric transmission system has been evaluated and found to be deficient in a study conducted by technical representatives of PNM, Plains Electric, and the Pool. An operating plan for improved load monitoring, equipment upgrades and optimization of some available power sources has been discussed. The plan, if implemented, would be intended to minimize exposure to complete loss of service (LM&A 1994).

Historically, off-site power system failures have disrupted operations in LANL facilities. Therefore, all facilities that require safe

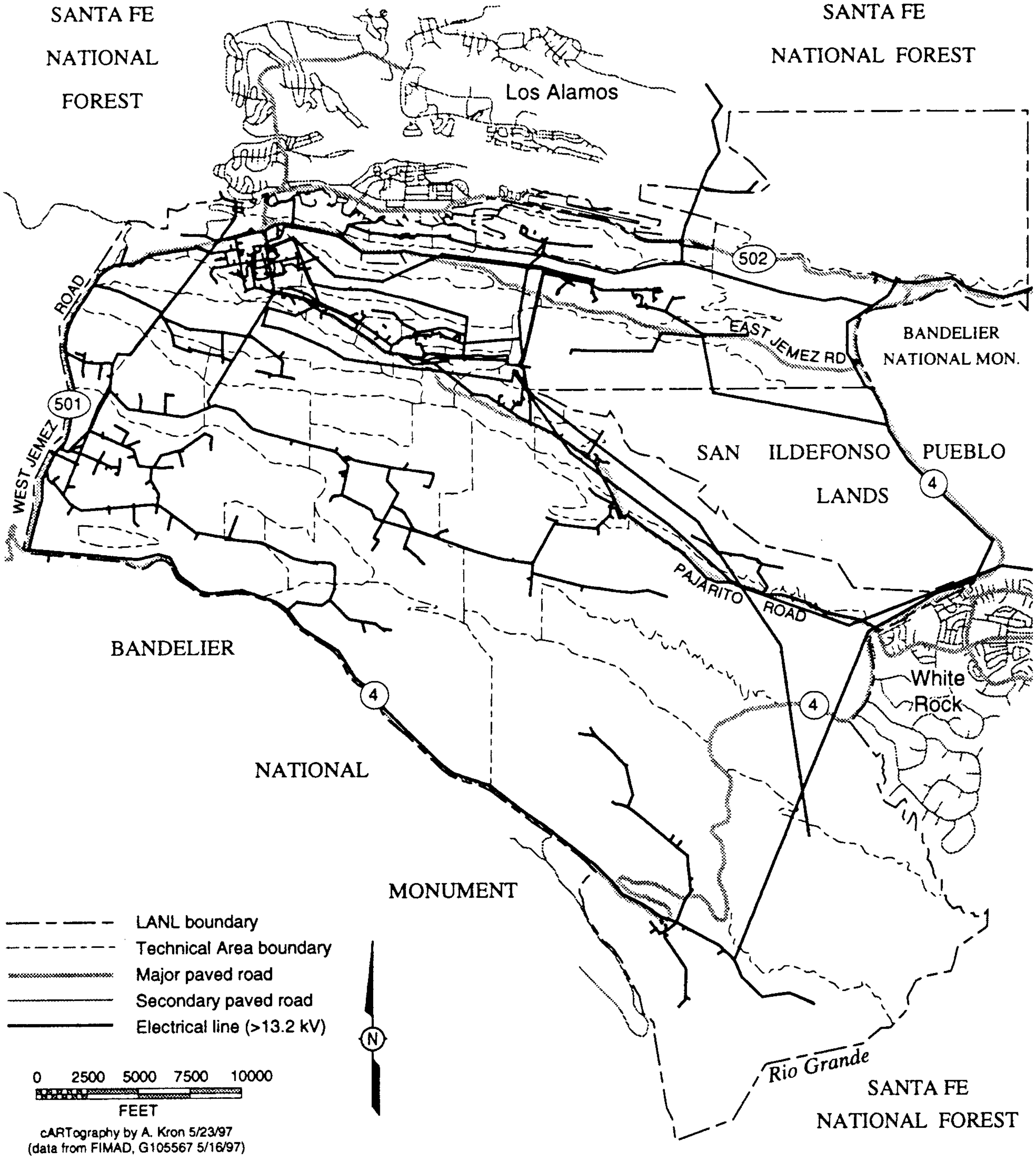


FIGURE 4.9.2.1–2.—*Los Alamos Area Electrical Power Distribution System*.

TABLE 4.9.2.1–2.—*Electric Peak Coincidental Demand (Kilowatt) (Fiscal Years 1991 to 1995)*

FISCAL YEAR	LANL BASE	LANSCE	LANL TOTAL	COUNTY TOTAL[a]	POOL TOTAL
1991	43,452	32,325	75,777	11,471	87,248
1992	39,637	33,707	73,344	12,426	85,770
1993	40,845	26,689	67,534	12,836	80,370
1994	38,354	27,617	65,971	11,381	77,352
1995	41,736	24,066	65,802	14,122	79,924

Source: Rea 1997
[a] Includes communities of Los Alamos, White Rock, and Bandelier National Monument.

TABLE 4.9.2.1–3.—*Electric Consumption (Megawatthour) (Fiscal Years 1991 to 1995)*

FISCAL YEAR	LANL BASE	LANSCE	LANL TOTAL	COUNTY TOTAL[a]	POOL TOTAL
1991	282,994	89,219	372,213	86,873	459,086
1992	279,208	102,579	381,787	87,709	469,496
1993	277,005	89,889	366,894	89,826	456,720
1994	272,518	79,950	352,468	92,065	444,533
1995	276,292	95,853	372,145	93,546	465,691

Source: Rea 1997
[a] Includes communities of Los Alamos, White Rock, and Bandelier National Monument.

shutdown capability for power outages are equipped with emergency generators to assure these needs are met. This includes nuclear facilities such as TA–55 and CMR, which require uninterrupted power for critical ventilation, control systems, and lighting.

The TA–3 steam/power plant currently provides the additional electric power needed to meet peak load demands when demand exceeds the allowable supply, delivered by two 115-kilovolt transmission lines. When electric power generation is required, steam generation is increased (additional gas is burned), and the extra steam is routed to three steam turbines for power generation. Typically, this occurs for only a few months out of the year when LANSCE is fully operational. Loss of power from the regional electric distribution system results in system isolation where the TA–3 steam/power plant is the only source of sufficient capacity to prevent a total blackout. The TA–3 steam/power plant is over 40 years old, and various upgrades of the steam turbine generators, battery banks, circuit breakers, metering, and power generation controls are needed. In addition, though the steam/power plant has a design capacity of 20 megawatts, the existing cooling system (composed of low-pressure steam condensers, pumps, valves and piping) limits the generating capacity to 14 megawatts.

The majority of LANL's 120-mile (200-kilometer) 115/13.8-kilovolt transformers, switchgear, and 13.8-kilovolt overhead electrical distribution system are past or nearing the end of their design life. Backup and replacement transformers and their ancillary equipment are needed to increase system reliability because of the increasing likelihood of component failure and the fact that many components are no longer readily available. Most of LANL's 480/277-volt and 208/120-volt systems would fall below industry reliability standards if used to supply additional power. In addition, the TA–3 substation requires an additional thyristor switched capacitor to maintain system stability during lightening storms. Finally, about 18.6 miles (30 kilometers) of 40-year-old underground cables and 13.8-kilovolt switchgear will require replacement within the next 10 years.

Water

DOE currently supplies potable water to all of the county, LANL, and BNM, and supplies some nonpotable water to LANL for industrial use. DOE has rights to withdraw 5,541.3 acre feet or about 1,806 million gallons (6,830 million liters) of water per year from the main aquifer. In addition, DOE obtained the right to purchase 1,200 acre feet or about 391 million gallons (1.48 billion liters) of water per year from the San Juan-Chama Transmountain Diversion Project in 1976. Although these San Juan-Chama water rights exist, no delivery system is in place, and DOE has no plans at this time to exercise this right (PC 1996c).

Potable water is obtained from deep wells located in three well fields (Gauje, Otowi, and Pajarito). This water is pumped into production lines, and booster pump stations lift this water to reservoir storage tanks for distribution. Figure 4.9.2.1–3 shows the existing water distribution system in the area near LANL. The entire water supply is disinfected with chlorine prior to distribution. DOE potable water production system consists of 14 deep wells, 153 miles (246 kilometers) of main distribution lines, pump stations, storage tanks, and 9 chlorination stations. DOE is currently negotiating with Los Alamos County for possible transfer of most of this system to county ownership. Los Alamos County already owns and maintains the distribution system for the communities of Los Alamos and White Rock (PC 1996e).

Portions of the LANL water system have been in place for about 50 years, including pressure reducing valves, block valves, hydrants, and 8,400 feet (2,600 meters) of transite asbestos fiber piping. In addition, another 30 miles (48 kilometers) of distribution piping is near the end of its useful life and needs replacement.

During fiscal year 1994, DOE withdrew 1,450 million gallons (5,490 million liters) from the aquifer. The county used about 66 percent of this total or about 958 million gallons (3.6 billion liters) (Westervelt 1995 and LAC 1995). The National Park Service used about 5 million gallons (19 million liters) for Bandelier, Tsankawi and Ponderosa Camp Grounds (LANL nd), and the remainder, approximately 487 million gallons (1,843 million liters), was used by LANL. (For more information on the potable water supply and quality see section 4.3.2, Groundwater Resources.)

Nonpotable water is supplied to the TA–16 steam plant from the Water Canyon Gallery. This system consists of about 1 mile (1.6 kilometers) of water line and a catchment basin improvement to a spring. In 1994, this gallery produced about 12 million gallons (45 million liters) of water.

4.9.2.2 *Safeguards and Security*

Safeguards and security operations are conducted at LANL to provide protection of national security interests, proprietary information, personnel, property and the general public. Items needing physical protection include special nuclear material (SNM), vital equipment, sensitive information, property, and facilities. Physical protection strategies are based on a graded approach utilizing threat analysis, risk assessments, and cost benefit analysis.

The Safeguards and Security Management Program provides support to LANL operations

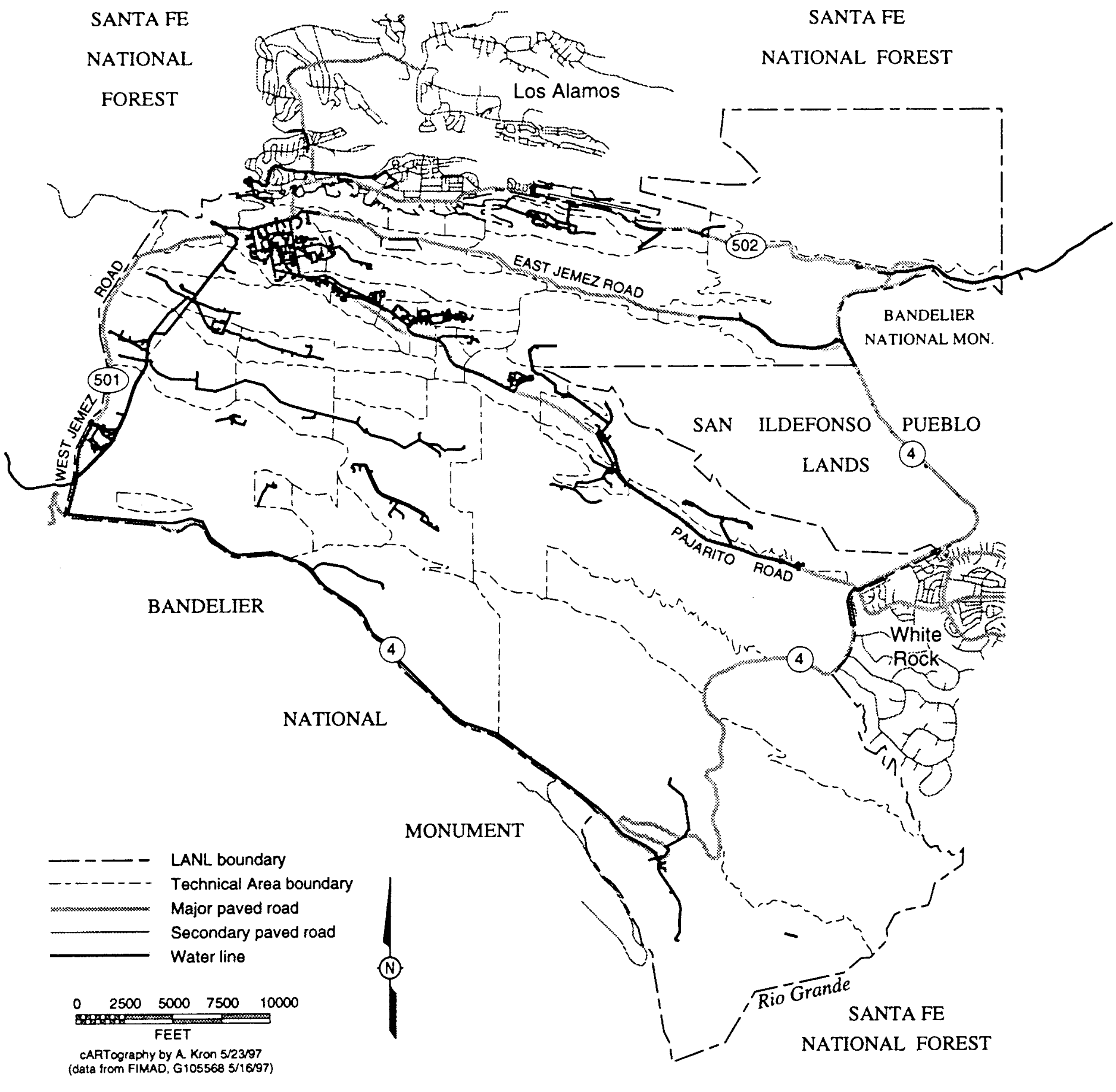


FIGURE 4.9.2.1–3.—*Los Alamos Area Water Distribution System.*

and includes the issuing and use of DOE identification badges with clearance levels and special access authorizations as well as physical security, including protective forces and electronic systems, nuclear material control and accountability, property protection, personnel security assurance, computing and communications, and personnel/information security. Some elements of this program were the subject of public interest during the SWEIS public scoping meetings; due to this interest, information security, material security, and the role of the protective force are explained further below.

Information Security

Some information at LANL is classified and requires protection because of national security interests. Information generated and received is reviewed to determine the proper level of classification, the extent to which the information may be disseminated, and the extent to which the information must be protected. Safes and vaults are used to protect sensitive, classified, or proprietary information. Persons wishing to use this information must have the appropriate level of DOE security clearance and a legitimate need for access to the information (referred to as "need to know"). Personal information about salaries, performance evaluations, and medical conditions, including radiation exposures, are also protected in accordance with laws intended to protect the privacy of individuals.

Material Security

At all DOE sites, including LANL, nuclear materials are controlled by a materials control and accountability program to deter, prevent, detect, and respond to unauthorized use, possession, or sabotage of these materials by employees or the public. This system provides:

- Real-time tracking of nuclear material movements
- A database for tracking inventories and providing transaction audit trails (including records of material movement internal to LANL and between LANL and other sites)
- Early detection of inventory inconsistencies (e.g., the form, location, and quantity of material)
- A variety of material measurement capabilities, including a formal program to monitor the performance of measurement equipment and to ensure measurement equipment is operating effectively

Access controls, materials surveillance procedures and physical containment (alarms, barriers, and guards) are determined based on the quantity and form of the material. Employee background checks and human reliability programs are used to screen personnel who have access to these nuclear materials. In addition, LANL organizations that have and use nuclear materials are required to maintain records of quantities and locations of these materials and provide for their safe storage.

Guard Force

LANL maintains a guard force through the services of PTLA. PTLA provides patrols of LANL properties, protection and escort for dignitaries, on-site demonstration containment, traffic and hazardous materials spill support in emergencies, and general plant security services. PTLA coordinates its activities with other DOE, local, state, and federal law enforcement offices as appropriate.

In cases where criminal activity has occurred (e.g., theft or vandalism), LANL contacts the appropriate law enforcement agency (in most cases it is the Los Alamos County Police Department, see section 4.9.1.8 for additional information). When appropriate, LANL also notifies the Federal Bureau of Investigation and the DOE Inspector General.

4.9.2.3 *Fire Protection*

LANL's fire protection program ensures that personnel and property are adequately protected against fire or related incidents, as described in section 4.6.3.3.

4.9.3 Waste Management

4.9.3.1 *Wastewater Treatment and Effluent Reduction*

LANL has three primary sources of wastewater: sanitary liquid wastes, HE-contaminated liquid wastes, and industrial effluent.

Sanitary Liquid Wastes

Sanitary liquid wastes are delivered by dedicated pipelines to the SWSC plant at TA–46. The plant has a design capacity of 600,000 gallons (2.27 million liters) per day, and in 1995 processed a maximum of about 400,000 gallons (1.5 million liters) per day (PC 1996l). Some septic tank pumpings are delivered periodically to the plant for treatment via tanker truck. Sanitary waste is treated by an aerobic digestion process (i.e., a digestion process which utilizes living organisms in the presence of oxygen). After treatment, the liquid from this process is recycled to the TA–3 power plant for use in cooling towers or is discharged to Sandia Canyon adjacent to the power plant under an NPDES permit and groundwater discharge plan. Under normal operating conditions, the solids from this process are dried in beds at the SWSC plant and are applied as fertilizer as authorized by the existing NPDES permit.

According to the LANL Utilities and Infrastructure Group, the TA–3 sewer lines between Pajarito Road and Diamond Drive and between Diamond Drive and the SWSC connection are 40 years old, and the current capacity is 58 to 68 percent of the original capacity due to deterioration and infiltration. In addition, the S-Site wastewater collection system is also 40 years old and repair or replacement of 12,000 feet (3,600 meters) of this line is also needed.

In addition to the SWSC, there are also 36 approved septic systems still in use at facilities located in 16 TAs (PC 1996l).

Separate from the LANL sanitary waste treatment system, Los Alamos County sanitary waste is processed at two separate facilities. The Bayo Canyon facility processes sewage from the Los Alamos townsite and the DOE Los Alamos Area Office building. This facility has a design capacity of 1.37 million gallons (5.2 million liters) of waste per day and in 1996 was processing approximately 0.9 million gallons (3.4 million liters) per day. The White Rock sewage treatment facility processes sewage from the White Rock community and has a design capacity of 0.82 million gallons (3.1 million liters) per day. In 1996, the facility processed about 0.5 million gallons (1.9 million liters) per day (PC 1996l).

High Explosives Contaminated Liquid Wastes

Wastewater contaminated with high explosives (HE wastewater) is generated at LANL. DOE is currently installing the equipment necessary to filter and recycle this HE wastewater. These actions are being taken to improve wastewater management from HE research and development and meet current and new regulatory standards for wastewater discharge. In addition to the new equipment, existing equipment is being modified by replacing water-sealed vacuum pumps and wet HE collection systems with systems that do not use water. When these modifications are completed, they are expected to reduce the amount of water used in HE processing (currently about 130,500 gallons [493,995 liters] per year) by approximately 99 percent.

To process the HE wastewater, solvents will be extracted at the existing processing facility (TA–16). Then, the HE wastewater will be filtered and recycled using the new equipment (located in an adjacent facility); HE wastewater will be trucked, as needed, to the HE Wastewater Treatment Facility (HEWTF). The HEWTF further treats the wastewater through filtering and then discharges to an NPDES-permitted outfall. The reader is referred to DOE–EA–1100 for a detailed description of the wastewater treatment system upgrade and impacts associated with its installation and use (DOE 1995c).

Sources of non-HE industrial wastewater are being eliminated from the HE processing areas. Outfall piping is being decontaminated (the HE removed), and stormwater will be allowed to discharge through these decontaminated pipes.

Industrial Effluent

DOE has decided to eliminate the effluent from several industrial outfalls at LANL to comply with new regulatory requirements and the discharge limitations specified in LANL's NPDES permit (section 4.3.1.3). The reader is referred to DOE/EA–1156 for a detailed description of the activities being undertaken and for an evaluation of consequences (DOE 1996a). Information regarding these effluents and their relationship to wetlands in the area is discussed in sections 4.3 and 4.5.

4.9.3.2 *Solid Waste*

Both LANL and Los Alamos County use the same county landfill located on DOE property. The Española area solid waste disposal site has been closed. Los Alamos has also contracted with Española to receive selected waste from that community. The Los Alamos landfill received about 22,013 tons (20 million kilograms) of solid waste from all sources during the period of July 1995 through June 1996, with LANL contributing about 22 percent, the city of Española contributing about 32 percent, and Los Alamos County contributing about 46 percent of the solid waste. At the current rate of input, the anticipated life of the landfill is estimated to be about 18 years (Zimmerman 1996).

4.9.3.3 *Radioactive and Hazardous Waste*

LANL generates radioactive and hazardous waste as a result of operations, as well as maintenance and construction activities. Annual waste generation rates have varied due to the level of operations at the various facilities, suspension of operations at various times in these facilities, construction activities, changes in the types of operations, and implementation of waste minimization initiatives. Waste generation across the key facilities was examined from 1990 through 1995; those years during this period that had atypical interruptions or operations were ignored, and the remaining years were used to establish an average waste generation rate for use as the "baseline" generation rate. Waste generation rates for the non-key facilities were averaged for the period from 1990 through 1995 for use as baseline for these facilities. Table 4.9.3.3–1 shows the range of waste generation rates over these periods by facility and the "baseline" generation rates used for the purposes of waste projections. (The baseline used for each waste type, by facility, is identified in the tables presented in section 3.6.)

Radioactive liquid waste generation is not measured at all facilities; therefore, the amounts received historically at TA–50 (section 2.2.2.14) were examined. These influents indicated a waste generation range of between 16.5 and 21.9 million liters per year, with an index of 20 million liters per year.

In addition to the waste generation rates presented in this section, LANL has a backlog of previously generated waste that is being

TABLE 4.9.3.3–1.—*Historical Waste Generation Ranges and Annual Baseline[a] Generation Rates at LANL (1990 Through 1995)*

FACILITY	TECHNICAL AREAS	CHEMICAL WASTE[b] (kilograms)		LOW LEVEL WASTE (cubic meters)		MIXED LOW LEVEL WASTE (cubic meters)		TRANSURANIC WASTE (cubic meters)		MIXED TRANSURANIC WASTE (cubic meters)	
		RANGE	BASELINE	RANGE	BASELINE	RANGE	BASELINE	RANGE	BASELINE	RANGE	BASELINE
Plutonium Facility Complex[c]	TA–55	2,363 - 8,685	4,200	308 - 630	590	2 - 39	11	29 - 88	84	2 - 30	25
Tritium Facilities	TA–16 and 21	119 - 3,713	1,100	20.06 - 64.04	40	0.7 - 6.27	2	NA	NA	NA	NA
Chemical and Metallurgy Research Building	TA–3	1,818 - 6,488	4,760	243 - 1,453	781	1.0 - 11.2	5.1	0.2 - 51.0	14.9	2.2 - 13.3	6.5
Pajarito Site	TA–18	361 - 4,856	2,000	11 - 218	71	0 - 3.72	0.75	NA	NA	NA	NA
Sigma Complex	TA–3	2,626 - 7,517	2,800	118 - 640	220	0.0 - 14.2	1	NA	NA	NA	NA
Materials Science Laboratory (MSL)[d]	TA–3	0 - 298	300	0	0	0 - 1	0	NA	NA	NA	NA
Target Fabrication Facility	TA–35	748 - 4,171	1,900	0.0 - 11.9	5	0.0 - 0.17	0.2	NA	NA	NA	NA
Machine Shops	TA–3	21,771 - 107,641	23,700	17 - 150	20	0.06 - 10.25	3.3	NA	NA	NA	NA
High Explosive Processing Facilities	TA–8, TA–9, TA–11, TA–16, TA–28 and TA–37	10,676 - 105,285	9,200	0 - 44	6	0.0 - 17.2	0.2	NA	NA	NA	NA
High Explosive Testing Facilities	TA–14, 15, 36, 39, 40	3,221 - 68,497	23,900	45 - 110	80	0.0 - 0.2	0.1	NA	NA	NA	NA
Los Alamos Neutron Science Center	TA–53	2,368 - 27,557	16,600	51 - 468	100	0.3 - 7.7	1[e]	NA	NA	NA	NA
Health Research Laboratory (HRL)[f]	TA–43	4557 - 15,250	4,900	7.99 - 85.7	23	0.01 - 2.73	0.42	NA	NA	NA	NA
Radiochemistry Laboratory	TA–48	542 - 12,573	2,000	97 - 903	150	0.07 - 17.0	2	NA	NA	NA	NA

TABLE 4.9.3.3–1.—*Historical Waste Generation Ranges and Annual Baseline*[a] *Generation Rates at LANL (1990 Through 1995)*-Continued

FACILITY	TECHNICAL AREAS	CHEMICAL WASTE[b] (kilograms)		LOW LEVEL WASTE (cubic meters)		MIXED LOW LEVEL WASTE (cubic meters)		TRANSURANIC WASTE (cubic meters)		MIXED TRANSURANIC WASTE (cubic meters)	
		RANGE	BASELINE	RANGE	BASELINE	RANGE	BASELINE	RANGE	BASELINE	RANGE	BASELINE
Radioactive Liquid Waste Treatment Facility[g]	TA–50 and 21	92 - 4,400	2,200	120 - 180	150	8 - 68	38	0 - 11	3	0	0
Solid, Radioactive and Chemical Waste Treatment, Storage, and LLW Disposal Facilities[g]	TA–54 and 50	18,000 - 160,000	110,000	28 - 150	88	1 - 65	3	0 - 33	27	0	0
Non-Key Facilities		375,000-1,062,000	651,000	173 - 1,416	520	1.1 - 117	30		0		0
Grand Total[h]			860,600		2,840		98		129		31.5

Source: LANL 1996b

NA indicates that this facility did not routinely generate these types of waste.

[a] The index for waste generation for each key facility is provided in chapter 3 (section 3.7).

[b] The chemical waste numbers reflect waste that exhibits a hazardous characteristic (ignitability, corrosivity, reactivity, or toxicity); is listed as a hazardous waste by EPA, is a mixture of listed hazardous waste and solid waste; or is a secondary waste associated with the treatment, storage, or disposal of a hazardous waste. This includes waste that is subject to regulation under RCRA, as well as PCB waste and asbestos waste regulated under the *Toxic Substances Control Act* (TSCA). This waste type also includes biomedical waste.

[c] The TA–55 TRU and mixed TRU index was established as 1988 through 1990, because the activities during this period that generate TRU and mixed TRU waste most closely approximate the level of activity defined in the No Action Alternative. Since that period, generation of these wastes has been substantially lower. The generation rates for 1988 to 1990 are included in the ranges presented for TRU and mixed TRU waste.

[d] MSL has generated relatively low quantities of waste, and its waste generation history is not maintained on the Waste Management database. Historical generation average values were provided by the Waste Coordinator for this facility.

[e] No index was established for low-level radioactive mixed waste (LLMW). The LLMW moratorium in the mid 1990's caused changes in operations and procedures such that no more that 1 cubic meter of LLMW is expected under any of the alternatives (this is consistent with the LLMW generation from 1993 to 1995).

[f] HRL generates biomedical waste, a subcategory of the chemical waste category shown in this table, and has since 1992. The HRL generated biomedical waste is from 18 kilograms to 705 kilograms. The index value used for biomedical waste generation is 130 kilograms.

[g] These facilities provide for storage, treatment, and disposal of waste generated throughout LANL. These activities generate secondary waste, the quantities of which are reflected in this table for these facilities. The index for LLMW is 1994 to 1995. The index for TRU waste is 1987 to 1991.

[h] The total reflected here is attributed to facility operations, and does not include the waste generated from the ER actions that have been completed from 1990 to 1995. Numbers are rounded.

stored at LANL. These consist of 27,096 cubic feet (759 cubic meters) of low-level radioactive mixed waste (LLMW) and 321,800 cubic feet (9,014 cubic meters) of transuranic (TRU) waste.

Finally, LANL has historically received small quantities of waste (LLW or TRU) from off-site locations (average of about five shipments a year from 1991 to 1996). Typically, these are wastes generated by LANL activities at other locations (e.g., due to LANL activities at the Nevada Test Site); however, there have also been cases where LLW or TRU generated at DOE locations without an on-site disposal capability send such waste to LANL for disposal. (In recent years these sites have included the Pantex Plant in Amarillo, Texas, the Kansas City Plant, and DOE facilities on Kirtland Air Force Base in Albuquerque, New Mexico.) Such off-site waste shipments would be expected to continue in the future at about the same rate as has been experienced in recent years (5 to 10 LLW and TRU waste shipments per year). These shipments, although not specifically listed in the waste generation rates and waste shipments analyzed, are within the quantities and shipment numbers projected due to the conservatism in these projections and the relatively small amounts of off-site waste anticipated for shipment to LANL.

4.9.4 Contaminated Space Within LANL Facilities

The information in this section provides an estimate of the existing radioactively contaminated space within LANL facilities as a basis for comparison with the changes in contaminated space presented as impacts in chapter 5 (sections 5.1.9, 5.2.9, 5.3.9, and 5.4.9). The intent is to provide an understanding of the gross effects of the alternatives on the decontamination or decommissioning liability associated with radioactive contamination in LANL facilities and equipment. There is no existing database or information source that identifies and tracks the amount of contaminated space at LANL; therefore, the estimates were generally made on the basis of process knowledge and "walkdowns" of the facilities.

While there are no existing guidelines or regulations directly related to contaminated space in this context, several guidelines, regulations, and management practices do indirectly influence the amount of radioactively contaminated space in DOE facilities. These existing guidelines, regulations, and management practices include ALARA (the concept of limiting exposures to levels that are as low as reasonably achievable), nuclear materials accountability (the routine measurement and accounting activities to control and track nuclear materials throughout DOE [including within LANL facilities and operations]), maintenance practices (including good housekeeping practices, ease and cost of maintenance, and ease and cost of replacement or refurbishment of equipment), and nuclear materials management (nuclear materials inventory management and control). Each of these factors leads to minimization of contaminated space in facilities.

While these pressures tend to minimize the amount of material that contaminates LANL facilities and equipment as well as the total amount of contaminated space, it takes very little radioactive material to effect a substantial increase in the difficulty and cost associated with eventual clean-up actions. For this reason, the approach to estimating contaminated space was relatively conservative. In most cases, a room containing glovebox systems was not counted as contaminated space unless there was no better way of including that process area. In general, the contaminated space within plutonium facilities, hot cells, process gloveboxes, and general laboratory areas was estimated on a footprint (square footage) basis. Duct or plenum space was presented on a volume or linear distance basis. Table 4.9.4–1 presents the contaminated space associated with the plutonium facility at TA–55, the CMR facility at TA–3, the Radiochemistry Facility at TA–48, the Tritium Facilities, TA–50, and TA–53. Pajarito Site (TA–18), TA–54, the Health Research Laboratory (HRL), the Materials Science Laboratory (MSL), the main shops, Sigma, the HE processing facilities, the firing sites, and the Target Fabrication Facility at TA–35, as well as the non-key facilities, have little or no contaminated space, as compared to the facilities included in Table 4.9.4–1.

TABLE 4.9.4–1.—*Estimated Existing Contaminated Space in LANL Facilities*

FACILITY	CONTAMINATED SPACE
TA–55	
Conveyor, Gloveboxes, Hoods, etc.	11,400 square feet (10,600 square meters)
Contaminated Ducts	1,100 cubic feet (30 cubic meters)
Laboratory Floor Space	59,600 square feet (5,550 square meters)
CMR Facility, TA–3	
Conveyor, Gloveboxes, Hoods, etc.	3,100 square feet (290 square meters)
Contaminated Ducts	760 cubic feet (20 cubic meters)
Hot Cell Floor Space	580 square feet (50 square meters)
Laboratory Floor Space	40,320 square feet (3750 square meters)
Radiochemistry Laboratory, TA–48	
Conveyor, Gloveboxes, Hoods, etc.	1,800 square feet (170 square meters)
Hot Cell Floor Space	17,060 square feet (1590 square meters)
Laboratory Floor Space	39,300 square feet (3650 square meters)
Tritium Facilities	
Weapons Engineering Tritium Facility (WETF) Process Room 14	1,460 square feet (140 square meters)
WETF Process Room 116	760 square feet (70 square meters)
WETF Process Room 120	1,300 square feet (120 square meters)
TA–33 (High Pressure Tritium Laboratory in Building 86)	7,500 cubic feet (210 cubic meters) of rubble (mostly cement)[a]
TA–21 Tritium System Test Assembly	8,000 square feet (740 square meters)
TA–21 Tritium Science and Fabrication Facility	750 square feet (70 square meters)
TA–18, Pajarito Site	< 500 square feet (47 square meters)
TA–50, RLWTF	37,000 square feet (3440 square meters)[b]
TA–53[c]	
Area A	178,000 cubic feet (4,980 cubic meters)
A-East Beam Stop	27,600 cubic feet (770 cubic meters)
Target Areas 5 and 6	9,000 cubic feet (250 cubic meters)
Lines B and C	100 cubic feet (3 cubic meters)
Lead Shielding	350 tons of lead shielding
Weapons Neutron Research and Proton Storage Ring	Unknown[d]

[a] This facility is being decommissioned, and the estimate made is for the concrete rubble that is projected to be generated for disposal from clean-up efforts.
[b] This facility processes liquid radioactive waste and includes large process areas, tanks, and a glovebox. Even though the entire facility is not contaminated, no method of estimated contaminated space for this facility was devised; the facility footprint is presented here.
[c] Contaminated space in these areas is typically materials in the target areas, which are best represented by material volumes.
[d] At the time these data were prepared, the Weapons Neutron Research and Proton Storage Ring were not available for experiments; it is not expected that experiments in these areas would result in large quantities of contaminated space/materials (as compared to the amounts noted for the other TA–53 facilities).
Source: Barr 1996

4.10 TRANSPORTATION

The primary methods and routes used to transport LANL-affiliated employees, commercial shipments, hazardous and radioactive material shipments, transportation packaging, transportation accidents, and on-site and off-site traffic volumes are presented in this subsection. Additional information on these subjects is included in volume III, appendix F.

> **_A Look Back in Time_**
>
> *The road was one of many challenges. The original laboratory buildings were located on Los Alamos mesa. Project managers refused to allow Sundt (Construction Company) to improve the Ranch School road; they did not want to draw attention to their activities! The narrow, unpaved road was unsuitable for heavy equipment. Trucks suffered numerous breakdowns, and parts were hard to replace in those days of wartime shortages.*
>
> *It was not until massive equipment for the project began arriving that Sundt was allowed to straighten the road, and then crews could only work at night to avoid delaying daytime deliveries.*
>
> *Source: Hoard nd*

4.10.1 Regional and Site Transportation Routes

Motor vehicles are the primary means of transportation to LANL. A public bus service located in Los Alamos operates within Los Alamos County. The Los Alamos bus system consists of seven buses that operate 5 days a week. The nearest commercial bus terminal is located in Santa Fe. The nearest commercial rail connection is at Lamy, New Mexico, 52 miles (83 kilometers) southeast of LANL. UC does not currently use rail for commercial shipments.

The primary commercial international airport in New Mexico is located in Albuquerque. The small Los Alamos County Airport is owned by the federal government, and the operations and maintenance are performed by the County of Los Alamos. The airport is located parallel to East Road at the southern edge of the Los Alamos community.

Constructed around 1943, the airport was opened to private pilot use in 1961. The airport has one runway running east-west at an elevation of 7,150 feet (2,180 meters). Takeoffs are predominantly from west to east, and all landings are from east to west. The airport is categorized as a private use facility; however, Federal Aviation Administration (FAA)-licensed pilots and pilots of transient aircraft may be issued permits to use the airport facilities. Until January 1996, the airport provided passenger and cargo service through specialized contract carriers such as Ross Aviation, which were under contract with DOE to provide passenger and cargo air service to Los Alamos County and LANL. Commercial air service, as provided by Ross Aviation, was discontinued in 1995. Peacock Air provided air service for part of 1996, and Mesa Airlines provided scheduled air carrier service briefly in 1997. DOE continues to negotiate with various companies to provide for service to the Los Alamos Airport (LAM 1996a and PC 1996q).

Northern New Mexico is bisected by I–25 in a generally northeast-southwest direction. This interstate highway connects Santa Fe with Albuquerque. The regional highway system and major roads in the LANL vicinity are illustrated in Figure 4.10.1–1. Regional transportation routes connecting LANL with Albuquerque and Santa Fe are I–25 to U.S. 84/285 to NM 502, with Española is NM 30 to NM 502, and with Jemez Springs and western communities is NM 4. Hazardous and radioactive material shipments leave or enter LANL from East Jemez Road to NM 4 to

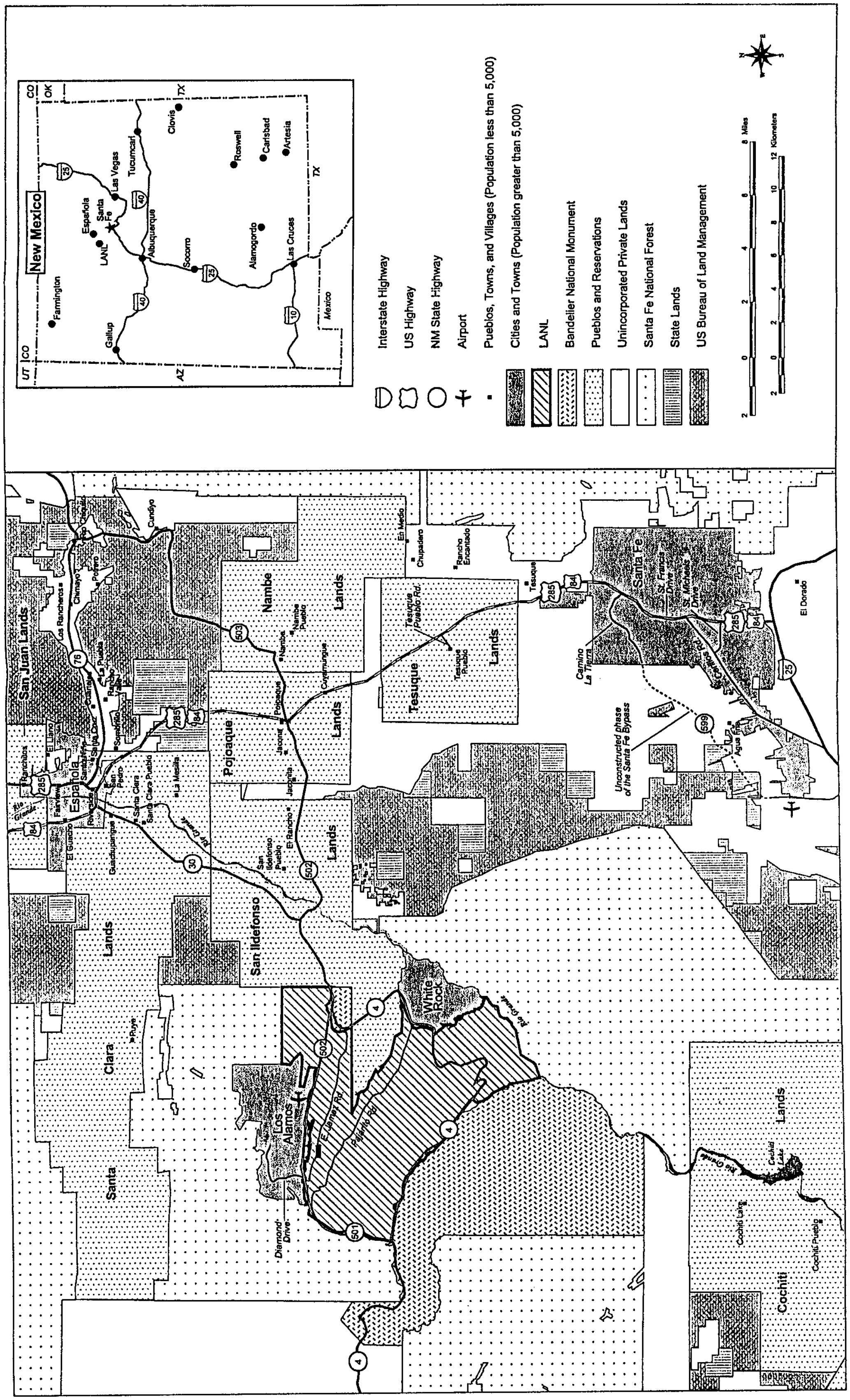


FIGURE 4.10.1–1.—*Regional Transportation Map.*

NM 502. East Jemez Road, as designated by the State of New Mexico and governed by 49 CFR 177.825, is the primary route for the transportation of hazardous and radioactive materials. The average daily traffic flow from 1990 through 1994 and estimated peak hourly traffic volumes for selected routes are presented in Table 4.10.1–1. Only two major roads, NM 502 and NM 4, access Los Alamos County. Los Alamos County traffic volume on these two segments of highway is primarily associated with LANL activities. Approximately 10,662 DOE and DOE contractor personnel administer and support LANL operations and activities (section 4.9, Socioeconomics). Most commuter traffic (approximately 63 percent) originates from Los Alamos County or east of Los Alamos County (Rio Grande Valley and Santa Fe, approximately 35 percent). Only 1 percent of LANL employees commute to LANL from the west along NM 4.

The primary route designated by the State of New Mexico to be used for radioactive and other hazardous material shipments to and from LANL is the approximately 40-mile (64-kilometer) corridor between LANL and I–25 at Santa Fe. This route passes through the Pueblos of San Ildefonso, Pojoaque, Nambe, and Tesuque and is adjacent to the northern segment of Bandelier National Monument. This primary transportation route also passes through residential and commercial segments of the city of Santa Fe for approximately 5 miles (9 kilometers) to I–25. There is a proposed Santa Fe bypass, leading from the northern edge of Santa Fe on U.S. 84/285 to I–25 west of Santa Fe. In the planning stages for over 12 years, this route is now under construction and is expected to be initially available for use later this year. The proposed alignment of the bypass is shown in Figure 4.10.1–1.

4.10.2 Transportation Accidents

Motor vehicle accidents in Los Alamos County from 1990 through 1994 are reported in Table 4.10.2–1.

From 1990 through 1994, there were 3,230 motor vehicle accidents on the regional transportation route between LANL and I–25 at Santa Fe. Heavy commercial vehicles (trucks) transporting materials to and from LANL accounted for less than 4 percent of accidents (Table 4.10.2–2).

4.10.3 LANL Shipments

Hazardous, radioactive, industrial, commercial, and recyclable materials, including wastes, are transported to, from, and on the LANL site during routine operations. Hazardous materials include commercial chemical products that are nonradioactive and are regulated and controlled based on whether they are listed materials, or if they exhibit the hazardous characteristics of ignitability, toxicity, corrosivity, or reactivity. Radioactive materials include SNMs (e.g., plutonium, enriched uranium), medical radioisotopes, and other miscellaneous radioactive materials. Off-site shipments, both to and from LANL, are carried by commercial carriers (including truck, air-freight, and government trucks), and by DOE safe secure transport (SST) trailers. Numerous regulations and requirements govern the transportation of hazardous and radioactive materials, including those of the U.S. Department of Transportation (DOT), NRC, DOE, FAA, International Air Traffic Association (IATA), and LANL.

4.10.3.1 *On-Site Shipments*

On-site hazardous material shipments are transported in conformance with DOT regulations. A shipment is considered an on-site shipment if both the origin and destination are at LANL. These shipments are transported in LANL-operated vehicles. Hazardous

TABLE 4.10.1–1.—*Traffic for Selected Highway Segments in the Vicinity of LANL*

HIGHWAY DESIGNATION	DESCRIPTION	HIGHWAY SEGMENT	SEGMENT LENGTH miles (kilometers)	AVERAGE DAILY TRAFFIC[a] 1994 (NO. OF VEHICLES)	PEAK HOURLY TRAFFIC[b] (NO. OF VEHICLES)
LANL SITE ROUTES					
NM 4	2-lane state highway	Intersection of NM 501 and NM 4 to Bandelier National Monument entrance	4 (6)	758	114
NM 4	2-lane state highway	Bandelier National Monument entrance to NM 502	9 (14)	1,029	154
NM 501	2-lane state highway	Intersection of NM 4 to Diamond Drive (West Jemez Road)	5 (8)	2,105	316
NM 501	4- to 6-lane state highway	Along Diamond Drive to NM 502	2 (3)	35,236	5,285
NM 502	2- to 4-lane state highway	Diamond Drive to the intersection of NM 4	6 (10)	16,286	2,443
East Jemez Road (truck route)	2-lane state highway	Intersection of NM 501 and Diamond Drive to NM 4	6 (10)	NA	NA
NM 502[c]	4-lane divided state highway with uphill truck lane	Intersection of NM 4 and NM 502 to NM 30	4 (6)	12,041	1,806
REGIONAL ROUTES					
NM 30	2- to 4-lane state highway	NM 502 to NM 201 in Española	8 (13)	6,371	956
NM 30	4-lane divided state highway	NM 201 to U.S. 84/285	1 (1.6)	12,003	1,801
NM 502[c]	4-lane divided state highway	NM 30 to U.S. 84/285	12 (19)	8,979	1,347
NM 4	2-lane state highway	San Ysidro to NM 485	10 (16)	2,535	380
U.S. 84/285[c]	4-lane divided U.S. highway	NM 502 to Tesuque Pueblo Road	7 (11)	29,333	4,400
U.S. 84/285[c]	4-lane divided U.S. highway	Tesuque Pueblo Road to Camino La Tierra (Santa Fe)	7 (11)	32,377	4,857
U.S. 84/285[c]	4- to 6-lane U.S. highway	Camino La Tierra to Cerrillos Road	3 (5)	37,957	5,694
U.S. 84/285[c]	4- to 6-lane U.S. highway	Cerrillos Road to St. Michael's Drive	1 (1.6)	47,124	7,069
U.S. 84/285[c]	4-lane U.S. highway	St. Michael's Drive to I–25	2 (3)	31,828	4,774

[a] Average daily traffic represents an annual average over a 7-day week.
[b] Peak hourly traffic is estimated as 15 percent of total daily traffic.
[c] Hazardous/radioactive material shipment route.
NA = Not available
Source: NMHTD 1995

TABLE 4.10.2–1.—*Accidents Within Los Alamos County (1990 Through 1994)*

YEAR	TOTAL NUMBER OF ACCIDENTS IN LOS ALAMOS COUNTY	PERCENT PRIVATELY OWNED VEHICLES	PERCENT LOS ALAMOS COUNTY VEHICLES	PERCENT DOE VEHICLES
1990	356	92	4	4
1991	358	89	5	6
1992	258	87	6	7
1993	325	88	8	4
1994	387	88	7	5

Source: PC ndb

TABLE 4.10.2–2.—*Truck Accident Rates in the Santa Fe to Los Alamos Area (1990 Through 1994)*

ROUTES[a]	TOTAL NUMBER OF ACCIDENTS	AVERAGE TRUCK TRAFFIC (VEHICLE/DAY)	PERCENT LANL VEHICLE/DOE VEHICLE
Through Santa Fe	97	2,104	3.7
U.S. 84/285	17	1,677	0.44
NM 502	5	462	0.49
NM 4	0	520	1.08
East Jemez Road	4	520	1.08

[a] Portion described in Table 4.10.1–1 as the Hazardous and Radioactive Material Route.
Sources: Fenner 1995, Fenner 1996, Vigil 1996

material shipments vary from bulk gases and liquids to small quantities of laboratory chemicals. Hazardous waste shipments are made to the hazardous waste storage facility at TA–50 and radioactive and hazardous waste shipments are made to the waste management area at TA–54. The number of LANL hazardous and radioactive material shipments made annually are presented in Table 4.10.3.1–1.

On-site radioactive material shipments are transported in conformance with DOT and NRC regulations or DOE requirements. A primary feature of these regulations is stringent packaging requirements governing shipments on public roads. In a few cases, it is not cost effective for LANL to meet these stringent packaging requirements. In such cases, roads are temporarily closed during the shipments; DOE safety requirements still apply in these cases. On-site radioactive shipments are made with LANL-operated vehicles. These vehicles vary depending on the quantity and radioactivity of the material shipped, from LANL-owned pick-up trucks to DOE-owned SSTs. Maintenance of these vehicles is closely monitored for physical performance as well as security.

4.10.3.2 *Off-Site Shipments*

LANL transports and receives radioactive and other hazardous materials shipments to and from other DOE facilities and commercial facilities nationwide. All shipments meet applicable DOT, NRC, and FAA regulations or DOE requirements, and most unclassified shipments are transported via commercial carriers. During 1990 through 1994, there were an average of 1,000 shipments per year (including waste shipments) according to the DOE database, which is called the Shipment Mobility/Accountability Collection (SMAC). These consisted, on average, of 800 shipments of hazardous materials and 200 shipments of radioactive materials. The difference between these totals and those listed in Table 4.10.3.1–1 is due to the classified shipments and other shipments for which transportation is not explicitly paid for by LANL; such shipments are not recorded in the SMAC database. The types of materials transported and the number of unclassified off-site radioactive and hazardous materials shipments are stated in Table 4.10.3.2–1. DOE regulations require an SST trailer be used for off-site shipments of special nuclear materials, weapons components, and explosive-like assemblies in DOE custody. SST trailers are similar in appearance to commercial tractor-trailers but are equipped with unique security and safeguard features that prevent unauthorized cargo removal and minimize the likelihood of an accidental radioactive materials release as a result of a vehicle accident. Classified shipments are made in an SST trailer. The designated hazardous materials route for Los Alamos County is East Jemez Road to NM 4 to NM 502.

TABLE 4.10.3.1–1.—*Annual LANL On-Site and Off-Site Shipments*

TYPE	NONHAZARDOUS	HAZARDOUS (NONRADIOACTIVE)	RADIOACTIVE
Off-Site	327,939	2,592	934
On-Site	Not Available	7,560	1,187

Source: Villa 1996

TABLE 4.10.3.2–1.—*Summary of Off-Site, Unclassified Radioactive and Hazardous Materials Shipments (1990 Through 1994)*

TRANSPORT MODE	MATERIAL CATEGORY	BOUNDING MATERIAL[a]	MAXIMUM SHIPPING QUANTITY[a]	NUMBER OF SMALL SHIPMENTS[b]	NUMBER OF LARGE SHIPMENTS[b]
Truck	Flammable	Hydrogen	50,000 ft^3	320	17
Truck	Toxic	Chlorine	2,000 lb	136	22
Truck	Radiological	Tritium	29,160 Ci	406	11
Truck	Explosive	HMX	13,801 lb	102	24
Air	Toxic	Chlorine	7 lb	160	15
Air	Explosive	HMX	195 lb	21	80
Air	Radiological	Tritium	970,000 Ci	1,185	1

Notes: SST trailer shipments not included. About 2,500 shipments screened due to low material toxicity. HMX is octahydro-1,3,5,7 tetranitro-1,3,5,7-tetrazocine. Large shipments are greater than 10 percent of the maximum shipping quantity.

[a] These columns reflect the material that bounds the risks associated with each material category and the maximum quantity of this material that has been shipped.

[b] These columns reflect the numbers of small and large shipments for each material in a particular material category; thus, these reflect the shipments of the bounding material and other materials in this category.

Source: SWEIS volume III, appendix F

REFERENCES

ACGIH 1993 — *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1992–1993*). American Conference of Governmental Industrial Hygienists. Cincinnati, Ohio. 1993.

Acquavella et al. 1982a — "Malignant Melanoma Incidence at the Los Alamos National Laboratory." J. F. Acqavella, G. S. Wilkinson, G. L. Tietjen, C. R. Key, and G. L. Voelz. *The Lancet.* pp. 883-884. April 17, 1982.

Acquavella et al. 1982b — J. F. Acqavella, G. S. Wilkinson, G. L. Tietjen, C. R. Key, and G. L. Voelz. *Health Physics*. Vol. 45, pp. 708-713. 1982

Allen 1989 — *Changes in the Landscape of the Jemez Mountains, New Mexico*. C. D. Allen. Ph.D. Dissertation. University of California. Berkeley, California. 1989.

Allen 1994 — *Elk Response to the La Mesa Fire and Current Status in the Jemez Mountains.* C. D. Allen. Proceedings of the Second La Mesa Fire Symposium. Los Alamos, New Mexico. March 29–31, 1994. USDA Forest Service. GTR-286. Fort Collins, Colorado. 1996.

Allen et al. 1995 — "Landscape-Scale Fire History Studies Support Fire Management Action at Bandelier." C. D. Allen, R. Touchan, and T. Swetnam. *Park Science.* U.S. Department of the Interior, National Park Service. Washington, D.C. Summer 1995.

ARSI 1994 — *National Park Service Visibility Monitoring and Data Analysis Program, Summary of Transmissometer-Based Visibility Data.* Prepared by Air Resource Specialists, Inc. ARS/IMP9394.RPT. Fort Collins, Colorado. October 1994.

Athas 1996 — *Investigation of Excess Thyroid Cancer Incidence in Los Alamos County*. W. F. Athas. New Mexico Department of Health. April 1996.

Athas and Key 1993 — *Los Alamos Cancer Rate Study: Phase I, Cancer Incidence in Los Alamos County, 1970–1990,* Final Report. W. F. Athas and C. R. Key. New Mexico Department of Health. March 1993.

Austin et al. 1981 — "Malignant Melanoma Among Employees of Lawrence Livermore National Laboratory." D. F. Austin, P. J. Reynolds, M. A. Snyder, M. W. Biggs, and H. A. Stubbs. *Lancet.* Vol. 2, pp. 712-716. 1981.

Bailey 1980 — *Ecoregions Map of the United States*. R. G. Bailey. USDA Forest Service Miscellaneous Publication 1391. Washington, D.C. 1980.

Barnard et al. 1996 "Retrospective Beryllium Exposure Assessment at the Rocky Flats Environmental Technology Site." A. E. Barnard et al. *American Industrial Hygiene Association Journal*. Vol. 57, pp. 804-808. 1996

Barr 1996 Letter from Mike Barr, GRAM, Inc., to Dave Ball. Subject: Contaminated Space at the Los Alamos National Laboratory. Los Alamos, New Mexico. May 13, 1996.

Bennett 1996 *Wetland Survey Map.* K. Bennett. Los Alamos National Laboratory, ESH-20 Group. Los Alamos, New Mexico. 1996.

BH&A 1995 *Needs Assessment for Fire Department Services and Resources*. Beatty, Harvey, & Associates. Los Alamos National Laboratory Contract Number B 000720015-35. Los Alamos, New Mexico. November 15, 1995.

BIA 1987 "Memorandum of Understanding Among the Bureau of Indian Affairs, the Department of Energy, and the Pueblo of San Ildefonso Regarding Testing for Radioactive and Chemical Contamination of Lands and Natural Resources Belonging to the Pueblo of San Ildefonso." MOU DE-GM32-87AL37160. U.S. Bureau of Indian Affairs, U.S. Department of Energy, and Pueblo of San Ildefonso. June 1987.

BIA 1996 Unpublished information obtained by the U.S. Bureau of Indian Affairs through interviews of various people from the Northern Pueblos Agency. 1996.

Birdsell et al. 1995 *Numerical Modeling of Unsaturated Ground Water Flow and Radionuclide Transport at MDA G.* K. H. Birdsell, W. E. Soll, N. D. Rosenberg, and B. A. Robinson. Los Alamos National Laboratory. LA-UR-95-2735. Los Alamos, New Mexico. September 1995.

Blake et al. 1995 *Environmental Geochemistry for Surface and Subsurface Waters in the Pajarito Plateau and Outlying Areas, New Mexico.* W. D. Blake, F. Goff, A. Adams, and D. Counce. Los Alamos National Laboratory. LA-12912-MS. Los Alamos, New Mexico. May 1995.

BNM 1995 *Fire Weather Database*. Bandelier National Monument. Office of the Ecologist. 1995.

BNM nd *Wildlife Observation Database*. Bandelier National Monument. DBF files for mammals, birds, plants, reptiles, and amphibians.

Bradford 1996 Memorandum from W. Bradford, ESH-EIS, to Doris Garvey, ESH/M889. Subject: NPDES Outfalls and Annual Volume Discharges for Other than Key Facilities. Los Alamos National Laboratory. Los Alamos, New Mexico. August 28, 1996.

Brooks 1989	*The Comparative Uptake and Interaction of Several Radionuclides in the Trophic Levels Surrounding the Los Alamos Meson Physics Facility (LAMPF) Waste Water Ponds*. G. H. Brooks, Jr. Thesis. Los Alamos National Laboratory. LA-11487-T. Los Alamos, New Mexico. 1989.
Broxton and Reneau 1995	*Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory*. D. E. Broxton and S. L. Reneau. Los Alamos National Laboratory. LA-13010-MS. Los Alamos, New Mexico. August 1995.
CEQ 1993	*Incorporating Biodiversity Considerations into Environmental Impact Analysis under the National Environmental Policy Act.* Council on Environmental Quality. Washington, D.C. January 1993.
CEQ 1997	*Considering Cumulative Effects under the National Environmental Policy Act*. Council on Environmental Quality. Washington, D.C. January 1997.
Cordell 1979	*Cultural Resources Overview: Middle Rio Grande Valley, New Mexico*. L. S. Cordell. U.S. Department of Agriculture, Forest Service, Southwestern Region. Albuquerque, New Mexico. 1979.
Cordell 1984	*Prehistory of the Southwest*. L. S. Cordell. Academic Press. New York, New York. 1984.
Crawford et al. 1993	*Middle Rio Grande Ecosystem: Bosque Biological Management Plan.* C. S. Crawford et al. Middle Rio Grande Interagency Team. October 1993.
Cross et al. 1996	*Aquatic Macroinvertebrates and Water Quality of Springs and Streams in White Rock Canyon along the Rio Grande, 1995.* S. Cross, L. Sandoval, and T. Gonzales. Los Alamos National Laboratory. LA-UR-96-510. Los Alamos, New Mexico. 1996.
Dale and Yanicak 1995	Memorandum from M. R. Dale and S. Yanicak, New Mexico Environment Department to U.S. Department of Energy Oversight Bureau file. Subject: Submittal of preliminary groundwater data obtained from the Pueblo of San Ildefonso. September 6, 1995.
Dale and Yanicak 1996	Memorandum from M. R. Dale and S. Yanicak, New Mexico Environment Department to U.S. Department of Energy Oversight Bureau file. Subject: 1994 and 1995 Environmental Surveillance Reports, on-site and off-site groundwater data. December 5, 1996.
Devaurs 1989	*Modeling of Radionuclide Transport at Inactive Material Disposal Area T, TA–21*. M. Devaurs. Los Alamos National Laboratory. LA-11544-MS. Los Alamos, New Mexico. 1989.

DOC 1990a — *1990 Census Summary Population and Housing Characteristics, New Mexico*. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1990.

DOC 1990b — *Statistical Abstract of the United States*. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1990.

DOC 1991 — *1990 Census of Population and Housing: Summary Population and Housing Characteristics, New Mexico*. U.S. Department of Commerce, Bureau of the Census. 1990 CPH-1-33. Washington, D.C. August 1991.

DOC 1993 — *1990 Census of Population: Social and Economic Characteristics, New Mexico.* U.S. Department of Commerce, Bureau of the Census, Economics and Statistical Administration. Washington, D.C. September 1993.

DOC 1994 — *County and City Data Book: 1994*, 12th Edition. U.S. Department of Commerce, Bureau of the Census, Economics and Statistical Administration. Washington, D.C. August 1994.

DOC 1996 — *Personal Income Data by Major Source and Earnings, by Industry, New Mexico and Los Alamos, Rio Ariba and Santa Fe Counties*. U.S. Department of Commerce, Bureau of Economic Analysis, Economic Information System. June 1996.

DOE 1979 — *Final Environmental Impact Statement, Los Alamos Scientific Laboratory Site, Los Alamos, New Mexico.* U.S. Department of Energy. DOE/EIS-0018. Washington, D.C. December 1979.

DOE 1991 — *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.* U.S. Department of Energy. DOE/EH-0173T. Washington, D.C. January 1991.

DOE 1994a — "Memorandum of Understanding Between the United States Department of Energy and the Los Alamos Medical Center Concerning Mutual Assistance and Emergency Support." U.S. Department of Energy, Washington, D.C., and Los Alamos Medical Center, Los Alamos, New Mexico. April 1994.

DOE 1994b — "Memorandum of Understanding Between the United States Department of Energy and St. Vincent Hospital Concerning Mutual Assistance and Emergency Support." U.S. Department of Energy, Washington, D.C., and St. Vincent Hospital, Santa Fe, New Mexico. June 1994.

DOE 1994c — *Hazard Baseline Documentation*. U.S. Department of Energy. DOE EM Standard 5502-94. August 1994.

DOE 1995a — Memorandum from D. Agar, Utilities Program Manager, PFMD. Subject: Environmental Requirements for the Transfer of Water System Assets at Los Alamos National Laboratory. U.S. Department of Energy, Albuquerque Operations Office. March 31, 1995.

DOE 1995b — *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement*. U.S. Department of Energy, Albuquerque Operations Office and Los Alamos Area Office. DOE/EIS-0228. Albuquerque, New Mexico. August 1995.

DOE 1995c — *Environmental Assessment, High Explosive Wastewater Treatment Facility*. U.S. Department of Energy. DOE/EA-1100 and Finding of No Significant Impact. Los Alamos, New Mexico. August 1995

DOE 1995e — Agreement in Principle between the DOE Albuquerque Operations Office and the State of New Mexico. October 2, 1995.

DOE 1995f — *Annual Report of Natural and Supplemental Gas Supply and Disposition, 1990–1994.* U.S. Department of Energy, Energy Information Administration. EIA-176. Washington, D.C. 1995.

DOE 1996a — *Environmental Assessment for Effluent Reduction*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1156. Los Alamos, New Mexico. July 3, 1996.

DOE 1996b — *Land and Facility Use Planning*. U.S. Department of Energy, Office of Field Management. Washington, D.C. July 9, 1996.

DOE 1996c — *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,* Rev. 1. U.S. Department of Energy. DOE Standard 1020-94. January 1996.

DOE 1997a — *Environmental Assessment for the Lease of Land for the Development of a Research Park at Los Alamos National Laboratory.* U.S. Department of Energy. DOE/EA-1212. Los Alamos, New Mexico. October 1997.

DOE 1997b — *Environmental Assessment for the Transfer of the DP Road Tract to the County of Los Alamos.* U.S. Department of Energy. DOE/EA-1184. Los Alamos, New Mexico. January 1997.

DOE nda — *DOE Occupational Radiation Exposure, 1995 Report.* U.S. Department of Energy, Assistant Secretary for Environment, Safety and Health. DOE/EH-0533. Washington, D.C.

DOE ndb	*DOE Occupational Radiation Exposure, 1992–1994 Report*. U.S. Department of Energy, Assistant Secretary for Environment, Safety and Health. DOE/EH-0533. Washington, D.C.
DOE ndc	*DOE Occupational Radiation Exposure, 1996 Report*. U.S. Department of Energy, Assistant Secretary for Environment, Safety and Health. DOE/EH-0564. Washington, D.C.
DOE ORPS 1990–1996	DOE Occurrence Reporting and Processing System Reports [ORPS] 1990–1996. U.S. Department of Energy. Washington, D.C.
DOI 1977	*Final Master Plan*. U.S. Department of the Interior, U.S. National Park Services, Bandelier National Monument. 1977.
DOI 1995	*Bandelier National Monument Draft Development Concept Plans: Frijoles Canyon and Tsankawi*. U.S. Department of the Interior. Washington, D.C. May 1995.
Dransfield and Gardner 1985	*Subsurface Geology of the Pajarito Plateau, Española Basin, New Mexico.* B. J. Dransfield and J. N. Gardner. Los Alamos National Laboratory. LA-10455-MS. Los Alamos, New Mexico. May 1985.
Dunmire and Tierney 1995	*Wild Plants of the Pueblo Province: Exploring Ancient and Enduring Uses.* W. W. Dunmire and G. D. Tierney. Museum of New Mexico Press. Albuquerque, New Mexico. 1995.
Durkin et al. 1995	*Riparian/Wetland Vegetation Communities of the Rio Grande: A Classification and Site Evaluation.* P. Durkin et al. University of New Mexico, Department of Biology. Albuquerque, New Mexico. May 1995.
EPA 1994	*The Watershed Protection Approach, 1993/1994 Activity Report.* U.S. Environmental Protection Agency, Office of Water. EPA-840-S-94-001. Washington, D.C. 1994.
EPA 1995	*A Report of the May 1994 Environmental Sampling and Analyses of Soil, Sediment, Surface, and Ground Water Conducted at the San Ildefonso Indian Reservation,* Draft. U.S. Environmental Protection Agency. Washington, D.C. June 29, 1995.
EPA 1996a	*Federal Facility Compliance Agreement with the U.S. Department of Energy Regarding Compliance with the Clean Air Act in the matter of Los Alamos National Laboratory*. Docket numbers 91-NM-C112-002 and 92-NM-C112-001. U.S. Environmental Protection Agency, Region 6. Washington, D.C. 1996.

EPA 1996b — *Administrative Order Regarding Compliance with the Clean Water Act at Los Alamos National Laboratory*. U.S. Environmental Protection Agency, Region 6. December 10, 1996.

EPA 1996c — Federal Facility Compliance Agreement Regarding Compliance with the *Clean Water Act* at Los Alamos National Laboratory. U.S. Environmental Protection Agency, Region 6. December 12, 1996.

Fenner 1995 — Letter from H. Allen Fenner, Transportation Planning Division, New Mexico Highway and Transportation Department, to Joe Matlock. Santa Fe, New Mexico. November 13, 1995.

Fenner 1996 — Letter from H. Allen Fenner, Transportation Planning Division, New Mexico State Highway Department, to W. R. Rhyne. Santa Fe, New Mexico. January 17, 1996

Ferenbaugh et al. 1994 — *Environmental Analysis of Lower Pueblo/Lower Los Alamos Canyon*. R. W. Ferenbaugh, T. E. Buhl, A. K. Stoker, N. M. Becker, J. C. Rodgers, and W. R. Hansen. Los Alamos National Laboratory. LA-12857-ENV. Los Alamos, New Mexico. 1994.

Ferenbaugh et al. 1998 — *Ecological and Human Health Risk Assessment Related to Large Game Animals Foraging Around the Perimeter of a Low-level Radioactive Waste Disposal Site at Los Alamos National Laboratory*. J. K. Ferenbaugh, P. R. Fresquez, M. E. Ebinger, G. J. Gonzales, and P. A. Jordan. Health Physics Society Annual Meeting. June, 1998.

Fetter 1988 — *Applied Hydrogeology*, Second Edition. C. W. Fetter. MacMillan Publishing Company. New York, New York. 1988.

Fong 1995 — Letter from S. Fong to the U.S. Department of Energy. Subject: RAD-NESHAP dose calculations. Los Alamos National Laboratory. ESH-17:95-274. Los Alamos, New Mexico. April 1995.

Ford-Schmid 1996 — "Reference Conditions for Los Alamos National Laboratory Streams Using Benthic Macroinvertebrate Assessment in Upper Pajarito Canyon." R. E. Ford-Schmid. *New Mexico Geological Society Guidebook* 47:441-448; and subsequent studies. 1996.

Foxx and Edeskuty 1995 — *Wildlife Use of NPDES Outfalls at Los Alamos, National Laboratory.* T. S. Foxx and B. Blea-Edeskuty. Los Alamos National Laboratory. LA-13009-MS. UC-902. Los Alamos, New Mexico. September 1995.

Foxx and Tierney 1982	*Vegetational Analysis of a Canyon Ecosystem at Los Alamos.* T. S. Foxx and G. D. Tierney. Los Alamos National Laboratory. LA-9576-MS. UC-11. Los Alamos, New Mexico. November 1982.
Foxx and Tierney 1985	"Checklist of Vascular Plants of the Pajarito Plateau and Jemez Mountains." T. S. Foxx and G. D. Tierney; drawings by D. Hoard. *Status of the Flora of the Los Alamos National Environmental Research Park.* Los Alamos National Laboratory. LA-8050-NERP, Vol. III. UC-11. Los Alamos, New Mexico. June 1985.
Frenzel 1995	*Geohydrology and Simulation of Groundwater Flow Near Los Alamos, North-Central New Mexico.* P. Frenzel. U.S. Geological Survey. Water Resources Investigations Report 95-4091. Washington, D.C. 1995.
Fresquez et al. 1995a	*Radionuclide Concentrations in Elk that Winter on Los Alamos National Laboratory Lands*. P. R. Fresquez, D. A. Armstrong, and J. G. Salazar. Los Alamos National Laboratory. LA-12795-MS. Los Alamos, New Mexico. 1995.
Fresquez et al. 1995b	*Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory*. P. R. Fresquez, D. R. Armstrong, and J. F. Salazar. Los Alamos National Laboratory. LA-12872-MS. Los Alamos, New Mexico. 1995.
Fresquez et al. 1995c	*Strontium Concentration in Chamisa (Chrysothamnus nauseosus) Shrub Plants Growing in a Former Liquid Waste Disposal Area in Bayo Canyon*. Los Alamos National Laboratory. LA-13050-MS. Los Alamos, New Mexico. 1995.
Fresquez et al. 1995d	*Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory: 1974 to 1994.* P. R. Fresquez, M. A. Mullen, and J. K. Ferenbaugh. Los Alamos National Laboratory. LA-UR-95-3671. Los Alamos, New Mexico. 1995.
Fresquez et al. 1996a	*Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons.* P. R. Fresquez, M. A. Mullen, J. K. Ferenbaugh, and R. A. Perona. Los Alamos National Laboratory. LA-13149-MS. Los Alamos, New Mexico. April 1996.
Fresquez et al. 1996b	*Radionuclide Concentrations In/On Vegetation at Radioactive-Waste Disposal Area G During the 1995 Growing Season,* progress report. Los Alamos National Laboratory. LA-13124-PR. Los Alamos, New Mexico.
Frisch 1979	*What Little I Remember*. Otto Frisch. 1979.

FWS 1990 — *National Wetlands Inventory*. Electronic version of wetlands map. U.S. Fish and Wildlife Service. Washington, D.C. 1990.

Gallaher 1997 — "Plutonium Concentrations and Likely Sources." Los Alamos National Laboratory. Los Alamos, New Mexico. Unpublished data. 1997.

Gallegos 1990 — Letter from R. M. Gallegos, New Mexico Environment Department Program Manager, Drinking Water Section, to Ms. Silvi Solomon, Concerned Citizens for Nuclear Safety. Santa Fe, New Mexico. November 20, 1990.

Gallegos et al. 1997a — *Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially Weighted Foraging Regime at the Los Alamos National Laboratory*. A. F. Gallegos, G. J. Gonzales, K. D. Bennett, and L. E. Pratt. Los Alamos National Laboratory. LA-13259-MS. Los Alamos, New Mexico. 1997.

Gallegos 1997b — *A Spatially Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory*. A. F. Gallegos, G. J. Gonzales, K. D. Bennett, L. E. Pratt, and D. S. Cram. Los Alamos National Laboratory. LA-13321-MS. Los Alamos, New Mexico. 1997.

Gardner and WoldeGabriel 1998 — *High-Precision Geologic Mapping to Evaluate the Potential for Seismic Surface Rupture at TA–55, Los Alamos National Laboratory*. Lavine Gardner and Vaniman WoldeGabriel. LA-13456-MS. Los Alamos National Laboratory. Los Alamos, New Mexico. June 1998.

Gardner and House 1987 — *Seismic Hazards Investigation at Los Alamos National Laboratory, 1984 to 1985*. J. N. Gardner and L. House. Los Alamos National Laboratory. LA-11072-MS. Los Alamos, New Mexico. October 1987.

Gardner et al. 1986 — "Stratigraphic Relations and Lithologic Variations in the Jemez Volcanic Field, New Mexico." J. N. Gardner, F. Goff, and R. C. Hagan. *Journal of Geophysical Research*, Vol. 91, No. B2, pp. 1763-1778. 1986.

Garvey 1997 — Memorandum from D. Garvey, ESH-EIS, to Corey Cruz, DOE Albuquerque Operations Office. Subject: NPDES outfalls. December 19, 1997.

Gonzales et al. 1997 — *Second Annual Review Update Preliminary Risk Assessment of Federally Listed Species at the Los Alamos National Laboratory.* G. J. Gonzales, A. F. Gallegos, and T. S. Foxx. Los Alamos National Laboratory, Ecology Group. LA-UR-97-4732. Los Alamos, New Mexico. 1997.

Gonzales et al. 1998a — *A Spatially Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory*. G. J. Gonzales, A. F. Gallegos, L. E. Pratt, T. S. Foxx, P. R. Fresquez, M. A. Mullen, and P. E. Gomez. LA-13399-MS. Los Alamos National Laboratory. Los Alamos, New Mexico. 1998.

Gonzales et al. 1998b	*Preliminary Risk Assessment of the Southwestern Willow Flycatcher (Empidonax traillii extimus) at the Los Alamos National Laboratory*. G. J. Gonzales, A. F. Gallegos, M. A. Mullen, K. D. Bennett, and T. S. Foxx. Los Alamos National Laboratory. LA-13508-MS. Los Alamos, New Mexico. 1998.
Graf 1993	*Geomorphology of Plutonium in the Northern Rio Grande.* W. L. Graf. Department of Geography, Arizona State University. Prepared for Los Alamos National Laboratory under Contract 9-X38-2886P-1. LA-UR-93-1963. Los Alamos, New Mexico. March 1993.
Graf 1995	*Fluvial Dynamics of Plutonium in the Los Alamos Canyon System, New Mexico.* W. L. Graf. Department of Geography, Arizona State University. Prepared for Los Alamos National Laboratory under Contract 9-X38-2886P-1. Los Alamos, New Mexico. June 1995.
GRAM 1997	*Noise/Vibration Impact Report*. Prepared by GRAM, Inc. for DOE under Contract No. DE-AC04-95AL99975. November 1997.
Griggs and Hein 1954	*Geology and Ground Water Resources of the Los Alamos Area, New Mexico.* R. L. Griggs and J. D. Hein. U.S. Geological Survey Water Supply Paper. 1954.
Gunderson 1993	Letter from T. Gunderson, Los Alamos National Laboratory, to J. Vozella, U.S. Department of Energy. Subject: Results of Los Alamos National Laboratory and New Mexico Environment Department sampling of the Buckman Well Field. Los Alamos, New Mexico. January 20, 1993.
Haarmann 1997	"Honey Bees as Indicators of Radionuclide Contamination: Exploring Colony Variability and Temporal Contaminant Accumulation." T. Haarmann. *Journal of Apicultural Research*. 36(2):77-87. 1997.
Haarmann 1998a	"Honey Bees as Indicators of Radionuclide Contamination: Comparative Studies of Contaminant Levels in Forager and Nurse Bees and in the Flowers of Three Plant Species." T. Haarmann. *Archives of Environmental Contamination and Toxicology*. 35:287-294. 1998.
Haarmann 1998b	"Honey Bees (Hymenoptera: Apidae) as Indicators of Radionuclide Contamination: Investigating Contaminant Redistribution Using Concentrations in Water, Flowers, and Honey Bees." T. Haarmann. *Journal of Economic Entomology*. 91(5): 1072-1077.

Hansen 1997 — *Development and Evaluation of a Radio Frequency Identification System to Measure Time Spent at Contaminated Sites and Level Radioactive Contamination for Medium Sized Mammals at Los Alamos National Laboratory*. Steve Hansen. Second Annual East Jemez Mountains Symposium. Santa Fe, New Mexico. October 1997.

Harrington 1916 — "The Ethnogeography of the Tewa Indians." John Peabody Harrington. *Twenty-Ninth Annual Report of the Bureau of American Ethnology, 1907–1908*. GPO, Vol. 29, p. 636. Washington, D.C. 1916.

Henderson and Harrington 1914 — "Ethnozoology of the Tewa Indians." J. Henderson and J. P. Harrington. *Bureau of American Ethnology Bulletin 56.* Washington, D.C. 1914.

Hink and Ohmart 1984 — *Middle Rio Grande Biological Survey,* Final report. V. C. Hink and R. D. Ohmart. U.S. Army Corps of Engineers. Contract Number DACW47-81-C-0015. Albuquerque, New Mexico. 1984.

Hoard nd — *Los Alamos Outdoors*. Dorothy Hoard.

Hodgson and Leve 1987 — *A Textbook of Modern Toxicology*. Ernest Hodgson and Patricia E. Levi. North Carolina State University, Toxicology Program. Raleigh, North Carolina. Published by Appleton and Lange. Norwalk, Connecticut. 1987.

HUD 1996 — *Median Income Limits 1996–National, for Los Alamos, New Mexico*. U.S. Department of Housing and Urban Development, HUD USER's Document Reproduction Service. DOC-002200. Rockville, Maryland and Washington, D.C. 1996.

Izett and Obradovich 1994 — "Argon-40/Argon-39 Age Constraints for the Jaramillo Normal Subchron and the Matuyama-Brunhes Geomagnetic Boundary." G. A. Izett and J. D. Obradovich. *Journal of Geophysical Research.* Vol. 99. 1994.

Jacobs 1989 — *Flora of Bandelier National Monument,* Final Report. B. F. Jacobs. Funded by the U.S. National Park Service. Contract No. PX7029-8-0484. Washington, D.C. March 14, 1989.

JCUS 1996 — *Gas Usage at Technical Areas 1, 2, and 3*. Johnson Controls Utilities Support. January 17, 1996.

Kelley 1948 — *Los Alamos Project, Pumice Investigation.* V. C. Kelley. Los Alamos Scientific Laboratory. Los Alamos, New Mexico. 1948.

Kelley 1970 — *Earthquake and Rockfall Potential Near Omega Site, Los Alamos, New Mexico*. T. E. Kelley. U.S. Geological Survey Paper. 1970.

Keystone 1991 — *Final Consensus Report of the Keystone Policy Dialogue on Biological Diversity on Federal Lands*. The Keystone Center. Keystone, Colorado. April 1991.

Kirk 1995 — Letter from Alan S. Kirk, Chief, Los Alamos Police Department, to George VanTiem, Los Alamos National Laboratory. Subject: Department Review, Los Alamos Police Department. Los Alamos, New Mexico. February 2, 1995.

Klement 1965 — "Radioactive Fallout Phenomena and Mechanisms." A. W. Klement. *Health Physics.* Vol. 11, pp. 1265-1274. 1965.

Koch et al. 1997 — *Development of a Land Cover Map for Los Alamos National Laboratory and Vicinity*. S. W. Koch, T. K. Budge, and R. Balice. Los Alamos National Laboratory. LA-UR-97-4628. Los Alamos, New Mexico. December 1997.

Kreiss et al. 1996 — "Machining Risk of Beryllium Disease and Sensitization with Median Exposures Below 2 micrograms per cubic meter." K. Kreiss et al. *American Journal of Industrial Medicine*. Vol. 30, pp. 16-25. 1996.

Krier et al. 1998a — *Stratigraphy and Geologic Structure at the SCC and NISC Building Sites, Technical Area 3, Los Alamos National Laboratory, New Mexico*. Caporuscio Krier, Lavine, and Gardner. LA-133507-MS. Los Alamos National Laboratory. Los Alamos, New Mexico. September 1998.

Krier et al. 1998b — *Stratigraphy and Geologic Structure at the Chemistry and Metallurgical Research (CMR) Building, Technical Area 3, Los Alamos National Laboratory, New Mexico*. Caporuscio Krier, Lavine, and Gardner. LA-13522-MS. Los Alamos National Laboratory. Los Alamos, New Mexico. October 1998.

LAC 1987 — *Los Alamos County Comprehensive Plan.* Los Alamos County. Los Alamos, New Mexico. 1987.

LAC 1995 — *Water Use and Cost, Fiscal Years 1991–1995*. Los Alamos County Department of Public Utilities. Los Alamos, New Mexico. 1995.

LAEDC 1995 — *Third Quarter Report*. Los Alamos Economic Development Corporation. Los Alamos, New Mexico. 1995.

LAHS nd — *Los Alamos, Beginning of an Era, 1943–1945*. Los Alamos Historical Society. Los Alamos, New Mexico.

LAM 1996a — "Council OKs/Supports Budget Operations Plan." *Los Alamos Monitor.* June 11, 1996.

LAM 1996b — Quote in the *Los Alamos Monitor* from E. Nettles, Los Alamos National Laboratory Emergency Management Group. Subject: Fire safety and management. Vol. 33, No. 145. July 21, 1996.

LANL 1992a — *Los Alamos Climatology Summary*. Los Alamos National Laboratory. LA-12232-MS. Los Alamos, New Mexico. 1992.

LANL 1992b — *Environmental Surveillance at Los Alamos During 1990*. Los Alamos National Laboratory. LA-12271-M8. UC-1990. Los Alamos, New Mexico. March 1992.

LANL 1993a — *Installation Work Plan for Environmental Restoration,* Revision 3. LA-UR-93-3987. Tracked Document 43. Los Alamos National Laboratory. Los Alamos, New Mexico. November 1993.

LANL 1993b — *Environmental Surveillance at Los Alamos During 1991*. Los Alamos National Laboratory. LA-12572-ENV. UC-902. Los Alamos, New Mexico. August 1993.

LANL 1993c — "Administrative Requirements: Workspaces, Hearing Conservation." *Los Alamos National Laboratory Manual*. Los Alamos National Laboratory. AR8-2. Los Alamos, New Mexico. October 1, 1993.

LANL 1994a — *Los Alamos National Laboratory Annual Air Emissions Report for the Calendar Year 1993*. Los Alamos National Laboratory. Los Alamos, New Mexico. June 1994.

LANL 1994b — *Environmental Surveillance at Los Alamos During 1992*. Los Alamos National Laboratory. LA-12764-MS. UC-902. Los Alamos, New Mexico. July 1994.

LANL 1994c — *RFI Work Plan for Operable Unit 1154, Environmental Restoration Program*. Los Alamos National Laboratory. LA-UR-94-1096. Los Alamos, New Mexico. May 1994.

LANL 1995a — *LANL Cultural Resource Electronic Database of Archaeological Sites*. Los Alamos National Laboratory. Los Alamos, New Mexico. 1995.

LANL 1995c — *Decommissioning Summary Site Plan*, Attachment 7, pp. 26-41. Los Alamos National Laboratory, Environmental Restoration Project. Los Alamos, New Mexico. 1995.

LANL 1995d — *Capital Asset Management Process, Fiscal Year 1997*. Los Alamos National Laboratory. LA-UR-95-1187. Los Alamos, New Mexico. 1995.

LANL 1995e — *Site Development Plan Update.* Los Alamos National Laboratory. LA-LP-95-113. Los Alamos, New Mexico. 1995.

LANL 1995f — *Environmental Surveillance at Los Alamos During 1993.* Los Alamos National Laboratory. LA-12973-ENV. UC-902. Los Alamos, New Mexico. October 1995.

LANL 1995g — Draft Biological and Floodplain/Wetland Assessment for Environmental Restoration Program, Operable Unit 1154, TA–57. Los Alamos National Laboratory. LA-UR-95-980. Los Alamos, New Mexico. April 6, 1995.

LANL 1996a — *Installation Work Plan,* Revision 6. Los Alamos National Laboratory. Los Alamos, New Mexico. December 1996.

LANL 1996b — Waste Projection Data Call responses from Los Alamos National Laboratory. Los Alamos, New Mexico. September 1996.

LANL 1996c — OSHA 200 Logs, Los Alamos National Laboratory, ESH-5. Los Alamos, New Mexico. 1991–1996.

LANL 1996d — *Future Land Use Site Planning Report.* Los Alamos National Laboratory, FSS-6, Physical Planning Office. FSS/FPD-96-030. Los Alamos, New Mexico. April 23, 1996.

LANL 1996e — *Environmental Surveillance at Los Alamos During 1994.* Los Alamos National Laboratory. LA-13047-ENV. UC-902. Los Alamos, New Mexico. July 1996.

LANL 1996f — *Groundwater Protection Management Program Plan,* Rev. 0.0. Los Alamos National Laboratory, Water Quality and Hydrology Group. Los Alamos, New Mexico. January 31, 1996.

LANL 1996g — Human Resources Information System printouts. J. F. Van Hecke, Jr. Los Alamos National Laboratory. Los Alamos, New Mexico. January 10, 1996.

LANL 1996h — Electronic database files. Los Alamos National Laboratory, Facility for Information Management, Analysis, and Display (FIMAD). Los Alamos, New Mexico. 1995–1996.

LANL 1996i — *Environmental Surveillance at Los Alamos During 1995.* Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.

LANL 1997c — *Environmental Surveillance and Compliance at Los Alamos During 1996.* Los Alamos National Laboratory, Environmental Assessments and Resource Evaluations Group. LA-13343-ENV. Los Alamos, New Mexico. 1997.

LANL 1997d — *Approaches for Upgrading Electrical Power System Reliability and Import Capability.* Los Alamos National Laboratory. Los Alamos, New Mexico. August 1997.

LANL 1997e — Field Observations of Eight Cultural Resource Sites in the Vicinity of LANL Firing Sites. Report transmitted from T. Ladino, Los Alamos National Laboratory, ESH-20/Ecol-98-0084. Los Alamos, New Mexico. October 29, 1997.

LANL 1998a — *Description of Technical Areas and Facilities at LANL.* Los Alamos National Laboratory. LA-UR-97-4275. Los Alamos, New Mexico. March 1998.

LANL 1998b — *Los Alamos National Laboratory Hydrogeologic Workplan*. Los Alamos National Laboratory. Los Alamos, New Mexico. May 1998.

LANL 1998c — *Threatened and Endangered Species Habitat Management Plan*. Los Alamos National Laboratory, Ecology Group, ESH-20. Los Alamos, New Mexico. November 1998.

LANL nd — National Park Service Support Water Use Data. Los Alamos National Laboratory, FSS-8 Group data. Los Alamos, New Mexico.

LANL et al. 1990 — *1990 Site Development Plan—Technical Site Information.* Los Alamos National Laboratory, Facilities Engineering Division Planning Group, ICF Kaiser Engineers, Inc., and Royston Hanamoto Alley and Abey. Los Alamos, New Mexico and Mt. Valley, California. LA-CP-90-405. September 1990.

Lansford et al. 1996 — *The Economic Impact of Los Alamos National Laboratory on North-Central New Mexico and the State of New Mexico, Fiscal Year 1995*. R. R. Lansford, L. D. Adcock, L. M. Gentry, and S. Ben-David. U.S. Department of Energy, Albuquerque Operations Office, in cooperation with the University of New Mexico, Albuquerque, New Mexico, and New Mexico State University, Las Cruces, New Mexico. August 1996.

LM&A 1994 — *Los Alamos Resource Pool Power Study*. Prepared by Lundberg, Marshall & Associates, Ltd., under Contract Number DE-ACOA-93AL82990, for the U.S. Department of Energy, Albuquerque Operations Office. Los Alamos, New Mexico. July 1, 1994.

Longmire et al. 1996 — *Natural Background Geochemistry, Geomorphology, and Pedogenesis of Selected Soil Profiles and Bandelier Tuff, Los Alamos, New Mexico.* P. A. Longmire, Steven L. Reneau, Paula M. Watt, Leslie D. McFadden, Jamie N. Gardner, Clarence J. Duffy, and Randall T. Rytig. Los Alamos National Laboratory. LA-12913-MS. Los Alamos, New Mexico. May 1996.

Lusk 1998 — *Los Alamos National Laboratory Canyon Bottom Use Study - Preliminary Results Presentation*. J. Lusk. U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office. June 19, 1998.

McCalpin 1998 — *Late Quarternary Faulting on the Pajarito Fault West of Los Alamos National Laboratory, North-Central New Mexico: Results from the Seven-Trench Transect Excavated in Summer of 1997*. McCalpin. GEO-HAZ Consulting, Inc. Estes Park, Colorado. August 1998.

McGehee 1995 — *Decontamination and Decommissioning of 28 'S-Site' Properties: Technical Area 16.* Ellen D. McGehee. Los Alamos National Laboratory. Cultural Resources Survey Report Number 84. Los Alamos, New Mexico. 1995.

McLin 1992 — *Determination of 100-Year Floodplain Elevations at Los Alamos National Laboratory*. S. G. McLin. Los Alamos National Laboratory. LA-12195-MS, UC-903. Los Alamos, New Mexico. August 1992.

McLin 1993 — *Analysis of Rockfall Hazards at Los Alamos National Laboratory*. S. G. McLin. Submitted to the Fourth U.S. Department of Energy Natural Phenomena Hazards Mitigation Conference, Atlanta, Georgia. Los Alamos National Laboratory. LA-UR-93-3007. Los Alamos, New Mexico. 1993.

NCRP 1987 — *Ionizing Radiation Exposure of the Population of the United States.* National Council on Radiation Protection and Measurements. NCRP Report No. 93. September 1987.

NMDE 1995a — *How Schools are Financed in New Mexico.* New Mexico State Department of Education. Santa Fe, New Mexico. June 1995.

NMDE 1995b — *New Mexico Public Schools Financial Statistics, Fiscal Years 1993-1994 Actual, 1994–1995 Estimated*. New Mexico State Department of Education. Santa Fe, New Mexico. 1995.

NMDL 1996 — *1990–1996 Annual Averages,* "Table C–Civilian Labor Force, Employment, Unemployment, and Unemployment Rate." New Mexico Department of Labor, Economic Research and Analysis. Santa Fe, New Mexico. April 1996.

NMED 1995 — *New Mexico Environment Department Safe Drinking Water Act Electronic Database, 1995*. Monitoring results for 1994 obtained from R. Asbury of New Mexico Environment Department. 1995.

NMFMB 1996 — *County and Municipal Governments Financial and Property Tax Data, Fiscal Year 1995 Annual Report.* State of New Mexico, Department of Finance and Administration, Local Government Division, Financial Management Bureau. Santa Fe, New Mexico January 1996.

NMHPD 1995 — *New Mexico State Register of Cultural Properties and National Register of Historic Places, Listings for Los Alamos County.* New Mexico Office of Cultural Affairs, Historic Preservation Division. Santa Fe, New Mexico. February 8, 1995.

NMHTD 1995 — Road Segments by Traffic (AADT) Information. Consolidated Highway Database. New Mexico State Highway and Transportation Department. Santa Fe, New Mexico. 1995.

NMIGA 1996 — *Indian Gaming and the New Mexico Economy*. Prepared for the New Mexico Indian Gaming Association by the Center for Applied Research. Denver, Colorado. October 30, 1996.

NMNRD 1994 — *Annual Resources Report.* State of New Mexico Energy, Minerals, and Natural Resources Department. Santa Fe, New Mexico. 1994.

Noss 1990 — "Conservation Biology." R. F. Noss. *The Journal of the Society for Conservation Biology.* Vol. 4, No. 4. December 1990.

NPS 1986 — *A Checklist of Mammals, Amphibians, and Reptiles of Bandelier National Monument.* U.S. Department of the Interior, National Park Service. Published by Southwest Parks and Monuments Association. Tucson, Arizona. 1986.

NPS 1990 — *Guidelines for Evaluating and Documenting Traditional Cultural Properties,* U.S. Department of the Interior, National Park Service, Interagency Resources Division. National Register Bulletin 38. Washington, D.C. 1990.

NPS 1992 — *A Checklist of Mammals, Amphibians, and Reptiles of Bandelier National Monument.* U.S. Department of the Interior, National Park Service. Published by Southwest Parks and Monuments Association. Tucson, Arizona. 1992.

Nyhan et al. 1978 — *Soil Survey of Los Alamos County*, *New Mexico.* J. W. Nyhan, L. W. Hacker, T. E. Calhoun, and D. L. Young. Los Alamos Scientific Laboratory. LA-6779-MS. Los Alamos, New Mexico. June 1978.

Olig et al. 1998 — *Probabilistic Seismic Hazard Analysis for Surface Fault Displacement at TA–3, Los Alamos National Laboratory*. Olig, Youngs, and Wong. Woodward Clyde Federal Services. Oakland, California. July 1998.

OPM 1994 — *Biennial Report of Employment by Geographic Area, Federal Civilian Workforce Statistics.* U.S. Office of Personnel Management. MW 68-22. Washington, D.C. December 31, 1994.

Ortiz 1995 — Letter from M. Jacquez-Ortiz, Community Relations Specialist, St. Vincent Hospital. Santa Fe, New Mexico. November 13, 1995.

PC 1995b — C. Pareza, GRAM Team. Telephone interview with H. Miller, Business Manager, Los Alamos Public Schools. Los Alamos, New Mexico. October 25, 1995.

PC 1995d — C. Ball, GRAM, Inc. Personal communications with the Los Alamos National Laboratory, Business Operations Division. November 13, 1995.

PC 1995f — C. Pazera, GRAM, Inc. Telephone conversation with Pete Garcia, Business Manager, Santa Fe Public Schools, regarding Santa Fe Schools enrollment, budget, planning, and bond issue. IN-51563. Santa Fe, New Mexico. November 16, 1995.

PC 1995g — C. Pazera, GRAM, Inc. Telephone conversation with B. Russell, Program Manager of the World Primary Health Care Act at the Community Primary Care Bureau of the New Mexico State Health Department, regarding statistics on primary care facilities. IN-51526. December 5, 1995.

PC 1996a — E. Rogoff, GRAM, Inc. Personal communication with T. Thompson, New Mexico State Engineer, regarding information on water rights for Española and Santa Fe. June 11, 1996.

PC 1996c — E. Rogoff, GRAM Team. Personal communication with K. McAda, U.S. Department of Energy, regarding San Juan-Chama water rights. February 27, 1996.

PC 1996e — Telephone interview with T. Glasco, Water System Manager, Los Alamos County Department of Public Utilities. Los Alamos, New Mexico. January 5, 1996.

PC 1996f — J. Fritts, GRAM Team. Personal communication with R. E. Ford-Schmid, New Mexico Environment Department. U.S. Department of Energy Oversight Bureau. Santa Fe, New Mexico. June 19, 1996.

PC 1996h — J. Fritts, GRAM Team. Personal communication with David B. Rogers, Los Alamos National Laboratory. Los Alamos, New Mexico. June 30, 1996.

PC 1996i — Personal communication with J. Gardner. 1996.

PC 1996j — C. Ball, GRAM, Inc. Telephone conversation with J. Hafer, Los Alamos Association of Realtors, Los Alamos, New Mexico. 1996.

PC 1996l — M. Barr, GRAM Team. Personal communication with P. Pizzoli, Los Alamos County Utilities Department, Los Alamos, New Mexico, concerning Los Alamos County sewage treatment facilities. November 1996.

PC 1996n	C. Pazera, GRAM, Inc. Telephone conversation with C. Pongrantz, Assistant Superintendent, Los Alamos Public Schools. Los Alamos, New Mexico. July 15, 1996.
PC 1996o	C. Pazera, GRAM, Inc. Telephone conversation with J. B. Chavez, Superintendent, Española Public School District. Española, New Mexico. July 16, 1996.
PC 1996p	J. Hogan, GRAM Team. Personal communication with E. Nettles, Los Alamos National Laboratory (Emergency Management), concerning fire risk and management. Los Alamos, New Mexico. July 8, 1996.
PC 1996q	Personal communication with Fred Brueggeman, Assistant County Administrator for Intragovernmental Relations. November 20, 1996.
PC 1996r	J. Hogan, GRAM Team. Personal communication with Brian Jacobs, National Park Service Botanist/Resource Specialist, Bandelier National Monument. 1996.
PC 1997a	C. Ball, GRAM, Inc. Personal communications with Kevin Fenner, Los Alamos County Community Development Department. October 2, 1996 and January 16, 1997.
PC 1997c	J. Frits, GRAM Team. Personal communication with M. Alexander, Los Alamos National Laboratory, regarding the University of California Storm Water Monitoring Program. Los Alamos, New Mexico. January 16, 1997.
PC 1997d	J. Fritts, GRAM Team. Personal communication with R. Pine, New Mexico Environment Department, regarding ongoing study of residential wells in Northern Santa Fe County; data from 1995-1996. Santa Fe, New Mexico. April 1997.
PC 1997f	C. L. Oakes, GRAM Team. Personal communication with Beverly Larson, LANL Cultural Resources Management Team, Los Alamos National Laboratory. Los Alamos, New Mexico. June 18, 1997.
PC 1997g	K. Agogino, DOE Albuquerque Operations. Personal communication with Dave Inglert, New Mexico Environment Department. U.S. Department of Energy, Oversight Bureau. Santa Fe, New Mexico. December 10, 1977.
PC 1998	K. Agogino, DOE Albuquerque Operations. Personal communications with Neil Williams, ESH-18, Los Alamos National Laboratory. Los Alamos, New Mexico. February 10, 1998.

PC ndb	Information obtained from interviews with various people at the Transportation Statistics Bureau, Transportation Planning Division, New Mexico State Highway and Transportation Department. Santa Fe, New Mexico.
Perkins and Thomas 1980	"Worldwide Fallout." R. W. Perkins and C. W. Thomas. *Transuranic Elements in the Environment.* U.S. Department of Energy, Technical Information Center. Washington, D.C. 1980.
Pettitt 1969	*Soil-Cement from Volcanic Material, Rural and Urban Roads*. R. A. Pettitt. 1969.
PNM 1996	Gas Transmission Operations District Map. Public Service Company of New Mexico (PNM). April 16, 1996.
PNM nd	Electric Transmission Operations District Map. Public Service Company of New Mexico (PNM).
Potter 1977	*Deer-Burro Utilization and Competition Study, Bandelier National Monument*, Final Report. L. D. Potter. University of New Mexico, Department of Biology. Albuquerque, New Mexico. January 14, 1977.
Promislow and Fettig 1996	*Development of Willow Habitats in White Rock Canyon of the Rio Grande.* M. Promislow and S. M. Fettig. Bandelier National Monument and ESSA Technologies, Ltd. October 1996.
Purtymun 1995	*Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area*." W. D. Purtymun. Los Alamos National Laboratory. LA-12883-MS. Los Alamos, New Mexico. January 1995.
Purtymun and Johansen 1974	"General Geohydrology of the Pajarito Plateau." W. D. Purtymun and S. Johansen. *New Mexico Geological Society Guidebook,* 25th Field Conference. Ghost Ranch, New Mexico. 1974.
Purtymun and Koopman 1965	*Physical Characteristics of the Tshirege Member of the Bandelier Tuff with Reference to Use as Building and Ornamental Stone.* W. D. Purtymun and F. C. Koopman. U.S. Geological Survey Open-File Report. 1965.
Purtymun et al. 1987	*Background Concentrations of Radionuclides in Soils and River Sediments in Northern New Mexico, 1974–1986.* W. D. Purtymun, R. J. Peters, T. E. Buhl, M. N. Maes, and F. H. Brown. Los Alamos National Laboratory. LA-11134-MS. Los Alamos, New Mexico. November 1987.

Purtymun et al. 1995	*Water Supply at Los Alamos During 1993.* W. D. Purtymun, S. G. McLin, A. K. Stoker, M. N. Maes, and T. A. Glasco. Los Alamos National Laboratory. LA-12951-PR. UC-903. Los Alamos, New Mexico. October 1995.
Rea 1997	Letter from K. H. Rea to D. Garvey. Subject: Utility Usage and Projections across SWEIS Alternatives. 1997.
Reneau 1994	*Potential Mesa-Edge Instability at Pajarito Mesa in Geological Site Characterization for the Proposed Mixed Waste Disposal Facility, Los Alamos National Laboratory.* S. L. Reneau. Los Alamos National Laboratory. Los Alamos, New Mexico. 1994.
Reneau 1995	"Geomorphic Studies at DP Mesa and Vicinity." S. L. Reneau. *Earth Science Investigations for Environmental Restoration, Los Alamos National Laboratory Technical Area 21.* D. E. Broxton and P. G. Eller, eds. Los Alamos National Laboratory. LA-12934-MS. UC-903. Los Alamos, New Mexico. June 1995.
Reneau et al.1995	*Landslides and Other Mass Movements Near Technical Area 33, Los Alamos National Laboratory.* S. L. Reneau, D. P. Dethier, and J. S. Carney. Los Alamos National Laboratory. LA-12955-MS. Los Alamos, New Mexico. 1995.
Reneau et al.1996	"New Evidence for the Age of the Youngest Eruptions in the Valles Caldera, New Mexico." S. L. Reneau, J. N. Gardner, and S. L. Forman. *Geology.* Vol. 24, No. 1. January 1996.
Richter 1958	*Elementary Seismology.* C. F. Richter. W. H. Freeman and Company, Inc. 1958.
Richeldi et al. 1993	"HLA-DPB1 Glutamate 69: A Genetic Marker of Beryllium Disease." L. Richeldi et al. *Science.* Vol. 262, pp. 242-244. 1993.
Robinson and Thomas 1991	*Time Spent in Activities, Locations, and Microenvironments: A California - National Comparison Project Report.* J. P. Robinson and J. Thomas. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory. Las Vegas, Nevada. 1991.
Rogers et al. 1996	"Recharge to the Pajarito Plateau Aquifer System." D. B. Rogers, A. K. Stoker, S. G. McLin, and B. M. Gallaher. *1996 Guidebook, Geology of the Los Alamos —Jemez Mountains Region.* Los Alamos National Laboratory. LA-UR-96-486. New Mexico Geological Society. Los Alamos, New Mexico. 1996.
Rosenberg et al. 1993	*Potential Transport of PCBs through Fractured Tuff at Area G.* N. D. Rosenberg, W. E. Soll, and H. J. Turin. Los Alamos National Laboratory. LA-UR-94-28. Los Alamos, New Mexico. December 1993.

Rothman 1992	*On Rims and Ridges–the Los Alamos Area Since 1880.* H. K Rothman. University of Nebraska Press. Lincoln, Nebraska. 1992.
Rothman nd	*Cultural and Environmental Change on the Pajarito Plateau.* H. K. Rothman. Vol. 64, pp. 185-211.
Self et al. 1986	"Explosive Rhyolitic Volcanism in the Jemez Mountains: Vent Locations, Caldera Development, and Relation to Regional Structure." S. Self, F. Goff, J. N. Gardner, J. V. Wright, and W. M. Kite. *Journal of Geophysical Research.* Vol. 91. 1986.
Stephens et al. 1993	*Hydrogeologic Review for the Environmental Restoration Program at Los Alamos National Laboratory.* D. B. Stephens, P. M. Kearl, and R. W. Lee. Prepared for the Los Alamos National Laboratory by Daniel B. Stephens & Associates, Inc. April 24, 1993.
Stoker 1993	Direct Testimony of Alan K. Stoker on Behalf of Petitioners Before the New Mexico Water Quality Control Commission. Subject: Conditional Certification of Draft National Pollutant Discharge Elimination System (NPDES) Permit No. NM0028355. Petitioners: The Regents of the University of California and the U.S. Department of Energy. March 31, 1993.
Stange et al. 1996	"Possible Health Risks from Low Level Exposure to Beryllium." A. W. Stange et al. *Toxicology*. Vol. III, pp. 213-224. 1996.
Stuart and Gauthier 1981	*Prehistoric New Mexico: A Background for Survey*. David E. Stuart and Rory P. Gauthier. New Mexico Historic Preservation Bureau. Santa Fe, New Mexico. 1981.
Travis 1992	"Pajarito Ornithological Survey." J. R. Travis. *Atlas of the Breeding Birds of Los Alamos County, New Mexico.* Los Alamos National Laboratory, Atlas Project Steering Committee. LA-12206, UC-908. Los Alamos, New Mexico. October 1992.
UK et al. 1997	*Beryllium Control Model*. Atomic Weapons Establishment. UK and U.S. Department of Energy, EH-5. Cardiff, United Kingdom. June 25, 1997.
UNM 1994	*Population Projections for the State of New Mexico by Age and Sex, 1990–2020*. University of New Mexico, Bureau of Business and Economic Research. Albuquerque, New Mexico. May 1994.
UNM 1998	*Ecological Assessment/Habitat Fragmentation of LANL*. University of New Mexico, National Heritage Program. Albuquerque, New Mexico. In progress 1998.

USFS 1987	*Santa Fe National Forest Plan*. U.S. Forest Service. 1987.
USFS 1996	"Elk Response to the La Mesa Fire and Current Status in the Jemez Mountains." U.S. Department of Agriculture, Forest Service. *Proceedings of the Second La Mesa Fire Symposium, Los Alamos, New Mexico.* March 29–31, 1994. C. D. Allen, ed. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-286. Fort Collins, Colorado. September 1996.
Vigil 1996	Letter from Alvaro Vigil, Transportation Planning Division, New Mexico State Highway Department, to W. R. Rhyne. Santa Fe, New Mexico. January 25, 1996.
Villa 1996	Presentation Viewgraph from August 24, 1996 SWEIS Workshop on LANL Transportation. Sandra A. Villa. Los Alamos National Laboratory. Los Alamos, New Mexico. 1996.
Voelz and Lawrence 1991	"A 42-Year Medical Follow-Up of Manhattan Project Plutonium Workers." G. L. Voelz and J. N. P. Lawrence. *Health Physics.* Vol. 61, No. 2, pp. 181-190. August 1991.
Voelz et al. 1985	G. L. Voelz, R. S. Grier, and L. H. Hempelmann. *Health Physics*. Vol. 48, pp. 249-259. 1985.
Voelz et al. 1997	"Fifty Years of Plutonium Exposure to the Manhattan Project Plutonium Workers: An Update." G. L. Voelz, J. N. P. Lawrence, and E. R. Johnson. *Health Physics*. Vol. 73, No. 4, pp. 611-619. 1997.
Wendorf 1954	"A Reconstruction of Northern Rio Grande Prehistory." Fred Wendorf. *American Anthropologist.* Vol. 56, pp. 200-227. 1954.
Westervelt 1995	"Water Use Data." R. Westervelt. August 16, 1995.
Whicker and Schultz 1982	*Radioecology: Nuclear Energy and the Environment.* F. W. Whicker and V. Schultz. CRC Press, Inc. Boca Raton, Florida. 1982.
Wiggs 1987	*Mortality Among Females Employed by the Los Alamos National Laboratory: An Epidemiological Investigation*. L. D. Wiggs. Ph.D. Thesis, University of Oklahoma. 1987.
Wiggs et al. 1988	*Suicide Mortality Among Female Nuclear Industry Workers*. L. D. Wiggs, C. A. Weber, and E. T. Lee. 116th Annual Meeting of the American Public Health Association. Washington, D.C. November 13–17, 1988.

Wiggs et al. 1994 “Mortality Through 1990 Among White Male Workers at the Los Alamos National Laboratory: Considering Exposures to Plutonium and External Ionizing Radiation.” L. D. Wiggs, E. R. Johnson, C. A. Cox-Devore, and G. L. Voelz. *Health Physics.* Vol. 67, No. 6, pp. 577-588. 1994.

Wilcox et al. 1994 *Frijolito Watershed: Integrated Investigations of a Rapidly Eroding Pinyon-Juniper Hillslope.* B. P. Wilcox, J. Pitlick, and C. D. Allen. Los Alamos National Laboratory. LA-UR-94-3933. Los Alamos, New Mexico. 1994.

Wilcox et al. 1996a “Runoff and erosion from a rapidly eroding pinyon-juniper hillslope.” B. P. Wilcox, C. D. Allen, J. Pitlick, and D. W. Davenport. British Geomorphological Research Group Symposium, September 20-22, 1996. CONF-960984-1. Bristol, United Kingdom. LA-UR-95-4042. National Biological Survey and Los Alamos National Laboratory, Los Alamos, New Mexico; Jemez Mountain Field Station; Colorado University, Boulder, Colorado. 1996.

Wilcox et al. 1996b “Runoff and erosion on the Pajarito Plateau: Observations from the field.” B. P. Wilcox, B. D. Newman, C. D. Allen, K. D. Reid, D. Brandes, J. Pitlick, and D. W. Davenport. *New Mexico Geological Society Guidebook*. 47th Field Conference, Jemez Mountains Region. pp. 433-439. 1996.

Wolff and Gardner 1995 “Is the Valles Caldera Entering a New Cycle of Activity?” J. A. Wolff and J. N. Gardner. *Geology*. Vol. 23, No. 5. May 1995.

Wolfman 1994 *Jemez Mountains Chronology Study*. Daniel Wolfman. Museum of New Mexico, Office of Archaeological Studies. Santa Fe, New Mexico. 1994.

Wong et al. 1995 *Seismic Hazards Evaluation of the Los Alamos National Laboratory,* Final Report, Vol. III. I. Wong, et al. Woodward-Clyde Federal Services. Oakland, California. February 24, 1995.

Yanicak 1996 *1995 Annual Performance Report for Environmental Oversight and Monitoring at Department of Energy Facilities in New Mexico*. S. Yanicak. New Mexico Environment Department. U.S. Department of Energy, Oversight and Monitoring Program. Santa Fe, New Mexico. 1996.

Zimmerman 1996 Memorandum from J. K. Zimmerman, Los Alamos County Engineer, to D. Riker and M. Tomlinson, Los Alamos County Public Works, Engineering Division. Subject: Landfill Life Cycle Calculations. Los Alamos, New Mexico. October 3, 1996.

CHAPTER 5.0
ENVIRONMENTAL CONSEQUENCES

This chapter describes the potential direct, indirect and cumulative environmental impacts, or changes, resulting from each of the reasonable alternatives for continuing the operation of LANL: the No Action Alternative, the Expanded Operations Alternative (DOE's Preferred Alternative, with the exception that pit manufacturing would not be implemented at a 50 pits per year level, single shifts, but only at a level of 20 pits per year in the near term), the Reduced Operations Alternative, and the Greener Alternative. Environmental impacts are described and discussed across the various aspects of the affected environment or resource areas that are likely to change at a site-wide level.[1] Aspects of the environment that are not expected to change as a result of implementing any of the four alternatives analyzed are not discussed in detail.

The Region of Influence (ROI) varies across the resources as well as across the alternatives. Chapter 4, Affected Environment, describes the current environment in and around LANL for each of the resource areas (e.g., Land Resources, Air Quality, and Water Quality). The information presented in chapter 4 is the foundation for understanding and evaluating the environmental impacts associated with the four alternatives.

Chapter 5 includes six major sections. Section 5.1 presents the methodologies used for the impact analysis for each resource area. Sections 5.2, 5.3, 5.4, and 5.5 present the impacts associated with the No Action, Expanded Operations, Reduced Operations, and Greener Alternatives, respectively. Section 5.6 presents unavoidable adverse impacts, the relationship of short-term uses and long-term productivity of resources, the irreversible or irretrievable commitment of resources, and the cumulative impacts associated with the continued operation of LANL. Each section except 5.6 is formatted to follow the presentation of the affected environment or resource areas discussed in chapter 4 (e.g., section 5.2.1 presents the impacts of the No Action Alternative to Land Resources). The most detailed discussion is presented in section 5.2, and the impacts associated with each of the other alternatives are usually compared to the impacts of the No Action Alternative (in section 5.2) to minimize repetition. A discussion of bounding potential credible accidents for the four alternatives is presented near the end of each of these sections (i.e., sections 5.2.11, 5.3.11, 5.4.11, and 5.5.11). The discussions in this SWEIS, including discussions in this chapter, are augmented by a classified supplement to the SWEIS. This supplement contains certain classified information and data related to the activities at LANL that, though important to support understanding of certain details underlying the SWEIS and its analyses, must be protected in

1. The scope of the SWEIS was developed prior to issuance of the Stockpile Stewardship and Management Programmatic Environmental Impact Statement (SSM PEIS, DOE 1996d) Record of Decision (ROD). Thus, the Expanded Operations Alternative was originally defined to include the high explosives component production and the secondary assembly production mission elements, as discussed in chapter 1. Accordingly, the environmental consequences of the Expanded Operations Alternative (described in section 5.3) include the impacts associated with these mission elements. However, because these activities do not contribute substantially to air quality, water resource, land resource, socioeconomic, or other impacts projected regarding LANL operations, the environmental consequences of the Expanded Operations Alternative with or without these mission elements are substantially the same. Therefore, DOE determined that it was not cost effective to restructure and reanalyze the Expanded Operations Alternative. To the extent that this affects the impact analyses, the environmental consequences of the Expanded Operations Alternative can be expected to be somewhat less than identified in section 5.3.

accordance with the *Atomic Energy Act of 1954* (42 United States Code [U.S.C.] §2011). This information includes details associated with some operations, experiments, processes, or source terms. DOE presents as much information as possible in this unclassified document. Furthermore, the environmental impacts are fully contained in the results presented to the public in this unclassified document.

The major contributors to environmental impacts of operating LANL are wastewater discharges and radioactive air emissions.

- Historic discharges to Mortandad Canyon from the Radioactive Liquid Waste Treatment Facility (RLWTF) have resulted in above background residual radionuclide (americium, plutonium, strontium-90, and cesium-137) concentrations in alluvial groundwater and sediments.
- Plutonium deposits have been detected along the Rio Grande between Otowi and Cochiti Lake.
- The principal contributors to radioactive air emissions have been and continue to be the Los Alamos Neutron Science Center (LANSCE) and high explosives testing activities.

In addition, trace amounts of tritium have been detected in some samples from the main aquifer. (Isolated results have indicated the presence of other radionuclides. However, results have not been duplicated in previous or subsequent samples, making these results suspect.)

The analysis in the SWEIS indicates that there are very few differences in the site-wide environmental impacts among the alternatives analyzed. The major discriminators among alternatives are: collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand. A summary of impacts is provided in section 3.6 in chapter 3. Tables 3.6.2–1 and 3.6.2–2 provide a direct comparison of expected consequences for each environmental factor across alternatives.

5.1 IMPACT ANALYSIS METHODOLOGIES

5.1.1 Land Resources Methodology

5.1.1.1 *Land Use*

The methodology used for assessing land use impacts is comparative in nature. The operations, facility construction and modification activities, and their predicted effects are compared against existing land use categories for the areas that could be influenced by such actions. In addition, the amounts of land disturbed or taken for construction are also identified. (This information is then used in the analysis of ecological and cultural resource impacts.)

5.1.1.2 *Visual Resources*

Visual impacts to the LANL viewshed depend on physical changes through development at the site, the ability for LANL structures to be seen by viewers because of changes in land cover, and the visibility of the area related to air or light pollution. Thus, this qualitative analysis addresses construction that may change the visibility of LANL structures or obscure views of the landscape, changes in land cover that may make LANL structures more or less visible, and changes in air or light pollution that could change visibility in the area.

5.1.1.3 *Noise*

Noise (unpleasant sounds), air blasts, and ground vibrations may be perceived both within and outside the LANL site boundaries due to the combined effect of the existing traffic, LANL high explosives research, and construction activities. The noise heard by people located outside the site boundaries may be very episodic (such as explosives testing) or may be long term in duration (such as traffic noise). This analysis examines projected activities with a focus on changes from existing noise conditions in the area, as well as the potential for noise impacts to workers and the public. Because noise and vibration impacts to cultural resources are addressed in the cultural resources impact analyses, such impacts are not discussed under land resources impacts.

5.1.2 Geology and Soils Methodology

The methodology used to assess potential impacts to geology and soils across the four alternatives was a two-step process. First, past LANL activities were evaluated to see how they had impacted the geology and soils in the Los Alamos area. The information from this study on the existing environment is presented in chapter 4 (section 4.2). Information from section 4.2 was then used as a basis for assessment of potential impacts that may result from implementing the four alternatives. The impact analysis focuses on any changes that have the potential for causing seismic events, slope instability, soils erosion, and changes to mineral resources. For example, observation and studies of the LANL site in the past have shown where slope stability problems are most likely to occur and under what circumstances. This type of information was then used to evaluate proposed activities to see if those same indicators leading to soil erosion were present in a new action or in a potential change to an existing activity. This manner of analysis is commensurate with the significance of the potential impact in this resource area.

Impacts to geology and soils are primarily associated with effects generated by proposed construction activities. However, for this SWEIS the majority of construction activities are within existing facilities. Where construction activities would occur outside of existing facilities (as in the expansion of Area G), they are explicitly addressed.

The effects on soil contamination from contaminants released to the atmosphere, either directly in gaseous effluents (e.g., air stack emissions) or indirectly from resuspension of on-site contamination (e.g., fugitive dust) were evaluated. As discussed in section 5.2.2, the information provided from the geology and soils sections directly relates to the analysis of several other sections within the SWEIS (such as cultural resources, human health, accidents, and ecological resources). For example, geologic hazards that are important components of accident scenarios are discussed in the accident sections, and the potential for human health and environmental impacts associated with soil contamination are discussed in the ecological and human health sections.

5.1.3 Water Resources Methodology

The primary differences in terms of water resources across the four alternatives are: (1) the change in flow from the permitted National Pollutant Discharge Elimination System (NPDES) outfalls and (2) the influences of water use to main aquifer.

The methodology used for assessing surface and groundwater impacts for the four alternatives was to first obtain index data on the NPDES outfalls (flow rates and analyte concentrations) and compare this information with projected NPDES flow rates and analyte concentrations for each of the alternatives. The majority of the changes, especially increases to NPDES flows for the alternatives, are contributed by the key facilities. Therefore, although index NPDES flows are discussed for the non-key facilities, flow projections for non-key facilities are assumed to be constant across the alternatives. If projections of NPDES outfall flows within each watershed vary within 5 percent of the index and historical NPDES outfall concentrations do not often exceed regulatory limits, effects are considered negligible. If projected NPDES outfall flow variations are greater than 5 percent of the index or historical NPDES outfall concentrations often exceed regulatory limits, consequences are evaluated qualitatively. This qualitative analysis includes evaluating the types of contamination that could originate from these outfalls and the potential for contamination in surface water, groundwater, and sediments to be transported off site. A qualitative analysis was done instead of a quantitative analysis because: (1) detailed information (i.e., distribution coefficient of radionuclides for soil, sediment, and alluvium; remaining sorption capacity of soil, sediment, and alluvium below outfall; vadose zone transport characteristics; moisture content; alluvial groundwater body lateral and vertical extent; alluvial groundwater flow rates alluvial recharge and discharge areas; recharge and discharge rates; stormwater and snowmelt runoff flow rates diluting the effluent; schedule of discharges relative to runoff event; and many others) is not available and (2) a reasonable qualitative assessment can be made. For stormwater runoff, the impact analysis focuses on changes across the alternatives that may have the potential for causing off-site migration of contaminants, such as new construction activities.

The water resources analysis was used as source information in several other sections within the SWEIS, such as ecological resources (i.e., potential effects of reduced flows to wetlands) and the human health and human and ecological risk (i.e., consumption of contaminated water and sediments).

The U.S. Geological Survey (USGS) MODFLOW model for north-central New Mexico (Frenzel 1995) was used to predict water level changes at the top of the main aquifer for the four alternatives. The model includes DOE supply wells, wells for the City of Santa Fe public water supply system, discharges from the Santa Fe sewage treatment plant, and 200 private and industrial wells in Santa Fe County. Water use projections for the purposes of modeling drawdown of the main aquifer and annual variations in LANL use were projected based on the alternative descriptions (particularly, the timing of construction projects and changes in operations). Projections for Los Alamos County and the National Park Service (NPS) were made also.

The Fenton Hill site (Technical Area [TA]–57), which was the location of LANL's Hot Dry Rock Geothermal Project and is still used for astrophysics research and experiments, is about 20 miles (32 kilometers) west of Los Alamos. The Hot Dry Rock Geothermal Project has been decommissioned and no further clean-up actions are anticipated. The NPDES permit was discontinued as of December 29, 1997, and during the time of operation there were no NPDES permit violations at the Fenton Hill site. For these reasons, there should be no impact to water resources from this facility, and this site is not discussed further in the SWEIS water resources impact analyses.

5.1.4 Air Quality Methodology

Radiological and nonradiological air pollutants are modeled differently, each with models most suitable for the purpose. Meteorological data sets also varied as was judged most appropriate given limitations on data, comparability of measurement points, and conventions typical for regulatory analyses. Details on these points are described below and in appendix B.

5.1.4.1 *Nonradiological Air Quality*

LANL has the potential to emit hundreds of air pollutants into the atmosphere from its laboratory operations (air toxic emissions) and fossil fuel-burning units (criteria pollutant emissions). An air quality assessment was conducted to estimate the potential impacts of the releases of these pollutants under each of the four alternatives identified for the SWEIS. Background information, including the methodology used for these analyses, is provided in this section.

In accordance with Title V of the *Clean Air Act*, as amended (42 U.S.C. §7401) and New Mexico Administrative Code (NMAC) 20 NMAC 2.70, the University of California (UC) submitted a *Clean Air Act* Operating Permit application to the New Mexico Environment Department (NMED) in December 1995 (20 NMAC 2.70, Operating Permit Application for LANL, LA-UR 95-4192).

In the operating permit application, LANL has voluntarily applied for plant-wide applicability limits (PALs) for nitrogen oxides (NOx), carbon monoxide, particulate matter (PM), sulfur dioxide, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs) (as defined in *Clean Air Act Amendments of 1990* at Section 112[b]), while demonstrating compliance with the applicable standards. LANL has voluntarily proposed permit terms for relevant emission units in order to demonstrate the enforceability of the PALs. The purpose of setting a PAL is to keep emissions below levels that trigger more stringent regulatory requirements and to define LANL's potential to emit. These PALs are intended to demonstrate "minor" source status with respect to HAPs and the Prevention of Significant Deterioration (PSD) Program. The amount of HAPs modeled in the screening process for the impact analysis occurs at a level below the proposed voluntary permit limits.

Criteria Pollutants

Criteria pollutants released into the atmosphere from LANL operations are emitted primarily from combustion facilities such as boilers, emergency generators, and motor vehicles. The analysis of these pollutants was conducted for emissions estimated under actual peak and annual average operating conditions of each major combustion unit. With the existing emission data and stack parameter information (i.e., heights, diameters, flow rates) for the criteria pollutants known, these emissions were modeled using the EPA Industrial Source Complex Short Term (ISCST3) model and meteorological data collected at TA–6.

Short-term and long-term concentrations of these pollutants were estimated at the sensitive receptors and the results were compared with applicable air quality standards. Both time frames were analyzed to address the potential short-term (acute) and long-term (chronic) impacts of these pollutants at locations where the public could have both short-term and long-term exposure to emissions from LANL facilities.

Because the emissions rates for the Expanded Operations Alternative are the greatest of the emission rates across the alternatives, the initial analysis of potential impacts due to criteria pollutants was based on these “bounding” emissions. Ambient air quality standards are established at levels that ensure an ample margin of safety, based on health risk assessments. Therefore, in cases where results of the Expanded Operations Alternative analysis of criteria pollutants demonstrate that the highest estimated concentration of a pollutant are well below the appropriate ambient air quality standards, no further analysis was performed. In cases where this alternative threatens such exceedances, more detailed analysis for each alternative was performed.

No quantitative analysis of vehicle emissions was performed as part of this analysis. Although the operational alternatives may have different effects on the travel patterns in the study area as a result of changes in the number of LANL employees who would commute to Los Alamos, the future population of Los Alamos County is not expected to change substantially under any of the alternatives. Therefore, changes in regional emissions under any of the future alternatives are not expected to be more than a few (less than 5) percent. Vehicle emissions were included in the assumed background concentrations for each of the criteria pollutants in the analysis. Background concentrations were assumed to be 20 percent of the relevant standard, a conservative assumption. Because the study area is in attainment for the pollutants that are released primarily from motor vehicles (carbon monoxide and ozone) and because there are no nearby heavily congested traffic areas or major sources or ozone precursors (i.e., hydrocarbons and nitrogen oxides), no potentially significant air quality impacts are expected from the commuter traffic emissions. The transportation analyses for each alternative include emissions impact estimates from trucks (e.g., commercial transport) associated with LANL’s operations across the U.S.

Toxic Air Pollutants

The pollutants and laboratory operations that may cause significant air quality impacts at LANL were identified through a progressive series of screening steps, each step involving fewer pollutants that were then screened by methods that involved more rigorous and realistic emission rates and modeling parameters than the step before. This approach, consistent with EPA guidance, focuses detailed analyses only on those chemicals that have a reasonable chance of being of concern. This approach is particularly useful for an installation such as LANL, where the research and development nature of the facility results in usage of a large number of chemicals, potentially released from hundreds of sources spread throughout a large geographic area, and at highly variable but relatively low usage rates.

The first screening step reduced a list of more than 2,000 chemicals purchased by LANL to a set of 382 on the basis of physical and chemical characteristics such as low vapor pressure or low toxicity, and small quantity. The second screening step involved a comparison of a calculated maximum rate derived from health-based standards to the potential emission rate from a TA. In this step, a screening level emission value (SLEV) was developed for each chemical and for each TA where that chemical was used. A SLEV is a theoretical maximum emission rate that, if emitted at that TA over a short-term (8-hour) or long-term (1-year) period, would not exceed a health-based guideline value (GV) (Table 5.1.4.1–1). This SLEV was compared to the emission rate that would result if all the chemicals purchased for use in the facilities at that TA over the course of 1 year were available to become airborne. Personnel knowledgeable of chemical usage and current and future operations reviewed these comparisons (put in the form of a ratio of SLEV to potential emission rate from the TA) and indicated whether or not it was possible that future chemical usage rates under any alternative could be increased by a factor indicated in these ratios. If there was an indication that usage could potentially be increased by that factor (a qualitative evaluation of whether chemical purchases could be increased by perhaps 10 times or 100 times over current rates), that chemical was referred to the next screening step.

The third step, performed for a set of 13 sources, some of which had multiple chemicals, involved a determination of more realistic emission rates based on actual knowledge of the process where the chemical was used and the modeling was conducted using actual stack parameters. If any chemical failed the screen at this point (a short- or long-term GV was exceeded), it was referred to the health and ecological risk assessment process of the SWEIS.

Additive effects of carcinogenic chemical emissions were also considered by calculating whether a GV could be exceeded in the case of emissions of the same chemical from multiple TAs, and whether a GV could be exceeded by adding the cancer risk from emissions of all carcinogenic chemicals from all TAs.

The EPA ISCST3 model was consistently used in this analysis, except for the third screening step in the case of modeling emissions from high explosives testing operations. In that case, a combination of the Hot Spot and the EPA ISCST3 models was more appropriate for modeling the emissions and conditions created by the detonation of explosives.

TABLE 5.1.4.1–1.—*Guideline Values Applied in the Nonradiological Air Quality Analysis*

Noncarcinogens Short-Term Guideline Values	While no national or State of New Mexico standards have been established for these pollutants, the NMED has developed GVs for determining whether a new or modified source emitting a toxic air pollutant would require a construction permit (20 NMAC 2.72, Subpart IV). These GVs are 8-hour concentrations that are 1/100 of the occupational exposure limits (OELs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) or the National Institute of Occupational Safety and Health (NIOSH).
Annual Average Guideline Values	The GVs used in this analysis are the inhalation reference concentrations (RfCs) from EPA's Integrated Risk Information System (IRIS). RfCs are daily exposure levels to the human population (including sensitive subgroups) during a lifetime (70 years) that could occur without appreciable risk of deleterious effects.
Carcinogens	The GVs used in this analysis to estimate potential impacts of carcinogenic toxic air pollutants from LANL operations are based on an incremental cancer risk of one in a million (1.0×10^{-6}) (i.e., one person in a million would develop cancer if exposed to this concentration over a lifetime)—a level of concern established in the *Clean Air Act*. The development of EPA risk estimates for exposure to carcinogens led to the concept of unit risk factors that are associated with exposure over a lifetime to annual average concentrations of chemicals. Therefore, only annual impact analyses of carcinogenic emissions were conducted. The impacts of the releases of carcinogenic toxic air pollutants were considered for more detailed analysis if the estimated combined incremental cancer risk associated with all of the carcinogenic pollutants emitted from LANL facilities at any location is greater than 1.0×10^{-6}. For the purpose of screening individual carcinogens, a cancer risk of 1.0×10^{-8} was established as the GV.

Two sets of receptors (i.e., locations where air quality levels were estimated) were considered for the methodology described above. The first set of receptors includes nearby identified actual locations of concentrated human activity that might be affected from the emissions from LANL facilities. These include: (1) schools, hospitals, parks, and playgrounds within Los Alamos; (2) residences (including those in trailer parks) in all directions surrounding all of LANL facilities in Los Alamos County; and (3) towns, cities, and sensitive national and cultural areas within approximately 50 miles (80 kilometers) of Los Alamos. These receptors are referred to as "sensitive receptors." The second set of receptors includes all of the fence line locations (in 10-degree increments) around each TA to which the public has access. These receptors are referred to as fence line receptors. Theoretical fence line receptors were considered in the comparison to short-term GVs; actual locations of receptors were considered in the comparison to long-term GVs (notably, carcinogens). Details on all aspects of this analysis may be found in appendix B (in volume III).

Of the 382 total pollutants, 35 carcinogenic pollutants were evaluated individually and were also considered in the additive impacts analysis of emissions from all of the TAs. A list of the toxic air pollutants evaluated is in attachment 2 to appendix B.

5.1.4.2 *Radiological Air Quality*

This section presents a discussion of the methods used to estimate the dose from radionuclide air emissions from LANL operations of selected modeled facilities. These methods were used for analysis of all alternatives; however, this information is not repeated in sections 5.2.4, 5.3.4, and 5.4.4. Prior to beginning the modeling of radionuclide air emissions under the SWEIS alternatives, historical data were reviewed for the index years 1990 through 1994. These data were used to verify that the modeled facilities under the SWEIS alternatives captured the majority of the emissions. The facilities listed in Table 5.1.4.2–1 were shown to represent over 99.7 percent of the dose to the LANL hypothetical maximally exposed individual (MEI) during the baseline years. Other facility emissions were not modeled due to their small contributions to the total. Additional information is presented in appendix B.

Air emission modeling and dose calculations were then performed for each facility listed in Table 5.1.4.2–1. The results of this modeling are presented for each of the four SWEIS

TABLE 5.1.4.2–1.—*Facilities Modeled for Radionuclide Air Emissions*

FACILITY	TYPE OF EMISSIONS
TA–3–29 (Chemistry and Metallurgy Research)	Point Emissions
TA–3–66 (Sigma Building)	Point Emissions
TA–3–102 (Machine Shops)	Point Emissions
TA–11 (High Explosives Testing)	Diffuse Emissions
TA–15/36 (Firing Sites)	Diffuse Emissions
TA–16 (Weapons Engineering Tritium Facility)	Point Emissions
TA–18 (Pajarito Site: Los Alamos Critical Experiments Facility)	Diffuse Emissions
TA–21 (TSTA and TSFF)[a]	Point Emissions
TA–48 (Radiochemistry Laboratory)	Point Emissions
TA–53 (LANSCE)[b]	Point and Diffuse Emissions
TA–54 (Area G)	Diffuse Emissions
TA–55 (Plutonium Facility)	Point Emissions

[a] Tritium System Test Assembly and Tritium Science and Fabrication Facility

[b] Five specific sources were modeled from TA–53 (Los Alamos Neutron Science Center). These include the TA–53 Exhaust Stack-2 (ES–2), Exhaust Stack-3 (ES–3), Isotope Production Facility, Low-Energy Demonstration Accelerator, and combined diffuse emissions.

alternatives. For each alternative analyzed, dose estimates were made to three specific receptors. These three receptors include the:

- *Facility-Specific Maximally Exposed Individual (FS MEI)*—Due to the distance between facilities across the LANL, each modeled facility was modeled independently. The FS MEI represents the location corresponding to a specific facility where the modeled dose was greatest. The location of the FS MEI was determined based on distance, direction, and meteorological data for each site. The dose commitments were then calculated at this location from all other modeled facilities; thus, the FS MEI represents the estimated dose to an individual from the specific facility and all other modeled facilities.
- *Site-Wide Maximally Exposed Individual (LANL MEI)*—The LANL MEI is the single highest FS MEI derived as described above. The LANL MEI was shown to be the same as the LANSCE FS MEI under all alternatives. The LANL MEI dose by alternative is presented in the air quality analyses, and the resultant human health risk effects due to these doses are presented in the human health analyses for each alternative.
- *Population Dose Within 50 miles (80 kilometers)*—Population dose estimates were made for the entire population within a 50-mile (80-kilometer) radius of LANL (i.e., the summation of all doses to all people within that radius). The population dose from each facility was modeled independently for each alternative. The total from all facilities for one alternative represents the population dose from that alternative. Dose estimates to the population were derived from both point source and diffuse emissions. The expected excess latent cancer fatalities (LCFs) for the exposed populations are presented in the human health analyses for each alternative.

  Using a composite of all modeled data, maps were developed showing estimated isodose lines (lines of equal dose) for each alternative. Estimates of dose at particular locations can be identified from these maps.

The results of this modeling were used to support human health impact analyses.

There are two general mechanisms in which radionuclides are dispersed into the ambient air from LANL operations. The first is through forced ventilation systems with pollution control devices through a stack or vent. The second is from diffuse or nonpoint source emissions. Diffuse emissions occur in areas such as firing sites, landfills, unvented buildings, and solid waste management units.

To estimate the dose impact from LANL operations, the facilities that emit the majority of radioactive materials to the air were identified. Twelve facilities were modeled within ten TAs. These facilities and types of radionuclide air emissions are listed in Table 5.1.4.2–1.

Radionuclide emission projections were made by LANL staff based on historical activity levels and corresponding emissions for each of the four alternatives. These emissions were used to model the doses and develop the isodose maps.

Individual and population dose estimates were calculated through the use of air dispersion modeling, which predicts the dispersion and dilution of radionuclide emissions at various locations. Following the release to the atmosphere, a radionuclide concentration at a given location is influenced by many variables including distance, direction, wind speed, wind direction, and others. Once the quantity of a radionuclide a person either ingests, inhales, or is otherwise exposed to is determined, the effective dose equivalent (EDE) is estimated by applying appropriate dose conversion factors for each radionuclide.

The air dispersion model used for these calculations was the *Clean Air Act* Assessment Package for 1988 (CAP–88). CAP–88 contains a modified Gaussian plume model that estimates the average dispersion of radionuclides released from up to six sources simultaneously. The model may be run on individual sources as well. The sources may be elevated stacks or uniform area (diffuse) sources. The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food, and intake rates to people from ingestion of food produced in the assessment area. The model calculates the committed effective dose equivalent (CEDE).

This model is approved by the EPA for demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61, Subpart H). This standard states: "Emissions of radionuclides to the ambient air from any DOE contiguous site shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 millirem" (40 Code of Federal Regulations [CFR] 61.92). Modeling of the dose to a hypothetical MEI was used to show that facility emissions would not exceed this standard under any of the alternatives.

The locations of the maximum dose estimates from each of the individual facilities emitting radionuclides were identified using estimated emissions and local meteorological conditions. This location is used as the FS MEI, and the dose is calculated from all air exposure pathways. The distance and direction to this location from all emissions points can then be calculated.

Each facility's emissions impacts on other facilities' MEIs were determined. The location of the maximum dose considering all emissions from all facilities, is designated as the LANL MEI.

Population dose estimates to a 50-mile (80-kilometer) radius were generated by CAP–88 using current population data. Composite maps of these calculations were also developed as mentioned. The health effects, predicted as a consequence of the radiological doses to off-site residents and recreational users, as well as those predicted from the population doses, are evaluated in the human health analyses in this chapter.

5.1.5 Ecological Resources, Biodiversity, and Ecological Risk Methodology

The conceptual scope of this impact analysis is the larger regional ecosystem in which the approximately 43-square-mile (111-square-kilometer) LANL site is immersed. LANL facilities, infrastructure, operations, and impacts—positive, negative, and undetermined—are an integral part of the patterns and processes of a complex regional landscape. Weather, topography, soils, plant and animal communities, and canyon systems carrying water from the Jemez Mountains east to the Rio Grande are continuous across the administrative boundaries of LANL, the NPS, U.S. Forest Service (USFS), regional Pueblos, and other regional land stewards. This ecological context has both spatial and temporal dimensions.

The spatial scope of effects analysis is defined by prominent landscape features in the larger region surrounding LANL that approximate ecological boundaries in terms of many processes important to ecosystem function. These geographical boundaries were determined from input from regional land and resource managers and consultants, review of the technical literature, and knowledge and experience of LANL biological science experts. This information was combined with environmental data from LANL, the State of New Mexico, and federal and private research to define an area that simultaneously includes a reasonably complete suite of representative ecological components as well as conditions that would bound impacts resulting from ongoing LANL operations and evaluated alternatives.

The temporal basis for this analysis extends from about the year 1850 to the present (as described in section 4.5), which captures the genesis and development of current dynamic processes operating in the regional ecosystem. This dimension provides the context necessary for identifying and analyzing impacts in the future.

Effects analysis is based primarily on two measurements of ecological organization: watershed units and major vegetation zones. The identified 14 regional watersheds plus the White Rock Canyon section of the Rio Grande and Cochiti Lake were delineated for effects assessment. Six major plant communities within five elevation-defined vegetation bands across the Pajarito Plateau were defined. Watersheds were overlain with community types to form a landscape grid that facilitated the description and analysis of vegetation and wildlife distributions. This analysis encompasses specific elements of ecosystem composition, structure, and function at the species, local, and regional ecosystem levels.

Biodiversity considerations form an important part of ecological impact assessment. Simply defined as "the variety of life and its processes," components of biodiversity analyzed consist of regional ecosystem diversity, local ecosystem or community diversity, and species diversity. These components are analyzed as part of the analysis of the following major factors contributing to the decline or loss of biodiversity as identified by the Council on Environmental Quality (CEQ 1993):

- Physical alteration of the landscape
- Over harvesting
- Disruption of natural processes
- Introduction of exotic species
- Pollution

Ecological risk is the likelihood that adverse effects may occur or are occurring as a result of exposure to one or more physical, chemical, or biological stressors (EPA 1992). Environmental pollution generated from past and present LANL operations and projected discharges from the four alternatives identified for continued operation of LANL could potentially pose a risk to biotic communities and ecological processes. Qualitative assessments of ecological risk from the four alternatives were based on findings of the Environmental Surveillance Monitoring Program, quantitative risk assessments of three threatened and two endangered species at LANL, and ongoing programs and plans that address mitigation of legacy and operational contaminants.

The impact analysis considered the potential for each alternative to affect habitats, ecological processes, biodiversity, and exposures to toxic chemicals and radionuclides.

5.1.6 Human Health Methodology

The detailed methodology used in evaluating potential consequences of continued operations of LANL on human health (the public and LANL workers) is described in volume III, appendixes B and D, sections B.1.1, B.2.1, and D.2. Estimates were made of the amount of radioactive or hazardous materials to which workers or the public could be exposed based on both site-wide and facility-specific estimates of emissions and effluents. Additionally, information from other resource area analyses (water resources, air quality, geology and soils, and ecological resources) are inputs for the human health analyses. Finally, recent information regarding LANL worker health incidents was used in predicting similar events over the next 10 years.

The radiation dose (for radioactive emissions) to the public and concentrations at receptor locations (for hazardous chemical emissions) from atmospheric emissions are calculated in appendix B, Air Quality (in volume III). The human health analysis translates these doses to their effects on human health. There are other potential exposures from liquid releases through the soil and aquatic pathways. However, the lesser contributions of current and projected LANL operations through environmental contamination in soil, sediment, surface water, and groundwater are so low that they cannot be partitioned from the existing contamination. The existing contamination is highly variable and much larger than annual incremental LANL contributions. This existing contamination consists of naturally occurring radionuclides and metals, weapons testing fallout, and contamination remaining from past operations. The decision was made to calculate the combined risk from the continued operation, plus the existing contamination. This exposure is almost entirely through ingestion of water, soil and sediment, and food. Estimates also were made of the inhalation and direct radiation exposure that can occur from being in the vicinity of radioactively contaminated soil.

Exposures for members of the public and for LANL workers were estimated for all alternatives. Estimates of risk were based on inhalation, ingestion, and dermal absorption pathways. For an individual, the risk value (in terms of excess LCFs) is the increased probability for that individual. Exposure and risk evaluations include individuals who are:

- Workers, site-wide or in a specific facility or specific job classification
- The LANL MEI located north-northeast of the LANSCE facility (TA–53); FS MEIs were also analyzed for the key facilities (appendix B, section B.1.1)
- Off-site residents near LANL (Los Alamos County and non-Los Alamos County residents)
- Resident and nonresident recreational users of the lands within LANL
- Individuals who may receive exposures via special pathways (e.g., smoking locally grown herbs or drinking these in teas, or increased intake of local fishes, or use of contaminated soil/clays in arts and crafts)

The last three of these were evaluated based on exposure scenarios for each of five receptors (Los Alamos County and non-Los Alamos County off-site residents, resident and nonresident recreational users, and individuals exposed through special pathways). In addition, the total inhalation dose and risk to the population within 50 miles (80 kilometers) of LANL were estimated. This risk is presented as the added number of cancer deaths (excess LCFs due to the dose estimated) from LANL operations.

Consequences were estimated by calculating the changes in risk to members of the public or to workers based on risk factors and reference values developed by the International Commission on Radiological Protection (ICRP), EPA, or other authoritative organizations. An estimate of the lifetime risk of dying from cancer due to chronic exposure to radionuclides or chemicals was made to determine human health consequence—that is, it was assumed that an individual received this dose every year for a 72-year lifetime.

An example of how consequence is estimated for radiation exposure would be estimating the excess LCFs over their lifetimes in a worker population as a function of the radiation dose estimated to be received by that population. The LCF is the product of the dose and the risk factor (0.0005 LCF per person-rem for the public and 0.0004 LCF per person-rem for workers) (discussed in appendix D, section D.1, Table D.1.1.2–1). The reader should recognize that these estimates are intended to provide a conservative measure of the potential impacts to be used in the decision-making process, and do not necessarily portray an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated impacts form an upper bound, and that actual consequences could be less, but probably would not be worse. This is discussed in the primer on the effects of radiation in appendix D, section D.1.1.

For consequence to the public, conservative estimates of potential exposures were made using environmental surveillance data (typically from 1991 to 1996), data from specific contaminated sites, and estimates of operations releases (effluents and emissions) associated with each alternative. The total risk to the public from LANL operations is proportional to the collective dose within the 50-mile (80-kilometer) radius from LANL (that is, to the sum of all the doses to individuals in that population). However, questions may arise about the range of exposures within that population. The most likely exposure to individual members of the public is typically near zero. The upper bound for individual exposure is expressed as the potential dose to the hypothetical MEI. The MEI is assumed to remain in place outdoors without shelter and without taking any protective action for the entire period of exposure. This may be for days during accidents and as long as an entire year for routine operations. In reality, no one would receive a dose approaching that of an MEI, but the concept is useful as an expression of the upper bound of any possible dose to an individual. The ICRP and federal guidance recognize that through limiting the dose to all individual members of the population, the entire population is protected (because the average dose is much less than the maximum dose) (ICRP 1977 and EPA 1987). The EPA uses the concept of MEI to ensure that no member of the public has exceeded specified dose limits. The methodology used to evaluate radiological air doses and chemical exposures from airborne emissions to the public is detailed in chapter 5, section 5.1.4. Also, appendix D (section D.2.) presents a more detailed discussion of methodologies used for estimating human health consequences.

The ingestion of radionuclides, chemicals, and metals was calculated for the total concentrations that exist in the environment, regardless of origin. The concentrations in the environment include naturally occurring radionuclides and chemicals, residual contamination from worldwide fallout and earlier LANL operations, and small quantities of contamination from more recent and ongoing operations. Because it is impractical to impossible to differentiate among these sources for most materials, this SWEIS analysis calculates the total risk from all these sources. This total risk would be affected by the alternatives only to the extent that additional operational and accidental emissions may occur.

The exposures through ingestion were calculated using the 95 percentile upper confidence limit (UCL) concentrations. In calculating the UCL, all samples of zero, negative value, or less than the detection limit were rejected. This significantly increases the average value and the UCL, and especially so when a large fraction of the samples show no detectable contamination.

Estimates of ingestion risk were based on standard assumptions from ICRP and/or EPA. Estimates were made of annual exposures (cancer rates are presumed to depend upon integrated exposure and to be independent of exposure rate). Concentrations of radionuclides and chemicals in environmental media were from the LANL environmental surveillance monitoring data collected from 1991 to 1996 (e.g., LANL 1997d). Background concentrations of radionuclides and chemicals in the soils and sediments and waters in the region around LANL were used to compare to LANL emissions/effluents and contaminated media on site.

Worker consequences were evaluated by estimating the changes that would occur in a specific alternative and determining the increment from actual exposure records at LANL for the base period (1991 through 1995). For example, for worker exposures to chemicals and to nonionizing radiation, and for the consequences of physical hazards (such as electrical hazards), the historical occupational record at LANL was examined and consequences were estimated by alternative, based on changes in the workforce associated with the alternative. No credit was taken for increased safety performance by LANL over that experienced during the base period.

Many of the estimates of consequence (such as risk of excess LCFs) were calculated using mathematical modeling. These results are estimates based on multiple assumptions about toxicity, exposure route, human behavior, and the movement of materials through the environment. Therefore, there are substantial uncertainties inherent in the human health evaluations presented in this chapter. These uncertainties include: model simplification of the actual process by which exposure occurs; the variance associated with sampling and measurements of concentration of chemicals and radionuclides in the environment; the simplifying and conservative assumptions made regarding the receptor location, age, and length of time in the area; and behavioral risk factors. Uncertainty also increases in areas having higher naturally occurring concentrations of some radionuclides and soil metals; the area around LANL has relatively high and extremely variable concentrations of natural uranium and many metal ores. A discussion of uncertainties and their impacts on the use of model results to evaluate consequences is given in appendix D, section D.2.

5.1.7 Environmental Justice Methodology

Because most of the topical analyses in the SWEIS considered potential impacts within a 50-mile (80-kilometer) radius of LANL, that distance was also considered for the environmental justice analysis. The presence of minority and low-income communities within that radius is described in chapter 4 (section 4.7), as is the methodology used to identify these communities. Figures 4.7.1–1 and 4.7.1–2 in chapter 4 illustrate how the area within a 50-mile (80-kilometer) radius was divided into sectors for the environmental justice analysis. It is noteworthy that the majority of the sectors reflect a substantial presence of minority and/or low-income populations. (For the purposes of the SWEIS, a substantial presence means greater than 25 percent of the population is considered to be minority or below the poverty level.) The impacts for each of the individual topical areas are, in essence, overlaid onto this figure to assess the impacts.

The environmental justice analysis is a comparative analysis. In order to determine whether impacts are disproportionate, the impacts in sectors with a substantial presence of minority or low-income populations are compared to the sectors that do not have a substantial presence of these populations. In this case, sectors 1–3 and 6–16, all within a 10-mile (16-kilometer) radius of LANL, do not have a substantial presence of minority or low-income populations and are used for this comparison.

It is presumed that the minority populations have traditional or cultural practices that include subsistence materials different than those of other populations in the area. There is little information regarding such materials and quantities used, but assumptions are made for the purposes of the human health analyses. These analyses are referred to as special pathways analyses. Because the special pathways may be more viable or important to minority populations, they are of interest in the analyses under Environmental Justice. Thus, this impact area analysis explicitly addresses the potential human health risks due to these special pathways.

5.1.8 Cultural Resources Methodology

For the purposes of impact assessment, cultural resources were grouped into three broad categories: prehistoric archaeological sites, historic resources, and traditional cultural properties (TCPs). Within these three categories, cultural resources were grouped into general types or classes for impact analysis as opposed to analyzing individual resources (e.g., simple and complex Pueblos, scientific laboratories, and ceremonial sites). More detailed information on these resources is included in volume III, appendix E. Data and impact levels occurring from LANL operations during the period of 1991 through 1995 were used as the background or baseline standard to compare any changes resulting from implementation of the four alternatives.

Sources of information used for impacts assessment included systematic archeological surveys of cultural resources present on LANL and recorded in the LANL cultural resource database; consultations with the LANL Cultural Resources Management Team, 23 Native American tribal governments, Hispanic communities, and the State Historic Preservation Office(r) (SHPO); and literature reviews of Native American and Hispanic TCPs. Also, results of the consequence analysis for air quality, surface and groundwater, human health risk, and noise and vibration were used to evaluate impacts to human users of TCPs and other potential impacts to cultural resources.

Impact assessment is based on general sources of effects or types of actions. These consist of the following:

- New construction
- Increased vibrations (from traffic, explosives testing, etc.)
- Increased erosion or siltation
- Shrapnel scatter from firing points
- Explosives (direct hits)
- Radiation hazards (from airborne or waterborne contamination)
- Hazardous material (nonradiological from airborne or waterborne contamination)
- Noise
- Security changes
- Hydrogeologic changes
- Maintenance changes

Impacts were evaluated according to four broad categories that reflect the criteria of effect (36 CFR 800.9) under the *National Historic Preservation Act* (16 U.S.C. §470). These categories consist of destruction/alteration; isolation and restriction of access; introduction of visual, audible, or atmospheric elements out of character with the resource; and neglect leading to deterioration and vandalism. Not all classes of cultural resources would be affected by every category of effect.

Effects to resource categories were evaluated for each of the four alternatives by means of a data matrix. Geographic overlay analysis and detailed project descriptions were used to assist in identifying the numbers and types of cultural resources that might be affected by the alternatives.

5.1.9 SOCIOECONOMICS, INFRASTRUCTURE, AND WASTE MANAGEMENT METHODOLOGY

5.1.9.1 *Socioeconomics*

Employment, Salaries, and Procurement

The primary (direct) and the secondary (indirect) impacts of LANL activities on employment, salaries, and procurement are analyzed in the SWEIS. The primary impacts are projected based on the changes in employment (in terms of full-time equivalents and procurement at LANL, including the full-time, part-time, and temporary employees of UC, Johnson Controls, Inc., Protection Technology of Los Alamos, and technical subcontractors. Changes in employment were projected by subject matter experts for each of the key facilities, and employment for the rest of LANL was assumed to remain the same. The changes in employment are associated with full implementation of each alternative. Although these changes are likely to happen over a few years, the analysis assumes that they occur within a year of the ROD for the SWEIS. The employment projections were made by job category, and the 1996 average annual salary for each job category was used to project annual salaries (LANL 1996a). The LANL annual procurement projections were made based upon historical procurement and the changes in activity levels and employment across alternatives (LANL 1995b, LANL 1996a, and LANL 1997a). Future procurement was distributed among the Tri-County Area (the three counties closest to LANL: Los Alamos County, Rio Arriba County, and Santa Fe County), the remaining New Mexico counties, and areas outside of New Mexico based on the historical distribution of procurement.

Changes in employment and procurement at LANL are expected to result in additional, secondary, changes in employment, salaries, and expenditures in the area, as well as changes in the demands on social services. These secondary impacts occur within a regional economy because jobs added in a primary industry such as LANL create local opportunities for new employment in supporting industries. Analysis of these secondary economic and social impacts of LANL activities across the alternatives utilizes multipliers derived from a 1996 DOE/New Mexico State University study (Lansford et al. 1996). These multipliers are:

- Employment: 2.71
- Salaries: 1.95
- Expenditures/Business Activity: 2.89

These multipliers are used to predict the total LANL socioeconomic impacts in the area. For example, if LANL were to expand employment by 100 full-time workers who would reside in the Tri-County area, the secondary effect of that action would be the addition of 171 new secondary jobs in the Tri-County labor market. On the other hand, if LANL were to reduce employment by 100 full-time workers, the reverberating effect across the Tri-County economy would be the loss of 171 other jobs.

The employment changes result in population changes in the Tri-County region. It should be noted that the 1996 report (reflecting 1995 data) has been updated since this SWEIS analysis was performed. The latest of this series of DOE/New Mexico State University reports was issued in May 1998 (reflecting 1997 data). The regional multipliers reflected in that recent report are about 5 percent greater than those reflected above. Because these multipliers are used only to determine the secondary socioeconomic impacts and because these changes are relatively small, the impact analyses influenced by these changes were not updated for the issuance of the final SWEIS. If these updated numbers were applied, population increases, housing demand, regional employment, local government finance, and services values would be slightly higher than presented in the final SWEIS. The DOE does not consider such slight changes to be substantial for the purposes of the SWEIS.

Only LANL changes in employment, incomes, and expenditures were used for this analysis. For example, changes because of tourist and skier visitation to the region were ignored, as were changes in non-LANL construction and retail sales.

Housing

The projections of housing distribution for the four alternatives were made by:

- Determining the potential housing growth for LANL employees in Los Alamos County by adding the county's housing units now under construction, potential housing conversions, and the buildable, vacant, single-family lots (PC 1996a and PC 1997c).
- Distributing the remaining housing growth for LANL employees between Santa Fe and Rio Arriba Counties, based on the availability of buildable land, the presence of utilities, and the presence of developer capital (PC 1996a and PC 1997c).

For analysis of housing, it was assumed that one unit of housing demand would be created for every 2.39 (the average household size) net additions to the area population. This algorithm is based on the relationship of housing units to population for the Tri-County region shown in the 1990 U.S. Census (DOC 1993b). Population projections were based on the 1990 U.S. Census information (DOC 1992 and DOC 1993a), New Mexico Department of Labor information (NMDL 1996), and on a 1994 study done by the University of New Mexico (UNM 1994).

Construction

Construction projects included in each of the SWEIS alternatives are detailed in chapter 3. The employment and salaries associated with LANL construction activities were projected separate from those for LANL operations. On average, field construction labor (the basis for construction employment and salaries) is about 24 percent of the total project cost. Although this percentage can vary substantially from project to project, this average percentage was used for the SWEIS analyses. The total project costs and the salaries estimates are in 1996 constant dollars and are subject to congressional appropriations. The average annual wage for construction workers in northern New Mexico, including supervisory personnel, is $35,000, which is the annual wage assumed for these analyses.

Total project costs were determined based upon the 1997 and 1998 Capital Asset Management Process (CAMP) reports (LANL 1997c) and other NEPA documents that discuss construction projects at LANL. Application of labor expenditures as a percentage of total project cost (24 percent) is the total construction salaries for each alternative. The total construction salary divided by $35,000, produced an estimate of the number of employees who would be engaged in construction at LANL each year for the period 1997 through 2006 for each alternative.

Local Government Finance

Changes in gross receipts tax yields, the key LANL-dependent local government tax revenue, were determined by dividing the 1995 gross receipts tax yields for Los Alamos, Rio Arriba, and Santa Fe Counties and the cities of Santa Fe and Española (NMDFA 1996, NMTR 1995, and NMTR 1996) by population, and multiplying that product by the changes in population (due to both primary and secondary employment changes) resulting from changes in LANL activities across the alternatives.

Services

Education finance impacts across the alternatives were based on calculating enrollment changes induced by LANL activities on total budget requirements. Thus, population changes were converted to school enrollment changes that were then multiplied by $4,009, which is the average New Mexico annual operating cost per public school student (NMDE 1995).

Impacts presented for other services (e.g., police, fire) are qualitative and were based on field interviews and the knowledge of subject matter experts (PC 1996b, PC 1997d, and BH&A 1995).

5.1.9.2 *Infrastructure*

Utilities

LANL annual requirements for electricity and water are projected by alternative based on historical use and on projected activity levels. These projections are considered maximum annual demands. Because most LANL facilities are not individually metered for utility usage (none of these facilities are individually metered for natural gas usage), useful projections could not be made on a facility-by-facility basis. However, the TA–53 facilities and operations discussed in chapter 3 (section 3.5.11) are substantial users of these utilities, and TA–53 is individually metered for electricity and water use. For this reason, electricity and water usage by alternative is projected for LANSCE separate from the rest of LANL facilities. Except for LANSCE electricity and water usage, LANL's utilities usage is not expected to change substantially from the baseline usage described in chapter 4 (section 4.9). Natural gas use is projected to continue at the baseline usage rate, which is the maximum amount used in recent years.

5.1.9.3 *Waste Management*

Radioactive and Hazardous Waste Generation

The generation of waste places a burden on the LANL waste treatment, storage, and disposal infrastructure. For this reason, LANL waste generation by alternative is presented in this section. The waste treatment, storage, and disposal activities could have impacts; those impacts are included in the other sections of this chapter (e.g., radioactive air emissions include those attributable to waste operations). Waste generation projections were based on projected operations as compared to the baseline waste generation. These projections take credit for fully developed and implemented waste minimization/pollution prevention measures, but do not assume implementation of actions that are currently in development or may occur in the future. Every indication is that the waste minimization/pollution prevention program at LANL will continue to reduce the waste that must be managed, so the projections made by alternative are considered conservative.

The report *Waste Management Strategies for LANL* (LANL 1998a) reflects the treatment and disposal of waste at LANL, as well as more detailed information regarding the waste types and applicable treatment processes.

5.1.9.4 *Contaminated Space*

The contamination of space and equipment places a burden on the LANL infrastructure for eventual cleanup, waste handling, and decontamination and decommissioning efforts (at additional cost, as compared to these actions for uncontaminated space and equipment). During the scoping activities for the SWEIS, members of the public suggested that DOE decision-making should consider this burden and requested that changes in contaminated space and equipment by alternative be presented in the SWEIS. For these reasons, the SWEIS includes estimates of changes in contaminated space and equipment by alternative, as compared to the baseline contaminated space presented in chapter 4 (section 4.9).

In general, the estimation of contaminated spaces was made within plutonium facilities, hot cells, process gloveboxes, and general laboratory areas on a foot print (square footage) basis, and was made by subject matter experts. Future clean-up costs or environmental impacts associated with eventual cleanup of LANL are dependent on the regulations and facility conditions at the time of the cleanup and cannot be predicted; thus, no attempt is made in the SWEIS to translate the contaminated space projections into a cost liability or into eventual cleanup actions and impacts. It is anticipated that such assessments will be made at the time DOE plans for such actions (presumed to be well beyond the 10-year time frame of the SWEIS).

5.1.10 Transportation Methodology

The methods and assumptions described in this analysis were selected to ensure meaningful comparisons among the SWEIS alternatives. In general, assumptions used in this analysis are intended to be conservative enough to ensure that the results do not underestimate the level of transportation risk, but not so conservative that the risk calculation is knowingly orders of magnitude too conservative or such that any differences between alternatives are obscured.

The analyses of both radioactive and hazardous material risks are largely accomplished with standard computer codes; the methodology is documented in more detail in volume III, appendix F. Figure 5.1.10–1 illustrates the basic transportation risk analysis methodology. As indicated in the figure, the overall transportation analysis was approached in two major segments:

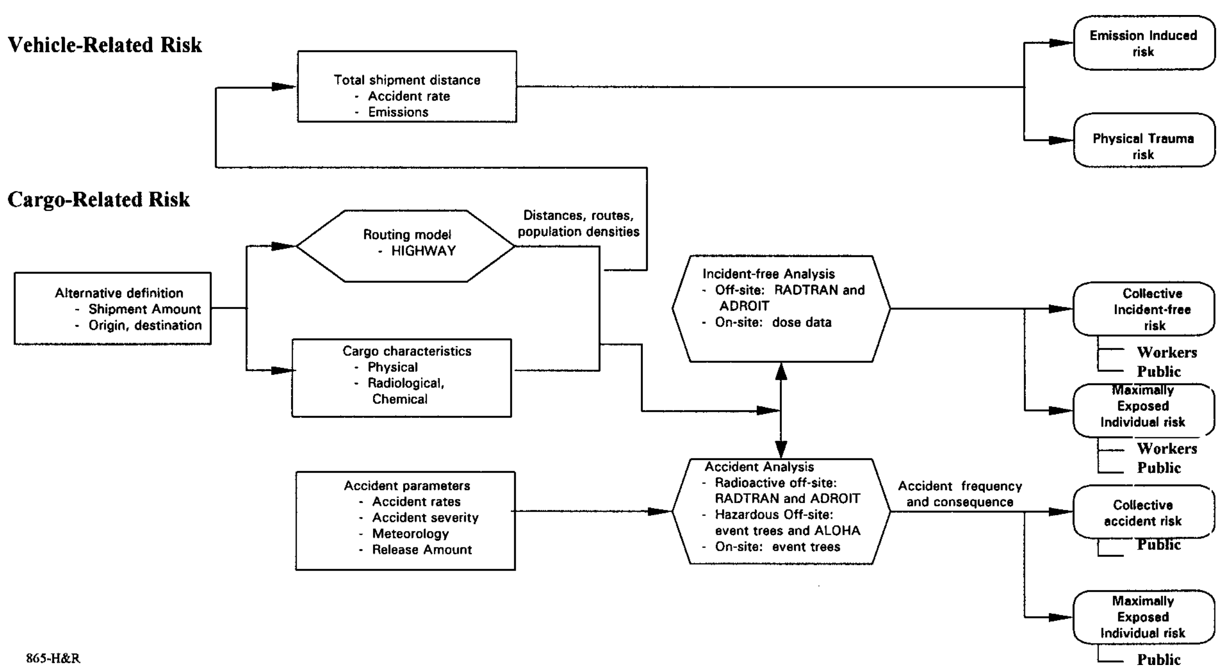


FIGURE 5.1.10–1.—*Transportation Risk Analysis Methodology.*

- Vehicle-related risk includes truck emissions and vehicle accidents (no release of cargo).
- Cargo-related risk includes both incident-free radiation exposure and accidents that could release radioactive or hazardous cargo.

5.1.10.1 *Determination of Shipment Amounts, Materials, and Physical Forms*

The determination of annual radioactive and hazardous chemical shipment amounts, materials, and physical forms, by SWEIS alternative, was intended to ensure that shipments that could contribute significantly to accident risk were projected and analyzed. Shipments of relatively small quantities and of materials that present substantially lesser hazards were not considered in as much detail. Shipments of waste are included in the SWEIS transportation analyses and are also discussed in section F.6.6 in appendix F.

The radioactive material shipment projections by alternative were determined by interviewing DOE and LANL subject matter experts. Historical shipment data, on site and off site, were used to help ensure completeness. On-site shipments of special nuclear material (SNM) at the gram level were not accounted for because their contribution to risk would be minor. The off-site and on-site radioactive material shipments for each SWEIS alternative are listed in appendix F.

The historical hazardous chemical shipments were determined primarily by using existing LANL databases, as well as by using DOE shipment mobility/accountability collection (SMAC) data. Large inventories and bulk shipments were identified from these databases. Through this process and through interviews with subject matter experts, bounding historical material types and quantities were identified. Where possible, future hazardous chemical shipment projections were made by subject matter experts (e.g., future explosive shipments are explicitly related to the alternative descriptions). In many cases, hazardous chemical shipment projections could not be explicitly determined in this manner because many chemicals are purchased in large quantities but are actually used in small quantities over long periods and across the entire site. In such cases, chemical shipment projections were made based on the ratios of projected shipments to historical shipments for materials that were explicitly related to alternative descriptions. This process and the bounding chemical shipments, on site and off site, by alternative are described in detail in appendix F (in volume III).

5.1.10.2 *Shipment Routes and Distances*

LANL shipments projected for each of the SWEIS alternatives include shipments to and from other DOE sites as well as to and from numerous non-DOE (e.g., commercial) sites. Subject matter experts identified DOE sites involved in such shipments. For shipments to sites other than DOE sites, five geographical areas are defined for radioactive material shipments: northeast, southeast, northwest, southwest, and New Mexico. The cities selected as representative of each area are Concord, Massachusetts; Aiken, South Carolina; Richland, Washington; Berkeley, California; and Albuquerque, New Mexico. These cities were chosen as conservatively representative (on the basis of the number of shipments) of the various shipment locations in the geographic area in the 1990 through 1994 baseline. Cargo air shipments are also made to and from the LANL site. Air shipments arrive at the Albuquerque International Airport and are transported by truck or van to LANL or vice versa.

In general, the transportation impacts presented in the SWEIS are reflected on an annual basis for each of four route segments: from LANL to U.S. 84/285; from U.S. 84/285 to I–25, remainder of New Mexico (all other transportation in the state), and outside New Mexico. Based on the routes established for this analysis, shipment mileage was calculated, and the population density along the route was estimated. The HIGHWAY code (Johnson et al. 1993) was used to determine the distance traveled for each off-site shipment route.

All routes for shipment of radioactive or hazardous material into or out of LANL are conservatively assumed to pass through Santa Fe. The Santa Fe Relief Route (currently being constructed) would replace 6.5 miles (10.5 kilometers) on U.S. 84/285 through Santa Fe to I–25, with 13.8 miles (22.2 kilometers) starting from U.S. 84/285 north of Santa Fe to exit number 276 of I–25, south of Santa Fe. Because of the location where the Relief Route meets I–25, travel on I–25 south of Santa Fe would be reduced by 6 miles (___ kilometers) of highway travel, and travel on I–25 north of Santa Fe would be increased by 6 miles (___ kilometers) of highway travel if the Relief Route were used. The Santa Fe Relief Route between I–25 and the junction of U.S. 84/285 with NM 502 consists of 1.2 miles (1.9 kilometers) of urban highway, 3.9 miles (1.9 kilometers) of suburban highway, and 14.9 miles (24 kilometers) of rural highway. Appendix F (in volume III) includes a detailed comparison of impacts between transportation through Santa Fe and using the proposed Santa Fe Relief Route. (The segments from U.S. 84/285 I–25 and the remainder of New Mexico are the only ones that would potentially be affected.) In most of the analyses, the differences are very small; these differences are discussed in the discussion of each type of transportation impact and are presented in more detail in appendix F (section F.7).

5.1.10.3 *Vehicle-Related Risks*

Truck traffic on public highways presents two types of health risks independent of the nature of the cargo: the health effect of air pollutants (primarily diesel fuel combustion products) and the injuries and fatalities caused by truck accidents. Aircraft accidents could also contribute to injuries and fatalities. Because there is no rail service to LANL, rail transport is not addressed.

As described in Figure 5.1.10–1, once the routes, distances, and population densities are determined (as described above), truck emissions and vehicle accident rates must be determined to calculate the vehicle-related risks. These factors are discussed further below.

Truck Emissions

Truck traffic produces air pollution from diesel engine exhaust, fugitive dust generated by the vehicle wake on the highway surface and shoulders, and particulates from tire wear on the paved surface. The primary health effect of diesel fuel combustion is caused by sulfur oxides and particulates, although nitrogen oxides and hydrocarbons are also produced. The health effect of these pollutants is increased sickness (morbidity) and death, generally occurring after a latency period of some years. No analysis was made for increased sickness because no data were available. The health effect has been evaluated by Rao et al. (1982) as 1.6×10^{-7} excess LCFs per truck mile (1.0×10^{-7} fatalities per truck kilometer) in urban areas. The result is limited to urban areas because the available air pollution mortality data were limited to metropolitan population subgroups.

The total number of radioactive and hazardous material shipments made annually under each alternative (detailed in appendix F, section F.5) and the urban mileage per shipment are used to determine the total annual urban mileage for all shipments. This mileage is converted to excess LCFs per year using the conversion factor from Rao et al. 1982, as noted above.

Truck Accidents

Four sets of truck accident rates are used in the analysis: state-specific; route-specific, between I–25 and the LANL site; on-site roads with and without road closure; and the safe secure transport (SST) trailer. To the extent possible, each of these sets of accident rates was determined based on existing accident rate data available from the U.S. Department of Transportation (DOT), the State of New Mexico, and previous on-site transportation risk analyses at LANL. The truck accident rate for closed roads was determined to be 1.44×10^{-8} accidents per mile (8.95×10^{-9} accidents per kilometer) based on an analysis of the types of truck accidents and the LANL site administrative controls (Rhyne 1994b). The accident rate for SST shipments was determined based on the actual SST accident rate for the 9-year period between 1988 and 1996 (7.7×10^{-8} accidents per mile [4.8×10^{-8} accidents per kilometer]) by extrapolating data for varying operating environments of five-axle vans in the appropriate weight range in commercial service (Phillips et al. 1994). The determination of these accident rates and the accident rates used for this analysis are discussed further in volume III, appendix F.

Aircraft Accidents

Air transport associated with shipments to and from LANL is assumed to be by commercial air-cargo carriers (such as Federal Express) to and from the Albuquerque International Airport. (Transport between this airport and LANL is by truck or van.) Shipments are picked up in the carrier's van and taken to an airport, flown to the destination city, and taken to the final destination by the carrier's van. Commercial air-cargo carriers are categorized as large certified air carriers and are assumed to fall in the subcategory of "large nonscheduled service" for which the 1992 accident rate was 7.9×10^{-9} accidents per mile (DOT 1992). Because the accident rate for similar shipments by truck is much greater (by two orders of magnitude) and this difference is not offset by a comparable difference in the consequences of these accidents, aircraft accidents were screened from further analysis.

5.1.10.4 *Cargo-Related Risks*

In addition to the vehicle-related risks, cargo-related risks are also analyzed in this section. These risks include incident-free radiation exposure, and exposure to radioactive or other hazardous materials due to an accidental release. The estimates of material amounts, physical forms, routing, and population densities along these routes that were described earlier in this section are used in these analyses. The following information presents the methods used to estimate cargo-related risks.

RADTRAN and ADROIT Analyses for Radioactive Materials

Two of the four risk measures illustrated in Figure 5.1.10–1 are modeled by RADTRAN or ADROIT. (These are discussed further in appendix F, section F.4.4.) The RADTRAN code is designed to produce conservative estimates of the radiological dose to workers and the public during incident-free transportation, as well as the radiological risks from potential accidents. RADTRAN is widely accepted and used both in the U.S. and internationally.

The ADROIT code was developed to replicate the RADTRAN incident-free and accident estimates specific to transport using DOE SST trailers. ADROIT end results are very similar to RADTRAN. These codes were applied to the impact analyses for off-site shipments of radioactive materials.

Incident-Free Radiation Exposure. The most important parameter for evaluation of incident-free radiation exposure is the package exterior radiation level. The transport index (TI) is used in RADTRAN to characterize the exterior radiation field. The TI is defined in 49 CFR 73.403 as "the exposure rate in millirems per hour at a distance of 3 feet (1 meter) from the surface of the package," and DOT regulations limit the value of TI to 10 or less for general commerce shipments. The TIs for LANL's on-site shipments are based on historical measurements. The average truck shipment TI is less than 2, and the average air shipment TI is approximately 0.1.

Annual radiation doses and excess LCFs are calculated for members of the public along the truck route, members of the public traveling on the truck route, members of the public at truck stops, truck and air crew members, and MEIs. All trucks are assumed to pass a residence 98 feet (30 meters) from the highway at a speed of 15 miles (24 kilometers) per hour.

Accidental Release of Radioactive Materials. Radioactive material shipments were evaluated to determine those that would likely present the largest calculated consequence (see appendix F). These are referred to as the bounding material shipments. The bounding radioactive material shipments included in the SWEIS transportation analyses are:

- Off-site shipment of plutonium-238 oxide powder in an SST
- Off-site shipment of americium-241 standards
- On-site shipment of plutonium-238 solution samples (performed with road closures)
- On-site shipment of irradiated targets (performed with road closures)

In addition to these shipments, off-site shipments of contact-handled transuranic (CH TRU) waste, remote-handled transuranic (RH TRU) waste, and plutonium weapon components (pits) are analyzed due to the level of public interest in such shipments that was expressed during scoping for the SWEIS.

In order to determine the frequency terms for these analyses, the frequencies of the shipments listed above were supplemented with the frequencies of other large shipments of similar materials. For example, the number of on-site plutonium-238 solution shipments was increased for analysis by the number of on-site weapons-grade plutonium solution shipments (see volume III, appendix F). Thus, the frequency term includes both plutonium-238 and weapons-grade plutonium shipments.

The impacts of an accidental release of radioactive materials from shipments are based on the accident scenario (and the associated forces on the packages), the fraction of the radioactive material in a package that could be released during an accident of a certain severity, and the fraction of material released that would be dispersed as an aerosol that could be inhaled into the respiratory tract. This information is used to determine the radiation dose that would result from the accident to exposed individuals.

The fraction of the radioactive material in a package that could be released during an accident is referred to as the release fraction. Release fractions vary according to the package type and the accident severity. Type B packages are designed to withstand the forces of severe accidents and, therefore, have smaller release fractions than Type A packaging (see appendix F for more information on packaging). Plutonium packages are designed to even higher standards. The RADTRAN and ADROIT models include the accident severity and the shipment packaging in consequence analyses.

Subsequent to release, dispersion of the material into the atmosphere as an aerosol and, in most cases of interest, inhalation into the respiratory tract (respirable aerosols only) would be required to produce a significant exposure to members of the public. Most solid materials are relatively nondispersible. Conversely, gaseous materials are easily dispersed. Liquid dispersibility depends on the liquid volatility. The aerosolization and respirable fractions depend on the physical form of the material. RADTRAN and ADROIT include all of these factors to determine respirable release fractions in calculating the accident consequences.

Health Risk Conversion Factors. The health risk conversion factors used throughout this analysis (as in the accident and human health analyses) to estimate the number of expected excess cancer-caused fatalities, from radiological exposures are 0.0005 cases of excess fatal cancer per person-rem for members of the public, and 0.0004 cases per person-rem for workers (ICRP 1991). Cancer-caused fatalities are determined over the lifetimes of exposed populations.

Event Tree Analyses for On-Site Radioactive and All Hazardous Chemical Accidents

Event trees are used for the analyses of on-site and off-site transportation accidents involving hazardous chemical inventories and on-site transportation accidents involving radioactive materials. An event tree is a graphical model for identifying and evaluating potential outcomes from a specific initiating event. The event tree depicts the chronological sequence of events (the accident scenario) that could result from the initiating event. In addition to identifying the accident scenarios, an event tree can also be used to quantify the frequencies of each scenario. The use of event trees for these analyses is explained further in appendix F.

The consequences of hazardous chemical accidents are determined using the Areal Locations of Hazardous Atmospheres (ALOHA™) computer model (NSC 1995), the dense gas dispersion (DEGADIS) model (Havens and Spicer 1985), and hand calculations, depending on the characteristics of the material and release mechanism. The consequences are presented in terms of numbers of fatalities, number of injuries, and impact to the MEI.

Hazardous material shipments were evaluated to determine those that would likely present the largest calculated consequence (see appendix F). These are referred to as the bounding material shipments. The bounding hazardous material shipments included in the SWEIS transportation analyses are:

- Off-site shipment of chlorine
- Off-site shipment of explosives
- Off-site shipment of propane

An examination of historical on-site shipments did not identify any unique materials or shipment risks. The off-site shipments identified above bound the accident risk both on site and off site.

Consequences of on-site radioactive material accidents were analyzed using hand calculations, based on the material and the accident scenario involved.

5.1.11 Accident Analysis Methodology

5.1.11.1 *Introduction*

Accidents are defined as unexpected or undesirable events that lead to the release of hazardous material within a facility or into the environment, exposing workers and the public to hazardous materials or radiation. Any activity therefore poses a certain amount of risk to the adjacent environment and human populations. The objective of this analysis is to characterize the overall risk posed by the operation, creating a context for the decision maker and putting the site in perspective for the public. Secondly, it quantifies the increment in risk among the alternatives, as an input to the decision. Table 5.1.11.1–1 lists the facilities by TA and/or building that were considered in the accident analysis.

TABLE 5.1.11.1–1.—*SWEIS Accident Analysis Facility Listing*

TECHNICAL AREA AND BUILDING NUMBER	FACILITY NAME
TA–0–1109	Potable Water Chlorinator
TA–0–1110	Potable Water Chlorinator
TA–3–29	Chemistry and Metallurgy Research (CMR) Facility
TA–3–66	Sigma Facility
TA–3–476	Toxic Gas Storage Shed
TA–9–21	Analytical Chemistry Building (worker hazard only)
TA–15–312	Dual Axis Radiographic Hydrodyamic Test (DARHT) Facility
TA–16–205	Weapons Engineering Tritium Facility (WETF)
TA–16–411	Assembly Building
TA–18–23	Pajarito Site Kiva #1 (seismic only)
TA–18–32	Pajarito Site Kiva #2 (seismic only)
TA–18–116	Pajarito Site Kiva #3
TA–18–169	Pajarito Site Solution High-Energy Burst Assembly (SHEBA) Building (seismic only)
TA–21–155	Tritium Systems Test Assembly (TSTA)
TA–21–209	Tritium Science and Fabrication Facility (TSFF)
TA–43–1	Health Research Laboratory (HRL) (seismic only)
TA–46–340	Waste Water Treatment Facility (WWTF)
TA–48–1	Radiochemistry Laboratory[a]
TA–50–1	Radioactive Liquid Waste Treatment Facility (seismic only)
TA–50–37	Radioactive Materials Research, Operations, and Demonstration (RAMROD) Facility
TA–50–69	Waste Characterization, Reduction, and Repackaging (WCRR) Facility
TA–54–G	Transuranic Waste Inspectable Storage Project (TWISP) (TA–54–229, TA–54–230, TA–54–231, and TA–54–232); Transuranic Waste Storage Domes (TA–54–48, TA–54–153, TA–54–224, TA–54–226, and TA–54–283); Tritium Waste Sheds (TA–54–1027, TA–54–1028, TA–54–1029, and TA–54–1041)
TA–54–38	Radioactive Assay and Nondestructive Testing (RANT) Facility
TA–54–39	Polychlorinated Biphenyl (PCB) Waste Storage Facility
TA–54–216	Legacy Toxic Gas Storage Facility
TA–55–4	Plutonium Facility
TA–55–185	Transuranic Waste Drum Staging Building
TA–59–1	Occupational Health Laboratory (worker hazard only)

[a] Table G.5.4.4–3 in volume III, appendix G, lists all facilities found to have a moderate or higher vulnerability to wildfire, and therefore, were considered in the site-wide wildfire analysis.

5.1.11.2 *Meaning of Risk and Frequency as Used in This SWEIS*

The word "risk" is defined in the dictionary as the probability that a specific loss or injury will occur. In this SWEIS, DOE couples the consequence of an event with the probability that it will occur, and calls this combination the risk. Note that a high consequence event would not necessarily have significant risk if its probability is very low.

The probability of the accident is typically expressed as a frequency; that is, an accident with a frequency of 0.001 per year has a probability of occurring once in 1,000 years and twice in 2,000 years. This is only another way of saying that the probability of the accident occurring in any particular year is 1 in 1,000.

For many events, the risk can be expressed mathematically as the product of the consequence and its probability. In illustration, if the expected public consequence of an accident at a particular facility is one cancer per accident, and if the accident has a probability of occurring once in 1,000 years, then the continuing risk presented by that accident is (1 x 1/1000) or 0.001 cancer per year. This product of consequence and probability is called "societal risk" in this SWEIS. It permits the ready comparison of accidents and alternatives without the burden of the details. The details of the analyses are presented in volume III, appendix G.

5.1.11.3 *Characterization of the Risk from Accidents*

Characterization includes a consideration of the type of the accident (e.g., fire, explosion, spill, leak, depressurization, criticality, etc.), the initiator (e.g., human error, chemical reaction, earthquake, strong wind, flood, vehicle accident, mechanical failure, etc.), and the material-at-risk (MAR) (e.g., plutonium, tritium, toxic chemical, explosives, inflammable gas, etc.). Characterization also considers the type of consequences of the accident (e.g., immediate fatalities, prompt reversible and irreversible health effects, latent cancers—some of which lead to eventual death and are referred to as fatal) and the magnitude of the consequences (e.g., to workers only, to hypothetical members of the public, to a few, some or many real individuals off site). Finally, characterization considers the likelihood that an accident will occur.

LANL is a complex and diverse site, and there is a wide range of accident scenarios that can be hypothesized, with a wide range of likelihoods and a wide range of realistic and imagined consequences. To characterize the accident risk at LANL, this analysis has deliberately chosen a range of types of accidents and a range of consequences, including accidents involving materials for which the public has shown concern. This analysis does not attempt to identify every possible accident, but instead selects accidents that characterize or dominate the risk to the public and workers from site operations. It thereby provides an objective context for the public to evaluate the risk posed by site operations, and a context for the decision among alternatives. It also allows the decision maker to consider whether mitigation measures are needed to reduce risk.

By identifying the locations of appreciable quantities of hazardous material, the accidents associated with these materials can be assessed. By grouping these accidents according to their likelihood or frequency, and the magnitude of their consequences, it is possible to select accidents for further characterization and qualitatively portray their relative risk. The accidents selected for this detailed analysis are those with bounding consequences as well as those that characterize the risk of operating LANL.

5.1.11.4 *Determining the Increment in Risk Among Alternatives*

If an accident is not reasonably foreseeable—that is, it is incredible—DOE does not consider that it contributes substantially to the risk of operating LANL (DOE 1993). If, on the other hand, a hazardous material has a reasonable chance of being involved in an accident, then the consequences and the likelihood of the accident are considered.

Specific accidents that contribute substantially to, or envelop the risk, are considered risk-dominant accidents or bounding accidents. They are not exceeded by other accidents analyzed or believed to be possible that involve that inventory. For instance, there may be a number of accidents that could disperse plutonium, with different initiators or different mitigation, but they are represented by the risk-dominant accident involving plutonium dispersal. This accident also may bound the consequences for other facilities that may have more sensitive site characteristics (such as larger populations), but have lesser inventories than those addressed by the analyses.

This suite of accidents was derived from consideration of the current operations plus currently planned changes. These constitute the baseline (No Action Alternative) condition that serves as a reference from which to evaluate the alternatives. Changes in locations, changes in MAR, and changes in types of operations were considered among the alternatives. These differences were then used to determine the changes to the probability and consequences of the accidents. In each of the sections discussing the impacts of the alternatives, the risk, as well as the change in risk from the No Action Alternative, is given in the summary tables.

5.1.11.5 *Methodology for Selection of Accidents for Analysis*

The analysis began with the establishment of the baseline risk from current operations, plus planned activities, that together constitute the No Action Alternative. The baseline was established by a process of safety documentation review, interviews with facility management, physical inspections ("walkdowns") of facilities, and discussions with facility management. Changes in the baseline risk were estimated for the Expanded Operations Alternative, the Reduced Operations Alternative, and the Greener Alternative to ascertain the human health impacts of the alternatives.

Assessing the human health consequences of accidents for the alternatives is a four-step process. The first step was to identify a broad spectrum of potential accident scenarios. These scenarios were obtained from available site-specific safety and environmental documents, from programmatic documents, from discussions with facility management, and from physical inspections (walkdowns) of the facilities.

The second step in the process used screening techniques to identify the specific scenarios that contribute significantly to risk (i.e., the scenarios that contribute an appreciable fraction of the total risk). Due to the large number of potential accident scenarios that could impact human health, it is impractical to evaluate them all in detail. This is a common problem encountered in risk assessments, and the standard approach (which was adopted here) is to apply rough bounding calculations during the screening steps. The calculations are performed to progressively greater degrees of detail until it becomes clear that the accident is either not risk-significant or requires a detailed analysis in order to determine the frequency and consequences of the accident (i.e., its risk).

Rigorous evaluations (the third step in the process) were only performed for the potentially risk-dominant scenarios identified in step two—that is, those which had a frequency of 10^{-6} or above and led to off-site consequences beyond insignificant.

The fourth step in assessing the human health impact of accidents for the alternatives was to carefully evaluate the effect of the alternatives on the accident scenarios. The important considerations involved in this evaluation were whether the alternative would result in the elimination of some accidents and the addition of others, whether the alternative would result in an increase or decrease in the frequency of some accidents, and whether the alternative would result in an increase or decrease in the amount of hazardous materials released. The results of the analysis indicate that, while a number of accidents are potentially affected by the alternatives, few of them are significant to public or worker risk.

It is important to recognize that as a result of several factors (the nature of the activities performed, the design features of the facilities at which the activities are performed, the conditions under which the activities are performed, and the location of the facility vis a vis the public), accidents are more likely to impact facility workers than they are to impact the public. This is true even though at LANL the public has access to many areas of the laboratory via roadway. Even for facility workers, the consequences in many cases would be dependent on the use by facility workers of personal protective equipment (PPE) and on the effectiveness of emergency response and mitigation actions taken to limit consequences (e.g., the timeliness of evacuation from the facility).

5.1.11.6 *Conservatism in the Analyses*

At all steps, when faced with uncertainties, the analysts selected the most probable or conservative value for accident probability and the quantity of hazardous materials released. Accepted models and expected atmospheric dispersion parameters were used in the modeling. Exposure conditions (location, time in the plume) were used that would maximize exposure of the total population and of individuals. Concentration planning guidelines appropriate to the public were used to evaluate impacts from chemical accidents. A conservative risk factor for excess LCFs was used to calculate radiological health effects; whereas, the true risk factor may be considerably less, as described in appendix D, section D.1 (in volume III). The resulting estimates of risks are quite conservative.

Despite the conservatism, some accident scenarios originally thought plausible were found by analysis to have a probability of less than 10^{-6} per year, (i.e., to be incredible). These accidents are retained in the appendix to preserve the information they contain, in illustration of the range of the analyses, and in demonstration of the conservativeness of the screening.

5.1.11.7 *Accident Scenario Screening and Selection*

Spectrum of Potential Accidents

Potential accident scenarios were first selected based on facility safety documentation review. Facility walkdowns and discussions with operations personnel also were undertaken to ensure a comprehensive look at the possible accidents. In this manner, scenarios from the safety documentation were validated and other scenarios added to make a comprehensive list.

For the facility walkdowns, a pre-visit facility walkdown/interview data collection form was prepared for each facility to facilitate the collection of a consistent set of facility data and transmitted to facility representatives. Preparation of the forms benefited from the experience of previous accident evaluations (including safety analyses, probabilistic risk assessments, and process hazard analyses). In addition, relevant DOE handbooks and standards were considered, as described in volume III, appendix G.

During and subsequent to the walkdowns, revised safety documentation was provided by the facility representatives. This documentation was subsequently reviewed, and a draft data collection document was prepared for each facility.

Identification of Accident Scenarios

Two primary types of data sources were used for radiological accident analysis: (1) safety documentation, including safety assessments (SAs), hazard analyses (HAs), process hazard analyses (PrHAs), probabilistic risk assessments (PRAs), and safety analysis reports (SARs); and (2) facility walkdown/interview data collection forms.

Where a facility had current safety documentation, that documentation was used to define accident scenarios. Owing to differences in scope between safety documentation and NEPA accident analyses, some supplementation of the safety documentation was necessary in a few instances in order to provide the required NEPA coverage (this was especially true in the area of seismically initiated sequences). The facility walkdowns were used to further evaluate the accident scenarios identified in the safety documentation, to evaluate whether additional accident scenarios were possible that were not included in the safety documentation, to evaluate whether there were accident frequency or accident consequence mitigation capabilities present that were not credited in the safety documentation, and to assess the impacts of the SWEIS alternatives on the accident scenarios. This latter consideration included whether accident frequencies or MAR could increase or decrease across the alternatives, and whether any accident scenario existed in one or some but not in all alternatives.

Documentation relied upon for the radiological facility accident analysis included the following:

- The LANL seismic hazard evaluation (Wong et al. 1995) and the LANL aircraft crash hazard evaluation (LANL 1996d)
- Basis for Interim Operation (BIO)
- Operational safety requirements
- Technical safety requirements Environmental assessments (EAs)
- EISs
- Facility descriptions (LANL 1998b)

Based on the results of the review of facility safety documentation and the facility walkdown/interview data collection process, a large suite of accident scenarios was identified and grouped by MAR (e.g., weapons-grade plutonium, source material plutonium, tritium, highly enriched uranium [HEU], depleted uranium (DU), etc.) for further consideration.

Accident Initiator Screening

Section G.3 in appendix G (in volume III) describes the comprehensive screening and evaluation of various accident types and initiators.

Accident types and accident initiators that could produce an accident with a frequency in excess of 10^{-7} per year when realistically estimated, or a frequency in excess of 10^{-6} per year when conservatively estimated, were treated as “credible” and “reasonably foreseeable.” Of course, accidents with frequencies less than this were not dismissed without considering whether they were capable of producing worse consequences than credible earthquakes, which affect the entire LANL site. It is also not plausible that many individual, but unlikely, accidents could rival earthquakes in risk, and so such accidents were not retained for detailed analysis.

Summary of Consequence Screening for Chemical Accidents

Thirty-seven chemicals were identified in the 1992 LANL database that met the following criteria:

- Has a time-weighted-average (TWA) less than 2 parts per million
- Is found in readily dispersible form (i.e., a gas or liquid)
- Has a boiling point less than 212 degrees Fahrenheit (°F) (100 degrees Celsius [°C]) and a vapor pressure greater than 0.5 millimeter mercury

These 37 chemicals were modeled for release of their largest 1992 inventory, using adverse dispersion conditions and the ALOHA™ code, which is described in appendix G, section G.2.3. The 10 releases that exceeded the Emergency Response Planning Guideline (ERPG)–3 at 328 feet (100 meters) distance were retained for further analysis. To these were added another eight chemicals of interest.

Releases of the actual inventories of these 18 chemicals at 78 locations were then modeled to see which would exceed the ERPG–3 concentration under conservative daytime dispersion conditions. In this modeling:

- Release was at surface level.
- Gases were released over 10 minutes.
- Liquids were spilled instantaneously and then evaporated from a puddle 0.4 inch (1 centimeter) deep.

The releases that exceeded the ERPG–3 concentration were examined with consideration of:

- Whether there is a large work force nearby or there is public exposure
- If a heavy gas, whether the public is protected by intervening canyons
- Whether the consequences are less than a release of the chemical from a different facility
- Whether the consequences are less than those of another chemical released from the same facility

With these considerations, a number of releases were selected and retained for detailed analysis. Formaldehyde was also retained as it represents the largest LANL inventory of a readily dispersible chemical carcinogen. These final selections are shown in Table 5.1.11.7–1.

Summary of Consequence Screening for Radiological Accidents

To facilitate radiological facility accident screening, integrated population exposure was established as an evaluation criterion. Consequences were calculated for the release of a unit of material and multiplied by the source term magnitude to obtain approximate consequences for screening. The calculations were performed with the Melcor Accident Consequence Code System (MACCS) 2 (as described in appendix G, section G.2.4), for both ground level releases and elevated releases.

Population distributions for the screening and detailed analysis calculations were created from the 1990 Census data for residential populations, and 1996 LANL workforce populations by TA. LANL workforce populations were included by centering the total TA population in the direction where there is the largest concentration of that TA's population. This is a conservative and approximate method because it results in some double counting of facility workers who have residences within the 50-mile (80-kilometer) radius of LANL.

With these releases and frequency estimates, a number of scenarios were selected and retained for further detailed analysis, as listed in Table 5.1.11.7–1. Several accidents scenarios that might or should have been screened out are listed in Table 5.1.11.7–2. They were, at first,

TABLE 5.1.11.7–1.—*Dominant Accidents at LANL*

PROCESS HAZARD ACCIDENTS	
CHLORINE RELEASES	
CHEM–01	Single cylinder release of chlorine (150 pounds) from a potable water chlorinator (TA–00–1109, bounding) due to equipment failure or human error during chlorine cylinder replacement or maintenance activities.
CHEM–03	Single cylinder release of chlorine (150 pounds) from toxic gas cylinder storage facility (TA–3–476) due human error during cylinder handling or cylinder deterioration due to unintended long-term exposure to weather.
CHEM–06	Chlorine gas release (150 pounds) from a process line at the Plutonium Facility (TA–55–4) due to mechanical damage to a supply manifold.
HIGHLY ENRICHED URANIUM RELEASE	
RAD–03	Reactivity excursion accident at Pajarito Site Kiva #3 (TA–18–116) with Godiva-IV outside the kiva, vaporizing part of the HEU fuel and melting the remainder.
PLUTONIUM RELEASES	
RAD–09	TRU waste drum failure or puncture at TA–54, Area G (bounding).
RAD–13	Plutonium melting and release accident at Pajarito Site Kiva #3 (TA–18–116).
RAD–15	Plutonium release from a laboratory and wing fire at the CMR Building.
MANMADE HAZARD ACCIDENTS	
CHLORINE RELEASE	
CHEM–02	Multiple-cylinder chlorine release (1,500 pounds) due to explosion or unsuppressed fire affecting a toxic gas storage facility (TA–3–476).
SELENIUM HEXAFLUORIDE AND SULFUR DIOXIDE RELEASE	
CHEM–04	Single cylinder release of toxic gas (selenium hexafluoride, historical bounding chemical) from the legacy toxic gas storage facility (TA–54–216) due to random cylinder failure or a forklift accident.
CHEM–05	Multiple cylinder release of toxic gas (sulfur dioxide, historical bounding chemical) from the legacy toxic gas storage facility (TA–54–216) due to a fire, a propane tank BLEVE, or a propagating random failure.
TRITIUM RELEASE	
RAD–05	Aircraft crash with explosion and/or fire at TA–21 resulting in a tritium oxide release.
PLUTONIUM RELEASE	
RAD–01	Plutonium release due to container storage area fire involving TRU waste drums (TA–54–38).
RAD–07	Plutonium release due to container storage area fire involving TRU waste drums (TA–50–69).
RAD–08	Aircraft crash with explosion and/or fire at the TRU waste dome area at TA–54 (TA–54–229, TA–54–230, TA–54–231, and TA–54–232).
RAD–16	Aircraft crash with explosion and/or fire at CMR Building resulting in a plutonium release.

TABLE 5.1.11.7–1.—*Dominant Accidents at LANL*-Continued

NATURAL PHENOMENA HAZARD ACCIDENTS	
MULTIPLE RELEASES OF HAZARDOUS MATERIAL	
SITE–01	Site-wide earthquake, resulting in damage to low capacity structure or internal components at multiple facilities.
SITE–02	Site-wide earthquake, resulting in damage to moderate capacity structures or internal components at multiple facilities.
SITE–03	Site-wide earthquake, resulting in structural damage or collapse to all facilities.
SITE–04	Site-wide wildfire, consuming combustible structures and vegetation.
RAD–12	Plutonium release from a seismically initiated event.

TABLE 5.1.11.7–2.—*Incredible Accidents That Were Analyzed*

PROCESS HAZARD ACCIDENTS	
RAD–04	Inadvertent detonation of a plutonium-containing assembly at or near the DARHT Facility firing point, resulting in an elevated, explosive-driven release of plutonium (TA–15).
RAD–10	Plutonium release from a degraded storage container in the Plutonium Facility (TA–55–4) vault during container retrieval.
RAD–11	Catastrophic containment failure after detonation of a plutonium-containing assembly at the DARHT firing point (TA–15), resulting in a ground-level release of plutonium.
RAD–14	Plutonium release from ion exchange column thermal excursion at TA–55–4 (the screening process identified this as the most likely initiator of a glovebox fire).
MANMADE HAZARD ACCIDENTS	
RAD–02	Plutonium release due to natural gas pipeline failure near TA–3–29, with no immediate ignition, ingestion of gas into facility, followed by explosion and fire.
RAD–06	Aircraft crash with explosion and/or fire at TA–50–37, resulting in a plutonium release from TRU waste drums.

considered credible accidents because of the conservatism applied in the original estimates of event frequency. However, after a more detailed evaluation of the accident progression, the events were found to be incredible. These scenarios are retained in appendix G for the information they contain.

Addition of Site-Wide Wildfire to the Accident Scenarios

Site-wide wildfires escaped consideration in the draft SWEIS. At the same time, there was a general recognition of the threat to LANL, as evidenced by the multiple agency cooperation in an ongoing fuel reduction effort. This oversight was brought to DOE's attention during the public hearings on the draft SWEIS, and an analysis began with input from the Española District of the Santa Fe National Forest (SFNF), the Bandelier National Monument (BNM) of the NPS, the Los Alamos Fire Department, and LANL departments and personnel. The final analysis appears as SITE–04.

The frequency of a large wildfire moving onto the LANL site was estimated to be 0.1, or one chance in 10 years. The extent of the subsequent fire and its consequences can vary widely according to the ensuing meteorological conditions. The SITE–04 analysis conservatively assumes that all combustible structures and vegetation over the western part of LANL are burned. The resulting public exposures were estimated for each facility, using (when available) existing calculations of public exposure from fire at that facility. Although the summed exposures from all buildings is modest, the frequency of the accident is high; as a result, the public risk places this accident in Table 5.1.11.7–1, "Dominant Accidents at LANL."

5.1.11.8 *Detailed Accident Evaluations*

The probability of a release (expressed as an annual frequency) of the hazardous material was calculated from the accident progressions in each of the scenarios retained for detailed analysis. The accident analysis included a step-by-step analysis of the initiating events and of the barriers that need to fail before a substantial amount of material can be made available for atmospheric transport to downwind receptors. The details are provided in volume III, appendix G.

Toxic chemical source terms were evaluated by looking at the release mechanisms to determine the amount and rates of material released, release heights, and other source term parameters for input to calculations of the atmospheric concentrations.

For radiological accidents, there are two source terms: the initial (prompt) source term and the subsequent, continuing suspension source term. The initial source term is the radioactive material driven airborne at the time of the accident. The suspension source term is the radioactive material that becomes airborne subsequent to the accident as a result of evaporation, winds, or other processes. For both of these terms, the characteristics of the release were evaluated to determine the amount of material available for atmospheric transport and the parameters that influence its dispersion. For most DOE nonreactor facilities, the dose from inhalation exposure dominates the overall dose from accidents.

DOE Handbook 3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Vols. I & II, December 1994 (DOE 1994), was used as the primary reference for calculation of radiological source terms. To maintain consistency across the accident analyses, DOE Handbook 3010-94 source term methodology has been applied to the aircraft crash accidents, although there is a separate DOE Standard 3014-96 that covers aircraft crashes (DOE 1996b).

Human Health Impact of Accidents

The final step in the process is the determination of human health impacts resulting through exposures. For chemical accidents, the concentrations of chemicals at various distances were made with ALOHA™, as described in appendix G, section G.2.1, and compared to the ERPGs. Once concentrations were determined using the ALOHA™ code, demographic data were used to determine the number of people exposed above each ERPG level. ERPGs are concentrations associated with different levels of reversible and serious health effects.

For radiological accidents, the effects on the surrounding populations were calculated using the MACCS2, as described in appendix G, section G.2.4. MACCS2 determines the expected collective doses to the population within a 50-mile (80-kilometer) radius of the accident, and then computes the acute fatalities and excess LCFs for this population. MACCS2 uses risk factors of about 0.0005 excess LCF per person-rem for the general population. Doses to the MEIs at specific off-site locations are used to characterize the maximum possible risk to an individual member of the public.

The resulting human health impacts are described in the following sections.

- No Action Alternative, section 5.2.11
- Expanded Operations Alternative, section 5.3.11
- Reduced Operations Alternative, section 5.4.11
- Greener Alternative, section 5.5.11

5.1.11.9 *Worker Accident Screening*

Analysis of worker accidents (other than the transportation and physical safety hazards discussed in the SWEIS transportation risk and human health analyses, respectively) was performed to provide estimates of potential health effects from chemical and radiological exposure for involved workers. (For purposes of this SWEIS, workers within the TA where the accident occurs are defined as "involved workers," and other on site LANL employees are defined as "noninvolved workers.") Worker accident analysis need not be either as extensive or detailed as the public accident analysis because worker health risk from industrial accidents (falls, electrical shock, crushing, etc.) dominates over worker health risk from exposure in radiological and chemical accidents.

Worker accidents were reviewed qualitatively in order to arrive at a list of accidents that is representative of the accident potential at LANL under the four alternatives. The process used was similar to the analysis of accidents with public impact. The purpose of the separate worker accident screening was to identify whether there are accident scenarios that could have greater consequence to workers than the worker consequences associated with the public accident scenarios.

Data to support the accident analysis were obtained from a variety of sources, both facility- and site-specific, as well as from industrial and nuclear generic databases and compilations. Data sources, detailed in appendix G, included safety and hazard analysis documentation, data forms generated during the facility walkdowns, LANL SWEIS alternatives documentation, and Occupational Safety and Health Administration (OSHA) Form 200 Injury/Illness Reports for LANL and other DOE facilities.

The summary listing identified over 600 potential worker accident scenarios. Potential worker accident scenarios were then sorted by material hazard and initiators and ranked according to relative risk. Risk was qualitatively assigned on the basis of the frequency and consequence ranking matrix for hazard evaluation described in section G.1 of appendix G. The array of worker accidents was not dissimilar from the array of accidents with public impact, so that the worker accident component of the selected public accidents also provides a representative picture of the worker accident potential. There are, however, some accidents that pose a risk to workers but not to the public. An example is the medical research at TA–43–1, field work on small mammal capture and blood sampling, where the exposures to workers are localized and the exposure to the population from a release would be mitigated by environmental attenuation. Another exception is energetic hazards, where potential hazardous sources do not involve the public.

The ranked worker accident scenarios were then compared to the public impact accidents with comparable risk rankings. From the review of the chemical and radiological accidents selected for detailed quantification of public risk and a screen of these accidents against the worker accidents, the following worker accidents were selected for more detailed evaluation (also listed in Table 5.1.11.9–1).

- Inadvertent high explosives detonation
- Biohazard contamination of a single worker
- Inadvertent criticality event
- Inadvertent exposure to electromagnetic radiation (x-rays, accelerator beam, laser, or radiofrequency [RF] source)

5.1.11.10 *Detailed Worker Accident Evaluations*

The worker accidents were qualitatively assessed because exposure can vary widely based on the exact sequence of the accident. One of the bounding parameters is the length of time that a worker is exposed to a hazardous material. Rapid evacuation, sheltering, and donning of protective equipment can greatly reduce a worker's exposure. Prompt medical treatment can also reduce the consequences. Therefore, worker accidents can be only qualitatively assessed for both the likelihood of the accident and its impact on individual workers. The human health results for the workers are provided in the following sections.

- No Action Alternative, section 5.2.11
- Expanded Operations Alternative, section 5.3.11
- Reduced Operations Alternative, section 5.4.11
- Greener Alternative, section 5.5.11

5.1.11.11 *Uncertainties and Sensitivities*

In principle, one could estimate the uncertainty associated with each step of the analysis for each accident scenario, and predict the uncertainty in the results (frequency, source term, consequences, risk, etc.). However,

TABLE 5.1.11.9–1.—*Dominant Worker Accidents at LANL*

PROCESS HAZARD ACCIDENTS	
WORK–01	Worker fatality due to inadvertent high explosives detonation.
WORK–02	Worker illness or fatality due to inadvertent biohazard contamination.
WORK–03	Multiple worker fatality due to inadvertent nuclear criticality event.
WORK–04	Worker injury or fatality due to inadvertent electronic radiation exposure (x-ray, accelerator beam, laser, or radiofrequency source exposure).
WORK–05	Worker exposure to plutonium released from a degraded storage container in the plutonium (TA–55–4) vault during container retrieval.

conducting such a full-scale quantitative uncertainty analysis is neither practical nor a standard practice for a study of this type. Instead, the analysis is intended to ensure, through judicious selection of release scenarios, models, and parameters, that the results represent and give a reasonable estimate of the actual risks.

This is accomplished by making conservative assumptions at each step of the calculations. The models, model parameters, and release scenarios are selected in such a way that most intermediate results and the final estimate of impacts are almost certainly greater than what would be expected should the events actually occur. That is, there is a small chance that the actual risk is greater than presented, but a very large chance that the actual risk is less.

Often, there are no differences between accident impacts among the alternatives, largely as a result of conservative approaches used in accident frequency and public consequence. The inventories used in the analyses are typically those of permitted or administrative limits (i.e., controls on the maximum amounts of material that can be processed at one time and/or in storage), rather than operational values (i.e., the actual amount of material needed to perform the task). The operational values would be more likely to change among the alternatives. The administrative limits or inventories are selected so that the analyses are sufficiently conservative and bounding to cover maximum possible operational values. The accident frequencies depend upon the accident initiators, such as an aircraft crash, earthquake, or wildfire. These particular initiators are independent of the operations and of inventory; therefore, the frequency or likelihood of such an event remains constant among the alternatives. In the few cases of accidents in which the frequency depends upon operations, the variation in frequency among the alternatives does not necessarily translate into a significant change in the risk of an environmental release to the public because the value of a release is very small. Likewise, the risk to workers is affected by the change in frequency of the operations; but, the consequence of a single accident remains the same. These details for specific accidents appear in volume III, appendix G.

5.1.11.12 Summary of Methodology for Supplement Analysis, SSM PEIS

The DOE is preparing a Supplement Analysis for the SSM PEIS (DOE 1996d) in accordance with an order issued by the U.S. District Court for the District of Columbia, resulting from a lawsuit filed against the DOE (chapter 1, section 1.5.2). The Supplement Analysis will: (1) assess the significance of recent seismic studies at LANL and (2) re-examine the plausibility of a building-wide fire at TA–55. With respect to the seismic analyses, the Supplemental Analysis will reflect the differences between DOE's understanding of seismic risk at the time the SSM PEIS and its ROD were prepared and the understanding of seismic risk at the completion of recent seismic studies (the last studies are expected to be finalized in March 1999). This analysis will reflect the difference, if any, in terms of both the frequency of the bounding seismically induced accident and the consequences of such an accident. This difference will then be examined for significance with respect to DOE's assignment of the pit production mission to LANL, as reflected in the SSM PEIS ROD.

With respect to the building-wide fire analyses, two types of accident scenarios will be considered: process and natural phenomena events. In addition, an analysis of the plausibility of a building-wide fire due to sabotage will be included in the Supplement Analysis. The process events will look at various classes of fire initiation (e.g., flammable material, electrical fires, equipment malfunctions, etc.). These process scenarios will be compared to historical data for glovebox and laboratory fires from the DOE complex, as well as from industry data to ensure a complete understanding of possible ways that fires could start at TA–55. These fires then will be analyzed for ways in which they could propagate throughout the Plutonium Facility (PF)–4 complex (including analyses for potential failure of the various barriers to fire propagation). These considerations of how and where a fire could start and then spread to envelop the entire PF–4 facility will be developed into an analysis of a building-wide fire at the LANL Plutonium Facility (PF–4 at TA–55).

The natural phenomena event that will be considered as part of the Supplement Analysis will be the seismically induced fire at TA–55. This analysis will look at the fragility of gloveboxes, cable trays, flammable gas cabinets, etc., in order to compare to postulated ground accelerations. Essentially, the analysis will examine the means to start fire in TA–55 through the seismically induced damage of material or equipment in the building. The analysis then will consider the spread of the fire throughout the building because of damaged fire barriers or the presence of material that is no longer contained because of damage from ground accelerations.

The plausibility of a building-wide fire due to sabotage will be examined, consistent with existing DOE threat guidance regarding sabotage and the tools and analyses routinely used to assess vulnerability to sabotage events. The nature of such analyses is that the result will be presented in terms of the potential that the attempted sabotage would be defeated; that is, the potential for the attempt to be detected and prevented or controlled prior to the saboteur's objective being met. This analysis is likely to be classified, in accordance with U.S. laws, due to the highly sensitive nature of information regarding LANL security features and their performance.

5.2 IMPACTS OF THE NO ACTION ALTERNATIVE

5.2.1 Land Resources

5.2.1.1 *Land Use*

Common to all four alternatives are ongoing environmental restoration activities. These include the decontamination and demolition of facilities and cleanup of land disposal sites located across LANL. Upon completion of restoration activities, these individual sites could be made available for different uses. It is currently estimated that these restoration actions would be ongoing over most of LANL for about the next 10 years. As sites are remediated, it is currently planned that the newly available site land uses would revert to the current land use category of the surrounding TA location. In the case of environmental restoration sites, this would change these areas back to Research and Development or Explosives land use categories from the Waste Disposal land use category designation. Because most of the sites are relatively small in size, this reversion will not result in significant land use acreage changes overall within the different categories of use. In the case of those TAs located next to the Los Alamos townsite, current evaluation of these areas reveals that they are not likely to undergo total decontamination or demolition and evacuation within the foreseeable future, so, accordingly, their land use category designations would not be expected to change within that time frame.

No changes to land use categories are anticipated from activities that are unique to this alternative. Activities identified for the key facilities under this alternative would occur primarily within existing facilities or within near proximity to them in disturbed areas and within the same type of land use category.

5.2.1.2 *Visual Resources*

Common to all four alternatives analyzed are environmental restoration activities that include the decontamination and demolition of facilities and cleanup of land disposal sites located across LANL. Upon completion of restoration activities, these sites will undergo soil stabilization through such efforts as vegetation reseeding or the installation of a site covering such as asphalt or concrete, dependent upon the identified future site uses. There will be a time period from the onset of site remediation through final site restoration when the viewshed will be minimally altered by the introduction of heavy equipment and vehicles and by any subsequent areas left bare of vegetation. Although some sites could be bare of vegetation or only sparsely covered for several subsequent growing seasons, this effect would be temporary and minor overall in nature. These sites are usually rather small in size and some may already be within developed, disturbed, or cleared areas.

No major changes to visual resources are anticipated from activities that are unique to the No Action Alternative. Construction activities identified for the key facilities under this alternative would occur within near proximity to existing buildings and parking areas in already disturbed locations. There would be a minimum of clearing activities required and these would be limited to a few acres. Fugitive dust generation during construction would be minimal and temporary. It would not be expected to change the overall air quality, nor would the ongoing operations at these facilities once they were initiated. There could be some changes at LANL's key facilities under this alternative that add to use of artificial nighttime personnel safety lighting around buildings and parking lots. These light sources would usually shed areas of localized light within the immediate vicinity of the building area and would not be expected to pose an adverse effect to wildlife in the area. Use of these additional light fixtures could result in an extremely slight increase in overall LANL area levels of light pollution that is unlikely to result in an expanded visibility of LANL by nighttime viewers located across the Rio Grande Valley.

5.2.1.3 *Noise*

Common to all four alternatives is LANL's continued contribution to the background noise generation with the Los Alamos County area. This background noise level is expected to remain at or near current levels for most of the foreseeable future regardless of the alternative that is implemented. There is no single representative measurement of ambient noise available for the LANL site. The upper regulatory limit for levels of noise experienced over a 16-hour period for workers is 80 decibels (dB) on the A-weighted frequency scale (dBA) (29 CFR 1910.95). Adverse permanent health effects are not expected to occur with levels of sound occurring constantly for up to 16 hours that are lower than that upper bounding regulatory limit. It is not anticipated that the background levels of noise associated with LANL activities under any of the four alternatives would approach this upper limit sound level based upon estimates of potential levels of site activities associated with each alternative relative to the existing environment.

The levels of noise and short-range ground vibrations generated by environmental restoration activities are consistent with those produced by most construction activities. Heavy equipment use, such as the operation of bulldozers, loaders, backhoes, and portable generators, typically produces noise with mean levels ranging from 81 to 85 dBA. For a comparison with these noise levels, normal conversation is usually conducted at a sound level of about 60 dBA (DOE 1995a). If heavy machinery were to be operated over a 16-hour period so that it produced noise at levels above 80 dBA constantly, it would be considered to be unsafe for workers. However, these noises are generally produced for short time periods or even sporadically. While occasional short spurts of site activities may result in noise levels in excess of 80 dBA, these are expected to be well within the levels of noise considered to be safe for likely exposure time durations of one-half hour (100 dBA) to one hour (96 dBA). Hearing protection is provided and worn by workers, as appropriate according to their standard operating procedures to afford them greater hearing protection. Additionally, some minor interior and outdoor construction activities are common across all alternatives. Noise produced by these activities would be mostly noticed by LANL workers at the site performing those activities; these workers would also be provided with hearing protection as part of their standard operating procedures.

Noise from these LANL construction-type activities may be somewhat noticeable to nearby members of the public, especially in the case of off-site environmental restoration activities. Because these activities are conducted during the daytime hours for short continuous durations, it is unlikely that the noise levels and ground vibrations produced by these activities would be sufficient to result in an adverse impact to the public. Nor are the noise levels likely to adversely affect sensitive wildlife receptors or their habitat. If certain sensitive wildlife species are found to occupy habitat areas near locations where these types of activities need to occur, or if the occupancy status of these habitat areas is unknown, it may be necessary to plan these activities so that they take place outside of the species' breeding seasons or else other special protective measures would need to be planned and implemented (e.g., hand digging).

Similarly, it is unlikely that workers, the public, or sensitive wildlife receptors would be adversely impacted by explosives testing that is common to some degree over the four alternatives. Workers are allowed to experience up to 100 impulsive/impact noise events at a maximum of 140 dBA per day and are kept away from harmful noise levels and air blasts by gated exclusion zones that control their entry into explosives firing site detonation points. The public is not allowed within the fenced TAs that have firing sites, and as mentioned in chapter 4 (section 4.1), noise levels produced by explosives tests are sufficiently reduced at locations where the public would be present to preclude hearing damages. Various studies are currently underway to gain an understanding of the effect of noises on sensitive wildlife species. The continued well-being of LANL's resident and long-term migratory populations of these sensitive species indicates that the level of noise generated by explosives testing under the No Action Alternative would at least be tolerated by these particular species.

Implementing the No Action Alternative would be expected to result in the previously discussed effects common to all alternatives. There would be no other anticipated effects unique to this alternative.

5.2.2 Geology and Soils

The information provided from the geology and soils sections feeds into several other sections within the SWEIS, such as human health, accidents, and ecological risk.

5.2.2.1 *Seismic Events or Volcanic Eruptions*

LANL operations under the No Action Alternative do not include activities that could trigger seismic events or volcanic eruptions (e.g., underground nuclear tests, operation of injection wells). Therefore, it is unlikely that operations under the No Action Alternative will have any geological impacts. Geologic hazards that are important components of accident scenarios are discussed in section 5.1.11.

5.2.2.2 *Slope Stability/Soil Erosion*

LANL operations under the No Action Alternative do not include any new activities that would result in any additional slope stability impacts. As discussed in section 4.2, the potential for rockfall and landslides and the historic downward cutting or erosion of surface water streams in the LANL regions, which results in steep canyon walls, will continue over time. These processes may destabilize supporting rocks. These processes will continue under the No Action Alternative; however, no new facilities near the canyon walls are planned. New rock catchers similar to those installed at TA–2 for the Omega West reactor should not be necessary under the No Action Alternative. All new activities that will disturb soils, such as environmental restoration activities, will continue to use mitigative measures (e.g., plastic lined trenches and the construction of flow barriers) to minimize the effect of surface runoff and soil erosion.

5.2.2.3 *Soils*

Soils in the area around LANL contain chemicals and radioactive materials, including those that are naturally occurring as well as those due to past LANL activities and worldwide fallout. These have the potential to affect human health and the environment. Most of the soil contamination due to LANL operations occurred as a result of past practices. (This contamination is referred to as "legacy contamination.") These past practices were associated with surface impoundments and disposal areas; experimental reactors; inactive firing sites; aboveground and underground storage tanks; PCB transformers; incinerators; chemical processing; shop machining that resulted in radioactive waste; and operations to develop, fabricate, and test explosive components for nuclear weapons. Although most of these activities are still ongoing at LANL, with the exception of underground testing, environmental regulations have become more stringent, and management of LANL operations is more proactive in minimizing such contamination.

Under the No Action Alternative, as sites are remediated, legacy soil contamination will be reduced. Legacy contamination is being addressed by the LANL Environmental Restoration (ER) Project, which is described in chapter 2 (section 2.1.2.5) of the SWEIS. In the future, consistent with the trend analyses discussed in chapter 4 (section 4.2.3.1), most radionuclides in soils, particularly tritium and uranium, from both on-site and off-site areas should continue to decrease. Contaminants such as DU, beryllium, lead, copper, and others are produced at firing sites and are of potential concern for deposition in sediments and soils. ER data to date show no appreciable difference between sediment samples and off-site samples (volume III, appendix D, Table D.3.4–1). Although a similar study is not available for soils because sediments are narrow bands of canyon bottom deposits that can be transported by surface water, this indicates that off-site deposition from runoff resulting from past firing site activities is minimal. Section 4.3.1.4 presents more information on sediments. When comparing LANL historical levels of firing sites activities with the No Action Alternative, historical levels during the time of peak activity (1980 to 1985) were approximately 2.8 times greater than proposed for the No Action Alternative (LANL 1995d). As a result, ongoing operations under the No Action Alternative should have little potential to contribute substantially to soil contamination, and as more remedial actions projects are completed, the overall levels of soil contamination will be reduced.

5.2.2.4 *Mineral Resources*

Although there is the potential that sand, gravel, and pumice deposits may exist within the LANL boundaries as discussed in section 4.2.4, the No Action Alternative will not affect the availability of these materials for mining purposes. The disturbed area for new construction activities associated with the new facilities or environmental restoration are small in comparison to the overall 43 square miles (111 square kilometers) of land that LANL occupies and, as discussed in section 5.1.1, are not in land use areas designated for mining activities.

5.2.3 Water Resources

5.2.3.1 *Surface Water*

The primary sources of potential impacts to surface water at LANL are the NPDES outfalls and transport of sediments contaminated from historic LANL activities. For the No Action Alternative, there are no new activities that will result in changes in stormwater runoff.

The volumes of effluent discharged into each watershed for the No Action Alternative are given in Table 5.2.3.1–1. In volume III, appendix A, Table A.1–1 presents a more detailed table of the NPDES outfalls for all four alternatives by facility (key and non-key), watershed, and location. In all of the alternatives there are no outfall discharges into the Barrancas, Bayo, Potrillo, Frijoles, Ancho, and Chaquehui watersheds. Ancho and Chaquehui canyons have baseline flows but no projected flows for the alternatives. Pueblo and Guaje watersheds have 1 million gallons (3.8 million liters) or less per year. For the No Action Alternative, 55 outfalls from key and non-key facilities discharge into eight separate watersheds. The estimated total discharge into all watersheds under the No Action Alternative is 261 million gallons (988 million liters) per year. This is an increase from the index effluent volume of 233 million gallons (882 million liters) discharged, as reflected in section 4.3. The number of outfalls remains constant across the alternatives.

TABLE 5.2.3.1–1.—*NPDES Discharges by Watershed Under the No Action Alternative*[a]

WATERSHED	#OUTFALLS		DISCHARGE, MGY					
			KEY FACILITIES		NON-KEY		TOTALS	
	INDEX	NA	INDEX	NA	INDEX	NA	INDEX	NA
Ancho	2	0	0.1	0.0	0.0	0.0	0.1	0.0
Cañada del Buey	3	3	0.0	0.0	6.4	6.4	6.4	6.4
Chaquehui	1	0	0.0	0.0	5.8	0.0	5.8	0.0
Guaje	7	7	0.0	0.0	0.7	0.7	0.7	0.7
Los Alamos	12	8	19.2	30.6	0.5	0.2	19.7	30.8
Mortandad	12	7	42.0	29.6	10.9	5.1	52.9	34.7
Pajarito	17	11	8.4	1.8	0.8	0.8	9.2	2.6
Pueblo	1	1	0.0	0.0	1.0	1.0	1.0	1.0
Sandia	11	8	4.4	42.7	103.5	127.9	107.9	170.6
Water	21	10	29.5	14.1	0.0	0.0	29.5	14.1
Totals	87	55	103.6	118.8	129.6	142.0	233.2	260.9

MGY = millions of gallons per year, NA = No Action Alternative

[a] NPDES Information Sources: Index information was provided by the Surface Water Data Team Reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997. Additional outfalls may be eliminated in the future, as discussed in the *Environmental Assessment for Effluent Reduction* (DOE 1996e), as well as several other outfalls that may be closed as part of LANL's ongoing outfall reduction program.

NPDES outfall effluent quality during the 10-year period analyzed (1997 through 2006) is expected to be similar to or improved over the effluent quality discharged during the period 1991 through 1995. LANL actions to improve compliance with permit conditions are continually being taken, including elimination of outfalls, improvements and corrective actions at specific outfalls, and implementation and completion of the Waste Stream Characterization Program and Corrections Project. Furthermore, several of the outfalls contain stormwater only; the cleanups at ER Project sites that will occur during the period of the SWEIS may result in improvement in the quality of the effluent in outfalls containing stormwater. As can be seen from Table 5.2.3.1–1, as of November 1997, 32 of the 87 index NPDES outfalls will be reduced to zero flow, resulting in 55 outfalls for the No Action Alternative (this is the case for all the alternatives). As the LANL outfall reduction program continues, it is anticipated that even more outfalls will be eliminated. No new outfalls are anticipated under any of the alternatives.

Another improvement to outfall effluent quality (in relation to the period 1991 through 1995) has occurred as a result of the improvements made at the High Explosives Wastewater Treatment Facility (HEWTF) (DOE 1995b). The new HEWTF, completed in October 1997, came on-line in February 1998 and will minimize the use of water in high explosives processes and will treat all remaining high explosives-contaminated wastewater at the new treatment facility. These changes will improve the quality of effluent from the HEWTF outfalls across the alternatives.

Improvements are also planned for outfall 051 at the TA–50 RLWTF. The effluent from the RLWTF have exceeded the DOE-Derived

Concentration Guide (DCG) for the public for the radionuclides americium-241, cesium-137, tritium, plutonium-238 and plutonium-239, and strontium-90 during the period 1990 through 1995 (LANL 1992, LANL 1993, LANL 1994, LANL 1995c, LANL 1996b, and LANL 1996c). A treatment system will be operational by early 1999 that will reduce concentrations of all of the above radionuclides, except tritium. Table 5.2.3.1–2 lists, for the above radionuclides, the average concentrations from 1990 through 1995 effluent, the predicted concentrations following treatment upgrades, and the DOE-DCGs for the public. The newly installed treatment system will result in concentrations of these radionuclides in effluent that will meet the DOE-DCGs for the public.

For liquid radioactive effluents, the "as low as reasonably achievable" (ALARA) and "best available technology" (BAT) processes are adopted, to determine the appropriate level of treatment. If discharges are below the DCGs reference values at the point of discharge to a surface waterway, generally no further treatment is required due to cost benefit considerations. Because the average tritium concentration (311,203 picocuries per liter) is well below the DOE-DCG (2,000,000 picocuries per liter), no further treatment of tritium was considered necessary. In addition, there is currently no practical treatment technology for tritium removal from the dilute concentrations present in the RLWTF effluent.

The effluent from the RLWTF has also exceeded the New Mexico Water Quality Control Commission (NMWQCC) standard for nitrate as nitrogen of 10 milligrams per liter. A nitrates removal system is being installed as part of the RLWTF improvements that will be operational by mid 1999. This new system will reduce the nitrates concentration levels below the NMWQCC standard.

As discussed in chapter 4 (section 4.3.1.2), LANL conducts a variety of construction, maintenance, and environmental activities that result in excavation or fill within water courses, which are waters of the U.S. under Section 404 of the *Clean Water Act*. These activities are done pursuant to 404 permits issued by the Army Corps of Engineers and certified per Section 401 by NMED. Each permit is issued pursuant to one or more specific nationwide permits. These include relevant permit conditions to protect water quality and wildlife that must be complied with by LANL and its construction contractors. The NMED also adds conditions as a part of its Section 401 certification that require application of "best management practices" to ensure satisfaction of New Mexico stream standards. Under the No

TABLE 5.2.3.1–2.—*TA–50 Radionuclide Summary*

RADIONUCLIDE	AVERAGE CONCENTRATIONS 1990 TO 1995[a]	PREDICTED CONCENTRATION AFTER TREATMENT[b]	DOE-DCG (PUBLIC)
Americium-241	155	25	30
Cesium-137	804	80	3,000
Tritium	311,203	311,203	2×10^6
Plutonium-238	66	17	40
Plutonium-239	28	27	30
Strontium-90	659	66	1,000

Note: All results are given in picocuries per liter.
Sources: [a] LANL 1992, LANL 1993, LANL 1994, LANL 1995c, LANL 1996b, and LANL 1996c; [b]Vance et al., 1996

Action Alternative, LANL will continue to comply with these permit requirements and use "best management practices" to ensure satisfaction of New Mexico stream standards.

As discussed under section 5.1.2, Water Resources Methodology, only the canyons with increased flows over the index are discussed in detail. It is assumed that for canyons with NPDES flows that are the same or reduced from the index flows, the impact will be negligible. Canyons that have an increase in outfall flows over the index are Los Alamos and Sandia Canyons. In Los Alamos Canyon the overall increase in flow of 11 million gallons (42 million liters) per year from the index is from the outfalls associated with the LANSCE Facility. In order to assess potential impacts, one needs to identify the types of contaminants that could originate from these outfalls and what type of contaminants may be transported off the site. The LANSCE outfalls with increased flow are 03A–047, 03A–048, and 03A–049. These outfalls are of the type containing cooling tower blowdown, evaporative coolers, chillers, condenser and air washer blowdown (Table 4.3.1.3–2 and Figure 4.3.1.3–1 in chapter 4 [legend numbers 18, 19, and 20] provide information regarding type and location, respectively). The primary noncompliance issues associated with these outfalls are for arsenic. LANL is in the process of designing a long-term corrective action that should help to eliminate future exceedances of arsenic. Corrective actions being evaluated include use of nontreated redwood and replacement of the wooden cooling towers with new units constructed of steel, fiberglass, and plastic. In 1996, outfalls 03A–048 and 03A–049 had a total of six arsenic exceedances; however, 1996 surface water monitoring stations for Los Alamos Canyon show levels of arsenic of less than 3 micrograms per liter, which is substantially less than the EPA drinking water standard of 50 micrograms per liter.

Elevated concentrations of tritium and other radionuclides have been detected in surface water samples in Los Alamos Canyon since the beginning of surveillance measurements in the mid 1960's. An industrial liquid waste treatment plant at TA–21 discharged effluent containing radionuclides into DP canyon, a tributary to Los Alamos Canyon, from 1952 to 1986. After 1986, the treated effluent was diverted to the TA–50 RLWTF. Up until 1989, Los Alamos Canyon received discharges containing radionuclides from the LANSCE Facility. In 1993, a cooling water leak was discovered at the Omega West Reactor (OWR). The OWR was shut down in 1992. The leak may have been occurring since beginning operation in 1956. The leak was repaired in 1993 soon after being discovered (LANL 1995c). However, the 1996 radiochemical analyses of runoff from Los Alamos Canyon (LANL 1997d) were well below the DOE-DCGs for the public. Within Los Alamos Canyon there are some relatively small areas that are being evaluated by the ER Project (chapter 2, section 2.1.2.5), where sediments may contain contaminants such as radionuclides, chemicals, and metals that are at higher levels than the LANL screening action levels (SALs). SALs are a benchmark for the potential for human health risk and are derived from toxicity data using a risk assessment approach (section 4.2.3.1). The ER Project plans to either remediate these areas or temporarily stabilize them until remediation, or permanently stabilize them such that potential transport of these contaminated sediments would be minimal. The reach in the vicinity of the LANSCE outfalls 03A–047, 03A–048, and 03A–49, is ephemeral and intermittent.

Table 4.3.1.1–1 in chapter 4 shows that the total volume of water at station E030, which is in the vicinity of these outfalls, was 160 million gallons (606 million liters) per water year in 1995. This is large in comparison to the additional 11 million gallons (42 million liters) identified in the No Action Alternative. Based on surface water monitoring results, particularly for arsenic and radiochemical analysis, and the relatively small increases in flow in Los Alamos Canyon as compared to the naturally occurring flows, the impacts to surface water from the increased flow in Los Alamos Canyon should be negligible.

Sandia Canyon has a small drainage area that heads at TA–3. Currently, under baseline conditions, the canyon primarily receives water from the cooling tower at the TA–3 power plant. These effluents support a continuous flow in a short reach of the upper part of the canyon (Figure 4.3.1.3–1); but, only during summer thundershowers does stream flow reach the LANL boundary at State Road 4, and only during periods of heavy thunderstorms or snowmelt does surface flow from Sandia Canyon extend beyond the LANL boundary.

In Sandia Canyon for the No Action Alternative, out of the total 63 million gallons per year (238 million liters) increase from the index, approximately 24 million gallons (91 million liters) per year are associated with outfalls from the cooling tower at TA–3, particularly outfall 01A–001, identified as 27 in Figure 4.3.1.3–1. All effluent from the TA–46 Sanitary Wastewater Systems Consolidation (SWSC) Facility is pumped to a reuse tank adjacent to the TA–3 power plant. When the power plant is in operation, water is drawn from the tank as makeup for the power plant cooling towers, where it is either lost to the air through evaporation or discharged to Sandia Canyon via the power plant outfall 01A–001. Outfall 13S, the original outfall for the TA–46 SWSC Facility, is located at the TA–46 SWSC Facility but is not used. However, the SWSC effluent, prior to being pumped over to TA–3, must meet the NPDES discharge limits for 05S (Table 4.3.1.3–2 shows NPDES effluent limits). The additional 24 million gallons (91 million liters) per year flow at TA–3 includes the increase flow projected from the SWSC plant. The additional outfall flow at TA–3 will support the continuous flow in the upper part of the canyon. The remaining 39 million gallons (148 million liters) per year increase in flow is from another LANSCE outfall, 03A–113 at TA–53, identified as 21 in Figure 4.3.1.3–1. The effluent water quality from both outfalls 01A–001 and 03A–113 is similar to the outfalls discussed previously for cooling towers. In 1996, both outfalls 01A–001 and 03A–113 were in compliance with the NPDES permit, and the radiochemical results of runoff from Sandia Canyon were well below the DOE-DCG for the public. Within Sandia Canyon, there are some relatively small areas that are being evaluated by the ER Project (chapter 2, section 2.1.2.5) where sediments may contain contaminants such as radionuclides, chemicals, and metals that are at higher levels than the LANL SALs. The ER Project plans to either remediate these areas or stabilize them such that potential transport of these contaminated sediments should be minimal.

Figure 4.3.1.3–1 in chapter 4 shows that the flow in Sandia Canyon is ephemeral and intermittent in the vicinity of outfall 03A–113, and Table 4.3.1.1–1 shows that the total volume of water at perimeter downstream station E–125 in Sandia Canyon was less than 2 million gallons (4 million liters) per year. Increased flow from outfall 03A–113 of 39 million gallons (148 million liters) per year may be sufficient to support a continuous flow for a short reach in the vicinity of the outfall. However, transport of contaminants off the site should be negligible.

For additional information on changes in NPDES outfall flows for each outfall for all the alternatives see volume III, appendix A.

5.2.3.2 *Groundwater*

Groundwater quantity and quality impacts to the three areas of groundwater under the Pajarito Plateau (alluvial, intermediate perched, and main aquifer) that may result from implementing the alternatives over the next

10 years were evaluated. As discussed under section 5.1.2, Water Resources Methodology, only the canyons with increased flows over the index are discussed in detail. It is assumed that for canyons with NPDES flows that are the same or reduced from the index flows, the impact will be negligible.

In order to better understand the extent of the effects of LANL activities on groundwater, more monitoring wells are being installed. Once constructed, the new monitoring wells should provide data for researchers to gain better understanding of how contaminants are transported from discharge sites. Because of the many questions concerning the hydraulic characterization of the Pajarito Plateau, such as recharge mechanisms for the main aquifer and the lack of hydrogeologic detail, LANL personnel prepared a Hydrogeologic Workplan that was approved by NMED in 1998 (LANL 1998d). The first of these wells to be installed is R-9 located in lower Los Alamos Canyon near the intersection of NM 501 and NM 4. On December 10, 1997, LANL personnel found preliminary indications of low levels of tritium in two perched groundwater zones. The water in which the tritium contamination was detected lies several hundred feet above the main aquifer, and the tritium levels were below the Safe Drinking Water Standards established by the EPA. LANL has previously detected extremely low level of tritium in the deep aquifer at several existing wells. Potential impacts to groundwater for the No Action Alternative are based on the most current information available.

Alluvial Groundwater

Alluvial groundwater aquifers may vary in size, dry out, or develop in locations where they previously did not exist in response to variations in seasonal snowmelt and thunderstorm runoff and LANL NPDES-permitted discharges into the canyons (LANL 1994). Of all LANL operational factors that may affect shallow groundwater quality and quantity, variations in NPDES discharges are the most significant. The canyons that may have an overall increase in alluvial groundwater volumes as a direct result of increased NPDES outfall volumes are Los Alamos and Sandia Canyons. Quantification of alluvial groundwater volume changes is not possible due to the high degree of uncertainty in many parameters (e.g., snowmelt, rainfall, infiltration rates, evaporation rates, canyon dimensions, storage capacity of alluvium). However, increases or decreases in discharges should result in similar changes in groundwater volumes.

In terms of changes in specific outfalls, the outfalls at the TA–50 RLWFT and the TA–16 HELWTF are worthy of further discussion and are described below.

Technical Area–50 Radioactive Liquid Waste Treatment Facility. The TA–50 RLWTF, which discharges into Mortandad Canyon will have several improvements over the next 10 years. Although historic discharges have been in compliance with existing NPDES permit requirements agreed upon by the EPA and LANL, improvements in discharge quality are necessary to meet more stringent requirements coming into effect over the next several years. Improvements in treatment technology (ultrafiltration/reverse osmosis) should allow compliance with the DOE-DCGs for the public for radionuclides by early 1999. Compliance for nitrate to within the new groundwater discharge limits established by NMED will be operational by mid 1999. Tritium activity in the discharge from the RLWTF will not be affected by the improved treatment technologies (section 5.2.3.1).

LANL projections for discharges from the RLWTF into Mortandad Canyon under the No Action Alternative are 6.6 million gallons (25 million liters) per year, as compared to the RLWTF index volume of 5.5 million gallons (21 million liters) per year. This flow rate is similar to that experienced in previous years, and no substantial changes to the volume of groundwater stored in the alluvium are anticipated.

Technical Area–16 S-Site Springs. The new HELWTF will be fully operational in mid 1998, resulting in a reduction in NPDES discharges of approximately 16 million gallons (61 million liters) per year into Canyon de Valle, a tributary to Water Canyon. This may reduce or eliminate flow in springs at S-Site.

The water quality discharging from the S-Site springs, some of which may have been contaminated by high explosives compounds and VOCs from past NPDES discharges, will likely improve due to the new HELWTF. The new plant will reduce the amount of water used in high explosives processing by 99 percent, and solvents will be extracted prior to high explosives processing rather than being discharged into Canyon de Valle.

Perched Groundwater

The Water Canyon Gallery has not been used as a source of potable water since 1991 and has not been used for boiler makeup water at TA–16 since 1994. LANL does not plan to use Water Canyon Gallery as a potable or industrial source over the next 10 years under any of the alternatives. The Water Canyon Gallery is on USFS land, and it is expected that it would only be used for wildlife watering.

Evaluations of impacts to intermediate perched groundwater quantity and quality resulting from operation changes under the alternatives are qualitative, because groundwater flow and contaminant pathways to the intermediate perched groundwater bodies are not well characterized nor understood. Chemical radionuclides in the vicinity of the outfalls with increased flow under the No Action Alternative are minimal. The type of outfalls that have increased flow are primarily from cooling tower blowdown, evaporative coolers, etc. The impacts to perched groundwater should be negligible. However, it is possible that NPDES discharges to Los Alamos and Sandia Canyons contribute to recharge to the intermediate perched groundwater and contaminant transport beneath Los Alamos and Sandia Canyons. The increase NPDES discharges to Los Alamos and Sandia Canyons may contribute to the transport of contaminants off the site. Environmental monitoring of the perched groundwater will continue, and as new wells are installed the information obtained will be used to better understand the effects of LANL on groundwater quality.

Main Aquifer Water Quality

As mentioned at the beginning of this section, new wells are being installed to better understand recharge to the main aquifer. Extremely low levels of tritium have been detected in the main aquifer (chapter 4, sections 4.3.2.2 and 4.3.2.3) and this trend will most likely continue under the No Action Alternative. Environmental monitoring of the main aquifer will continue, and as new wells are installed the information will be used to better understand the effects of LANL on groundwater quality in the main aquifer. The impacts resulting from the increased NPDES outfall flows, under the No Action Alternative, to the main aquifer water quality should be negligible.

Public Water Supply

DOE has groundwater rights to about 1,805 million gallons (6,830 million liters) per year from the main aquifer. These rights provide water, including drinking water, to LANL, Los Alamos County, and the NPS (for BNM). A conservative projection of maximum LANL water use under the No Action Alternative is 712 million gallons (2,695 million liters) per year. Los Alamos County and the NPS did not provide projections, but in 1994 the county used about 958 million gallons (3,626 million liters) from this water right, and the NPS used about 5 millions gallons

(19 million liters). Based on this information, it is expected that the water requirements of this community can be met within the existing water rights from the main aquifer.

For the purposes of modeling drawdown of the main aquifer, water usage was projected annually. The total water usage from DOE water rights was projected to average 1,593 million gallons (6,030 million liters) per year under the No Action Alternative, with a maximum annual use of 1,620 million gallons (6,130 million liters) and a minimum annual use of 1,534 million gallons (5,880 million liters).

The USGS MODFLOW model for north-central New Mexico (Frenzel 1995) was used to predict water level changes at the top of the main aquifer for the alternatives. The model includes DOE supply wells, wells for the city of Santa Fe public supply system, discharges from the Santa Fe sewage treatment plant, and 200 private and industrial wells in Santa Fe County. Details of the conceptual model, assumptions, uncertainties and limitations, and input parameters for the groundwater model are described in volume III, appendix A.

The model results reflect water level changes at the top of the main aquifer across the alternatives, given continued draw from the aquifer by DOE, Española, and Santa Fe. Table 5.2.3.1–3 shows predicted water level changes at the surface of the main aquifer during the period from 1997 through 2006 for the No Action Alternative. These changes are not all due to LANL operations; the changes for the on-site well fields and the Guaje well field are largely attributable to LANL operations and Los Alamos County. Although the water use modeled includes water use in Española and Santa Fe, the differences between the alternatives are due only to LANL operations. Springs in White Rock Canyon in the vicinity of the Buckman well field may actually increase in flow due to rising groundwater levels (from 0.1 to 3.8 feet [.03 to 1.2 meters]). The rising water levels result from the continuing recovery

TABLE 5.2.3.1–3.—*Maximum Water Level Changes at the Top of the Main Aquifer Under the No Action Alternative (1997 Through 2006)*

WATER LEVEL CHANGE IN FEET[a,b]	
AREA OF CONCERN ON SITE	
Pajarito Well Field	-13.2
Otowi Well Field (Well 0-4)	-12.9
AREA OF CONCERN OFF SITE	
DOE - Guaje Well Field	-8.7
Santa Fe Water Supply	
Buckman Well Field	+21.6
Santa Fe Well Field	-20.6
San Juan Chama Diversion	0.0
Springs	
White Rock Canyon Springs, Maximum Drop	0.0
White Rock Canyon Springs, Maximum Rise	+1.0
Other Springs (Sacred, Indian)	+3.8
San Ildefonso Pueblo Supply Wells	
West of Rio Grande:	
Household, Community Wells	+0.6
Los Alamos Well Field	+3.8
East of Rio Grande:	
Household, Community Wells	0.0

[a] Negative value (-) indicates water level drop; positive value (+) indicates water level rise.

[b] Also, the water level changes projected by the regional MODFLOW model represent average changes over a whole grid-cell (i.e., a square that is a mile on a side). They are, for the most part, not predictive of the water level changes at any single point within the cell (for example, a supply well). Pumping wells have characteristic “cones of depression” where the water surface reflects an inverted cone, and water levels at the well may be quite difference from levels even a few ten’s of feet away. Whether any individual well would exhibit water level changes consistent with the predicted grid-cell average change is a function of, for example, its location within the grid-cell; proximity to other pumped wells; and the individual well operation, construction, and hydraulics. Hence, the water level changes predicted by the model can only be considered qualitatively and not be considered as finite changes.

in the vicinity of the Los Alamos well field, which was shut down in 1992, and recovery in the vicinity of Santa Fe's Buckman well field, which will be shut down in 1999. Operations of both well fields are independent of the alternatives and significantly affect water levels in the main aquifer in the vicinity of the Rio Grande. Therefore, the water level changes and the resulting impacts to White Rock Canyon Springs are identical across the alternatives.

In comparison to the thicknesses of the eight model layers (total = 5,600 feet [1,707 meters]), the maximum drawdown predicted for DOE well fields represents a reduction of main aquifer saturated thickness of less than 1 percent. Water use projections indicate that the total volume of water to be withdrawn from DOE well fields from 1997 through 2006 is less than 0.1 percent of the main aquifer volume (22 trillion gallons [83 trillion liters]) of water in storage beneath the Pajarito Plateau. In summary, the drawdowns in DOE well fields are minimal relative to the total thickness of the main aquifer, and the volume of water to be used over the period from 1997 through 2006 is negligible relative to the volume of water in storage.

5.2.4 Air Quality

This section describes the estimated air quality impacts from LANL operations under the No Action Alternative. The discussion includes estimated impacts from nonradiological and radiological air emissions. Additional detail and information on the material in this section is included in volume III, appendix B.

5.2.4.1 *Nonradiological Air Quality Impacts*

The results of the Expanded Operations Alternative analysis of criteria pollutants demonstrate that the highest estimated concentration of each pollutant would be below the standards established to protect human health with an ample margin of safety. For criteria pollutants, the No Action Alternative emission rates are lower than those under the Expanded Operations Alternative. Therefore, criteria pollutant emissions under the No Action Alternative are also expected to be below these levels.

For toxic air pollutants, the bounding analyses (based on the emission rates under the Expanded Operations Alternative) indicate that the only pollutant emissions with the potential to exceed the guideline values under any SWEIS alternative are the emissions from High Explosives Firing Site (HEFS) operations and the additive risk from all the pollutants from all TAs on receptor sites located near the Los Alamos Medical Center. Emissions from the firing site operations under the No Action Alternative are projected to be one-third the emissions projected under the Expanded Operations Alternative. Linear extrapolation of pollutant concentrations based on this difference in emissions results in concentrations that are below the GVs. Therefore, the pollutants released from LANL firing site operations under the No Action Alternative are not expected to cause air quality impacts that would affect human health.

As discussed in section 5.3.4.1, the combined cancer risk due to all carcinogenic pollutants from all TAs is dominated by the chloroform emissions from the HRL. Under the No Action Alternative, chloroform use is projected to be similar to current usage (about 55 pounds per year [17 liters per year], or about 15 percent less than projected under the Expanded Operations Alternative). Assuming that 100 percent of the chloroform used is emitted (and assuming no change in other carcinogenic pollutant emissions as compared to those under the Expanded Operations Alternative), the estimated combined incremental cancer risk at the Los Alamos Medical Center is slightly above the guideline value of 1.0×10^{-6}. Because it is known that less than 100 percent of the chloroform used is emitted (as much as 25 pounds per year [8 liters per year] are disposed of as liquid chemical waste), the incremental cancer risk under the No Action Alternative would be less than the GV.

Based on the information discussed above, pollutants released under the No Action Alternative are not expected to cause air quality impacts that would affect human health and the environment.

5.2.4.2 *Radiological Air Quality Impacts*

Facility-Specific Maximally Exposed Individual

Table 5.2.4.2–1 shows the distance and direction and estimated dose to each FS MEI under the No Action Alternative. The highest FS MEI dose under this alternative was calculated to be 3.11 millirem per year, which is 31.1 percent of the regulatory limit (which is 10 millirem per year for the air pathway).

LANL Maximally Exposed Individual

The location of the highest dose from all facility emissions was 2,625 feet (approximately

TABLE 5.2.4.2–1.—*Facility-Specific Maximally Exposed Individual Information—No Action Alternative*

FACILITY	MEI DISTANCE feet (meters)	DIRECTION	DOSE[a] (mrem/yr)
TA–3–29 (CMR Building)	3,576 (1,090)	North	0.43
TA–3–66 (Sigma Building)	3,560 (1,085)	North	0.43
TA–3–102 (Machine Shops)	3,379 (1,030)	North	0.34
TA–11 (High Explosive Testing)	4,298 (1,310)	South	0.31
TA–15/36 (Firing Sites)	7,415 (2,260)	Northeast	2.26
TA–16 (WETF)	2,886 (880)	South-Southeast	0.31
TA–18 (Pajarito Site: LACEF)	2,821 (860)	Northeast	1.73
TA–21 (TSTA and TSFF)	1,050 (320)	North	1.41
TA–48 (Radiochemistry Laboratory)	2,920 (890)	North-Northeast	1.66
TA–53 (LANSCE)[b]	2,625 (800)	North-Northeast	3.11
TA–54 (Area G)[c]	1,197 (365)	Northeast - LANL Boundary	0.75
	5,331 (1,625)	Southeast - White Rock	0.43
TA–55 (Plutonium Facility)	3,691 (1,125)	North	1.66

[a] For each FS MEI, the total dose was calculated by adding the contributions from each modeled facility. Note that an MEI is assumed not to leave or to take protective measures.
[b] This is also the location of the LANL MEI. Five specific sources were modeled from TA–53. These include the TA–53 ES–2, ES–3, IPF, LEDA and combined diffuse emissions.
[c] Two FS MEI locations were considered for TA–54, because Area G borders San Ildefonso Pueblo land. The first is an MEI location at the LANL boundary, 1,197 feet (365 meters) northeast of Area G. No person from the Pueblo currently is known to live along this boundary. The second is an actual MEI location in the town of White Rock, approximately 5,331 feet (1,625 meters) southeast of Area G.

800 meters) north-northeast of LANSCE. This location defines the LANL MEI. The dose to this location from all facility emissions was calculated to be 3.11 millirem per year.

Population Dose

The collective dose to the population living within a 50-mile (80-kilometer) radius from LANL was calculated for emissions from all facilities and found to be 13.59 person-rem per year. The values reported for population doses for this alternative, as well as the other alternatives, are higher than has been reported in the recent annual environmental reports. It is important to recognize that the alternatives analyzed represent increased operations when compared to recent history. (For example, LANSCE and firing site operations currently planned are higher than achieved in recent years.) The material throughput at the different facilities under the various alternatives is presented in chapter 3 (section 3.6).

An examination of the detailed data contained in appendix B (volume III) reveals that most (52 percent) of the collective population dose comes from emissions from the TA–15/36 firing sites. This is in contrast to the dose delivered to the LANL MEI, most of whose dose comes from LANSCE. The reason is that the firing site emits long-lived uranium isotopes; whereas, the LANSCE facility emits short-lived air activation products that decay quickly. Collectively, diffuse emissions (including those from TA–15/36) account for 52.8 percent of the population dose under the No Action Alternative.

Isodose Maps

Isodose maps present the estimated doses within a 50-mile (80-kilometer) radius from LANL. These isodose maps are shown in Figures 5.2.4.2–1 and 5.2.4.2–2. The isodose lines represent the summation of all modeled emissions and their subsequent estimated annual doses. Due to the summation, the resulting lines do not necessarily match individual wind rose patterns. This is due to the multiple facilities that contribute to the summed doses, as well as the distances displayed in the figure. To determine the dose at a specific location, individuals need only find the location on these maps and interpolate between the isopleths.

5.2.5 Ecological Resources, Biodiversity, and Ecological Risk

This section discusses potential impacts to ecological resources (including wetlands), biodiversity, and ecological risk. Under the No Action Alternative, LANL operations would continue at their currently planned level. Construction activities would be limited largely to those required to maintain facilities for currently authorized activities. Because of this continuation of current operational levels, there would not be any appreciable change to landscape features.

Ecological Resources and Biodiversity

A continuation of the current LANL facility operation and planned actions as reflected in DOE management plans that implement currently assigned programs would enhance present biological resources (including protected and sensitive species), ecological processes, and biodiversity. This enhancement would result largely from ongoing actions and plans whose objectives are to eliminate or reduce pollutants that could potentially pose a risk to biological systems, and biological management plans that would be incorporated into existing LANL operations to protect and enhance its biological resources. Key actions and plans and their objectives are briefly stated as follows:

- *Environmental Restoration Project.* Objectives are to remediate potentially contaminated sites resulting from historic

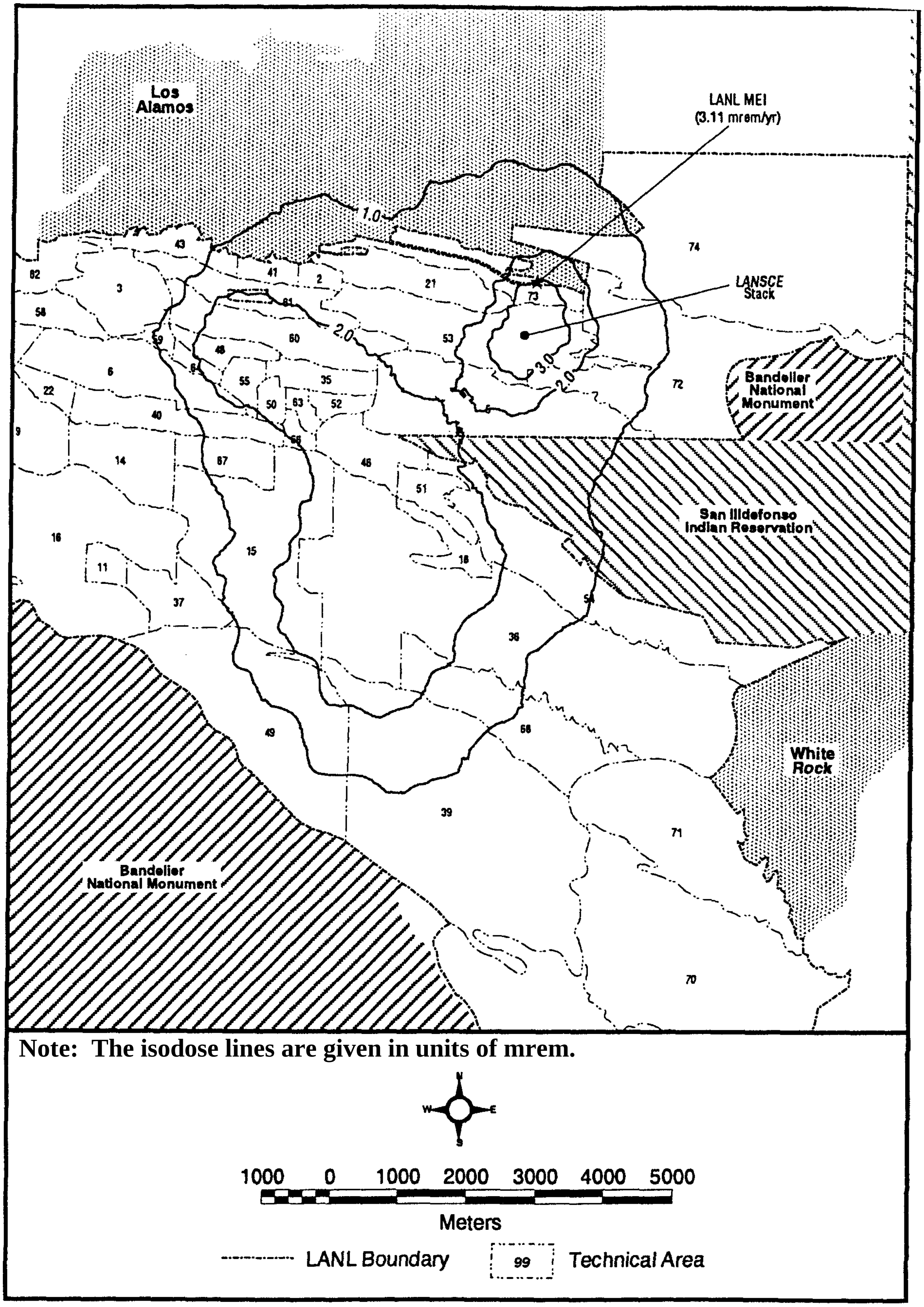


FIGURE 5.2.4.2–1.—*Isodose Map Showing Doses Greater Than 1 Millirem per Year for the No Action Alternative.*

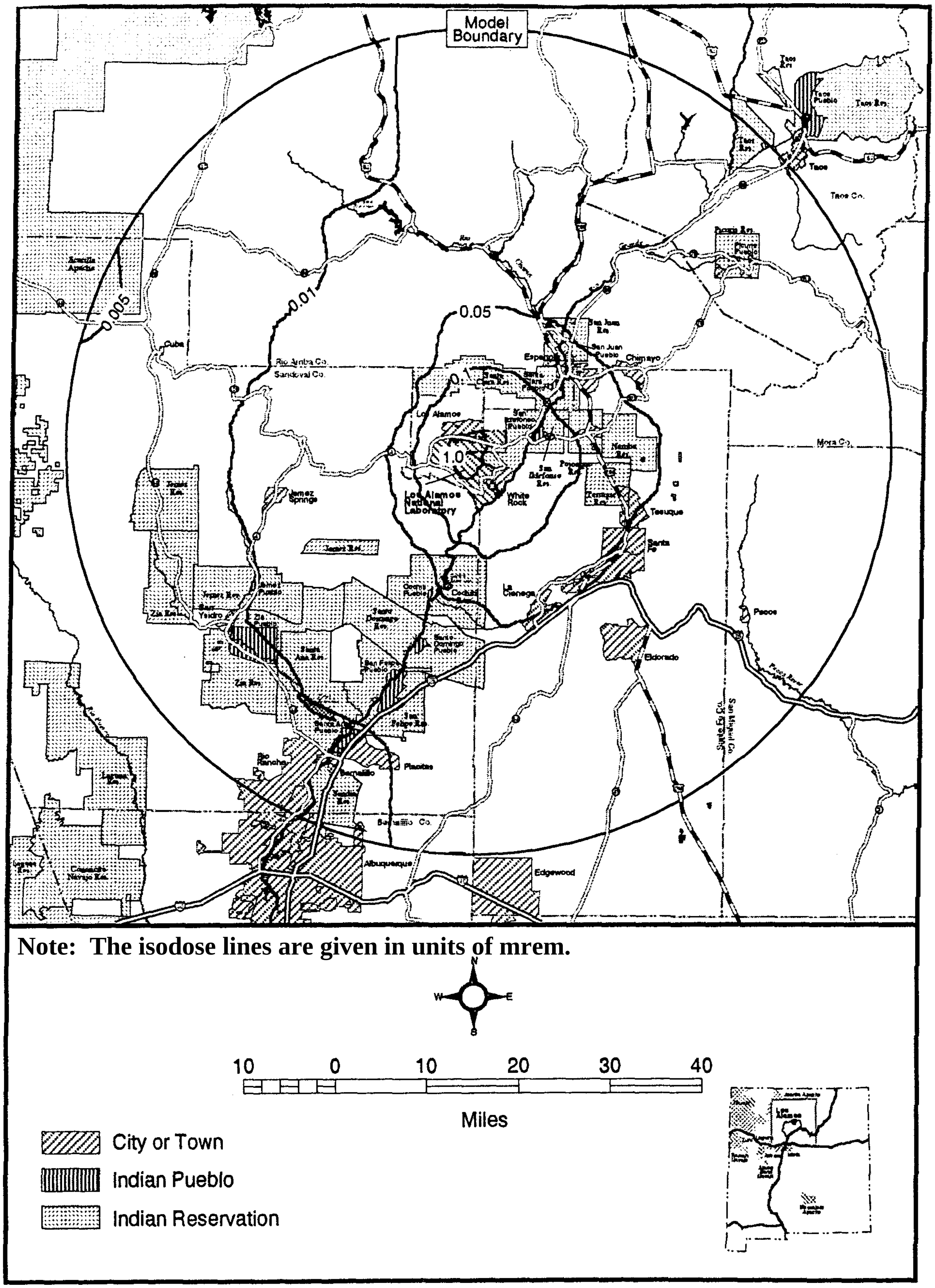


FIGURE 5.2.4.2–2.—*Isodose Map Showing Doses Less Than 1 Millirem per Year for the No Action Alternative.*

treatment, storage, and disposal practices at LANL; meet the environmental clean-up requirements of the *Resource Conservation and Recovery Act* (RCRA) (42 U.S.C. §6901); and decontaminate and decommission facilities previously contaminated by radioactive and hazardous materials, such restorations can result in ecological disturbance during individual actions.

- *Waste Stream Characterization Program and Outfall Reduction Program.* Objectives are to reduce the possibility that LANL activities could produce wastewater discharges into the ecosystem.
- *Construction of a New High Explosives Wastewater Treatment Facility.* Objectives are to further improve outfall effluent quality by reducing the amount of water used in high explosives (HE) processing, eliminating non-HE industrial wastewater, preventing contamination of stormwater, and treating all HE-contaminated wastewater.
- *Completion of New Wastewater Treatment System at the TA–50 RWLTF.* Objective is to reduce radionuclide and nitrate concentrations in the treatment plant effluent.
- *Threatened and Endangered Species Habitat Management Plan.* Objectives are to identify the combined effects of many LANL projects on threatened, endangered, or sensitive species; provide long-range planning information for all future LANL projects; and develop long-range management measures to protect habitat for these species (see chapter 4, section 4.5.1.6).
- *Initiate Natural Resources Management Plan.* Objectives will be to determine conditions and to recommend management measures that will restore, sustain, and enhance the biological quality and ecosystem integrity at LANL within the context of a dynamic Pajarito Plateau ecosystem (see section 4.5.1.6).

In addition to these continuing actions and plans, studies are underway to make a more quantitative assessment of trophic level transport of radionuclides of interest. These assessments would refine measures being taken for protection of biological resources should any concerns arise.

These ongoing programs and planning actions would not only benefit resources on LANL but would contribute to a more regionalized management strategy, thereby improving the current fragmented and compartmentalized management by five or more agencies. A regionalized management strategy would significantly lessen the decline or loss of regional biological diversity resulting from anthropogenic disturbances (e.g., risk of catastrophic wildfire, erosion, elk overpopulation, and habitat loss and fragmentation). The roots of these environmental issues predate LANL, yet are common to (or sensitive to) all alternatives evaluated in the SWEIS. Their resolution is to be found through a philosophy of environmental stewardship, permanent interagency coordination, and development of a joint planning and management program.

The presence of LANL, with its highly restricted access and limited planned land disturbing activities, would continue to provide habitat and protection for a rich diversity of plants and animals, including an appreciable number of threatened, endangered, and other sensitive species. The presence of measures to protect threatened and endangered species (e.g., habitat protection, access and activity restrictions, and noise and light restrictions), combined with surveys and studies associated with the stated Threatened and Endangered Species Management Plan, would continue to protect and conserve these protected species.

Terrestrial and Wetland Habitat

Common to the No Action, Reduced Operations, and Greener Alternatives, is the absence of activities that would result in the loss of terrestrial habitat. Further, a reduction in the number of wetlands as a consequence of outfall reduction would reduce wetland habitat under all four SWEIS alternatives.

As demonstrated in Table 5.2.3.1–1 of section 5.2.3, Water Resources, there would be a reduction in the number of outfalls over the index period and an increase in the volume of effluent discharged by some remaining outfalls. This reduction includes many of the 27 outfalls proposed for closure and evaluated in the *Environmental Assessment for Effluent Reduction* (DOE 1996e), as well as several others that have been closed as part of LANL's Outfall Reduction Program. While it is possible that not all 27 closures discussed under effluent reduction may be realized, this is the planned reduction, as reflected in the *Environmental Assessment for Effluent Reduction*. Thus, the elimination of 27 outfalls is used as the bounding case for the purposes of this SWEIS. The number of outfalls remains constant across all four alternatives.

The elimination of industrial effluent from up to 27 outfalls could result in a decrease of approximately 8.6 acres (3.5 hectares) of wetlands. Most of these are linear riparian wetlands that vary in size from 0.001 acre (0.0004 hectares) to 4.4 acres (1.8 hectares). Many wetlands associated with outfalls have other water sources that have contributed to the establishment and maintenance of the wetlands. Consequently, some outfalls would continue to have the same plant species in about the same proportions as they do now. Other outfall wetlands would experience a moderate amount of replacement of vegetation with species that require less water. Still, many would undergo a more pronounced change in character, with a high degree of replacement by other species requiring less water. The reduction would result in a localized die-off of aquatic invertebrates and possibly some small numbers of small mammals and amphibians with limited ranges. These species would be replaced with those characteristic of drier habitats. There would be very localized decrease in biodiversity. Cessation of some watering sources may cause some localized displacement of large- and medium-sized animals. However, because larger mammals can travel to other available water sources, daily and seasonal movement may only change slightly.

The possible loss of up to 8.6 acres (3.5 hectares) of wetlands associated with the elimination of industrial effluent from up to 27 outfalls, combined with about 5 acres (2 hectares) from past and planned LANL actions could result in the cumulative loss of about 13.6 acres (5.5 hectares). Because there are about 161 wetlands covering about 50 acres (20 hectares) within LANL boundaries, about 36.4 acres (14.7 hectares) or 73 percent of all wetlands would still remain available for wildlife use. The cumulative effect of these actions on large mammals, such as deer and elk, would be changes in animal distribution and patterns of movement. As industrial effluent from outfalls continues to be eliminated over the next 3 to 5 years, these large mammals would adapt and utilize other available water sources, both natural and human caused. Any measurable effects of a continuing reduction in outfalls could be a local reduction in elk density at LANL, but this would not likely alter the overall pattern of elk movement, use, and numbers in the Jemez Mountains.

An increase in the quantity of discharge from remaining outfalls under the No Action Alternative, specifically in Sandia and Los Alamos Canyons, is within historic fluctuations, which are governed by project types and operational levels. This increase would not be expected to significantly affect channel morphology nor associated biological features. An increase in flow holds the potential for the expansion of existing wetlands. However, because of the narrow canyon floors and steep canyon sides, this potential may be only marginal. There could be a small increase in opportunity for wildlife watering.

The biological and ecological consequences of a wildfire on LANL are potentially significant. LANL and surrounding lands are generally forested areas with high fuel loading. Although fire is a natural part of biological systems, anthropogenic influences such as grazing, logging, and fire suppression have produced conditions that can have pronouced adverse effects on forest ecosystems. Natural high-frequency, low-intensity fire regimes have been replaced with low-frequency, high-intensity fires that consume a higher percentage of vegetation. As reflected in other nearby areas that have experienced severe wildfires in the past (e.g., the Water Canyon, La Mesa, Dome, and Oso Complex fires), the potential for wildfires encroaching on LANL exists. Biological and ecological consequences of a severe wildfire involving LANL would result from loss of habitat soil erosion, sedimentation, and increased risk from contaminants. The loss of forest or woodland habitat would result in a temporary loss of habitat for a broad spectrum of animals. As vegetation is re-established, an altered community of animal species would follow, its composition changing with the evolution of the plant community. The pattern of burned vegetation will play a significant role in renewed wildlife use. Early plant communities of grasses and herbaceous growth can have a high biomass and species diversity, as exhibited by nearby areas affected by recent wildfires. This expansion of grass and herbaceous growth could provide additional forage for the large elk population in and around LANL and contribute to existing management concerns.

Impacts to threatened and endangered species (e.g., the Mexican spotted owl) from a wildfire would depend on several factors such as the burn pattern, the time of day that the burn occurs, the type of fire, topography, and if nesting is occurring. Threatened and endangered species have remained or returned to nearby areas that have experienced recent burns. Some species, such as the peregrine falcon, could benefit through improved foraging habitat. Perhaps the most significant impact to threatened and endangered species that could be precipitated by a wildfire is the general disturbance caused by the fire-fighting effort itself (e.g., fire-fighting crews, aircraft, and vehicular traffic).

Increased runoff resulting from the burning of vegetation cover would result in a commensurate increase in water channel scouring, enlargement, and headcutting. This process and any accompanying sedimentation would have the potential to degrade or remove the limited riparian vegetation on LANL. Wetlands associated with water courses could also be affected, and perhaps several would be removed for a period of time because of changes in channel morphology. With the degradation of riparian vegetation and wetlands would be an associated reduction or loss of habitat for a variety of invertebrates, small and large mammals, amphibians, reptiles, and a diversity of birds.

Any impact of legacy contaminants transported to downstream riverine and lake ecosystems is unknown, but there could potentially be an increase in ecological risk. A more extensive discussion of the biological effects of a wildfire at LANL can be found in volume III, appendix G, Accident Analysis.

Ecological Risk

As stated (in sections 5.2.2.3, 5.2.3.1, 5.2.4.1, and 5.2.4.2), ongoing operations under the No Action Alternative have little potential to contribute substantially to soil, water, and air contamination. Contaminants such as DU, beryllium, lead, copper, and others are produced at firing sites and are of potential concern for conveyance in sediments. However, the estimated soil concentrations from future air concentrations at the firing sites would be at orders of magnitude less than those in the average background or maximum legacy contamination. Also, as more remedial action projects are completed, the overall levels of soil and water contamination would be reduced.

Because of the absence of increased levels of contamination, there would not be an incremental change in ecological risk. There are no projected differences in firing site emissions among the No Action, Reduced Operations, and Greener Alternatives.

5.2.6 Human Health

The consequences of implementing the No Action Alternative on public health and worker health are presented below. The methodologies used to evaluate consequences are summarized in section 5.1.6 and detailed in appendix D, section D.2. Detailed discussions of the results are presented in appendix D, sections D.3 and D.4. There is a discussion of the terminology used in the human health evaluation presented in appendix D, section D.1. "Risk," as used in the Human Health Consequences section, refers to the probability of toxic or cancer mortality consequences under the specific exposure scenarios analyzed.

5.2.6.1 *Public Health*

The consequences of continued operations of LANL on public health under the No Action Alternative are presented below. The evaluation is presented in four topics: (1) the consequences of external radiation and airborne radioactivity from LANL operations; (2) consequences of chemical emissions from LANL facilities; (3) consequences of ingestion of local foodstuffs, water, and incidental intake of soils and sediments to residents, to recreational users of the canyon lands on or near LANL, and to special receptors (traditional Native American and Hispanic life styles) and; (4) a summary of consequences to the public along transportation routes (summarized from the analyses in section 5.2.10). (Risks from accidents are discussed in section 5.2.1.1.)

Regional Consequences of Airborne Radioactivity Inhalation and Immersion

As shown in section 5.2.4.2, the doses from airborne radioactive emissions from LANL were estimated to a 50-mile (80-kilometer) radius from LANSCE (the central point assumed for LANL emissions). Both facility-specific and site-wide doses were calculated (volume III, appendix B).

The location of the highest potential dose from all emissions, called the LANL MEI, was estimated to be 2,625 feet (approximately 800 meters) north-northeast of LANSCE (TA–53). This location is within the LANL reservation, and the dose to the MEI at this location is estimated to be 3.11 millirem per year, which is 0.9 percent of the backgound dose (about 360 millirem per year). This location borders the Los Alamos townsite and is a conservative estimate for a MEI from LANL-wide emissions.

Table 5.2.6.1–1 summarizes the LANL MEI dose and presents the corresponding risk of excess LCF to the MEI. These risks are presented on a lifetime basis, assuming that the LANL MEI received the estimated dose of 3.11 millirem each year for a 72-year life. The excess LCF risk was estimated to be 0.0001 over a lifetime.

The isodose maps showing both the estimated dose near LANL and to a 50-mile (80-kilometer) radius of LANL are provided as Figures 5.2.4.2–1 and 5.2.4.2–2. The collective dose to the population that lives within the 50-mile (80-kilometer) radius is given in Table 5.2.6.1–1, estimated to be 13.6 person-rem per year of operation with an estimated lifetime excess LCF risk of about 0.0068 per year of operation. (As summarized in appendix D, the lifetime risk of dying from cancer in the U.S. is more than 23 percent for men and more than 20 percent for women. Based on this rate, approximately 40,000 people

TABLE 5.2.6.1–1.—*Estimated Public Health Consequences for LANL Maximally Exposed Individual and the Population Within 50-Mile (80-Kilometer) Radius of LANL for the No Action Alternative*

PARAMETER	LANL MEI	50-MILE RADIUS POPULATION
Dose	3.11 millirem per year	13.59 person-rem per year
Excess LCF	0.00011 per lifetime (72 year)	0.0068 per year of operation

within the 50-mile [80-kilometer] radius of LANL would be expected to die from cancer.)

A level of 1 millirem per year is a benchmark used as a screen for negligible individual consequences (NCRP 1993). In the No Action Alternative, there are six facilities with FS MEIs estimated to receive at least a 1 millirem per year dose, based on contributions from all facilities to these locations (volume III, appendix B):

- LANSCE, 3.11 millirem per year to the FS MEI
- HE Testing Sites (TA–15 and TA–36), 2.26 millirem
- Pajarito Site (TA–18), 1.73 millirem
- Radiochemistry Laboratory (TA–48), 1.66 millirem
- Plutonium Facility (TA–55), 1.66 millirem
- Tritium System Test Assembly (TSTA) and Tritium Science and Fabrication Facility (TSFF) (TA–21), 1.41 millirem

External Radiation: Two Special Cases

One contribution to public dose results from jogging or hiking the access road north of TA–21 and is attributable to cesium-137 known to be on the ground within the TA in Area F (LANL 1997d). The MEI dose is not expected to change from that currently estimated as an EDE of 2.9 millirem per year (chapter 4, section 4.6). For this MEI, the excess LCF risk over a lifetime from that dose would be about 1.4×10^{-6} per year of operation, assuming that the MEI exposure was equivalent to about 24, 4-hour days per year, a very conservative estimate.

Another contribution to public dose would result from TA–18 “road-open” operations (that is, undertaken at TA–18 for which roads are not closed). About four exposures per year would be expected for the MEI (who is assumed to be passing TA–18 on Pajarito Road at the time of maximum radiation flux during an experiment) out of the 100 operations per year at TA–18. The maximum dose to the MEI per operational event was estimated 4.75 millirem. Assuming that a maximum of four events would contribute to the MEI, the annual projected MEI EDE dose would be 19 millirem per year. This would result in a lifetime excess LCF risk of about 9.5×10^{-6} per year of operation.

Nonionizing Radiation

The only uncontained nonionizing radiation source in use or planned for LANL is the microwave transmitter in TA–49. It is extremely unlikely that a member of the public would be exposed to this source. However, the consequence of a 1-second exposure at the shortest distance a person could get to the transmitter was examined (volume III, appendix D, section D.2.2.2). The consequence to a person exposed at 1,640 feet (500 meters) is negligible, elevating body temperature approximately 0.04°F (0.02°C) and not affecting biochemical processes.

Consequences of Airborne Chemical Emissions

For the nonradiological (chemical) air quality analysis, a screening was conducted for each TA within LANL to identify potential chemical emissions under normal operations of the four alternatives that would need to be assessed for public health consequences. In the analysis of the Expanded Operations Alternative (which had the greatest emissions out of the four alternatives), four TAs involved in HE testing were identified (TA–14, TA–15, TA–26, and TA–39) for public health consequence analysis for three specific chemicals (beryllium, lead, and DU). While these operations result in emissions of other chemicals as well (aluminum, copper, iron, tantalum, and tungsten), the health effects of these other emissions were not analyzed in detail because their toxicity reference doses and estimated concentrations in air are relatively low. The emissions of the three chemicals analyzed were evaluated for potential human health effects under each of the SWEIS alternatives. (Sections 5.1.4 and 5.2.4, and appendix B, section B.2.3, include additional information regarding nonradiological air emissions screening and analysis.)

Hazard indices (HIs) were calculated for two of the three metals evaluated quantitatively (lead and uranium). An HI equal to or above 1 is considered consequential from a human toxicity standpoint. For the No Action Alternative, the worst-case HI for lead did not exceed one in a million (10^{-6}). For DU, the worst-case HI did not exceed 1 in 100,000 (10^{-5}).

Beryllium has no established EPA reference concentration for inhalation from which to calculate the HI. Beryllium was evaluated as a carcinogen, however. The excess LCF rate for beryllium under the No Action Alternative was estimated to be less than 3.6 x 10^{-7} per year; that is, none.

Carcinogenic Risk from Air Emissions

The screening process described in volume III, appendix B, identified no individual carcinogenic chemical air emission that required analysis for public health consequences. For carcinogens, an estimate also was made of the combined lifetime incremental cancer risk due to all carcinogenic pollutants from all TAs (appendix B, attachment 6).

This was found to be less than 1 in 1 million for the No Action Alternative because projected emissions for this alternative are far less than those analyzed for the Expanded Operations Alternative (which was only slightly above the screening GV of 1 x 10^{-6}). Thus, it is expected that a negligible increase in incremental combined cancer risk will result from the No Action Alternative.

Consequences of Ingestion to Residents, Recreational Users, and Special Pathways Receptors

The risk to public health from ingestion of water, foodstuffs, and from incidental ingestion of soils and sediments was estimated from environmental surveillance data within and surrounding LANL. The risk of toxicity and carcinogenicity will continue to be dominated by existing concentrations of radionuclides and chemicals in environmental media due to naturally occurring materials, fallout and other anthropogenic sources affecting the region, and historical operations (including emissions/ effluents, and accidental spills and releases). In addition, the potential for short-term exposures to contaminated sites at LANL, identified in the LANL ER Project, was evaluated using the ER database from LANL (appendix D, section D.3.5, Tables D.3.5–5 and D.3.5–6).

The consequences of ingestion were estimated for hypothetical individuals based on five exposure scenarios (as discussed in 5.1.6). The consequences estimated are based on

95th percentile values of detected analytes for the periods of environmental surveillance data sets available for the 1990's. The estimates were also made using the worst-case (95th percentile) uptake rates for the specific food components.

The LANL-wide maximum hypothetical risk from ingestion is the non-Los Alamos County resident who is also a resident recreational user of LANL lands and is also subject to the exposures in the special pathways analyzed. This composite hypothetical risk was used to represent the LANL-wide MEI dose from ingestion because it contains the maximum number of potential pathways for ingestion risk.

Tables 5.2.6.1–2 and 5.2.6.1–3 summarize the total radiological annual ingestion dose and excess LCF to members of the public. Per Table 5.2.6.1–3, the total worst-case ingestion doses for the off-site resident of Los Alamos County and non-Los Alamos County resident are 0.011 and 0.017 rem per year, respectively. If this person is also a recreational user of the Los Alamos canyons, drinking canyon water and ingesting canyon sediments, the worst-case additional dose ranges up to 0.001 rem per year, according to the amount of time spent in the canyons (see footnote b in Table 5.2.6.1–3). If the individual has traditional Native American or Hispanic lifestyles, the values found in the final columns of the table should be used in place of the values in the first columns for off-site residents. Per the values in the final columns, these "special pathways receptors" can have worst-case 3.1 millirem per year additional dose. The associated excess LCF risks for the off-site residents are 8.6 x 10^{-6} per year of exposure and 9.1 x 10^{-7} per year of exposure for the individual who is also an avid recreational user. The worst-case doses are for a 95th percentile intake of the 95th percentile contamination level, referred to as the UCL. Ingestion pathway calculations included all radionuclides detected in the media. This includes natural background, weapons testing fallout, and previous releases. The actual contribution from continued operations at LANL is only a small fraction of this value. These values apply to the baseline and to all four alternatives. The data and analyses for these calculations are in appendix D, section D.3.3.

Estimates were made of the potential risk from metals exposure to public health using environmental surveillance data in the mid 1990's monitoring of metals in groundwater, surface water, soils and sediments, vegetables, fruit (Los Alamos County only) and fish (appendix D, section D.3.3 and associated tables). Table 5.2.6.1–4 identifies HI values of 1 for any of the MEIs, and excess LCF risks exceeding 10^{-6} to these MEIs via ingestion pathways.

Arsenic was identified as having an HI greater than 1 in groundwater within the water supplies of Los Alamos County and San Ildefonso Pueblo. Excess LCF risks are elevated also (Table 5.2.6.1–4). Elevated excess LCF risk from arsenic was estimated for worst-case consumption of incidental soils, sediments, surface water, and NPDES discharges by some residents and recreational users of LANL. While the risk associated with arsenic ingestion is greater than 10^{-6} per year in many pathways, the arsenic is not associated with LANL discharges. Arsenic is endemically present in the geology and soils and groundwaters and surface waters of the region in which New Mexico is located (volume III, appendix D, section D.3.4).

Beryllium has no HI for ingestion exceeding 1. However, the excess LCF rate estimated from worst-case ingestion of waters and soils is elevated (Table 5.2.6.1–4). While the risk associated with beryllium ingestion is greater than 10^{-6} in several pathways, the beryllium concentrations in waters, soils, and sediments are typical of those in background in the northern New Mexico region. Based on the environmental surveillance data from LANL, the portion of beryllium associated with LANL operations is not a significant contributor to

TABLE 5.2.6.1–2.—*Average Public Radiological Dose and Potential Consequences by Ingestion Pathways, All Alternatives* [f]

EXPOSURE PATHWAY	RECEPTOR[a]									
	OFF-SITE RESIDENT LOS ALAMOS COUNTY		OFF-SITE RESIDENT NON-LOS ALAMOS COUNTY		NONRESIDENT RECREATIONAL USER[b]		RESIDENT RECREATIONAL USER[b]		SPECIAL PATHWAYS RECEPTORS[c]	
	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr
Produce										
• Fruit	0.00064	3.2×10^{-7}	0.00046	2.3×10^{-7}	--	--	--	--	--	--
• Vegetables	0.00098	4.9×10^{-7}	0.0013	6.7×10^{-7}						
Meat (Cattle: Free Ranging Steer)	--	--	0.00027	1.4×10^{-7}	--	--	--	--	--	--
Milk	0.000073	3.7×10^{-8}	0.00005	2.5×10^{-8}	--	--	--	--	--	--
Fish	--	--	0.000054	2.7×10^{-8}	--	--	--	--	0.00019	9.4×10^{-8}
Honey	7.4×10^{-7}	3.7×10^{-10}	1.3×10^{-8}	6.3×10^{-12}	--	--	--	--	--	--
Elk	0.000077[d]	3.9×10^{-8}	0.00005[d]	2.6×10^{-8}	--	--	--	--	0.000034[e]	1.7×10^{-8}
Deer	0.000018	9.0×10^{-9}	0.00038	1.9×10^{-7}	--	--	--	--	--	--
Pinyon Nuts	--	--	0.000016	7.7×10^{-9}	--	--	--	--	0.00013	6.5×10^{-8}
Indian Tea (Cota)	--	--	--	--	--	--	--	--	0.00075	3.8×10^{-7}
Groundwater	0.0014	7.2×10^{-7}	0.0042	2.1×10^{-6}	--	--	--	--	--	--
Surface Water										
• Creeks	--	--	--	--	0.00017	8.6×10^{-8}	0.00046	2.3×10^{-7}	--	--
• NPDES Discharge					0.000022	1.1×10^{-8}	0.000059	3.0×10^{-8}		
Soils	0.000078	3.9×10^{-8}	0.000078	3.9×10^{-8}	1.2×10^{-6}	5.9×10^{-10}	3.1×10^{-6}	1.6×10^{-9}	--	--
Sediments	0.00065	3.3×10^{-7}	0.00065	3.3×10^{-7}	0.000016	8.3×10^{-9}	0.000044	2.2×10^{-8}	--	--
Sum Ingestion Dose/Risk	0.0039	2.0×10^{-6}	0.0075	3.8×10^{-6}	0.00021	1.0×10^{-7}	0.00057	2.8×10^{-7}		

TABLE 5.2.6.1–2.—*Average Public Radiological Dose and Potential Consequences by Ingestion Pathways, All Alternatives*[f] -Continued

[a] Receptor is a hypothetical person who has an average (50^{th} percentile) intake of the 95^{th} UCL concentration in every medium.
[b] The nonresident recreational user lives in Los Alamos County or a neighboring county, and is in the Los Alamos canyons 12 visits per year for 6 hours per visit. The resident recreational user lives in Los Alamos County or a neighboring county, and is in the Los Alamos canyons 24 visits per year of 8 hours per visit.
[c] Special pathways receptors are those with traditional Native American or Hispanic lifestyles. See text.
[d] Elk muscle.
[e] Elk heart and liver.
[f] Because almost all public ingestion is from naturally occurring radionuclides, weapons testing fallout, and contamination from past operations, the ingestion dose is not affected by the alternatives. See section 5.1.6.

TABLE 5.2.6.1–3.—*Worst-Case Public Radiological Dose and Potential Consequences by Ingestion Pathways, All Alternatives* [f]

EXPOSURE PATHWAY	RECEPTOR[a]									
	OFF-SITE RESIDENT LOS ALAMOS COUNTY		OFF-SITE RESIDENT NON-LOS ALAMOS COUNTY		NONRESIDENT RECREATIONAL USER[b]		RESIDENT RECREATIONAL USER[b]		SPECIAL PATHWAYS RECEPTORS[c]	
	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr	DOSE (rem/yr)	EXCESS LCF/yr
Produce										
• Fruit	0.0026	1.3×10^{-6}	0.0016	8.2×10^{-7}	--	--	--	--	--	--
• Vegetables	0.0027	1.3×10^{-6}	0.004	2.0×10^{-6}						
Meat (Cattle: Free Ranging Steer)	--	--	0.00067	3.4×10^{-7}	--	--	--	--	--	--
Milk	0.0002	9.8×10^{-8}	0.00014	6.8×10^{-8}	--	--	--	--	--	--
Fish	--	--	0.00017	8.5×10^{-8}	--	--	--	--	0.00046	2.3×10^{-7}
Honey	2.6×10^{-6}	1.3×10^{-9}	4.5×10^{-8}	2.2×10^{-11}	--	--	--	--	--	--
Elk	0.00019[d]	9.4×10^{-8}	0.00013[d]	6.4×10^{-8}	--	--	--	--	0.000034[e]	1.7×10^{-8}
Deer	0.000044	2.2×10^{-8}	0.00091	4.5×10^{-7}	--	--	--	--	--	--
Pinyon Nuts	--	--	0.000016	7.7×10^{-9}	--	--	--	--	0.00013	6.5×10^{-8}
Indian Tea (Cota)	--	--	--	--	--	--	--	--	0.0026	1.3×10^{-6}
Groundwater	0.0023	1.2×10^{-6}	0.0067	3.4×10^{-6}	--	--	--	--	--	--
Surface Water										
• Creeks	--	--	--	--	0.00028	1.4×10^{-7}	0.00074	3.7×10^{-7}	--	--
• NPDES Discharge					0.000036	1.8×10^{-8}	0.000096	4.8×10^{-8}		
Soils	0.00031	1.6×10^{-7}	0.00031	1.6×10^{-7}	4.7×10^{-6}	2.4×10^{-9}	0.000012	6.3×10^{-9}	--	--
Sediments	0.0026	1.3×10^{-6}	0.0026	1.3×10^{-6}	0.000066	3.3×10^{-8}	0.00018	8.8×10^{-8}	--	--
Sum Ingestion Dose/Risk	0.011	5.5×10^{-6}	0.017	8.6×10^{-6}	0.00039	1.9×10^{-7}	0.0010	5.1×10^{-7}		

TABLE 5.2.6.1–3.—*Worst-Case Public Radiological Dose and Potential Consequences by Ingestion Pathways, All Alternatives*[f] -Continued

[a] Receptor is a hypothetical person who has a worst-case (95^{th} percentile) intake of the 95^{th} UCL concentration in every medium.
[b] The nonresident recreational user lives in Los Alamos County or a neighboring county, and is in the Los Alamos canyons 12 visits per year for about 6 hours per visit. The resident recreational user lives in Los Alamos County or a neighboring county, and is in the Los Alamos canyons 24 visits per year of 8 hours per visit.
[c] Special pathways receptors are those with traditional Native American or Hispanic lifestyles. See text.
[d] Elk muscle.
[e] Elk heart and liver.
[f] Because almost all public ingestion is from naturally occurring radionuclides, weapons testing fallout, and contamination from past operations, the ingestion dose is not affected by the alternatives. See section 5.1.6.

TABLE 5.2.6.1–4.—*Metals Exposure and Risk via Ingestion Pathways and Hypothetical Receptors Used to Evaluate Potential Public Health Consequence, All Alternatives*

EXPOSURE PATHWAY		RECEPTOR									
		OFF-SITE RESIDENT LOS ALAMOS COUNTY		OFF-SITE RESIDENT NON-LOS ALAMOS COUNTY		NON-RESIDENT RECREATIONAL USER		RESIDENT RECREATIONAL USER		SPECIAL PATHWAYS RECEPTORS[c]	
	CHEMICAL	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr
Produce											
• Fruit[a]	Arsenic	< 1	0.000084	NA	NA	NA	NA	NA	NA	NA[c]	NA[c]
	Beryllium	< 1	0.00014								
	Lead	1.5	b								
• Vegetables	Arsenic	2.2	0.00099								
	Beryllium	< 1	0.00023								
	Lead	18	b								
Fish	Arsenic			< 1	0.00033					3.2	0.0014
	Beryllium	NA	NA	< 1	0.0002	NA	NA	NA	NA	< 1	0.013
	Lead			< 1	b					6.8	b
	Cadmium			< 1	$< 10^{-6}$					1.4	1.3×10^{-6}
Groundwater	Arsenic	4.5	0.002	2.5	0. 0011	NA		NA		NA[c]	
	Beryllium	< 1	0.00036	< 1	0.003						
Surface Water	Arsenic	NA	NA	NA	NA	< 1	1.9×10^{-6}	< 1	5.0×10^{-6}	NA[c]	NA[c]
	Beryllium					< 1	0.000045	< 1	0.00012		
NPDES Discharge	Arsenic					< 1	4.8×10^{-6}	< 1	0.000013		
Soils	Arsenic	< 1	0.000033	< 1	0.000033	< 1	$< 10^{-6}$	< 1	$< 10^{-6}$	NA[c]	NA[c]
	Beryllium	< 1	0.000024	< 1	0.000024	< 1	$< 10^{-6}$	< 1	$< 10^{-6}$		

TABLE 5.2.6.1–4.—*Metals Exposure and Risk via Ingestion Pathways and Hypothetical Receptors Used to Evaluate Potential Public Health Consequence, All Alternatives*-Continued

EXPOSURE PATHWAY		RECEPTOR									
		OFF-SITE RESIDENT LOS ALAMOS COUNTY		OFF-SITE RESIDENT NON-LOS ALAMOS COUNTY		NON-RESIDENT RECREATIONAL USER		RESIDENT RECREATIONAL USER		SPECIAL PATHWAYS RECEPTORS[c]	
	CHEMICAL	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr	HI*	EXCESS LCF/yr
Sediments	Arsenic	< 1	0.00013	< 1	0.00013	< 1	$< 10^{-6}$	< 1	$< 10^{-6}$	NA[c]	NA[c]
	Beryllium	< 1	0.000026	< 1	0.000026	< 1	$< 10^{-6}$	< 1	1.2×10^{-6}		

[a] No data were available on regional metals concentrations in store bought fruit. Metals data are provided for homegrown fruit in Los Alamos County only. There were data for fruits raised within the LANL reservation, although there are no receptors affected because these fruits are not used as food sources.

[b] Lead is considered a potential human carcinogen but no slope factor has been established by EPA to estimate carcinogenic risk because there are so few data supporting its development. Many studies indicate a link between lead uptake in children and elevated blood lead levels in children associated with learning disabilities and other physiological impacts. The estimate of HI presented here was made for a standard adult male (approximately 71.8 kilograms).

[c] Special pathways receptors are those who have additional risk because of traditional Native American or Hispanic lifestyles. There are no receptors for pinto beans, sweet corn, and zucchini grown in an environmental restoration study site in Los Alamos County.

NA = Not applicable

beryllium concentrations in the immediate area of LANL (appendix D, section D.3.4).

Dose from Ingestion of Water from Supply Wells

The radiation doses from ingestion of water from supply wells for off-site Los Alamos County residents (Table D.3.3–1) and San Ildefonso (Table D.3.3–5) run from about 1 to 7 millirem per year, mostly due to naturally occurring uranium. (The concentrations used in these analyses include contribution from background.)

Consequences to the Public Along Transportation Routes

Section 5.2.10 details the analysis of transportation consequences. Public health consequences include the dose and excess LCF risk associated with routine, accident-free transportation. Table 5.2.10–2 shows the population dose and excess LCF for normal (accident-free) off-site shipments throughout the U.S. The population dose and excess LCF associated with exposures occurring during stops for transportation segments near LANL are provided in Table 5.2.6.1–5. Doses associated with living along and sharing routes with these shipments are detailed in Table 5.2.10–2, and are less than those associated with stops. Risks associated with accidents during transportation are also discussed in section 5.2.10.

TABLE 5.2.6.1–5.—*Radiation Doses and Excess LCF Risks Estimated to the Public at Stops During Transportation of Materials from LANL*

ROUTE SEGMENT	PERSON-REM PER YEAR (AT STOPS)	EXCESS LCF RISK PER YEAR
LANL to U.S. 84/285	3.2	0.0016
U.S. 84/285	3.3	0.0016

5.2.6.2 *Worker Health*

Worker risks associated with continued operations of LANL include radiological (ionizing and nonionizing) risks, chemical exposure risks, and risk of injury during normal operations. The consequences to worker health from implementing the No Action Alternative are given below and detailed in appendix D, section D.2.2.

Radiological Consequences

Ionizing Radiation Consequences. Table 5.2.6.2–1 summarizes the projected doses and associated excess LCF risks from implementation of the No Action Alternative for continued operations of LANL.

The collective worker dose under the No Action Alternative is conservatively projected to be approximately twice that measured in 1993 to 1995. In terms of the average non-zero dose to an individual worker, the No Action Alternative is conservatively projected to result in 0.14 rem per year, as compared with 0.097 rem per year, 1993 to 1995 (chapter 4, section 4.6.2.2). The estimated excess LCF risk over a lifetime is 0.000054 per year of operation.

Nonionizing Radiation Consequences. It is expected that there will continue to be negligible effects to LANL worker health from nonionizing radiation sources including ultraviolet sources, infrared radiation from instrumentation and welding, lasers, magnetic and electromagnetic fields, and microwaves (including the large station at TA–49). (See volume III, appendix D, section D.2.2.2 for methodology used to estimate nonionizing radiation from LANL operations to humans and wildlife and for the estimated results.)

TABLE 5.2.6.2–1.—*Worker Ionizing Radiation Annual Doses and Associated Lifetime Excess LCF Risks Under the No Action Alternative*

LANL Collective Worker Dose (person-rem per year)	446
Estimated Excess LCF Risk (across the worker population) per year of operation	0.18
Average Non-Zero Worker Dose (rem per year)	0.14
Estimated Excess LCF Risk (average worker > 0 dose)	0.000054

Chemical Exposure Consequences

There have been no chemical exposures resulting in hospitalization or extended medical care at LANL in the 1990's (section 4.6.2.1). This section examines the occasional reportable, but minor, chemical exposure likely during normal operations at LANL. Because beryllium operations in support of DOE missions are being concentrated at LANL, the consequences to workers are discussed as a special case below.

It is anticipated that there will continue to be a few chemical exposures annually, such as to:

- Airborne asbestos
- Lead paint particulates
- Crystalline silica
- Fuming perchloric acid, hydrofluoric acid
- Skin contact with acids or alkalis

Based on the performance for the index period (1990 to 1996), there would be expected to be a reportable chemical exposures of one to three incidents per year at LANL, using the current worker population of approximately 9,000 individuals.

Under the No Action Alternative, it is expected that there will be a worker population of approximately 10,000 individuals, approximately 10 percent higher than index period employment levels. For the purposes of the SWEIS, it is assumed that there is negligible additional benefit of the Chemical Hygiene Program at LANL over the period analyzed, and that the rate of chemical exposures continues at the index period rates. Therefore, it is expected that reportable chemical exposures from continued operations would continue at a rate of one to three injuries per year over the next 10 years.

Beryllium Processing Consequences. Beryllium exposure of workers is a potential risk of operating the Beryllium Technology Center (BTC), Building 3-141, in the Sigma Complex. Other uses of beryllium at LANL are metals applications and present little risk. The worker risks associated with HE testing applications of beryllium at LANL are the same as that for the public MEI and are presented in section 5.2.6.1 above. There is additional risk at BTC because of powders processing. This risk is primarily from aerosol and small particulate inhalation (chapter 4, section 4.6). The BTC is configured as a clean facility; that is, it has the appearance and characteristics of a surgical theater. The consequences to the workers are minimized by multiple and redundant engineering controls, and workers are monitored though LANL's Industrial Hygiene (IH) Program. The engineering controls include: (1) flexible and robust heating, ventilation, and air conditioning (HVAC) systems supporting a variety of processing enclosures that capture aerosols and particulates at their point of generation in the process; (2) physical separation of higher hazard operations; (3) in-BTC IH monitoring laboratory allowing immediate detection of potential exposures to aerosols and particulates; (4) access limited to beryllium workers only;

and (5) waste minimization and contamination control via use of in-facility laundry and facility-wide filtration systems. It is not anticipated that consequences to workers would be measurable; that is, no sensitization to beryllium would be detected using the LANL IH monitoring program.

Physical Safety Hazards

Table 5.2.6.2–2 compares the projected reportable cases of accidents and injuries estimated to occur during normal operations (including from building modifications, maintenance and construction) for the No Action Alternative and that experienced during the index period. The No Action Alternative is expected to result in an increase in reportable accidents and injuries proportional to increases in worker population. These incidents are considered to be normal consequences of normal operations of LANL. These estimates of accident rate conservatively assume that the aggressive Health and Safety Program underway at LANL does not achieve any reduction in the accidents and injuries rate.

The consequences of these accidents and injuries are expected to be similar to those experienced in the past, and typically are those associated with health response and recovery from acute trauma. Therefore, the consequences include physical pain and therapy/treatment for recovery such as those associated with bone setting, shoulder dislocation reset, and subsequent physical therapy. Some injuries may also result in continuing consequences to the worker that could affect productivity or lifestyle, such as motor skill loss due to nerve damage or cardiovascular debilitation resulting from electrical shock.

TABLE 5.2.6.2–2.—*Projected Annual Reportable Worker Accidents and Injuries for Normal Operations in the No Action Alternative Compared with the Index Period*

PARAMETER ESTIMATED	PARAMETER VALUE AND UNITS
Projected Worker Population	Approximately 10,000
Projected Reportable Accidents and Injuries	460/year
Change from Index (1993 to 1996)	+ 10%

5.2.7 Environmental Justice

As indicated in sections 5.2.1 and 5.2.2, no substantive adverse impacts to land resources or geology and soils are anticipated for the continued operation of LANL under the No Action Alternative. Thus, no disproportionately high or adverse impacts to minority or low-income communities are anticipated for these impact areas. The potential impacts to surface water, groundwater, and ecological resources associated with the No Action Alternative would affect all communities in the area equally (see sections 5.2.3 and 5.2.5 for additional information on the potential for impacts to these resources). Thus, no disproportionately high or adverse impacts to minority or low-income communities are anticipated to be associated with these resource areas.

Contaminants in air emissions decrease in concentration (and thus in impact) with distance from LANL. This is illustrated in Figure 5.2.7–1, which projects the dose from radiological air emissions within 50 miles (80 kilometers) of LANL. Similarly, the concentrations of chemical contaminants from air emissions at LANL decrease as the distance from LANL increases. Thus, impacts due to air emissions are equal to or lower in the sectors with substantial minority and/or low-income populations than they are in sectors 1–3 and 6–16, and such impacts do not disproportionately impact the minority or low-income populations. (See section 5.2.4

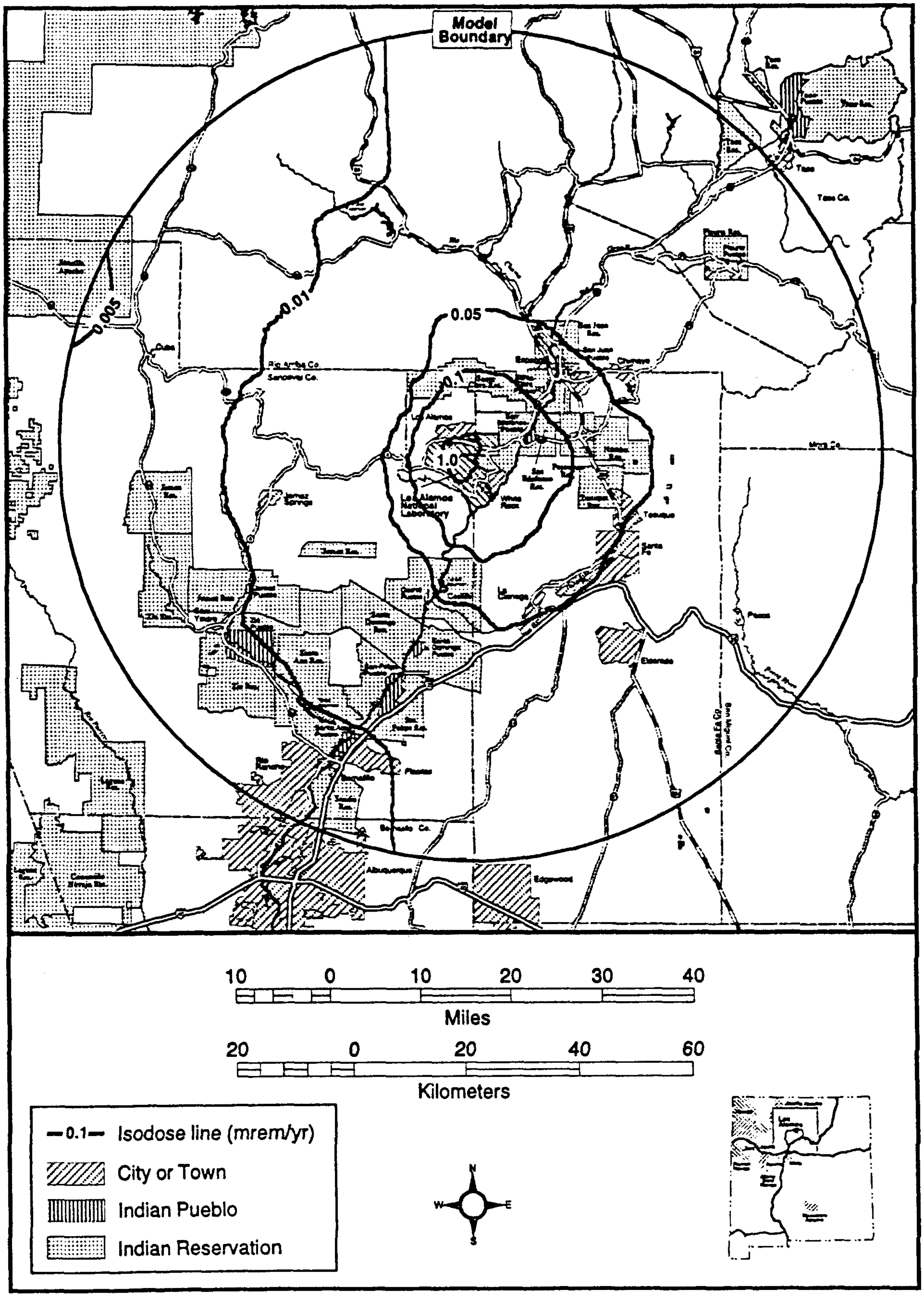


FIGURE 5.2.7–1.—*Isodose Lines from Airborne Releases for the No Action Alternative Within 50 Miles (80 Kilometers) of LANL.*

regarding the impacts anticipated for air emissions under the No Action Alternative.)

The air pathway is one example of the analysis of potential human health impacts. As presented in section 5.2.6, there is minimal potential for LANL operations to adversely affect human health for off-site residents or recreational users in the area around LANL under the No Action Alternative. The human health analysis also includes an analysis of exposures through special pathways, including ingestion of game animals, fish, native vegetation, surface waters, sediments, and local produce, absorption of contaminants in sediments through the skin, and inhalation of plant materials. The special pathways have the potential to be important to the environmental justice analysis, because some of these pathways may be more important or viable for the traditional or cultural practices of minority populations in the area. However, human health effects associated with these special pathways would not present disproportionately high or adverse impacts under the No Action Alternative.

As shown in section 5.2.10, impacts to public health from transportation on the site and from LANL to U.S. 84/285 are estimated to be 0.0016 excess LCFs per year from incident-free transportation and 0.040 deaths or injuries per year from transportation accidents. Impacts from transportation on route segments that pass through minority or low-income communities (particularly the segment on U.S. 84/285 to I–25) are estimated to be 0.0016 excess LCFs per year from incident-free transportation and 0.090 deaths or injuries per year from transportation accidents. Therefore, no high and adverse impact is expected to a member of the general public or to a member of a minority or low-income population due to transportation in the vicinity of LANL.

5.2.8 Cultural Resources

Impacts to prehistoric resources, historic resources, and TCPs are summarized in Table 5.2.8–1 and are discussed below. A brief statement regarding impacts to spiritual aspects follows these discussions. Common to all alternatives, coordination would be accomplished with the SHPO in compliance with Section 106 of the *National Historic Preservation Act* for any individual undertakings.

5.2.8.1 *Prehistoric Resources*

Impacts to prehistoric resources could potentially result from three general sources: shrapnel (material fragments) and vibration caused by high explosives testing at 13 existing firing sites, release of hazardous material (nonradioactive), and release of radioactive material.

Shrapnel and vibration from high explosives testing at 13 firing sites could potentially affect three types of prehistoric sites: cavate (cave) pueblos, rock shelters, and overhangs. Freestanding prehistoric (or pueblo) walls are not typically found on LANL; rather, LANL resources include a number of stable mounds of varying heights that were formed by collapsed walls and earth. Much of the material released by explosive tests is either aerosolized or reduced to millimeter size, dust-like particles upon detonation. However, some larger fragments are also released. Studies of hydrodynamic tests at Los Alamos have shown that fragments produced from explosive tests are released according to a well known fragmentation distribution. Based on fragmentation distributions for a series of computer studies of the breakup of various weapons systems during hydrodynamic tests (tests of mock-up nuclear packages during which high explosives are detonated) with different quantities of high explosives (up to 500 pounds of explosives), almost all particles

TABLE 5.2.8–1.—*Projected Impacts to Prehistoric Resources, Historic Resources, and TCPs Under the No Action Alternative*

ACTION TYPE	PUEBLO STRUCTURES	ERODED PUEBLOS/ RUBBLE/ ARTIFACT SCATTER	CAVATE PUEBLOS/ ROCK ART/ SHELTERS/ OVERHANGS	TRAILS/ STEPS/ STONE ARRANGE-MENTS	U.S. TERRITORIAL HOMESTEAD SITES	NUCLEAR ENERGY ERA (1943 TO 1989) BUILDINGS, DISTRICTS, AND SITES)	TRADITIONAL CULTURAL PROPERTIES (TCP)				
							CEREMONIAL AND ARCHAEOLOGICAL SITES	NATURAL FEATURES	ETHNOBOTANICAL GATHERING SITES	ARTISAN MATERIALS GATHERING SITES	SUBSISTENCE FEATURES
New Construction (buildings, facilities, etc.)	Negligible (construction is within existing buildings)										
Modifications in Facility Layout (roads, parking lots, pits)	Negligible (policy and procedures in place to avoid or minimize impacts)										
Modification of Existing Buildings (changing building function)	Negligible (policy and procedures in place to avoid or minimize impacts)					Negligible (policy and procedures in place to avoid or minimize impacts) for facilities continuing to operate. Potential for neglect for any facilities/operations that are discontinued.	Negligible (policy and procedures in place to avoid or minimize impacts).				
Change in Hydrology (surface and groundwater quality and quantity; erosion and siltation rates)	None						Traditional communities have indicated that water quality degradation produces adverse impacts: damage, introduction of elements out of character with the setting, and isolation of TCPs. Assessment of impacts to site specific TCPs is not possible because their locations and nature are not known.				
Explosives Impacts (shrapnel scatter)	Negligible (no resources sensitive to these impacts are located near enough to be impacted).		Minor effect—more quantitative study required to refine impacts.		None		Adverse impacts may be produced from destruction of or damage to the TCP, introduction of elements out of character with the setting, and/or isolation of sites within or near firing site hazard zones. Assessment of impacts to site specific TCPs is not possible because their specific locations and nature are not known.				
Explosives Impacts (vibration)	None		Potential for low level of impact.		None		Potential for disturbance. Assessment of impacts to site specific TCPs is not possible because their specific locations and nature are not known.		None		
Explosives (noise)	None						Explosives noise at any TCP may be considered as adverse due to the introduction of elements out of character with the setting of the TCP.				
Hazardous Material (non-radiological)	Legacy contaminants present the greatest concern. There is insufficient data available to evaluate this impact or to assess the additive effects of ongoing operations. However, contamination due to ongoing operations is projected to be small compared to legacy contamination and the background concentrations of hazardous materials in the area.					Potential for future operations to add contaminants that may limit preservation options.	All forms of hazardous materials near TCPs are considered by traditional communities as adverse impacts, producing damage, alteration, introduction, and isolation. Assessment of impacts to site specific TCPs is not possible because their specific locations and nature are not known.				
Radiation Hazards	Legacy contaminants present the greatest concern. There is insufficient data available to evaluate this impact or to assess the additive effects of ongoing operations. However, contamination due to ongoing operations is projected to be small compared to legacy contamination and the background concentrations of hazardous materials in the area.					Potential for future operations to add contaminants that may limit preservation options.	Traditional communities have stated that radioactive contamination of TCPs produces adverse impacts due to destruction, alternation, introduction of elements out of character with the TCP, and isolation. Assessment of impacts to site-specific TCPs is not possible because their specific locations and nature are not known.				
Security (fencing, lighting, monitoring)	Continued security at LANL will restrict access by the general public, and in essence, provide protection to these resources.						Continued restricted access by traditional communities to TCPs within security areas. Security measures also restrict access to these resources by other members of the public, and thus provide some measure of protection to TCPs.				

fall within 800 feet (244 meters) of the firing site and no particles are observed outside of 1,200 feet (366 meters).

Of the identified 23 cavate pueblos, rock shelters, and overhangs within the 1,200-foot (366-meter) radius of the firing sites, eight are within the 800-foot (244-meter) radius and 15 are within the 800- to 1,200-foot (244- to 366-meter) radius. Probability calculations that a fragment of firing debris would fall within 1 square foot (0.9 square meter) placed at the center of each archeological site indicate a likelihood of 0.07 or 7 in one hundred at 100 feet (30 meters), 0.000005 or 5 in 1 million at 800 feet (244 meters), and 0.0000002 or 2 in 10 million at 1,200 feet (366 meters). The influence of topographical variations and vegetation that may shield sites is not considered in these probabilities.

Physical impacts to cultural resources at firing sites from either explosion-generated fragments or vibration have not been well studied. However, the findings of October 1997 field observations of eight cultural resource (cavate/ rock shelter/overhang) sites located within an 800-foot (244-meter) radius of active firing sites did not reveal any visible effects that could be attributable to fragments or vibration caused by past and current firing site activities (LANL 1997b). Based on these qualitative observations, the probability for cultural sites to be affected by firing site activities is low.

Studies of firing site generated ground vibrations conducted at LANL demonstrated that explosive amounts as high as 500 pounds would not induce vibrations that would affect structures at BNM. Any impacts caused by higher amounts of explosives is not known and would require further analysis.

Accumulated hazardous and radioactive materials at firing sites, contiguous areas, and any additive amounts resulting from No Action operational levels have the potential to limit access to archeological sites for future study. The extent of this potential is not known because of the scarcity of data. However, no instances of restricted access because of health-threatening levels of hazardous or radioactive materials are known to date. In addition, LANL's environmental monitoring and soil survey program has not identified firing sites as restricted to access because of any accumulated hazardous or radioactive materials. Additional data are needed for future studies regarding the preservation of prehistoric resources because isolating a site from access for future study would be an adverse impact.

Security levels would be maintained under the No Action Alternative. Security levels (and, thus, levels of protection for cultural resources) vary depending on the types of activities at a particular location. Surveillance of public access roads within LANL has been effective in protecting prehistoric resources, and archaeological sites within limited public access areas have been fenced or gated to prevent vandalism.

5.2.8.2 *Historic Resources*

Impacts to historic resources could potentially result as a consequence of additional contributions of hazardous and radioactive materials to what is currently present in some Nuclear Energy Period (1943 to 1989) buildings. Some contamination does exist in several buildings, a feature that was inherent in their past function and handling techniques. Investigations are currently ongoing to determine the extent of contamination and relationship to National Register of Historic Places (NRHP) eligibility. In cases where buildings have been demolished, mitigation measures (e.g., photographing, recording, and documenting of the property) have been accomplished in coordination with the SHPO. While the rules for implementing the *National Historic Preservation Act* (16 U.S.C. §470) do not preclude a site from being eligible for or listed on the NRHP because of contamination, additional contamination could potentially exceed some threshold level that would impede or slow down the process of evaluating the site for eligibility. However, numerous safeguards (e.g., strict hazardous materials handling and disposal procedures) are currently employed that minimize or preclude contamination. Therefore, the likelihood that additional contamination would significantly impact current levels of contaminants is considered negligible.

Many historic structures, particularly Nuclear Energy Period buildings, are not being actively utilized and, consequently, are not being actively maintained.

5.2.8.3 *Traditional Cultural Properties*

The Pajarito Plateau contains a high density of cultural resources and active traditional sites. These resources are significant to numerous Native American tribes and Hispanic groups, and represent areas of spiritual importance and traditional use. Many of these cultural sites are archaeological remains that are affiliated with several contemporary Native American tribes who consider them TCPs. Other tangible and intangible cultural resources in the LANL area contain no archaeological remains, but still retain cultural significance because of their use in traditional beliefs and practices. Overall, the traditional groups consulted considered all archaeological sites, human burials, shrines, rivers and water sources, trails, plants, animals, and minerals to be TCPs because these resources are integral to their traditional and cultural lifestyles.

Actions that may be perceived as impacting TCPs both on and adjacent to LANL consist of changes in hydrology features (surface and groundwater quality and quantity, erosion and siltation rates), explosives impacts (shrapnel, vibration, and noise), hazardous materials (nonradioactive), radiation hazards, and security features. Changes in hydrology features are viewed as adverse, damaging or altering features, and introducing elements that are out of character with the setting. Impacts resulting from explosives testing, presence of hazardous materials, and radiation hazards are viewed in much the same way—having the potential for damaging or altering features, introducing elements out of character with the setting, and limiting access to areas for conducting traditional or ceremonial activities. Security measures are viewed as limiting access to areas for conducting traditional or ceremonial activities; however, these same security measures may protect these TCPs from vandalism or other damage.

A detailed assessment of impacts to TCPs (other than archeological sites) is not possible because site-specific locations are not known. However, a continuation of activities at the No Action Alternative level is not anticipated to alter existing conditions and procedures are present that permit some limited access to restricted areas.

Spiritual Entities

The effect(s) that the continued presence and operation of LANL may have on any “unseen” or “spiritual” entities is unknown. The very esoteric nature of this issue precludes an assessment that would adequately reflect individual beliefs or faith.

5.2.9 Socioeconomics, Infrastructure, and Waste Management

This section describes the social, economic, infrastructure, and waste generation impacts of activities at LANL under the No Action Alternative.

5.2.9.1 *Socioeconomic Impacts*

Employment, Salaries, and Population

The primary (direct) impacts to employment, salaries, and population are presented in Table 5.2.9.1–1 for the LANL workforce only. The secondary (indirect) impacts and the total population changes projected are presented in Table 5.2.9.1–2 for the Tri-County area. For the purposes of the SWEIS, it is assumed that these changes take place within a year of the ROD for the SWEIS.

Housing

The population changes anticipated in the Tri-County area, reflected in Table 5.2.9.1–2, are projected to result in demand for 559 additional (new) housing units. The distribution of this demand in the three counties is projected to be: 130 additional units in Los Alamos County; 201 additional units in Rio Arriba County; and 228 additional units in Santa Fe County.

In Los Alamos County, the projected housing demand can be accommodated from absorption of apartment vacancies and the inventory of houses for sale and new construction. Beyond 130 units, no new housing units can be anticipated because of the absence of buildable land in private ownership. This constraint upon supply would be expected to exert an upward pressure on rents and house prices.

The projected housing demand in Rio Arriba and Santa Fe Counties can be accommodated without significant pressure on rents and house sales prices. Both counties possess a sufficient inventory of finished lots and parcels, have access to adequate mortgage capital, and have sufficient entrepreneurial developer talent to absorb the demand.

Construction

Table 5.2.9.1–3 contains the results of the analysis of construction spending, labor salaries, and labor employment for the period fiscal year 1997 through fiscal year 2006. Construction activities associated with this alternative are expected to draw workers already present in the Tri-County area who historically have worked from job to job in the region. Thus, this employment is not expected to influence socioeconomic factors.

Local Government Finance

Under this alternative, the Tri-County annual gross receipts tax yields would be expected to increase by $1.2 million. This increase would be matched by increases in service levels adequate to meet public demand.

Services

Annual school enrollment in the Tri-County area would increase by 227 students. Additional annual funding assistance of about $910,000 from the State of New Mexico would be required for school operations because of these enrollment increases.

In Los Alamos, the school district can absorb the anticipated new enrollment levels. This school district has excess capacity because of its discretionary policy of accepting out-of-district students who are the children of LANL employees and subcontractors. In Rio Arriba County and the cities of Española and Santa Fe, adequate classroom capacity exists because of recent school construction projects.

The demand for police, fire, and other municipal services would be expected to increase in proportion to the increase in gross receipts tax yields, as discussed above. However, any changes in local government services tend to be inelastic in the short-term and typically are responsive only after the completion of at least one full budget cycle.

TABLE 5.2.9.1–1.—*Summary of Primary LANL Employment, Salaries[a], and Procurement Under the No Action Alternative[b]*

	LOS ALAMOS COUNTY	RIO ARRIBA COUNTY	SANTA FE COUNTY	TRI-COUNTY TOTAL	OTHER NEW MEXICO COUNTIES	NEW MEXICO TOTAL	OUTSIDE NEW MEXICO	TOTAL
Employees	4,995	2,090	2,032	9,117	664	9,781	196	9,977
Difference[c]	160	171	195	526	56	582	20	602 (+ 6%)
Salaries ($M)	264.2	52	85.4	401.6	19	420.7	10.1	430.8
Difference[c]	9.6	7	11.1	27.7	2.7	30.4	1.5	31.9 (+8%)
Procurement ($M)	217.1	1.7	21	239.8	123.8	363.6	236.7	600.2
Difference[c]	1.4	0.0	0.3	1.7	1.4	3.1	5	8.1 (+ 1%)

[a] Salaries are for UC employees only; subcontractor salaries (Johnson Controls, Inc.; Protection Technology of Los Alamos, etc.) are included in the procurement dollars.
[b] Reflects projected locations of employee residences and LANL procurement activities.
[c] Difference is as compared to fiscal year 1996. Percent difference is shown in parentheses in the far right (TOTAL) column.

TABLE 5.2.9.1–2.—*Summary of Total Tri-County Employment, Salaries, Business Activity, and Population Changes Under the No Action Alternative*

	PRIMARY CHANGE	SECONDARY CHANGE	TOTAL TRI-COUNTY CHANGE	TRI-COUNTY PRIMARY WORKER CHANGE[a]	TRI-COUNTY SECONDARY WORKER CHANGE[b]	TOTAL TRI-COUNTY WORKER CHANGE	TOTAL TRI-COUNTY POPULATION CHANGE[c]
Employment/ Population	526	899	1,425	421	270	691	1,337 (+ 1%)
Personal Incomes	$27 million	$26 million	$53 million (< +1%)				
Annual Business Activity	$2 million	$4 million	$6 million (< +1%)				

Note: Percentages in parentheses are the percentage change that the number represents. These are provided for total population change, total personal income change, and total annual business activity change.
[a] This is the number of direct workers moving to the Tri-County area, assuming that 80 percent of new LANL employees are from outside this area.
[b] This is the number of secondary workers moving to the Tri-County area, assuming that 30 percent of secondary employment is from outside this area.
[c] This is the total population increase in the Tri-County area, assuming that, on average, each worker moving to the area increases the population by 1.935.

TABLE 5.2.9.1–3.—*Construction Spending, Labor Salaries, and Labor Employment Numbers Under the No Action Alternative (Fiscal Year 1997 Through 2006)*

YEAR	CONTRACT $M	LABOR $M	EMPLOYEES
1997	63	15	432
1998	187	45	1,282
1999	208	50	1,426
2000	219	53	1,502
2001	210	50	1,440
2002	120	29	823
2003	91	22	624
2004	90	22	617
2005	109	26	747
2006	108	26	741

$M = dollars given in millions
Sources: DOC 1996, PC 1997a, and PC 1997b

5.2.9.2 *Infrastructure Impacts*

Annual electricity use projected under the No Action Alternative is a total of 717 gigawatt-hours, 372 gigawatt-hours for LANSCE, and 345 gigawatt-hours for the rest of LANL. The peak electrical demand is projected to be 108 megawatts, 58 megawatts for LANSCE and 50 megawatts for the rest of LANL[1]. The supply of electricity to the Los Alamos area (which includes LANL, the communities of Los Alamos and White Rock, and BNM) is provided by two 115 kilovolt transmission lines (contractually limited to 72 megawatts during winter months when El Vado and Abiquiu hydroelectric output is negligible, and to about 94 megawatts during the spring and early summer months) and supplemented by the LANL steam/power plant at TA–3 (with an operating capacity of about 12 megawatts in the summer and about 15 megawatts in the winter) (DOE 1997). The existing supply of electricity to the Los Alamos area is not sufficient year-round to meet the projected peak electrical demand for LANL operations under this alternative; thus, periods of brown-outs are anticipated unless measures are taken to increase the supply of electricity to the area. (See sections 1.6.3.1 and 4.9.2 regarding ongoing efforts to increase electrical power supply to this area.) This situation is exacerbated by the additional electrical demand for BNM, and the communities of Los Alamos and White Rock. (While these organizations did not provide use projections, their historical usage is reflected in chapter 4, section 4.9.2.)

Natural gas use is projected to be 1,840,000 decatherms annually. The gas delivery capacity to the Los Alamos area is between approximately 9,000,000 and about 11,000,000 decatherms per year (Kumar 1997). Although electrical demand may increase natural gas demand for the generation of electricity at TA–3, demand should continue to be dominated by heating requirements and is not expected to exceed this projection.

LANL water use projected under the No Action Alternative is a total of 712 million gallons (2.7 billion liters) per year, 218 million gallons (825 million liters) per year for LANSCE, and 494 million gallons (1.9 billion liters) per year for the rest of LANL. This is well within DOE water rights, about 1,806 million gallons (6.9 billion liters) per year; however, this water right also provides for water used by Los Alamos County and BNM. Based on existing information regarding non-LANL water use, the water demands of this community can be met within the existing water rights. (Water demand is also discussed in section 5.1.3.) The peak water requirements for the area were determined to be 7,300 gallons (27,740 liters) per minute; the firm rated capacity of the

1. These values include the proposed Strategic Computing Complex (SCC) Project annual electricity and peak electrical demand for a 50-TeraOp operation and are reflected in all the alternatives. The SCC project was as an interim action to the SWEIS.

delivery system is 7,797 gallons (29,629 liters) per minute (Lundberg 1997).

The projected water use for the proposed Strategic Computing Complex (SCC) project is not reflected in the total number for LANL water use projections (for any of the alternatives) because DOE and LANL are committed to no net increase of water usage when the SCC project becomes operational at a 50-TeraOp level in approximately fiscal year 2002. The estimated water use for the SCC without water conservation would have been 120 gallons (450 liters) per minute or 63 million gallons (240 million liters) per year. The SCC project intends to make full use of the treated sanitary wastewater effluent from the TA–46 SWSC plant to meet its goal of no net increase of water usage (Holt 1998).

5.2.9.3 *Waste Management*

The annual and 10-year total generation projections for radioactive and hazardous waste are reflected in Table 5.2.9.3–1. These projections include waste from key facilities, all other LANL facilities, waste management facilities, the ER Project, and construction activities. Liquid waste is not projected by radioactive facility because measurements of individual contributions are not made for all facilities. The total amount of radioactive liquid waste (RLW) projected for receipt at TA–50 is 6.6 million gallons (25 million liters) per year for this alternative.

The other environmental impacts from waste management activities are presented elsewhere in this document. The impacts associated with the specific operations of the waste management facilities are found in the various impact areas analyzed in this document; all other facilities and specific effluents and source terms for the key facilities are summarized in chapter 3 (section 3.6) for waste management facilities (principally at TA–50 and TA–54). Transportation of waste, for example, is included in the analysis of transportation impacts of the various alternatives (volume III, appendix F, section F.6.6). The transportation of low-level radioactive waste (LLW) for off-site disposal and the expansion of Area G were the only variables identified from the review of waste management strategies. The differences between these strategies are reflected in the differences between the alternatives. (Expanded Operations is the only alternative that includes expansion of on-site disposal.)

Much of LANL TRU and chemical waste, as well as a portion of the LLW, would be treated and shipped off the site for disposal. (As noted in chapter 4, section 4.9.3.3, LANL receives small amounts of TRU waste from other sites. Some of that waste is from nondefense activities and is currently ineligible for disposal at the Waste Isolation Pilot Plant [WIPP]. Under all alternatives, such nondefense TRU waste would be stored at LANL pending the development of disposal options.) LANL is capable of meeting applicable WAC, and off-site disposal capacities are much greater than LANL's waste volumes.

5.2.9.4 *Contaminated Space*

The activities reflected in the No Action Alternative are projected to increase the total contaminated space at LANL by 63,000 square feet (5,853 square meters), as compared to the baseline established for the SWEIS as of May 1996 (section 4.9.4). The majority of this increase is due to implementation of actions that have already received a review in accordance with NEPA but that had not been implemented at the time the baseline was established (including the Nuclear Materials Storage Facility [NMSF] at TA–55; introduction of tritium into TA–16 Building 450 for neutron tube target loading; implementation of the low-energy demonstration accelerator [LEDA] and IPF at TA–53; size-reduction at the Waste Characterization, Reduction, and Repackaging [WCRR] Facility; and treatment research and

TABLE 5.2.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the No Action Alternative*[a]

FACILITY	TECHNICAL AREAS	CHEMICAL WASTE[b] (kilograms)		LOW LEVEL RADIOACTIVE WASTE (cubic meters)		MIXED LOW LEVEL WASTE (cubic meters)		TRANSURANIC WASTE (cubic meters)		MIXED TRANSURANIC WASTE (cubic meters)	
		ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR
Plutonium Facility Complex	TA–55	5,250	52,500	688	6,880	12	120	124	1,240	36	360
Tritium Facilities[c]	TA–16 & 21	1,100	11,000	450	4,500	2	20	NA	NA	NA	NA
Chemical and Metallurgy Research Building[d]	TA–3	7,970	79,700	1,380	13,800	16.4	164	18.7	187	8.1	81
Pajarito Site	TA–18	4,000	40,000	145	1,450	1.5	15	NA	NA	NA	NA
Sigma Complex	TA–3	5,500	55,000	420	4,200	2	20	NA	NA	NA	NA
Materials Science Laboratory	TA–3	600	6,000	0	0	0	0	NA	NA	NA	NA
Target Fabrication Facility	TA–35	3,800	38,000	10	100	0.4	4	NA	NA	NA	NA
Machine Shops	TA–3	142,000	1.42×10^6	280	2,800	0	0	NA	NA	NA	NA
High Explosives Processing Facilities	TA–8, 9, 11, 16, 28 & 37	11,000	110,000	11	110	0.2	2	NA	NA	NA	NA
High Explosives Testing Facilities	TA–14, 15, 36, 39, 40	25,200	252,000	300	3,000	0.3	3	0.2	2	NA	NA
Los Alamos Neutron Science Center	TA–53	16,600	166,600	156	1,560	1	10	NA	NA	NA	NA
Health Research Laboratory[e]	TA–43	7,050	70,500	14	140	2.7	27	NA	NA	NA	NA
Radiochemistry Laboratory	TA–48	2,000	20,000	170	1,700	2	20	NA	NA	NA	NA
Radioactive Liquid Waste Treatment Facility[f]	TA–50 & 21	2,200	22,000	150	1,500	0	0	21	210	0	0
Waste Treatment, Storage, and Disposal Facilities[f]	TA–54 & 50	920	9,200	174	1,740	4.0	40	27	270	0	0
Non-Key Facilities		651,000	6.51×1^6	520	5,200	30	300	0	0	0	0
Environmental Restoration Project[g]		2×10^6	2×10^7	4,257	42,570	548	5,480	11	110	0	0
Grand Total[h]		2.886×10^6	2.886×10^7	9,130	91,300	622	6,220	202	2,020	44	440

NA indicates that this facility does not routinely generate these types of waste.
[a] Radioactive liquid waste generation is not projected by facility (see text in section 5.2.9.3, Radioactive and Hazardous Waste Generation).
[b] The chemical waste numbers reflect waste that exhibits a hazardous characteristic (ignitability, corrosivity, reactivity, or toxicity), is listed as a hazardous waste by EPA, is a mixture of listed hazardous waste and solid waste, or is a secondary waste associated with the treatment, storage, or disposal of a hazardous waste. This includes waste that is subject to regulation under RCRA, as well as PCB waste and asbestos waste regulated under the *Toxic Substance Control Act*. Biomedical waste is also included in this category of waste.
[c] These projections include 4,000 cubic meters of LLW due to backlogged waste.
[d] These LLW projections include 4,000 cubic meters of LLW generation anticipated due to the CMR Building Upgrades, Phase II.
[e] These projections include 10,000 kilograms of chemical waste, 250 kilograms of biomedical waste (a special form of chemical waste), 44 cubic meters of LLW, and 24 cubic meters of low-level radioactive mixed waste associated with ongoing efforts to remove obsolete and contaminated equipment.
[f] These facilities provide for storage, treatment, and disposal of waste generated throughout LANL. These activities generate secondary waste, the quantities of which are reflected in this table for these facilities.
[g] The ER Project is projected to generate 11 cubic meters per year of TRU and mixed TRU waste together. All of this waste is presented under the TRU waste columns.
[h] Grand totals have been rounded.

TRU waste characterization at the Radioactive Materials Research, Operations, and Demonstration [RAMROD] Facility at TA–50).

5.2.10 Transportation

The transportation impacts projected for the No Action Alternative are summarized in this section. More detailed information regarding these impacts is included in volume III, appendix F.

5.2.10.1 *Vehicle-Related Risks*

Truck Emissions in Urban Areas

For the No Action Alternative, the projected risk is 0.032 excess LCF over a lifetime per year of operation. Use of the Santa Fe Relief Route would have a very small effect on this risk (it would change to 0.031 excess LCF per year). The only difference is that the Santa Fe Relief Route would have 1.2 miles (1.9 kilometers) less of urban highway mileage. Approximately 65 percent of the risks are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments.

Truck Accident Injuries and Fatalities

The impacts projected for the No Action Alternative are presented in Table 5.2.10.1–1 (additional information on these analyses is provided in appendix F, section F.6.3). Use of the Santa Fe Relief Route would reduce the risks of accidents, injuries, and fatalities by almost one-half of those indicated for the segment from U.S. 84/285 to I–25 due to the assumption that the accident rate on the Santa Fe Relief Route would be much lower than for the route through Santa Fe. Use of the Santa Fe Relief Route would not substantially change the risks of accidents, injuries, and fatalities on the remainder of New Mexico segment, as compared to the risks reflected for this segment in Table 5.2.10.1–1. Approximately 65 percent of the impacts are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments. Again, all shipments are assumed to result in a return by an empty truck.

5.2.10.2 *Cargo-Related Risks*

Incident-Free Radiation Exposure

The incident-free radiation exposure impacts projected for the off-site shipments under the No Action Alternative are presented in Table 5.2.10.2–1; note that the total is the total dose and risk throughout the U.S. attributable to LANL operations, and that this total is dominated by the segments outside New Mexico. The aircraft segment is for overnight carrier service; the truck segment to/from the

TABLE 5.2.10.1–1.—*Truck Accident Injuries and Fatalities Projected for LANL Shipments Under the No Action Alternative*

ROUTE SEGMENT	NUMBER OF ACCIDENTS PER YEAR	NUMBER OF INJURIES PER YEAR	NUMBER OF FATALITIES PER YEAR
On-Site	0.015	0.0031	0.00015
LANL to U.S. 84/285	0.17	0.035	0.0017
U.S. 84/285 to I–25	0.41	0.086	0.0041
Remainder of New Mexico	0.67	0.64	0.072
Outside New Mexico	3.2	3.0	0.30
Total	4.5	3.8	0.38

TABLE 5.2.10.2–1.—*Incident-Free Population Dose and Lifetime Excess LCFs for Off-Site Shipments per Year of Operation Under the No Action Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL (PUBLIC)					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	person-rem/year	excess LCF/year	person-rem/year	excess LCF/year	person-rem/year	excess LCF/year	person-rem/year	excess LCF/year
LANL to U.S. 84/285	5.9	0.0024	0.032	0.000016	0.51	0.00026	3.2	0.0016
U.S. 84/285 to I–25	7.9	0.0032	0.38	0.00019	3.6	0.0018	3.3	0.0016
Remainder of New Mexico	45	0.018	0.1	0.00005	1.7	0.00085	24	0.012
Outside New Mexico	410	0.16	2.8	0.0014	24	0.012	180	0.09
Aircraft	2.4	0.0012	NA	NA	NA	NA	NA	NA
Totals	470	0.19	3.3	0.0017	30	0.015	210	0.11

NA = Not applicable

airport is included in the truck results. In general, use of the Santa Fe Relief Route would result in only small changes in this type of impact. Truck crew doses and nonoccupational doses for people at rest stops would increase due to the increased length of the Santa Fe Relief Route for many of the radioactive material shipments (those north-bound on I–25). Nonoccupational doses for people sharing the road would decrease due to the lower traffic density projected for the relief route.

The MEI dose occurs between LANL and I–25 and is 0.0003 rem.

Driver Doses from On-Site Shipments of Radioactive Materials. The projected collective radiation dose for LANL drivers under the No Action alternative is 4.184 person-rem. This collective dose would be expected to result in 0.00167 excess LCF among these drivers.

The average individual driver dose is projected to be 0.174 rem per year, which is well below the DOE radiation protection limit of 5 rem per year.

Transportation Accidents

The following discussion addresses the potential impacts of accidents leading to the release of either radioactive or hazardous material being transported in support of LANL operations under the No Action Alternative. Results are given for both off-site and on-site shipments.

Off-Site Radioactive Materials Shipments. The RADTRAN and ADROIT codes were used to analyze accident impacts for the bounding off-site radioactive material shipments. The MEI doses calculated with RADTRAN do not vary by alternative and are given in Table 5.2.10.2–2. The population dose and corresponding excess LCF per year for these shipments are presented in Table 5.2.10.2–3 for these accidents. ADROIT results that are separated into frequency and consequence components are not readily available. The product, MEI dose risk, can be presented in terms of excess LCF per year; for the No Action Alternative, the MEI dose risk due to plutonium-238 oxide and due to pit shipments were each less than 1×10^{-10} excess LCF per year.

TABLE 5.2.10.2–2.—*MEI Doses and Associated Frequencies for Off-Site Radioactive Materials Accidents*

ROUTE SEGMENT	SHIPMENT TYPE					
	AMERICIUM-241		CH TRU		RH TRU	
	MEI DOSE (rem)	FREQUENCY PER TRIP	MEI DOSE (rem)	FREQUENCY PER TRIP	MEI DOSE (rem)	FREQUENCY PER TRIP
LANL to U.S. 84/285	59	1.8×10^{-7}	21	6.4×10^{-8}	0.16	6.0×10^{-9}
U.S. 84/285 to I–25	59	2.5×10^{-7}	21	7.4×10^{-8}	0.16	5.6×10^{-9}
Remainder of New Mexico	59	9.9×10^{-7}	21	1.4×10^{-6}	0.16	1.3×10^{-7}
Rest of U.S.	59	0.000011	NA	NA	NA	NA

NA = Not available; CH TRU = contact-handled TRU waste; RH TRU = remote-handled TRU waste

TABLE 5.2.10.2–3.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the No Action Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM -241	CH TRU	RH TRU	PLUTONIUM -238	PITS	TOTAL	
	person-rem/year	person-rem/ year	person-rem/ year	person-rem/ year	person-rem/ year	person-rem/ year	excess LCF/ year
LANL to U.S. 84/285	0.015	0.0014	3.1×10^{-6}	4×10^{-7}	2×10^{-6}	0.016	8.0×10^{-6}
U.S. 84/285 to I–25	0.24	0.019	0.000042	1×10^{-6}	0.00001	0.26	0.00013
Remainder of New Mexico	0.031	0.012	0.000026	4×10^{-7}	4×10^{-6}	0.043	0.000022
Rest of U.S.	2.5	NA	NA	4×10^{-6}	0.00002	2.5	0.0012

NA = Not available; CH TRU = contact-handled TRU waste; RH TRU = remote-handled TRU waste

The use of the Santa Fe Relief Route would reduce the projected population dose (and therefore the excess LCFs per year) by about one-third for the U.S. 84/285 to I–25 segment, as compared to use of the route through Santa Fe. This difference is primarily due to the difference in population density along these routes. (The lower traffic density on the relief route is also a factor.) The use of the Santa Fe Relief Route would increase the projected population dose (and therefore the excess LCFs per year) for the remainder of New Mexico segment to about double that identified if the route through Santa Fe is used. This difference is due to the increase (6 miles [9.7 kilometers] more) in the distance traveled on I–25 for north-bound shipments.

On-Site Radioactive Materials Shipments. The bounding on-site shipments involving radioactive materials are the transport of plutonium-238 solution from the CMR to TA–55 and the transport of irradiated targets from the LANSCE to TA–48. Both types of shipments are made with the roads closed to all people except personnel directly involved in the transport. Therefore, no member of the public would be expected to be involved in the postulated truck accident or to be a bystander after the postulated truck accident.

The MEI dose is calculated using the following assumptions. In the case of plutonium-238 solution, it is assumed that a person would stand very close to the evaporating liquid for 10 minutes before being warned away. In the case of the irradiated target cask failure, a narrow radiation beam would be produced that would be lethal after 10 minutes of continuous exposure at a distance of 6 feet (1.8 meters) from the cask, and it is assumed that a person would stand in this beam for 10 minutes.

The resulting MEI doses, frequencies, and MEI risks per year of operation are given in Table 5.2.10.2–4. The bounding Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility or Pulsed High-Energy Radiation Machine Emitting X-Rays (PHERMEX) shipment accidents could result in an off-site MEI dose of 76 rem and fatalities to LANL truck crews and other individuals within 80 feet (24 meters) of the explosion (DOE 1995b). The frequency of such shipments has been added to the frequency of irradiated target shipments.

Hazardous Materials Shipments. The bounding hazardous materials shipments for transportation accident analyses are major chlorine shipments (toxic), major propane shipments (flammable), and major explosives shipments. The consequences of an accident involving a major explosives shipment is bounded by the consequences of an accident involving a major propane shipment, so the frequency of explosives shipments was added to the frequency of propane shipments (rather than analyzing them separately).

Accidental Chlorine Release. The probability of the bounding accidental chlorine release (event) was determined from event trees by

TABLE 5.2.10.2–4.—*MEI Doses and Frequencies for Bounding On-Site Radioactive Materials Accidents Under the No Action Alternative*

SHIPMENT TYPE	EVENT FREQUENCY PER YEAR	MEI DOSE	MEI RISK
Plutonium-238 Solution	8.8×10^{-8}	8.7 rem	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCF per year)
Irradiated Targets	3.1×10^{-6}	acute fatality	3.1×10^{-6} fatalities per year

using 1-ton (908-kilogram) container failure thresholds (Rhyne 1994a) and force magnitude probabilities (Dennis et al. 1978). (Although LANL is not expected to store or handle chlorine containers this large, they have in the past, and the risks associated with transport of this size container bound the risks of toxic material shipments.) The ALOHA™ computer model (NSC 1995) was used to estimate release rates from the 1-ton (908-kilogram) container, and the DEGADIS (Havens and Spicer 1985) model was used to predict downwind chlorine concentrations following the postulated release. (A separate version of DEGADIS is used because the version incorporated in ALOHA™ does not readily provide time variation of downwind concentrations.)

The number of fatalities or injuries associated with the bounding chlorine accident would depend on the population density and the ability of people to avoid harmful exposure by going indoors or leaving the affected area. The ability of people to avoid harmful exposure (to escape) would depend on various factors; an escape fraction of 0.98 is used for all route segments. This fraction is based on analysis of a transportation accident producing fatal releases of ammonia (Glickman and Raj 1992) and should be applicable to chlorine because the same dispersion coefficients apply, resulting in similar plume shapes and gradients of concentration. For both, there will be objectionable odor a short time prior to concentrations that have serious effects. The plumes tend to be visible and of modest transverse dimension, with very objectionable odor and strong respiratory irritation at their edges, permitting recognition and urging prompt escape on foot. The projected frequencies, consequences and risks associated with major chlorine accidents under the No Action Alternative are presented in Table 5.2.10.2–5.

The use of the Santa Fe Relief Route would result in about one-third the risk of fatalities and one-tenth the risk of injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight increase in this risk of injuries and fatalities on the remainder of New Mexico segment because of the extra 6 miles (10 kilometers) traveled on I–25 for northbound traffic (chlorine shipments are all assumed to travel north on I–25).

Accidental Propane Release. The bounding consequence from a propane release would be the generation of a fireball. The fireball would likely occur too soon after the postulated truck accident for evacuation to be effective. The fireball would have a radius of about 148 feet (45 meters) and would burn for about 3 seconds. Many people would be protected by buildings or automobiles for this short duration. It is assumed that 50 percent of the available population would be shielded from the fireball, 10 percent would be fatalities, and the remainder would be injured (Geffen et al. 1980). In addition, fatal second-degree burns might be experienced out to a radius of 620 feet (189 meters). The percentages of available people that would be exposed to the radiant heat flux are assumed to be 0.16 percent, 12 percent, and 19 percent in urban, suburban, and rural areas, respectively (Geffen et al. 1980).

The number of people that would be affected depends on the population density. The projected frequencies, consequences, and risks associated with major propane accidents under the No Action Alternative are presented in Table 5.2.10.2–6.

The use of the Santa Fe Relief Route would result in about one-third the risk of fatalities and one-fifth the risk of injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight decrease in the risk of injuries and fatalities on the

TABLE 5.2.10.2–5.—*Frequencies, Consequences, and Risk for a Major Chlorine Accident Under the No Action Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	0.000028	0.065	0.24	8.6×10^{-6}	0.000032
	Suburban	4.6×10^{-6}	1.5	5.6		
U.S. 84/285 to I–25	Rural	0.000022	0.053	0.2	0.00029	0.0011
	Suburban	0.000047	3.0	11		
	Urban	0.000014	11	40		
Remainder of New Mexico	Rural	0.00016	0.015	0.056	0.000052	0.00019
	Suburban	0.000017	1.5	5.5		
	Urban	2.8×10^{-6}	8.4	32		
Remainder of U.S.	Rural	0.0012	0.028	0.1	0.0012	0.0047
	Suburban	0.0003	1.6	6.1		
	Urban	0.00007	10	39		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

TABLE 5.2.10.2–6.—*Frequencies, Consequences, and Risk for a Major Propane Accident Under the No Action Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	9.8×10^{-6}	0.28	1.1	9.7×10^{-6}	0.000039
	Suburban	1.7×10^{-6}	4.2	17		
U.S. 84/285 to I–25	Rural	7.5×10^{-6}	0.23	0.92	0.00015	0.0006
	Suburban	0.000017	8.4	34		
	Urban	5.0×10^{-6}	1.8	7.3		
Remainder of New Mexico	Rural	0.000065	0.15	0.6	0.00012	0.00048
	Suburban	0.000021	5.1	20		
	Urban	2.6×10^{-6}	1.5	6.1		
Remainder of U.S.	Rural	0.000083	0.09	0.36	0.000067	0.00027
	Suburban	0.000011	4.8	19		
	Urban	5.4×10^{-6}	1.9	7.5		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

remainder of New Mexico segment because of the 6 miles (10 kilometers) reduction in distance traveled on I–25 for southbound traffic (propane shipments are all assumed to travel south on I–25).

5.2.11 Accident Analysis

Transportation accidents for the No Action Alternative are addressed in section 5.2.10. High-frequency (greater than 1 in 100) occupational accidents for the No Action Alternative are addressed in section 5.2.6.

5.2.11.1 *Multiple Source Release of Hazardous Material from Site-Wide Earthquake and Wildfire*

Site-Wide Earthquake

Earthquakes are site-wide in nature. They are the only credible initiator that can release material from multiple facilities at the same time. Three scenarios have been postulated for site-wide earthquake-initiated releases. Each of the scenarios has a different magnitude earthquake that results in different degrees of damage and consequences. In addition, RAD–12 is a facility-specific accident scenario, discussed in the DARHT EIS (DOE 1995a), that is earthquake-initiated (by a very large earthquake) but has a substantially different probability for the scenario than is reflected in the site-wide scenario. The estimates for both structural damage to LANL facilities and the amount of material released are conservative. Earthquakes dominate the radiological accident risk.

Table 5.2.11.1–1 is a summary of the annual frequency of earthquake and wildfire scenarios and their consequences. For radiological releases, the consequences are expressed as excess LCFs, per year, in excess of the normal incidence of fatal cancers. Comparisons to the incidence of fatal cancers in the surrounding population can be made to evaluate the risk from these accidents relative to the public's inherent cancer risk. Overall, it should be noted that for the scenarios hypothesized for both SITE–01 and SITE–02, the number of excess LCFs is within the normal fluctuation in cancer fatalities from one year to the next. As noted in section 5.2.6, and in appendix D, section D.1.2.1, the lifetime risk of dying from cancer in the U.S. is more than 23 percent for men and more than 20 percent for women; based on this rate, approximately 40,000 people within the 50-mile (80-kilometer) radius of LANL would be expected to die from cancer.

Table 5.2.11.1–2 is a summary of the risk from exposure to toxic chemicals as a result of the site-wide accidents. (RAD–12 is not reflected on this table because this scenario does not involve the release of toxic chemicals.) Chemical exposure is evaluated as the expected number of people exposed annually to concentrations greater than a given ERPG–2 or ERPG–3.

For earthquakes, one can expect fatalities among workers and the public caused directly by the earthquake itself, irrespective of any releases. Many of the office buildings, including such facilities as the administration complex or off-site office buildings, etc., would be expected to suffer substantial damage from higher frequency, lower magnitude earthquakes. Therefore, the population effects resulting from exposures to hazardous materials are thought to be a small or modest increment to the human and material impacts directly attributable to the earthquake.

Site-Wide Wildfire

The frequency of a large fire encroaching on LANL is estimated as the joint probability of ignition in the adjacent forests, high extreme fire danger with a failure to promptly extinguish the fire, and a 3-day period of favorable meteorological conditions. (See volume III,

TABLE 5.2.11.1–1.—*Summary of Radiological Risks from Earthquake-Initiated and Wildfire Accident Scenarios at LANL—No Action Alternative*

SCENARIO DESCRIPTION	FREQUENCY (EVENT PER YEAR)[a,e]	CONSEQUENCE MEASURES[b,c,d,f]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
NATURAL PHENOMENA			
SITE–01 Moderate earthquake on the Pajarito Fault or a large earthquake in the Rio Grande Rift zone, resulting in structural damage and/or severe internal damage to comparatively low capacity facilities.	Approximately 0.0029 per year (i.e., one such event in approximately 350 years); considered an unlikely event	Approximately 16 excess LCFs Mean population dose approximately 27,726 person-rem MEI doses 20 rem	0.046
SITE–02 Large earthquake on the Pajarito Fault, resulting in structural damage and/or severe internal damage to low and moderate capacity facilities.	Approximately 0.00044 per year (i.e., one such event in approximately 2,300 years); considered an unlikely event	Approximately 24 excess LCFs Mean population dose approximately 41,340 person-rem MEI dose ≤ 34 rem	0.011
SITE–03[g] Very large earthquake on the Pajarito Fault and perhaps the Embudo Fault, resulting in structural damage to essentially all facilities.	Approximately 0.000071 per year (i.e., one such event in approximately 14,000 years); considered an extremely unlikely event	Approximately 134 excess LCFs Mean population dose approximately 210,758 person-rem MEI dose 247 rem	0.0095
SITE–04 Large wildfire encroaching on Los Alamos, consuming combustible structures and vegetation.	Approximately 0.1 per year (i.e., one such event in approximately 10 years); considered a likely event.	Approximately 0.34 excess LCFs Mean population dose approximately 675 person-rem MEI dose < 25 rem	0.034
RAD–12[h] Plutonium release from a seismically initiated event	Approximately 1.5 x 10^{-6} per year (about one such event in about 1,000,000 years); considered an extremely unlikely event	18 excess LCFs Mean population dose approximately 35,800 person-rem MEI dose 138 rem	0.000027

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure.
[e] The frequency is more correctly described as the probability of occurrence in any 12-month period. See detailed explanation under Meaning of Risk and Frequency in volume III, appendix G, section G.1.
[f] Impacts, in terms of LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.
[g] There is a potential for fault rupturing to occur at the CMR Building (TA–3–29) at a somewhat lower frequency than the SITE–03 earthquake (estimated at 1 to 3 x 10^{-5}/year). Should this occur in association with the SITE–03 earthquake, a conservative estimate results in an additional 133,833 person-rem population dose (increasing excess LCFs by 99), and an increase to the MEI of 134 rem.
[h] This accident was analyzed in the DARHT EIS (DOE 1995a), and because it is an earthquake-initiated event, it is presented here for consistency.

TABLE 5.2.11.1–2.—*Summary of Chemical Exposure Risks from Site-Wide Accident Scenarios at LANL—No Action Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a,d]	CONSEQUENCE MEASURE[b,c]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
NATURAL PHENOMENA			
SITE–01 Moderate earthquake on the Pajarito Fault or a large earthquake in the Rio Grande Rift zone, resulting in structural damage and/or severe internal damage to comparatively low capacity facilities.	Approximately 0.0029 per year (i.e., one such event in approximately 350 years); considered an unlikely event.	Several tens of people exposed at or above ERPG–2 or –3 levels at distances to a substantial fraction of a mile from multiple sources.	0.058
SITE–02 Large earthquake on the Pajarito Fault, resulting in structural damage and/or severe internal damage to low and moderate capacity facilities.	Approximately 0.00044 per year (i.e., one such event in approximately 2,300 years); considered an unlikely event.	Approximately 100 people exposed above ERPG–2 or 3 levels to a distance of about one mile from multiple sources.	0.044
SITE–03 Very large earthquake on the Pajarito Fault and perhaps the Embudo Fault, resulting in structural damage to essentially all facilities.	Approximately 0.000071 per year (i.e., one such event in approximately 14,000 years); considered an extremely unlikely event.	Approximately 100 people exposed above ERPG–2 or –3 levels to a distance of about 1 mile from the sources.	0.0071
SITE–04 Wildfire consuming vegetation and combustible structures	Approximately 0.1 per year.	Approximately 11 people exposed above the ERPG–2 level from a formaldehyde release.	1.1

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] The frequency is more correctly described as the probability of occurrence in any 12-month period. See detailed explanation under Meaning of Risk and Frequency in volume III, appendix G, section G.1.

appendix G for a complete discussion of the accident analysis.) The postulated scenario is quite credible in view of the present density and structure of fuel surrounding and within LANL and the townsite, and the historical occurrence of three major fires in the past 21 years.

This analysis has shown that these fire-favorable weather conditions occur on the order of once per year; the ignition sources are prevalent; and fire-fighting capability is hampered by limited accessibility. Therefore, this site-wide accident analysis concludes that a major fire, as described, is not only credible but also likely. The probability is on the order of 0.1 per year (1 every 10 years), a frequency that is identical for all alternatives. Although the probability of occurrence is 0.1 per year, the conditions for occurrence exist at least once every year.

The analysis for the joint probability of occurrence of weather and fire danger conditions and the fuel loading provides a conservative but realistic assessment of the potential for the occurrence of a wildfire scenario that will impact LANL facilities, buildings, and land.

The analysis conservatively assumes that all combustible structures and vegetation over the western part of LANL are burned. The public exposures were estimated separately for airborne radionuclides and beryllium from burning vegetation and soils, and from radiological and chemical releases from burning facilities. When available, existing analyses from facility fires were used; otherwise, new model calculations were run.

About 400 person-rem, or 75 percent of the total population exposure of 675 person-rem, results from a wildfire at TA–54. The results from RAD–08, an aircraft crash-initiated fire at TA–54, were used for the wildfire. The two fires would be quite different; one entails aircraft fuel that challenges waste containers. At present, the fuel loading within the dome structures is small, so that RAD–08 results very conservatively bound the consequences of a wildfire at TA–54. This facility and the others that contribute public exposure in the wildfire scenario are being considered for actions to reduce the external wildfire fuel.

Another 189 person-rem results from total release of the tritium inventory at the Weapons Engineering Tritium Facility (WETF), including 44.5 ounces (1,260 grams) in storage, which is assumed to bound an increased administrative limit that may be established. The storage containers are resistant to fire, but have been assumed to release their entire content in tritiated water form, in accord with the highly conservative nature of this analysis.

Because the frequency of the site-wide wildfire is 0.1 per year, the radiological risk (product of the frequency and consequence) from this accident is exceeded only by the site-wide earthquake. On the other hand, no excess LCFs are expected from the event. (See Table 5.2.11.1–1 for a summary of the wildfire analysis.) There would be unquantified health effects from smoke inhalation and possible fatalities from fighting the fires. There would be substantial impact from impairment of mission and from the loss of buildings at LANL and in the townsite. This impact is not evaluated, just as it is not evaluated for earthquakes.

5.2.11.2 *Plutonium Releases from Manmade and Process Hazards at LANL*

A summary of the frequency and consequences for plutonium releases is given in Table 5.2.11.2–1. These releases reflect a variety of initiators depending on the type of activities or manmade hazards in the area, such as an aircraft crash. The consequences indicate that no excess LCFs are expected from any of the plutonium accident scenarios.

Due to the low consequences and frequencies, these accidents do not pose a significant risk to the public.

An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and TA–55–4 is presented in volume III, appendix G, section G.4.1.2.

Substantial differences exist between the nuclear facililty and operations being conducted in TA–55–4 today and those that were present at the Rocky Flats Plant in 1969. TA–55–4 was designed to correct the deficiences detected in older facilities such as the Rocky Flats Plant and is being upgraded to meet the even more stringent requirements of the 1990's, including enhanced seismic resistance and fire containment.

5.2.11.3 *Highly Enriched Uranium Release from Process Hazard Accident at LANL*

The site has only a few accident scenarios involving uranium among those with the highest risks evaluated. This is due to the difference in specific activity between plutonium and HEU. Of accidents releasing HEU, RAD–03 is dominant. The postulated source term was 16 pounds (7.2 kilograms) of uranium. The excess LCFs are estimated at less than 1; that is, no cancer fatality is expected. Details of the accident analysis can be found in appendix G. The results are summarized in Table 5.2.11.3–1.

5.2.11.4 *Tritium Release from a Manmade Hazard Accident*

The scenario initiated by an aircraft crash event is the dominant accident that involves tritium. In this scenario, the entire inventory of tritium at TSTA or TSFF is converted by fire to tritiated water. This is a conservative assumption because water is readily absorbed by the body; whereas, gaseous tritium is not. Nevertheless, for this accident, no excess LCFs are expected to occur, as indicated in Table 5.2.11.4–1.

5.2.11.5 *Chemical Releases from Manmade and Process Hazard Accidents at LANL*

For the chlorine releases, on-site personnel could be exposed to concentrations in excess of ERPG–2. Chlorine has a highly objectionable odor, which prompts sheltering and escape; however, personnel can be quickly overcome when exposed to high concentrations. Details for each accident are found in volume III, appendix G. The results are summarized in Tables 5.2.11.5–1 and 5.2.11.5–2.

5.2.11.6 *Worker Accidents at LANL*

Worker accidents are characterized by higher frequencies and potential for prompt fatalities. Generally, the fatalities would be a consequence of the accident itself, such as a detonation of high explosives. Chemical and radiological exposures to workers depend heavily on the response to an event, such as putting on protective equipment and exiting the area. Accidents that affect workers only are summarized in Table 5.2.11.6–1. Table 5.2.11.6–2 summarizes the effects to workers from the accidents associated with public impacts. Additional details can be found in the appendix G, Accident Analysis.

TABLE 5.2.11.2–1.—*Summary of Radiological Consequences for Plutonium Release Scenarios at LANL—No Action Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a,e]	CONSEQUENCE MEASURES[b,c,d,f]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
MANMADE HAZARDS			
RAD–01 Plutonium release from RANT Facility transuranic waste container storage area fire.	Approximately 0.0016 per year (i.e., one event in approximately 600 years); considered an unlikely event	Approximately 0.04 excess LCF Mean population dose approximately 72 person-rem MEI at nearest public access (on Pajarito Road): approximately 46 rem, at most exposed residence: approximately 4 rem	0.000064
RAD–07 Plutonium release from WCRR Facility transuranic waste container storage area fire.	0.00015 per year (i.e., one in 7,000 years); considered an unlikely event	Approximately 0.7 excess LCF Mean population dose: approximately 1,300 person-rem MEI dose at closest public access (Pajarito Road): approximately 74 rem, MEI at habitation: approximately 4 rem	0.00011
RAD–08 Plutonium release from TWISP transuranic waste storage domes due to aircraft crash and fire.	4.3×10^{-6} per year (i.e., one event in approximately 200,000 years); considered an extremely unlikely event	Approximately 0.2 excess LCF Mean population dose: approximately 400 person-rem MEI at nearest public access (Pajarito Road and nearest border with White Rock): 22 rem	8.6×10^{-7}
RAD–16 Plutonium release due to aircraft crash at the CMR Building.	Approximately 3.5×10^{-6} per year (i.e., one event in approximately 300,000 years)	Approximately 0.03 excess LCF Mean population dose: approximately 56 person-rem, no expected excess LCFs; MEI at closest public access, approximately 3 rem, approximately 0.03 rem at nearest habitation	1×10^{-7}

TABLE 5.2.11.2–1.—*Summary of Radiological Consequences for Plutonium Release Scenarios at LANL—No Action Alternative*-Continued

SCENARIO DESCRIPTION	LIKELIHOOD[a,e]	CONSEQUENCE MEASURES[b,c,d,f]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
PROCESS HAZARD ACCIDENTS			
RAD–09 Plutonium release due to transuranic waste drum failure or puncture (for "high" and typical activity in drum).	0.0041per year (i.e., one in approximately 250 years for high-activity drum) 0.4 per year (i.e., one in 2.5 years for typical drum)	0.12 excess LCF from high activity drum Mean population dose for release: approximately 230 person-rem MEI (high activity drum) at closest access (Pajarito Road) approximately 23 rem; approximately 0.86 rem at closest habitation. 0.0022 excess LCF from typical activity drum Mean population dose: approximately 4.4 person-rem MEI (typical activity drum) at closest access (Pajarito Road) approximately 0.41 rem; approximately 0.86 rem at closest habitation	0.00049 0.0009
RAD–13 Plutonium release from flux trap irradiation experiment at TA–18.	0.000016 per year (i.e., one event in approximately 65,000 years)	Approximately 0.08 excess LCF Mean population dose: approximately 160 person-rem MEI at closest public access (Pajarito Road): approximately 120 rem; at closest habitation: approximately 0.12 rem.	1.3×10^{-6}
RAD–15 Plutonium release from CMR. (1) Laboratory Fire	(1) 0.000036 per year	(1) Approximately 0.0023 excess LCF Mean population dose: approximately 4.5 person-rem MEI approximately 4.1 rem	(1) 8.3×10^{-8}
(2) Wing Fire	(2) 0.000032 per year	(2) Approximately 0.85 excess LCF Mean population dose: approximately 1,700 person-rem MEI approximately 91 rem	(2) 2.7×10^{-5}

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure.
e The frequency is more correctly described as the probability of occurrence in any 12-month period. See detailed explanation under Meaning of Risk and Frequency in volume III, appendix G, section G.1.
[f] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

TABLE 5.2.11.3–1.—*Summary of Radiological Consequences from Highly Enriched Uranium Release Scenarios at LANL—No Action Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c,d,e]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
RAD–03 Highly enriched uranium release from power excursion accident with Godiva-IV outside Kiva #3.	3.4×10^{-6} per year	Approximately 0.06 excess LCF Mean population dose: approximately 110 person-rem MEI at nearest public access (Pajarito Road) Approximately 150 rem; at nearest habitation approximately 0.5 rem	2×10^{-7}

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure. The MEI dose is provided for an individual located on Pajarito Road at a distance of 160 feet (50 meters) from the facility, even through Pajarito Road would be closed to the public during outdoor operations.
[e] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

TABLE 5.2.11.4–1.—*Summary of Radiological Consequences from Tritium Release Scenarios at LANL—No Action Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c,d,e]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
RAD–05 Tritium oxide release due to aircraft crash at TSFF.	5.3×10^{-6} per year (i.e., one accident in 190,000 years).	Approximately 0.012 excess LCF Mean population dose: 24 person-rem MEI approximately 0.01 rem[f]	6.4×10^{-8}

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure.
[e] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation
[f] This is at 1,200 feet (360 meters) distance. The closest public access would likely be involved in the crash.

TABLE 5.2.11.5–1.—*Summary of Chlorine Exposure Scenarios at LANL—No Action Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
PROCESS HAZARD ACCIDENTS			
CHEM–01 Chlorine release (150 pounds [68 kilograms]) from potable water treatment station, due to human error during cylinder changeout or maintenance, or due to random hardware failures.	Approximately 0.0012 per year (i.e., one such event in approximately 800 years)	For the risk-dominant large leak scenario, an average of approximately 43 persons exposed above ERPG–2 levels, and approximately 12 persons exposed above ERPG–3 levels, to distances of up to a few tenths of a mile.	0.052
CHEM–02 Multiple cylinder (1,500 pounds [680 kilograms]) from toxic gas storage shed at gas plant, due to fire or aircraft crash.	Approximately 0.00013 per year (i.e., one in approximately 8,500 years)	Average of 292 people within LANL (ranging from none to 1,000 depending upon wind direction) exposed at or above ERPG–2 or –3 levels; town protected by canyon from highest concentrations.	0.038
CHEM–03 Chlorine release (150 pounds [68 kilograms]) from toxic gas storage shed at gas plant, due to random failure or human errors during cylinder handling.	Approximately 0.00012 per year (i.e., one in approximately 8,000 years)	An average of approximately 263 exposed above ERPG–2 levels; or 239 above ERPG–3 levels, at distances to a fraction of a mile, all within LANL; town protected by canyon from highest concentrations.	0.032
CHEM–06 Chlorine gas release outside Plutonium Facility.	Approximately 0.063 per year (i.e., one event in approximately 16 years)	Average number exposed at or above ERPG–2 doses is approximately 102, and above ERPG–3, approximately 7 at ranges to a fraction of a mile.	6.426

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.

TABLE 5.2.11.5–2.—*Summary of Chemical Exposure Scenarios—No Action Alternative*

SCENARIO	DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
CHEM–04	Bounding single container release of toxic gas (selenium hexafluoride) from waste cylinder storage.	Approximately 0.004 per year (i.e., one in about 250 years)	Average number of off-site persons exposed above ERPG–2 level is zero; toxic effects generally limited to the source's TA (TA–54).	0
CHEM–05	Bounding multiple cylinder release of toxic gas (sulfur dioxide) from waste cylinder storage.	Approximately 0.00051 per year (i.e., one event in approximately 7,000 years)	Under conservative daytime conditions, no one outside the source area (TA–54) would see levels above ERPG–2. Under least favorable conditions, 13 persons could be exposed above ERPG–3 levels.	0

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.

TABLE 5.2.11.6–1.—*Summary of Worker Accident Scenarios at LANL—No Action Alternative*

SCENARIO	DESCRIPTION	FREQUENCY[a]	NUMBER OF WORKER CASUALTIES PER ACCIDENT
WORK–01	Inadvertent detonation of high explosives.	0.001 to 0.01 per year (i.e., one in approximately 100 to 1,000 years)	1 to 15 fatalities or injuries.
WORK–02	Biohazard contamination of a single worker.	0.01 to 0.1 per year (i.e., one in approximately 10 to 100 years)	One diagnosed infection.
WORK–03	Inadvertent criticality at CMR Facility, Critical Experiments Facility, or Plutonium Facility.	< 0.0001 per year (i.e., one in more than 10,000 years)	Substantial doses to those few workers in the immediate vicinity, with possible fatalities from acute exposures.
WORK–04	Inadvertent exposure of workers to electromagnetic radiation.	0.01 to 0.1 per year (i.e., one in approximately 10 to 100 years)	Typically one, rarely several, casualties.
WORK–05	Plutonium release from degraded storage container at Plutonium Facility.	0.23 per year for exposure to workers	Significant but nonlethal doses to one or two workers.

[a] Accident likelihood estimates are conservative, given the information available.

TABLE 5.2.11.6–2.—*Summary of Consequences to Workers at Origination Facilities for Accident Scenarios*

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
SITE–01	Moderate earthquake on the Pajarito Fault or a large earthquake in the Rio Grande Rift zone resulting in structural damage and/or severe internal damage to comparatively low capacity facilities.	Workers in buildings that are structurally damaged or that suffer partial or total collapse (unusual, but possible) could be injured or killed. Worldwide experience with very severe earthquakes indicates that a priori predictions of the numbers of injuries and fatalities are not possible. The experience clearly indicates that large numbers of fatalities (i.e., many hundreds to thousands of deaths) are not commonly experienced except under special conditions. These special conditions include severe earthquakes with large numbers of persons in severely substandard structures that suffer complete collapse. Modern structures do not often experience such failures, even in very severe earthquakes. Other circumstances under which large numbers of fatalities could occur include seismically induced, widespread fires. Other impacts to workers could include delayed emergency response (including medical assistance) and indirect effects from releases of hazardous materials (both inside facilities and to the environment).
SITE–02	Large earthquake on the Pajarito Fault resulting in structural damage and/or severe internal damage to comparatively moderate capacity facilities.	See SITE–01.
SITE–03	Very large earthquake on the Pajarito Fault and perhaps the Embudo Fault resulting in structural damage to essentially all facilities.	See SITE–01.
SITE–04	Site-wide wildfire consuming combustible buildings and vegetation.	Most workers would be evacuated before the fire front arrives. However, there are possible fatalities from fighting the fire. There would be effects from smoke inhalation that are not predictable or quantified.
CHEM–01	Chlorine release (up to 150 pounds [68 kilograms]) from potable water treatment station due to human error during cylinder changeout or maintenance, or due to random hardware failures.	For the cylinder rupture event, it is unlikely that workers will be present because the nature of the event is assumed to occur at random rather than as a result of worker activity. Even with very prompt response by workers inside the building when the release occurs, severe injury or fatality is possible with large chlorine leak rates. The number of injuries and fatalities depends on the exact number and location of workers at the facility at the time of the event. For small leak rates, the likelihood of injury or death is low due to the “self-annunciating” nature of the event.
CHEM–02	Multiple cylinder (1,500 pounds [680 kilograms]) from toxic gas storage shed at gas plant due to fire or aircraft crash.	Workers present at the gas plant facility (TA–3–170 and environs) could be injured or killed, depending upon wind direction and wind speed. However, the chlorine gas and fire causing the release will be readily visible, and escape from the plume, even on foot, is likely. Workers attempting to fight the fire without personal protective equipment could be overcome by chlorine gas.

TABLE 5.2.11.6–2.—*Summary of Consequences to Workers at Origination Facilities for Accident Scenarios*-Continued

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
CHEM–03	Chlorine release (150 pounds [68 kilograms]) from toxic gas storage shed at gas plant due to random cylinder failure or multiple human errors during cylinder handling.	Gas plant workers who are directly involved in handling the cylinders of chlorine could be exposed to ERPG–2 or ERPG–3 concentrations for the human error contributor to this event. In the case of random failures, it is unlikely that workers will be in the immediate vicinity of the cylinder. Gas plant workers could be exposed to high concentrations of chlorine if located outdoors, but these employees would be able to evacuate the area rapidly which would tend to reduce exposure consequences.
CHEM–04	Bounding single container release of toxic gas (selenium hexafluoride) from waste cylinder storage.	There are typically four or five employees in the area during normal work hours. Injuries or fatalities could occur due to exposures as well as missiles from cylinder rupture. Workers are trained to leave the area in the event of a gas release. Consequences would depend on wind speed and direction.
CHEM–05	Bounding multiple cylinder release of toxic gas (sulfur dioxide) from waste cylinder storage.	See CHEM–04.
CHEM–06	Chlorine gas release outside Plutonium Facility.	Air intakes at TA–55–4 are on the west end of the building about 18 feet above the ground and the chlorine release location is on the north side of the building at ground level. In addition, there is an isolation valve in the intake ductwork. Thus, it is unlikely that chlorine will be drawn into the building. Personnel located outdoors could be exposed to ERPG–2 and ERPG–3 concentrations of chlorine, but these employees would be able to evacuate the area rapidly that would tend to reduce exposure consequences.
RAD–01	Plutonium release from RANT facility TRU waste container storage area fire.	There are about a dozen employees at the facility during day shift who could be at risk of plutonium inhalation as a result of this fire. However, the employees would be expected to take shelter or evacuate the area, which would reduce exposures. No lethal exposures would be expected.
RAD–03	HEU release from power excursion accident with Godiva-IV outside Kiva #3.	Personnel would not be located outdoors during an experiment leading to this accident. The TA–18 control building provides 40% attenuation of gamma radiation, and ventilation systems would be secured in the event of an accident, minimizing the air exchange rate with the outdoors. No acute fatalities are expected for this accident.
RAD–05	Tritium oxide release due to aircraft crash at TSFF or TSTA.	An aircraft crash into the building could result in severe injuries or deaths to nearly all the occupants of the building. Nearby workers not within the facility could also be injured or killed as a result of the crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash could be exposed to tritium oxide, but the release plume would be elevated and may “skip over” the immediate crash site before returning to the ground at some distance.
RAD–07	Plutonium release from WCRRF TRU waste container storage area fire.	There are typically five WCRR Facility workers present during normal operations. The postulated accident would not result in an immediate release, providing time for implementation of evacuation or other protective measures. No fatal exposures are expected.

TABLE 5.2.11.6–2.—*Summary of Consequences to Workers at Origination Facilities for Accident Scenarios*-Continued

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
RAD–08	Plutonium release from TWISP TRU waste storage domes due to aircraft crash and fire.	A small number of workers may be present during normal operations and could be directly affected by crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash could be exposed to plutonium, but the release plume would be elevated and may "skip over" the immediate crash site before returning to the ground at some distance.
RAD–09	Plutonium release due to TRU waste drum failure or puncture.	The accident would result in an immediate dispersal of plutonium to the area where the work is being performed. The dose to the worker would be dependent on ambient conditions and the speed with which protective actions could be taken (e.g., evacuation). No acute fatalities are expected for this accident.
RAD–10	Plutonium release from degraded storage container at Plutonium Facility (same as WORK–05, except that RAD–10 results in a release to the public, which was determined to be incredible).	See WORK–05.
RAD–13	Plutonium release from flux trap irradiation experiment at TA–18.	See RAD–03.
RAD–15	Plutonium release from hydride-dehydride glovebox fire.	From one to three workers may be present during the operations. These workers could be killed or injured due to the direct effects of a laboratory fire, or could be exposed to plutonium particulates via inhalation. Other workers could be affected by smoke inhalation. Workers outside the facility would not be expected to be impacted due to redundant trains of HEPA filtration between the accident location and the outside environment.
RAD–16	Plutonium release due to aircraft crash at the CMR Building.	An aircraft crash into the building could result in severe injuries or deaths to nearly all the occupants of the building. Nearby workers not within the facility could also be injured or killed as a result of the crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash could be exposed to plutonium, but the release plume would be elevated and may "skip over" the immediate crash site before returning to the ground at some distance.

5.3 IMPACTS OF THE EXPANDED OPERATIONS ALTERNATIVE

The DOE's Preferred Alternative is the Expanded Operations Alternative, with the exception that pit manufacturing would not be implemented at a 50 pits per year level, single shifts, but only at a level of 20 pits per year in the near term.

5.3.1 Land Resources

5.3.1.1 *Land Use Impacts*

Under the Expanded Operations Alternative, changes to the current overall land use categories are not expected from activities that are unique to this alternative, with the exception of a change to the land use designation at TA–67 if that site is chosen for the development of a new LLW disposal facility, as described in volume II, part I.

In the case of selecting that alternative, a roadway would be cleared and constructed from the R-Site Road to the TA–67 site; the combined total action would result in the clearing of about 60 acres (24 hectares) of forested land and a change in the current designation of that area from the Explosives land use category to a land use category of Explosives/Waste Disposal. The preferred alternative for the expansion of the TA–54/Area G LLW Disposal Area, expansion into Zones 4 and 6, would remove about 41 acres (17 hectares) from its current use as undeveloped wildlife habitat. Another alternative for the expansion of the LLW disposal site, the development of the North Site at TA–54, would remove about 49 acres (20 hectares) from that site's current use as undeveloped wildlife habitat. These changes at TA–54 would not alter the designated category of land use of Waste Disposal because the entirety of Mesita del Buey has been categorized for waste management and disposal activities usage.

Construction of a road between TA–55, the Plutonium Facility, and the TA–3, Chemistry and Metallurgy Research (CMR) Building area, to support pit production activities under the Expanded Operations Alternative (this applies to all project-specific siting and construction [PSCC] alternatives on this subject, as described in volume II, part II) would remove a small amount of acreage (about 7 acres [3 hectares]) from its current use as undeveloped, previously disturbed vegetated wildlife habitat; however, this would not alter the designated land use category of Research and Development use. Under the Preferred Alternative, at the 20 pits per year production rate, this road would not be constructed, and the corresponding land use impacts would not be incurred.

Other activities identified for this alternative also would occur, primarily within existing facilities or near to them and within the same type of land use category areas.

An increase in population in the Tri-County area due to an increase in employment would result in an increase in recreational use of surrounding lands and facilities. As shown in Table 5.3.9.1–2, there could be an estimated increase of about 4,230 individuals, or about 2.5 percent. This population level is within historical fluctuations due to changing laboratory activity levels. This increase in recreational use would likely include hiking, fishing, hunting, picnicking, camping, and skiing. Many of these activities, including visitation of archeological sites, would take place on adjacent lands administered by the SFNF and the NPS. This increase, while small, would contribute to increased recreational, wildlife, and cultural resource management measures being taken by these agencies to balance increasing numbers of visitors and accompanying noise and activity with natural and cultural resource needs.

5.3.1.2 *Visual Impacts*

The Expanded Operations Alternative would be expected to include the same effects as discussed under the No Action Alternative. Additionally, under this alternative there would be an expansion of the Area G LLW disposal landfill site at TA–54 or the construction and use of a new LLW disposal site and roadway at TA–67, and the construction of a roadway between TA–55 and TA–3, together with the possible construction of an add-on to the existing Plutonium Facility 4 at TA–55 or a new building nearby within the security fenced area at TA–55. The Area G landfill expansion would not be visible from Pajarito Road. However, the Area G landfill expansion would be visible from San Ildefonso land; Zones 4 and 6 are both farther away from the LANL boundary and would be less visible than the existing Area G landfill site, while the North Site is closer to the LANL boundary and would be more visible than the existing landfill site to people located on San Ildefonso land. The TA–67 landfill site would be visible from Pajarito Road, but would not be visible from San Ildefonso land.

Construction at the TA–67 site would change the view scape of the mesa top from that of forest to industrial development. Portions of the TA–55 to TA–3 roadway and its security fencing may be visible to motorists along Pajarito Road. The new roadway would be constructed in an already developed area and so would not significantly change the view scape of that area. Construction of an add-on to the Plutonium Facility or construction of a new building nearby would not alter the view scape of the TA–55 Plutonium Facility area because that area is already heavily developed.

Under the Expanded Operations Alternative there would be additional perimeter security floodlighting placed along the new roadway leading from TA–55 to TA–3, and around the new building within TA–55 if that alternative is chosen. This would result in very minor effects at the TA–55 and TA–3 area because of the limited area and length of the roadway. At the 20 pits per year production rate, the Preferred Alternative, these impacts would not be incurred because the road would not be constructed.

Similarly, additional perimeter security floodlighting would be placed around the Area G landfill expansion area or the TA–67 landfill area, both of which would be lighted for nighttime security purposes. The effect of additional lighting at the Area G landfill would be slightly noticeable during the night, especially to workers in the nearby areas. Nighttime lighting of the TA–67 area with both security floodlighting and parking lot safety lighting would be noticeable to LANL workers and potentially to off-site viewers because there are currently no areas along the Pajarito mesa that are similarly lighted. Additionally, such lighting might result in a short-term adjustment of wildlife use of the TA–67 site area. Use of these additional light fixtures at both the TA–54 and TA–67 locations and the TA–55 area could result in a slight increase in overall LANL area levels of light pollution, but is unlikely to result in a significantly expanded nighttime visibility of LANL from locations across the Rio Grande Valley.

Potential effects to the BNM and Dome Wilderness viewsheds would be similar to that of other area neighbors. Additional light sources could result in a slight increase in overall LANL levels of light pollution. Newly lighted areas may be visible to viewers at higher elevations at certain vantage points, but would not likely result in any appreciable expansion of the nighttime visibility of LANL as viewed from far distances. Expansion of the TA–54 Area G into Zones 4 and 6 would likely result in a minimal perception of clearing enlargement from BNM or Dome Wilderness vantage points due to forest growth between the vantage point and site location, the TA–54 site location on a mesa somewhat sloped to the southeast (away from these neighboring areas), and the amount of disturbance present in the general site area. A newly constructed disposal site at TA–67 would similarly be expected to result in a minimal perception of clearing enlargement from BNM or Dome Wilderness vantage points due to the forest growth between the vantage point and the site location, the TA–67 site location on a mesa somewhat sloped toward the southeast, and to the elevation of the TA–67 site relative to the neighboring vantage points in question. The construction of a roadway between TA–55 and TA–3 (which would not be constructed for the 20 pits per year production rate, the Preferred Alternative) would not likely be seen from off-site vantage points because of its relatively small size and the surrounding forest growth. If a vantage point exists from which the road can be viewed, it would likely result in little added viewshed impact given its location along Pajarito Road and the general state of development in the TA–3, TA–59, and TA–55 areas. An increase in the frequency of explosives should not affect the BNM and Dome Wilderness viewsheds.

5.3.1.3 *Noise*

Under the Expanded Operations Alternative there would be a slight increase in the amount of interior and outdoor construction activities at LANL. These would individually be within the level of effects described for the No Action Alternative, but may be ongoing for a longer total period of time. The construction of either the Area G landfill expansion or a new replacement facility within TA–67 would result in levels of sound and short-range ground vibrations that would be no different than those associated with current Area G landfill activities. Workers would be primarily affected by these noises, although motorists may occasionally hear low levels of equipment noises along Pajarito Road under certain climatic conditions. The construction of the roadway between TA–55 and TA–3 for pit production implementation would be short term and consistent with routine construction activities associated with road construction. Road construction would not be performed for a 20 pits per year production rate, the Preferred Alternative. Other planned construction activities under this alternative are mostly small-scale outdoor activities or interior to existing buildings, or the construction of an add-on to an existing building, or construction of a new building within close proximity to others. Effects of these construction activities would be primarily limited to involved workers and are not likely to result in any adverse effect to sensitive wildlife species or their habitat within the vicinity.

The primary noise, airblast waves, and ground vibration impacts from the implementation of this alternative would be generated by the increased number of HE tests, although these explosions and the resulting noise would still be occasional (rather than continuous) events. These would individually not result in effects that would be different than the effects currently generated whenever there is a HE test. The effects of these activities on cultural resources in the vicinity of the tests are addressed in section 5.3.8. It is not expected that such tests would adversely affect off-site sensitive receptors (e.g., those at BNM or at White Rock). Noises heard at that distance would be similar to thunder in intensity, and airblast and ground vibrations are not expected to be present off site of LANL at intensities great enough to adversely affect real properties. It is uncertain if any sensitive wildlife species would be adversely affected by additional numbers of "thunder-like" explosives testing events over that represented by the No Action Alternative. This is unlikely, however, given their continued presence in areas over the country that are known to be within higher-than-average lightning event areas.

5.3.2 Geology and Soils

Potential impacts for the Expanded Operations Alternative on geology and soils would be essentially the same as those for the No Action Alternative. LANL historical levels of firing site activities were 1.2 times greater than proposed for the Expanded Operations Alternative (LANL 1995d). For the same reasons as discussed under the No Action Alternative, the Expanded Operations Alternative should have little potential to contribute substantially to soil or sediment contamination. The expansion of Area G, TA–54, would temporarily result in slightly more disturbed soils than the other alternatives. This, however, would not have a significant impact on soil erosion or geology in the area because: (1) only a few disposal cells are open at any one time and (2) after a disposal cell is filled and closed, it is then revegetated. Because Zone 4 is currently designated for LLW disposal and Zone 6 is designated for solid waste management, this land is not available to be mined for mineral resources. These impacts would not change for other PSSC alternatives.

5.3.3 Water Resources

5.3.3.1 *Surface Water*

Table 5.3.3.1–1 shows the total flow from the NPDES outfalls for each of the major watersheds under the Expanded Operations Alternative. The estimated total gallons discharged into all watersheds equals 278 million gallons (1,052 million liters) under the Expanded Operations Alternative. This is an increase from the index effluent volume of 233 million gallons (882 million liters).

NPDES outfall effluent quality during the period of the SWEIS (1997 through 2006) is

TABLE 5.3.3.1–1.—*NPDES Discharges by Watershed Under the Expanded Operations Alternative*[a]

WATERSHED	#OUTFALLS		DISCHARGE (MGY) KEY FACILITIES					
			KEY FACILITIES		NON-KEY FACILITIES		TOTALS	
	INDEX	EXPANDED	INDEX	EXPANDED	INDEX	EXPANDED	INDEX	EXPANDED
Ancho	2	0	0.1	0.0	0.0	0.0	0.1	0.0
Cañada del Buey	3	3	0.0	0.0	6.4	6.4	6.4	6.4
Chaquehui	1	0	0.0	0.0	5.8	0.0	5.8	0.0
Guaje	7	7	0.0	0.0	0.7	0.7	0.7	0.7
Los Alamos	12	8	19.2	44.6	0.5	0.2	19.7	44.8
Mortandad	12	7	42.0	32.3	10.9	5.1	52.9	37.4
Pajarito	17	11	8.4	1.8	0.8	0.8	9.2	2.6
Pueblo	1	1	0.0	0.0	1.0	1.0	1.0	1.0
Sandia	11	8	4.4	42.8	103.5	127.9	107.9	170.7
Water	21	10	29.5	14.2	0.0	0.0	29.5	14.2
Totals	87	55	103.6	135.7	129.6	142.0	233.2	277.8

MGY: millions of gallons per year

[a] NPDES Information Sources: Index information was provided by the Surface Water Data Team Reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997. Additional outfalls may be eliminated in the future, as discussed in the *Environmental Assessment for Effluent Reduction* (DOE 1996e), as well as several other outfalls that may be closed as part of LANL's ongoing outfall reduction program.

expected to be the same under this alternative as described for the No Action Alternative, including the radionuclide concentrations in effluent from TA–50, as presented in Table 5.3.3.1–1. In volume III, appendix A, Table A.1–1 presents a more detailed table of the NPDES outfalls for all four alternatives by facility (key and non-key), watershed, and location. Similar to the No Action Alternative, the canyons that have an increase in outfall flow over the index are Los Alamos Canyon and Sandia Canyon. The increase in flow for Sandia Canyon is the same as that discussed for the No Action Alternative. The potential impacts from the increase in flow of 25 million gallons (95 million liters) per year in Los Alamos Canyon should be minimal for the same reasons as discussed in the No Action Alternative.

Under the Expanded Operations Alternative, a dedicated transportation corridor approximately 1 mile (1.6 kilometers) in length would be constructed between TA–55 and TA–3, parallel to Pajarito Road. It would occupy an area of approximately 7 acres (2.8 kilometers). This nearly paved surface would result in slightly more stormwater runoff. Construction activities at LANL employ engineering controls to prevent contamination of stormwater runoff. The effects at this slight increase in stormwater runoff should be minimal in terms of both erosion and sediment transport. At the 20 pits per year production rate (Preferred Alternative), the road would not be constructed.

5.3.3.2 *Alluvial Groundwater*

The increases in NPDES outfall discharges (as compared to the No Action Alternative) are expected to result in proportionally greater alluvial groundwater volumes.

The values listed above illustrate that under the Expanded Operations Alternative, the volume of effluent discharged into Mortandad Canyon from RLWTF (9.3 million gallons [35 million liters] per year) would approach double that of the RLWTF index volume of 5.5 million gallons (21 million liters) per year. Such an increase may substantially increase the volume of groundwater stored in the alluvium, raising the groundwater table and extending the groundwater body farther down the canyon. Previous estimates of water stored in the alluvium in Mortandad Canyon range from 4 to 8 million gallons (15 to 30 million liters). The capacity for additional storage is unknown. Also unknown are the rates of infiltration into the tuff below and the volume lost to evaporation. If evaporation rates or infiltration rates into the underlying tuff beneath the alluvium are sufficiently low, it is possible that increasing the discharge volume may eventually result in groundwater resurfacing as seeps or springs farther down the canyon. However, it is important to note that this is unlikely because under past conditions of maximum discharge (up to 13 million gallons [50 million liters] per year) at RLWTF, no springs or wetlands were created.

Another important factor to consider is that the overall flow from NPDES outfalls into Mortandad Canyon will be decreased from the baseline by 16 million gallons (61 million liters) per year. The majority of the outfalls with reduced flows are TA–48 and TA–35, and they are either just upstream or close to the RLWTF outfall.

The impacts to alluvial groundwater quality should be minimal; however, any additional groundwater could increase infiltration into the tuff below the alluvium. The potential for groundwater migration down the Guaje Mountain Fault zone, located approximately one-quarter mile (0.4 kilometer) downstream of RLWTF outfall, may also increase. Increased infiltration through the tuff or the fault zone may allow more rapid transport of contaminants to the main aquifer. As discussed in the No Action Alternative, tritium and nitrate have been detected in the main aquifer beneath Mortandad Canyon, indicating that migration pathways possibly do exist (LANL 1992, LANL 1993, LANL 1994, and LANL 1995c). LANL will continue to monitor downstream of the RLWTF the main aquifer and alluvial groundwater for any indicators of potential problems.

As discussed for the No Action Alternative, the new HELWTF became fully operational in 1998 and water quality will likely improve in Canyon de Valle near TA–16.

5.3.3.3 *Perched Groundwater*

Groundwater flow and contaminant pathways to the intermediate perched groundwater bodies are not well characterized nor understood. It is possible that the increased NPDES discharges to Los Alamos and Sandia Canyons under this alternative could increase recharge of the intermediate perched groundwater and contaminant transport beneath these canyons.

5.3.3.4 *Main Aquifer*

Recharge mechanisms to the main aquifer are uncertain. However, for the same reasons as discussed under the No Action Alternative, impacts resulting from increased NPDES outfall flows to the main aquifer water quality should be negligible under the Expanded Alternative.

A conservative projection of LANL water use under the Expanded Operations Alternative is 759 million gallons (2,873 million liters) per year. Los Alamos County and the NPS did not provide projections, but in 1994 the County used about 958 million gallons (3,626 million liters) from this water right and the NPS used about 5 million gallons (19 million liters). Based on this information, it is expected that the water requirements of this community can be met within the existing water rights from the main aquifer; however, projected use may approach 100 percent of the existing water rights to the main aquifer under this alternative.

For the purposes of modeling drawdown of the main aquifer, annual water use projections were made. The total water usage from DOE water rights was projected to average 1,724 million gallons (6,525 million liters) per year under the Expanded Operations Alternative, with a maximum annual use of 1,751 million gallons (6,628 million liters) and a minimum annual use of 1,665 million gallons (6,302 million liters).

The model results reflect water level changes at the top of the main aquifer across the alternatives, given continued draw from the aquifer by DOE, Española, and Santa Fe. Table 5.3.3.4–1 shows predicted water level changes at the surface of the main aquifer during the period from 1997 through 2006 for the Expanded Operations Alternative; as noted in section 5.2.3.1, these changes are not all due to LANL operations. Although the water use modeled includes water use in Española and Santa Fe, the differences between the alternatives are due only to LANL operations. The impacts to the volume of water in the main aquifer under this alternative are very similar to those described for the No Action Alternative; the drawdowns in DOE well fields are minimal relative to the total thickness of the main aquifer, and the volume of water to be used over the period from 1997 through 2006 is negligible relative to the volume of water in storage.

Details of the conceptual model, assumptions, uncertainties and limitations, and input parameters for the groundwater model are described in volume III, appendix A.

5.3.3.5 *Area G*

In 1997, a draft Performance Assessment (PA) and Composite Analysis (CA) were prepared for the current solid LLW disposal facility, Area G. The PA was approved by DOE in October 1998 (LANL 1998c). The purpose of the PA is to determine if Area G disposal of LLW generated and projected since September 26, 1988, would result in radiation doses to members of the public that exceed performance objectives specified by DOE

TABLE 5.3.3.4–1.—*Maximum Water Level Changes at the Top of the Main Aquifer Under the Expanded Operations Alternative (1997 Through 2006)*

WATER LEVEL CHANGE IN FEET[a,b]	
AREA OF CONCERN ON SITE	
Pajarito Well Field	-15.6
Otowi Well Field (Well 0-4)	-15.2
AREA OF CONCERN OFF SITE	
DOE - Guaje Well Field	-9.3
Santa Fe Water Supply	
Buckman Well Field	+21.6
Santa Fe Well Field	-20.6
San Juan Chama Diversion	0.0
Springs	
White Rock Canyon Springs, Maximum Drop	0.0
White Rock Canyon Springs, Maximum Rise	+1.0
Other Springs (Sacred, Indian)	+3.8
San Ildefonso Pueblo Supply Wells	
West of Rio Grande	
Household, Community Wells	+0.6
Los Alamos Well Field	+3.8
East of Rio Grande	
Household, Community Wells	0.0

[a] Negative value (-) indicates water level drop; positive value (+) indicates water level rise.
[b] Also, the water level changes projected by the regional MODFLOW model represent average changes over a whole grid- cell (i.e., a square that is a mile on a side). They are, for the most part, not predictive of the water level changes at any single point within the cell (for example, a supply well). Pumping wells have characteristic "cones of depression" where the water surface reflects an inverted cone, and water levels at the well may be quite different from levels even a few ten's of feet away. Whether any individual well would exhibit water level changes consistent with the predicted grid-cell average change is a function of, for example, its location within the grid-cell; proximity to other pumped wells; and the individual well operation, construction, and hydraulics. Hence, the water level changes predicted by the model can only be considered qualitatively and can not be considered as finite changes.

Order 5820.2A and the report, *Interim Format and Content Guide and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments* (DOE 1996c). In a complementary fashion, the CA is used to evaluate options for ensuring that exposures from all waste disposed of at Area G will not impart doses to future members of the public in excess of specified limits. Together, the PA and CA provide a comprehensive evaluation of the potential radiological exposures to future members of the public from past, present, and future waste disposal at Area G. The PA includes as part of the "future disposal of waste at Area G" the expansion of Area G, as discussed in volume II, part I of this SWEIS. Doses are projected beyond 1,000 years after facility closure, which is assumed to occur in 2044. These results are compared with performance objectives. The results of the PA in terms of surface water and groundwater impact are summarized in the following paragraphs. While the PA and CA are specific to Zone 4 at Area G, the geologic features of the entire Mesita del Buey have essentially identical site characteristics, and the PA and CA results for Zone 4 would be applicable to the Zone 6 and North Site locations as well. While there are some differences between the characteristics between the Zone 4 and TA–67 sites, these are sufficiently similar that the PA and CA results would be expected to be applicable to TA–67; the one potential exception to this statement is that the fault underlying part of TA–67 could introduce some additional issues regarding the use of TA–67 for waste disposal (Newell 1998).

Flooding of the disposal facility is not a major concern due to the natural inclination for runoff from the mesa into canyon; temporary ponding within disposal pits, however, has occurred. A recent field study at Area G demonstrated that disposal cells covers are subject to sheet erosion, with only small, localized rill occurring infrequently. The expansion of Area G would temporarily result in slightly more disturbed soils. This, in turn, would result in slightly more stormwater runoff.

Observation wells and moisture-access holes were drilled in Cañada del Buey and Pajarito Canyon to determine if perched water existed within canyon alluvium and, if present, if it extended beneath Mesita del Buey. Wells in Cañada del Buey were essentially dry, and it was concluded that perched water in Pajarito Canyon, adjacent to Mesita del Buey, is confined to the alluvium in the stream and does not extend to the flank of the canyon.

It was concluded that the main aquifer is the only source capable of serving municipal and industrial water needs, and the PA results show that the design of Area G takes advantage of the natural ability of the site to contain radioactivity (Purtyman 1995). The very dry host rock effectively decouples radioactivity in LLW from the main aquifer for thousands of years. The groundwater performance objective is a maximum effective dose equivalent of 4 millirem per year to any member of the public from the consumption of drinking water drawn from wells outside of the land-use boundary. The groundwater protection analysis from the PA and CA resulted in peak annual doses within 1,000 years at the point of maximum exposure, the east-southeast boundary of Area G and Parjarito Canyon, of 7.5×10^{-8} and 0.000035 millirem, respectively. These doses are more than 100,000 times smaller than the dose performance objectives.

5.3.4 Air Quality

5.3.4.1 *Nonradiological Air Quality Impacts*

Criteria Pollutants

As stated in section 5.1.4, estimates of future emission rates were based on the operations anticipated under the Expanded Operations Alternative—the worst-case alternative with respect to emission rates from the combustion sources. The results of the Expanded Operations Alternative analysis of criteria pollutants demonstrate that the highest estimated concentration of each pollutant would be below the standards established to protect human health with an ample margin of safety. These results are presented in Table 5.3.4.1–1.

Toxic Air Pollutants

In all but two cases, the estimated pollutant concentrations were below the corresponding GVs established for this analysis. GVs are the levels established to screen emission rates for further analysis. The two cases where estimated emission rates were above GVs and were referred to the human health and ecological risk assessment processes are:

- Emissions from HE Firing Site operations at TA–14, TA–15, TA–36, TA–39, and TA–40 (appendix B, attachment 13); the estimated concentration of a pollutant is greater than its GV for the following releases:
  - DU, beryllium, lead, aluminum, copper, tantalum, tungsten, and iron from TA–15
  - DU, beryllium, lead, copper, and iron from TA–36
  - Beryllium, lead, aluminum, and copper from TA–39
  - DU and lead from TA–14
  - Copper from TA–40
- The additive emissions from all of the pollutants from all TAs on receptor sites located near the Los Alamos Medical Center (appendix B, attachment 6)

The combined incremental cancer risks associated with releases of all carcinogenic pollutants from all TAs at the receptor locations where these impacts actually occur are slightly above GV of 1.0×10^{-6} only at the two locations within the LANL medical center: 1.17×10^{-6} at

TABLE 5.3.4.1–1.—*Results of Criteria Pollutants Analysis (Expanded Operations Alternative)*

POLLUTANT	TIME PERIOD	MAXIMUM ESTIMATED CONCENTRATIONS ($\mu g/m^3$)	ASSUMED BACKGROUND CONCENTRATIONS[a] ($\mu g/m^3$)	TOTAL POLLUTANT CONCENTRATIONS ($\mu g/m^3$)	NEW MEXICO CONTROLLING AMBIENT AIR QUALITY STANDARDS[b] ($\mu g/m^3$)
Carbon Monoxide	1 hour	2,712	2,350	5,062	11,750
	8 hours	1,436	1,560	2,996	7,800
Nitrogen Dioxide	24 hours	90[c]	29	119	147
	Annual	9	15	24	74
Sulfur Dioxide	3 hours	254	205	459	1,025
	24 hours	130	41	171	205
	Annual	18	8	26	41
Total Suspended Particulates	24 hours	18	30	48	150
	Annual	2	12	14	60
PM_{10}	24 hours	9	30	39	150
	Annual	1	10	11	50
Lead	3 months (calendar quarter)	0.00007	0.30	0.30	1.5

[a] No data exist for background values. It was conservatively assumed that background concentrations were 20 percent of the corresponding standard. As there are almost no other combustion sources in and around Los Alamos, the background concentrations would be much less than the 20 percent assumed concentrations.

[b] New Mexico Ambient Air Quality standards, for some of the pollutants, are stated in parts per million (ppm). These values were converted to micrograms per cubic meter ($\mu g/m^3$), with appropriate corrections for temperature and pressure (elevation) following New Mexico Dispersion Modeling Guidelines (NM 1996).

[c] New Mexico Air Quality Bureau accepts Ozone Limiting Method (OLM) to more accurately determine nitrogen dioxide (NO_2) concentrations. The 24-hour maximum modeled concentration for nitrogen oxide was 520 $\mu g/m^3$. This concentration, when modeled using OLM, is only 90 $\mu g/m^3$ of NO_2.

an air intake duct, and 1.07 x 10^{-6} at an operable window.

The major contributors to the estimated combined cancer risk values are chloroform, formaldehyde, and trichloroethylene from TA–43, the HRL, and multiple sources for methylene chloride. The estimated maximum cancer risk for each of these individual pollutants is 9 x 10^{-7}, 5 x 10^{-8}, 7 x 10^{-8}, and 7 x 10^{-8}, respectively. Of these, the relative contribution of chloroform emissions alone to the combined cancer risk value is more than 87 percent (conservatively assuming that 100 percent of the chloroform used is emitted). The impacts of TA–43 emissions are due to a combination of relatively high emission rates, close proximity between receptors and sources, and the elevation of the receptors.

5.3.4.2 *Radiological Air Quality Impacts*

This section addresses the radiation dose to the FS MEI, LANL MEI and the population dose from LANL radionuclide air emissions under the Expanded Operations Alternative.

Facility-Specific Maximally Exposed Individual

MEI dose estimates are shown in Table 5.3.4.2–1. This table shows the highest FS MEI dose is 5.44 millirems per year, which is 54.4 percent of the regulatory limit for the air pathway. The EPA regulatory limit would not be exceeded from emissions of these facilities under the Expanded Operations Alternative.

TABLE 5.3.4.2–1.—*Facility-Specific Information—Expanded Operations Alternative*

FACILITY	DOSE[a] (mrem/yr)
TA–3–29 (CMR)	1.32
TA–3–66 (Sigma Building)	1.32
TA–3–102 (Machine Shops)	1.02
TA–11 (High Explosive Testing)	0.73
TA–15/36 (Firing Sites)	4.99
TA–16 (WETF)	0.70
TA–18 (Pajarito Site: LACEF)	4.39
TA–21 (TSTA and TSFF)	2.55
TA–48 (Radiochemistry Laboratory)	3.67
TA–55 (Plutonium Facility)	3.67
TA–53 (LANSCE)[b]	5.44
TA–54 (Boundary)[c]	1.81
TA–54 (White Rock)	1.07

[a] For each FS MEI, the total dose was calculated by adding the contributions from each modeled facility. An MEI does not leave or take protective measures.

[b] This is also the LANL MEI. Five specific sources were modeled from TA–53. These include the TA–53 ES-2, ES-3, IPF, LEDA and combined diffuse emissions.

[c] Two FS MEI locations were considered for TA–54 because Area G is bordering San Ildefonso Pueblo land. The first is a MEI location at the LANL boundary, 1,197 feet (365 meters) northeast of Area G. No person from the Pueblo currently is known to live along this boundary. The second is an actual MEI location in the town of White Rock, approximately 5,331 feet (1,625 meters) southeast of Area G.

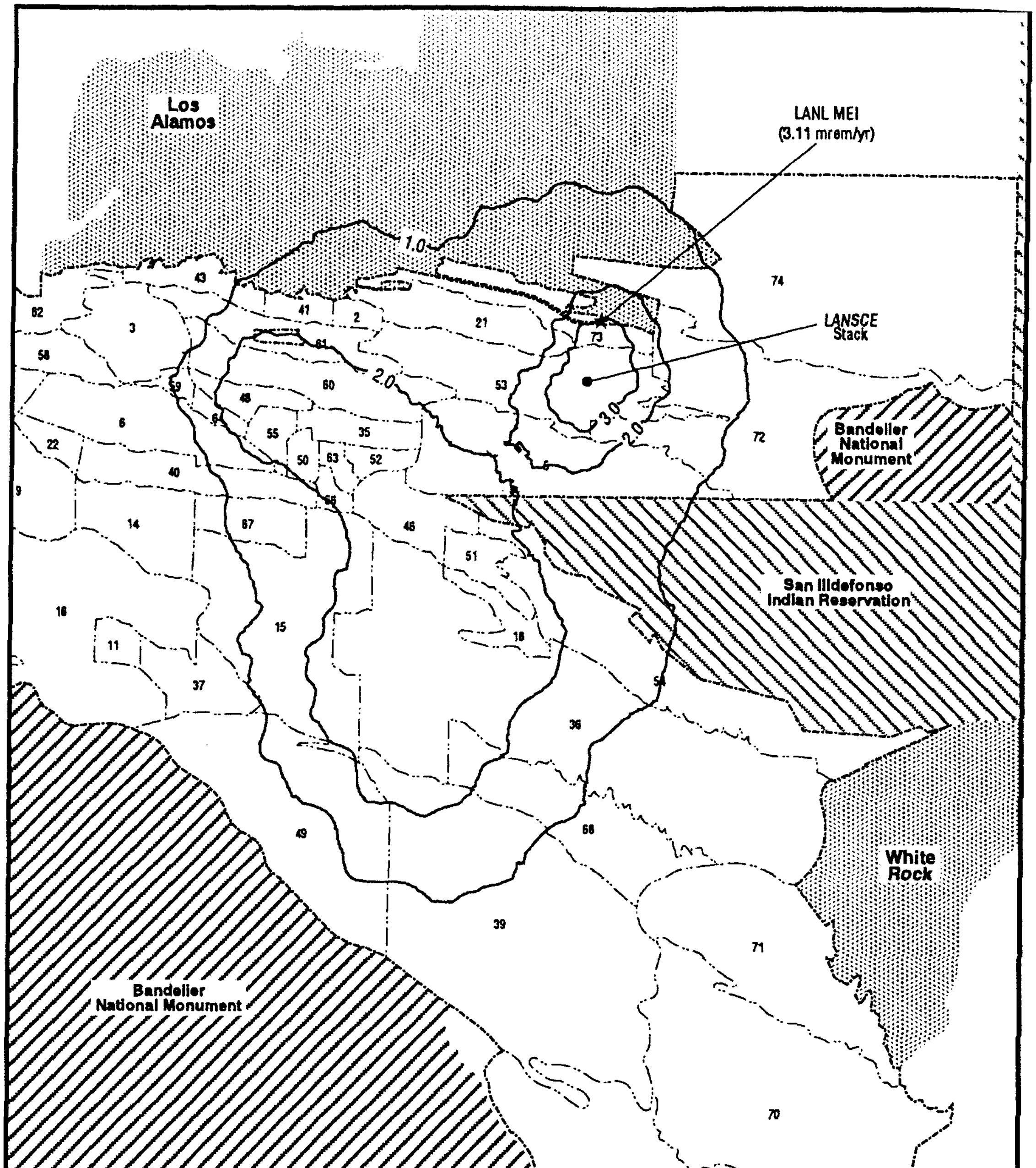
LANL Maximally Exposed Individual

The location of the LANL MEI (2,625 feet [approximately 800 meters] north-northeast of TA–53) was shown to be identical to the FS MEI with the highest dose under the Expanded Operations Alternative. The LANL MEI dose was also calculated to be 5.44 millirems per year.

Population Dose. The collective dose to the population living within a 50-mile (80-kilometer) radius from LANL was calculated to be 33.09 person-rem per year. TA–15/36 accounts for 64.1 percent of this dose (collective diffuse emissions, including those from these TAs, account for 64.5 percent of this dose). The values reported for population doses for this alternative, as well as the other alternatives, is higher than has been reported in the recent annual environmental reports. It is important to recognize that the alternatives analyzed represent increased operations when compared to recent history. The material throughput at the different facilities under the various alternatives is presented in chapter 3 (section 3.6).

Isodose Maps. The isodose maps for the Expanded Operations Alternative are shown in Figures 5.3.4.2–1 and 5.3.4.2–2.

Pit Production. The impacts listed above are influenced only slightly by pit production activities. At the CMR Building, there are two types of contributions: (1) analytical chemistry support and (2) activities moved from TA–55 to the CMR Building under the "CMR Building Use" Alternative for pit production. At a pit production rate of 80 pits per year, regardless of the PSSC alternative, analytical chemistry support is projected to contribute about 13 microcuries per year to the total CMR Building air emissions (which are projected to be about 760 microcuries per year under the Expanded Operations Alternative).



Note: The isodose lines are given in units of mrem.

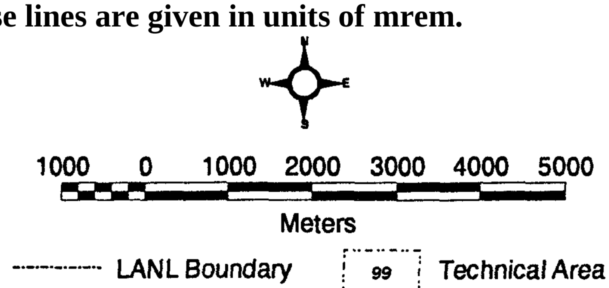
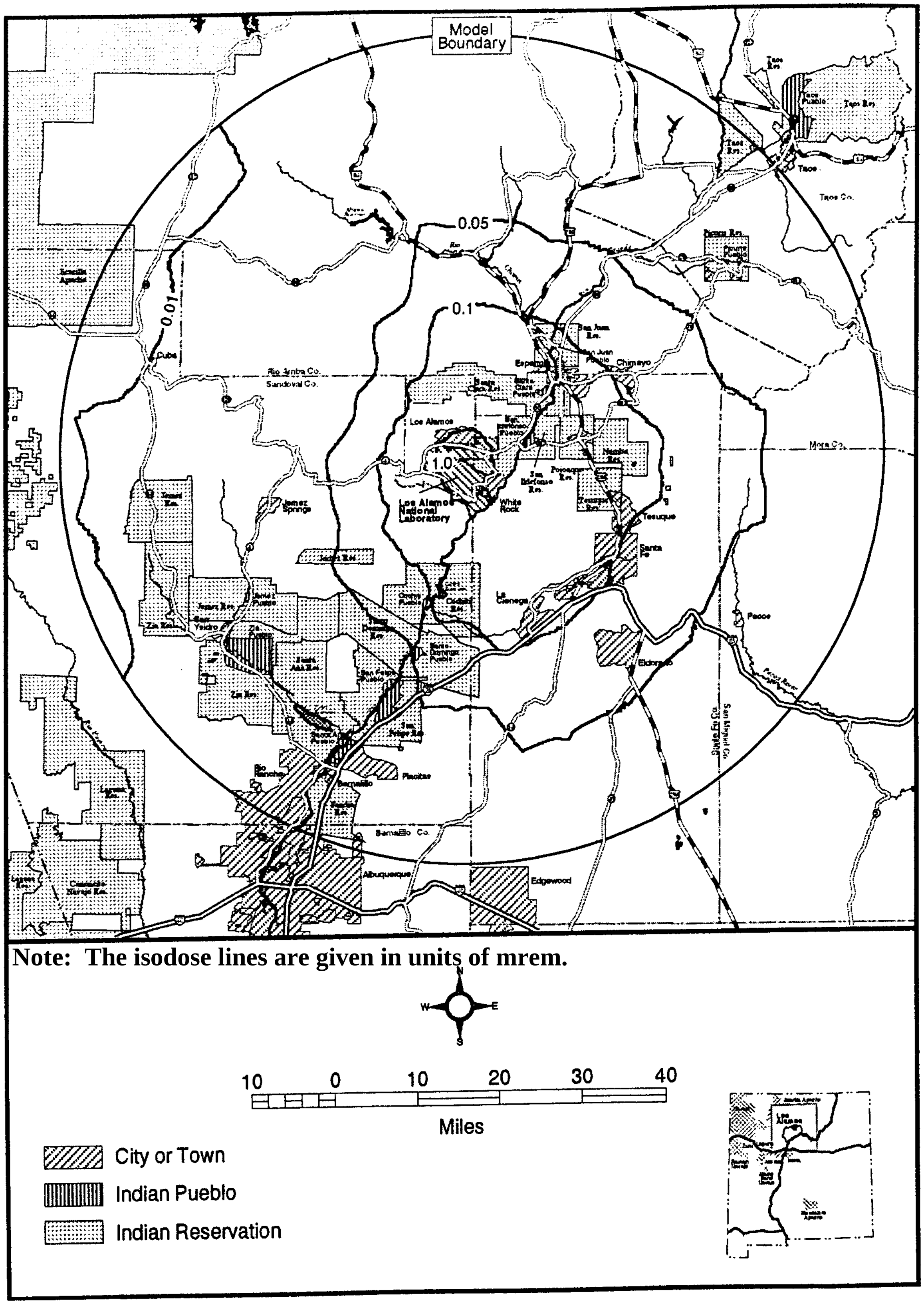


FIGURE 5.3.4.2–1.—*Isodose Map Showing Doses Greater Than 1 Millirem per Year for the Expanded Operations Alternative.*



Note: The isodose lines are given in units of mrem.

FIGURE 5.3.4.2–2.—*Isodose Map Showing Doses Less Than 1 Millirem per Year for the Expanded Operations Alternative.*

At a pit production rate of 20 pits per year (Preferred Alternative), the analytical chemistry contribution to air emissions is projected to be about 3 microcuries per year (or about a quarter of the 80 pits per year contribution to emissions).

Under the Brownfield and TA–55 Add-on Alternatives, as well as at the 20 pits per year production rate (Preferred Alternative), the analytical chemistry contribution to air emissions is the only contribution directly attributable to pit production. However, under the PSSC "CMR Building Use" Alternative (at 80 pits per year), activities that contribute to air emissions are moved from TA–55 to the CMR Building. The total contribution of these activities to CMR Building emissions is projected to be about 25 microcuries per year (as compared to the CMR Building total emissions of 760 microcuries). Thus, the CMR Building radioactive air emission rates directly attributable to pit production work at LANL do not substantially influence the FS MEI dose, the LANL MEI dose, the population dose, or the isodose maps.

At TA–55, there are two types of activity contributions important to understanding pit production impacts: (1) pit production work within TA–55 and (2) activities that would be moved to the CMR Building under the PSSC "CMR Building Use" Alternative. The pit production work at LANL contributes about 11 microcuries per year to air emissions at the 80 pits per year rate; at the 20 pits per year rate (Preferred Alternative), the contribution would be about 3 microcuries per year. For the PSSC "CMR Building Use" Alternative, activities that contribute about 25 microcuries per year in emissions (under the Expanded Operations Alternative level of operations) are transferred to the CMR Building. Under the Brownfield and TA–55 Add-on PSSC Alternatives, as well as at the 20 pits per year rate (Preferred Alternative), those activities would remain at TA–55 (and those emissions would remain at TA–55).

The PSSC "CMR Building Use" Alternative results in total TA–55 particulate radioactive air emissions of about 27 microcuries per year. At the 20 pits per year rate (Preferred Alternative), the total TA–55 particulate air emissions would be about 44 microcuries per year. The radioactive particulate air emissions associated with TA–55 operations, including those associated with pit production activities, are substantially smaller than emissions throughout LANL that contribute substantially to the LANL MEI, the population dose, and the isodose map contours. While the TA–55 MEI dose could change slightly depending on the PSSC alternative selected (or as compared to that at the 20 pits per year rate, the Preferred Alternative), such changes would not be expected to be substantial for the following reasons:

- The 25 microcuries per year associated with activities that might move to the CMR Building under the PSSC "CMR Building Use" Alternative, is a small amount compared to other radioactive air emissions in the area.
- Whether those emissions (25 microcuries per year) occur at the CMR Building or at TA–55, they contribute to the TA–55 MEI dose. (Of course, their contribution to the TA–55 MEI dose is greater as a TA–55 emission than as a CMR Building emission.)
- The TA–55 MEI dose has substantial contributions from other facilities in the area—99 percent of the TA–55 MEI dose under the PSSC "CMR Building Use" Alternative is due to facility emissions other than those of TA–55. (See volume III, appendix B, Table B.1.2.1.–2.)

In short, the TA–55 radioactive air emissions differences due to the different PSSC alternatives (or the 20 pits per year rate, the Preferred Alternative) are not expected to result in substantial changes in the impacts reflected above.

5.3.4.3 *Project-Specific Siting and Construction Analyses*

As noted in volume II, part I, the expansion of Area G into Zones 4 and 6 would generate dust particles and vehicle exhaust during construction, in addition to the operational impacts discussed above. Additionally, trees cleared from the area may be chipped and burned on site. These construction impacts would be mitigated through dust suppression methods such as misting, and any burning would be performed under an open burning permit such that air quality standards would not be violated. These construction activities would not be expected to degrade the quality of air in residential areas. The impacts would be similar under any of the alternatives considered in this PSSC analysis, with the potential for increased clearing and wood burning associated with the TA–67 alternative.

As discussed in volume II, part II, the construction activities associated with the enhancement of pit manufacturing would not be expected to change radiological air emissions. Nonradiological emissions associated with this construction activity would be expected, but would not exceed regulatory standards and would not be expected to impact workers or the public. The impacts would be similar under any of the alternatives considered in this PSSC analysis. (Note that the nonradiological emission impacts associated with these construction activities would not be incurred at the 20 pits per year production rate, the Preferred Alternative.)

5.3.5 Ecological Resources, Biodiversity, and Ecological Risk

Impacts to ecological resources and biodiversity resulting from implementation of the Expanded Operations Alternative would be similar to that of the No Action Alternative, even considering the chemical emissions that exceeded GVs, as discussed in section 5.3.4. Ongoing LANL facility operation and planned actions would enhance current biological resources (including protected and sensitive species), ecological processes, and biodiversity. There would be a small habitat loss due to the expansions of pit manufacturing and Area G's disposal area, as discussed in section 5.3.5.1. Impact to wetlands as a consequence of outfall reduction and an increase in effluent discharges would be approximately the same as for the No Action Alternative. While effluent quantities would be higher than No Action, the potential for expansion of wetlands would remain low.

There would be an increase in the frequency of explosives testing associated with Expanded Operations. However, the noise and vibration associated with individual testing events would be the same as currently experienced, and no adverse impacts to animals, including threatened and endangered species, are anticipated from this increase in testing frequency.

As with the No Action Alternative, Expanded Operations would have little potential to contribute substantially to soil, water, and air contamination. The projected slight increase in deposition of contaminants resulting from an increase in the frequency of explosives testing would be small relative to historical deposition rates. Consequently, there would not be a discernible change from the No Action level of ecological risk. Again, the continued cleanup of legacy contamination is expected to reduce the contribution of past (legacy) LANL operations to ecological risk.

5.3.5.1 *Project-Specific Siting and Construction Analyses*

The proposals to expand pit manufacturing operations and expand Area G's LLW disposal area are integral components of expanded operations. These two components of expanded operations involve removal and disturbance of habitat as a consequence of facility construction.

The removal of vegetation (primarily ponderosa pine-Gambel oak woodland) due to the proposed road connecting TA–3 with TA–55 would remove a small amount of habitat for small mammals and birds, and the possible erection of a mile-long security fence could alter large mammal movement along Pajarito Road. This habitat loss would be small, and altered large animal movement should not appreciably affect animal behavior and habitat use. Disturbance to wildlife utilizing adjacent habitat due to construction noise and activity would be minor and short term. Under the Preferred Alternative, at the 20 pits per year production rate, this would not be built, so these impacts would not be incurred.

Both the peregrine falcon and the bald eagle could utilize the area proposed for the road as part of their overall foraging area. A preliminary model for Mexican spotted owl habitat indicates that fragmented patches of potential nesting/roosting habitat exists within 0.2 mile (0.32 kilometer) of the proposed connector road, and the road area includes foraging habitat. The bald eagle is not likely to be adversely affected by the very small loss of low use foraging habitat, and the loss of less than 0.05 percent of foraging habitat available for the peregrine falcon on LANL is not likely to result in an adverse effect. The Mexican spotted owl is not likely to be adversely affected because of the fragmented nature of potential nesting/roosting habitat, current high level of noise and disturbance in the area, and very small reduction (0.06 percent) of available foraging habitat within LANL boundaries. Because these impacts are related to the road, if the road is not built under any of the PSSC alternatives, these impacts would not be incurred. (Also, under the Preferred Alternative at 20 pits per year production rate, at the road would not be built and these impacts would not be incurred.)

The phased expansion of Area G would involve the gradual removal of approximately 41 acres (16 hectares) of pinyon-juniper woodland. This removal would change or eliminate bird and small mammal habitat in direct proportion to the acreage disturbed. Because of the local and regional abundance of this community type and partial ground cover restoration following pit closure, wildlife habitat loss and disturbance would be small. Disturbance resulting from construction noise and activity would be minor and short term. No new impacts to large mammals are anticipated. Area G is part of the LANL-wide foraging habitat for the peregrine falcon and a nest site is located more than 3 miles (4.8 kilometers) away. Implementation of the proposed action would not affect nesting habitat nor would the eventual loss of up to 41 acres (16 hectares) (0.05 percent) of available foraging habitat on LANL adversely affect the peregrine falcon. The nature of these impacts would be the same for any of the PSSC alternatives considered, with the only difference being the acreage involved (volume II, part I).

5.3.6 Human Health

The consequences of implementation of the Expanded Operations Alternative on public health and worker health are presented below. As discussed in section 5.1.6 and in volume III (appendix G, section G.1), “risk,” as used in the SWEIS human health analysis, refers to the probability of toxic or cancer mortality under the specific exposure scenarios analyzed.

5.3.6.1 *Public Health*

The consequences of continued operations of LANL on public health under the Expanded Operations Alternative are presented below for the same topics discussed in section 5.2.6.1.

Regional Consequences of Airborne Radioactivity Inhalation and Immersion

The LANL MEI was estimated to be 2,625 feet (approximately 800 meters) north-northeast of LANSCE (TA–53). This location is within the LANL reservation, and the dose to the MEI at this location is 5.44 millirem per year (section 5.3.4.2), corresponding to a 72-year lifetime dose of 390 millirem. This location borders the Los Alamos townsite and is a conservative estimate for a MEI from LANL emissions. The background total effective dose equivalent (TEDE) dose in the Los Alamos area is estimated to be 360 millirem per year (section 4.6.1.1); thus, the dose to the MEI is 1.5 percent of the background dose.

Table 5.3.6.1–1 summarizes the LANL MEI dose and presents the corresponding risk of excess LCF to the MEI. These risks are presented on a lifetime basis, assuming that the LANL MEI received the estimated dose of 5.44 millirem each year for a 72-year life. The excess LCF risk was estimated to be 0.0002 over a lifetime.

The isodose maps showing both the estimated dose near LANL and within a 50-mile (80-kilometer) radius of LANL are given in Figures 5.3.4.2–1 and 5.3.4.2–2. The population dose within the 50-mile (80-kilometer) radius is also given in Table 5.3.6.1–1, estimated to be 33.1 person-rem per year. As reflected in the table, the annual operations excess LCF risk was estimated to be about 0.017.

In the Expanded Operations Alternative, there are 11 facilities with FS MEIs receiving a dose that would exceed 1 millirem per year (volume III, appendix B):

- LANSCE, 5.44 millirem per year to the FS MEI
- HE Testing Sites (TA–15 and TA–36), 4.99 millirem
- Pajarito Site (TA–18), 4.39 millirem
- Radiochemistry Laboratory (TA–48). 3.67 millirem
- Plutonium Facility (TA–55), 3.67 millirem
- TSTA and TSFF (TA–21), 2.55 millirem
- Area G (at LANL boundary), 1.81 millirem
- CMR Building, 1.32 millirem
- Sigma, 1.32 millirem
- Area G (at White Rock), 1.07 millirem
- Machine Shop, 1.02 millirem

External Radiation: Two Special Cases

As discussed in section 5.2.6.1, one contribution to public dose results from jogging or hiking for 96 hours on the access road north of TA–21 and is attributable to cesium-137 known to be on the ground within the TA. The MEI dose is not expected to change under the Expanded Operations Alternative from that estimated under the No Action Alternative (an EDE of 2.9 millirem per year and an excess LCF risk of about 1.4 x 10^{-6} per year).

Another contribution to public dose, as discussed in section 5.2.6.1, would result from TA–18 "road-open" operations. At the 95 percent confidence level, six exposures per

TABLE 5.3.6.1–1.—*Estimated Public Health Consequences for LANL MEI and the Population Within a 50-Mile (80-Kilometer) Radius of LANL for the Expanded Operations Alternative*

PARAMETER	LANL HYPOTHETICAL MEI	50-MILE (80-KILOMETER) RADIUS POPULATION
Dose	5.44 millirem/year	33.09 person-rem/year
Excess LCF	0.000196/lifetime (72 year)	0.017/year of operations

year of 4.75 millirem each would be expected for the MEI out of the 150 operations per year at TA–18 under the Expanded Operations Alternative. This would result in an annual projected MEI EDE of 28.5 millirem per year. The lifetime excess LCF risk for this dose is about 0.0000142 per year of operation.

Nonionizing Radiation

The only uncontained nonionizing radiation source in use or planned for LANL is the microwave transmitter in TA–49. The consequence of a public exposure to this source under the Expanded Operations Alternative is the same as for the No Action Alternative; as discussed in section 5.2.6.1, this consequence is negligible.

Consequences of Airborne Chemical Emissions

In the analysis of the Expanded Operations Alternative, four technical areas involved in HE testing were identified (TA–14, TA–15, TA–26, and TA–39) to require public health consequence analysis for specific chemicals (beryllium, lead, and DU). As discussed in section 5.2.6.1, other chemical emissions from HE testing operations were not analyzed in detail because their toxicity reference values and estimated concentrations in air were minor, as compared to those emissions analyzed in detail. Hazard indices were calculated for two of these three metals. An HI equal to or above 1 is considered consequential from a human toxicity standpoint. For the Expanded Operations Alternative, the worst-case HI for lead did not exceed 1.5 in 100,000 (0.000015). For DU, the worst-case HI did not exceed 6.5 in 100,000 (0.000065).

Beryllium has no established EPA reference dose from which to calculate the HI. Beryllium was evaluated as a carcinogen, however. The excess LCF for beryllium under the Expanded Operations Alternative was estimated to be 3.6×10^{-7} per year.

Carcinogenic Risk from Air Emissions

The screening process described in volume III, appendix B, identified no individual carcinogenic chemical air emission that required analysis for public health consequences. For carcinogens, an estimate also was made of the combined lifetime incremental cancer risk due to all carcinogenic pollutants from all TAs. The risk factors used are conservative, and represent the upper bound of the risk. The carcinogenic risk is also uncertain, and could be much smaller, as discussed in appendix D, section D.1.1.8.

This incremental combined cancer risk to the public due to all carcinogenic pollutants from all TAs exceeded the 1.0×10^{-6} GV level at two locations at the Los Alamos Medical Center: receptor site 175, the air duct 39 feet (12 meters) above grade (1.17×10^{-6}), and receptor site 180, an operable window 5 yards (1.5 meters) above grade (1.07×10^{-6}) (section 5.3.4.1 and appendix B, attachment 6, Table D). The incremental combined cancer risk estimated under the Expanded Operations Alternative for these two locations are dominated by the contribution estimated for chloroform emissions from HRL, next to the Los Alamos Medical Center.

The sensitivity of the incremental combined cancer risk analysis to chloroform is so great that the realism of the assumptions made for chloroform emissions estimation were examined. The assumptions were found to be unrealistic because the screening analysis assumed that 100 percent of the chloroform used was emitted into the air outside HRL. Records at HRL indicate that at least 50 percent of the annual usage of chloroform is disposed as liquid waste and could not be, therefore, released to the air. Using the more realistic but maximum concentrations of chloroform that could be emitted into the air, the incremental combined cancer risk at the two receptor locations at Los Alamos Medical Center would be 7.3 to 7.4×10^{-7}. This value is below the GV for human health consequences from carcinogenic air emissions. No further analysis was conducted because any further analysis would simply reduce the estimated incremental combined cancer risk toward more realistic levels. It is believed that negligible increase in incremental combined cancer risk will result from the Expanded Operations Alternative.

Consequences of Ingestion to Residents, Recreational Users, and Special Pathways Receptors

The risk to the public from ingestion under the Expanded Operations Alternative does not differ from that associated with the No Action Alternative; this is because most of the risk is attributable to the existing levels of contamination in water and soils in the area. This is discussed further in sections 5.1.6 and 5.2.6.1. Tables 5.2.6.1–2 and 5.2.6.1–3 summarize the total radiological annual ingestion dose and excess LCF to members of the public. Per Table 5.2.6.1–3, the total worst-case ingestion doses for the off-site resident of Los Alamos County and non-Los Alamos County resident are 0.011 and 0.017 rem per year, respectively. If this person is also a recreational user of the Los Alamos canyons, drinking canyon water and ingesting canyon sediments, the worst-case additional dose ranges up to 0.001 rem per year, according to the amount of time spent in the canyons (see footnote b in Table 5.2.6.1–3). If the individual has traditional Native American or Hispanic lifestyles, the values found in the final columns of the table should be used in place of the values in the first columns for off-site residents. Per the values in the final columns, these "special pathways receptors" can have worst-case 3.1 millirem per year additional dose. The associated excess LCF risks for the off-site residents are 8.6×10^{-6} per year of exposure and 9.1×10^{-7} per year of exposure for the individual who is also an avid recreational user. These worst-case doses are for a 95th percentile intake of the 95th percentile contamination level, referred to as the UCL. Ingestion pathway calculations included all radionuclides detected in the media. This includes natural background, weapons testing fallout, and previous releases. The actual contribution from continued operations at LANL is only a small fraction of this value. These values apply to the baseline and to all four alternatives. The data and analyses for these calculations are in appendix D, section D.3.3. Table 5.2.6.1–3 summarizes the risk associated with metals ingestion to MEIs in the LANL region, which does not vary among alternatives. The risk factors used are conservative and represent the upper bound of the risk. The carcinogenic risk also is uncertain and could be much smaller, as discussed in appendix D, section D.1.1.8.

Consequences to the Public along Transportation Routes

Section 5.3.10 details the analysis of transportation consequences. Public health consequences include the dose and excess LCF risk associated with routine, accident-free transportation. Table 5.3.10–2 shows the population dose and excess LCF for normal (accident-free) off-site shipments. The population dose and excess LCF associated with exposures occurring during stops for transportation segments near LANL is provided in Table 5.3.6.1–2. Doses associated with living along and sharing routes with these shipments are detailed in Table 5.3.10–2, and are less than those associated with stops. Risks associated with accidents during transportation also are discussed in section 5.3.10.

5.3.6.2 *Worker Health*

Worker risks associated with continued operations of LANL include radiological (ionizing and nonionizing) risks, chemical exposure risks, and risk of injury during normal operations. The consequences to worker health from implementing the Expanded Operations Alternative are given below and detailed in volume III, appendix D, section D.2.2.

TABLE 5.3.6.1–2.—*Radiation Doses and Excess LCF Risks Estimated to the Public at Stops During Transportation of Materials and Wastes from LANL Under the Expanded Operations Alternative*

ROUTE SEGMENT	PERSON-REM PER YEAR (AT STOPS)	EXCESS LCF RISK PER YEAR
LANL to U.S. 84/285	4.0	0.0020
U.S. 84/285	4.2	0.0021

Radiological Consequences

Ionizing Radiation Consequences. Table 5.3.6.2–1 summarizes the projected doses and associated excess LCF risks from implementation of the Expanded Operations Alternative.

The collective worker dose under the Expanded Operations Alternative is conservatively projected to be approximately four times that measured in 1993 to 1995. In terms of the average non-zero dose to an individual worker, the Expanded Operations Alternative is expected to result in 0.24 rem per year for Expanded Operations Alternative, as compared with 0.097 rem per year, 1993 to 1995. The estimated lifetime excess LCF risk is 0.000096 per year of operation.

Of the total worker radiation dose under this alternative (833 person-rem per year), about 220 person-rem per year is associated with pit production activities, regardless of the PSSC alternative selected. (This is an increase of about 150 person-rem per year over the exposures for such activities under the No Action Alternative.) Under the Preferred Alternative, at the 20 pits per year rate, the pit production contribution would be about 90 person-rem per year, and the total worker exposure would be about 704 person-rem per year (with a corresponding 15 percent decrease in the estimated excess LCF risk).

Nonionizing Radiation. It is expected that there will continue to be negligible effects to LANL worker health from nonionizing radiation sources, including ultraviolet sources, infrared radiation from instrumentation and welding, lasers, magnetic and electromagnetic fields, and microwaves (including the large station at TA–49). (Also see volume III, appendix D, section D.2.2 for evaluation used to estimate nonionizing radiation from LANL operations to humans and wildlife and section D.4, for estimated results.)

Chemical Exposure Consequences

It is anticipated that there will continue to be a few exposures annually, particularly exposures to:

- Airborne asbestos
- Lead paint particulates
- Crystalline silica
- Fuming perchloric acid, hydrofluoric acid
- Skin contact with acids or alkalis

TABLE 5.3.6.2–1.—*Annual Worker Doses and Associated Lifetime Excess LCF Risks Under the Expanded Operations Alternative*

LANL Collective Worker Dose (person-rem/year)	833
Estimated Excess LCF Risk (across the worker population) per year of operation	0.33
Average Non-Zero Worker Dose (rem/year)	0.24
Estimated Excess LCF Risk (average worker > 0 dose)	0.000096

Under the Expanded Operations Alternative, it is expected that there will be a worker population of approximately 11,000 individuals, approximately 22 percent higher than index period employment levels. For the purposes of the SWEIS, it is assumed that there is negligible additional benefit of the chemical hygiene program at LANL over the period analyzed, and that the rate of chemical exposures continues at the index period rates. Therefore, it is expected that reportable chemical exposures from continued operations would increase over the next 10 to 15 years to a total of two to five reportable chemical exposures per year.

Beryllium Processing Consequences. It is anticipated that beryllium operations under the Expanded Operations Alternative would be 50 to 60 percent higher than in the No Action Alternative. However, it is not anticipated that consequences to workers would be measurable, that is, no sensitization to beryllium would be detected using the LANL IH monitoring program.

Physical Safety Hazards

Table 5.3.6.2–2 compares the projected reportable accidents and injuries estimated for normal operations occurring under the Expanded Operations Alternative and that experienced during the index period. The Expanded Operations Alternative is expected to result in an increase in reportable cases due to increases in worker population. These incidents are considered within the consequences of normal operations of LANL because of the relatively higher frequency of occurrence than major accidents (section 5.3.11). These results assume that the aggressive Health and Safety Program underway at LANL does not achieve any additional reduction in reportable cases.

TABLE 5.3.6.2–2.—*Projected Annual Reportable Accidents and Injuries for the Expanded Operations Alternative Compared with the Index Period*

PARAMETER ESTIMATED	PARAMETER VALUE AND UNITS
Projected Worker Population	Approximately 11,000
Projected Reportable Accidents and Injuries	507/year
Change from Index (1993 to 1996)	+21 %

The consequences of these accidents and injuries are expected to be similar to those experienced in the past, and typically are those associated with health response and recovery from acute trauma. Therefore, the consequences include physical pain and therapy/treatment for recovery such as those associated with bone setting, shoulder dislocation reset, and subsequent physical therapy. Some injuries may also result in continuing consequences to the worker that could affect productivity or lifestyle, such as motor skill loss due to nerve damage or cardiovascular debilitation resulting from electrical shock or electrocution.

Project-Specific Siting and Construction Analyses

As discussed in volume II, parts I and II, workers involved in the construction activities associated with the expansion of the LLW disposal area and the enhancement of pit manufacturing operations would be exposed to risks typical of construction activities (e.g., back injuries, being crushed beneath heavy equipment, electrical hazards, etc.). These risks are mitigated by administrative controls and personal protective equipment, as needed. These risks are essentially the same under each of the alternatives considered in these PSSC analyses.

As discussed in volume II, part II, workers involved in the construction activities associated with the enhancement of pit manufacturing operations would receive about 45 person-rem due to radiation exposures associated with work inside TA–55, PF–4, and another 1.2 person-rem due to radiation exposures associated with work inside the CMR Building under the PSSC "CMR Building Use" Alternative. This means that 0.018 total excess LCFs (out of the entire construction workforce for the period of construction activity) would be expected due to the construction activity in these facilities. These impacts would not be expected for the other PSSC alternatives because they do not involve construction within operating nuclear facilities. Under the Preferred Alternative, equipment installation associated with establishing pit production at the 20 pits per year level would result in a small fraction of the exposure described above.

5.3.7 Environmental Justice

As indicated in sections 5.3.1 and 5.3.2, no substantive adverse impacts to land resources or geology and soils are anticipated for the continued operation of LANL under the Expanded Operations Alternative. Thus, no disproportionately high and adverse impacts to minority or low-income communities are anticipated for these impact areas. The potential impacts to surface and groundwater and ecological resources associated with the Expanded Operations Alternative would affect all communities in the area equally. (See sections 5.3.3 and 5.3.5 for additional information on the potential for impacts to these resources.) Thus, no disproportionately high or adverse impacts to minority or low-income communities are anticipated to be associated with these resource areas.

Figure 5.3.7–1 reflects the dose from radiological air emissions within 50 miles (80 kilometers) of LANL under the Expanded Operations Alternative. As discussed in section 5.2.7, impacts due to air emissions are equal to or lower in the sectors with substantial minority and/or low-income populations than they are in sectors 1–3 and 6–16, and such impacts are not disproportionately high or adverse with respect to the minority or low-income populations. (See section 5.3.4 regarding the impacts anticipated for air emissions under the Expanded Operations Alternative.)

The air pathway is one example of the analysis of potential human health impacts. As presented in section 5.3.6, there is minimal potential for LANL operations to adversely affect human health for off-site residents or recreational users in the area around LANL under the Expanded Operations Alternative. Similarly, the special pathways have little potential to impact human health under this alternative. Thus, the Expanded Operations Alternative would not present disproportionately high or adverse impacts to human health in minority or low-income communities (section 5.3.6.1).

As shown in section 5.3.10, impacts from on-site transportation and from LANL to U.S. 84/285 are estimated to be 0.0020 excess LCFs per year from incident-free transportation and 0.082 deaths and injuries per year from transportation accidents. Impacts from transportation on route segments that pass through minority or low-income communities (particularly the segment from U.S. 84/285 to I–25) are estimated to be 0.0021 excess LCFs per year from incident-free transportation and 0.18 deaths and injuries per year from transportation accidents. Therefore, no high and adverse impact is expected to either a member of the general public or to a member of a minority or low-income population due to transportation in the vicinity of LANL transportation routes.

As noted in volume II of the SWEIS, none of the alternatives for the Expansion of Area G (part I of volume II) or for the Enhancement of Pit Manufacturing Operations (part II of volume II) would be expected to have high and adverse

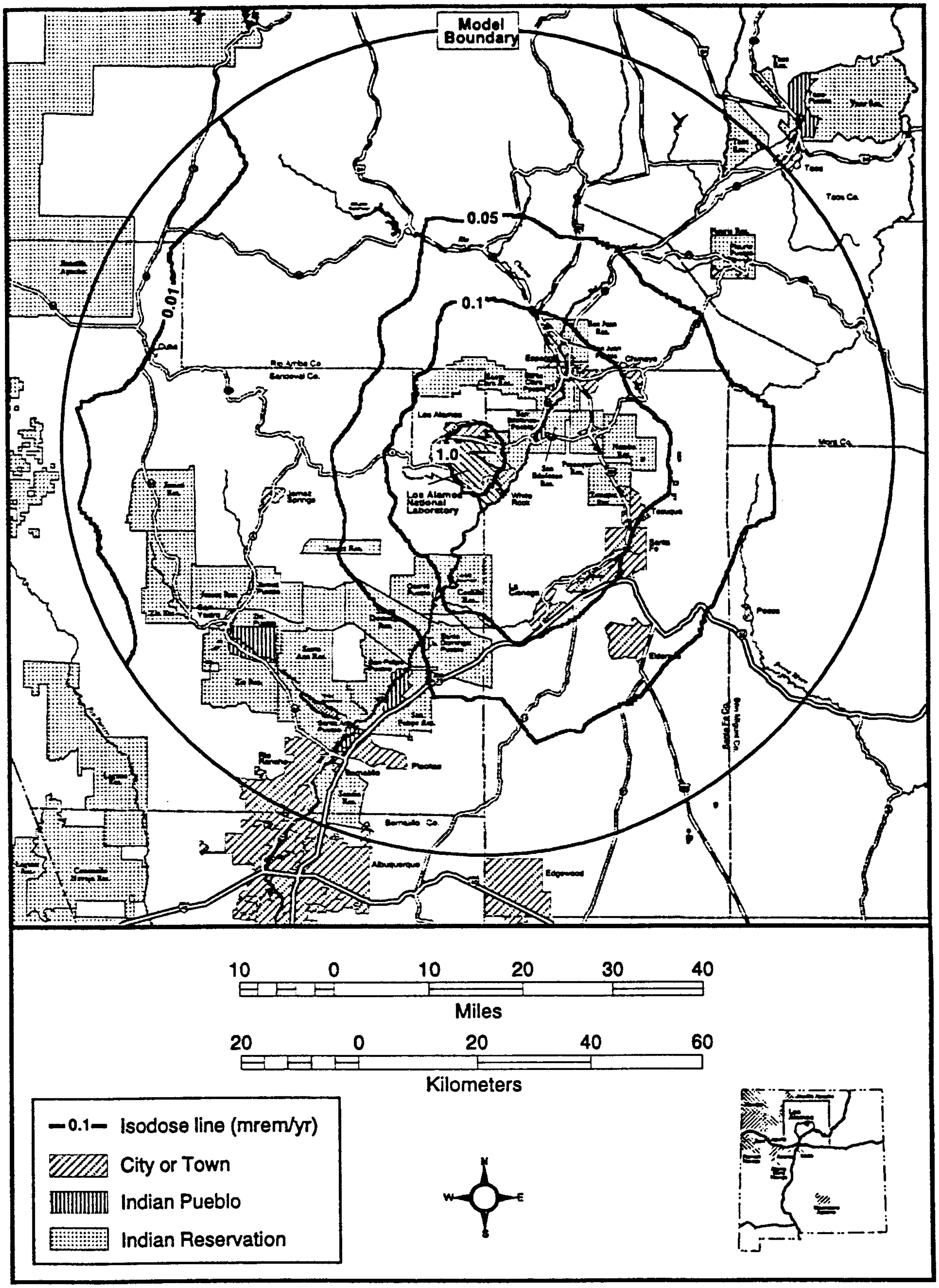


FIGURE 5.3.7–1.—*Isodose Lines from Airborne Releases for the Expanded Operations Alternative Within 50 Miles (80 Kilometers) of LANL.*

health or environmental effects to any populations. Thus, no environmental justice impacts are projected for siting and construction activities under this alternative. This would be true for any of the PSSC alternatives considered.

5.3.8 Cultural Resources

Impacts to prehistoric resources, historic resources, and TCPs are summarized in Table 5.3.8–1 and are discussed below. Note that any construction impacts associated with construction of the road between TA–55 and TA–3 (associated with pit production activities) would not be incurred at the 20 pits per year production rate, the Preferred Alternative.

5.3.8.1 *Prehistoric Resources*

Impacts to prehistoric resources as a consequence of implementing the Expanded Operations Alternative would be similar to those resulting from the No Action Alternative, with the only differences in operational impacts being due to frequency or intensity (e.g., increased radiological air emissions) of the impacts. However, the Expanded Operations Alternative also includes construction measures associated with the Expansion of Area G LLW Disposal Area that could potentially impact 15 prehistoric sites located at Zones 4 and 6 that have been determined eligible for inclusion in the NRHP. The other construction action included in the Expanded Operations Alternative, Enhancement of Pit Manufacturing Operations, includes construction that is in close proximity to one NRHP-eligible archaeological site and one historic site that is ineligible for the NRHP but would not affect these sites.

A data recovery plan has been prepared for the eight sites at Zone 4 and accepted by the SHPO. Consultation would have to be accomplished with the four Accord Pueblos, as well as any culturally affiliated or interested Pueblos. An accompanying data recovery plan would be prepared for the remaining seven sites at Zone 6. The recovery plan would include concerns resulting from consultation with the Accord Pueblos as well as any other Native American or Hispanic community with identified TCP and *Native American Graves Protection and Repatriation Act* (NAGPRA) (25 U.S.C. §3001) concerns. The New Mexico SHPO would review the data recovery plan for Zone 6 prior to implementation of any mitigation measures and would be requested to concur in a determination of no adverse effect before the start of project construction.

Should any historic resources (i.e., prehistoric, historic, and TCPs) be inadvertently discovered during the expansion of Area G, construction activities in the immediate vicinity of the property would cease until their significance and ultimate disposition is determined in consultation with the New Mexico SHPO, Indian tribes with the closest known cultural affiliation, and the Advisory Council on Historic Preservation. For purposes of compliance with Section 3(d) of the NAGPRA, inadvertent discovery of human remains and funerary objects (associated and unassociated), would result in the cessation of construction activities, protection of the discovered items, notice of the discovery sent to the Indian tribes with the closest known cultural affiliation, and direction asked for treatment and disposition of the human remains or funerary objects. The 30-day delay period following official certification that notification of the accidental discovery has been received by the agency or tribe would be followed.

An increase in the frequency of explosives testing under the Expanded Operations Alternative would correspondingly increase the potential for shrapnel impacts to those sites that are vulnerable. Similarly, a higher frequency of testing could accelerate vibration damage to susceptible sites. There would not be an increase in the magnitude of explosive tests with the Expanded Operations Alternative. As with the No Action Alternative, no impacts to resources at BNM are expected due to

TABLE 5.3.8–1.—*Projected Impacts to Prehistoric Resources, Historic Resources, and Traditional Cultural Properties Under the Expanded Operations Alternative*

ACTION TYPE	PUEBLO STRUCTURES	ERODED PUEBLOS/ RUBBLE/ ARTIFACT SCATTER	CAVATE PUEBLOS/ ROCK ART/ SHELTERS/ OVERHANGS	TRAILS/ STEPS/ STONE ARRANGE-MENTS	U.S. TERRITORIAL/ HOMESTEAD SITES	NUCLEAR ENERGY ERA (1943–1989) BUILDINGS, DISTRICTS, AND SITES)	TRADITIONAL CULTURAL PROPERTIES (TCP)				
							CEREMONIAL AND ARCHAEOLOGICAL SITES	NATURAL FEATURES	ETHNOBOTANICAL GATHERING SITES	ARTISAN MATERIAL GATHERING SITES	SUBSISTENCE FEATURES
New construction (buildings, facilities, etc.)	15 National Register eligible sites affected. It is anticipated that a determination of no adverse effect would be achieved based on a data recovery plan which would be developed in consultation with the NM SHPO, ACHP, and four Accord Pueblos. Procedures in place to address historic properties inadvertently discovered during construction.				Negligible (Policy and procedures in place to avoid or minimize impacts)		Consultation with four Accord Pueblos to identify and mitigate any potential adverse effects, including human remains and funerary objects.				
Modifications in facility layout (roads, parking lots, pits)	Same as the No Action Alternative										
Modification of existing buildings (changing building function)	Same as the No Action Alternative										
Change in hydrology (surface and groundwater quality and quantity; erosion and siltation rates)	Same as the No Action Alternative										
Explosives impacts (shrapnel scatter)	Similar to the No Action Alternative. The increased frequency of explosive testing could mean accelerated damage to resources.										
Explosives impacts (vibration)	Similar to the No Action Alternative. The increased frequency of explosive testing could mean accelerated damage to resources.										
Explosives (noise)	None (Same as No Action Alternative.)						Similar to the No Action Alternative. The increased frequency of explosive testing could mean accelerated damage to resources.				
Hazardous material (nonradiological)	Similar to the No Action Alternative. The increased emissions could increase potential for adverse effects.						Similar to the No Action Alternative. The increased emissions could increase potential for adverse effects.				
Radiation hazards	Similar to the No Action Alternative. The increased emissions could increase potential for adverse effects.						Similar to the No Action Alternative. The increased emissions could increase potential for adverse effects.				
Security (fencing, lighting, monitoring)	Same as the No Action Alternative										

explosion-generated ground vibrations from explosives as high as 500 pounds (227 kilograms). As stated, further research is necessary to quantitatively assess impacts from higher amounts of explosives.

In the event that unforeseen circumstances arise in the design of construction features associated with the enhancement of pit manufacturing operations that could affect the one NRHP-eligible site, appropriate mitigation measures, including data recovery, would be designed and implemented in consultation with the New Mexico SHPO and concerned Native American communities.

5.3.8.2 *Historic Resources*

Impacts to historic resources would be comparable to those for the No Action Alternative.

5.3.8.3 *Traditional Cultural Properties*

Impacts would be similar to those for the No Action Alternative (subsection 5.2.8) with the exception of construction activities associated with the expansion of Area G low-level waste disposal and enhancement of pit manufacturing. As stated, consultation would be accomplished with the Accord Pueblos as well as any culturally affiliated or interested Pueblos and tribes. Any concerns expressed would result in actions to negate or minimize any adverse impacts to TCPs associated with construction related actions. These impacts would be similar for any of the PSSC alternatives considered.

An increased level of operation resulting in increased production of shrapnel, vibrations, noise, hazardous materials, and radioactive hazardous could further increase any adverse affect to TCPs.

Construction and operational activities associated with the expansion of Area G and the enhancement of pit manufacturing is not expected to affect surface or groundwater quality—a traditional natural resource identified by some tribal groups. The potential for soil erosion during construction and operations would be avoided or minimized by measures such as fences, mulching, berms, slope contouring, trenching, and revegetation. Planned disposal practices at Area G (e.g., isolation of the closed burial pits) would minimize the potential for water running across and off the site and conveying erosional products to water drainages. Contamination of groundwater from the expansion of Area G is highly unlikely because of the natural resistance that Bandelier tuff has to fluid migration and the distance to area aquifers.

Spiritual Entities

As with the No Action Alternative, no assessment of impacts to “unseen” or “spiritual” entities was attempted.

5.3.9 Socioeconomics, Infrastructure, and Waste Management

This section describes the social, economic, and infrastructure impacts of activities at LANL under the Expanded Operations Alternative.

The socioeconomic and infrastructure aspects of all construction under the Expanded Operations Alternative, including the two projects discussed in volume II of the SWEIS, are included in the analyses and discussions in this section.

5.3.9.1 *Socioeconomic Impacts*

Employment, Salaries, and Population

The primary (direct) impacts of the Expanded Operations Alternative on employment, salaries, and population are presented in Table 5.3.9.1–1 for the LANL workforce only.

TABLE 5.3.9.1–1.—*Summary of Primary LANL Employment, Salaries[a], and Procurement Under the Expanded Operations Alternative[b]*

	LOS ALAMOS COUNTY	RIO ARRIBA COUNTY	SANTA FE COUNTY	TRI-COUNTY TOTAL	OTHER NEW MEXICO COUNTIES	NEW MEXICO TOTAL	OUTSIDE NEW MEXICO	TOTAL
Employees	4,995	2,604	2,657	10,256	828	11,084	267	11,351
Difference[c]	160	685	820	1,665	220	1,885	91	1,976 (+21%)
Salaries ($M)	264.4	74.7	123.2	462.3	27.8	490.1	15.6	505.6
Difference[c]	9.8	29.7	48.9	88.4	11.5	99.8	6.9	106.7 (+27%)
Procurement ($M)	221	1.9	21.9	244.8	128.3	373	253.6	626.6
Difference[c]	5.3	0.2	1.2	6.8	5.9	12.5	22	34.5 (+6%)

[a] Salaries are for UC employees only; subcontractor salaries (Johnson Controls, Inc., Protection Technology of Los Alamos, etc.) are included in the procurement dollars.
[b] Reflects projected locations of employee residences and LANL procurement activities.
[c] Difference is as compared to fiscal year 1996. Percent difference is shown in parentheses in the far right (TOTAL) column.

The secondary (indirect) impacts and the total population changes projected are presented in Table 5.3.9.1–2 for the Tri-County area. These changes are assumed to occur within a year of the ROD for the SWEIS. Note that about 260 of the total LANL employment listed is for pit production operations. Under the Preferred Alternative, at the 20 pits per year rate, pit production employment is estimated to be about 100 full-time equivalent employees (FTEs). This difference is a small fraction of total employment under the Expanded Operations Alternative, so impacts at the 20 pits per year level (Preferred Alternative) would not be substantially different than those presented in the remainder of the socioeconomics analyses in this section.

Housing

The population changes anticipated in the Tri-County area, as presented in Table 5.3.9.1–2, are projected to result in demand for 1,770 additional (new) housing units. The distribution of this demand in the three counties is projected to be: 130 additional units in Los Alamos County; 739 additional units in Rio Arriba County; and 901 additional units in Santa Fe County.

In Los Alamos County, the projected housing demand can be accommodated from absorption of apartment vacancies and the inventory of houses for sale and new construction. Beyond 130 units, no new housing units can be anticipated because of the absence of buildable land in private ownership. This constraint upon supply would be expected to exert an upward pressure on rents and house prices.

The projected housing demand in Rio Arriba and Santa Fe Counties can be accommodated without significant pressure on rents and house sales prices. Both counties possess a sufficient

TABLE 5.3.9.1–2.—*Summary of Total Tri-County Employment, Salaries, Business Activity, and Population Changes Under the Expanded Operations Alternative*

	PRIMARY CHANGE	SECONDARY CHANGE	TOTAL TRI-COUNTY CHANGE	TRI-COUNTY PRIMARY WORKER CHANGE[a]	TRI-COUNTY SECONDARY WORKER CHANGE[b]	TOTAL TRI-COUNTY WORKER CHANGE	TOTAL TRI-COUNTY POPULATION CHANGE[c]
Employment/ Population	1,665	2,847	4,512	1,332	854	2,186	4,230 (+2.5%)
Personal Incomes	$88 million	$84 million	$172 million (< +1%)				
Annual Business Activity	$7 million	$13 million	$20 million (< +1%)				

Note: Percentages in parentheses are the percentage change that the number represents. These are provided for total population change, total personal income change, and total annual business activity change.

[a] This is the number of direct workers moving to the Tri-County area, assuming that 80 percent of new LANL employees are from outside this area.

[b] This is the number of secondary workers moving to the Tri-County area, assuming that 30 percent of secondary employment is from outside this area.

[c] This is the total population increase in the Tri-County area, assuming that, on average, each worker moving to the area increases the population by 1.935.

inventory of finished lots and parcels, have access to adequate mortgage capital, and have sufficient entrepreneurial developer talent to absorb the demand.

Construction

Table 5.3.9.1–3 contains the results of the analysis of construction spending, labor salaries, and labor employment for the period fiscal year 1997 through fiscal year 2006. To some extent, construction under this alternative would draw workers already present in the Tri-County area who have historically worked from job to job in the region. To the extent that the Expanded Operations Alternative adds construction workers to the Tri-County area, this would be a seasonal occurrence. Thus, these construction activities are expected to only marginally affect general business activity, personal income levels, and employment levels.

TABLE 5.3.9.1–3.—*Construction Spending, Labor Salaries, and Labor Employment Numbers Under the Expanded Operations Alternative (Fiscal Year 1997 Through 2006)*

YEAR	CONTRACT $M	LABOR $M	EMPLOYEES
1997	63	15	432
1998	187	45	1,282
1999	224	54	1,536
2000	251	60	1,721
2001	264	63	1,810
2002	215	52	1,474
2003	216	52	1,481
2004	139	33	953
2005	109	26	747
2006	108	26	741

$M = dollars given in millions

Source: (DOC 1996, PC 1997a, and PC 1997b)

Local Government Finance

Under this alternative, the Tri-County annual gross receipts tax yields would be expected to increase by $3.7 million. This increase would be matched by increases in service levels adequate to meet public demand.

Services

Annual school enrollment in the Tri-County area would be expected to increase by 719 students. Additional annual funding assistance of about $2.88 million from the State of New Mexico would be required for school operations because of these enrollment increases.

In Los Alamos, the school district can absorb the anticipated new enrollment levels. This school district has excess capacity because of its discretionary policy of accepting out-of-district students who are the children of LANL employees and subcontractors. In Rio Arriba County and the cities of Española and Santa Fe, adequate classroom capacity exists because of recent school construction projects.

The demand for police, fire, and other municipal services would be expected to increase in proportion to the increase in gross receipts tax yields, as discussed above. However, any changes in local government services tend to be inelastic in the short term and typically are responsive only after the completion of at least one full budget cycle.

5.3.9.2 *Infrastructure Impacts*

Annual electricity use projected under the Expanded Operations Alternative is a total of 782 gigawatt-hours, 437 gigawatt-hours for LANSCE and 345 gigawatt-hours for the rest of LANL. The peak electrical demand is projected to be 113 megawatts, 63 megawatts for LANSCE and 50 megawatts for the rest of LANL[1]. The existing supply of electricity to the Los Alamos area is not sufficient year-round to meet the projected electrical peak demand for LANL operations under this alternative; thus, periods of brownouts are anticipated unless measures are taken to increase the supply of electricity to the area. (Sections 1.6.3.1 and 4.9.2 discuss ongoing efforts to increase electrical power supply to this area.) This situation is exacerbated by the additional electrical demand for BNM and the communities of Los Alamos and White Rock. (While these organizations did not provide use projections, their historical usage is reflected in section 4.9.2 of chapter 4.)

Natural gas use is projected to be 1,840,000 decatherms annually, the same as projected under the No Action Alternative. Although electrical demand may increase natural gas demand for the generation of electricity at TA–3, demand should continue to be dominated by heating requirements and is not expected to exceed this projection.

Water use projected under the Expanded Operations Alternative is a total of 759 million gallons (2.9 billion liters) per year, 265 million gallons (1 billion liters) per year for LANSCE, and 494 million gallons (1.9 million liters) per year for the rest of LANL. This is well within DOE water rights, about 1,806 million gallons (6.8 million liters) per year; however, this water right also provides for water used by Los Alamos County and BNM. Based on existing information regarding non-LANL water use, the water demands of this community can be met within the existing water rights. (Water demand is also discussed in section 5.3.3.) The peak water requirements are the same as identified under the No Action Alternative.

1. These values include the proposed SCC Project annual electricity and peak electrical demand for a 50-TeraOp operation and are reflected in all the alternatives. The SCC project was as an interim action to the SWEIS.

These impacts have a minimal contribution from pit production activities. Thus, these impacts would not be substantially different regardless of which PSSC alternative is selected (nor would they be substantially different for pit production at the 20 pits per year rate, the Preferred Alternative).

5.3.9.3 *Waste Management*

The annual and 10-year total generation projections for radioactive and hazardous waste are reflected in Table 5.3.9.3–1. Radioactive liquid waste is not projected by facility because measurements of individual contributions are not made for all facilities. The total amount of radioactive liquid waste projected for receipt at TA–50 is ___ million gallons (35 million liters) per year for this alternative. These projections include waste from key facilities, all other LANL facilities, waste management facilities, the ER Project, and construction activities. In addition to the volumes reflected in Table 5.3.9.3–1, the "CMR Building Use" Alternative, discussed in the PSSC Analysis for Enhancement of Plutonium Pit Manufacturing Operations (volume II, part II), would generate an additional 427 cubic meters (559 cubic yards) of TRU waste, 288 cubic meters (377 cubic yards) of TRU mixed waste, 1,193 cubic meters (1,560 cubic yards) of LLW, and 31 cubic meters (41 cubic yards) of low-level radioactive mixed waste (LLMW) waste during construction activity. Neither of the other alternatives discussed in this PSSC are expected to generate any radioactive waste. (Under the Preferred Alternative, at the 20 pits per year rate, a fraction of the waste generation projected for the PSSC "CMR Building Use" Alternative would be incurred; this is a small portion of the totals generated for each of these waste types, so impacts would not be substantially different for construction to achieve this lower rate.) The PSSC analysis for the expansion of Area G (volume II, part I) reflects that no radioactive waste generation is expected under any of the alternatives analyzed. Pit production operations contribute little to waste generation, with the exception of TRU waste generation (which would increase by about 3,535 cubic feet [100 cubic meters] per year). Under the Preferred Alternative, at the 20 pits per year rate, this increase would be about 530 cubic feet (15 cubic meters) per year.

Under this alternative, LLW would be treated and disposed of on the site in an expanded Area G (see volume II, part I). As discussed for the No Action Alternative, much of LANL TRU and chemical waste would be treated and shipped off site for disposal; nondefense TRU waste from other sites would be stored at LANL pending the development of disposal options. As with the No Action Alternative, LANL is capable of meeting applicable waste acceptance criteria, and off-site disposal capacities are much greater than LANL's waste volumes.

5.3.9.4 *Contaminated Space*

The activities reflected in the Expanded Operations Alternative are projected to increase the total contaminated space at LANL by 73,000 square feet (6,782 square meters) over the next 10 years, as compared to the baseline established for the SWEIS as of May 1996 (chapter 4, section 4.9). The majority of this increase is due to implementation of actions that have already been reviewed under NEPA, but which had not been implemented at the time the baseline was established, as discussed in the No Action Alternative (section 5.2.9). Additional construction and operations in LANSCE (TA–53) and the Machine Shops (TA–3) result in an additional 5,000 square feet (460 square meters) in each of these facilities under this alternative.

Selection of either the Brownfield or TA–55 add-on alternatives from the PSSC Analysis of the Enhancement of Plutonium Pit Manufacturing (volume II, part II) would result in an additional 15,300 square feet (1,420 square meters) of contaminated space.

TABLE 5.3.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the Expanded Operations Alternative*[a]

FACILITY	TECHNICAL AREAS	CHEMICAL WASTE[b] (kilograms)		LOW LEVEL WASTE (cubic meters)		MIXED LOW LEVEL WASTE (cubic meters)		TRANSURANIC WASTE (cubic meters)		MIXED TRANSURANIC WASTE (cubic meters)	
		ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR
Plutonium Facility Complex	TA–55	8,340	83,400	740	7,400	13	130	310	3,100	102	1,020
Tritium Facilities[c]	TA–16 & TA–21	1,700	17,000	480	4,800	3	30	NA	NA	NA	NA
Chemistry and Metallurgy Research Building[d]	TA–3	11,200	112,000	1,860	18,600	19.6	196	46.6	466	20.4	204
Pajarito Site	TA–18	4,000	40,000	145	1,450	1.5	15	NA	NA	NA	NA
Sigma Complex	TA–3	10,000	100,000	960	9,600	4	40	NA	NA	NA	NA
Materials Science Laboratory	TA–3	600	6,000	0	0	0	0	NA	NA	NA	NA
Target Fabrication Facility	TA–35	3,800	38,000	10	100	0.4	4	NA	NA	NA	NA
Machine Shops	TA–3	474,000	4.74×10^6	606	6,060	0	0	NA	NA	NA	NA
High Explosives Processing Facilities	TA–8, 9, 11, 16, 28 & 37	13,000	130,000	16	160	0.2	2	NA	NA	NA	NA
High Explosives Testing Facilities	TA–14, 15, 36, 39, 40	35,300	353,000	940	9,400	0.9	9	0.2	2	NA	NA
Los Alamos Neutron Science Center[e]	TA–53	16,600	166,600	1,085	10,850	1	10	NA	NA	NA	NA
Health Research Laboratory[f]	TA–43	13,280	132,800	34	340	3.4	34	NA	NA	NA	NA
Radiochemistry Laboratory	TA–48	3,300	33,000	270	2,700	3.8	38	NA	NA	NA	NA
Radioactive Liquid Waste Treatment Facility[g]	TA–50 & TA–21	2,200	22,000	160	1,600	0	0	30	300	0	0
Waste Treatment, Storage, and Disposal Facilities[g]	TA–54 & TA–50	920	9,200	174	1,740	4	40	27	270	0	0
Non-Key Facilities		651,000	6.51×10^6	520	5,200	30	300	0	0	0	0
ER Project[h]		2×10^6	2×10^7	4,257	42,570	548	5,480	11	110	0	0
Grand Total[i]		3.2493×10^6	3.2493×10^7	12,240	122,400	633	6,330	425	4,250	122	1,220

TABLE 5.3.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the Expanded Operations Alternative*[a]-Continued

NA indicates that this facility does not routinely generate these types of waste.

[a] Radioactive liquid waste generation is not projected by facility (see text in section 5.3.9.3).

[b] The chemical waste numbers reflect waste that exhibits a hazardous characteristic (ignitability, corrosivity, reactivity, or toxicity), is listed as a hazardous waste by EPA, is a mixture of listed hazardous waste and solid waste, or is a secondary waste associated with the treatment, storage, or disposal of a hazardous waste. This includes waste that is subject to regulation under RCRA, as well as PCB waste and asbestos waste regulated under the *Toxic Substance Control Act*. This waste category also includes biomedical waste.

[c] These projections include 141,000 ft^3 (4,000 m^3) of LLW due to backlogged waste.

[d] These LLW projections include 141,000 ft^3 (4,000 m^3) of LLW generation anticipated due to the CMR Building Upgrades, Phase II.

[e] These projections include 228,000 ft^3 (6,450 m^3) of LLW due to the construction of the new Long-Pulse Spallation Source Facility and 86,000 ft^3 (2,450 m^3) of LLW due to upgrades to Areas A5 and A6, as well as reduced operational waste generation during these construction activities.

[f] These projections include 22,000 lbs (10,000 kg) of chemical waste, 550 lbs (250 kg) of biomedical waste (a special form of chemical waste), 1,560 ft^3 (44 m^3) of LLW, and 850 ft^3 (24 m^3) of LLMW associated with ongoing efforts to remove obsolete and contaminated equipment.

[g] These facilities provide for storage, treatment, and disposal of waste generated throughout LANL. These activities generate secondary waste, the quantities of which are reflected in this table for these facilities.

[h] The ER Project is projected to generate 390 ft^3 (11 m^3) per year of TRU and mixed TRU waste together. All of this waste is presented under the TRU waste columns.

[i] Grand totals have been rounded.

The "CMR Building Use" Alternative from that PSSC Analysis, utilizes existing unused space in the CMR Building, would use existing nuclear space, and thus would not incrementally increase the contaminated space at LANL facilities.

Although not considered "contaminated space" for the purposes of this SWEIS, selection of the PSSC Preferred Alternative (expansion of Area G into Zones 4 and 6) would result in disposal of LLW in up to 41 acres (17 hectares) of land not previously used for disposal. Selection of the North site alternative or the TA–67 alternative would result in disposal of LLW in 49 acres (20 hectares) or 50 acres (21 hectares), respectively, of land not previously used for disposal.

5.3.10 Transportation

The transportation impacts projected for the Expanded Operations Alternative are summarized in this section. On-site and off-site shipments under this alternative are greater than these under the No Action Alternative (with the exception that no LLW is shipped off the site for disposal). More detailed information regarding these shipments and the impacts is included in volume III, appendix F.

5.3.10.1 *Vehicle-Related Risks*

Truck Emissions in Urban Areas

For the Expanded Operations Alternative, the projected impact from vehicle emissions is 0.066 excess LCF over a lifetime of operation per year. Use of the Santa Fe Relief Route would have a very small effect on this risk (it would change to 0.064 excess LCF per year). The only difference is that the Santa Fe Relief Route would have 1.2 miles (2 kilometers) less of urban highway mileage. Approximately 65 percent of excess LCFs are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments.

Truck Accident Injuries and Fatalities

The impacts projected for the Expanded Operations Alternative are presented in Table 5.3.10.1–1. (Additional information is provided in appendix F, section F.6.3.) Use of the Santa Fe Relief Route would reduce the risks of accidents, injuries, and fatalities by almost one-half of those indicated for the segment from U.S. 84/285 to I–25 due to the assumption that the accident rate on the Santa Fe Relief Route would be much lower than for the route through Santa Fe. Use of the Santa Fe Relief Route would not substantially change the risks of accidents, injuries, and fatalities on the remainder of the New Mexico segment, as compared to the risks reflected for this segment in Table 5.3.10.1–1. Approximately 65 percent of the impacts are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments. Again, all shipments are assumed to result in a return by an empty truck.

5.3.10.2 *Cargo-Related Risks*

Incident-Free Radiation Exposure

The incident-free radiation exposure impacts projected for the off-site shipments under the Expanded Operations Alternative are presented in Table 5.3.10.2–1; as noted in section 5.2.10.2, the total is the dose throughout the U.S., and is dominated by the segments outside of New Mexico. The aircraft segment is for overnight carrier service; the truck segment to and from the airport is included in the truck results. In general, use of the Santa Fe Relief Route would result in only small changes in this type of impact. Truck crew doses and nonoccupational doses for people at rest stops would increase due to the increased length of the Santa Fe Relief Route for north-bound shipments carrying the radioactive material. Nonoccupational doses for people sharing the road would decrease due to the lower traffic density projected for the relief route.

TABLE 5.3.10.1–1.—*Truck Accident Injuries and Fatalities Projected for LANL Shipments Under the Expanded Operations Alternative*

ROUTE SEGMENT	NUMBER OF ACCIDENTS PER YEAR	NUMBER OF INJURIES PER YEAR	NUMBER OF FATALITIES PER YEAR
On Site	0.033	0.007	0.00033
LANL to U.S. 84/285	0.34	0.071	0.0034
U.S. 84/285 to I–25	0.82	0.18	0.0082
Remainder of New Mexico	1.4	1.3	0.15
Outside New Mexico	6.4	6.0	0.62
Total	9.0	7.6	0.78

TABLE 5.3.10.2–1.—*Incident-Free Population Dose and Lifetime Excess LCFs for Off-Site Shipments per Year of Operation Under the Expanded Operations Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	person-rem/year	excess LCF/ year	person-rem/year	excess LCF/ year	person-rem/year	excess LCF/ year	person-rem/year	excess LCF/ year
LANL to U.S. 84/285	7.4	0.003	0.04	0.00002	0.65	0.00032	4.0	0.002
U.S. 84/285 to I–25	10	0.004	0.49	0.00024	4.6	0.0023	4.2	0.0021
Remainder of New Mexico	55	0.022	0.12	0.000062	2.1	0.001	30	0.015
Outside New Mexico	510	0.2	3.5	0.0018	30	0.015	230	0.12
Aircraft	2.4	0.0012	NA	NA	NA	NA	NA	NA
Total	580	0.23	4.2	0.0021	37	0.019	270	0.14

NA = Not applicable

MEI dose occurs between LANL and I–25 and is 0.00038 rem per year of operation.

Driver Doses from On-Site Shipments of Radioactive Materials

The projected collective radiation dose for LANL drivers under the Expanded Operations Alternative is 10.292 person-rem. This collective dose would be expected to result in 0.00412 excess LCFs over a lifetime per year of operation among these drivers.

The average individual driver dose is projected to be 0.429 rem per year, which is well below the DOE radiation protection limit of 5 rem per year.

Transportation Accidents

The following discussion addresses the potential impacts of accidents leading to the release of either radioactive or hazardous material being transported in support of LANL operations under the Expanded Operations Alternative. Results are given for both off-site and on-site shipments.

Off-Site Radioactive Materials Shipments

The MEI doses calculated with RADTRAN do not vary by alternative and are given in Table 5.2.10.2–2. The population dose and corresponding lifetime excess LCF per year of operation for these shipments are presented in Table 5.3.10.2–2 for these accidents. ADROIT results separated into frequency and consequence components are not readily available. The product, MEI dose risk, can be presented in terms of excess LCF per year; for the Expanded Operations Alternative, MEI dose risk due to plutonium-238 oxide and due to pit shipments were each about 1×10^{-10} excess LCF per year.

The use of the Santa Fe Relief Route would reduce the projected population dose (and therefore, the excess LCFs per year) to about one-third for the U.S. 84/285 to I–25 segment, as compared to use of the route through Santa

TABLE 5.3.10.2–2.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the Expanded Operations Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM -241	CH TRU	RH TRU	PLUTONIUM -238	PITS	TOTAL	
	person-rem/year	person-rem/year	person-rem/year	person-rem/year	person-rem/year	person-rem/year	excess LCF/year
LANL to U.S. 84/285	0.016	0.0019	3.8×10^{-6}	1×10^{-6}	6×10^{-6}	0.018	9.0×10^{-6}
U.S. 84/285 to I–25	0.25	0.024	0.000053	2×10^{-6}	0.00002	0.27	0.00014
Remainder of New Mexico	0.033	0.016	0.000033	1×10^{-6}	8×10^{-6}	0.049	0.000024
Rest of U.S.	2.7	NA	NA	8×10^{-6}	0.00004	2.7	0.0014

NA = Not available

Fe. This difference is primarily due to the difference in population density along these routes. (Lower traffic density projected on the relief route is also a factor.) The use of the Santa Fe Relief Route would increase the projected population dose (and, therefore, excess LCFs per year) for the remainder of New Mexico segment to about double that identified if the route through Santa Fe is used. This difference is due to the increase (6 miles [10 kilometers] more) in the distance traveled on I–25 for northbound shipments.

On-Site Radioactive Materials Shipments

The MEI doses, frequencies, and MEI risks due to the bounding on-site shipments involving radioactive materials are given in Table 5.3.10.2–3. As noted in section 5.2.10.2, the frequency of the bounding DARHT and PHERMEX shipments has been added to the frequency of irradiated target shipments.

Hazardous Materials Shipments

The bounding hazardous materials shipments for accident analyses are major chlorine shipments (toxic), major propane shipments (flammable), and major explosives shipments. The consequences of an accident involving a major explosives shipment is bounded by the consequences of an accident involving a major propane shipment, so the frequency of explosives shipments was added to the frequency of propane shipments (rather than analyzing them separately).

TABLE 5.3.10.2–3.—*MEI Doses and Frequencies for Bounding On-Site Radioactive Materials Accidents Under the Expanded Operations Alternative*

SHIPMENT TYPE	EVENT FREQUENCY PER YEAR	MEI DOSE	MEI RISK
Plutonium-238 Solution	1.7×10^{-7}	8.7 rem	1.4×10^{-6} rem/year (5.8×10^{-10} excess LCF/year)
Irradiated Targets	3.2×10^{-6}	acute fatality	3.2×10^{-6} fatalities/year

Accidental Chlorine Release

The projected frequencies, consequences, and risks associated with major chlorine accidents under the Expanded Operations Alternative are presented in Table 5.3.10.2–4.

The use of the Santa Fe Relief Route would result in about one-sixth the risk of fatalities and injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight increase in the risk of fatalities and injuries on the remainder of New Mexico segment because of the extra 6 miles (10 kilometers) traveled on I–25 for northbound traffic (chlorine shipments are all assumed to travel north on I–25).

Accidental Propane Release

The projected frequencies, consequences, and risks associated with major propane accidents under the Expanded Operations Alternative are presented in Table 5.3.10.2–5.

The use of the Santa Fe Relief Route would result in slightly less risk of fatalities and about one-third of the risk of injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in about half the risk of injuries and fatalities on the remainder of New Mexico segment because of the 6 miles (10 kilometers) reduction in distance traveled on I–25 for southbound traffic (propane shipments are all assumed to travel south on I–25).

TABLE 5.3.10.2–4.—*Frequencies, Consequences, and Risk for a Major Chlorine Accident Under the Expanded Operations Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	0.000062	0.065	0.24	0.000019	0.000072
	Suburban	0.00001	1.5	5.6		
U.S. 84/285 to I–25	Rural	0.000048	0.053	0.2	0.00064	0.0024
	Suburban	0.0001	3.0	11		
	Urban	0.000032	11	40		
Remainder of New Mexico	Rural	0.00036	0.015	0.056	0.00011	0.00042
	Suburban	0.000038	1.5	5.5		
	Urban	6.2×10^{-6}	8.4	32		
Remainder of U.S.	Rural	0.0026	0.028	0.1	0.0028	0.01
	Suburban	0.00066	1.6	6.1		
	Urban	0.00016	10	39		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

TABLE 5.3.10.2–5.—*Frequencies, Consequences, and Risk for a Major Propane Accident Under the Expanded Operations Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	0.000022	0.28	1.1	0.000022	0.000086
	Suburban	3.7×10^{-6}	4.2	17		
U.S. 84/285 to I–25	Rural	0.000017	0.23	0.92	0.00033	0.0013
	Suburban	0.000037	8.4	34		
	Urban	0.000011	1.8	7.3		
Remainder of New Mexico	Rural	0.00014	0.15	0.6	0.00026	0.0011
	Suburban	0.000046	5.1	20		
	Urban	5.8×10^{-6}	1.5	6.1		
Remainder of U.S.	Rural	0.00018	0.09	0.36	0.00015	0.00059
	Suburban	0.000023	4.8	19		
	Urban	0.000012	1.9	7.5		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

Traffic Impacts from the Project-Specific Siting and Construction Analyses

The PSSC analyses in volume II (parts I and II) identify relatively minor increases in on-site traffic due to the construction associated with these two projects (Expansion of Area G and Enhancement of Plutonium Pit Manufacturing). The impact analyses identified in this section would not be expected to change due to these types of changes; the conservatism built into these analyses is considered adequate to address these relatively minor and transitory changes.

The alternatives examined for the Enhancement of Plutonium Pit Manufacturing did not reflect any variation in construction traffic across the alternatives. However, much of the on-site operational transportation examined in this section of the SWEIS may be reduced to approximately the No Action levels if the Brownfield or Add-on to TA–55 alternatives were selected. This is because such alternatives would not have the same level of transportation between TA–55 and CMR Building, and this would result in a reduction in driver doses from on-site transportation of radioactive materials to approximately the levels identified in the No Action Alternative for this type of impact. The frequency of on-site transportation accidents would also be reduced in this case. Under the Preferred Alternative, at the 20 pits per year rate, transportation impacts for on- and off-site transportation would be similar to, but slightly less than, the impacts presented in this section. (At this lower rate, there would be fewer shipments between TA–55 and the CMR Building, as well as fewer shipments to and from Oak Ridge and Pantex.) The selection of the "CMR Building Use" Alternative from this PSSC analysis would be expected to result in the operational impacts described in this section.

The alternatives examined for the expansion of Area G did not reflect any variation in construction traffic across the alternatives, except that a new burial site (other than at TA–54) would be expected to require increased construction activity and traffic, with a slightly higher probability of a traffic accident involving workers. This could result in a slightly higher probability of worker injury or death than is presented in this section of the SWEIS.

5.3.11 Accident Analysis

Transportation accidents for the Expanded Operations Alternative are addressed in section 5.3.10. High-frequency (greater than 1 in 100) occupational accidents for the Expanded Operations Alternative are addressed in section 5.3.6.

5.3.11.1 *Multiple Source Release of Hazardous Material from Site-Wide Earthquake and Wildfire*

The risks from these accidents are driven primarily by the frequency and magnitude of an earthquake and wildfire in the area. Because the same types of operations will be conducted in the same facilities, and the inventories of MAR will be about the same; there are no substantial changes between the No Action and the Expanded Operations Alternatives. Therefore, there is no change in risk among the alternatives from site-wide earthquakes. Tables 5.2.11.1–1 and 5.2.11.1–2 show these results.

5.3.11.2 *Plutonium Releases from Manmade and Process Hazards at LANL*

A summary of the frequency and consequences for plutonium releases is given in Table 5.3.11.2–1. These releases reflect a variety of initiators depending on the type of activities or manmade hazards in the area, such as an aircraft crash.

For these accidents there are minor variations in such activities as the handling of drums, the

TABLE 5.3.11.2–1.—*Summary of Radiological Consequences for Plutonium Release Scenarios at LANL—Expanded Operations Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a,f]	CONSEQUENCE MEASURES[b,c,d,e,g]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
MANMADE HAZARDS			
RAD–01 Plutonium release from RANT Facility transuranic waste container storage area fire.	Approximately 1,600 per year (i.e., one event in approximately 600 years); considered an unlikely event	Approximately 0.04 excess LCF Mean population dose approximately 72 person-rem MEI at nearest public access (on Pajarito Road) approximately 46 rem, at most exposed residence approximately 4 rem	0.000064 No change in likelihood or severity among the alternatives.
RAD–07 Plutonium release from WCRRF transuranic waste container storage area fire.	0.0003 per year (i.e., one in 3,000 years); considered an unlikely event	Approximately 0.7 excess LCF Mean population dose: approximately 1,300 person-rem MEI dose at closest public access (Pajarito Road) approximately 74 rem, MEI at habitation: approximately 4 rem	0.00021 No change in the severity of the accident from the No Action Alternative. Likelihood increases, as compared to No Action.
RAD–08 Plutonium release from TWISP transuranic waste storage domes due to aircraft crash and fire.	4.3×10^{-6} per year (i.e., one event in approximately 200,000 years); considered an extremely unlikely event	Approximately 0.2 excess LCF Mean population dose: approximately 400 person-rem MEI at nearest public access (Pajarito Road and nearest boarder with White Rock): 22 rem	8.6×10^{-7} No change in the likelihood or severity of the accident from the No Action Alternative.
RAD–16 Plutonium release due to aircraft crash at the CMR Building.	Approximately 3.5×10^{-6} per year (i.e., one event in approximately 300,000 years)	Approximately 0.03 excess LCF Mean population dose: approximately 56 person-rem, no expected excess LCFs; MEI at closest public access, approximately 3 rem, approximately 0.03 rem at nearest habitation	1.05×10^{-7} No change in the likelihood or severity of the accident from the No Action Alternative.
PROCESS HAZARD ACCIDENTS			
RAD–09 Plutonium release due to transuranic waste drum failure or puncture (for "high" and typical activity in drum).	0.0049 per year (i.e., one in approximately 250 years for high-activity drum); 0.49 per year (i.e., one in 2 years for typical drum)	0.12 excess LCF from high activity drum Mean population dose for release approximately 230 person-rem MEI (high activity drum) at closest access (Pajarito Road) approximately 23 rem; approximately 0.86 rem at closest habitation 0.0022 excess LCF from typical activity drum Mean population dose approximately 4.4 person-rem MEI (typical activity drum) at closest access (Pajarito Road) approximately 0.41 rem; approximately 0.86 rem at closest habitation	0.00059 No change in the severity of the accident from the No Action Alternative. 0.0011 No change in the severity of the accident from the No Action Alternative.

TABLE 5.3.11.2–1.—*Summary of Radiological Consequences for Plutonium Release Scenarios at LANL—Expanded Operations Alternative*-Continued

SCENARIO DESCRIPTION	LIKELIHOOD[a,f]	CONSEQUENCE MEASURES[b,c,d,e,g]	SOCIETAL RISK (EXCESS LATENT CANCER FATALITIES PER YEAR)
RAD–13 Plutonium release from flux trap irradiation experiment at TA–18.	0.000016 per year (i.e., one event in approximately 65,000 years)	Approximately 0.08 excess LCF Mean population dose approximately 160 person-rem MEI at closest public access (Pajarito Road), approximately 120 rem; at closest habitation approximately 0.12 rem.	0.0000013 No change in the likelihood or severity of the accident from the No Action Alternative.
RAD–15 Plutonium release from CMR Building. (1) Laboratory Fire	(1) 0.000036 per year	(1) Approximately 0.088 excess LCF Mean population dose approximately 175 person-rem MEI at nearest public access (Diamond Road) approximately 0.41 rem; approximately 0.48 rem at closest habitation	(1) 3.2 x 10^{-6} Accident severity changes due to an increase in the amount of material.
(2) Wing Fire	(2) 0.000032 per year	(2) Approximately 1.7 excess LCF Mean population dose: approximately 3,400 person-rem MEI at nearest public access (Diamond Road) approximately 91 rem; approximately 90 rem at closest habitation	(2) 0.000054 Accident severity changes due to an increase in the amount of material.

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure.
[e] The symbol ~ means approximately.
[f] The frequency per year is more correctly described as the probability of occurrence in any 12-month period. See detailed explanation under Meaning of Risk and Frequency in volume III, appendix G, section G.1.
[g] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

number of trips, and the number of experiments. These changes tend to increase or decrease the risk by 10 to 20 percent. These changes do not alter the overall risk profile for the site or substantially alter the relative ranking of each of these accidents.

An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and TA–55–4 are presented in volume III, appendix G, section G.4.1.2.

Substantial differences exist between the nuclear facility and operations being conducted in TA–55–4 today and those that were present at the Rocky Flats Plant in 1969. TA–55–4 was designed to correct the deficiencies detected in older facilities such as the Rocky Flats Plant and is being upgraded to meet the even more stringent requirements of the 1990's, including enhanced seismic resistance and fire containment.

5.3.11.3 *Highly Enriched Uranium Release from Process Hazard Accident*

As discussed in section 5.2.11.3, this accident is the dominant accident for the release of HEU. Because the number of pulse operations would increase for the Expanded Operations Alternative, the frequency of the scenario will increase. The associated risk is reflected in Table 5.3.11.3–1.

5.3.11.4 *Tritium Release from a Manmade Hazard Accident at LANL*

As presented in section 5.2.11.4, the aircraft crash event is the dominant accident that involves tritium. Because no changes in operations or inventories from the No Action Alternative are expected, the frequency and consequences of this scenario under the Expanded Operations Alternative are the same as presented under the No Action Alternative in Table 5.2.11.4–1.

5.3.11.5 *Chemical Releases from Manmade and Process Hazard Accidents at LANL*

For the chlorine releases, on-site personnel could be exposed to concentrations in excess of ERPG–2. Chlorine has a highly objectionable odor, which prompts sheltering and escape; however, personnel can be quickly overcome when exposed to high concentrations. There is a small increase in risk for chemical accidents over the No Action Alternative. These results are shown in Tables 5.3.11.5–1 and 5.3.11.5–2.

5.3.11.6 *Worker Accidents*

Because the Expanded Operations Alternative includes the same types of activities that were considered for the No Action Alternative with no changes in the frequency or amounts of materials used in these activities, an individual worker is subject to the same risk. Therefore, the frequencies and consequences of worker accidents under the Expanded Operations Alternative are the same as those reflected in Table 5.2.11.6–1.

TABLE 5.3.11.3–1.—*Summary of Radiological Consequences from Highly Enriched Uranium Release Scenarios at LANL—Expanded Operations Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c,d,e]	SOCIETAL RISK (EXCESS LATENT FATALITIES PER YEAR)
RAD–03 Highly enriched uranium release from power excursion accident with Godiva-IV outside Kiva #3.	4.3×10^{-6} per year	Approximately 0.06 excess LCF Mean population dose: approximately 110 person-rem MEI at nearest public access (Pajarito Road) Approximately 150 rem; at nearest habitation approximately 0.5 rem	2.6×10^{-7}

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.
[d] MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure. The MEI dose is provided for an individual located on Pajarito Road at a distance of 160 feet (50 meters) from the facility, even through Pajarito Road would be closed to the public during outdoor operations.
[e] Impacts, in terms of excess LCFs per year of operation, are used to quantify the risks of exposure to radiation. When the impact is applied to an individual (e.g., an MEI), the risk is a lifetime incremental probability of a fatal cancer per year of operation. When applied to a population of individuals, the risk is the incremental number of fatal cancers anticipated in the exposed population for each year of operation.

TABLE 5.3.11.5–1.—*Summary of Chlorine Exposure Scenarios at LANL—Expanded Operations Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c,d]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
PROCESS HAZARD ACCIDENTS			
CHEM–01 Chlorine release (150 pounds [68 kilograms]) from potable water treatment station, due to human error during cylinder changeout or maintenance, or due to random hardware failures.	Approximately 0.0013 per year (i.e., one such event in approximately 800 years)	For the risk-dominant large leak scenario, an average of approximately 43 persons exposed above ERPG–2 levels, and approximately 12 persons exposed above ERPG–3 levels, to distances of up to a few tenths of a mile.	0.056 Small change in the likelihood or severity of the accident from the No Action Alternative.
CHEM–02 Multiple cylinder (1,500 pounds [680 kilograms]) from toxic gas storage shed at Gas Plant, due to fire or aircraft crash.	Approximately 0.00015 per year (i.e., one in approximately 8,000 years)	Average of 292 people within LANL (ranging from none to 1,000 depending upon wind direction) exposed at or above ERPG–2 or –3 levels; town protected by canyon from highest concentrations.	0.044 (Frequency increases by 14% from the no action alternative; no change in severity)
CHEM–03 Chlorine release (150 pounds [68 kilograms]) from toxic gas storage shed at Gas Plant, due to random failure or human errors during cylinder handling.	Approximately 0.00012 per year (i.e., one in approximately 8,000 years)	An average of approximately 263 exposed above ERPG–2 levels; or 239 above ERPG–3 levels, at distances to a fraction of a mile, all within LANL; town protected by canyon from highest concentrations.	0.032 No change in likelihood or severity over the No Action Alternative.
CHEM–06 Chlorine gas release outside Plutonium Facility.	Approximately 0.063 per year (i.e., one event in approximately 16 years)	Average number exposed at or above ERPG–2 doses is approximately 102, and above ERPG–3, approximately 7 at ranges to a fraction of a mile.	6.426 No change in likelihood or severity over the No Action Alternative.

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.

TABLE 5.3.11.5–2.—*Summary of Chemical Exposure Scenarios—Expanded Operations Alternative*

SCENARIO	DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c,d]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
CHEM–04	Bounding single container release of toxic gas (selenium hexafluoride) from waste cylinder storage.	Approximately 0.004 per year (i.e., one in about 250 years)	Average number of off-site persons exposed above ERPG–2 level is zero; toxic effects generally limited to the source's TA (TA–54).	0 No changes in frequency or severity from the No Action Alternative.
CHEM–05	Bounding multiple cylinder release of toxic gas (sulfur dioxide) from waste cylinder storage.	Approximately 0.00051 per year (i.e., one event in approximately 2,000 years)	Under conservative daytime conditions, no one outside the source area (TA–54) would see levels above ERPG–2. Under least favorable conditions, 13 persons could be exposed above ERPG–3 levels.	0 No changes in frequency or severity from the No Action Alternative.

[a] Accident likelihood estimates are conservative, given the information available.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but utilize average (rather than most unfavorable) weather conditions.

5.4 IMPACTS OF THE REDUCED OPERATIONS ALTERNATIVE

5.4.1 Land Resources

5.4.1.1 *Land Use*

Changes to land use and land use categories under the Reduced Operations Alternative would be the same as for the No Action Alternative.

5.4.1.2 *Visual Resources*

Changes to visual resources under the Reduced Operations Alternative would be the same as for the No Action Alternative.

5.4.1.3 *Noise*

Changes to noise levels, air blasts and ground vibrations associated with high explosives testing under the Reduced Operations Alternative would be the same as for the No Action Alternative. The total of LANL activities would decrease with a corresponding slight decrease in total noise producing events, which would reduce the potential to impact workers.

5.4.2 Geology and Soils

Potential impacts for the Reduced Operations Alternative on geology and soils would be the same as those for the No Action Alternative.

5.4.3 Water Resources

5.4.3.1 *Surface Water*

Table 5.4.3.1–1 shows the total flow from the NPDES outfalls for each of the major watersheds under the Reduced Operations Alternative. In volume III, appendix A, Table A.1–1 presents a more detailed table of the NPDES outfalls for all four alternatives by facility (key and non-key), watershed, and location. The estimated total gallons discharged into all watersheds equals 218 million gallons (825 million liters) under the Reduced Operations Alternative. This is a decrease from the index effluent volume of 233 million gallons (882 million liters).

NPDES outfall effluent quality during the period of the SWEIS (1997 through 2006) is expected to be the same under this alternative as described for the No Action Alternative, including the radionuclide concentrations in effluent from TA–50, as presented in Table 5.2.3.2–2. The only canyon that has an increase in outfall flow over the baseline is Sandia Canyon. The projected increase in flow to Sandia Canyon is slightly more than one-half that projected for the No Action Alternative. The potential impacts resulting from this increase in flow in Sandia Canyon should be the same as discussed under the No Action Alternative. For the Reduced Operations Alternative, there are no new activities that would result in changes in stormwater runoff.

5.4.3.2 *Alluvial Groundwater*

The relative decreases in NPDES outfall discharges (as compared to No Action) are expected to result in proportionally lower alluvial groundwater volumes.

The projected discharge from RLWTF into Mortandad Canyon under the Reduced Operations Alternative is 5.3 million gallons (20 million liters) per year, about the same as the RLWTF index volume of 5.5 million gallons (21 million liters) per year.

The new HELWTF will likely result in improved water quality to Canyon de Valle, as discussed in the No Action Alternative.

TABLE 5.4.3.1–1.—*NPDES Discharges by Watershed Under the Reduced Operations Alternative*[a]

WATERSHED	# OUTFALLS		FLOWS (MGY)					
			KEY FACILITIES		NON-KEY		TOTALS	
	INDEX	REDUCED	INDEX	REDUCED	INDEX	REDUCED	INDEX	REDUCED
Ancho	2	0	0.1	0.0	0.0	0.0	0.1	0.0
Cañada del Buey	3	3	0.0	0.0	6.4	6.4	6.4	6.4
Chaquehui	1	0	0.0	0.0	5.8	0.0	5.8	0.0
Guaje	7	7	0.0	0.0	0.7	0.7	0.7	0.7
Los Alamos	12	8	19.2	16.4	0.5	0.2	19.7	16.6
Mortandad	12	7	42.0	28.3	10.9	5.1	52.9	33.4
Pajarito	17	11	8.4	1.8	0.8	0.8	9.2	2.6
Pueblo	1	1	0.0	0.0	1.0	1.0	1.0	1.0
Sandia	11	8	4.4	15.4	103.5	127.9	107.9	143.3
Water	21	10	29.5	14.1	0.0	0.0	29.5	14.1
Totals	87	55	103.6	76.0	129.6	142.0	233.2	218.1

MGY = millions of gallons per year

[a] NPDES Information Sources: Index information was provided by the Surface Water Data Team Reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997. Additional outfalls may be eliminated in the future (as discussed in the *Environmental Assessment for Effluent Reduction* [DOE 1996e]) as well as several other outfalls that may be closed as part of LANL's ongoing outfall reduction program.

5.4.3.3 *Perched Groundwater*

Groundwater flow and contaminant pathways to the intermediate perched groundwater bodies are not well characterized nor understood. It is possible that NPDES discharges to Los Alamos and Sandia Canyons under the Reduced Operations Alternative, could contribute to recharge of the intermediate perched groundwater and contaminant transport beneath Los Alamos and Sandia Canyons. However, unlike the No Action and the other alternatives, NPDES discharges to Los Alamos Canyon under the Reduced Operations Alternative will be slightly less than the index.

5.4.3.4 *Main Aquifer*

Recharge mechanisms to the main aquifer are uncertain. However, for the same reasons as discussed under the No Action Alternative, impacts resulting from decreased NPDES outfall flows under the Reduced Alternative should be negligible. A conservative projection of LANL water use under the Reduced Operations Alternative is 602 million gallons (2,279 million liters) per year. Los Alamos County and the NPS did not provide projections, but in 1994 the County used about 958 million gallons (3,626 million liters) from this water right and the NPS used about 5 million gallons (19 million liters). Based on this information, it is expected that the water requirements of this community can be met within the existing water rights from the main aquifer.

For the purposes of modeling drawdown of the main aquifer, annual water use projections were made. The total water usage from DOE water rights was projected to average 1,451 million gallons (5,492 million liters) per year under the Reduced Operations Alternative, with a maximum annual use of 1,470 million gallons

(5,564 million liters) and a minimum annual use of 1,444 million gallons (5,466 million liters).

The model results reflect water level changes at the top of the main aquifer across the alternatives, given continued draw from the aquifer by DOE, Española, and Santa Fe. Table 5.4.3.4–1 shows predicted water level changes at the surface of the main aquifer during the period from 1997 through 2006 for the Reduced Operations Alternative; as noted in section 5.2.3.1, these changes are not all due to LANL operations. Although the water use modeled includes water use in Española and Santa Fe, the differences between the alternatives are due only to LANL operations. The impacts to the volume of water in the main aquifer under this alternative are very similar to those described for the No Action Alternative; the drawdowns in the DOE well fields are minimal relative to the total thickness of the main aquifer, and the volume of water to be used over the period from 1997 through 2006 is negligible relative to the volume of water in storage. Details of the conceptual model, assumptions, uncertainties and limitations, and input parameters for the groundwater model are described in volume III, appendix A.

TABLE 5.4.3.4–1.—*Maximum Water Level Changes at the Top of the Main Aquifer Under the Reduced Operations Alternative (1997 Through 2006)*

WATER LEVEL CHANGE IN FEET[a,b]	
AREA OF CONCERN ON SITE	
Pajarito Well Field	-10.7
Otowi Well Field (Well 0-4)	-10.3
AREA OF CONCERN OFF SITE	
DOE - Guaje Well Field	-8.1
Santa Fe Water Supply	
Buckman Well Field	+21.7
Santa Fe Well Field	-20.6
San Juan Chama Diversion	0.0
Springs	
White Rock Canyon Springs, Maximum Drop	0.0
White Rock Canyon Springs, Maximum Rise	+1.0
Other Springs (Sacred, Indian)	+3.8
San Ildefonso Pueblo Supply Wells	
West of Rio Grande	
Household, Community Wells	+0.6
Los Alamos Well Field	+3.8
East of Rio Grande	
Household, Community Wells	0.0

[a] Negative value (-) indicates water level drop; positive value (+) indicates water level rise.
[b] Also, the water level changes projected by the regional MODFLOW model represent average changes over a whole grid- cell (i.e., a square that is a mile on a side). They are, for the most part, not predictive of the water level changes at any single point within the cell (for example, a supply well). Pumping wells have characteristic "cones of depression" where the water surface reflects an inverted cone, and water levels at the well may be quite different from levels even a few ten's of feet away. Whether any individual well would exhibit water level changes consistent with the predicted grid-cell average change is a function of, for example, its location within the grid-cell; proximity to other pumped wells; and the individual well operation, construction, and hydraulics. Hence, the water level changes predicted by the model can only be considered qualitatively and can not be considered as finite changes.

5.4.4 Air Quality

5.4.4.1 *Nonradiological Air Quality Impacts*

Criteria Pollutants

Criteria pollutant emissions under the Reduced Operations Alternative are less than those under the Expanded Operations Alternative. Because the bounding analysis of criteria pollutant emissions for all alternatives (based on the emissions under the Expanded Operations Alternative) results in estimated concentrations of each pollutant below the standards established to protect human health with an ample margin of safety, criteria pollutant emissions under the Reduced Operations Alternative would also be below these levels.

Toxic Air Pollutants

As discussed in section 5.1.4, the only toxic air emissions with the potential to impact human health and the environment under any alternatives are those associated with high explosives test site operations and the additive emissions from all the pollutants from all TAs on receptor sites located near the Los Alamos Medical Center. Under the Reduced Operations Alternative, such emissions are projected to be similar to those addressed in the No Action Alternative (section 5.1.4). Therefore, pollutants released from LANL operations under the Reduced Operations Alternative are not expected to cause air quality impacts that would affect human health and the environment.

5.4.4.2 *Radiological Air Quality Impacts*

This section addresses the radiation dose to the FS MEI, LANL MEI and the population dose from LANL radionuclide air emissions under the Reduced Operations Alternative.

Facility-Specific Maximally Exposed Individual

Table 5.4.4.2–1 shows the FS MEI doses under the Reduced Operations Alternative. The highest MEI dose was 1.88 millirem per year, which is 18.8 percent of the regulatory limit for the air pathway. This table shows the EPA regulatory limit would not be exceeded from emissions of these facilities under the Reduced Operations Alternative.

LANL Maximally Exposed Individual

The location of the highest dose from all facility emissions was 2,625 feet (approximately 800 meters) north-northeast of TA–53. LANL MEI dose was calculated to be 1.88 mrem per year under the Reduced Operations Alternative.

TABLE 5.4.4.2–1.—*Facility-Specific Information Reduced Operations Alternative*

KEY FACILITY	DOSE[a] (mrem/yr)
TA–3-29 (CMR)	0.36
TA–3-66 (Sigma)	0.36
TA–3-102 (Shops)	0.29
TA–11 (HE Testing)	0.31
TA–15/36 (Firing Sites)[c]	1.76
TA–16 (Tritium Facility)	0.22
TA–18 (Pajarito Site)	1.51
TA–21 (Tritium Facility)	1.22
TA–48 (Radiochemistry Laboratory)	1.08
TA–55 (Plutonium Facility)	1.08
TA–53 (LANSCE)[b]	1.88
TA–54 (Boundary)[c]	0.68
TA–54 (White Rock)	0.39

[a] For each FS MEI, the total dose was calculated by adding the contributions from each modeled facility. An MEI does not leave or take protective measures.
[b] This is also the LANL MEI. Five specific sources were modeled from TA–53. These include the TA–53 ES–2, ES–3, IPF, LEDA, and combined diffuse emissions.
[c] Two FS MEI locations were considered for TA–54 because Area G is bordering San Ildefonso Pueblo land. The first is a MEI location at the LANL boundary, 1,197 feet (365 meters) northeast of Area G. No person from the Pueblo currently is known to live along this boundary. The second is an actual MEI location in the town of White Rock, approximately 5,331 feet (1,625 meters) southeast of Area G.

Population Dose

The collective dose to the population living within a 50-mile (80-kilometer) radius from LANL was calculated to be 10.83 person-rem per year under the Reduced Operations Alternative. TA–15/36 accounted for 65.3 percent of this dose (collective diffuse emissions, including those from these TAs, accounted for 66.3 percent of this dose).

The values reported for population doses for this alternative, as well as the other alternatives, is higher than has been reported in the recent annual environmental reports. It is important to recognize that the alternatives analyzed represent increased operations when compared to recent history. The material throughput at the different facilities under the various alternatives is presented in chapter 3, section 3.6.

Isodose Maps

The isodose maps for the 50-mile (80-kilometer) region are shown on Figures 5.4.4.2–1 and 5.4.4.2–2.

5.4.5 Ecological Resources, Biodiversity, and Ecological Risk

Impacts to ecological resources and biodiversity resulting from reducing the scale of operations would not vary appreciably from those of the No Action Alternative. An overall reduction in outfall discharges could cause a commensurate decrease in the extent of affected wetlands. There would not be any incremental changes from the No Action level of ecological risk.

5.4.6 Human Health

The consequences of implementing the Reduced Operations Alternative on public health and worker health are presented below. As discussed in section 5.1.6, "risk," as used in the SWEIS human health analysis, refers to the probability of toxic or cancer mortality consequences under the specific exposure scenarios analyzed.

5.4.6.1 *Public Health*

The consequences of continued operations of LANL on public health under the Reduced Operations Alternative are presented below for the same topics discussed in section 5.2.6.1.

Regional Consequences of Airborne Radioactivity Inhalation and Immersion

The LANL MEI was estimated to be 2,625 feet (800 meters) north-northeast of LANSCE (TA–53). This location is within the LANL reservation, and the dose at this location is estimated to be 1.88 millirem per year (section 5.4.4.2), corresponding to a 72-year lifetime dose of 0.14 rem. This location borders the Los Alamos townsite and is a conservative estimate for an MEI from LANL emissions. The background (TEDE) dose in the Los Alamos area is estimated to be 360 millirem per year; thus, the dose to the MEI is 0.5 percent of the background dose.

Table 5.4.6.1–1 summarizes the LANL MEI dose and presents the corresponding risk of excess LCF to the MEI. The risk of development of nonfatal cancer is also presented. These risks are presented on a lifetime basis, assuming that the hypothetical LANL MEI received the estimated dose of 1.88 millirem each year for a 72-year life. The excess LCF risk was estimated to be 0.000068 over a lifetime.

TABLE 5.4.6.1–1.—*Estimated Public Health Consequences for LANL MEI and the Population Within a 50-Mile (80-Kilometer) Radius of LANL for the Reduced Operations Alternative*

PARAMETER	LANL MEI	50-MILE (80-KILOMETER) RADIUS POPULATION
Dose	1.88 millirem/year	10.83 person-rem/year
Excess LCF	0.000068/lifetime (72 year)	0.0054/year of operations

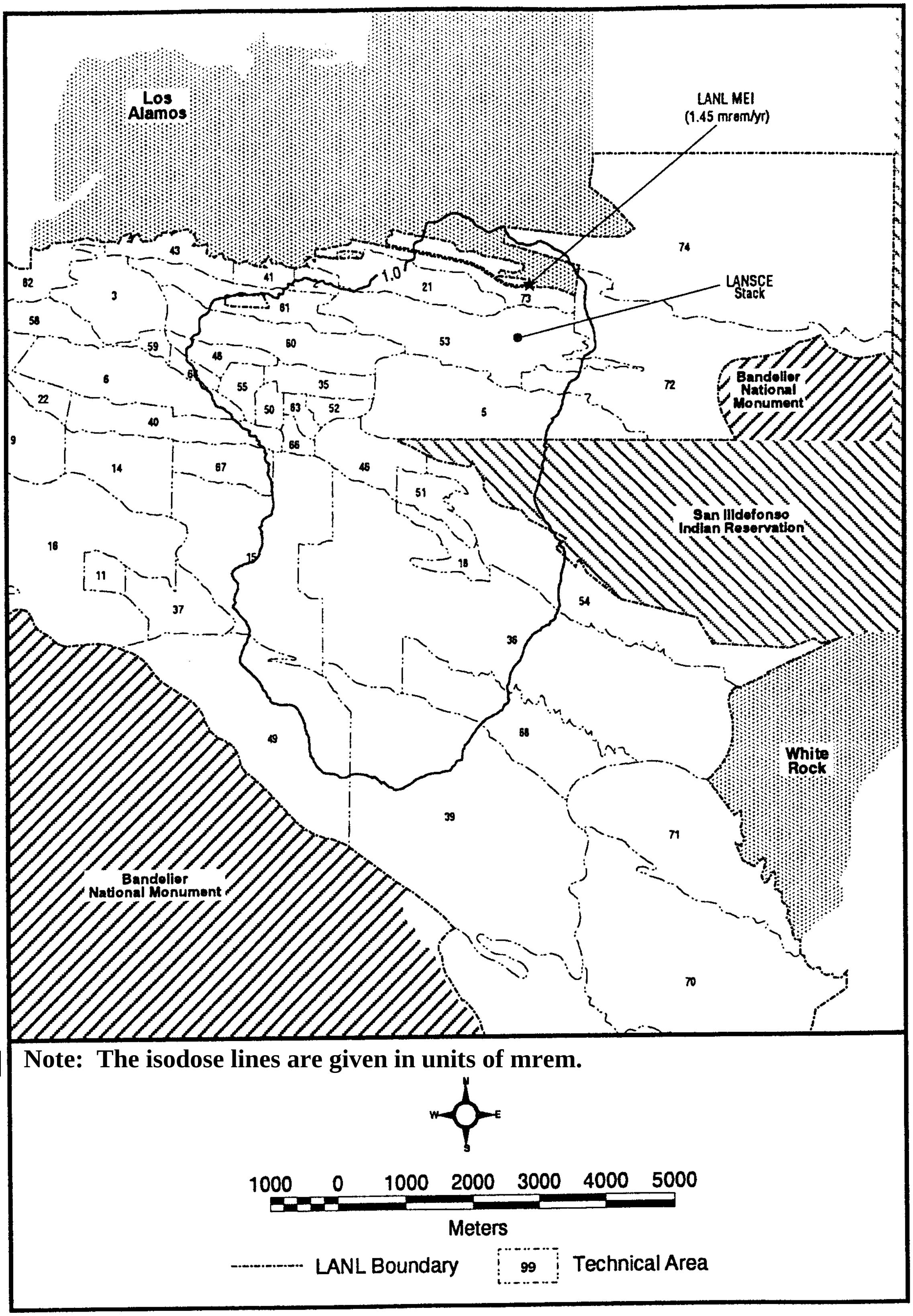


FIGURE 5.4.4.2–1.—*Isodose Map Showing Doses Greater Than 1 Millirem per Year for the Reduced Operations Alternative*.

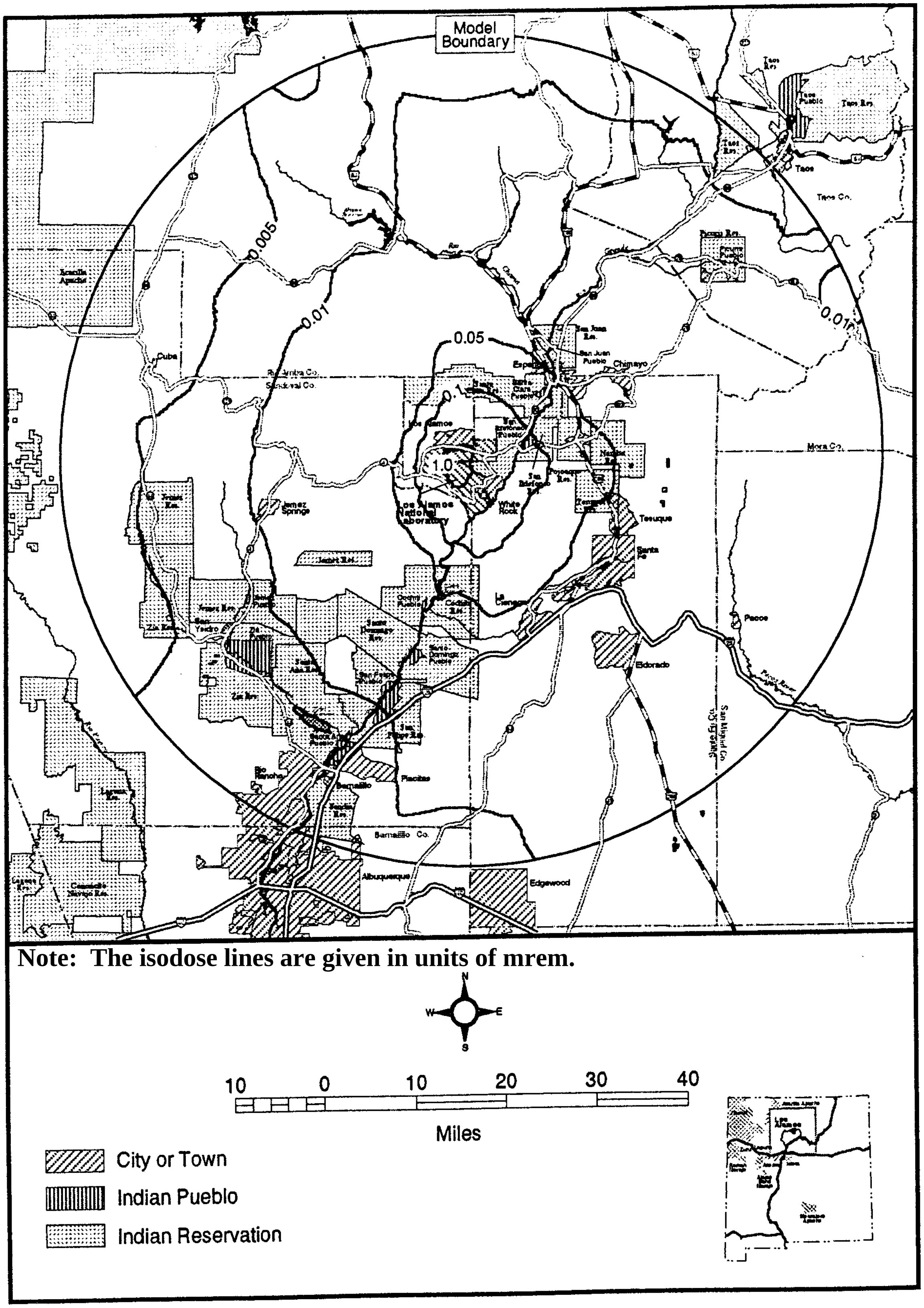


FIGURE 5.4.4.2–2.—*Isodose Map Showing Doses Less Than 1 Millirem per Year for the Reduced Operations Alternative.*

The isodose maps showing both the estimated dose near LANL and within a 50-mile (80-kilometer) radius of LANL are given in Figures 5.4.4.2–1 and 5.4.4.2–2. The population dose within the 50-mile (80-kilometer) radius is also given in Table 5.4.6.1–1, estimated to be 10.8 person-rem per year. As reflected in the table, the annual operations excess LCF risk was estimated to be 0.0054.

In the Reduced Operations Alternative, there are six facilities with FS MEIs receiving a dose that would exceed 1 millirem per year (volume III, appendix B):

- LANSCE, 1.88 millirem per year to the facility MEI
- HE Testing Sites (TA–15 and TA–36), 1.76 millirem
- Pajarito Site (TA–18), 1.51 millirem
- TSTA and TSFF (TA–21), 1.22 millirem
- Radiochemistry Laboratory (TA–48), 1.08 millirem
- Plutonium Facility (TA–55), 1.08 millirem

External Radiation: Two Special Cases

As discussed in section 5.2.6.1, one contribution to public dose results from jogging or hiking for 96 hours on the access road north of TA–21 and is attributable to cesium-137 known to be on the ground within the TA. The MEI dose is not expected to change under the Reduced Operations Alternative from that estimated under the No Action Alternative (an EDE of 2.9 millirem per year and an excess LCF risk of about 1.4 x 10^{-6} per year).

The other contribution to public dose, as discussed in section 5.2.6.1, would result from TA–18 "road-open" operations. At the 95 percent confidence level, four exposures per year would be expected for the MEI out of the 100 operations per year at TA–18 under the Reduced Operations Alternative (the same as for the No Action Alternative). This would result in an annual projected MEI EDE dose of 19 millirem per year. The lifetime excess LCF risk for this dose is about 9.5 x 10^{-6} per year of operation.

Nonionizing Radiation

The only uncontained nonionizing radiation source in use or planned for LANL is the microwave transmitter in TA–49. The consequence of a public exposure to this source under the Reduced Operations Alternative is the same as for the No Action Alternative; as discussed in section 5.2.6.1, this consequence is negligible.

Consequences of Airborne Chemical Emissions

For the Reduced Operations Alternative, these consequences are the same as those under the No Action Alternative; the worst-case HI for lead did not exceed one in a million (10^{-6}); for depleted uranium, the worst-case HI did not exceed 1 in 100,000 (0.00010); and the excess LCF for beryllium (evaluated as a carcinogen) under the Reduced Operations Alternative was estimated to be less than 3.6 x 10^{-7} per year. These analyses are presented in detail in volume III, appendix D.

Carcinogenic Risk from Air Emissions

The screening process described in appendix B identified no individual carcinogenic chemical air emission that required analysis for public health consequences. For carcinogens, an estimate also was made of the combined lifetime incremental cancer risk due to all carcinogenic pollutants from all TAs (appendix B, attachment 6).

This combined cancer risk is less than 1 in 1 million for the Reduced Operations Alternative because projected emissions for this alternative are less than those analyzed for the Expanded Operations Alternative (which was just slightly above the screening guideline value of 1 x 10^{-6}).

It is believed that negligible increase in incremental combined cancer risk will result from the Reduced Operations Alternative.

Consequences of Ingestion to Residents, Recreational Users, and Special Pathways Receptors

The risk to the public from ingestion under the Reduced Operations Alternative does not differ from that associated with the No Action Alternative; this is because most of the risk is attributable to the existing levels of contamination in water and soils in the area. This is discussed further in section 5.2.6.1. Table 5.2.6.1–2 summarizes the ingestion radiological annual dose and excess LCF per year to the MEIs. Tables 5.2.6.1–2 and 5.2.6.1–3 summarize the total radiological annual ingestion dose and excess LCF to members of the public. Per Table 5.2.6.1–3, the total worst-case ingestion doses for the off-site resident of Los Alamos County and non-Los Alamos County resident are 0.011 and 0.017 rem per year, respectively. If this person is also a recreational user of the Los Alamos canyons, drinking canyon water and ingesting canyon sediments, the worst-case additional dose ranges up to 0.001 rem per year, according to the amount of time spent in the canyons (see footnote b in Table 5.2.6.1–3). If the individual has traditional Native American or Hispanic lifestyles, the values found in the final columns of the table should be used in place of the values in the first columns for off-site residents. Per the values in the final columns, these "special pathways receptors" can have worst-case 3.1 millirem per year additional dose. The associated excess LCF risks for the off-site residents are 8.6×10^{-6} per year of exposure and 9.1×10^{-7} per year of exposure for the individual who is also an avid recreational user. These worst-case doses are for a 95th percentile intake of the 95th percentile contamination level, referred to as the UCL. Ingestion pathway calculations included all radionuclides detected in the media. This includes natural background, weapons testing fallout, and previous releases. The actual contribution from continued operations at LANL is only a small fraction of this value. These values apply to the baseline and to all four alternatives. The data and analyses for these calculations are in volume III, appendix D, section D.3.3. Table 5.2.6.1–3 summarizes the risk associated with metals ingestion to MEIs in the LANL region.

Consequences to the Public Along Transportation Routes

Section 5.4.10 details the analysis of transportation consequences under this alternative. Public health consequences include the dose and excess LCF risk associated with routine, accident-free transportation. Table 5.4.10–2 shows the population dose and excess LCF for normal (accident-free) off-site shipments. The population dose and excess LCFs associated with exposures occurring during stops for transportation segments near LANL are provided in Table 5.4.6.1–2. Doses associated with living along route and sharing routes with these shipments are detailed in Table 5.4.10–2, and are less than those associated with stops. Risks associated with accidents during transportation also are discussed in section 5.4.10.

5.4.6.2 *Worker Health*

Worker risks associated with continued operations of LANL include radiological

TABLE 5.4.6.1–2.—*Radiation Doses and Excess LCF Risks Estimated to the Public at Stops During Transportation of Materials and Wastes from LANL*

ROUTE SEGMENT	PERSON-REM PER YEAR (AT STOPS)	EXCESS LCF RISK PER YEAR
LANL to U.S. 84/285	3.4	0.0017
U.S. 84/285	3.6	0.0018

(ionizing and nonionizing) risks, chemical exposure risks, and risk of injury during normal operations. The consequences to worker health from implementing the Reduced Operations Alternative are given below and detailed in appendix D, section D.2.2.

Radiological Consequences

Ionizing Radiation Consequences. Table 5.4.6.2–1 summarizes the projected doses and associated excess LCF risks from implementation of the Reduced Operations Alternative.

The collective worker dose under the Reduced Operations Alternative is conservatively projected to be 18 percent less than that measured in 1993 to 1995. In terms of the average non-zero dose, the Reduced Operations Alternative is expected to result in less than that experienced in recent years (0.08 rem per year for Reduced Operations compared with 0.097 rem per year, 1993 to 1995). The estimated lifetime excess LCF risk is 0.000033 per year of operation.

Nonionizing Radiation. It is expected that there will continue to be negligible effects to LANL worker health from nonionizing radiation sources including ultraviolet sources, infrared radiation from instrumentation and welding, lasers, magnetic and electromagnetic fields, and microwaves (including the large station at TA–49). (Also see appendix D, section D.2.2.2 for evaluation used to estimate nonionizing radiation from LANL operations to humans and wildlife, and for the estimated results.)

Chemical Exposure Consequences

It is anticipated that there will continue to be a few exposures annually, particularly exposures to:

- Airborne asbestos
- Lead paint particulates
- Crystalline silica
- Fuming perchloric acid, hydrofluoric acid
- Skin contact with acids or alkalis

Under the Reduced Operations Alternative, it is expected that there will be a worker population of approximately 9,300 individuals, approximately equal to the index period employment levels. For the purposes of the SWEIS, it is assumed that there is negligible additional benefit of the chemical hygiene program at LANL over the period analyzed, and that the rate of chemical exposures continues at the index period rates. Therefore, it is expected that reportable chemical exposures would not change from the index period, approximately one to three reportable chemical exposures per year.

Beryllium Processing Consequences. It is anticipated that beryllium operations in the Reduced Operations Alternative would be the same as in the No Action Alternative. It is not anticipated that consequences to workers would be measurable; that is, no sensitization to beryllium would be detected using the LANL industrial hygiene monitoring program.

TABLE 5.4.6.2–1.—*Annual Worker Doses and Associated Lifetime Excess LCF Risks Under the Reduced Operations Alternative*

LANL Collective Worker Dose (person-rem/yr)	170
Estimated Excess LCF Risk (across the worker population) per year of operation	0.07
Average Non-Zero Worker Dose (rem/yr)	0.08
Estimated Excess LCF Risk (average worker > 0 dose)	0.000033

Physical Safety Hazards

Table 5.4.6.2–2 compares the projected reportable accidents and injuries estimated for normal operations occurring under the Reduced Operations Alternative and that experienced during the index period. The Reduced Operations Alternative is expected to result in no change in reportable accidents or injuries due to increases in worker population. These accidents and injuries are considered as consequences of normal operations because of their frequency. These results assume that the aggressive Health and Safety Program underway at LANL does not achieve any additional reduction in reportable cases.

The consequences of these accidents and injuries are expected to be similar to those experienced in the past, and typically are those associated with health response and recovery from acute trauma. Therefore, the consequences include physical pain and therapy/treatment for recovery such as those associated with bone setting, shoulder dislocation reset, and subsequent physical therapy. Some injuries may also result in continuing consequences to the worker that could affect productivity or lifestyle, such as motor skill loss due to nerve damage or cardiovascular debilitation resulting from electrical shock or electrocution.

TABLE 5.4.6.2–2.—*Projected Annual Reportable Accidents and Injuries for the Reduced Operations Alternative Compared with the Index Period*

PARAMETER ESTIMATED	PARAMETER VALUE AND UNITS
Projected Worker Population	Approximately 9,300
Projected Reportable Accidents and Injuries	417/year
Change from Index (1993 to 1996)	Negligible Change

5.4.7 Environmental Justice

As indicated in sections 5.4.1 and 5.4.2, no substantive adverse impacts to land resources or geology and soils are anticipated for the continued operation of LANL under the Reduced Operations Alternative. Thus, no disproportionately high and adverse impacts to minority or low-income communities are anticipated for these impact areas. The potential impacts to surface and groundwater and ecological resources associated with the Reduced Operations Alternative would affect all communities in the area equally (see sections 5.4.3 and 5.4.5 for additional information on the potential for impacts to these resources). Thus, no disproportionately high or adverse impacts to minority or low-income communities are anticipated to be associated with these resource areas.

Figure 5.4.7–1 reflects the dose from radiological air emissions within 50 miles (80 kilometers) of LANL under the Expanded Operations Alternative. As discussed in section 5.2.7, impacts due to air emissions are equal to lower in the sectors with substantial minority and/or low-income populations than they are in sectors 1–3 and 6–16, and such impacts are not disproportionately high or adverse with respect to the minority or low-income populations (see section 5.4.4 regarding the impacts anticipated for air emissions under the Reduced Operations Alternative).

The air pathway is one example of the analysis of potential human health impacts. As presented in section 5.4.6, there is minimal potential for LANL operations to adversely affect human health for off-site residents or recreational users in the area around LANL under the Reduced Operations Alternative. Similarly, the special pathways have little potential to impact human health under this alternative. Thus, the Reduced Operations Alternative would not present disproportionately high or adverse impacts to

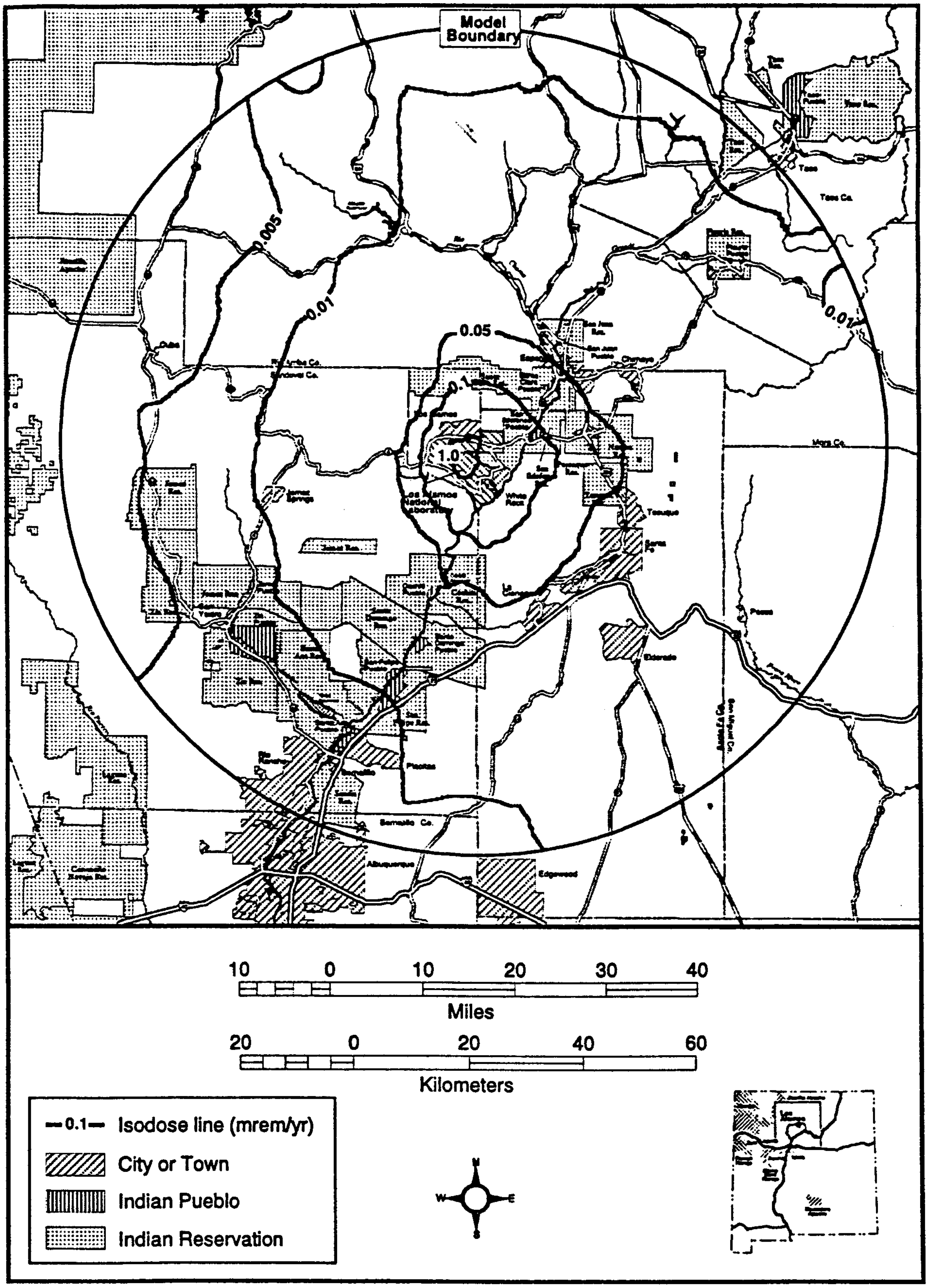


FIGURE 5.4.7–1.—*Isodose Lines from Airborne Releases for the Reduced Operations Alternative Within 50 Miles (80 Kilometers) of LANL.*

human health in minority or low-income communities (section 5.4.6.1).

As shown in section 5.4.10, impacts from on-site transportation and from LANL to U.S. 84/285 are estimated to be 0.0017 excess LCFs per year from incident-free transportation and 0.042 deaths and injuries per year from transportation accidents. Impacts from transportation on route segments that pass through minority or low-income communities (particularly the segment from U.S. 84/285 to I–25) are estimated to be 0.0018 excess LCFs per year from incident-free transportation and 0.095 deaths or injuries per year from transportation accidents. Therefore, no high and adverse impact is expected to either a member of the general public or to a member of a minority or low-income population due to transportation in the vicinity of LANL transportation routes.

5.4.8 Cultural Resources

Construction activities and explosive test activities under this alternative are essentially the same as those under the No Action Alternative. Because these are the activities with the most potential for impacts to cultural resources, impacts to prehistoric resources, historic resources, and TCPs under the Reduced Operations Alternative would be similar to those stated for the No Action Alternative in subsection 5.2.8, including the associated table. DOE would continue to manage and protect the 1,295 inventoried archaeological resources in compliance with the *Archaeological Resources Protection Act* (16 U.S.C. §470aa), Sections 3, 4, 6, and 7, and related legislation (see chapter 4). Management and protection of historic structures would be similar to that of the No Action Alternative (section 5.2.8).

Spiritual Entities

As with the No Action Alternative, no assessment of impacts to "unseen" or "spiritual" entities was attempted.

5.4.9 Socioeconomics, Infrastructure, and Waste Management

This section describes the social, economic, and infrastructure impacts of activities at LANL under the Reduced Operations Alternative.

5.4.9.1 *Socioeconomic Impacts*

Employment, Salaries, and Population

The primary (direct) impacts of this type are presented in Table 5.4.9.1–1 for the LANL workforce only. The secondary (indirect) impacts and the total population changes projected are presented in Table 5.4.9.1–2 for the Tri-County area. These changes are assumed to occur within a year of the ROD for the SWEIS.

Housing

The population changes anticipated in the Tri-County area, based on the total employment changes described above, are projected to result in a reduction in demand of 27 housing units. The distribution of this reduction in the three counties is: a reduction of 6 units in Los Alamos County; a reduction of 10 units in Rio Arriba County; and a reduction of 11 units in Santa Fe County.

A reduction in housing demand at these levels is not expected to exert any significant pressure on rents and house prices, and is not expected to effect apartment vacancies or turnover periods for house sales in any of these three counties.

Construction

Table 5.4.9.1–3 contains the results of the analysis of construction spending, labor salaries, and labor employment for the period fiscal year 1997 through fiscal year 2006. Construction activities associated with this alternative are expected to draw workers already present in the Tri-County area who

TABLE 5.4.9.1–1.—*Summary of Primary LANL Employment, Salaries[a], and Procurement Under the Reduced Operations Alternative[b]*

	LOS ALAMOS COUNTY	RIO ARRIBA COUNTY	SANTA FE COUNTY	TRI-COUNTY TOTAL	OTHER NEW MEXICO COUNTIES	NEW MEXICO TOTAL	OUTSIDE NEW MEXICO	TOTAL
Employees	4,821	1,913	1,832	8,566	607	9,173	174	9,347
Difference[c]	(14)	(6)	(5)	(25)	(1)	(26)	(2)	(28) (-< 1%)
Salaries ($M)	252.4	44.6	73.7	370.7	16.3	387	8.5	395.4
Difference[c]	(2.9)	(0.4)	(0.6)	(3.2)	0	(3.3)	(0.2)	(3.5) (- 1%)
Procurement ($M)	215.4	1.7	20.6	237.7	121.8	359.5	228.8	588.4
Difference[c]	(0.3)	0.0	(0.1)	(0.3)	(0.6)	(1.0)	(2.8)	(3.7) (- 1%)

( ) indicates a decrease as compared to baseline.
[a] Salaries are for UC employees only; subcontractor salaries (Johnson Controls, Inc.; Protection Technology of Los Alamos, etc.) are included in the procurement dollars.
[b] Reflects projected locations of employee residences and LANL procurement activities.
[c] Difference is as compared to fiscal year 1996. Percentage difference is shown in parentheses in the far right (TOTAL) column.

TABLE 5.4.9.1–2.—*Summary of Total Tri-County Employment, Salaries, Business Activity, and Population Changes Under the Reduced Operations Alternative*

	PRIMARY CHANGE	SECONDARY CHANGE	TOTAL TRI-COUNTY CHANGE	TRI-COUNTY PRIMARY WORKER CHANGE[a]	TRI-COUNTY SECONDARY WORKER CHANGE[b]	TOTAL TRI-COUNTY WORKER CHANGE	TOTAL TRI-COUNTY POPULATION CHANGE[c]
Employment/ Population	(25)	(43)	(68)	(20)	(13)	(33)	(64) (-< 1%)
Personal Incomes	($3 million)	($3 million)	($6 million) (-< 1%)				
Annual Business Activity	($0.3 million)	($0.7 million)	($1 million) (-< 1%)				

( ) indicates a decrease as compared to baseline. Percentages in parentheses are the percentage change that the number represents. These are provided for total population change, total person income change, and total annual business activity change.
[a] This is the number of direct workers moving to the Tri-County area, assuming that 80 percent of new LANL employees are from outside this area.
[b] This is the number of secondary workers moving to the Tri-County area, assuming that 30 percent of secondary employment is from outside this area.
[c] This is the total population increase in the Tri-County area, assuming that, on average, each worker moving to the area increases the population by 1.935 (and each worker leaving the area decreases the population by 1.935).

TABLE 5.4.9.1–3.—*Construction Spending, Labor Salaries, and Labor Employment Numbers Under the Reduced Operations Alternative (Fiscal Year 1997 Through 2006)*

YEAR	CONTRACT $M	LABOR $M	EMPLOYEES
1997	63	15	432
1998	187	45	1,282
1999	208	50	1,426
2000	219	53	1,502
2001	210	50	1,440
2002	120	29	823
2003	91	22	624
2004	90	22	617
2005	109	26	747
2006	108	26	741

$M = dollars given in millions
Sources: DOC 1996, PC 1997a, and PC 1997b

historically have worked from job to job in the region. Thus, this employment is not expected to influence socioeconomic factors.

Local Government Finance

Under this alternative, the Tri-County gross receipts tax yields would not be expected to change substantially (about a $100,000 decrease from the baseline yield).

Services

Annual school enrollment in the Tri-County area would decrease by 11 students. This enrollment change would have no discernible effect on classroom capacity. Annual funding assistance from the State of New Mexico could be reduced by about $44,000 because of these enrollment decreases.

The demand for police, fire, and other municipal services would not be expected to change substantially.

5.4.9.2 *Infrastructure Impacts*

Annual electricity use projected under the Reduced Operations Alternative is a total of 508 gigawatt-hours, 163 gigawatt-hours for LANSCE, and 345 gigawatt-hours for the rest of LANL. The peak electrical demand is projected to be 88 megawatts, 38 megawatts for LANSCE, and 50 megawatts for the rest of LANL[1]. The existing supply of electricity to the Los Alamos area is not sufficient year-round to meet the projected electrical peak demand for LANL operations under this alternative; thus, periods of brownouts are anticipated unless measures are taken to increase the supply of electricity to the area. (Sections 1.6.3.1 and 4.9.2 discuss ongoing efforts to increase electrical power supply to this area.) This situation is exacerbated by the additional electrical demand for BNM and the communities of Los Alamos and White Rock. (While these organizations did not provide use projections, their historical usage is reflected in section 4.9.2 of chapter 4.)

Natural gas use is projected to be 1,840,000 decatherms annually, the same as projected under the No Action Alternative. Demand should continue to be dominated by heating requirements.

Water use projected under the Reduced Operations Alternative is a total of 602 million gallons (2,279 million liters) per year, 108 million gallons (409 million liters) per year for LANSCE, and 494 million gallons (1,870 million liters) per year for the rest of LANL. This is well within DOE water rights, about 1,806 million gallons (6,836 million liters) per year; however, this water right also provides for water used by Los Alamos County and BNM. Based on existing information regarding non-LANL water use, the water

1. These values include the proposed SCC Project annual electricity and peak electrical demand for a 50-TeraOp operation and are reflected in all the alternatives. The SCC project was as an interim action to the SWEIS.

demands of this community can be met within the existing water rights (water demand is also discussed in section 5.4.3). The peak water requirements are the same as identified under the No Action Alternative.

5.4.9.3 *Waste Management*

The annual and 10-year total generation projections for radioactive and hazardous waste are reflected in Table 5.4.9.3–1. Radioactive liquid waste is not projected by facility because measurements of individual contributions are not made for all facilities. The total amount of radioactive liquid waste projected for receipt at TA–50 is 53 million gallons (200 million liters) over 10 years (or an average of 5.3 million gallons [20 million liters] per year) for this alternative. These projections include waste from key facilities, all other LANL facilities, waste management facilities, the ER Project, and construction activities.

Due to the reduced level of operations under this alternative, this alternative generates less waste than is generated under the No Action Alternative. As with the No Action Alternative, much of LANL's LLW, TRU, and chemical waste would be treated and packaged to meet waste acceptance criteria and shipped off the site for disposal; nondefense TRU waste from other sites would be stored at LANL pending the development of disposal options. Off-site disposal capabilities are much greater than the waste volumes generated at LANL.

5.4.9.4 *Contaminated Space*

The activities reflected in the Reduced Operations Alternative are projected to increase the total contaminated space at LANL by 63,000 square feet (5,853 square meters) over the next 10 years (the same as the No Action Alternative), as compared to the baseline established for this SWEIS as of May 1996 (chapter 4, section 4.9). The majority of this increase is due to implementation of actions that have already been reviewed under NEPA, but which had not been implemented at the time the baseline was established (the same ones discussed in the No Action Alternative).

5.4.10 Transportation

The transportation impacts projected for the Reduced Operations Alternative are summarized in this section. More detailed information regarding these impacts is included in volume III, appendix F. Although the number of many types of operational shipments associated with the Reduced Operations Alternative are lower than in the other alternatives, the number of LLW shipments for off-site disposal increases substantially as compared to the number of LLW shipments under the No Action Alternative (because the Reduced Operations Alternative reflects off-site disposal of most LLW). Due to the larger number of LLW shipments under this alternative, the total number of shipments of radioactive materials under the Reduced Operations Alternative is actually larger than the number of such shipments under the No Action Alternative (although this is still fewer shipments than are associated with the Expanded Operations or Greener Alternatives). For this reason, the transportation impacts associated with off-site radioactive shipments under the Reduced Operations Alternative are actually greater than the impacts associated with such shipments under the No Action Alternative (this is not true for off-site radioactive materials accidents because LLW transportation accidents are not among the bounding accidents).

5.4.10.1 *Vehicle-Related Risks*

Truck Emissions in Urban Areas

For the Reduced Operations Alternative, the projected risk is 0.034 excess LCF per year. Use of the Santa Fe Relief Route would have a very small effect on this risk (it would change to

TABLE 5.4.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the Reduced Operations Alternative*[a]

FACILITY	TECHNICAL AREAS	CHEMICAL WASTE[b] (kilograms)		LOW LEVEL WASTE (cubic meters)		MIXED LOW LEVEL WASTE (cubic meters)		TRANSURANIC WASTE (cubic meters)		MIXED TRANSURANIC WASTE (cubic meters)	
		ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR
Plutonium Facility Complex	TA–55	5,250	52,500	688	6,880	12	120	81	810	27	270
Tritium Facilities[c]	TA–16 & 21	1,000	10,000	440	4,400	2	20	NA	NA	NA	NA
CMR Building[d]	TA–3	5,890	58,900	1,280	12,800	16.2	162	15.8	158	7.0	70
Pajarito Site	TA–18	4,000	40,000	145	1,450	1.5	15	NA	NA	NA	NA
Sigma Complex	TA–3	5,500	55,000	420	4,200	2	20	NA	NA	NA	NA
Materials Science Laboratory	TA–3	600	6,000	0	0	0	0	NA	NA	NA	NA
Target Fabrication Facility	TA–35	3,800	38,000	10	100	0.4	4	NA	NA	NA	NA
Machine Shops	TA–3	142,000	1.42×10^6	280	2,800	0	0	NA	NA	NA	NA
HE Processing Facilities	TA–8, 9, 11, 16, 28 & 37	7,000	70,000	8	80	0.2	2	NA	NA	NA	NA
HE Testing Facilities	TA–14, 15, 36, 39, 40	25,200	252,000	300	3,000	0.3	3	0.2	2	NA	NA
Los Alamos Neutron Science Center[e]	TA–53	16,600	166,600	156	1,560	1	10	NA	NA	NA	NA
Health Research Laboratory[f]	TA–43	5,050	50,500	14	140	2.5	25	NA	NA	NA	NA
Radiochemistry Laboratory	TA–48	1,600	16,000	120	1,200	1.3	13	NA	NA	NA	NA
Radioactive Liquid Waste Treatment Facility[g]	TA–50 & 21	2,200	22,000	150	1,500	0	0	21	210	0	0
Waste Treatment, Storage, and Disposal Facilities[g]	TA–54	920	9,200	174	1,740	4.0	40	27	270	0	0
Non-Key Facilities		651,000	6.51×10^6	520	5,200	30	300	0	0	0	0
ER Project[h]		2×10^6	2×10^7	4,257	42,570	548	5,480	11	110	0	0
Grand Total[i]		2.878×10^6	2.878×10^7	8,960	89,600	621	6,210	156	1,560	34	340

TABLE 5.4.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the Reduced Operations Alternative*[a]-Continued

NA indicates that this facility does not routinely generate these types of waste.

[a] Radioactive liquid waste generation is not projected by facility (section 5.4.9.3).

[b] The chemical waste numbers reflect waste that exhibits a hazardous characteristic (ignitability, corrosivity, reactivity, or toxicity), is listed as a hazardous waste by EPA, is a mixture of listed hazardous waste and solid waste, or is a secondary waste associated with the treatment, storage, or disposal of a hazardous waste. This includes waste that is subject to regulation under RCRA, as well as PCB waste and asbestos waste regulated under *Toxic Substances Control Act*. This waste category also includes biomedical waste.

[c] These projections include 141,000 cubic feet (4,000 cubic meters) of LLW due to backlogged waste.

[d] These LLW projections include 141,000 cubic feet (4,000 cubic meters) of LLW generation anticipated due to the CMR Building Upgrades, Phase II.

[e] These projections reflect reduced operational waste generation during construction activities that are included in this alternative.

[f] These projections include 22,000 pounds (10,000 kilograms) of chemical waste, 550 pounds (250 kilograms) of biomedical waste (a special form of chemical waste), 1,560 cubic feet (44 cubic meters) of LLW, and 850 cubic feet (24 cubic meters) of LLMW associated with ongoing efforts to remove obsolete and contaminated equipment.

[g] These facilities provide for storage, treatment, and disposal of waste generated throughout LANL. These activities generate secondary waste, the quantities of which are reflected in this table for these facilities.

[h] The ER Project is projected to generate 390 cubic feet (11 cubic meters) per year of TRU and mixed TRU waste together. All of this waste is presented under the TRU waste columns.

[i] Grand totals have been rounded.

0.033 excess LCF per year). The only difference is that the Santa Fe Relief Route would have 1.2 miles (1.9 kilometers) less of urban highway mileage. Approximately 65 percent of the excess LCFs are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments. All shipments are conservatively assumed to result in an empty truck making the return trip. This is appropriate for WIPP and LLW shipments and for many SST shipments; however, most shipments are in general commerce and would not include the return of an empty truck.

Truck Accident Injuries and Fatalities

The impacts projected for the Reduced Operations Alternative are presented in Table 5.4.10.1–1. (Additional information is provided in volume III, appendix F, section F.6.3.) Use of the Santa Fe Relief Route would reduce the risks of accidents, injuries, and fatalities by almost one-half of those indicated for the segment from U.S. 84/285 to I–25 due to the assumption that the accident rate on the Santa Fe Relief Route would be much lower than for the route through Santa Fe. Approximately 65 percent of the impacts are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments. Again, all shipments are assumed to result in a return by an empty truck.

5.4.10.2 *Cargo-Related Risks*

Incident-free Radiation Exposure

The incident-free radiation exposure impacts projected for the off-site shipments under the Reduced Operations Alternative are presented in Table 5.4.10.2–1; as noted in section 5.2.10.2, the total is the dose throughout the U.S. and is dominated by the segments outside of New Mexico. The aircraft segment is for overnight carrier service; the truck segment to and from the airport is included in the truck results. In general, use of the Santa Fe Relief Route would result in only small changes in this type of impact. Truck crew doses and nonoccupational doses for people at rest stops would increase due to the increased length of the Santa Fe Relief Route for north-bound shipments carrying the radioactive material. Nonoccupational doses for people sharing the road would decrease due to the lower traffic density projected for the relief route.

MEI dose occurs between LANL and I–25 and is 0.00032 rem.

Driver Doses from On-Site Shipments of Radioactive Materials

The projected collective radiation dose for LANL drivers under the Reduced Operations Alternative is 4.262 person-rem. This collective dose would be expected to result in 0.0017 excess LCFs among these drivers.

The average individual driver dose is projected to be 0.178 rem per year, which is well below the DOE radiation protection limit of 5 rem per year.

Transportation Accidents

The following discussion addresses the potential impacts of accidents leading to the release of either radioactive or hazardous material being transported in support of LANL operations under the Reduced Operations Alternative. Results are given for both off-site and on-site shipments.

Off-Site Radioactive Materials Shipments

MEI doses calculated with RADTRAN do not vary by alternative and are given in Table 5.2.10.2–2. The population dose and corresponding excess LCF per year for these shipments are presented in Table 5.4.10.2–2 for these accidents. ADROIT results that are separated into frequency and consequence components are not readily available. The product, MEI dose risk, can be presented in

TABLE 5.4.10.1–1.—*Truck Accident Injuries and Fatalities Projected for LANL Shipments Under the Reduced Operations Alternative*

ROUTE SEGMENT	NUMBER OF ACCIDENTS PER YEAR	NUMBER OF INJURIES PER YEAR	NUMBER OF FATALITIES PER YEAR
On-Site	0.014	0.0029	0.00014
LANL to U.S. 84/285	0.18	0.037	0.0018
U.S. 84/285 to I–25	0.43	0.091	0.0043
Remainder of New Mexico	0.70	0.68	0.075
Outside New Mexico	3.6	3.3	0.33
Total	4.9	4.1	0.41

TABLE 5.4.10.2–1.—*Incident-Free Population Dose and Lifetime Excess LCFs for Off-Site Shipments per Year of Operation Under the Reduced Operations Alternative*

ROUTE SEGMENT	TRUCK DRIVER OR AIRCREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	person-rem/year	excess LCF/year	person-rem/year	excess LCF/year	person-rem/year	excess LCF/year	person-rem/year	excess LCF/year
LANL to U.S. 84/285	6.4	0.0026	0.034	0.000017	0.56	0.00028	3.4	0.0017
U.S. 84/285 to I–25	8.7	0.0035	0.42	0.00021	3.4	0.0017	3.6	0.0018
Remainder of New Mexico	50	0.02	0.12	0.00006	1.9	0.00095	27	0.014
Outside New Mexico	440	0.18	2.9	0.0014	0.25	0.012	200	0.1
Aircraft	2.4	0.0012	NA	NA	NA	NA	NA	NA
Total	510	0.21	3.5	0.0017	31	0.015	230	0.12

NA = Not applicable, rem = roentgen equivalent man

TABLE 5.4.10.2–2.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the Reduced Operations Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM -241	CH-TRU	RH-TRU	PLUTONIUM -238	PITS	TOTAL	
	person-rem/year	person-rem/year	person-rem/year	person-rem/year	person-rem/year	person-rem/year	excess LCF/year
LANL to U.S. 84/285	0.015	0.0014	2.9×10^{-6}	4×10^{-7}	2×10^{-6}	0.016	8.0×10^{-6}
U.S. 84/285 to I–25	0.24	0.019	0.00004	1×10^{-6}	8×10^{-6}	0.26	0.00013
Remainder of New Mexico	0.031	0.012	0.000025	4×10^{-7}	4×10^{-6}	0.043	0.000022
Rest of U.S.	2.5	NA	NA	4×10^{-6}	0.00001	2.5	0.0012

NA = Not applicable

terms of excess LCF per year; for the Reduced Operations Alternative, MEI dose risk due to plutonium-238 oxide and due to pit shipments were each less than 1×10^{-10} excess LCF per year.

The use of the Santa Fe Relief Route would reduce the projected population dose (and therefore the excess LCFs per year) to about one-third for the U.S. 84/285 to I–25 segment, as compared to use of the route through Santa Fe. This difference is primarily due to the difference in population density along these routes. (The lower traffic density along the relief route is also a factor.) The use of the Santa Fe Relief Route would increase the projected population dose (and therefore excess LCFs per year) for the remainder of New Mexico segment to about double that identified if the route through Santa Fe is used. This difference is due to the increase (6 miles [9.6 kilometers] more) in the distance traveled on I–25 for north-bound shipments.

On-Site Radioactive Materials Shipments

The MEI doses, frequencies, and MEI risks due to the bounding on-site shipments involving radioactive materials are given in Table 5.4.10.2–3. As noted in section 5.2.10.2, the frequency of the bounding DARHT and PHERMEX shipments has been added to the frequency of irradiated target shipments.

TABLE 5.4.10.2–3.—*MEI Doses and Frequencies for Bounding On-Site Radioactive Materials Accidents Under the Reduced Operations Alternative*

SHIPMENT TYPE	EVENT FREQUENCY PER YEAR	MEI DOSE	MEI RISK
Plutonium-238 Solution	8.8×10^{-8}	8.7 rem	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCF/year)
Irradiated Targets	2.9×10^{-6}	acute fatality	2.9×10^{-6} fatalities/ year

Hazardous Materials Shipments

The bounding hazardous materials shipments for accident analyses are major chlorine shipments (toxic), major propane shipments (flammable), and major explosive shipments. The consequences of an accident involving a major explosive shipment is bounded by the consequences of an accident involving a major propane shipment, so the frequency of explosives shipments was added to the frequency of propane shipments (rather than analyzing them separately).

Accidental Chlorine Release

The projected frequencies, consequences, and risks associated with major chlorine accidents under the Reduced Operations Alternative are presented in Table 5.4.10.2–4.

The use of the Santa Fe Relief Route would result in about one-tenth the risk of fatalities and injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight increase in the risk of fatalities and injuries on the remainder of New Mexico segment because of the extra 6 miles (9.6 kilometers) traveled on I–25 for northbound traffic (chlorine shipments are all assumed to travel north on I–25).

Accidental Propane Release

The projected frequencies, consequences, and risks associated with major propane accidents under the Reduced Operations Alternative are presented in Table 5.4.10.2–5.

The use of the Santa Fe Relief Route would result in about one-third the risk of fatalities and one-fourth the risk of injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight decrease in the risk of injuries and fatalities on the Remainder of New Mexico segment because of the 6-mile (9.6-kilometer) reduction in distance traveled on I–25 for southbound traffic (propane shipments are all assumed to travel south on I–25).

5.4.11 Accident Analysis

Transportation accidents for the Reduced Operations Alternative are addressed in section 5.4.10. High-frequency (greater than 1 in 100) occupational accidents for the Reduced Operations Alternative are addressed in section 5.4.6.

5.4.11.1 *Multiple Source Release of Hazardous Material from Site-Wide Earthquake and Wildfire*

The risks from these accidents are driven primarily by the frequency and magnitude of the earthquakes and wildfires in the area. Because the same types of operations will be conducted in the same facilities and the inventories of MAR will be about the same, there are no substantial changes in risk from earthquakes between the No Action and the Reduced Operations Alternatives.

For the wildfire scenario, the frequency will remain the same, but the MAR will be reduced by about 25 percent at TSTA, reducing the consequences by approximately 1 percent (6 person-rem) compared to the No Action Alternative. Table 5.2.11.1–1 and 5.2.11.1–2 can be referenced for the results of the No Action Alternative.

TABLE 5.4.10.2–4.—*Frequencies, Consequences, and Risk for a Major Chlorine Accident Under the Reduced Operations Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	0.000026	0.065	0.24	8.0×10^{-6}	0.00003
	Suburban	4.3×10^{-6}	1.5	5.6		
U.S. 84/285 to I–25	Rural	0.00002	0.053	0.20	0.00027	0.001
	Suburban	0.000044	3.0	11		
	Urban	0.000013	11	40		
Remainder of New Mexico	Rural	0.00015	0.015	0.056	0.000048	0.00018
	Suburban	0.000016	1.5	5.5		
	Urban	2.6×10^{-6}	8.4	32		
Remainder of U.S.	Rural	0.0011	0.028	0.10	0.0012	0.0044
	Suburban	0.00028	1.6	6.1		
	Urban	0.000066	10	39		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

TABLE 5.4.10.2–5.—*Frequencies, Consequences, and Risk for a Major Propane Accident Under the Reduced Operations Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER TRIP	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	9.2×10^{-6}	0.28	1.1	9.2×10^{-6}	0.000037
	Suburban	1.6×10^{-6}	4.2	17		
U.S. 84/285 to I–25	Rural	7.1×10^{-6}	0.23	0.92	0.00014	0.0006
	Suburban	0.000016	8.4	34		
	Urban	4.8×10^{-6}	1.8	7.3		
Remainder of New Mexico	Rural	0.000062	0.15	0.6	0.00011	0.00048
	Suburban	0.00002	5.1	20		
	Urban	2.5×10^{-6}	1.5	6.1		
Remainder of U.S.	Rural	0.000078	0.09	0.36	0.000063	0.00027
	Suburban	9.9×10^{-6}	4.8	19		
	Urban	5.1×10^{-6}	1.9	7.5		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

5.4.11.2 *Plutonium Releases from Manmade and Process Hazards at LANL*

For the Reduced Operations Alternative, the frequencies and consequences of these accidents are the same as under the No Action Alternative. These are presented in Table 5.2.11.2–1.

An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between Rocky Flats and TA–55–4 are presented in volume III, appendix G, section G.4.1.2.

Substantial differences exist between the nuclear facility and operations being conducted in TA–55–4 today and those that were present at the Rocky Flats Plant in 1969. TA–55–4 was designed to correct the deficiencies detected in older facilities such as the Rocky Flats Plant and is being upgraded to meet the even more stringent requirements of the 1990's, including enhanced seismic resistance and fire containment.

5.4.11.3 *Highly Enriched Uranium Release from Process Hazard Accident*

As discussed in section 5.2.11.3, this accident is the dominant accident for release of HEU. Because there are no planned changes in the number of experiments or the inventories associated with this activity, the frequency and consequences of this scenario under the Reduced Operations Alternative are the same as presented under the No Action Alternative. These are reflected in Table 5.2.11.3–1.

5.4.11.4 *Tritium Release from a Manmade Hazard Accident at LANL*

As presented in section 5.2.11.4, the aircraft crash event is the dominant accident that involves tritium. Because no changes in operations or inventories from the No Action Alternative are made, the consequences and frequencies associated with these scenarios are the same as those presented in Table 5.2.11.4–1.

5.4.11.5 *Chemical Releases from Manmade and Process Hazard Accidents at LANL*

For the chlorine releases, on-site personnel could be exposed to concentrations in excess of ERPG–2. Chlorine has a highly objectionable odor, which prompts sheltering and escape; however, personnel can be quickly overcome when exposed to high concentrations.

The number of accidental releases of chlorine depends upon the number of times the material is handled. The minor changes in activity levels cause the risk to decrease by about 5 to 10 percent. The incremental risk for this alternative over the No Action Alternative is essentially zero. These changes do not alter the overall risk profile for the site or substantially alter the relative ranking of each of these accidents. These results are provided in Tables 5.4.11.5–1 and 5.4.11.5–2.

5.4.11.6 *Worker Accidents*

Because there are no changes in the types of activities, frequencies, or inventories from the No Action Alternative, an individual worker is subject to the same risk, as presented in Table 5.2.11.6–1.

TABLE 5.4.11.5–1.—*Summary of Chlorine Exposure Scenarios at LANL—Reduced Operations Alternative*

SCENARIO DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
PROCESS HAZARD ACCIDENTS			
CHEM–01 Chlorine release (150 pounds [68 kilograms]) from potable water treatment station, due to human error during cylinder changeout or maintenance, or due to random hardware failures.	Approximately 0.0011 per year (i.e., one such event in approximately 900 years)	For the risk-dominant large leak scenario, an average of approximately 43 persons exposed above ERPG–2 levels, and approximately 12 persons exposed above ERPG–3 levels, to distances of up to a few tenths of a mile.	0.047 The Reduced Operations Alternative is 5% less likely than the No Action due to the handling of one less chlorine cylinder; no change in severity.
CHEM–02 Multiple cylinder (1,500 pounds [680 kilograms]) from toxic gas storage shed at Gas Plant, due to fire or aircraft crash.	Approximately 0.00012 per year (i.e., one in approximately 8,500 years)	Average of 292 people within LANL (ranging from none to 1,000 depending upon wind direction) exposed at or above ERPG–2 or –3 levels; town protected by canyon from highest concentrations.	0.035 Frequency increases by 8% from the No Action Alternative; no change in severity.
CHEM–03 Chlorine release (150 pounds [68 kilograms]) from toxic gas storage shed at Gas Plant, due to random failure or human errors during cylinder handling.	Approximately 0.00012 per year (i.e., one in approximately 8,000 years)	An average of approximately 263 exposed above ERPG–2 levels; or 239 above ERPG–3 levels, at distances to a fraction of a mile, all within LANL; town protected by canyon from highest concentrations.	0.032 No change in likelihood or severity over the No Action Alternative.
CHEM–06 Chlorine gas release outside Plutonium Facility.	Approximately 0.063 per year (i.e., one event in approximately 16 years)	Average number exposed at or above ERPG–2 doses is approximately 102, and above ERPG–3, approximately 7 at ranges to a fraction of a mile.	6.426 No change in likelihood or severity over the No Action Alternative.

[a] Accident likelihood estimates are conservative, given the information available. However, for the particularly unlikely accidents, it is possible that there are causal mechanisms that were missed, so the possibility of a more probable scenario cannot be rigorously ruled out.

[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.

[c] Accident consequences are generally conservative (pessimistic), but do not bound the effects of accidents occurring under unusually unfavorable weather conditions. The results quoted are weather averaged.

TABLE 5.4.11.5–2.—*Summary of Chemical Exposure Scenarios—Reduced Operations Alternative*

SCENARIO	DESCRIPTION	LIKELIHOOD[a]	CONSEQUENCE MEASURES[b,c]	SOCIETAL RISK (NUMBERS AT OR ABOVE ERPG–2 PER YEAR)
CHEM–04	Bounding single container release of toxic gas (selenium hexafluoride) from waste cylinder storage.	Approximately 0.004 per year (i.e., one in about 250 years)	Average number of off-site persons exposed above ERPG–2 level is zero; toxic effects generally limited to the source's TA (TA–54).	0 No changes in frequency or severity from the No Action Alternative.
CHEM–05	Bounding multiple cylinder release of toxic gas (sulfur dioxide) from waste cylinder storage.	Approximately 0.00014 per year (i.e., one event in approximately 7,000 years)	Under conservative daytime conditions, no one outside the source area (TA–54) would see levels above ERPG–2. Under least favorable conditions, 13 persons could be exposed above ERPG–3 levels.	0 No changes in frequency or severity from the No Action Alternative.

[a] Accident likelihood estimates are conservative, given the information available. However, for the particularly unlikely accidents, it is possible that there are causal mechanisms that were missed, so the possibility of a more probable scenario cannot be rigorously ruled out.
[b] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release.
[c] Accident consequences are generally conservative (pessimistic), but do not bound the effects of accidents occurring under unusually unfavorable weather conditions. The results quoted are weather averaged.

5.5 IMPACTS OF THE GREENER ALTERNATIVE

5.5.1 Land Resources

5.5.1.1 *Land Use*

Changes to land use under the Greener Alternative would be the same as for the No Action Alternative.

5.5.1.2 *Visual Resources*

Changes to visual resources under the Greener Alternative would be the same as for the No Action Alternative.

5.5.1.3 *Noise*

Changes to noise levels and air blasts associated with high explosives testing under the Greener Alternative would be the same as for the No Action Alternative. The overall LANL on-site activities (due to the increased operational levels in activities not related to weapons) would increase under implementation of the Greener Alternative resulting in an overall greater total number of noise producing events for workers. This could be a slight negative impact to the worker noise environment, as compared to the No Action Alternative.

5.5.2 Geology and Soils

Potential impacts for the Greener Alternative on geology and soils would be the same as those for the No Action Alternative.

5.5.3 Water Resources

5.5.3.1 *Surface Water*

Table 5.5.3.1–1 shows the total flow from the NPDES outfalls for each of the major watersheds under the Greener Alternative. In volume III, appendix A, Table A.1–1 presents more detailed information on the NPDES outfalls for all four alternatives by facility (key and non-key), watershed, and location. The estimated total gallons discharged into all watersheds totals 275 million gallons (1,041 million liters) under the Greener Alternative. This is an increase from the index effluent volume of 233 million gallons (882 million liters).

NPDES outfall effluent quality during the period of the SWEIS (1997 through 2006) is expected to be the same under this alternative as described for the No Action Alternative, including the radionuclide concentrations in effluent from TA–50, as presented in Table 5.2.3–2. The canyons with increased NPDES outfall flows (Los Alamos and Sandia) are the same as the No Action and the Expanded Operations Alternatives. The increased flow volumes in these two canyons are the same as the Expanded Operations Alternative, and the potential impacts should be minimal for the same reasons as discussed in the No Action and the Expanded Operations Alternatives. For the Greener Alternative, there are no new activities that will result in changes to stormwater runoff.

5.5.3.2 *Alluvial Groundwater*

The NPDES outfall discharges are similar to those under Expanded Operations and are expected to result in similar alluvial groundwater volumes.

The projected discharge from the RLWTF into Mortandad Canyon under the Greener Alternative is 6.6 million gallons (25 million liters) per year, as compared to the RLWTF index volume of 5.5 millions gallons (21 million liters) per year.

The new HELWTF will result in improved water quality to Canyon de Valle as discussed under the No Action Alternative.

TABLE 5.5.3.1–1.—*NPDES Discharges by Watershed Under the Greener Alternative*[a]

WATERSHED	#OUTFALLS		DISCHARGES (MGY)					
			KEY FACILITIES		NON-KEY		TOTALS	
	INDEX	GREENER	INDEX	GREENER	INDEX	GREENER	INDEX	GREENER
Ancho	2	0	0.1	0.0	0.0	0.0	0.1	0.0
Cañada del Buey	3	3	0.0	0.0	6.4	6.4	6.4	6.4
Chaquehui	1	0	0.0	0.0	5.8	0.0	5.8	0.0
Guaje	7	7	0.0	0.0	0.7	0.7	0.7	0.7
Los Alamos	12	8	19.2	44.5	0.5	0.2	19.7	44.7
Mortandad	12	7	42.0	29.6	10.9	5.1	52.9	34.7
Pajarito	17	11	8.4	1.8	0.8	0.8	9.2	2.6
Pueblo	1	1	0.0	0.0	1.0	1.0	1.0	1.0
Sandia	11	8	4.4	42.8	103.5	127.9	107.9	170.7
Water	21	10	29.5	14.1	0.0	0.0	29.5	14.1
Totals	87	55	103.6	132.3	129.6	142.0	233.2	274.9

MGY: millions of gallons per year

[a] NPDES Information Sources: Index information was provided by the Surface Water Data Team Reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997. Additional outfalls may be eliminated in the future, as discussed in the *Environmental Assessment for Effluent Reduction* (DOE 1996e), as well as several other outfalls that may be closed as part of LANL's ongoing outfall reduction program.

5.5.3.3 *Perched Groundwater*

Groundwater flow and contaminant pathways to the intermediate perched groundwater bodies are not well characterized nor understood. It is possible that the increased NPDES discharges to Los Alamos and Sandia Canyons under this alternative could increase recharge of the intermediate perched groundwater and contaminant transport beneath these canyons.

5.5.3.4 *Main Aquifer*

Recharge mechanisms to the main aquifer are uncertain. However, for the same reasons as discussed under the No Action Alternative, impacts resulting from increased NPDES outfall flows under the Greener Alternative should be negligible.

A conservative projection of LANL water use under the Greener Alternative is 759 million gallons (2,873 million liters) per year. Los Alamos County and the NPS did not provide projections, but in 1994 the County used about 958 million gallons (3,626 million liters) from this water right and the NPS used about 5 million gallons (19 million liters). Based on this information, it is expected that the water requirements of this community can be met within the existing water rights from the main aquifer; however, projected use may approach 100 percent of the existing water rights to the main aquifer under this alternative.

For the purposes of modeling drawdown of the main aquifer, annual water use projections were made. The total water usage from DOE water rights was projected to average 1,670 million gallons (6,321 million liters) per year under the Greener Alternative, with a maximum annual use of 1,697 million gallons (6,423 million liters) and a minimum annual use of 1,611 million gallons (6,098 million liters).

The model results reflect water level changes at the top of the main aquifer across the alternatives, given continued draw from the aquifer by DOE, Española, and Santa Fe. Table 5.5.3.4–1 shows predicted water level changes at the surface of the main aquifer during the period from 1997 through 2006 for the Greener Alternative; as noted in section 5.2.3.1, these changes are not all due to LANL operations. Although the water use modeled includes water use in Española and Santa Fe, the differences between the alternatives are due only to LANL operations. The impacts to the volume of water in the main aquifer under this alternative are very similar to those described for the No Action Alternative; the drawdowns in DOE well fields are minimal relative to the total thickness of the main aquifer, and the volume of water to be used over the period from 1997 through 2006 is negligible relative to the volume of water in storage. Details of the conceptual model, assumptions, uncertainties and limitations, and input parameters for the groundwater model are described in volume III, appendix A.

5.5.4 Air Quality

5.5.4.1 *Nonradiological Air Quality Impacts*

Criteria pollutant emissions under the Greener Alternative are less than those under the Expanded Operations Alternative. Because the bounding analysis of criteria pollutant emissions for all alternatives (based on the emissions under the Expanded Operations Alternative) results in estimated concentrations of each pollutant below the standards established to protect human health with an ample margin of safety, criteria pollutant emissions under the Greener Alternative would also be below these levels.

As discussed in section 5.1.4, the only toxic air emissions with the potential to impact human

TABLE 5.5.3.4–1.—*Maximum Water Level Changes at the Top of the Main Aquifer Under the Greener Alternative (1997 Through 2006)*

WATER LEVEL CHANGE IN FEET[a,b]	
AREA OF CONCERN ON SITE	
Pajarito Well Field	-14.5
Otowi Well Field (Well 0-4)	-14.2
AREA OF CONCERN OFF SITE	
DOE - Guaje Well Field	-9.0
Santa Fe Water Supply	
Buckman Well Field	+21.6
Santa Fe Well Field	-20.6
San Juan Chama Diversion	0.0
Springs	
White Rock Canyon Springs, Maximum Drop	0.0
White Rock Canyon Springs, Maximum Rise	+1.0
Other Springs (Sacred, Indian)	+3.8
San Ildefonso Pueblo Supply Wells	
West of Rio Grande	
Household, Community Wells	+0.6
Los Alamos Well Field	+3.8
East of Rio Grande	
Household, Community Wells	0.0

[a] Negative value (-) indicates water level drop; positive value (+) indicates water level rise.

[b] Also, the water level changes projected by the regional MODFLOW model represent average changes over a whole grid-cell (i.e., a square that is a mile on a side). They are, for the most part, not predictive of the water level changes at any single point within the cell (for example, a supply well). Pumping wells have characteristic “cones of depression” where the water surface reflects an inverted cone, and water levels at the well may be quite different from levels even a few ten’s of feet away. Whether any individual well would exhibit water level changes consistent with the predicted grid-cell average change is a function of, for example, its location within the grid-cell; proximity to other pumped wells; and the individual well operation, construction, and hydraulics. Hence, the water level changes predicted by the model can only be considered qualitatively and cannot be considered as finite changes.

health and the environment under any alternatives are those associated with HEFS operations and the additive emissions from all the pollutants from all TAs on receptor sites located near the Los Alamos Medical Center. Under the Greener Alternative, such emissions are projected to be similar to those addressed in the No Action Alternative (section 5.1.4). Therefore, pollutants released from LANL operations under the Greener Alternative are not expected to cause air quality impacts that would affect human health and the environment.

5.5.4.2 *Radiological Air Quality Impacts*

This section addresses the radiation dose to the FS MEI, LANL MEI, and the population dose from LANL radionuclide air emissions under the Greener Alternative.

Facility-Specific Maximally Exposed Individual

Table 5.5.4.2–1 shows the FS MEI for each facility analyzed under the Greener Alternative. The highest MEI dose was 4.52 millirems per year, which is 45.2 percent of the regulatory limit for the air pathway. The EPA regulatory limit would not be exceeded from emissions of these facilities under the Greener Alternative.

TABLE 5.5.4.2–1.—*Facility-Specific Information—Greener Alternative*

FACILITY	DOSE[a] (MREM/YR)
TA–3–29 (CMR)	0.35
TA–3–66 (Sigma)	0.35
TA–3–102 (Shops)	0.28
TA–11 (High Explosive Testing)	0.31
TA–15/36 (Firing Sites)	2.17
TA–16 (Tritium Facility)	0.31
TA–18 (Pajarito Site)	1.93
TA–21 (Tritium Facility)	1.54
TA–48 (Radiochemistry Laboratory)	1.64
TA–55 (Plutonium Facility)	1.64
TA–53 (LANSCE)[b]	4.52
TA–54 (Boundary)[c]	0.79
TA–54 (White Rock)	0.45

[a] For each FS MEI, the total dose was calculated by adding the contributions from each modeled facility. An MEI does not leave or take protective measures.
[b] This is also the LANL MEI. Five specific sources were modeled from TA–53. These include the TA–53 ES–2, ES–3, IPF, LEDA and combined diffuse emissions.
[c] Two FS MEI locations were considered for TA–54 because Area G is bordering San Ildefonso Pueblo land. The first is a MEI location at the LANL boundary, 1,197 feet (365 meters) northeast of Area G. No person from the Pueblo currently is known to live along this boundary. The second is an actual MEI location in the town of White Rock, approximately 5,331 feet (1,625 meters) southeast of Area G.

LANL Maximally Exposed Individual

The location of the LANL MEI (2,625 feet [approximately 800 meters] north-northeast of TA–53) was shown to be identical to the FS MEI with the highest dose under this alternative. The LANL MEI dose was calculated to be 4.52 millirems per year under the Greener Alternative.

Population Dose

The collective dose to the population living within a 50-mile (80-kilometer) radius from LANL was calculated for emissions from all key facilities and found to be 13.79 person-rem per year. TA–15/36 account for 51.3 percent of this dose, and collectively, collective diffuse emissions, including those from these TAs, account for 52.1 percent of this dose. The values reported for population doses for this alternative, as well as the other alternatives, is higher than has been reported in the recent annual environmental reports. It is important to recognize that the alternatives analyzed represent increased operations when compared to recent history. The material throughput at the different facilities under the various alternatives is presented in chapter 3, section 3.6.

Isodose Maps

The isodose maps for the 50-mile (80-kilometer) region are shown on the isodose maps in Figures 5.5.4.2–1 and 5.5.4.2–2.

5.5.5 Ecological Resources, Biodiversity, and Ecological Risk

Impacts to ecological resources and biodiversity resulting from the Greener Alternative would not vary appreciably from those of the No Action alternative. There would not be any incremental changes from the No Action level of ecological risk.

5.5.6 Human Health

The consequences of implementing the Greener Alternative on public health and worker health are presented below. As discussed in section 5.1.6, "risk," as used in the SWEIS human health analysis, refers to the probability of toxic or cancer mortality under the specific exposure scenarios analyzed.

5.5.6.1 *Public Health*

The consequences of continued operations of LANL on public health under the Greener Alternative are presented below for the same topics discussed in section 5.2.6.1.

Regional Consequences of Airborne Radioactivity Inhalation and Immersion

The LANL MEI was estimated to be 2,625 feet (approximately 800 meters) north-northeast of LANSCE (TA–53). This location is within the LANL reservation, and the dose at this location is estimated to be 4.5 millirem per year (section 5.5.4.2), corresponding to a 72-year lifetime dose of 320 millirem. This location borders the Los Alamos townsite and is a conservative estimate for an MEI from LANL emissions. The background (TEDE) dose in the Los Alamos area is estimated to be 360 millirem per year; thus, the dose is 1.3 percent of the background dose.

Table 5.5.6.1–1 summarizes the LANL MEI dose and presents the corresponding excess risk of excess LCF to the MEI. These risks are presented on a lifetime basis, assuming that the hypothetical LANL MEI received the estimated dose of 4.5 millirem each year for a 72-year life. The excess LCF risk was estimated to be 0.0002 over a lifetime.

The isodose maps showing both the estimated dose near LANL and within a 50-mile (80-kilometer) radius of LANL are given in Figures 5.5.4.2–1 and 5.5.4.2–2. The population dose within the 50-mile (80-kilometer) radius is also given in Table 5.5.6.1–1, estimated to be 13.8 person-rem per year. As reflected in the table, the annual operations excess LCF risk was estimated to be 0.0069.

In the Greener Alternative, there are six facilities with FS MEIs receiving a dose that would exceed 1 millirem per year (volume III, appendix B):

- LANSCE, 4.52 millirem per year to the facility MEI
- HE Testing Sites (TA–15 and TA–36), 2.17 millirem
- Pajarito Site (TA–18), 1.93 millirem
- Radiochemistry Laboratory (TA–48), 1.64 millirem
- Plutonium Facility, 1.64 millirem
- TSTA and TSFF (TA–21), 1.54 millirem

External Radiation: Two Special Cases

As discussed in section 5.2.6.1, one contribution to public dose results from jogging or hiking the access road north of TA–21 and is attributable to cesium-137 known to be on the ground within the TA. The MEI dose is not expected to change

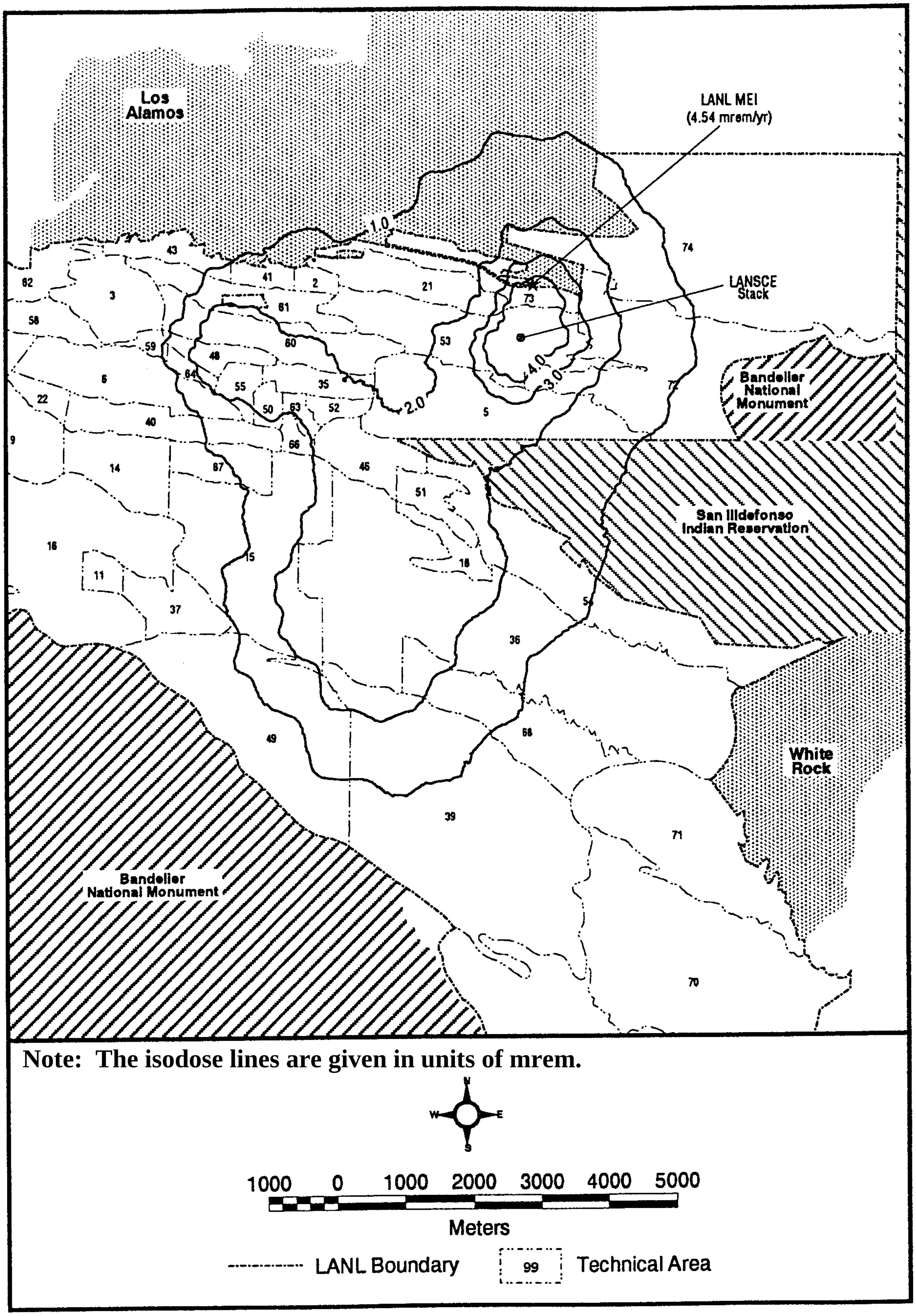


FIGURE 5.5.4.2–1.—*Isodose Map Showing Doses Greater Than 1 Millirem per Year for the Greener Alternative.*

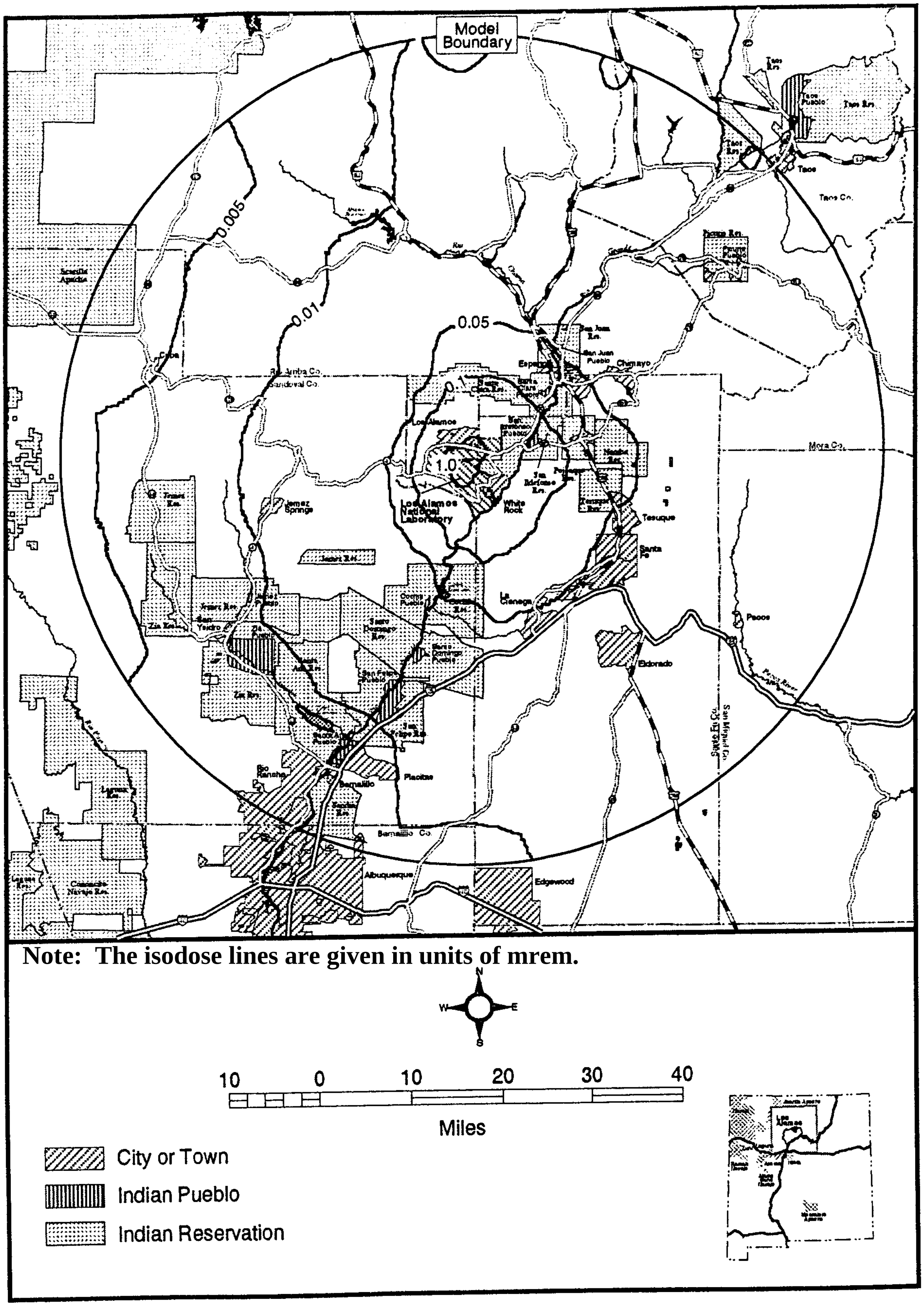


FIGURE 5.5.4.2–2.—***Isodose Map Showing Doses Less Than 1 Millirem per Year for the Greener Alternative.***

TABLE 5.5.6.1–1.—*Estimated Public Health Consequences for LANL MEI and the Population Within 50-Mile (80-Kilometer) Radius of LANL for the Greener Alternative*

PARAMETER	LANL HYPOTHETICAL MEI	50-MILE (80-KILOMETER) RADIUS POPULATION
Dose (Committed Effective Dose Equivalent)	4.52 millirem/year	13.79 person-rem/year
Excess LCF	0.0002/lifetime (72 year)	0.0069/year of operations

under the Greener Alternative from that estimated under the No Action Alternative (an EDE of 2.9 millirem per year and a lifetime excess LCF risk of about 1 x 10^{-6} per year of operation).

The other contribution to public dose, as discussed in section 5.2.6.1, would result from TA–18 "road-open" operations. At the 95 percent confidence level, four exposures per year would be expected for the MEI out of the 100 operations per year at TA–18 under the Greener Alternative (the same as for the No Action Alternative). This would result in an annual projected MEI EDE dose of 19 millirem per year. The lifetime excess LCF risk for this dose is about 9.5 x 10^{-6} per year of operation.

Nonionizing Radiation

The only uncontained nonionizing radiation source in use or planned for LANL is the microwave transmitter in TA–49. The consequence of a public exposure to this source under the Greener Alternative is the same as for the No Action Alternative; as discussed in section 5.2.6.1, this consequence is negligible.

Consequences of Airborne Chemical Emissions

For the Greener Alternative, these consequences are the same as those under the No Action Alternative; the worst case HI for lead did not exceed one in a million (10^{-6}); for DU, the worst case HI did not exceed 1 in 100,000 (0.00010); and the excess LCF for beryllium (evaluated as a carcinogen) under the Greener Alternative was estimated to be less than 3.6 x 10^{-7} per year. These analyses are presented in detail in volume III, appendix D.

Consequences of Ingestion and Dermal Exposures to Residents, Recreational Users, and Special Pathways Receptors

The risk to the public from ingestion under the Greener Alternative does not differ from that associated with the No Action Alternative; this is because most of the risk is attributable to the existing levels of contamination in water and soils in the area. This is discussed further in section 5.2.6.1. Table 5.2.6.1–2 summarizes the ingestion radiological annual dose and excess LCF per year to the MEIs. Tables 5.2.6.1–2 and 5.2.6.1–3 summarize the total radiological annual ingestion dose and excess LCF to members of the public. Per Table 5.2.6.1–3, the total worst-case ingestion doses for the off-site resident of Los Alamos County and non-Los Alamos County resident are 0.011 and 0.017 rem per year, respectively. If this person is also a recreational user of the Los Alamos canyons, drinking canyon water and ingesting canyon sediments, the worst-case additional dose ranges up to 0.001 rem per year, according to the amount of time spent in the canyons (see footnote b in Table 5.2.6.1–3). If the individual has traditional Native American or Hispanic lifestyles, the values found in the final columns of the table should be used in place of the values in the first columns for off-site residents. Per the values in the final columns, these "special pathways receptors" can have worst-case 3.1 millirem per year additional dose. The associated excess LCF risks for the off-site residents are 8.6×10^{-6} per year of exposure and 9.1×10^{-7} per year of exposure for the individual who is also an avid recreational user. These worst-case doses are for a 95th percentile intake of the 95th percentile contamination level, referred to as the UCL. Ingestion pathway calculations included all radionuclides detected in the media. This includes natural background, weapons testing fallout, and previous releases. The actual contribution from continued operations at LANL is only a small fraction of this value. These values apply to the baseline and to all four alternatives. The data and analyses for these calculations are in appendix D, section 3.3. Table 5.2.6.1–3 summarizes the risk associated with metals ingestion to MEIs in the LANL region.

Consequences to the Public along Transportation Routes

Section 5.5.10 details the analysis of transportation consequences. Public health consequences include the dose and excess LCF risk associated with routine, accident-free, transportation. Table 5.5.10–2 shows the population dose and excess LCF for normal (accident-free) off-site shipments. The population dose and excess LCF that are associated with exposures occurring during stops for transportation segments near LANL are provided in Table 5.5.6.1–2. Doses associated with living along route and sharing routes with these shipments are detailed in Table 5.5.10–2, and are less than those associated with stops. Risks associated with accidents during transportation also are discussed in section 5.5.10.

TABLE 5.5.6.1–2.—*Radiation Doses and Excess LCF Risks Estimated to the Public at Stops During Transportation of Materials and Wastes from LANL*

ROUTE SEGMENT	PERSON-REM PER YEAR (AT STOPS)	EXCESS LCF RISK PER YEAR
LANL to U.S. 84/285	3.6	0.0018
U.S. 84/285	3.8	0.0019

5.5.6.2 *Worker Health*

Worker risks associated with continued operations of LANL include radiological (ionizing and nonionizing) risks, chemical exposure risks, and risk of injury during normal operations. The consequences to worker health from implementing the Greener Alternative are given below and detailed in volume III, appendix D, section D.2.2.

Radiological Consequences

Ionizing Radiation Consequences. Table 5.5.6.2–1 summarizes the projected doses and associated excess LCF risks from implementation of the Greener Alternative.

The collective worker dose under the Greener Alternative is conservatively projected to be approximately 2.3 times that measured in 1993 to 1995. In terms of the average non-zero dose, the Greener Alternative is expected to result in

TABLE 5.5.6.2–1.—*Annual Worker Doses and Associated Lifetime Excess LCF Risks Under the Greener Alternative*

LANL Collective Worker Dose (person-rem/year)	472
Estimated Excess LCF Risk (across the worker population) per year of operation	0.19
Average Non-Zero Worker Dose (rem/year)	0.14
Estimated Excess LCF Risk (average worker > 0 dose)	0.000056

0.14 rem per year for Greener, compared with 0.097 rem per year, 1993 to 1995. The estimated lifetime excess LCF risk is 0.000056 per year of operation.

Nonionizing Radiation. It is expected that there will continue to be negligible effects to LANL worker health from nonionizing radiation sources including ultraviolet sources, infrared radiation from instrumentation and welding, lasers, magnetic and electromagnetic fields, and microwaves (including the large station at TA–49). (Also see volume III, appendix D, section D.2.2.2 for evaluation used to estimate nonionizing radiation from LANL operations to humans and wildlife and for the estimated results.)

Carcinogenic Risk from Air Emissions

The screening process described in appendix B identified no individual carcinogenic chemical air emission that required analysis for public health consequences. For carcinogens, an estimate also was made of the combined lifetime incremental cancer risk due to all carcinogenic pollutants from all TAs (appendix B, attachment 6).

This incremental combined cancer risk is less than 1 in 1 million for the Greener Alternative because the projected emissions for this alternative are less than for the Expanded Operations Alternative (which was slightly above the screening guideline value of 1×10^{-6}). It is believed that negligible increase in incremental combined cancer risk will result from the Greener Alternative.

Chemical Exposure Consequences

It is anticipated that there will continue to be a few chemical exposures annually, particularly exposures to:

- Airborne asbestos
- Lead paint particulates
- Crystalline silica
- Fuming perchloric acid, hydrofluoric acid
- Skin contact with acids or alkalis

Under the Greener Alternative, it is expected that there will be a worker population of approximately 10,000 individuals, approximately 10 percent higher than the index period employment levels. For the purposes of the SWEIS, it is assumed that there is negligible additional benefit of the Chemical Hygiene Program at LANL over the period analyzed, and that the rate of chemical exposures continues at the index period rates. Therefore, it is expected that reportable chemical exposures would not change appreciably from the index period, approximately one to three reportable chemical exposures per year.

Beryllium Processing Consequences. It is anticipated that beryllium operations in the Reduced Operations Alternative would be the same as in the No Action Alternative. It is not anticipated that consequences to workers would be measurable; that is, no sensitization to beryllium would be detected using the LANL IH monitoring program.

Physical Safety Hazards

Table 5.5.6.2–2 compares the projected reportable cases of accidents and injuries estimated for normal operations occurring under the Greener Alternative and that experienced during the index period. The Greener Alternative is expected to result in a slight increase in reportable cases due to increases in worker population. These accidents and injuries are considered as consequences of normal operations because of their frequency. These results assume that the aggressive Health and Safety Program underway at LANL does not achieve any additional reduction in reportable cases.

The consequences of these accidents and injuries are expected to be similar to those experienced in the past, and typically are those

TABLE 5.5.6.2–2.—*Projected Reportable Annual Accidents and Injuries for the Greener Alternative Compared with the Index Period*

PARAMETER ESTIMATED	PARAMETER VALUE AND UNITS
Projected Worker Population	Approximately 10,000
Projected Reportable Accidents and Injuries	460/year
Change from Index (1993 to 1996)	+ 10%

associated with health response and recovery from acute trauma. Therefore, the consequences include physical pain and therapy/treatment for recovery such as those associated with bone setting, shoulder dislocation reset and subsequent physical therapy. Some injuries also may result in continuing consequences to the worker that could affect productivity or lifestyle, such as motor skill loss due to nerve damage or cardiovascular debilitation resulting from electrical shock or electrocution.

5.5.7 Environmental Justice

As indicated in sections 5.5.1 and 5.5.2, no substantive adverse impacts to land resources or geology and soils are anticipated for the continued operation of LANL under the Greener Alternative. Thus, no disproportionately high and adverse impacts to minority or low-income communities are anticipated for these impact areas. The potential impacts to surface and groundwater and ecological resources associated with the Greener Alternative would affect all communities in the area equally (see sections 5.5.3 and 5.5.5 for additional information on the potential for impacts to these resources). Thus, no disproportionately high or adverse impacts to minority or low-income communities are anticipated to be associated with these resource areas.

Figure 5.5.7–1 reflects the dose from radiological air emissions within 50 miles (80 kilometers) of LANL under the Greener Alternative. As discussed in section 5.2.7, impacts due to air emissions are equal to or lower in the sectors with substantial minority and/or low-income populations than they are in sectors 1–3 and 6–16, and such impacts are not disproportionately high or adverse with respect to the minority or low-income populations (see section 5.5.4 regarding the impacts anticipated for air emissions under the Expanded Operations Alternative).

The air pathway is one example of the analysis of potential human health impacts. As presented in section 5.5.6, there is minimal potential for LANL operations to adversely affect human health for off-site residents or recreational users in the area around LANL under the Greener Alternative. Similarly, the special pathways have little potential to impact human health under this Alternative. Thus, the Greener Alternative would not present disproportionately high or adverse impacts to human health in minority or low-income communities (section 5.4.6.1).

As shown in section 5.5.10, impacts from on-site transportation and from LANL to U.S. 84/285 are estimated to be 0.0018 excess LCFs per year from incident-free transportation and 0.040 deaths or injuries per year from transportation accidents. Impacts from transportation on route segments that pass through minority or low-income communities (particularly the segment from U.S. 84/285 to I–25) are estimated to be 0.0019 excess LCFs per year from incident-free transportation and 0.091 deaths or injuries per year from transportation accidents. Therefore, no high and adverse impact is expected to either a member of the general public or to a member of a minority or low-income population due to

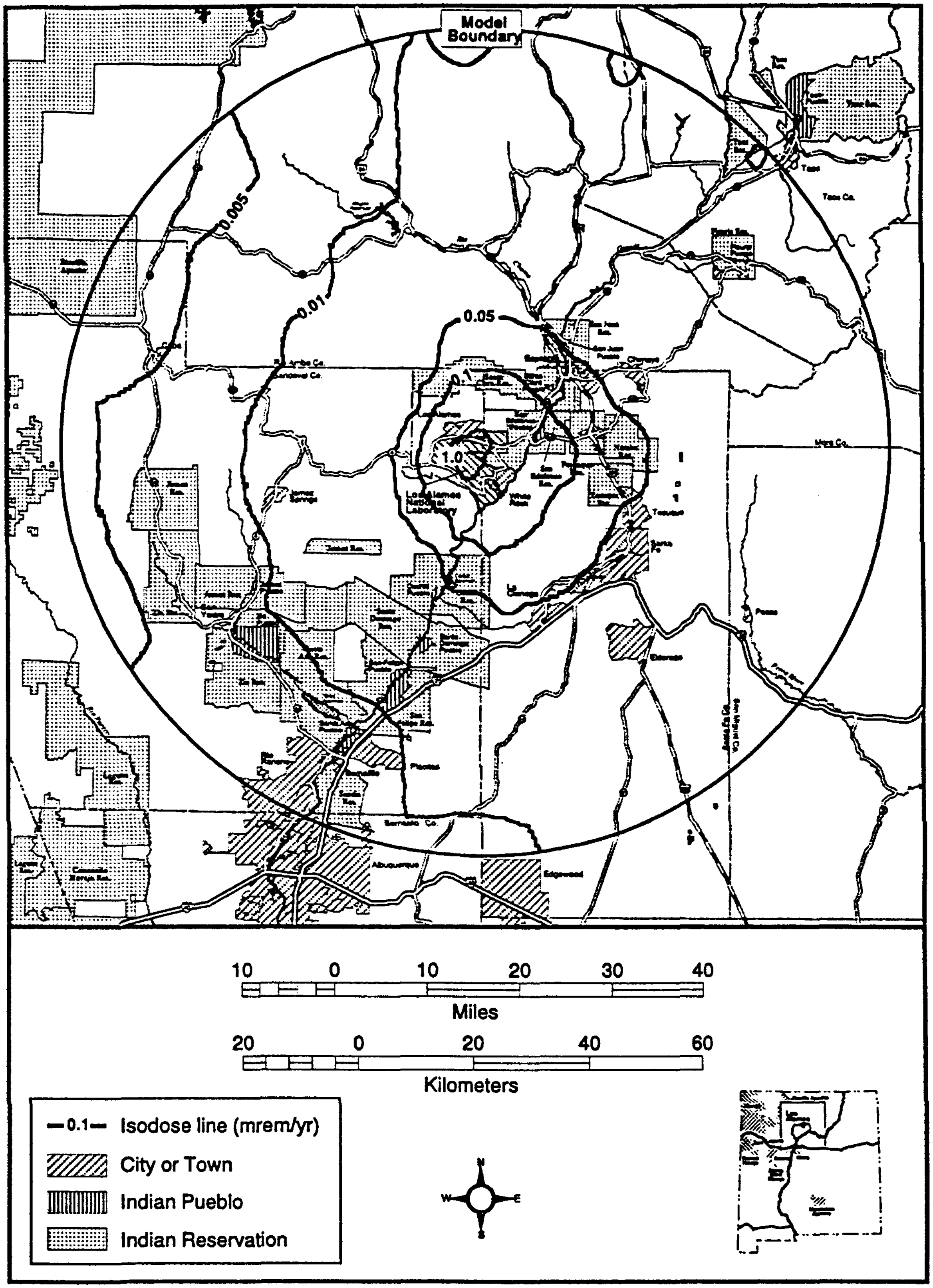


FIGURE 5.5.7–1.—*Isodose Lines from Airborne Releases for the Greener Alternative Within 50 Miles (80 Kilometers) of LANL.*

transportation in the vicinity of LANL transportation routes.

5.5.8 Cultural Resources

Construction activities and explosive test activities under this alternative are essentially the same as those under the No Action alternative. Because these are the activities with the most potential for impacts to cultural resources, impacts to prehistoric resources, historic resources, and TCPs under the Greener Alternative would be similar to those stated for the No Action Alternative in section 5.2.8. Management and protection of prehistoric and historic resources also would be similar to that of the No Action Alternative.

Spiritual Entities

As with the No Action Alternative, no assessment of impacts to "unseen" or "spiritual" entities was attempted.

5.5.9 Socioeconomics, Infrastructure, and Waste Management

This section describes the social, economic, and infrastructure impacts of activities at LANL under the Greener Alternative.

5.5.9.1 *Socioeconomic Impacts*

Employment, Salaries, and Population

The primary (direct) impacts of this type are presented in Table 5.5.9.1–1 for the LANL workforce only. The secondary (indirect) impacts and the total population changes projected are presented in Table 5.5.9.1–2 for the Tri-County area. These changes are assumed to occur within a year of the ROD for the SWEIS.

Housing

The population changes anticipated in the Tri-County area, based on the total employment changes described above, are projected to result in 551 additional (new) demand for housing units. The distribution of this demand in the three counties is projected to be: 130 additional units in Los Alamos County, 197 additional units in Rio Arriba County, and 224 additional units in Santa Fe County.

In Los Alamos County, the projected housing demand can be accommodated from absorption of apartment vacancies and the inventory of houses for sale and new construction. Beyond 130 units, no new housing units can be anticipated because of the absence of buildable land in private ownership. This constraint upon supply would be expected to exert an upward pressure on rents and house prices.

The projected housing demand in Rio Arriba and Santa Fe counties can be accommodated without significant pressure on rents and house sales prices. Both counties possess a sufficient inventory of finished lots and parcels, have access to adequate mortgage capital, and have sufficient entrepreneurial developer talent to absorb the demand.

Construction

Table 5.5.9.1–3 contains the results of the analysis of construction spending, labor salaries, and labor employment for the period fiscal year 1997 through fiscal year 2006. Construction activities associated with this alternative are expected to draw workers already present in the Tri-County area who historically have worked from job to job in the region. Thus, this employment is not expected to influence socioeconomic factors such as local government finance.

Under this alternative, the Tri-County annual gross receipts tax yields would be expected to increase by $1.1 million. This increase would

TABLE 5.5.9.1–1.—*Summary of Primary LANL Employment, Salaries[a], and Procurement Under the Greener Alternative[b]*

	LOS ALAMOS COUNTY	RIO ARRIBA COUNTY	SANTA FE COUNTY	TRI-COUNTY TOTAL	OTHER NEW MEXICO COUNTIES	NEW MEXICO TOTAL	OUTSIDE NEW MEXICO	TOTAL
Employees	4,995	2,082	2,032	9,109	661	9,770	198	9,968
Difference[c]	160	163	195	518	53	571	22	593 (+6%)
Salaries ($M)	264.4	51.5	85.5	401.4	19	420.4	10.3	430.7
Difference[c]	9.8	6.5	11.2	27.5	2.7	30.1	1.6	31.8 (+8%)
Procurement ($M)	217.3	1.8	21	240.1	124.2	364.3	237.5	601.8
Difference[c]	1.6	0.1	0.3	2.1	1.8	3.8	5.9	9.7 (+2%)

[a] Salaries are for UC employees only; subcontractor salaries (Johnson Controls, Inc.; Protection Technology of Los Alamos, etc.) are included in the procurement dollars.
[b] Reflects projected locations of employee residences and LANL procurement activities.
[c] Difference is as compared to baseline (fiscal year 1996). Percent difference is shown in parentheses in the far right (TOTAL) column.

TABLE 5.5.9.1–2.—*Summary of Total Tri-County Employment, Salaries, Business Activity, and Population Changes Under the Greener Alternative*

	PRIMARY CHANGE	SECONDARY CHANGE	TOTAL TRI-COUNTY CHANGE	TRI-COUNTY PRIMARY WORKER CHANGE[a]	TRI-COUNTY SECONDARY WORKER CHANGE[b]	TOTAL TRI-COUNTY WORKER CHANGE	TOTAL TRI-COUNTY POPULATION CHANGE[c]
Employment/ Population	518	886	1,404	414	266	680	1,316 (+1%)
Personal Incomes	$28 million	$27 million	$55 million (+ < 1%)				
Annual Business Activity	$2 million	$4 million	$6 million (+ < 1%)				

Note: Percentages in parentheses are the percentage change that the number represents. These are provided for total population change, total personal income change, and total business activity change.
[a] This is the number of direct workers moving to the Tri-County area, assuming that 80 percent of new LANL employees are from outside this area.
[b] This is the number of secondary workers moving to the Tri-County area, assuming that 30 percent of secondary employment is from outside this area.
[c] This is the total population increase in the Tri-County area, assuming that, on average, each worker moving to the area increases the population by 1.935.

TABLE 5.5.9.1–3.—*Construction Spending, Labor Salaries, and Labor Employment Numbers Under the Greener Alternative (Fiscal Year 1997 Through 2006)*

YEAR	CONTRACT ($M)	LABOR ($M)	EMPLOYEES
1997	63	15	432
1998	187	45	1,282
1999	208	50	1,426
2000	219	53	1,502
2001	210	50	1,440
2002	120	29	823
2003	91	22	624
2004	90	22	617
2005	109	26	747
2006	108	26	741

$M = dollars given in millions
Source: (DOC 1996, PC 1997a, and PC 1997b)

be matched by increases in service levels adequate to meet public demand.

Services

Annual school enrollment in the Tri-County area would increase by 224 students. Additional annual funding assistance of about $898,000 from the State of New Mexico would be required for school operations because of these enrollment increases.

In Los Alamos, the school district can absorb the anticipated new enrollment levels. This school district has excess capacity because of its discretionary policy of accepting out-of-district students who are the children of LANL employees and subcontractors. In Rio Arriba County and the cities of Española and Santa Fe, adequate classroom capacity exists because of recent school construction projects.

The demands for police, fire, and other municipal services would be expected to increase in proportion to the increase in gross receipts tax yields, as discussed above. However, any changes in local government services tend to be inelastic in the short term and typically are responsive only after the completion of at least one full budget cycle.

5.5.9.2 *Infrastructure Impacts*

Annual electricity use projected under the Greener Alternative is a total of 782 gigawatt-hours, 437 gigawatt-hours for LANSCE, and 345 gigawatt-hours for the rest of LANL. The peak electrical demand is projected to be 113 megawatts, 63 megawatts for LANSCE and 50 megawatts for the rest of LANL[1]. The existing supply of electricity to the Los Alamos area is not sufficient year-round to meet the projected electrical peak demand for LANL operations under this alternative; thus, periods of brown-outs are anticipated unless measures are taken to increase the supply of electricity to the area. (In chapter 1, sections 1.6.3.1 and 4.9.2 discuss ongoing efforts to increase electrical power supply to this area.) This situation is exacerbated by the additional electrical demand for BNM, and the communities of Los Alamos and White Rock. (While these organizations did not provide use projections, their historical usage is reflected in chapter 4, section 4.9.2.)

Natural gas use is projected to be 1.84×10^6 decatherms annually, the same as projected under the No Action Alternative. Although electrical demand may increase natural gas demand for the generation of electricity at TA–3, demand should continue to be dominated by heating requirements and is not expected to exceed this projection.

Water use projected under the Greener Alternative is a total of 759 million gallons

1. These values include the proposed SCC Project annual electricity and peak electrical demand for a 50-TeraOp operation and are reflected in all the alternatives. The SCC project was as an interim action to the SWEIS.

(2,873 million liters) per year, 265 million gallons (1,003 million liters) per year for LANSCE and 494 million gallons (1,869 million liters) per year for the rest of LANL. This is well within DOE water rights, about 1,806 million gallons (6,836 million liters) per year; however, this water right also provides for water used by Los Alamos County and BNM. Based on existing information regarding non-LANL water use, the water demands of this community can be met within the existing water rights (water demand is also discussed in section 5.5.3). The peak water requirements are the same as identified under the No Action Alternative.

5.5.9.3 *Waste Management*

The annual and 10-year total generation projections for radioactive and hazardous waste are reflected in Table 5.5.9.3–1. Radioactive liquid is not projected by facility because measurements of individual contributions are not made for all facilities. The total amount of radioactive liquid waste projected for receipt at TA–50 is 66 million gallons (250 million liters) over 10 years (or an average of 6.6 million gallons [25 million liters] per year) for this alternative. These projections include waste from key facilities, all other LANL facilities, waste management facilities, the ER Project, and construction activities.

The waste volumes generated under this alternative are very similar to those under the No Action Alternative; TRU and mixed TRU wastes under this alternative are lower (due to the reduced weapon-related activities), while the other categories are slightly higher (due to the increased nonweapons work). As with the No Action Alternative, much of LANL’s LLW, TRU, and chemical waste would be treated and packaged to meet WAC and shipped off the site for disposal; nondefense TRU waste from other sites would be stored at LANL pending the development of disposal options. Off-site disposal capabilities are much greater than the waste volumes generated at LANL.

5.5.9.4 *Contaminated Space*

The activities reflected in the Greener Alternative are projected to increase the total contaminated space at LANL by 63,000 square feet (5,853 square meters) over the next 10 years (the same as for the No Action Alternative), as compared to the baseline established for the SWEIS as of May 1996 (chapter 4, section 4.9). The majority of this increase is due to implementation of actions that have already been reviewed under NEPA, but which had not been implemented at the time the baseline was established (the same ones discussed in the No Action Alternative).

5.5.10 Transportation

5.5.10.1 *Vehicle-Related Risks*

The transportation impacts projected for the Greener Alternative are summarized in this section. As with the Reduced Operations Alternative, most of the LLW generated is shipped off the site for disposal under the Greener Alternative. While most other shipments are similar to those under the No Action Alternative, these LLW shipments increase the total number of shipments and total shipment miles enough that the transportation impacts under the Greener Alternative approach (but are less than) those of Expanded Operations for off-site radioactive material shipments. More detailed information regarding these impacts is included in volume III, appendix F.

Truck Emissions in Urban Areas

For the Greener Alternative, the projected risk is 0.036 excess LCF per year. Use of the Santa Fe Relief Route would have a very small effect on this risk (it would change to 0.035 excess LCF per year). The only difference is that the Santa Fe Relief Route would have 1.2 miles (1.93 kilometers) less of urban highway mileage. Approximately 65 percent of the excess LCFs are due to radioactive material

TABLE 5.5.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the Greener Alternative*[a]

FACILITY	TECHNICAL AREAS	CHEMICAL WASTE[b] (kilograms)		LOW LEVEL WASTE (cubic meters)		MIXED LOW LEVEL WASTE (cubic meters)		TRANSURANIC WASTE (cubic meters)		MIXED TRANSURANIC WASTE (cubic meters)	
		ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR	ANNUAL AVERAGE	10-YEAR
Plutonium Facility Complex	TA–55	5,250	52,500	688	6,880	12	120	127	1,270	35	350
Tritium Facilities[c]	TA–16 & TA–21	1,300	13,000	450	4,500	2	20	NA	NA	NA	NA
CMR Building[d]	TA–3	8,270	82,700	1,410	14,100	16.5	165	19.5	195	8.7	87
Pajarito Site	TA–18	4,000	40,000	145	1,450	1.5	15	NA	NA	NA	NA
Sigma Complex	TA–3	5,500	55,000	420	4,200	2	20	NA	NA	NA	NA
Materials Science Laboratory	TA–3	600	6,000	0	0	0	0	NA	NA	NA	NA
Target Fabrication Facility	TA–35	3,800	38,000	10	100	0.4	4	NA	NA	NA	NA
Machine Shops	TA–3	142,000	1.42×10^6	280	2,800	0	0	NA	NA	NA	NA
HE Processing Facilities	TA–8, 9, 11, 16, 28 & 37	7,000	70,000	8	80	0.2	2	NA	NA	NA	NA
HE Testing Facilities	TA–14, 15, 36, 39, 40	25,200	252,000	300	3,000	0.3	3	0.2	2	NA	NA
Los Alamos Neutron Science Center[e]	TA–53	16,600	166,600	1,085	10,850	1	10	NA	NA	NA	NA
Health Research Laboratory[f]	TA–43	13,280	132,800	34	340	3.4	34	NA	NA	NA	NA
Radiochemistry Laboratory	TA–48	2,900	29,000	240	2,400	3.4	34	NA	NA	NA	NA
Radioactive Liquid Waste Treatment Facility[g]	TA–50 & TA–21	2,200	22,000	150	1,500	0	0	21	210	0	0
Waste Treatment, Storage, and Disposal Facilities[g]	TA–54	920	9,200	174	1,740	4.0	40	27	270	0	0
Non-Key Facilities		651,000	6.51×10^6	520	5,200	30	300	0	0	0	0
Environmental Restoration Project[h]		2×10^6	2×10^7	4,257	42,570	548	5,480	11	110	0	0
Grand Total[i]		2.89×10^6	2.89×10^7	10,200	102,000	625	6,250	206	2,060	44	440

TABLE 5.5.9.3–1.—*Projected Annual and 10-Year Total Waste Generation Under the Greener Alternative*[a]-Continued

NA indicates that this facility does not routinely generate these types of waste.

[a] Radioactive liquid waste generation is not projected by facility (see text in section 5.5.9.3, Radioactive and Hazardous Waste Generation).

[b] The chemical waste numbers reflect waste that exhibits a hazardous characteristic (ignitability, corrosivity, reactivity, or toxicity), is listed as a hazardous waste by EPA, is a mixture of listed hazardous waste and solid waste, or is a secondary waste associated with the treatment, storage, or disposal of a hazardous waste. This includes waste that is subject to regulation under RCRA, as well as PCB waste and asbestos waste regulated under *Toxic Substance Control Act*. This category also includes biomedical waste.

[c] These projections include 141,000 cubic feet (4,000 cubic meters) of LLW due to backlogged waste.

[d] These LLW projections include 141,000 cubic feet (4,000 cubic meters) of LLW generation anticipated due to the CMR Building Upgrades, Phase II.

[e] These projections include 228,000 cubic feet (6,450 cubic meters) of LLW due to the construction of the new Long-Pulse Spallation Source Facility and 86,000 cubic feet (2,450 cubic meters) of LLW due to upgrades to Areas A5 and A6, as well as reduced operational waste generation during these construction activities.

[f] These projections include 22,000 pounds (10,000 kilograms) of chemical waste, 550 pounds (250 kilograms) of biomedical waste (a special form of chemical waste), 1,560 cubic feet (44 cubic meters) of LLW, and 850 cubic feet (24 cubic meters) of LLMW associated with ongoing efforts to remove obsolete and contaminated equipment.

[g] These facilities provide for storage, treatment, and disposal of waste generated throughout LANL. These activities generate secondary waste, the quantities of which are reflected in this table for these facilities.

[h] The ER Project is projected to generate 390 cubic feet (11 cubic meters) per year of TRU and mixed TRU waste together. All of this waste is presented under the TRU waste columns.

[i] Grand totals have been rounded.

shipments and 35 percent are due to hazardous chemical shipments. All shipments are conservatively assumed to result in an empty truck making the return trip. This is appropriate for WIPP and LLW shipments and for many SST shipments; however, most shipments are in general commerce and would not include the return of an empty truck.

Truck Accident Injuries and Fatalities

The impacts projected for the Greener Alternative are presented in Table 5.5.10.1–1 (additional information is provided in volume III, appendix F, section F.6.3). Use of the Santa Fe Relief Route would reduce the risks of accidents, injuries, and fatalities by almost one-half of those indicated for the segment from U.S. 84/285 to I–25 due to the assumption that the accident rate on the Santa Fe Relief Route would be much lower than for the route through Santa Fe. Use of the Santa Fe Relief Route would not substantially change the risks of accidents, injuries, and fatalities on the remainder of New Mexico segment, as compared to the risks reflected for this segment in Table 5.5.10.1–1. Approximately 65 percent of the impacts are due to radioactive material shipments and 35 percent are due to hazardous chemical shipments. Again, all shipments are assumed to result in a return by an empty truck.

5.5.10.2 *Cargo-Related Risks*

Incident-Free Radiation Exposure

The incident-free radiation exposure impacts projected for the off-site shipments under the Greener Alternative are presented in Table 5.5.10.2–1; as noted in section 5.2.10.2, the total is the dose throughout the U.S. and is dominated by the segments outside of New Mexico. The aircraft segment is for overnight carrier service; the truck segment to and from the airport is included in the truck results. In general, use of the Santa Fe Relief Route would result in only small changes in this type of impact. Truck crew doses and nonoccupational doses for people at rest stops would increase due to the increased length of the Santa Fe Relief Route for north-bound shipments carrying the radioactive material. Nonoccupational doses for people sharing the road would decrease due to the lower traffic density projected for the relief route. The MEI dose occurs between LANL and I–25 and is 0.00034 rem.

Driver Doses from On-Site Shipments of Radioactive Materials

The projected collective radiation dose for on-site shipments of radioactive materials is 4.5 person-rem. This collective dose would be expected to result in 0.00181 excess LCFs among these drivers.

The average individual driver dose is projected to be 0.189 rem, which is well below the DOE radiation protection limit of 5 rem per year.

Transportation Accidents

The following discussion addresses the potential impacts of accidents leading to the release of either radioactive or hazardous material being transported in support of LANL operations under the Greener Alternative. Results are given for both off-site and on-site shipments.

Off-Site Radioactive Materials Shipments. The MEI doses calculated with RADTRAN do not vary by alternative and are given in Table 5.2.10.2–2. The population dose and corresponding excess LCF per year for these shipments are presented in Table 5.5.10.2–2 for these accidents. ADROIT results that are separated into frequency and consequence components are not readily available. The product, MEI dose risk, can be presented in terms of excess LCF per year; for the Greener Alternative, the MEI dose risk due to plutonium-238 oxide and due to pit shipments were each less than 1×10^{-10} excess LCF per year.

TABLE 5.5.10.1–1.—*Truck Accident Injuries and Fatalities Projected for LANL Shipments Under the Greener Alternative*

ROUTE SEGMENT	NUMBER OF ACCIDENTS PER YEAR	NUMBER OF INJURIES PER YEAR	NUMBER OF FATALITIES PER YEAR
On-Site	0.015	0.0031	0.00015
LANL to U.S. 84/285	0.17	0.035	0.0019
U.S. 84/285 to I–25	0.41	0.086	0.0046
Remainder of New Mexico	0.67	0.64	0.08
Outside New Mexico	3.2	3.0	0.35
Total	4.5	3.8	0.44

TABLE 5.5.10.2–1.—*Incident-Free Population Dose and Lifetime Excess LCFs for Off-Site Shipments per Year of Operation Under the Greener Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	person-rem/year	excess LCF/ year	person-rem/year	excess LCF/ year	person-rem/year	excess LCF/ year	person-rem/year	excess LCF/ year
LANL to U.S. 84/285	6.8	0.0027	0.036	0.000018	0.59	0.0003	3.6	0.0018
U.S. 84/285 to I–25	9.2	0.0037	0.44	0.00022	4.2	0.0021	3.8	0.0019
Remainder of New Mexico	52	0.021	0.13	0.000065	2.0	0.001	28	0.014
Outside New Mexico	460	0.18	3.0	0.0015	26	0.013	210	0.1
Aircraft	2.4	0.0012	NA	NA	NA	NA	NA	NA
TOTAL	530	0.21	3.6	0.0018	33	0.015	250	0.12

NA = Not applicable

TABLE 5.5.10.2–2.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the Greener Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM-241	CH TRU	RH TRU	PLUTONIUM-238	PITS	TOTAL	
	person-rem/year	person-rem/year	person-rem/year	person-rem/year	person-rem/year	person-rem/year	excess LCF/year
LANL to U.S. 84/285	0.016	0.0015	3.2×10^{-6}	4×10^{-7}	2×10^{-6}	0.018	9.0×10^{-6}
U.S. 84/285 to I–25	0.25	0.02	0.000044	1×10^{-6}	8×10^{-6}	0.27	0.00014
Remainder of New Mexico	0.033	0.013	0.000027	4×10^{-7}	4×10^{-6}	0.046	0.000023
Rest of U.S.	2.7	NA	NA	4×10^{-6}	0.00001	2.7	0.0014

NA = Not available; CH TRU = contact-handled TRU waste; RH TRU = remote-handled TRU waste

The use of the Santa Fe Relief Route would reduce the projected population dose (and therefore, the excess LCFs per year) by about one-third for the U.S. 84/285 to I–25 segment, as compared to use of the route through Santa Fe. This difference is primarily due to the difference in population density along these routes. (The lower traffic density along the relief route is also a factor.) The use of the Santa Fe Relief Route would increase the projected population dose (and therefore the excess LCFs per year) for the remainder of New Mexico segment to about double that identified if the route through Santa Fe is used. This difference is due to the increase (6 miles [9.65 kilometers] more) in the distance traveled on I–25 for north-bound shipments.

On-Site Radioactive Materials Shipments. The MEI doses, frequencies, and MEI risks due to the bounding on-site shipments involving radioactive materials are given in Table 5.5.10.2–3. As noted in section 5.2.10.2, the frequency of the bounding DARHT and PHERMEX shipments has been added to the frequency of irradiated target shipments.

Hazardous Materials Shipments. The bounding hazardous materials shipments for accident analyses are major chlorine shipments (toxic), major propane shipments (flammable), and major explosive shipments. The consequences of an accident involving a major explosive shipment is bounded by the consequences of an accident involving a major propane shipment, so the frequency of

TABLE 5.5.10.2–3.—*MEI Doses and Frequencies for Bounding On-Site Radioactive Materials Accidents Under the Greener Alternative*

SHIPMENT TYPE	EVENT FREQUENCY PER YEAR	MEI DOSE	MEI RISK
Plutonium-238 Solution	8.8×10^{-8}	8.7 rem	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCF/year)
Irradiated Targets	3.2×10^{-6}	acute fatality	3.2×10^{-6} fatalities/year

explosives shipments was added to the frequency of propane shipments (rather than analyzing them separately).

Accidental Chlorine Release. The projected frequencies, consequences, and risks associated with major chlorine accidents under the Greener Alternative are presented in Table 5.5.10.2–4.

The use of the Santa Fe Relief Route would result in about one-sixth the risk of fatalities and one-tenth the risk of injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight increase in injuries and fatalities on the remainder of New Mexico segment because of the extra 6 miles (9.65 kilometers) traveled on I–25 for northbound traffic (chlorine shipments are all assumed to travel north on I–25).

Accidental Propane Release. The projected frequencies, consequences, and risks associated with major propane accidents under the Greener Alternative are presented in Table 5.5.10.2–5.

The use of the Santa Fe Relief Route would result in about one-third the risk of fatalities and one-fourth the risk of injuries on the U.S. 84/285 to I–25 segment, as compared to the use of the route through Santa Fe. These differences are due to the lower population density along the Santa Fe Relief Route. The use of the Santa Fe Relief Route would result in a slight decrease in injuries and fatalities on the remainder of New Mexico segment because of the 6 miles (9.5 kilometers) reduction in distance traveled on I–25 for southbound traffic (propane shipments are all assumed to travel south on I–25).

5.5.11 Accident Analysis

Transportation accidents for the Greener Alternative are addressed in section 5.5.10. High-frequency (greater than 1 in 100) occupational accidents for the Greener Alternative are addressed in section 5.5.6.

5.5.11.1 *Multiple Source Release of Hazardous Material from Site-Wide Earthquake and Wildfire*

The risks from these accidents are driven primarily by the frequency and magnitude of an earthquake and wildfire in the area. Because the same types of operations will be conducted in the same facilities and the inventories of MAR will be about the same, there are no substantial changes between the No Action and the Greener Alternatives. Tables 5.2.11.1–1 and 5.2.11.1–2 show these results.

5.5.11.2 *Plutonium Releases from Manmade and Process Hazards at LANL*

For the Greener Alternative, the activities and conditions that determine the material release and accident progressions do not change. Therefore, the frequencies and consequences of these scenarios under the Greener Alternative are the same as those presented for the No Action Alternative in Table 5.2.11.2–1.

An overview of the 1969 plutonium fire at the Rocky Flats site and a comparison of the design and operational differences between the Rocky Flats Plant and TA–55–4 are presented in volume III, appendix G, section G.4.1.2.

Substantial differences exist between the nuclear facility and operations being conducted at TA–55–4 today and those that were present at the Rocky Flats Plant in 1969. TA–55–4 was designed to correct the deficiencies detected in older facilities such as the Rocky Flats Plant and is being upgraded to meet the even more stringent requirements of the 1990's, including

TABLE 5.5.10.2–4.—*Frequencies, Consequences, and Risk for a Major Chlorine Accident Under the Greener Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	0.000028	0.065	0.24	8.6×10^{-6}	0.000032
	Suburban	4.6×10^{-6}	1.5	5.6		
U.S. 84/285 to I–25	Rural	0.000022	0.053	0.2	0.00029	0.0011
	Suburban	0.000047	3.0	11		
	Urban	0.000014	11	40		
Remainder of New Mexico	Rural	0.00016	0.015	0.056	0.000052	0.00019
	Suburban	0.000017	1.5	5.5		
	Urban	2.8×10^{-6}	8.4	32		
Remainder of U.S.	Rural	0.0012	0.028	0.1	0.0012	0.0047
	Suburban	0.0003	1.6	6.1		
	Urban	0.00007	10	39		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

TABLE 5.5.10.2–5.—*Frequencies, Consequences, and Risk for a Major Propane Accident Under the Greener Alternative*

ROUTE SEGMENT	AREA	EVENT FREQUENCY PER YEAR	ESTIMATED NUMBER OF FATALITIES PER EVENT	ESTIMATED NUMBER OF INJURIES PER EVENT	RISK OF FATALITIES PER YEAR[a]	RISK OF INJURIES PER YEAR[a]
LANL to U.S. 84/285	Rural	9.6×10^{-6}	0.28	1.1	9.7×10^{-6}	0.000039
	Suburban	1.6×10^{-6}	4.2	17		
U.S. 84/285 to I–25	Rural	7.4×10^{-6}	0.23	0.92	0.00015	0.0006
	Suburban	0.000016	8.4	34		
	Urban	5.0×10^{-6}	1.8	7.3		
Remainder of New Mexico	Rural	0.000064	0.15	0.6	0.00012	0.00048
	Suburban	0.000021	5.1	20		
	Urban	2.6×10^{-6}	1.5	6.1		
Remainder of U.S.	Rural	0.000081	0.09	0.36	0.000067	0.00027
	Suburban	0.00001	4.8	19		
	Urban	5.3×10^{-6}	1.9	7.5		

[a] Because individual factors were rounded for presentation, multiplication of the factors on this table may not exactly match the results in these columns.

enhanced seismic resistance and fire containment.

5.5.11.3 *Highly Enriched Uranium Release from Process Hazard Accident at LANL*

As discussed in section 5.2.11.3, this accident is the dominant accident for the release of HEU. Because there are no planned changes in the number of experiments or the inventories associated with this activity, the frequency and consequences of this scenario under the Greener Alternative are the same as presented under the No Action Alternative in Table 5.2.11.3–1.

5.5.11.4 *Tritium Release from a Manmade Hazard*

As presented in section 5.2.11.4, the aircraft crash event is the dominant accident that involves tritium. Because no changes in operations or inventories from the No Action Alternative are made, the consequences and frequencies associated with these scenarios are the same as those presented for the No Action Alternative in Table 5.2.11.4–1.

5.5.11.5 *Chemical Releases from Manmade and Process Hazard Accidents at LANL*

For the chlorine releases, on-site personnel could be exposed to concentrations in excess of ERPG–2. Chlorine has a highly objectionable odor, which prompts sheltering and escape; however, personnel can be quickly overcome when exposed to high concentrations.

Because no changes in operations or inventories from the No Action Alternative are made, the frequencies and consequences of these scenarios are the same as those under the No Action Alternative, as presented in Tables 5.2.11.5–1 and 5.2.11.5–2.

5.5.11.6 *Worker Accidents at LANL*

Although there are some planned decreases under this alternative in the handling of high explosives, the accident frequencies remain within same range of values as for the No Action Alternative. Therefore, the frequencies and consequences of these scenarios under the Greener Alternative are the same as those presented for the No Action Alternative in Table 5.2.11.6–1.

5.6 CUMULATIVE AND UNAVOIDABLE IMPACTS

5.6.1 Cumulative Impacts

Cumulative impact is defined by the CEQ NEPA regulations as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of which agency (federal or not federal) or person undertakes such other actions." This discussion of cumulative impacts deals with the effect of LANL operations when added to similar effects from the actions of other entities within the same region of influence. Effects are discussed by impact or resource area, and as can be seen from the discussions of each environmental impact area of analysis in chapter 5, the region of influence can vary. Some effects of LANL operations are not detectable beyond the facility or site boundary, while others involve effects with the potential to extend beyond site boundaries, interact with other sources of the same impact, and so may be managed under a regional regulatory authority (such as for criteria pollutants under the *Clean Air Act)*. Other effects, such as fire control or the movement of grazing animals, are best viewed within a common habitat or natural resource area.

This site-wide analysis in large measure is, by its scope, an analysis of cumulative impacts. To analyze the effects of LANL operations, regions of influence were selected to identify the maximum extent of impacts while still providing a discussion of effects that can be evaluated meaningfully. These impacts represent the effects from all operations at the site, and some effects do not have contributors from sources other than LANL. The following discussion represents all operational alternatives. The nature of the impacts from LANL operations and those of the surrounding area are such that the analyses presented in the previous sections of chapter 5 are, in fact, most of the relevant materials on this subject. The discussion that follows is not greatly influenced by the variation in impacts from the alternatives because most of these impacts are not significant and/or there is little contribution to impacts from other sources that are in the same region of influence as LANL. Information was gathered from city, county, state, tribal, and other federal organizations concerning future plans for development and to get information on any regional planning efforts. Following is a summary of the effects from LANL operations presented in this regional context and in a cumulative sense where such additional information was not already used in the previous section of the impact analysis.

5.6.1.1 *Land Use*

Much of the area around LANL is undeveloped USFS and NPS land, and is projected to remain undeveloped. Future land use patterns are projected to remain the same within the LANL site, and trends in population growth for the region immediately surrounding Los Alamos are likely to continue to increase the urban nature of development. Sections on land use in chapters 4 and 5 of this document provide more detail on these subjects and the cumulative impacts for this aspect of the analysis.

There is a potential for a change in these projections in land use for some parcels on the LANL site that have been identified for possible conveyance and transfer as part of PL 105-119 (also see chapter 4, section 4.1.1.4). The DOE has submitted the first required deliverable to Congress that gives a preliminary identification of 10 parcels that could be considered for transfer, comprising a total of approximately 4,600 acres (1,860 hectares). Those parcels are being evaluated further in the LANL Conveyance and Transfer (CT) EIS (DOE 1998a) (see chapter 1, section 1.5.10) for possible restrictions that may limit their use because of cultural and ecological resource impacts. These parcels also will be evaluated by the ER Project to determine whether any needed remedial actions to allow unrestricted use are practical and could be completed in a 10-year time frame. Transferred lands are available for historic, cultural, or environmental preservation purposes; economic diversification purposes; or community self-sufficiency purposes, as stated in the law. A maximum of 1,158 acres (468 hectares) of the total acreage proposed to be transferred and conveyed would be developed or the land use otherwise changed (DOE 1998a).

5.6.1.2 *Water Resources*

Direct wastewater discharges to the canyons were evaluated in previous sections of this chapter, and no impacts were identified from the quality of current discharges. Soil contaminants from past operations can be affected by surface water flows within the canyons and potentially be carried further down the canyons and into the perched water zones or the underlying deep aquifer. The potential for this type of transport from stormwater runoff as well as transport caused by potential variation in future industrial discharges are discussed in this document. These also are factors in mitigative actions and specific risk analyses for each of the units to be evaluated under the ER Project. No other major water discharge to upper and middle reaches of these canyons occurs from human activity other than from LANL operations and the sanitary wastewater treatment that is performed for these operations as well as for the county, and no other planned discharges were evident. The Los Alamos County sewage treatment plant that discharges into the lower portions of Cañada del Buey is not likely to be a factor of concern for contaminant transport because no contamination above regional background reference levels is found in sediments in that portion of Cañada del Buey or in the lower portion of Mortandad Canyon, which receives the waters from Cañada del Buey. LANL operations are therefore the only activities of interest from the standpoint of cumulative impacts. The Los Alamos County sewage treatment plant in Bayo Canyon does discharge into an area of measurable radioactive contamination from past operations. Levels of contaminants have remained relatively constant in recent years and are slightly above background levels in the vicinity of the plan. While stormwater events are the primary force for movement of sediments, there is the potential for this discharge to contribute to the movement of sediments contaminated with radionuclides in the lower portions of Pueblo Canyon and Los Alamos Canyon. More details on these subjects may be found in the water resource sections of this document.

New development under the CT EIS (DOE 1998a) proposed action could degrade the surface water quality, increasing the pollutant loads and surface runoff volumes from construction activity and the increase in impermeable areas. Increases in discharges to wastewater treatment plants could be 132 million gallons (500 million liters) per year for the Bayo plant and 41 million gallons (155 million liters) per year for the White Rock plant.

5.6.1.3 *Air Quality*

No sources of air pollutants, other than those from LANL operations, were identified that would be of relevance for an evaluation of cumulative impacts; therefore, to give perspective on this situation, a brief description is provided below of the region that could be influenced by LANL operations. Except for Bernalillo County (greater Albuquerque area), the State of New Mexico manages the entire state as one air quality district. This district includes several wilderness areas, national parks, and national monuments and must consider the special status of these areas under the regulations for the prevention of significant deterioration (PSD). The proximity of BNM's wilderness area to LANL is of special note. The largest sources in the state for criteria pollutants are in the Four Corners area, about 200 miles (320 kilometers) to the northwest, and the Bernalillo County area about 50 miles (80 kilometers) to the southwest; but neither areas exhibit major influence in the proximity of the LANL site. Sources in the immediate area are relatively small and separated from one another. Past ambient air quality monitoring by LANL and the State of New Mexico in the vicinity of BNM showed values well below standards developed to protect human health with an ample margin of safety, and monitoring was discontinued in 1994. No future development at LANL is proposed that would require evaluation under PSD regulations. Industrial development in the general area puts little pressure on ambient air quality concerns, and complex permitting or monitoring strategies are not necessary in this area to prevent degradation of air quality.

Only very minor effects from LANL operations could be identified from emissions of toxic air pollutants. No other sources of pollutants having the same potential effect at these receptors of concern for LANL operations were identified. Although some of the impact analyses considered receptors within a 50-mile (80-kilometer) radius of the site, impacts are primarily associated with areas close to the site.

There would be increases in criteria pollutants from mobile sources and homes using natural gas or propane from implementing the CT EIS proposed action. Slight increases in emissions of hazardous air pollutants would be expected from the development of new industrial facilities.

Implementation of the draft Surplus Plutonium Disposition (SPD) EIS Lead Assembly Alternative (DOE 1998b) at LANL would increase the radiological emissions to the MEI by no more than 0.01 millirem per year. Overall, LANL would be expected to remain within the 10 millirem per year NESHAP limit.

5.6.1.4 *Ecological Resources*

The analysis of direct effects on ecological resources from LANL operations in previous sections of this chapter shows that these effects do not, in most cases, extend beyond the perimeter of the site. Where contaminants from LANL are found off the site, contributions from sources other than worldwide fallout were not identified. Analysis of these effects are found in previous sections of this chapter. Additionally, potential effects on biota and ecosystems discussed in those sections are presented within the context of the larger regional ecosystem in which the LANL site is immersed. Potential effects from existing soil contaminants were identified, some dominated by naturally occurring metals, some dominated by legacy contamination from LANL operations. No current or planned additions of contaminants of concern by LANL or any other entity were identified.

The LANL site is relatively large and undeveloped, and serves as a reservation for a wide diversity of plants and animals. Although the impacts to biota and ecosystems are beneficial in this aspect, the site is affected by land uses predating LANL and influenced by fragmented management strategies. Resolution of problems such as risk of catastrophic wildfire, erosion, elk overpopulation, and habitat loss and fragmentation, will benefit from permanent interagency coordination and the development of a joint planning and management program with the other land management agencies. The continuation of and implementation of ongoing site programs and planning actions such as the ER Project, the Threatened and Endangered Species Habitat Management Plan, and the Natural Resources Management Plan will place site managers in a position to contribute in a meaningful way to regionalized strategies as they develop. Discussions in previous sections of this chapter present this regional context in the evaluation of impacts.

Implementation of the CT EIS proposed action would cause approximately 1,230 acres (498 hectares) of ponderosa pine forest and pinyon-juniper woodland habitat to be heavily modified or lost. Also, approximately 3.8 percent of American peregrine falcon and Mexican spotted owl preferred habitat available at DOE/LANL would be affected.

5.6.1.5 *Cultural Resources*

The presence of federal lands adjacent to LANL and the highly restricted nature of the LANL site tends to prevent impacts to these resources from activities other than those directly attributable to LANL operations, and therefore, the discussion of impacts in previous sections of the chapter represents the analysis of cumulative impacts for this aspect of the analysis. Impacts from LANL operations extending beyond the site boundaries were not noted. The analysis in previous sections noted the potential for on-site impacts to TCPs from explosives, residual contamination, and restriction of access; but insufficient information on locations of these sites limits this area of analysis. More information may be found in chapter 4, (section 4.8), chapter 5, and appendix E.

The proposed action under the CT EIS would cause the development of approximately 1,020 acres (413 hectares) and use of tracts for recreation that could result in physical destruction, damage, or alteration of cultural resources on the subject tracts and in adjacent areas.

5.6.1.6 *Socioeconomics*

Government operations (federal, state, local, tribal) and service-sector businesses dominate the economics of the region influenced by LANL by a very large margin. Activities at LANL itself are estimated to directly and indirectly account for more than a third of employment, wage and salary, and business activity in the Tri-County region. The service sector aspect of the economy has experienced little growth in recent years, although projections of population growth, particularly in Santa Fe County, can reasonably be expected to result in the continued major influence of this economic sector. No major fluctuation in other aspects of the economy or introductions of significant new activities were identified. The discussion of impacts in previous sections of this chapter evaluates impacts in the area influenced by LANL (the Tri-County region) and in the context of identified growth patterns. Those sections may therefore be referred to for details on cumulative impacts for this aspect of the analysis.

Short-term economic gains would be expected from employment due to construction activities for new development under the CT EIS proposed action. The long-term gains would be dependent on the intensity and success of the development.

5.6.1.7 *Infrastructure*

LANL is a significant user of electric power in the region, but is not the dominant user in northern New Mexico. Within the electric power pool that serves LANL, direct use by LANL is about 80 percent of the total. The system serving LANL is near capacity, and future projections on electric power use from LANL under all alternatives, except Reduced Operations, indicate that demand will exceed capacity. Consideration of options to increase system capacity is complicated by the fact that the systems for other major power users in the region (the cities in northern New Mexico) are also nearing capacity, and demand from these users is also projected to exceed capacity. While the regional system capacity problem will exist regardless of the alternative selected for LANL operations, selection of an option to deal with LANL alone is strongly influenced by these regional considerations. No specific proposals have been fully developed to remedy this situation (although, as noted in chapter 1, section 1.6.3.1, some specific solutions are being evaluated), and further analysis of environmental impacts will be necessary as future options are developed sufficiently to analyze them. Previous sections of this chapter discuss these electric power issues in the context of regional problems and may therefore be referred to for details on cumulative impacts for this aspect of the analysis.

Natural gas use is projected to remain within the capacity of the current system to provide it. Even if electricity demand increases natural gas demand for the generation of electricity at the LANL main power plant, demand for natural gas should continue to be dominated by heating requirements, and increase in demand sufficient to exceed capacity is not expected. Currently, there are no projections from other consumers in the region using the same natural gas supply lines that show demand potentially exceeding capacity. The evaluation of impacts in this resource area in previous sections of this chapter discuss natural gas use in this regional user context, and may therefore be referred to for details on this aspect of the cumulative impact analysis.

Potable water use was analyzed in previous sections of this chapter in the context of multiple users of a common aquifer and projected future use patterns of these users. The potential drawdown associated with LANL activities as well as services provided to other entities under the DOE water rights were modeled along with the other users in the region. All the users of the aquifer in the Española Basin are assumed to influence one another, but the exact relationships are unknown. Effects such as reduction in the height of the water table at a particular location are primarily influenced by major pumping operations in the immediate area. As pumping by DOE or by the City of Santa Fe shifts from one well field to another, water table height increases in the abandoned area and reduces in the new area. Therefore, even though Santa Fe may be the major water user in the area, total water use in the region still comprises a small fraction of the total volume within the main aquifer, and overall effects, while measurable, are not pronounced. Water use is projected to remain within existing water rights (which cumulatively constitute less than 1 percent of the estimated volume of the aquifer, as discussed in volume III, appendix A, section A.5), and no reduction in the discharge volume from springs in the area is foreseen.

The only aspects of solid waste management that have considerations of cumulative impact are those associated with the multiple users of the Los Alamos County landfill, and the potential for use of the LANL LLW disposal area by other DOE generators. Sufficient capacity in the county solid waste landfill will remain for the foreseeable future, and a decision on expansion of the LLW disposal area is likely to be driven by needs at LANL and not elsewhere. Sections of this document dealing with waste management activities contain more information on this aspect of cumulative impacts.

The total increases in utility usage for the CT EIS proposed action would be as follows:

- Electric use, 31 gigawatt-hours
- Peak power, 5 megawatts
- Natural Gas, 459 million cubic feet
- Water, 382 million gallons per year
- Solid Waste, 2,385 tons per year

Land development under the proposed CT EIS could result in an increased use of 382 million gallons (1,450 million liters) per year of groundwater, a significant increase over the water rights allocation of 1,805 million gallons (6,830 million liters) per year. Under the Expanded Operations and Preferred

Alternatives, the estimated water rights use would be 1,724 million gallons (6,525 million liters) per year. Implementation of the CT EIS proposed action would exceed the water rights allocation. Implementation of the Special Neutron Source (SNS) EIS proposed action of the 1-megawatt beam would use 42 million gallons (160 million liters) per year of groundwater, which could not be met with the current water infrastructure and water rights.

The Spallation Neutron Source (SNS) EIS proposed 1-megawatt beam would use 62 megawatts of peak power. LANL's existing electrical infrastructure is not adequate to support the additional power demand. The increase in peak power demand would exacerbate the power supply-demand problems in the Los Alamos region.

The additional impacts from implementing the draft SPD EIS, Lead Assembly Alternative at LANL would include a total of 4,840 cubic feet (137 cubic meters) of TRU waste, 24,900 cubic feet (705 cubic meters) of LLW, and relatively small quantities of other hazardous and nonhazardous wastes. These impacts are not a significant contributor to the waste management activities at LANL. The annual electricity requirements would increase by 0.72 gigawatt-hours, with an increase peak power demand of 0.3 megawatts. The annual process water usage would increase by 20,000 gallons (76,000 liters) per year. Both the electrical power and water usages are minor in the context of LANL's overall requirements and, thus, are not significant contributors to the power and water concerns at LANL.

5.6.1.8 *Transportation*

The future population of Los Alamos is not projected to increase significantly, although future land transfers may increase local traffic. As discussed in other sections, no other major cause for growth in the region has been identified, although some communities are expected to increase in size just as other areas of the state. Impacts associated with traffic congestion and vehicle emissions discussed in previous sections of this chapter consider the effects attributable to LANL operations in the context of effects that may be present from other sources, as well as the effect of future growth in the area. More detail on cumulative impacts may be found in those sections. Hazardous chemical and radioactive materials shipments comprise about 1 percent of the off-site truck shipments for LANL. The number of these type of shipments may increase above the No Action levels for the Expanded Operations, Reduced Operations (driven by waste shipments) and Greener Alternatives, but the percentage is likely to remain about the same. For perspective on the regional context for these types of shipments, the percentage of truck shipments that carry hazardous chemicals or radioactive materials in the State of New Mexico has been estimated by state transportation officials to be about 10 percent, although some segments of highway, such as I–40, may be much higher.

Under the CT EIS proposed action, the peak traffic entering or exiting all 10 tracts could increase by a range of approximately 751 to 3,775 trips per day. Many of the current roads and intersections would have to be upgraded to accommodate the new traffic levels.

The draft SPD EIS (DOE 1998b), Lead Assembly Alternative, documents the additional transportation impacts should LANL, be selected for this activity. Plutonium dioxide would already be at LANL, so no shipping would be required for this material. LANL would receive uranium dioxide and other material needed to assemble mixed oxide (MOX) fuel bundles from a nuclear fuel fabricator and would ship MOX fuel assemblies to a reactor site. Approximately 20 shipments of radiative materials would be carried out by DOE. The total distance traveled on public roads by trucks carrying radioactive materials would be about 34,000 miles (55,000 kilometers). The dose to transportation workers from all transportation activities under this lead assembly alternative has been estimated at 1.5 person-rem; the dose to the public has been estimated at 10.3 person-rem. Accordingly, the incident-free transportation of radioactive material would result in 5.9×10^{-4} excess LCFs; among transportation workers and 5.1×10^{-3} excess LCFs in the total affected population over the duration of the transportation activities. The estimated number of nonradiological fatalities from vehicular emissions would be 1.5×10^{-4}. Estimates of the total ground transportation accident risks indicate a radiological dose to the population of 6.2 person-rem, resulting in a total population risk of 3.1×10^{-3} excess LCFs and traffic accidents resulting in 6.7×10^{-4} traffic fatality.

5.6.1.9 Human Health

The development of the CT EIS proposed action could bring as many as 900 new residents into closer proximity to LANL facilities at the DOE Los Alamos Area Office and DP Road Tracts, and another 2,200 residents and lodgers at the White Rock Tract. Commercial development could bring as many as 6,000 private-sector employees into existing radiation buffer zones at the DP Road, TA–21, and Airport Tracts. These developments would mean increased public exposures to radiological and chemical emissions from LANL, from normal operations and hypothetical accidents. A substantial increase in the public collective radiation dose would result.

Implementation of the Lead Assembly Alternative, analyzed in the draft SPD EIS (DOE 1998b), at LANL would contribute the following impacts. The expected number of excess LCFs as a result of the radiation released from these activities in the general population residing within 50 miles (80 kilometers) of LANL would be 1.2×10^{-5}. The expected number of excess LCFs to involved workers would be 0.011. The expected annual dose to the MEI is 9.0×10^{-3} millirem per year, which corresponds to an associated excess LCF risk of 4.5×10^{-9}. Transportation related to these activities would not be expected to result in any excess LCFs either. Thus, implementation of the lead assembly fabrication activities at LANL would pose no significant health risks to the public.

5.6.2 Unavoidable Adverse Impacts

Operating LANL under any alternative involves the release of small quantities of radioactive and hazardous materials via routinely monitored air and water effluent discharges. Analysis has shown these discharges to be of minimal consequence; nonetheless, they represent an impact that is unavoidable. Control measures commensurate with potential risk are in place, and in an evolutionary manner, seek to reduce these discharges to the lowest practical levels. Solid radioactive and hazardous waste, and sanitary wastes also result from routine operations, and must be treated and disposed. The active recycle, waste minimization, and waste avoidance programs at LANL continuously work to reduce the volume and types of these wastes. Potential disturbance of biological and cultural resources can result from operations, and restricted access to some traditional cultural properties might be viewed as adverse.

5.6.3 Irreversible and Irretrievable Commitments of Resources

Operations at LANL under the various alternatives require the consumption of a number of resources. Table 3.6.2–1 in chapter 3 shows the projected usage of water, natural gas, and electricity across the SWEIS alternatives. (These resources are also discussed by alternative in sections 5.2.9.2, 5.3.9.2, 5.4.9.2, and 5.5.9.2.) While deficiencies in some of the local distribution systems for gas and electricity were discussed in this analysis, no shortages in total regional supplies were noted. There also are many materials requirements for maintenance of facilities, and operations require the consumption of the entire range of expected products and materials, such as chemicals. There is an active recycling program at LANL; most products are expended or disposed. Approximately 43 square miles (111 square kilometers) are reserved for laboratory operations. A large amount of that area remains undisturbed, and development has been, and will continue to be, concentrated in areas of like operations. While it is theoretically possible to consider that the entire facility could be decommissioned and removed, operations, including waste disposal, are expected to continue into the foreseeable future. These lands are therefore removed from use for other purposes. An active environmental restoration program seeks to reduce the risk from past discharges of radioactive and hazardous materials; but, not all areas are expected to be restored to their original condition. LLW disposal at LANL places strict limitations on alternative or future uses of the disposal areas. The disposal sites would require monitoring and various forms of protective actions, including administrative access control, for an extended period of time.

5.6.4 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

A decision to operate LANL under any alternative requires the commitment of resources that cannot be recovered, the acceptance of impacts from normal operations that release pollutants and cause disturbances. The national resource embodied in LANL, which is continually tapped by different entities throughout the U.S. as well as abroad, is used to work on problems involving national security, energy resources, environmental quality, and in science.

A large portion of the knowledge and capability necessary to support the nuclear weapons program resides at LANL. The program implemented by DOE, and as discussed in the SSM PEIS (DOE 1996d), has been reduced in size, refocused, and operations consolidated to a fewer number of sites.

REFERENCES

BH&A 1995 — *Needs Assessment for Fire Department Services and Resources, Los Alamos National Laboratory, Los Alamos, New Mexico*. Beatty, Harvey & Associates. New York, New York. November 15, 1995.

Bradford 1996 — W. Bradford, ESH-EIS. Memorandum to Doris Garvey, ESH/M889, on *NPDES Outfalls and Annual Volume Discharges for Other than Key Facilities.* August 28, 1996.

CEQ 1993 — *Incorporating Bidodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act.* Council on Environmental Quality. Washington, D.C. 1993.

Dennis et al. 1978 — *Severities of Transportation Accidents Involving Large Packages*. SAND-77-0001. A. W. Dennis et al. Sandia National Laboratories. Albuquerque, New Mexico. 1978.

DOC 1992 — *1990 Census of Population, General Population Characteristics, New Mexico*. 1990 CP-1-33. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1992.

DOC 1993a — *1990 Census of Population, Social and Economic Characteristics, New Mexico*. 1990 CP-2-33. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1993.

DOC 1993b — *1990 Census of Housing, Detailed Housing Characteristics, New Mexico.* 1990 CH-2-33. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1993.

DOC 1996 — *Personal Income by Major Source and Earnings by Industry, New Mexico and Los Alamos, Rio Arriba, and Santa Fe Counties, 1989 through 1994*. U.S. Department of Commerce, Bureau of Economic Analysis, Economic Information System. Washington, D.C. June 1996.

DOE 1993 — *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements.* U.S. Department of Energy, Office of NEPA Oversight. May 1993.

DOE 1994 — *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities.* DOE Handbook 3010-94, Vols. I & II. U.S. Department of Energy. December 1994.

DOE 1995a *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement.* DOE/EIS-0228. U.S. Department of Energy, Albuquerque Operations Office and Los Alamos Area Office, Albuquerque, New Mexico. August 1995.

DOE 1995b *Environmental Assessment, High Explosive Wastewater Treatment Facility.* DOE/EA-1100. Los Alamos National Laboratory, Los Alamos, New Mexico. August 1995.

DOE 1996b *Accident Analysis for Aircraft Crash Into Hazardous Facilities.* DOE Standard 3014-96. U.S. Department of Energy. October 1996.

DOE 1996c *Interim Format and Content Guide and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments.* U.S. Department of Energy. Washington, D.C. October 1996.

DOE 1996d *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*. DOE/EIS-0236. U.S. Department of Energy, Office of Defense Programs, Washington, D.C. 1996.

DOE 1996e *Environmental Assessment for Effluent Reduction.* DOE/EA-1156. U.S. Department of Energy, Los Alamos Area Office. Los Alamos, New Mexico. September 11, 1996.

DOE 1997 *Approaches for Upgrading Electrical Power System Reliability and Import Capability*. LA-UR-96-3882. Prepared by Lundberg, Marshall & Associates, Ltd., for the U.S. Department of Energy, Albuquerque Operations Office, under Contract Number DE-ACOA-93AL82990. Albuquerque, New Mexico. August 28, 1997.

DOE 1998a *Draft Environmental Impact Statement for the Conveyance and Transfer of Certain Land Tracts Administered by the Department of Energy and Located at Los Alamos National Laboratory, Los Alamos and Santa Fe Counties, New Mexico*. (Predecisional Draft). U.S. Department of Energy, Los Alamos Area Office. Los Alamos, New Mexico. December 14, 1998.

DOE 1998b *Surplus Plutonium Disposition Environmental Impact Statement.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/Draft EIS-0283. Washington, D.C. July 1998.

DOT 1992 *FAA Statistical Handbook of Aviation: Calendar Year 1992.* FAA APO-94-5. U.S. Department of Transportation, Federal Aviation Administration. Washington, D.C. 1992.

EPA 1987 — *Radiation Protection Guidance to the Federal Agencies for Occupational Exposure*. *Federal Register*, Vol. 52, No. 17 (52 FR 2822-2834). January 27, 1987.

EPA 1992 — *Framework for Ecological Risk Assessment.* U.S. Environmental Protection Agency. Report No. EPA/630/R-92/001. Washington, D.C. 1992.

Frenzel 1995 — *Geohydrology and Simulation of Groundwater Flow near Los Alamos, North-Central New Mexico.* P. Frenzel. USGS Water Resources Investigations Report 95-4091. 1995.

Garvey 1997 — D. Garvey, ESH-EIS. Memorandum to Corey Cruz, DOE Albuquerque Operations, regarding NPDES outfalls. December 19, 1997.

Geffen et al. 1980 — *An Assessment of the Risk of Transporting Propane by Truck and Train*. C. A. Geffen et al. PNL-3308. Pacific Northwest Laboratory, Richland, Washington. 1980.

Glickman and Raj 1992 — *A Comparison of Theoretical and Actual Consequences in Two Fatal Ammonia Accidents*. T. A. Glickman and P. K. Raj. *Transportation of Dangerous Goods: Assessing the Risks.* F. Frank Saccomanno and Keith Cassidy, eds. Institute for Risk Research, University of Waterloo. Ontario, Canada. 1992.

Havens and Spicer 1985 — *Development of an Atmospheric Dispersion Model for Heavier-than-Air Gas Mixtures*. CG-D-22-85. J. A. Havens and T. O. Spicer. U.S. Coast Guard. Washington, D.C. 1985.

Holt 1998 — Memorandum from James Holt, Program Director, Institutional Facilities and Construction, Los Alamos National Laboratory, to Herman LeDoux, U.S. Department of Energy. October 22, 1998.

ICRP 1977 — *Recommendations of the International Commission on Radiological Protection*. International Commission on Radiological Protection. ICRP Publication No. 26, Annals of the ICRP 1, (3). Pergamon Press. New York. 1977.

ICRP 1991 — *Recommendations of the International Commission on Radiological Protection*. International Commission on Radiological Protection. ICRP Publication No. 60. Pergamon Press. New York. 1991.

Johnson et al. 1993 — HIGHWAY 3.1 + An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual. ORNL/TM-12124. P. E. Johnson, D. S. Joy, D. B. Clarke, and J. M. Jacobi. Oak Ridge National Laboratory. Oak Ridge, Tennessee. March 1993.

Kumar 1997	J. Kumar, Lundberg, Marshall & Associates, Ltd., Letter to D. Agar, U.S. Department of Energy, regarding the capacity gas line that supplies the Los Alamos area. Prepared under Contract Number DE-ACOA-93AL82990. August 27, 1997.
LANL 1992	*Environmental Surveillance at Los Alamos During 1990*. Los Alamos National Laboratory. LA-12271-M8. UC-1990. Los Alamos, New Mexico. March 1992.
LANL 1993	*Environmental Surveillance at Los Alamos During 1991*. Los Alamos National Laboratory. LA-12572-ENV. UC-902. Los Alamos, New Mexico. August 1993.
LANL 1994	*Environmental Surveillance at Los Alamos During 1992*. Los Alamos National Laboratory. LA-12764-MS. UC-902. Los Alamos, New Mexico. July 1994.
LANL 1995b	Information on historical LANL procurement received from the LANL Business Operations Division. Los Alamos National Laboratory. Los Alamos, New Mexico. November 13, 1995; October 17, 1996; and January 3, 1997.
LANL 1995c	*Environmental Surveillance at Los Alamos During 1993*. Los Alamos National Laboratory. LA-12973-ENV. UC-902. Los Alamos, New Mexico. October 1995.
LANL 1995d	*Materials Expended Report for PHERMEX*. Los Alamos National Laboratory. DX-11-95-109. Los Alamos, New Mexico. March 16, 1995.
LANL 1996a	Information on LANL salaries received from the University of California Payroll Department. Los Alamos National Laboratory. Los Alamos, New Mexico. November 21, 1996, and December 12, 1996.
LANL 1996b	*Environmental Surveillance at Los Alamos During 1994*. Los Alamos National Laboratory. LA-13047-ENV. UC-902. Los Alamos, New Mexico. July 1996.
LANL 1996c	*Environmental Surveillance at Los Alamos During 1995*. Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.
LANL 1996d	*Evaluation of Aircraft Crash Hazard at Los Alamos National Laboratory Facilities*. Los Alamos National Laboratory. LA-13105. Los Alamos, New Mexico. July 1996.
LANL 1997a	SH-EIS:97-159: Kenneth Rea to Corey Cruz, subject: socioeconomic data corrections. June 18, 1997.

LANL 1997b — Field Observations of Eight Cultural Resource Sites in the Vicinity of LANL Firing Sites. Report transmitted from T. Ladino, Los Alamos National Laboratory, ESH-20/Ecol-98-0084. Los Alamos, New Mexico. October 29, 1997.

LANL 1997c — *Capital Asset Management Process, Fiscal Year 1997.* Los Alamos National Laboratory. LA-UR-95-1187. Los Alamos, New Mexico. 1997.

LANL 1997d — *Environmental Surveillance and Compliance at Los Alamos during 1996.* Los Alamos National Laboratory, Environmental Assessments and Resource Evaluations Group. LA-13343-ENV. Los Alamos, New Mexico. 1997.

LANL 1998a — *Waste Management Strategies for LANL*. Los Alamos National Laboratory. LA-UR-97-4764. Los Alamos, New Mexico. April 1998.

LANL 1998b — *Description of Technical Areas and Facilities at LANL.* Los Alamos National Laboratory. LA-UR-97-4275. Los Alamos, New Mexico. March 1998.

LANL 1998c — *Performance Assessment and Composite Analysis for the Los Alamos National Laboratory Low-Level Waste Material Disposal Area G*. Los Alamos National Laboratory. LA-UR-97-85. Los Alamos, New Mexico. Submitted to the U.S. Department of Energy March 1997. Approved October 1998.

LANL 1998d — *Los Alamos National Laboratory Hydrogeologic Workplan*. Los Alamos National Laboratory. Los Alamos, New Mexico. May 1998.

Lansford et al. 1996 — *The Economic Impact of Los Alamos National Laboratory on North-Central New Mexico and the State of New Mexico, Fiscal Year 1995*. R. R. Lansford, L. D. Adcock, L. M. Gentry, and S. Ben-David. U.S. Department of Energy, Albuquerque Operations Office, in cooperation with the University of New Mexico, Albuquerque, New Mexico, and New Mexico State University, Las Cruces, New Mexico. August 1996.

Lundberg 1997 — Information provided by J. Lundberg, Lundberg, Marshall & Associates, Ltd., to D. Agar, U.S. Department of Energy, regarding the peak water demand and the capacity of the water delivery system that supplies the Los Alamos area. Prepared under Contract Number DE-ACOA-93AL82990. August 28, 1997.

NCRP 1993 — *A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields.* National Council on Radiation Protection. NCRP Report No. 119. Bethesda, Maryland. December 31, 1993.

Newell 1998 — *Application of the TA–54, Area G Radiological Performance Assessment to Alternatives Considered in the LANL SWEIS for Low-Level Waste Disposal*. D. Newell. Los Alamos National Laboratory. Los Alamos, New Mexico. January 7, 1998.

NM 1996 — *New Mexico Dispersion Modeling Guidelines* (Revised). January 1996.

NMDE 1995 — *New Mexico Public Schools Financial Statistics, Fiscal Years 1993-1994, Actual: 1994–1995, Estimated*. New Mexico State Department of Education. Santa Fe, New Mexico. 1995.

NMDFA 1996 — *Financial and Property Tax Data by County and Municipality, Fiscal Year 1995*. New Mexico Department of Finance and Administration, Local Government Division. Santa Fe, New Mexico. 1996.

NMDL 1996 — "Table C. Civilian Labor Force, Employment, and Unemployment, 1990–1995." New Mexico Department of Labor, Economic Research and Analysis Unit. Santa Fe, New Mexico. April 1966.

NMTR 1995 — Information on local government finance, as reported in *Economic Review*, 1994. New Mexico Taxation and Revenue Department. Sunwest Bank. Albuquerque, New Mexico. 1995.

NMTR 1996 — Information on local government finance, as reported in *Economic Review*, 1995. New Mexico Taxation and Revenue Department. Sunwest Bank. Albuquerque, New Mexico. 1996.

NSC 1995 — *ALOHA™ + Areal Locations of Hazardous Atmospheres, User's Manual*. National Safety Council. Itasca, Illinois. 1995.

PC 1996a — C. Ball, GRAM Team, Personal communications with Kevin Fenner, Los Alamos County Community Development Director; John Valentine, President, Sunwest Bank of Rio Arriba County; and Ivan Guillan, City Planner, City of Española; regarding community services and housing. October 2, 1996.

PC 1996b — C. Ball, GRAM Team, Personal communication with Fred Brueggmann, Assistant Los Alamos County Administrator for Intergovernmental Relations, regarding community services, local government finance, and DOE local government assistance payments. October 2, 1996.

PC 1997a — C. Ball, GRAM Team, Personal communication with Radon Tolman, LANL SWEIS Project Office, Los Alamos, New Mexico, regarding construction algorithms. February 20, 1997.

PC 1997b — C. Ball, GRAM Team, Personal communication with Robert Turner, Vice President, Bradbury and Stamm Construction Company, Albuquerque, New Mexico, regarding construction algorithms. February 20, 1997.

PC 1997c — C. Ball, GRAM Team, Personal communications with Kevin Fenner, Los Alamos County Community Development Director; John Valentine, President, Sunwest Bank of Rio Arriba County; and Ivan Guillan, City Planner, City of Española; regarding community services and housing. January 16, 1997.

PC 1997d — C. Pazera and C. Ball, GRAM Team, Personal communications with personnel from the Los Alamos Police Department. Los Alamos, New Mexico. January 23, 1997, and January 27, 1997.

Phillips et al. 1994 — *Determination of Influence Factors and Accident Rates for the Armored Tractor/Safe Secure Trailer*. J. S. Phillips, D. B. Clauss, and D. F. Blower. SAND93-0111. Sandia National Laboratories. Albuquerque, New Mexico. 1994.

Purtymun 1995 — *Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs and Surface Water Stations in the Los Alamos Area*. W. D. Purtymun. Los Alamos National Laboratory. LA-12883-MS. Los Alamos, New Mexico. 1995.

Rao et al. 1982 — *Non-Radiological Impacts of Transporting Radioactive Material*. R. K. Rao, E. L. Wilmot, and R. E. Luna. DE8-2012844. Sandia National Laboratories. Albuquerque, New Mexico. February 1982.

Rhyne 1994a — *Hazardous Materials Transportation Risk Analysis: Quantitative Approaches for Truck and Train*. W. R. Rhyne. Van Nostrand Reinhold. New York, New York. 1994.

Rhyne 1994b — *Risk Management of the Transport of Irradiated Targets from LAMPF to TA-48.* W. R. Rhyne. SM-BUS-6-TQC-53.0. H&R Technical Associates. Oak Ridge, Tennessee. July 1994.

UNM 1994 — *Population Projections for the State of New Mexico by Age and Sex, 1990–2020.* University of New Mexico, Bureau of Economic Research. Albuquerque, New Mexico. May 1994.

Vance et al. 1996 — "An Evaluation of Options for Implementing New Radioactive Liquid Waste Treatment Processes at Los Alamos National Laboratory." Jane Vance et al. Vance and Associates, Inc. July 1996.

Wong et al. 1995 — *Seismic Hazards Evaluation of the Los Alamos National Laboratory,* Final Report. Volume III. I. Wong, et al. Woodward-Clyde Federal Services. Oakland, California. 1995.

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CHAPTER 6.0
MITIGATION MEASURES

The regulations promulgated by the Council on Environmental Quality (CEQ) to implement the procedural provisions of NEPA (42 United States Code [U.S.C.] §4321) require that an EIS include a discussion of appropriate mitigation measures (40 Code of Federal Regulations [CFR] 1502.14[f]; 40 CFR 1502.16[h]). The term "mitigation" includes the following:

- Avoiding an impact by not taking an action or parts of an action
- Minimizing impacts by limiting the degree of magnitude of an action and its implementation
- Rectifying an impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments (40 CFR 1508.20)

This chapter describes mitigation measures that are built into the alternatives analyzed and those additional measures that will be considered by DOE to further mitigate the adverse impacts identified in chapter 5. These measures address the range of potential impacts of continuing to operate LANL (including those areas where the lack of information regarding resources or mechanisms for impact to resources results in substantial uncertainty in impact analyses). The mitigation measures built into the alternatives analyzed (section 6.1) are of two types: (1) existing programs and controls (including regulations, policies, contractual requirements, and administrative procedures); and (2) specific measures built into the alternatives that serve to minimize the effects of activities under the alternatives. The existing programs and controls are too numerous to list here; but a general description is provided, as well as the role of existing programs in operating LANL and pertinent examples of how these mitigate adverse impacts.

Additional mitigation measures that could further reduce the adverse impacts identified in chapter 5 are discussed in section 6.2. The description of these measures in this chapter does not constitute a commitment to undertake any of these measures. Any such commitments would be reflected in the Record of Decision (ROD) following this SWEIS, with a more detailed description and implementation plan in a Mitigation Action Plan following the ROD.

6.1 MITIGATION MEASURES INCLUDED IN THE SWEIS ALTERNATIVES

6.1.1 Existing Programs and Controls

The activities undertaken at LANL are performed within the constraints of applicable regulations, applicable DOE orders, contractual requirements, and approved policies and procedures. The laws and regulations applicable to federal facilities are discussed in chapter 7; many of these requirements are established with the intent of protecting human health and the environment. It is assumed that these or similar regulatory controls will be in place for the next 10 years. These regulations, when complied with, mitigate the potential adverse impacts of operations to the public, the worker, and the environment. For example, the *Clean Air Act* (CAA) (42 U.S.C. §7401) regulates air emissions and the *Clean Water Act* (33 U.S.C. §1251) regulates liquid effluent discharges in a manner designed to protect human health and reduce the adverse environmental effects of routine operations.

In addition to the regulations applicable to LANL, chapter 7 also discusses other requirements (including DOE orders and external standards and regulations that would not otherwise apply to federal facilities) that apply to operations at LANL through the contract between DOE and the University of California (UC). As discussed in chapter 7, these requirements are established and enforced through contractual mechanisms. As with the regulations that apply to LANL, it is assumed that these or similar controls will be in place for the next 10 years. These requirements also mitigate the potential for adverse impacts. For example, the application of DOE design standards results in more robust facility designs for modern nuclear facilities, which reduces the potential for catastrophic releases from such facilities in the event of earthquakes, high winds, or other natural phenomena. Similarly, the application of occupational safety and health regulations in 29 CFR 1900, and other standards promulgated by the American National Standards Institute (ANSI), the U.S. Department of Defense (DoD), and DOE, as well as the use of other life safety and fire safety codes and manuals, limit worker exposures to workplace hazards, which reduces the potential for adverse worker health effects.

DOE and LANL also have instituted policies and procedures that apply to work conducted at LANL that mitigate the potential adverse effects of operations; it is assumed that these or similar policies and procedures will continue over the next 10 years. These are numerous and include, but are not limited to:

- Procedures that control work conducted at LANL (to ensure that work conducted is planned and reviewed, funded, within the applicable regulations and requirements, within the range of risks accepted by DOE and UC, and is otherwise authorized)
- Policies regarding the knowledge, skills, and abilities of personnel assigned to perform hazardous work (including required training)
- Policies reflected in agreements with other entities (such as the Accords with the four Pueblos located nearest to LANL) that establish policies and protocols regarding consultations and other discussions regarding LANL activities
- Policies and procedures regarding the stoppage and restart of work where unexpected hazards or resources are identified (for example, the policies regarding recovery of information from archaeological sites uncovered by excavation)

Work controls reduce potential impacts by ensuring that work conducted is within the range of activities that have been studied for potential environmental and human health effects. Policies regarding the knowledge, skills, and abilities of personnel conducting work at LANL reduce potential impacts by ensuring that only personnel with an appropriate understanding of the work and its potential hazards may undertake that work (which minimizes the potential for adverse human health and environmental effects from inadvertent actions due to a lack of this understanding). Policies for consultations and discussions with other entities mitigate effects by providing an opportunity to avoid or change actions that could cause an adverse impact. For example, consultation with Pueblos could identify the potential to impact traditional cultural properties (TCPs) prior to implementing a construction project or operations and could identify alternative siting or operational approaches that would avoid the impact. Policies and procedures regarding the stoppage and restart of work are similar in effect to work controls; when unexpected situations occur that impose unexpected hazards or reveal unexpected resources (e.g., cultural resources), work is stopped (as soon as this can be done safely) until work plans and authorizations can be modified in consideration of the newly uncovered information. This reduces potential impacts in a manner similar to work controls, as discussed above.

DOE also has established programs and projects at LANL to increase the level of knowledge regarding the environment around LANL, health of LANL workers, health of the public around LANL, and the effects of LANL operations on these, as well as to avoid or reduce impacts and remediate contamination from previous LANL activities. These programs and projects reduce potential adverse impacts by providing for heightened understanding of the resources that could be impacted; avoidance of some impacts (where mechanisms for impact to specific resources are known and avoidable); early identification of impacts (which can enable stoppage or mitigation of the impacts); reduction of ongoing impacts; or providing for beneficial management opportunities for natural, cultural, and sensitive resources, where appropriate. It is assumed that such activities will continue for the next 10 years. Examples of these programs and projects are:

- The Environmental Surveillance and Compliance Program at LANL monitors LANL for permit and environmental management requirements. This program also includes evaluation of samples from various environmental media for radioactive materials and other hazardous materials locally and regionally (chapter 4, page 4–1). The data generated under this program are collected routinely and publicly reported at least annually, and these data are analyzed to determine regulatory compliance and to determine environmental trends over long periods of time.
- The Threatened and Endangered Species Habitat Management Plan is intended to provide long-range planning information for future LANL projects, and protect habitat at LANL for these species (section 4.5.1.6).
- A Natural Resource Management Plan is being developed (in various stages) at LANL to determine existing conditions of natural resources in the area (including expanded biomonitoring) and to recommend management measures that will restore, sustain, and enhance the biological quality and ecosystem integrity at LANL (section 4.5.1.6).
- Studies of public and worker health in and around LANL have been conducted (some by DOE and some by other agencies) to assess human health in the region and to assess the potential for adverse human health effects due to LANL operations (section 4.6).
- LANL is also implementing a Groundwater Protection Management Program Plan (GWPMPP) to assess current groundwater conditions and monitor and protect groundwater. A *Resource Conservation and Recovery Act* (RCRA) Hydrogeologic Workplan is also being implemented to supplement and verify existing information on the environmental setting at LANL and to collect analytical data on groundwater contamination (sections 4.3.2.1 and 4.3.2.2).
- The Safeguards and Security Program restricts unauthorized access to areas of LANL with high potential for impact to human health and the environment. Such access restrictions aid in limiting the potential for intentional or inadvertent actions that could result in environmental or human health effects (section 4.9.2.2).
- Emergency management and response capabilities at LANL provide for planning, preparedness, and response capabilities that can aid in containing and remediating the effects of accidents or adverse operational impacts (section 4.6.3.1).
- LANL's Fire Protection Program ensures that personnel and property are adequately

protected against fire or related incidents, including fire protection and life safety (section 4.6.3.3).

- Pollution Prevention and Waste Minimization Programs at LANL reduce the wastes generated and to some extent the effluents and emissions from facilities (section 2.1.2.1).
- Water and Energy Conservation Programs at LANL are intended to reduce use of these resources, which should assist in mitigating the effects of water withdrawal and electrical consumption that occasionally exceed supply.
- The Environmental Restoration (ER) Project at LANL (which includes decontamination and decommissioning [D&D]) was established to assess and remediate contaminated sites that either were or still are under LANL control (section 2.1.2.5). The ER Project serves an important role in reducing the potential for future impacts to human health and the environment due to legacy contaminants in the environment. It is assumed that the current mitigation practices used in remediation actions will continue to be used (section 2.1.2.5).
- Electric power reliability is an issue under all alternatives due to the limited supply lines and the age of the distribution system equipment, as well as the limits of the on-site supplemental power supply (section 4.9.2.1). DOE is evaluating a proposed action that would bring a third power line (from the Norton substation) to LANL (chapter 1, section 1.6.3.1).

While this list is not all-inclusive, it does reflect the importance of these programs in mitigating the potential adverse impacts of operating LANL.

6.1.2 Specific Mitigation Measures Incorporated in the SWEIS Alternatives

Several specific mitigation measures are included in the SWEIS alternatives. Unless otherwise noted below, the analyses in chapter 5 assume that these measures are implemented. These specific measures are:

- *Development and Use of a Dedicated Transportation Corridor Between TA–55 and TA–3 (TA–55 and TA–3, Expanded Operations Alternative, section 3.2.1, section 5.3.10, and volume II, part II)*. The proposed transportation corridor is included in the Expanded Operations Alternative to mitigate the on-site transportation risk and inconvenience to the public (due to road closures) that would be attributed to the increase in transportation between TA–55 and the Chemistry and Metallurgy Research (CMR) Building under this alternative. The analysis in the Expanded Operations Alternative is very conservative because it includes the impacts of constructing the road and impacts of transport on existing roads. If the road is not constructed, the transportation risk would be that analyzed in section 5.3.10 for on-site shipments. The impacts attributable to constructing the road (see volume II, part II and section 5.3.5) would not be incurred. If the road is built and used, the impacts due to road construction would be the same as those analyzed, and the on-site transportation risk would be reduced because shipments between TA–55 and the CMR Building would no longer routinely use public roads. This measure would not be implemented under the Preferred Alternative.
- *The Santa Fe Relief Route (All LANL Facilities, All Alternatives, sections 5.1.10, 5.2.10, 5.3.10, 5.4.10, 5.5.10, and appendix F)*. DOE has made the agreed upon contributions to construction of this route and continues to work with state and

local governments to ensure its completion. This route is expected to be available for use in 1998. The transportation impact analyses in this SWEIS address impacts for use of existing routes as well as use of the relief route.

- *CMR Building Upgrades (CMR Building at TA–3, All Alternatives, section 3.1.3).* DOE is working to upgrade the CMR Building to maintain existing capabilities and improve safety features, and completion of these upgrades is presumed in the impact analyses.
- *Planned Maintenance and Refurbishment Activities (e.g., Plutonium Facility at TA–55 and Sigma at TA–3, All Alternatives, sections 2.1.2.3, 3.1.1, and 3.1.5).* It is assumed that DOE maintenance of existing facilities in use at LANL will continue in a manner that maintains or improves (reduces) the level of risk associated with facility operations.
- *Radioactive Liquid Waste Treatment Upgrades (TA–50, All Alternatives, sections 3.1.14, 4.3, 5.1.3, 5.2.3, 5.3.3, 5.4.3, and 5.5.3).* It is assumed that the planned treatment upgrades to TA–50 will proceed, resulting in improved quality of effluent from this facility.
- *Effluent Reduction Activities (All LANL Facilities, All Alternatives, sections 4.3, 5.1.3, 5.2.3, 5.3.3, 5.4.3, and 5.5.3).* It is expected that activities to reduce the number of outfalls and the total effluent from these outfalls will continue, as presented in section 4.3.
- *Phased Containment for Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility (One of the High Explosives [HE] Firing Sites, All Alternatives, section 3.1.10).* Implementation of the phased containment approach, as described in the DARHT Final EIS (DOE 1995) and ROD (60 *Federal Register* [FR] 53588) is assumed in the SWEIS impact analyses.
- *Design of the Long-Pulse Spallation Source (LPSS) (TA–53, Expanded Operations and Greener Alternatives, section 3.2.11).* The air emissions associated with operations in this proposed experimental facility are dominated by the "activation" of air in the path of the proton beam. The design of the facility is to include evacuation (removal) of much of the air in the beam path as well as a short enough beam path to limit the emissions from this operation so that it contributes, at most, 1 millirem per year to the facility and site-wide maximally exposed individual (MEI).

6.2 OTHER MITIGATION MEASURES CONSIDERED

In addition to those mitigation measures described in section 6.1, other feasible mitigation measures considered in the preparation of this SWEIS are presented in this section. Those specific measures are:

- *Eliminate Public Access to Part or All of LANL*. At various times DOE has considered the possibility of closing public access to part or all of the LANL site. While this is typically suggested for security reasons, such an action would also tend to reduce public health risk by removing access to on-site locations that contribute most to public health risk. While such an action could potentially reduce public health consequences, it could also substantially alter traffic patterns and loadings on the remaining public roads in the area and could have other positive and negative effects. A more detailed NEPA analysis of the potential effects of this type of action would be necessary before it could be implemented.
- *Land Transfers and Financial Assistance*. Transfers of portions of LANL land are being examined, as discussed in section 4.1.1.4. Such action would provide land resources that could be used to reduce

economic dependence on LANL and/or provide the means for growth in housing, parks, and recreational space. Thus, land transfers could mitigate the effect of changes in LANL employment and spending on the area's economy. At times, financial assistance has been provided to communities near LANL for similar reasons (community development, funding for community services, etc.). While land transfers are neither proposed or analyzed in this SWEIS, such actions could mitigate the socioeconomic impacts presented in chapter 5. On May 6, 1998, DOE published a Notice of Intent (NOI) to prepare an EIS for the Proposed Conveyance and Transfer of Certain Land Tracts in the *Federal Register* (63 FR 25022).

- *Extensive Ethnographic Study.* An extensive ethnographic study regarding the traditional and cultural practices and resources in the LANL area could increase knowledge of specific TCPs at LANL and could provide opportunities for mitigation of impacts to specific TCPs. Attempts to identify specific TCPs at LANL have encountered concerns from traditional groups because of the potential for increased risk to these resources if they are identified.
- *Develop a Cultural Resources Management Plan*. Such a plan would include studies to increase the level of knowledge regarding potential shrapnel and vibration damage to prehistoric and historic resources near firing sites, existing levels of contamination for prehistoric and historic resources and plans to avoid levels that would limit data recovery, plans for management of former nuclear weapons complex properties, and implementation of programmatic agreements with the State Historic Preservation Office(r) (SHPO).
- *Develop a Wildfire Management Plan for the LANL Site*. Such a plan would reduce the fuel loading surrounding the site and around individual facilities that have moderate or higher vulnerability to burning as a result of wildfire. The probability of an approaching wildfire encroaching upon the site can be reduced by removing and thinning vegetation on the site boundary and within the site. Ongoing efforts to reduce the vegetation at the site boundary exist that would be accelerated. The vulnerability of individual facilities depends upon the amount and height of the exterior fuel loading and its proximity to the facility (see "Evaluation of Building Fires" in volume III, appendix G, section G.5.4.4). Consideration is being given to reducing the vulnerability of individual facilities that contribute to potential public exposure. Long-term actions would be taken to reduce the fuel loads in the forested areas surrounding LANL, and a forest and land management program would be undertaken to prevent or mitigate the potential for large wildfires to occur. In the near term, mitigation actions, such as for TA–54, will be taken to ensure that the wildfire risk to this facility is reduced to low or extremely low prior to the start of the 1999 fire season.
- *Limited Power Supply.* DOE and other regional electric power users continue to work with suppliers to remedy foreseeable power supply and reliability issues. The impact analyses in this SWEIS emphasize the severity of these issues and the consequences if they are not resolved. Solutions to power supply issues are essential to mitigate the effects of power demand under all alternatives. DOE is committed to measures that will conserve energy and avoid, or at least minimize, periods of brownouts. Some of the measures being contemplated by DOE include: (1) limiting operation of large users of electricity to periods of low demand, (2) reduced operation of low-energy demonstration accelerator (LEDA) (not implement all phases of this project), and (3) contractual mechanisms to bring additional electric power to the region.

REFERENCES

DOE 1995 — *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement.* DOE/EIS-0228. U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico. August 1995.

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CHAPTER 7.0
APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

7.0 INTRODUCTION

As part of the NEPA process, the SWEIS must consider if actions described under its alternatives would result in a violation of any federal, state, or local laws or requirements (40 Code of Federal Regulations [CFR] 1508.27) or require a federal permit, license, or other entitlement (40 CFR 1502.25). This chapter provides a baseline summary assessment of the major existing environmental requirements, agreements, and permits that relate to continuing operations at LANL.

Requirements governing operations at LANL arise primarily from six sources: Congress, federal agencies, executive orders, the New Mexico State Legislature, state agencies, and local governments. In general, the federal statutes establish national policies, create broad legal requirements, and authorize federal agencies to create regulations that conform to the statute. Detailed implementation of these statutes is delegated to various federal agencies, such as DOE, the U.S. Department of Transportation (DOT), and the EPA. For many environmental laws under the jurisdiction of EPA, state agencies may be delegated responsibility for the majority of program implementation activities, such as permitting and enforcement, but EPA usually retains oversight of the delegated program.

In addition to implementing some federal programs, state legislatures develop their own laws. In New Mexico, the statutes passed by the New Mexico State Legislature are found in the New Mexico Statutes Annotated, and regulations are found in the New Mexico Administrative Code (NMAC). State statutes, much like federal statutes, establish broad policies and legal requirements. State regulations, developed by state agencies, establish specific legal requirements as authorized by the statutes.

Executive orders establish policies and requirements for federal agencies. Executive orders are applicable to executive branch agencies, but do not have the force of law or regulation.

Regulatory agreements and compliance orders may also be initiated to establish responsibilities and time frames for federal facilities to come into compliance with provisions of applicable federal and state laws. There are also other agreements, memorandums of understanding, or formalized arrangements that establish cooperative relationships and requirements.

DOE has authority to regulate some environmental activities, as well as the health and safety aspects of operation of its nuclear facilities. The *Atomic Energy Act of 1954* (AEA), as amended (40 United States Code [U.S.C.] §2011), is the principal authority for DOE regulatory activities not externally regulated by other federal or state agencies. Regulation of DOE activities is primarily established through the use of DOE orders and regulations. External environmental laws, regulations, and executive orders can be categorized as applicable to broad environmental planning and consultation requirements, or as applicable to regulatory environmental protection and compliance activities, although some requirements are applicable to both planning and operations compliance.

7.1 DOE REGULATORY AUTHORITIES FOR ENVIRONMENT, SAFETY AND HEALTH

7.1.1 *Atomic Energy Act of 1954*

The AEA (42 U.S.C. §2011 *et seq.*) makes the federal government responsible for regulatory control of the disposal of radioactive waste, as well as production, possession, and use of three types of radioactive material: source, special nuclear, and byproduct material. Regulations promulgated by the U.S. Nuclear Regulatory Commission (NRC) under the AEA establish standards for the management of these radioactive materials, licensing of nuclear facilities, and the protection of the public and property against radiation. The AEA authorizes DOE to set radiation protection standards for itself and its contractors for DOE nuclear facilities, and provides exclusions from NRC licensing for defense production facilities. NRC regulates private and commercial nuclear activities, but currently has no regulating authority at most DOE facilities. In December 1996, DOE announced that it would begin a process of transferring oversight of nuclear safety to the NRC for all DOE nuclear facilities (DOE 1996). The transfer will require legislative action.

The AEA authorizes DOE to establish standards that protect health and minimize danger to life or property from activities under DOE's jurisdiction. The mechanisms through which DOE manages its facilities are the promulgation of regulations and issuance of DOE orders and associated standards and guidance. Requirements for environmental protection, safety and health are implemented at DOE sites, primarily through contractual mechanisms that establish the applicable DOE requirements for management and operating contractors.

DOE orders apply to LANL through the management and operating contract with the University of California (UC) (DOE 1997b). The applicable DOE orders or parts thereof, and applicable external and internal standards, are listed and maintained current in Appendix G of the contract and are enforced and modified through contractual mechanisms. Appendix G of the contract establishes a wide range of internal requirements for business systems and reporting, safeguards and security, and environment, safety, and health. In the current contract (effective October 1, 1997), all applicable environment, safety, and health protection standards (including both external and DOE requirements) are found in a set of Work Smart Standards in Appendix G of the contract.

The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) regulations generally do not directly apply to DOE nuclear facilities and management and operating contractors. However, for protection of worker safety and health, the Work Smart Standards adopted in Appendix G of the contract include the applicable occupational safety and health regulations (29 CFR 1900); American National Standards Institute (ANSI) standards; National Fire Protection Association (NFPA) standards; U.S. Department of Defense (DoD) standards (for explosives operations); DOE orders (for firearms safety, explosives safety, nuclear facilities safety, pressure safety, construction safety, packaging and transportation, and emergency management); various other codes, manuals, and standards for safety; and various LANL internal standards. This set of Work Smart Standards contractually establishes worker safety and health protection requirements for LANL, as well as emergency response and public protection requirements where there is no external regulatory authority.

Nuclear safety regulations are found in Title 10 of the CFR. Several nuclear safety rules and environmental procedural rules are in effect (for example, 10 CFR 835, *Occupational Radiation*

Protection), and more are in final stages of promulgation. Nuclear safety regulations are effective under the schedule and implementing requirements in each rule, regardless of whether they are included in the contract. DOE contractors are also required to comply with all applicable external laws and regulations, regardless of contract language.

The principal DOE orders having a direct impact on environmental protection and compliance activities at LANL are summarized in the following sections.

7.1.1.1 *DOE Order 451.1A, National Environmental Policy Act Compliance Program*

This order establishes DOE internal requirements and responsibilities for implementing NEPA, the *Council on Environmental Quality (CEQ) Regulations Implementing the Procedural Provisions of NEPA* (40 CFR 1500 through 1508), and the *DOE NEPA Implementing Procedures* (10 CFR 1021).

7.1.1.2 *DOE Order 5400.1, General Environmental Protection Program*

This order establishes the environmental protection program requirements, authorities, and responsibilities for DOE operations for ensuring compliance with applicable federal, state, and local environmental protection laws and regulations, executive orders, and internal DOE policies. This order provides for environmental protection standards, notification of and reporting requirements for discharges and unplanned releases, environmental protection and program plans, and environmental monitoring and surveillance requirements. It establishes formal recognition that DOE's environmental management activities are extensively, but not entirely, regulated by EPA, state, and local environmental agencies, and it provides requirements for satisfying these externally imposed regulations. In addition, it establishes requirements for those environmental protection programs that are not externally regulated.

7.1.1.3 *DOE Order 5400.5, Radiation Protection of the Public and Environment*

This order establishes standards and requirements for operations of DOE and its contractors with respect to protection of members of the public and the environment against undue risk from ionizing radiation. This order provides for general standards; requirements for radiation protection of the public and the environment; derived concentration guides (DCGs) for air and water; and guidelines, limits, and controls for residual radioactive materials. The order also establishes DOE's objective to operate its facilities and conduct its activities so that radiation exposures to members of the public are maintained within the limits established by this order, and to control radioactive contamination through the management of DOE's real and personal property. The requirements of this order are incorporated into the proposed 10 CFR 834, which is being promulgated as a nuclear safety regulation.

7.1.1.4 *DOE Order 5820.2A, Radioactive Waste Management*

DOE Order 5820.2A establishes the policies, guidelines, and minimum requirements by which DOE and its contractors manage radioactive waste, mixed waste, and contaminated facilities. This order establishes the DOE policy that radioactive and mixed wastes be managed in a manner that ensures protection of the health and safety of the public, DOE, contractor employees, and the environment. In addition, the generation, treatment, storage, transportation, and/or disposal of radioactive wastes, and the other pollutants or hazardous substances they contain, must be accomplished in a manner that minimizes the generation of such wastes across program office functions and complies with all applicable federal, state, and local environmental, safety, and health laws and regulations and DOE requirements.

These DOE orders are implemented by DOE, and by UC/LANL (through contractual direction). With the exception of radioactive materials, all environmental protection and compliance activities at LANL are externally regulated by other federal and state agencies. Environmental planning and consultation requirements are applicable to DOE and LANL in accordance with the specific language in each law, regulation, or executive order. The above-listed DOE orders and any applicable nuclear safety regulations are discussed in the following sections as they relate to external environmental planning and consultation requirements, or as applicable to regulatory environmental protection and compliance activities.

7.2 Laws, Regulations and Executive Orders Related to Environmental Planning and Consultation

7.2.1 *National Environmental Policy Act of 1969*, as Amended and Executive Order 11514, as Amended by Executive Order 11991

The NEPA of 1969, as amended (42 U.S.C. §4321 *et seq.*), requires federal agencies to evaluate the effect proposed actions would have on the quality of the human environment and to document this evaluation with a detailed statement. NEPA requires consideration of environmental impacts of an action during the planning and decision-making stages of a project.

Implementing regulations for NEPA have been developed by the CEQ, which oversees the NEPA process for the Executive Branch of the federal government. These regulations (40 CFR 1500 through 1508) set forth the general requirements that federal agencies must follow. DOE also has issued agency NEPA implementing procedures that are codified at 10 CFR 1021.

There are other environmental and cultural resource consultation requirements that must be complied with to ensure NEPA compliance. Each of these other laws or executive orders has unique review and compliance procedures established that are independent of NEPA. Accordingly, although compliance with these statutes comprises an important subset of the NEPA process, compliance with applicable requirements is mandatory for all projects, independent of NEPA. For example, under NEPA review, proposed actions are evaluated for possible effects on cultural resources (archaeological sites or historic buildings) in accordance with the *National Historic Preservation Act of 1966* (16 U.S.C. §470); for their potential impact on floodplains or wetlands in accordance with relevant executive orders; and for effects on threatened, endangered, or sensitive species in accordance with the *Endangered Species Act* (16 U.S.C. §1531). A discussion of the planning and consultation requirements for these types of resources is found in the following sections.

Executive Order 11514, *Protection and Enhancement of Environmental Quality,* as amended by Executive Order 11991, requires federal agencies to monitor and control their activities continually to protect and enhance the quality of the environment. The executive order contains requirements to ensure that federal agencies include the public in the decision-making process. The DOE NEPA implementing regulations (10 CFR 1021) and DOE Order 451.1A address this executive order through implementation of 40 CFR 1500–1508.

7.2.2 *Endangered Species Act*, as Amended, and Related Requirements

This act requires that federal agencies ensure that any actions authorized, funded, or carried out by federal agency are not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat. The act is jointly administered by the U.S. Department of Commerce and the U.S. Department of the Interior (DOI). The *Endangered Species Act* (16 U.S.C. §1531 *et seq.*) requires federal agencies to consult with the U.S. Fish and Wildlife Service (FWS). While biological assessment procedures may be integrated into the NEPA process, the consultation requirements with FWS must still be followed for any LANL activity with the potential to affect threatened or endangered species. Implementing regulations are delineated in *Endangered and Threatened Wildlife and Plants* (50 CFR 17) and *Interagency Cooperation* (50 CFR 402). The state has also issued regulations pertaining to plants specific to the state entitled, *Endangered Plants* (75-6-1, NMSA 1978).

There are several additional federal statutes that provide protection to sensitive or otherwise regulated wildlife species, two of which are the *Migratory Bird Treaty Act*, as amended (16 U.S.C. §703), and the *Bald Eagle Protection Act*, as amended (16 U.S.C. §668). The first act protects migratory birds by specifying mode of harvest, hunting seasons, and bag limits. The act is intended to protect birds that have common migratory patterns within the U.S., Canada, Mexico, Japan, and Russia. Implementing regulations are found in *Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants* (50 CFR 10) and *Migratory Bird Hunting* (50 CFR 20). The second act makes it unlawful to take (capture, kill, or destroy), molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the U.S. A permit must be obtained from the DOI to relocate a nest that interferes with resource development or recovery operations. Implementing regulations are delineated in *Eagle Permits* (50 CFR 22).

The New Mexico *Wildlife Conservation Act* (17-2-37 *et seq.*, NMSA 1978) also establishes requirements for protecting wildlife, primarily related to taking for sport purposes and permits for collecting and use.

DOE meets the requirements of these laws by contacting and consulting with federal and state agencies responsible for protecting animal and plant species within the State of New Mexico. FWS, the U.S. Forest Service (USFS), the National Park Service (NPS), the Bureau of Indian Affairs (BIA), the National Biological Service, New Mexico Environment Department (NMED), and the New Mexico Department of Game and Fish (NMDGF), are contacted regarding concerns each agency may have about LANL activities.

In accordance with Section 7 of the *Endangered Species Act*, a biological assessment and Section 7 Endangered Species Consultation for activities included in the SWEIS are being conducted with the FWS.

7.2.3 *National Historic Preservation Act*, as Amended

This act provides that sites with significant national historic value be placed on the National Register of Historic Places (NRHP). Government agencies must locate and inventory historic properties and cultural resources under their jurisdiction prior to undertaking an activity that might harm them, with the intent of minimizing such harm through appropriate mitigation actions. As required by Section 106 of the *National Historic Preservation Act* (16 U.S.C. §470), proposed LANL activities are evaluated in consultation with the State Historic Preservation Office(r) (SHPO) for possible effects on cultural resources. Most surveys are conducted on DOE property; however, when appropriate, surveys are conducted on land owned by other federal agencies, state-owned land, tribal lands, or other private holdings, and LANL holds discussions, as appropriate, with various Indian tribes to determine how new LANL activities might affect cultural resources. The tribes are also requested to provide input on what mitigation measures they want implemented before LANL begins an activity. DOE must also obtain comments from the Advisory Council on Historic Preservation prior to undertaking a potentially damaging activity at LANL. Implementing regulations include *Protection of Historic and Cultural Properties* (36 CFR 800). Consultation requirements are applicable to actions discussed in the SWEIS, as well as any future activities at LANL.

7.2.4 *National Historic Preservation,* Executive Order 11593

This executive order requires federal agencies, including DOE, to locate, inventory, and nominate properties under their jurisdiction or control to the NRHP if those properties qualify. DOE is required to provide the Advisory Council on Historic Preservation the opportunity to comment on possible impacts of a proposed activity on any potentially eligible or listed resources.

7.2.5 *American Indian Religious Freedom Act of 1978*

This act establishes that it is U.S. policy to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise their traditional religions, including access to sites, uses and possession of sacred objects, and the freedom to worship through ceremonies and traditional rites. In accordance with the *American Indian Religious Freedom Act* (42 U.S.C. §1996), LANL activities are planned so that they do not adversely affect the practice of traditional religions. Tribal groups are notified of projected construction activities and are requested to inform DOE if any activity will affect a traditional cultural property.

7.2.6 *Native American Graves Protection and Repatriation Act of 1990*

This act states that tribal descendants shall own American Indian human remains and cultural items discovered on federal lands after November 16, 1990. When items are discovered during an activity on federal lands, the activity is to cease and appropriate tribal governments are to be notified. Work on the activity can resume 30 days after the receipt of certification that notice has been received by the tribal governments. As required by the *Native American Graves Protection and Repatriation Act* (NAGPRA) (25 U.S.C. §3001), LANL has completed a summary list of cultural items excavated in the past from archaeological sites on LANL property, including prior to 1990. Copies of this summary were sent to local Pueblos having ancestral ties to the Pajarito Plateau. This summary provides a basis for future repatriation of cultural items to tribal governments.

7.2.7 *Archaeological Resource Protection Act*, as Amended

The *Archaeological Resource Protection Act* (16 U.S.C. §470aa) requires the preservation and management of archaeological resources on lands administered by federal agencies. LANL maintains a cultural resources management database, and this information continues to be used in planning remediation and other construction activities to prevent damage to or destruction of archaeological resources at LANL. Archaeological survey reports are prepared by LANL cultural resource specialists and are submitted to Native American communities for review and concurrence.

7.2.8 *Indian Sacred Sites*, Executive Order 13007

Executive Order 13007 requires: "In managing federal lands, each executive branch agency with statutory or administrative responsibility for the management of federal lands shall, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, (1) accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and (2) avoid adversely affecting the physical integrity of such sacred sites. Where appropriate, agencies shall maintain the confidentiality of sites." Requests by the Pueblos to use sacred sites on LANL are accommodated to the extent practicable, and consultation regarding potential impacts to sacred sites is conducted through the NEPA review process and through ongoing processes established in the Pueblo Accords and Cooperative Agreements, which are discussed below.

7.2.9 Pueblo Accords

Four federally recognized Indian tribes, the Pueblos of Cochiti, Jemez, Santa Clara, and San Ildefonso, have special relationships with the land now occupied by LANL. Federal laws and executive orders guarantee tribal members access to religious sites and recognize tribal rights to cultural properties, burial materials, and other articles of antiquity. However, Congress has assigned responsibilities to DOE that preclude open access to LANL land. Thus, some of the tribes' interests in, and uses for LANL land are difficult to reconcile.

To achieve mutual goals of improved understanding and cooperation, the four Pueblos and DOE are recognized as sovereign entities that will interact with one another on a government-to-government basis. DOE and each of these four Pueblos have executed formal accord documents setting forth these relationships (DOE 1992a, DOE 1992b, DOE 1992c, and DOE 1992d). The governor of each Pueblo signed an accord on behalf of the Pueblo. Each accord was also signed by the Assistant Secretary for Defense Programs on behalf of DOE and was approved as to form by the Area Director of the BIA, DOI.

The accords provide a framework for government-to-government relationships between each of the Pueblos and DOE. Further, the accords identify general procedures by which the sovereign entities will interact. By signing the accords, DOE has made a commitment to provide information and involve the Pueblos in long-range planning and decisions. The accords state DOE's commitment to working with its contractors and subcontractors and with other federal, state, and local agencies to clarify the roles and responsibilities of these entities that appear to conflict or overlap as they relate to the Pueblos.

DOE has also executed Cooperative Agreements with each of the four Pueblos that provide funding to the tribes for cooperative activities (DOE 1993, DOE 1994a, DOE 1994b, and DOE 1997a). UC, which operates LANL for DOE, also signed Cooperative Agreements with the Pueblos of Jemez, Cochiti, San Ildefonso, and Santa Clara (UC 1994a, UC 1994b, UC 1994c, and UC 1996). The agreements address Pueblo participation in health and safety matters; in LANL activities concerning the SWEIS and other NEPA activities; in environmental restoration, waste and environmental planning and management; and in other cooperative and collaborative efforts.

7.2.10 *Protection of Wetlands*, Executive Order 11990, and *Floodplain Management*, Executive Order 11988

Executive Order 11990 requires government agencies to avoid short- and long-term adverse impacts to wetlands whenever a practicable alternative exists. Executive Order 11988 directs federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken. Impacts to floodplains are to be avoided to the extent practicable. DOE issued regulations (10 CFR 1022) that establish procedures for compliance with these executive orders. DOE follows these regulations in evaluating proposed actions for wetlands and floodplain impacts. No floodplain/wetlands impacts were identified for the SWEIS that require coordination under these executive orders.

7.2.11 *Environmental Justice*, Executive Order 12898

This order directs each federal agency to identify and address disproportionately high adverse human health or environmental impacts on minority and low-income populations resulting from an agency's programs, policies, or activities. The order further directs each federal agency to collect, maintain, analyze, and make information publicly available on the race, national origin, and income level of populations in areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on these populations. This requirement applies when such facilities or sites become the subject of a substantial federal environmental administrative or judicial action. Environmental justice impacts are being identified and addressed through the SWEIS, and the policies and data analysis requirements of this executive order remain applicable to future actions at LANL.

7.2.12 New Mexico Environmental Oversight and Monitoring Agreement

The Environmental Oversight and Monitoring Agreement, known as the Agreement in Principle (AIP), between DOE and the State of New Mexico, provides for technical and financial support by DOE for state activities in environmental oversight, monitoring, access, and emergency response. The agreement, which was initially signed in October 1990, covers Los Alamos and Sandia National Laboratories, the Waste Isolation Pilot Plant (WIPP), and the Inhalation Toxicology Research Institute. Under the agreement, NMED is the lead state agency and provides independent environmental monitoring and emergency planning review services related to all DOE activities at these sites in New Mexico. On October 2, 1995, DOE and NMED extended the AIP for an additional 5 years (DOE 1995).

7.2.13 *Recreational Fisheries*, Executive Order 12962

This order directs federal agencies to improve the quantity, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreation fishing opportunities; establishes a National Recreational Fisheries Coordination Council and mandates the preparation of a comprehensive Recreational Fishery Resources Conservation Plan; requires federal agencies to aggressively work to identify and minimize conflicts between recreational fisheries and their respective responsibilities under the *Endangered Species Act of 1973*; and expands the role to the Sport Fishing and Boating Partnership Council.

7.2.14 *Migratory Bird Treaty Act*

This act (16 U.S.C. §703) makes it unlawful to pursue, hunt, take, capture, kill (or attempt any of the preceding) any migratory bird or nest or eggs of such bird.

7.3 LAWS, REGULATIONS, AND EXECUTIVE ORDERS RELATED TO REGULATORY ENVIRONMENTAL PROTECTION AND COMPLIANCE

Regulatory environmental protection requirements are designed to protect human health and the environment, including the air, water, and land. Environmental protection statutes and regulations derived from authorities in statutes: (1) create procedures for examining actions that may harm the environment before carrying out that action; (2) establish standards that protect human health and the environment; (3) provide limits for releases into the environment; and (4) create management requirements for specific substances (e.g., asbestos and pesticides).

Federal Compliance with Pollution Control Standards, Executive Order 12088, amended by Executive Order 12580, requires federal agencies, including DOE, to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the *Clean Air Act (CAA)*, *Noise Control Act*, *Clean Water Act*, *Safe Drinking Water Act*, *Toxic Substance Control Act*, and the *Resource Conservation and Recovery Act* (RCRA). In general, DOE and LANL must comply with applicable federal and state requirements to the same extent as any other entity. Noncompliance with these requirements can lead to enforcement actions.

Since LANL was constructed and began operations in the 1940's, before the advent of current environmental requirements, operational nuclear safety and national security were the dominant factors in the early design and operation of facilities. With the enactment of environmental laws and regulations from the 1960's to the present, resources and philosophies have changed to shift to a greater emphasis on environmental protection and achieving compliance with all applicable environmental requirements. Due to its long history, LANL has had difficulty in achieving compliance with some regulatory requirements, and has a legacy of environmental clean-up requirements from past management practices for waste, spills, and releases. Several compliance orders and agreements are also in effect with regulatory agencies to bring LANL into full compliance with specific regulatory requirements.

Depending on the regulatory background and framework of each federal and state law, there may be a primary regulatory enforcement authority at the federal level or at the state level. For some environmental resources, there may be both federal and state laws with applicable requirements, or DOE orders and regulations may be the primary considerations. Permitting for emissions and/or effluent discharges may also be at the federal level, state level, or both levels.

Applicable regulatory environmental laws and regulations can be categorized by media into air, water, land (which includes waste management, toxic substances, pollution prevention, and environmental restoration), and community right-to-know and emergency planning. For each resource category, there is a framework consisting of federal, state, local or DOE order requirements, which together regulate operations at LANL.

7.4 AIR RESOURCES

7.4.1 *Clean Air Act*, as Amended

The CAA (42 U.S.C. §7401 *et seq.*) establishes air quality standards to protect public health and the environment from the harmful effects of air pollution. The act requires establishment of national standards of performance for new stationary sources of emissions limitations for any new or modified structure that emits or may emit an air pollutant, and standards for emission of hazardous air pollutants (HAPs). In addition, the CAA requires that specific emission increases be evaluated to prevent a significant deterioration in air quality.

The *Clean Air Act Amendments of 1990*, signed into law on November 15, 1990, both enhanced and expanded existing authorities and created new programs in the areas of permitting, enforcement, operations in nonattainment areas (areas not meeting air quality standards), control of acid rain, regulation of air toxins, mobile sources, and protection of the ozone layer. Section 118 of the act and Executive Order 12088 require that each federal agency, such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with "all federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution to the same extent as any nongovernmental entity.

EPA is the regulating authority for the CAA. However, EPA has granted the State of New Mexico primacy for regulating air quality under an approved State Implementation Plan (SIP). Authority for implementing the regulations promulgated for stratospheric ozone protection and the accidental release provisions of the act have not yet been delegated to the state. EPA also administers the National Emission Standards for Hazardous Air Pollutants (NESHAP) for radioactive emissions, including radon (subparts B, H, I, K, Q, R, T, and W). In New Mexico, all of the CAA regulations, with these exceptions, have been adopted by the state as part of the SIP, and are regulated under the *New Mexico Air Quality Control Act* (74-6-1, NMSA 1978).

NESHAP limits the radiation dose to the public from airborne radionuclide emissions from DOE facilities to 10 millirem per year effective dose equivalent (40 CFR 61.92). The standards also prescribe emission monitoring and test procedures for determining compliance with the 10 millirem per year standard, and reporting and permit provisions. EPA issued Notices of Noncompliance to DOE in 1991 and 1992 for not meeting all the provisions of 40 CFR 61, Subpart H. A Federal Facilities Compliance Agreement signed June 13, 1996, with EPA Region 6, provided an enforceable mechanism for bringing LANL into compliance (EPA 1996a). The compliance agreement required full compliance for all sources by March 1997, and LANL achieved full compliance in June 1996. In November 1994, Concerned Citizens for Nuclear Safety (CCNS) filed a CAA citizens' suit against DOE and UC, alleging LANL was not in compliance with Subpart H. In January 1997, DOE and UC entered into both a settlement agreement and consent decree. Highlights of the settlement agreement and consent decree include DOE-funded independent technical audits of LANL's radionuclide air emissions compliance program, the addition of some environmental monitoring stations, and quarterly public meetings conducted by UC on the environment.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, also incorporates the EPA NESHAP standard for public doses from air emissions and provides for additional monitoring and evaluation of total public radiation dose from other pathways. Unplanned releases of radioactive effluents to the air are also reported and analyzed under provisions of DOE Order 5400.5. LANL has reported 13 air releases of radioactive materials through effluent stacks in the period 1991 through 1996. These reported releases usually involved a higher than normal operational limit radionuclide measurement determined through stack monitoring processes in place, or an unplanned release. These have usually included small quantities of tritium, and also occasionally very small quantities of other radionuclides. Only one release of tritium, in January 1994, exceeded the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) (42 U.S.C. §9601) reportable quantity. All air releases were analyzed for impact on the environment and the public both in terms of dose and need for corrective action in accordance with DOE requirements in DOE Order 5400.5, DOE Order 232.1, and 40 CFR, Subpart H.

The federal regulations promulgated to implement the requirements of CAA Title VI, "Stratospheric Ozone Protection," are codified in *Protection of Stratospheric Ozone* (40 CFR 82). The primary purpose of these regulations is to eliminate the production of certain ozone-depleting substances and require users of the substances to reduce emissions to the atmosphere through recycling and mandatory use of certified maintenance technicians. These requirements are applicable to LANL, and are implemented accordingly.

On June 20, 1996, EPA promulgated *Accidental Release Prevention Requirements: Risk Management Programs* under CAA, Section 112 (r)(7), which amended 40 CFR 68. The intent of this regulation is to prevent accidental releases to the air and mitigate the consequences of such releases by focusing prevention measures on chemicals that pose the greatest risk to the public and the environment. This regulation will require the preparation of risk management plans for listed regulated chemicals at LANL by June 1999, and within 3 years after listing any new regulated chemical.

On July 18, 1997, the EPA adopted a new National Ambient Air Quality Standard (NAAQS) for particulate matter (PM) with a diameter less than or equal to 2.5 micrometers ($PM_{2.5}$), and reference methods for determining attainment with the standard. Also on July 18, 1997, EPA revised the NAAQS and associated reference method for determining ozone attainment. Both standards will be incorporated into the SIP for New Mexico and be applicable to LANL. Determination of attainment of both standards is based on a reference method utilizing 3-year averaging.

In addition to the existing federal programs, the *Clean Air Act Amendments of 1990* mandate new programs that may affect future LANL programs. These programs require technology for controlling hazardous air pollutants and replacing chlorofluorocarbons. Regulations are still being developed to implement these aspects of the act.

7.4.2 *New Mexico Air Quality Control Act*

Nonradioactive air emissions from LANL facilities are subject to the regulatory requirements established under the *New Mexico Air Quality Control Act* (sections 74-2-1 *et seq.*, NMSA 1978). The New Mexico Environmental Improvement Board, as provided by the *New Mexico Air Quality Control Act*, regulates air quality through a series of air quality control regulations in NMAC. These regulations are administered by NMED. NMAC provides emission standards for emission sources and processes such as open burning, boilers, and asphalt plants. Some of the main regulations relevant to LANL operations are discussed below.

7.4.2.1 *Construction Permits*

Provisions of 20 NMAC 2.72 require construction permits for any new or modified source of any regulated air contaminant if they exceed threshold emission rates. More than 500 toxic air pollutants are regulated, and each chemical's threshold hourly rate is based on its toxicity. Each new or modified air emission source is reviewed, and conservative estimates are made of maximum hourly chemical use and emissions. These estimates are compared with the applicable 20 NMAC 2.72 limits to determine whether additional permits are required.

7.4.2.2 *Operating Permits*

On July 21, 1992, EPA promulgated 40 CFR 70, O*perating Permit Program*, which implements Title V of the CAA. The purpose of this program is to: (1) identify all the air quality regulations and emission limitations applicable to an air pollution source; and (2) establish monitoring, record keeping, and reporting requirements necessary to demonstrate continued compliance with these requirements. This regulation required each state to develop an operating permit program meeting the minimum requirements set forth in 40 CFR 70 and submit their program to EPA for review by November 1993. The NMED Operating Permit Program established under 20 NMAC 2.70 was approved by EPA in December 1994. It requires that all major producers of air pollution obtain an operating permit from NMED. Due to LANL's potential to emit large quantities of regulated air pollutants (nitrogen oxides and carbon monoxide—primarily from steam plants), LANL is considered a major source.

In accordance with 20 NMAC 2.70, LANL submitted an operating permit application to NMED in December 1995. NMED has issued a Notice of Completeness for the application but has not yet issued an operating permit.

7.4.2.3 *Prevention of Significant Deterioration*

This regulation (20 NMAC 2.74) has stringent requirements that must be addressed before construction of any new, large stationary source can begin. Under 20 NMAC 2.74, wilderness areas, national parks, and national monuments receive special protection; thus, the proximity of Bandelier National Monument's (BNM) Wilderness Area could have an impact on any proposed new construction at LANL. All of the new or modified air emission sources at LANL are reviewed for compliance with the requirements of 20 NMAC 2.74. Because the total emissions of any criteria pollutant from LANL are below the regulation's threshold of 250 tons a year, currently this regulation does not apply to LANL.

7.4.2.4 *Emission Standards for Hazardous Air Pollutants*

In its regulation governing emission standards for HAPs (20 NMAC 2.78), NMED has adopted by reference all of the federal NESHAP provisions, except those for radionuclides. The only two nonradionuclide NESHAP provisions applicable to LANL are those for asbestos and beryllium.

Under NESHAP for asbestos, LANL is required to notify NMED of asbestos removal operations and disposal quantities and to ensure that these operations produce no visible emissions. Asbestos removal activities involving less than 160 square feet (15 square meters) are covered by an annual small-job notification to NMED. Projects involving greater amounts of asbestos require separate advance notification to NMED. Quantities of asbestos wastes for both small and large jobs are reported to NMED on a quarterly basis. These reports include any asbestos contaminated, or potentially contaminated, materials with radionuclides. Radioactivity contaminated material is disposed of in a designated radioactive asbestos burial area. Nonradioactive asbestos is transported off the site to designated commercial asbestos disposal areas.

The beryllium NESHAP includes requirements for preconstruction and preoperation approval of beryllium machining operations and for start-up testing of stack emissions from these operations. Before the beryllium NESHAP became applicable for DOE operations in the mid 1980's, NMED, DOE, and LANL agreed to follow the NMED new-source preconstruction/ preoperation approval process for large, existing beryllium-machining operations at LANL. Since then, several very small beryllium machining operations that were already in existence have been registered with NMED.

7.4.3 *Noise Control Act of 1972*

By the *Noise Control Act of 1972* (42 U.S.C. §4901), Congress directed all federal agencies to carry out the programs under their control to promote an environment free from noise that jeopardizes public health or welfare. Furthermore, it requires any federal agency engaged in any activity resulting, or which may result, in the emission of noise, to comply with federal, state, interstate, and local requirements respecting control and abatement of environmental noise to the same extent that any person is subject to such requirements. Beyond the general obligation in the act and implementing regulations, there are no specific federal requirements regulating environmental noise, nor are there state requirements. Noise exposures to occupational workers are regulated under OSHA, and for DOE contractors through an equivalent program implemented by DOE orders. The Los Alamos County Code (Chapter 8.28) does have noise restrictions, with identified permissible noise levels for residential areas during specified times. Permits can be requested for exceedances for noise generating activities of a temporary nature.

7.5 WATER RESOURCES

7.5.1 *Clean Water Act*, as Amended

The *Clean Water Act* (33 U.S.C. §1251) has a goal to "restore and maintain the chemical, physical and biological integrity of the nation's waters," including to "provide for the protection and propagation of fish, shellfish, and wildlife." The regulations that implement the *Clean Water Act* contain limitations and permitting requirements for discharges of pollutants from point sources; disposal of dredged or fill material at wetlands and other waters of the U.S.; stormwater discharges from construction and industrial runoff; and oil discharges. Key elements of the act include: (1) nationally applicable, technology-based effluent limitations set by EPA for specific industry categories; and (2) water quality standards set by states.

EPA is the regulating authority for point source and stormwater discharge permits in New Mexico. Permits are issued and enforced by EPA Region 6 in Dallas, Texas. New Mexico does not have a state point source discharge permit program. However, NMED performs some compliance evaluation inspections and monitoring for EPA through a water quality grant issued under Section 106 of the act. The U.S. Army Corps of Engineers administers the dredged or fill material permit program (Section 404) of the *Clean Water Act*. LANL submits applications as necessary for disposal of dredged and fill material under Section 404 for construction activities. The *New Mexico Groundwater Protection Act* (74-6B-1 *et seq.*, NMSA 1978), *Water Quality Act* (74-6-1 *et seq.*, NMSA 1978) and implementing regulations establish state standards for protection of surface and groundwater resources that are also applicable to LANL activities.

7.5.1.1 *National Pollutant Discharge Elimination System Permit Program/ Liquid Radioactive Discharges*

The *Clean Water Act* contains provisions for the National Pollutant Discharge Elimination System (NPDES), a permitting program for the discharge of pollutants from any point source into waters of the U.S. Individual NPDES permits set limitations for specified pollutants at specific outfalls.

LANL has operated under three primary NPDES permits. UC and DOE are co-operators on a site-wide NPDES permit (EPA 1994) issued by EPA Region 6 and effective August 1, 1994, covering the industrial and sanitary effluent discharges at Los Alamos. Industrial discharges from the hot dry rock geothermal facility, Fenton Hill (Technical Area [TA]–57), are permitted separately (EPA 1979). This permit was canceled as of December 1997. A General Permit for storm water associated with industrial activity (EPA 1992) was also issued in September 1992. These permits regulate all routine effluent discharges at LANL. Storm water discharges associated with facility construction or environmental restoration activities are also authorized through the applicable NPDES program. Then they are included in the General Industrial Storm Water Permit or terminated as applicable. The number of NPDES General Permits for construction storm water discharges varies, with usually five to eight in effect at one time.

During the early 1990's, LANL was listed as a "Significant Non-Compliant Federal Facility" by EPA Region 6 for NPDES violations. DOE and LANL have had several Federal Facility Compliance Agreements and parallel administrative orders in effect to correct NPDES deficiencies. The current DOE compliance agreement (Docket No. VI–96–1237, December 12, 1996) (EPA 1996b) and the current LANL administrative order (AO Docket No. VI–96–1236, December 10, 1996) (EPA 1996c) include schedules for coming into full compliance with the *Clean Water Act* by completing the High Explosives Wastewater Treatment Facility (HEWTF) and Waste Stream Characterization projects. These corrective actions required by the compliance agreement and the administrative order are continuing.

Although maintaining a 98 to 99 percent compliance rate with required permit limitations, LANL has had, and continues to have, chronic problems meeting NPDES industrial/sanitary permit conditions. Exceedances are self reported under the conditions of the permit, and have consisted of occasional exceedances at some outfalls of arsenic, chlorine, total suspended solids, hydrogen-ion concentration, chemical oxygen demand, biological oxygen demand, cyanide, vanadium, copper, iron, oil and grease, silver, phosphorus, and radium. The total number of exceedances for calendar years 1991 through 1996 are shown in Figure 7.5.1.1–1.

LANL actions to improve compliance with permit conditions are continually being taken including, elimination of outfalls, improvements and corrective actions at specific outfalls, and implementation of the Waste Stream Characterization Program and Corrections Project.

Radioactive liquid effluent discharges are regulated by DOE Order 5400.5. One NPDES permitted outfall at TA–50, the Radioactive Liquid Waste Treatment Facility, began operations in 1963. This outfall has continued to discharge residual radionuclides to Mortandad Canyon in liquid effluents to the present time. DOE Order 5400.5 specifies DCGs for liquid radioactive effluents, which provide a reference for determining dose to various exposure pathways. For liquid radioactive effluents, the "as low as reasonably achievable" (ALARA) and "best available

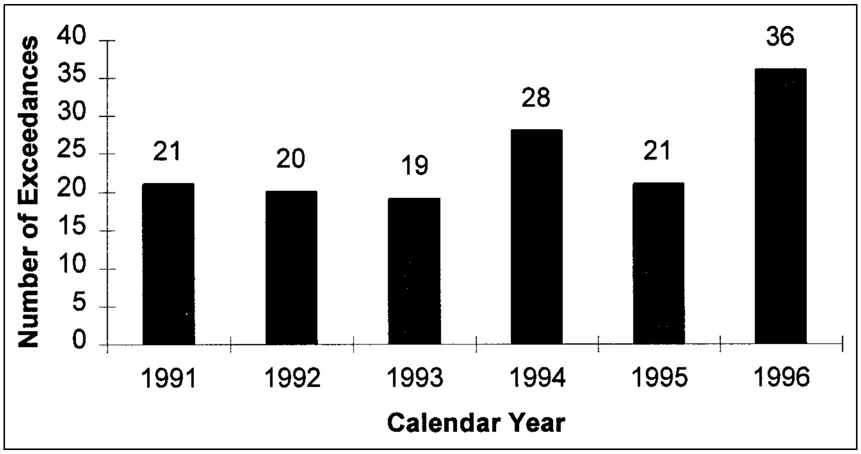

FIGURE 7.5.1.1–1.—*National Pollutant Discharge Elimination System Permit Exceedances.*

technology" (BAT) processes are adopted to determine the appropriate level of treatment. If discharges are below the DCG reference values at the point of discharge to a surface waterway, generally no further treatment is required due to cost/benefit considerations. Historic discharges to Mortandad Canyon have resulted in above background residual radionuclide concentrations in alluvial groundwater and sediments. For calendar year 1996, two DCGs were exceeded in TA–50 effluents (for americium-241 and plutonium-238). The TA–50 discharge also contains nitrates that have caused the alluvial groundwater to exceed the state groundwater standard of 10 milligrams per liter. LANL is working to continue to upgrade the treatment process at TA–50 to correct these problems. Investigation and cleanup, if required, are conducted through the Environmental Restoration Project, and interim controls (sediment traps) have been implemented to control movement of contaminants off the site.

7.5.1.2 *Unplanned Discharges, Spills, and Releases*

LANL also has had continuing problems with unplanned liquid discharges, or spills of water contaminants, which are required to be reported to NMED as unpermitted discharges to surface water or groundwater under the New Mexico Water Quality Control Commission (NMWQCC) regulations. Primarily, these have consisted of unpermitted or unplanned releases of potable water, wastewater or sewage, cooling water, and steam condensate from line breaks and overflows, with occasional reportable small quantity releases of mineral oil, gasoline, diesel oil, hydraulic oil, ethylene glycol, and other liquids. Some discharges of oil are also reportable to the National Response Center pursuant to 40 CFR 110.6. Spills and releases are reported in accordance with regulations, and cleanup is conducted by LANL as necessary. NMED administratively reviews and closes actions taken on reported spills as staff and time permits. The total number of liquid spills reportable to NMED for the period 1991 through 1996 are shown in Figure 7.5.1.1–2.

LANL has had six releases involving spills, leaks, or seepage of water with low levels of radioactive contamination in the period 1991 through 1996. These are evaluated and cleaned up if necessary in accordance with DOE Order 5400.5 criteria.

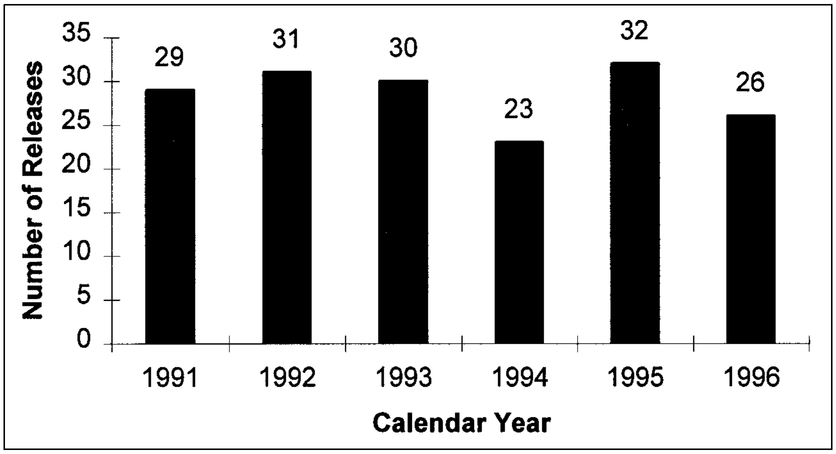

FIGURE 7.5.1.1–2.—*Liquid Release Notifications.*

7.5.1.3 *Spill Prevention Control and Countermeasure Plan*

LANL has a spill control and countermeasure plan for oil spills (LANL 1997), as required by 40 CFR 112 under the *Clean Water Act*. This plan requires that secondary containment be provided for all aboveground storage tanks containing oil. The plan also provides for spill control at oil storage sites at LANL. This plan meets requirements of both EPA and NMED for control of spills to surface areas and below the ground surface.

7.5.1.4 *Sanitary Sewage Sludge Management Program*

In December 1992, EPA promulgated 40 CFR 503, *Standards for Use or Disposal of Sewage Sludge*. The purpose of these regulations is to establish numerical, management, and operational standards for the beneficial use or disposal of sewage sludge through land application or surface disposal. Under the Part 503 regulations, LANL is required to collect representative samples of sewage sludge to demonstrate that it is not a hazardous waste and that it meets the minimum federal standards for pollutant concentrations. In 1996, analytical sampling demonstrated 100 percent compliance with land application standards. However, low levels of polychlorinated biphenyls (PCBs) detected in the sludge have caused LANL to suspend land application of sludge, in preference to other disposal options. All sewage sludge generated at the TA–46 Sewage Treatment Plant is now handled as PCB-contaminated waste and disposed of off the site rather than by land application.

7.5.1.5 *Safe Drinking Water Act, as Amended*

The *Safe Drinking Water Act* (SDWA) (42 U.S.C. §300f) sets national standards for contaminant levels in public drinking water systems, regulates the use of underground injection wells, and prescribes standards for groundwater aquifers that are a sole source of drinking water. Primary enforcement responsibility for the act is by the states. EPA has given NMED authority to administer and enforce federal drinking water regulations and standards in New Mexico. This act authorizes regulations that establish national drinking water standards for contaminants in public drinking water systems. The implementing regulations are found in *National Interim*

Primary Drinking Water Regulations. The regulations also set maximum contaminant level goals (40 CFR 142) and secondary standards to control contaminants in drinking water that primarily affect aesthetic qualities related to public acceptance of drinking water (40 CFR 143). These standards have been adopted by New Mexico and are included in the *New Mexico Drinking Water Regulations*. The state has issued regulations containing maximum contaminant levels (MCLs) and standards for radioactive contamination (20 NMAC 7.1). EPA maintains oversight responsibilities over the states, sets new contaminant standards as appropriate, and maintains separate enforcement responsibility for the Underground Injection Control Program.

The SDWA applies to federal facilities that own or operate a public water system. A "public water system" means a system for the provision of piped water for human consumption that has at least 15 service connections or regularly serves at least 25 individuals. DOE provides drinking water to LANL, Los Alamos County, and BNM. LANL, as operator of the water system, is required to monitor drinking water quality for organic and inorganic compounds, radionuclides, metals, and coliforms. LANL has established a sampling program for ensuring SDWA compliance.

7.5.1.6 *Groundwater Protection Requirements*

There are numerous federal, state, and DOE requirements related to groundwater protection and management. The State of New Mexico protects groundwater via the NMWQCC regulations, which control discharges of water contaminants onto or below the ground surface to protect all groundwater of the State of New Mexico. Under these regulations, a groundwater discharge plan may be required to be submitted to and approved by NMED for a discharging facility (or by the Oil Conservation Division for energy/mineral extraction activities). Subsequent discharges must comply with the terms and conditions of the discharge plan. In 1997, LANL had three Groundwater Discharge Plans in effect. The NMWQCC regulations were significantly expanded in 1995 with the adoption of comprehensive abatement regulations. The purpose of these regulations is to abate both surface and subsurface contamination for designated or future uses. Of particular importance to DOE and LANL is the contamination that may be present in alluvial groundwater.

Groundwater monitoring and protection requirements are also included in DOE Order 5400.1, *General Environmental Protection Program*. The order requires LANL to prepare a Groundwater Protection Management Program Plan (GWPMPP) and to implement the program outlined by that plan. The GWPMPP also fulfills the requirements of Chapter IV, Section 9, of DOE Order 5400.1, which requires development of a groundwater monitoring plan. The groundwater monitoring plan identifies all DOE requirements and regulations applicable to groundwater protection and includes strategies for sampling, analysis, and data management. LANL's GWPMPP was most recently approved by DOE on March 15, 1996 (LANL 1996).

Section 9c of Chapter IV of DOE Order 5400.1 requires that groundwater monitoring needs be determined by site-specific characteristics and, where appropriate, that groundwater monitoring programs be designed and implemented in accordance with RCRA regulations 40 CFR 264, Subpart F, or 40 CFR 265, Subpart F. The section also requires that monitoring for radionuclides be in accordance with DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

In addition to DOE Order 5400.1, Module VIII of the LANL RCRA permit requires LANL to collect information to supplement and verify existing information on the environmental setting at the facility and collect analytical data on groundwater contamination. Under Task III, Section A.1, LANL is required to conduct a program to evaluate hydrogeological conditions. Under Task III, Section C.1, LANL is required to conduct a groundwater investigation to characterize any plumes of contamination at the facility.

Historically, the groundwater monitoring requirements of RCRA (40 CFR 264 Subpart F) have not been applied to LANL's regulated hazardous waste management units (treatment, storage, and disposal) because DOE and LANL had submitted groundwater monitoring waiver demonstrations based on the depth to groundwater and lack of physical evidence of contaminant migration to these depths. However, on May 30, 1995, NMED denied DOE/LANL groundwater monitoring waiver demonstrations, and groundwater monitoring program plans were requested for DOE/LANL to bring the laboratory into compliance with RCRA. In the denial letter, NMED recommended the development of a comprehensive groundwater monitoring program plan that addresses both site-specific and LANL-wide groundwater monitoring objectives. This was in part satisfied with submittal of a revised GWPMPP in 1995. In an August 17, 1995, letter, NMED again expressed concerns over groundwater protection, listed four unresolved issues, and requested a RCRA Hydrogeologic Workplan. On December 6, 1996, a draft Hydrogeologic Workplan was submitted to NMED addressing these unresolved issues. LANL is currently implementing actions defined in the Hydrogeologic Workplan. The Hydrogeologic Workplan was approved by NMED March 1998 and revised by LANL May 1998 (LANL 1998).

7.6 LAND RESOURCES (WASTE MANAGEMENT, TOXIC SUBSTANCES, POLLUTION PREVENTION, AND ENVIRONMENTAL RESTORATION)

Federal facilities are subject to a variety of federal and state environmental statutes and implementing regulations related to waste management, prevention of pollution, and environmental cleanup. These requirements are primarily oriented toward prevention of pollution of land resources, and cleanup of past spills and releases. These include the RCRA; the *Federal Facility Compliance Act*; the *Toxic Substances Control Act* (TSCA); the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA); and the CERCLA. These acts address the management of waste and hazardous substances, and the release or threat of release of hazardous substances, primarily to soil and groundwater. The *Hazardous Material Transportation Act* is also included, which governs the transportation of hazardous materials and waste.

7.6.1 *Resource Conservation and Recovery Act*

The RCRA (42 U.S.C. §6901 *et seq.*) regulates the management of solid waste. Solid waste is broadly defined to include any garbage, refuse, sludge, or other discarded material including solid, liquid, semisolid, or contained gaseous materials resulting from industrial, commercial, mining, or agricultural activities. Specifically excluded as solid waste is source, special nuclear, or byproduct material as defined by AEA. Nonhazardous solid waste is regulated under subtitle D of RCRA, the *New Mexico Solid Waste Act* (NMSWA) (74-9-1 *et seq.*, NMSA 1978), and its implementing regulations, the New Mexico Solid Waste Management Regulations (20 NMAC 9). New Mexico has primary regulatory authority. The state does not have authority to regulate the management and disposal of radioactive waste from DOE facilities operated under AEA.

LANL maintains an industrial solid waste landfill at Area J of TA–54 (on Mesita del Buey), which is subject to and operates under New Mexico's Solid Waste Management Regulations (20 NMAC 9.1). The landfill is used as a disposal site for solid wastes (such as classified wastes, other nonhazardous waste materials, and "special solid waste" as defined by the State of New Mexico) and as a staging area for nonradioactive asbestos waste, which is later shipped off the site to an approved commercial disposal facility. Radioactive asbestos waste and asbestos waste suspected of being contaminated with radioactive material (excluded as solid wastes under the New Mexico regulations) are disposed in a dedicated cell constructed at TA–54, Area G.

LANL disposes of most sanitary solid waste and rubble at the Los Alamos County Landfill and an adjacent rubble pile on East Jemez Road. This landfill lies on DOE property, but is owned and operated by Los Alamos County under a special-use permit (an agreement between DOE's Los Alamos Area Office and the county specifies the types of wastes that may be disposed of in the landfill). LANL contributes about one-third of the total volume of wastes entering this landfill. As the owner and operator, Los Alamos County is responsible for day-to-day operational compliance and obtaining necessary permits from the state under 20 NMAC 9.1.

In 1976, RCRA established requirements and procedures for the management of hazardous wastes. As amended by the *Hazardous and Solid Waste Amendments of 1984* (HSWA), RCRA Subtitle C defines hazardous wastes that are subject to regulation and sets standards for generation of waste and for treatment, storage, and disposal facilities. The HSWA emphasizes reducing the volume and toxicity of hazardous waste. The RCRA and HSWA also establish permitting and corrective action (i.e., cleanup) requirements for RCRA-regulated hazardous waste facilities.

Original jurisdiction for implementing hazardous waste management aspects of the RCRA was with the EPA; however, the RCRA authorizes EPA to delegate responsibility to individual states as they develop satisfactory implementation programs. EPA granted base RCRA authorization to New Mexico on January 25, 1985, transferring regulatory authority over hazardous wastes under the RCRA to NMED. State authority for hazardous waste regulation is set forth in the *New Mexico Hazardous Waste Act* and Hazardous Waste Management Regulations (20 NMAC 4.1), which adopt, with a few minor exceptions, all of the federal regulations in effect. On July 25, 1990, the State of New Mexico's Hazardous Waste Program was authorized by EPA to regulate mixed waste in lieu of the federal program.

On November 8, 1989, DOE and UC, as co-operators of LANL, were granted a RCRA operating permit, which establishes requirements for hazardous waste management units. A Part A application for mixed waste storage and treatment units throughout LANL was submitted on January 25, 1991. Permit modifications and additional revised Part A and Part B applications have been submitted since 1991 for mixed waste units. All existing mixed waste units are operating either under permit or interim status pending permit issuance.

DOE and EPA signed a Federal Facility Compliance Agreement on March 15, 1994, addressing identified noncompliances with stored mixed waste treatment requirements under the land disposal restrictions (LDRs). This compliance agreement was terminated with issuance by the State of New Mexico of a *Federal Facility Compliance Order* in October 1995 under the *Federal Facility Compliance Act*, which addresses treatment schedules for mixed waste to meet LDR standards.

LANL has received a number of compliance orders issued by NMED for noncompliances with hazardous waste management requirements. DOE and LANL are subject to a three-party consent agreement for compliance orders issued by NMED in 1993 regarding corrective actions that resolved the Transuranic Waste Inspectable Storage Project (TWISP) at TA–54, Area G (NMED 1993). This project involves the recovery of transuranic (TRU) and TRU-mixed waste containers stored on earthen covered pads at TA–54, Area G, and placement of that waste into compliant inspectable storage. The deadline for completion of this project is September 2003.

LANL also is currently subject to an Amended Stipulations, dated May 23, 1995, that is part of a settlement reached in response to Compliance Order NMHWA 94-09 (NMED 1995a). The Amended Stipulation requires LANL to exercise due diligence in addressing and working off 644 gas cylinders that had exceeded the allowable 1-year storage limit for land disposal restriction. All but four of the gas cylinders have been dealt with under the terms of the Amended Stipulation. Until these four cylinders meet the terms of the Amended Stipulation, LANL will continue to submit quarterly progress reports, as required by the Amended Stipulation, to demonstrate due diligence in working off the cylinders. All other compliance orders relating to hazardous waste activities have been closed.

The HSWA (1984) modified the hazardous waste permitting sections of the RCRA (Sections 3004 and 3005). In accordance with these provisions, LANL's permit to operate includes a section (HSWA Module VIII) that prescribes a specific corrective action program for LANL, the primary focus of which is the investigation and cleanup, if required, of inactive sites called solid waste management units (SWMUs). The HSWA Module specifies the corrective action process, which is being implemented at LANL by the Environmental Restoration Project.

The corrective action process at LANL consists of: (1) preparing RCRA facility investigations to identify the extent of contamination in the environment and the pathways along which these contaminants could travel to human and environmental receptors; (2) preparing corrective measures studies if needed to evaluate alternative remedies for reducing risks to human and environmental health and safety in a cost-effective manner; and (3) corrective measures implementation—the remedy chosen is implemented, its effectiveness is verified, and ongoing control and monitoring requirements are established.

7.6.2 Radioactive Waste Management Requirements

Low-level radioactive waste (LLW) is a waste that contains radioactivity and is not classified as high-level radioactive waste, TRU waste, or spent nuclear fuel. Solid LLW usually consists of clothing, tools, and glassware. Low-level radioactive liquid waste consists primarily of water circulated as cooling water. Radioactive waste management at LANL is regulated under the AEA, through applicable DOE orders (primarily DOE Order 5820.2A, *Radioactive Waste Management*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment*). DOE Order 5400.5 also provides criteria and processes for the release of materials (through sale or disposal) to assure that released materials do not constitute a hazard to the public and the environment due to their radioactive content. This includes materials that are not waste. LANL has reported and taken corrective action for a number of incidents involving the inadvertent release of contaminated materials not releasable under the criteria in DOE Order 5400.5. During the period 1991 through 1996, these incidents have usually consisted of the discovery of contaminated equipment at salvage yards or in other uncontrolled locations, and in two reported incidents at the Los Alamos County Landfill. When incidents are discovered, actions are taken to immediately control the material as radioactive contaminated, and it is removed to a controlled area or decontaminated in accordance with DOE radiation control requirements.

Low-level radioactive mixed waste (LLMW) is waste containing both hazardous and low-level radioactive components. As a hazardous waste, mixed waste is regulated under the RCRA and New Mexico hazardous waste management regulations. Because it is radioactive, the radioactive component is also regulated under the AEA through applicable DOE orders. LLMW is disposed of at off-site facilities.

Due to the nationwide lack of DOE treatment capacity and capability for mixed waste, LANL has continued to store many mixed wastes on the site. On March 15, 1994, DOE and EPA signed a Federal Facility Compliance Agreement to address compliance with the storage prohibitions for mixed waste at LANL. This agreement was terminated with the issuance of the Federal Facility Compliance Order in October 1995 with NMED implementing the Site Treatment Plan for LANL, under provisions of the *Federal Facility Compliance Act*.

TRU waste, regardless of form or source, is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than or equal to 100 nanocuries per gram at the time of assay. TRU waste at LANL is scheduled to be sent to the WIPP when that facility opens. TRU waste is subject to the waste acceptance criteria (WAC) for WIPP, DOT shipping requirements, and applicable DOE orders dealing with its safe handling and management.

7.6.3 *Federal Facility Compliance Act*

The *Federal Facility Compliance Act* (Public Law [PL] 102–386, 106 Stat. 1505), enacted in 1992, amended RCRA and waives sovereign immunity from fines and penalties for RCRA violations at federal facilities. However, the act postponed the waiver for 3 years for storage prohibition violations with regard to land disposal restrictions for DOE's mixed wastes. It also required DOE to prepare plans for developing the required treatment capacity for its mixed waste for each site at which it stores or generates mixed waste. Each plan (referred to as a site treatment plan) must be approved by the state or EPA after consultation with other affected states, consideration of public comments, and issuance of an order by the regulatory agency requiring compliance with the plan. The act further provides that DOE will not be subject to fines and penalties for storage prohibition violations for mixed waste as long as it is in compliance with an existing agreement, order, or permit.

The *Federal Facility Compliance Act* requires that site treatment plans contain schedules for developing treatment capacity for mixed waste for which identified technologies exist. For mixed waste without an identified existing treatment technology, DOE must provide schedules for identifying and developing technologies.

LANL has submitted site treatment plans to NMED to address the development of new treatment capabilities in compliance with the act. A Federal Facility Compliance Order was issued on October 4, 1995, to address treatment schedules for mixed waste (NMED 1995b). The Mixed Waste Land Disposal Restriction Federal Facility Compliance Agreement with EPA of March 15, 1994, was terminated with this new agreement.

7.6.4 Underground Storage Tanks, RCRA Subtitle I

Underground storage tanks (USTs) containing petroleum or hazardous substances are regulated as a separate program under Subtitle I of the RCRA, which establishes regulatory requirements for USTs containing hazardous or petroleum materials. NMED has been delegated authority for regulating USTs under the New Mexico Underground Storage Tank Regulations, which implement the *New Mexico Hazardous Waste Act* and the *New Mexico Groundwater Protection Act*. These regulations include requirements for: (1) design, construction, and installation of new tanks; (2) maintenance of a leak detection system and associated record keeping; (3) reporting of hazardous or petroleum releases; (4) corrective action in the event of a release; and (5) closure of UST systems. All existing tank systems must either meet new tank performance standards or undergo closure by December 22, 1998. All LANL USTs will be upgraded or undergo closure by the December 22, 1998 deadline. LANL complied with the deadline for upgrading, replacing, or properly closing all USTs at LANL.

7.6.5 *Comprehensive Environmental Response, Compensation, and Liability Act*, as Amended

CERCLA (PL 96-510) (42 U.S.C. §9601 *et seq.*), as amended by *Superfund Amendments and Reauthorization Act* (SARA) of 1986 (PL 99-499), provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and cleanup of inactive hazardous substances disposal sites. The CERCLA also established a fund that is financed by hazardous waste generators and is used to financially support clean-up and response actions of abandoned hazardous waste sites when no financially responsible party(ies) can be found. Parties responsible for the contamination of sites are liable for all costs incurred in the clean-up and remediation process. EPA is the regulating authority for the act. Some applicable implementing regulations are contained in the *National Oil and Hazardous Substances Pollution Contingency Plan* (40 CFR 300), and *Designation, Reportable Quantities, and Notification* (40 CFR 302).

LANL has been evaluated and did not score high enough to be placed on the National Priority List for past releases into the environment. Therefore, all legacy contamination found in the environment at LANL is primarily cleaned up under RCRA corrective action authority (HSWA Permit Module VIII). Executive Order 12580, which applies to facilities that are not on the National Priorities List, delegates responsibility to the heads of executive departments and agencies at those facilities for undertaking remedial and removal actions for releases or threatened releases. This authority applies to any clean-up actions not included as a RCRA corrective action.

The CERCLA was amended by the SARA in 1986. The SARA Title III establishes additional requirements for emergency planning and reporting of hazardous substance releases. The SARA Title III is also known as the *Emergency Planning and Community Right-to-Know Act* (EPCRA), which, due to its unique requirements, is discussed separately below. The SARA also created liability for damages to or loss of natural resources resulting from releases into the environment, and required the designation of federal and state officials to act as public trustees for natural resources. The *New Mexico Natural Resources Trustee Act* (75-7-1 *et seq.*, NMSA 1978) is the state statute designed to protect state natural resources. DOE, as the federal trustee, and the State of New Mexico have authority to act as trustees for most resources at LANL. The DOI retains authority for certain designated sensitive natural resources. Other natural resource trustees act for lands surrounding LANL, including the Pueblo tribes. Procedures for conducting natural resource damage assessments are codified at 43 CFR 11. A strategy and plan for integrating the natural resource damage assessment requirements into the HSWA corrective action (environmental restoration) process at LANL is being developed.

LANL is subject to and required to report releases to the environment under the notification requirements in 40 CFR 302. In the period 1991 through 1996, LANL has had four releases to the environment exceeding a reportable quantity in 40 CFR 302.4. One was a planned release by remote detonation of an overpacked chlorine cylinder on May 18, 1993, resulting in the release of a maximum of 100 pounds of chlorine under controlled conditions. Another was a stack release of tritium exceeding 100 curies on January 25, 1994, at TA–33. Two additional reportable releases involved the release of a water/ethylene glycol mixture (coolant) in excess of 1 pound on June 18, 1993 and June 22, 1993.

7.6.6 *Toxic Substances Control Act*

The TSCA (15 U.S.C. §2601 *et seq.*) is administered by EPA. Unlike other statutes that regulate chemicals and their risk after they have been introduced into the environment, the TSCA was intended to require testing and risk assessment before a chemical is introduced into commerce. The TSCA also establishes record-keeping and reporting requirements for new information regarding adverse health and environmental effects of chemicals. The TSCA also governs the manufacture, use, storage, handling, and disposal of PCBs; sets standards for cleaning up PCB spills; and establishes standards and requirements for asbestos identification and abatement in schools.

Because LANL's research and development activities are not usually related to the manufacture of new chemicals, PCB regulations (40 CFR 761) are LANL's main concern under the TSCA. Activities at LANL that are governed by PCB regulations include, but are not limited to, management and use of authorized PCB-containing equipment, such as transformers and capacitors; management and disposal of substances containing PCBs (dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, slurries, dredge spoils, and soils); and management and disposal of materials or equipment contaminated with PCBs as a result of spills.

The TSCA regulates PCB items and materials having concentrations exceeding 50 parts per million. The regulations contain an antidilution clause that requires waste to be managed based on the PCB concentration of the source (transformer, capacitor, PCB equipment, etc.), regardless of the actual concentration in the waste. If the concentration at the source is unknown, the waste must be managed as though it were a spill of mineral oil with an assumed PCB concentration of 50 to 500 parts per million. At LANL, PCB-contaminated wastes are transported off the site for treatment and disposal unless they also have a radioactive component. Wastes in solid form containing both radionuclides and PCBs are disposed at Area G (TA–54), which has been approved by EPA for such disposal (provided that strict requirements are met with respect to notification, reporting, record keeping, operating conditions, environmental monitoring, packaging, and types of wastes disposed).

LANL has reported four small spills (0.34 fluid ounces [10 milliliters] to 0.5 gallons [1.9 liters]) involving PCB-contaminated materials during the period 1991 through 1996. None of these spills exceeded CERCLA reportable quantities, and they were cleaned up using the policy and guidelines in 40 CFR 761.

LANL currently has no treatment or disposal facilities for liquid wastes that contain both radionuclides and PCBs. Such wastes have been stored at Area L at TA–54 for longer than 1 year (in violation of TSCA regulations that stipulate a maximum of 1 year for “storage for disposal” of PCBs). However, commercial facilities do not exist to accept these wastes because of the radionuclide component. In August 1996, EPA and DOE signed a national Federal Facility Compliance Agreement allowing long-term storage of these radioactive liquid wastes containing PCBs, and establishing requirements for DOE to meet in the interim (EPA 1996d).

The asbestos abatement regulations of the TSCA (40 CFR 763) relate primarily to the identification and abatement of asbestos containing materials in schools. LANL conducts asbestos abatement projects in accordance with OSHA requirements (29 CFR 1926), and applicable requirements of the CAA NESHAP 40 CFR 61, Subpart M for notification and waste management/disposal, and the New Mexico Solid Waste Management Regulations.

7.6.7 *Hazardous Materials Transportation Act*

This act defines the requirements of DOT applicable to the packaging and transportation of hazardous materials. The regulations list and classify the materials that DOT (the regulating authority) has designated as “hazardous.”

Implementing regulations include *General Information, Regulations, and Definitions* (49 CFR 171); *Hazardous Materials Tables, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements* (49 CFR 172); *General Requirements for Shipments and Packaging*s (49 CFR 173); *Carriage by Rail* (49 CFR 174); *Carriage by Public Highway* (49 CFR 177); and *Specifications for Packagings* (49 CFR 178). Specific packaging requirements for radioactive materials are in 49 CFR 173, Subpart I. The requirements prescribed in Subpart I are in addition to, not in place of, requirements of the NRC set forth in 10 CFR 71.

DOE must comply with the *Hazardous Materials Transportation Act* (49 U.S.C. §801 *et seq.*) and implementing regulations, and with specific facility WAC when packaging and transporting waste destined for WIPP and other off-site federal or commercial facilities. LANL must also meet applicable manifesting requirements for shipping hazardous materials such as preparing shipping papers, marking and labeling packages, and placarding transport vehicles as outlined in the act and implementing regulations. Because LANL consists of many separate TAs connected in many instances by public roads, inter-TA transportation requirements must consider applicable packaging and transportation requirements for the movement of hazardous materials within LANL as well. This may include meeting the transportation requirements fully, or utilizing road closures or other means to maintain compliance with the regulations. The state agency regulating transportation of hazardous materials is the Motor Transportation Division of the New Mexico Tax and Revenue Department (65-3-13, NMSA 1978). New Mexico has adopted by reference the hazardous materials transportation regulations promulgated by DOT.

7.6.8 *Federal Insecticide, Fungicide, and Rodenticide Act*

This act regulates the use, registration, and disposal of several classes of pesticides. In order to ensure that pesticides are applied in a manner that protects the applicators, workers, and the environment, LANL must meet requirements of the FIFRA (7 U.S.C. §136 *et seq.*). Implementing regulations include recommended procedures for the disposal and storage of pesticides (40 CFR 165 [proposed regulation]) and worker protection standards (40 CFR 170). EPA is the regulating authority for LANL. LANL is also regulated by the *New Mexico Pest Control Act*, administered by the Board of Regents of New Mexico State University. The LANL Pest Control Management Plan, which includes programs for vegetation, insects, and small animals, was established in 1984 and is revised as necessary.

7.6.9 *Pollution Prevention Act of 1990*

The *Pollution Prevention Act of 1990* (42 U.S.C. §13101 *et seq.*) sets the national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal. In response to this act, DOE committed to voluntary participation in EPA's 33/50 Pollution Prevention Program, as set forth in Section 313 of SARA. The goal, for facilities already involved in Section 313 compliance, was to achieve a 33 percent reduction in release of 17 priority chemicals by 1997 from a 1993 baseline. LANL did not have releases that exceeded reportable thresholds for any of the 17 priority chemicals listed. In August 1993, Executive Order 12856 was issued, expanding the 33/50 program and requiring DOE to reduce its total release of all toxic chemicals by 50 percent by December 31, 1999. In response, DOE has developed Departmental Pollution Prevention Goals and Pollution Prevention Program Plans to meet these goals. Each DOE site, including LANL, develops its own site goals contributing to the DOE-wide goals and implements actions to achieve those goals. For Fiscal Year 1996, LANL met or exceeded all waste pollution prevention commitments.

7.7 COMMUNITY RIGHT-TO-KNOW AND EMERGENCY PLANNING

7.7.1 *Emergency Planning and Community Right-to-Know Act* and Executive Order 12856

This act is also known as SARA Title III. Section 313 of the EPCRA (42 U.S.C. §11001 *et seq.*) requires facilities meeting certain standard industrial classification code criteria to submit an annual toxic chemical release inventory report (*Toxic Chemical Release Reporting: Community-Right-to-Know* [40 CFR 372]). For facilities subject to the EPCRA requirements, a report describing the use of, and emissions from, Section 313 chemicals stored or used on site and meeting threshold planning quantities, must be submitted to EPA and the New Mexico Emergency Management Bureau every July for the preceding calendar year.

Other provisions of the EPCRA require planning notifications (Section 302–303), extremely hazardous substance release notifications (Section 304), and annual chemical inventory/Material Safety Data Sheet reporting (Section 311–312). Implementing regulations include but are not limited to *Emergency Planning and Notification* (40 CFR 355), *Material Safety Data Sheet Reporting* (40 CFR 370.21), and *Inventory Reporting* (40 CFR 370.28).

On August 3, 1993, Executive Order 12856, *Right-to-Know Laws and Pollution Prevention Requirements* directed all federal agencies to reduce and report toxic chemicals entering any waste stream; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative prevention technologies. Federal agencies were also defined as persons for the purposes of the EPCRA, requiring all federal facilities, regardless of standard industrial classification code to meet the requirements of the act.

LANL does not meet standard industrial classification code criteria for Section 313 reporting but has voluntarily submitted annual toxic chemical release inventory reports since 1987. All research operations are exempt under provisions of the regulation, and only pilot plants, production, or manufacturing operations at LANL are reported.

The *New Mexico Hazardous Chemicals Information Act* (74-4E-1 to 74-4E-9, NMSA 1978) implements the hazardous chemical information and toxic release reporting requirements of SARA Title III for covered facilities in New Mexico. Applicable reporting requirements under the provisions of the EPCRA and the state law are met by DOE and LANL in accordance with the executive order.

APPENDIX 7.A
CONSULTATIONS

In the process of preparing this SWEIS, DOE has had discussions with numerous organizations (including the New Mexico Department of Game and Fish, the BIA, the USFS, the NPS, and counties and municipalities near LANL) regarding issues, concerns, and interests associated with the operation of LANL and with the preparation of the SWEIS. Of these discussions, a few of them are considered to be consultations for the purposes of the SWEIS, where DOE specifically requested positions, advice, or input from organizations. The subjects of these consultations and the agencies or organizations consulted were:

SUBJECT OF CONSULTATIONS	AGENCIES OR ORGANIZATIONS CONSULTED
Threatened and Endangered Species	U.S. Fish and Wildlife Service
Environmental Monitoring Data	New Mexico Environment Department
Cultural Resources	New Mexico State Historic Preservation Office(r)
Traditional Cultural Properties[a]	Pueblo of Acoma Pueblo de Cochiti Pueblo of Jemez Pueblo of Laguna Pueblo of Nambe Jicarilla Apache Tribe Mescalero Apache Tribe Navajo Nation Hopi Tribe Pueblo of Picuris Pueblo of Pojoaque Pueblo of Sandia Pueblo of San Ildefonso Pueblo of Santa Clara Pueblo of Santa Domingo Pueblo of Taos Pueblo of Tesuque Pueblo of Zia Pueblo of Zuni Pueblo of San Juan Western Network New Mexico Acequia Association

[a] Many tribal governments and other organizations were contacted. Those listed here are the ones that agreed to a consultation relationship with DOE for the purposes of the SWEIS.

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REFERENCES

DOE 1992a — Accord between the Pueblo of Santa Clara, a Federally Recognized Indian Tribe and the U.S. Department of Energy. December 8, 1992.

DOE 1992b — Accord between the Pueblo of San Ildefonso, a Federally Recognized Indian Tribe and the U.S. Department of Energy. December 8, 1992.

DOE 1992c — Accord between the Pueblo of Jemez, a Federally Recognized Indian Tribe and the U.S. Department of Energy. December 8, 1992.

DOE 1992d — Accord between the Pueblo of Cochiti, a Federally Recognized Indian Tribe and the U.S. Department of Energy. December 8, 1992.

DOE 1993 — Cooperative Agreement DE-FC04-93AL-97270. Los Alamos Pueblos Project. Recipient Santa Clara Pueblo. September 30, 1993.

DOE 1994a — Cooperative Agreement DE-FC04-94AL-99997. Los Alamos Pueblos Project. Recipient Jemez Pueblo. August 13, 1994.

DOE 1994b — Cooperative Agreement DE-FC04-94AL-99996. Los Alamos Pueblos Project. Recipient Cochiti Pueblo. August 13, 1994.

DOE 1995 — New Mexico Agreement in Principle between the DOE Albuquerque Operations Office and the State of New Mexico. October 2, 1995.

DOE 1996 — Report of the Department of Energy Working Group on External Regulation. DOE/US-0001. U.S. Department of Energy. December 1996.

DOE 1997a — Cooperative Agreement DE-FC04-97AL-77460. Los Alamos Pueblos Project. Recipient San Ildefonso Pueblo. February 20, 1997.

DOE 1997b — Contract No. W-7405-ENG-36 with the Regents of the University of California for Management of the Los Alamos National Laboratory. (Effective October 1, 1997.)

EPA 1979 — *Industrial Discharges from the Hot Dry Rock Geothermal Facility at LANL.* NPDES Permit NM0028576. U.S. Environmental Protection Agency, Region 6. October 15, 1979.

EPA 1992 — *General Permit for Storm Water Associated with Industrial Activity at LANL.* NPDES Permit NMR00A384. U.S. Environmental Protection Agency, Region 6. September 1992.

EPA 1994 *Industrial and Sanitary Effluent Discharges at LANL.* NPDES Permit NM0028355. U.S. Environmental Protection Agency, Region 6. August 1, 1994.

EPA 1996a Federal Facility Compliance Agreement Regarding Compliance with the Radionuclide NESHAP at Los Alamos National Laboratory. U.S. Environmental Protection Agency, Region 6. June 13, 1996.

EPA 1996b Federal Facility Compliance Agreement Regarding Compliance with the *Clean Water Act* at Los Alamos National Laboratory. U.S. Environmental Protection Agency, Region 6. December 12, 1996.

EPA 1996c Administrative Order Regarding Compliance with the *Clean Water Act* at Los Alamos National Laboratory. U.S. Environmental Protection Agency, Region 6. December 10, 1996.

EPA 1996d Federal Facility Compliance Agreement on Storage of Polychlorinated Biphenyls. U.S. Environmental Protection Agency. August 8, 1996.

LANL 1996 *Groundwater Protection Management Program Plan for Los Alamos National Laboratory*, Revision 0.0. Los Alamos National Laboratory. Los Alamos, New Mexico. Approved March 15, 1996 and January 31, 1996.

LANL 1997 *Spill Prevention Control and Countermeasures Plan for the Los Alamos National Laboratory*, Revision 4. Los Alamos National Laboratory. Los Alamos, New Mexico. March 1997.

LANL 1998 *Hydrogeologic Workplan for Los Alamos National Laboratory*. Los Alamos National Laboratory. Los Alamos, New Mexico. May 1998.

NMED 1993 Consent Agreement for Compliance Orders 93-01, 93-02, 93-03, and 93-04, between the University of California, U.S. Department of Energy, New Mexico Environment Department, and Los Alamos National Laboratory. December 10, 1993.

NMED 1995a Amended Stipulation for Compliance Order NMHWA 94-09, by and among the New Mexico Environment Department, the University of California, U.S. Department of Energy, and Los Alamos National Laboratory. May 24, 1995.

NMED 1995b Federal Facility Compliance Order, Compliance with the Site Treatment Plan for the Treatment of Mixed Waste at the Los Alamos National Laboratory. New Mexico Environment Department. Santa Fe, New Mexico. October 4, 1995.

UC 1994a Cooperative Agreement between the Pueblo of Jemez, a Federally Recognized Indian Tribe and the University of California as Operator of the Los Alamos National Laboratory. University of California. November 14, 1994.

UC 1994b Cooperative Agreement between the Pueblo of Cochiti, a Federally Recognized Indian Tribe and the University of California as Operator of the Los Alamos National Laboratory. University of California. November 14, 1994.

UC 1994c Cooperative Agreement between the Pueblo of San Ildefonso, a Federally Recognized Indian Tribe and the University of California as Operator of the Los Alamos National Laboratory. University of California. November 14, 1994.

UC 1996 Cooperative Agreement between the Pueblo of Santa Clara, a Federally Recognized Indian Tribe and the University of California as Operator of the Los Alamos National Laboratory. University of California. December 12, 1996.

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CHAPTER 8
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Name: **J. Randall Kirchner**
Affiliation: H&R Technical Associates, Inc.
Education: B.S., Nuclear Engineering, University of Tennessee
Technical Experience: Over 13 years of experience in probabilistic risk assessment, nuclear facility safety analysis, and transportation risk analysis
SWEIS Responsibility: Transportation risk analysis

Name:	**Vadim Kogan**
Affiliation:	Parsons Brinckerhoff
Education:	Ph.D., Chemical Engineering, Moscow Institute of Chemical Technology
Technical Experience:	22 years in environmental engineering field
SWEIS Responsibility:	Nonradiological air quality

Name:	**John Lambright**
Affiliation:	BETA Corporation, International, and Self-Employed Consultant
Education:	B.S., Nuclear Engineering M.S., Nuclear Engineering Ph.D., Nuclear Engineering
Technical Experience:	More than 20 years in risk assessment, safety analysis, and hazards analysis
SWEIS Responsibility:	Accident analysis

Name:	**Alice Lovegrove**
Affiliation:	Parsons Brinckerhoff
Education:	B.E., State University of New York at Stony Brook M.S., State University of New York at Stony Brook
Technical Experience:	10 years in air quality
SWEIS Responsibility:	Nonradiological air quality

Name:	**Beth Medina**
Affiliation:	Parsons Brinckerhoff
Education:	B.A., Art, California State University, Long Beach
Technical Experience:	11 years of experience preparing environmental documents and graphics
SWEIS Responsibility:	Land use

Name:	**Paul E. McCluer**
Affiliation:	H&R Technical Associates, Inc.
Education:	B.S., Chemical Engineering, Tennessee Technological University
Technical Experience:	8 years of experience in DOE nuclear facility safety analysis and process hazards analysis in the refining and chemical processing industries and author or co-author of more than 30 reports and publications in the areas of DOE nuclear facility safety analysis and process hazards analysis
SWEIS Responsibility:	Transportation risk analysis

Name:	**Donna McCormick**
Affiliation:	Parsons Brinckerhoff
Education:	B.L.A., Landscape Architecture, California Polytechnic University
Technical Experience:	11 years of experience preparing environmental documents, visual assessments, and landscape architecture
SWEIS Responsibility:	Land use

Name:	**Jere Millard**
Affiliation:	Dames & Moore, Inc.
Education:	B.A., Biology & Psychology, Colorado State University M.S., Radiobiology, Colorado State University M.S., Health Physics, Colorado State University Ph.D., Health Physics, Colorado State University
Technical Experience:	18 years in radiation physics/radiation ecology
SWEIS Responsibility:	Human health and ecological risk

Name:	**Douglas Minnema**
Affiliation:	U.S. Department of Energy
Education:	B.S., Nuclear Engineering, University of Michigan M.S., Nuclear Engineering, University of Michigan M.S., Radiological Health, University of Michigan Ph.D. Candidate, Nuclear Engineering, University of New Mexico (in progress)
Technical Experience:	• 18 years in nuclear engineering, health physics, and radiological control • Certified Health Physicist
SWEIS Responsibility:	Lead Preparer for human health risk; Technical Advisor on transportation, and accident analysis

Name:	**Robert A. Monsalve-Jones**
Affiliation:	GRAM, Inc.
Education:	A.S., Nuclear Engineering, Pennsylvania State University B.S., Radiation Protection, Thomas Edison State College
Technical Experience:	24 years as a Radiation Protection Specialist and Health Physicist in nuclear powerplants and at decontamination and decommissioning projects, and performing environmental investigations, risk analysis, and dose assessments for DOE and private clients, nationally and internationally
SWEIS Responsibility:	Radioactive air quality and human health

Name:	**Elizabeth Mooney**
Affiliation:	Dames & Moore, Inc.
Education:	B.S., Zoology and Wildlife Ecology, Michigan State University M.A., Environmental Toxicology, The American University
Technical Experience:	• 10 years in toxicology • 5 years in risk assessment • 10 years in ecology
SWEIS Responsibility:	Ecological risk

Name:	**Abby Nagy**
Affiliation:	Dames & Moore, Inc.
Education:	B.S., Chemical Engineering, Ohio State University
Technical Experience:	7 years in chemical engineering process and environmental analysis
SWEIS Responsibility:	Transportation and environmental restoration

Name:	**Marilyn Norcini**
Affiliation:	GRAM, Inc.
Education:	M.A., History, Museum Studies, Cooperstown Graduate Programs, State University of New York, Oneonta M.A., Anthropology, University of Arizona Ph.D., Anthropology, University of Arizona
Technical Experience:	22 years of experience in cultural resources interpretation
SWEIS Responsibility:	Cultural resources

Name:	**Claudia Oakes**
Affiliation:	Parsons Brinckerhoff
Education:	Ph.D. (ABD), Geography, University of Texas at Austin
Technical Experience:	5 years as an environmental specialist in biogeographic studies and geophysical and cultural applications
SWEIS Responsibility:	Cultural resources

Name:	**John Ordaz**
Affiliation:	U.S. Department of Energy
Education:	B.S., Chemical Engineering, New Jersey Institute of Technology
Technical Experience:	20 years of experience, including over 7 years in DOE program management and NEPA compliance
SWEIS Responsibility:	DOE/HQ Program Manager; also, Lead Preparer for the Comment Response Document (volume IV)

Name:	**Carol S. Pazera**
Affiliation:	Parsons Brinckerhoff
Education:	B.A., Secondary Education, University of Illinois M.A., Latin American Studies, University of Texas at Austin M.S., Community and Regional Planning, University of Texas at Austin
Technical Experience:	3 years in socioeconomics
SWEIS Responsibility:	Socioeconomics

Name:	**Chuck Pergler**
Affiliation:	GRAM, Inc.
Education:	B.S., Range and Wildlands Science, University of California M.S., Range Management, University of California
Technical Experience:	14 years developing and implementing natural resource range plans, biological assessments, NEPA manager, and technical author
SWEIS Responsibility:	Biodiversity and ecological risk

Name:	**Susan Perlman**
Affiliation:	SWCA Environmental Consultants
Education:	B.S., Environmental Forestry, Colorado State University M.A., History, New Mexico State University
Technical Experience:	8 years of historical research in ethnography
SWEIS Responsibility:	Cultural resources

Name:	**Jeffrey P. Petraglia**
Affiliation:	Tetra Tech, Inc.
Education:	B.A., Nuclear Engineering, Pennsylvania State University
Technical Experience:	14 years of experience in safety and accident analyses
SWEIS Responsibility:	Aircraft crash accident analysis

Name:	**Beverly Ausmus Ramsey**
Affiliation:	Enterprise Advisory Services, Inc.
Education:	B.S., Chemistry/Biology M.S., Systems Ecology Ph.D., Systems Ecology
Technical Experience:	29 years of experience in environmental management and facility operations, especially radiological, hazardous and mixed waste management, facilities licensing, and regulatory compliance. Experience includes more than 25 years of experience in NEPA analysis and documentation, including human health impacts, ecological impacts, and cumulative impacts analysis
SWEIS Responsibility:	Technical Advisor on human health

Name:	**William R. Rhyne**
Affiliation:	H&R Technical Associates
Education:	B.S., Nuclear Engineering, University of Tennessee M.S., Nuclear Engineering, University of Virginia D.Sc., Nuclear Engineering, University of Virginia
Technical Experience:	• Over 30 years of experience in transportation risk analysis, DOE nuclear facility safety analysis, and commercial nuclear reactor safety analysis • Author or co-author of more than 50 reports and publications in the areas of transportation risk analysis and nuclear facility safety analysis • Author of Hazardous Materials Transportation Risk Analysis: Quantitative Approaches for Truck and Train
SWEIS Responsibility:	Transportation risk analysis

Name:	**Eric Rogoff**
Affiliation:	GRAM, Inc.
Education:	B.S., Geology, with Distinction, University of Kansas M.S., Hydrology, University of Arizona M.Phil., Geology, Yale University
Technical Experience:	7 years of experience in environmental consulting
SWEIS Responsibility:	Water resources, geology, and soils

Name:	**Francis Rowsome**
Affiliation:	U.S. Department of Energy
Education:	B.A., Physics (cum laude), Harvard University Graduate studies in theoretical physics, Cornell University
Technical Experience:	24 years of experience in nuclear safety engineering
SWEIS Responsibility:	Technical Advisor for accident analysis

Name:	**Noel Savignac**
Affiliation:	Self-employed Consultant
Education:	B.A., Biology, Lake Forest College M.S., Physiology, University of New Mexico Ph.D., Health Physics, Colorado State University
Technical Experience:	27 years in radiation protection, environmental assessment, and impact analyses
SWEIS Responsibility:	Human health

Name:	**Steve Sholly**
Affiliation:	BETA Corporation, International
Education:	B.S., Shippensburg State College
Technical Experience:	15 years in risk assessment, safety analysis, and hazards analysis
SWEIS Responsibility:	Accident analysis

Name:	**Mark Sifuentes**
Affiliation:	U.S. Department of Energy
Education:	B.S., Biology (Chemistry minor) M.S., Microbiology (Radiobiology minor)
Technical Experience:	28 years in NEPA compliance and biological sciences
SWEIS Responsibility:	Lead Preparer for: biological and ecological resources, and cultural resources

Name:	**Donald G. Silva**
Affiliation:	GRAM, Inc.
Education:	E.M.B.A., Management, University of New Mexico M.S.C.E., Air Pollution, New York University M.S., Industrial Hygiene, Environmental Health, Harvard University B.C.E., Sanitary Engineering, Manhattan College
Technical Experience:	• 38 years in environmental field including 27 years in direct NEPA documentation and methodology development • Diplomat of American Academy of Environmental Engineers
SWEIS Responsibility:	Contractor (GRAM, Inc.) Project Manager 1996 to 1997

Name:	**Bret E. Simpkins**
Affiliation:	Tetra Tech, Inc.
Education:	B.S., Nuclear Engineering, University of New Mexico M.S., Nuclear Engineering, University of New Mexico
Technical Experience:	13 years of experience in Safety and Accident Analyses
SWEIS Responsibility:	Accident analysis

Name:	**Constance L. Soden**
Affiliation:	U.S. Department of Energy
Education:	B.A., Radiation Biophysics
Technical Experience:	23 years of experience in the areas of occupational health and environmental protection
SWEIS Responsibility:	Lead Preparer for cumulative and unavoidable impacts

Name:	**Joel Soden**
Affiliation:	Parsons Brinckerhoff
Education:	M.S., Hunter College
Technical Experience:	• 24 years in air quality • Supervised a number of projects in various air quality fields
SWEIS Responsibility:	Nonradiological air quality

Name:	**John Stanford**
Affiliation:	GRAM, Inc.
Education:	B.A., Architecture, University of Houston M.S., City Planning, Georgia Tech
Technical Experience:	• 10 years in city/county urban planning • 3 years at Los Alamos National Laboratory, Facility Management
SWEIS Responsibility:	Land use

Name:	**Arlan Swihart**
Affiliation:	BETA Corporation, International
Education:	B.S., Emergency Administration and Planning, University of North Texas
Technical Experience:	• 3 years in solid waste management • 4.5 years in emergency planning/hazard management (hazard identification, scenario development, and consequence analysis)
SWEIS Responsibility:	Transportation analyses

Name:	**Erich C. Thomas**
Affiliation:	GRAM, Inc.
Education:	B.S., Western Washington University M.S., Western Washington University
Technical Experience:	17 years of technical geologic investigations and related assessments
SWEIS Responsibility:	Environmental restoration

Name:	**Gordon L. Tucker**
Affiliation:	GRAM, Inc.
Education:	M.S., Systems Management, University of Southern California M.S., Meteorology, University of Wisconsin B.S., Electrical Engineering, University of Massachusetts
Technical Experience:	• 25 years in meteorology/atmospheric science • 4 years of hazardous chemicals safety training
SWEIS Responsibility:	Air quality (meteorology and atmospheric dispersion modeling)

Name:	**Leonard R. Voellinger**
Affiliation:	Parsons Brinckerhoff
Education:	B.A., George Washington University M.A., Southwest Texas State University
Technical Experience:	19 years in cultural resource analysis and management
SWEIS Responsibility:	Cultural resources

Name:	**Darlene Williams**
Affiliation:	GRAM, Inc.
Education:	B.A., Geology and Mineralogy, Williams College
Technical Experience:	• 6 years in the hazardous waste management industry • Experience includes oversight work for the EPA, Remedial Investigation/Feasibility Study report preparation and work on DOE’s Transuranic Waste Program
SWEIS Responsibility:	Geology and soils

Name:	**Michael Williams**
Affiliation:	BETA Corporation, International
Education:	B.S., Environmental & Resource Management, Southwest Texas State University
Technical Experience:	10 years of experience in environmental assessments, environmental restoration, emergency response, accident analysis/ accident investigation, and regulatory compliance
SWEIS Responsibility:	Accident analysis and transportation analysis

Name:	**Elizabeth Withers**
Affiliation:	U.S. Department of Energy
Education:	B.S., Botany, Louisiana Tech University M.S., Life Sciences, Louisiana Tech University
Technical Experience:	16 years in environmental analysis experience, including 5 years in plant taxonomy and wetland ecology, 5 years in RCRA and CERCLA compliance and human health risk analysis, and 6 years in NEPA compliance
SWEIS Responsibility:	Lead Preparer for land resources; also participated in ecological resources analysis

Name:	**Steven Wolf**
Affiliation:	Parsons Brinckerhoff
Education:	M.S., Mathematics
Technical Experience:	22 years of preparing risk assessments to include noise and vibrations
SWEIS Responsibility:	Noise and vibration analysis

CHAPTER 9.0
LIST OF AGENCIES, ORGANIZATIONS, AND INDIVIDUALS TO WHOM COPIES OF THIS SWEIS HAVE BEEN SENT

UNITED STATES SENATE

The Honorable Jeff Bingaman
Washington, D.C.

The Honorable Jeff Bingaman
Albuquerque, New Mexico

The Honorable Jeff Bingaman
Subcommittee on Strategic Forces
Committee on Armed Services
Washington, D.C.

The Honorable Pete V. Domenici
Washington, D.C.

The Honorable Pete V. Domenici
Albuquerque, New Mexico

The Honorable Pete V. Domenici
Subcommittee on Energy and Water Development
Committee on Appropriations
Washington, D.C.

The Honorable Harry Reid
Subcommittee on Energy and Water Development
Committee on Appropriations
Washington, D.C.

The Honorable Robert Smith
Subcommittee on Strategic Forces
Committee on Armed Services
Washington, D.C.

UNITED STATES HOUSE OF REPRESENTATIVES

The Honorable Duncan Hunter
Subcommittee on Military Procurement
Committee on National Security
Washington, D.C.

The Honorable Ron Packard
Subcommittee on Energy and Water Development
Committee on Appropriations
Washington, D.C.

The Honorable Norman Sisisky
Subcommittee on Military Procurement
Committee on National Security
Washington, D.C.

The Honorable Joseph Skeen
Washington, D.C.

The Honorable Joseph Skeen
Roswell, New Mexico

The Honorable Thomas Udall
Washington, D.C.

The Honorable Thomas Udall
Santa Fe, New Mexico

The Honorable Peter Visclosky
Subcommittee on Energy and Water Development
Committee on Appropriations
Washington, D.C.

The Honorable Heather Wilson
Washington, D.C.

The Honorable Heather Wilson
Albuquerque, New Mexico

FOUR ACCORD PUEBLOS

Governor Isaac Herrera
Pueblo of Cochiti
Cochiti, New Mexico

Governor Raymond Gachupin
Pueblo of Jemez
Jemez, New Mexico

Governor Terry Aguilar
Pueblo de San Ildefonso
Santa Fe, New Mexico

Governor Walter Dasheno
Pueblo of Santa Clara
Española, New Mexico

PUEBLOS AND TRIBAL GOVERNMENTS

Northern Pueblos and Tribal Governments

Governor David Perez
Pueblo of Nambe
Santa Fe, New Mexico

Governor Eagle Rael
Pueblo of Picuris
Peñasco, New Mexico

Governor Jacob Viarrial
Pueblo of Pojoaque
Santa Fe, New Mexico

Governor Anthony Moquino
Pueblo of San Juan
San Juan, New Mexico

Governor Carl Concha
Pueblo of Taos
Taos, New Mexico

Governor Milton Herrera
Pueblo of Tesuque
Santa Fe, New Mexico

President Arnold Cassador
Jicarilla Apache Tribe
Dulce, New Mexico

President A. Paul Ortega
Mescalero Apache Tribe
Mescalero, New Mexico

President Kelsey Begay
Navajo Nation
Window Rock, Arizona

Southern Pueblos

Governor Lloyd Tortalita
Pueblo of Acoma
Acomita, New Mexico

Governor Alvino Lucero
Pueblo of Isleta
Isleta, New Mexico

Governor Harry Early
Pueblo of Laguna
Laguna, New Mexico

Governor Anthony Ortiz
Pueblo of San Felipe
San Felipe, New Mexico

Governor Inez Baca
Pueblo of Sandia
Bernalillo, New Mexico

Governor Bruce Sanchez
Pueblo of Santa Ana
Bernalillo, New Mexico

Governor Alex Bailon
Pueblo of Santo Domingo
Santo Domingo, New Mexico

Governor Amadeo Shije
Pueblo of Zia
Zia Pueblo, New Mexico

Governor Malcolm Bowekaty
Pueblo of Zuni
Zuni, New Mexico

ADDITIONAL TRIBAL AND PUEBLO GOVERNMENT AND ORGANIZATIONS

Stanley Pino, Chairman
All Indian Pueblo Council
Albuquerque, New Mexico

Bernie Teba, Director
Eight Northern Indian Pueblo Council
San Juan Pueblo, New Mexico

William Weahkee, Director
Five Sandoval Indian Pueblos, Inc.
Bernalillo, New Mexico

Leigh Jenkins
Hopi Cultural Preservation Office
Kykotsmovi, Arizona

Department of Environmental and Cultural Preservation
Pueblo de San Ildefonso
Santa Fe, New Mexico

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U.S. Department of Agriculture
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Santa Fe National Forest
Santa Fe, New Mexico

Robert Remillard
U.S. Department of Agriculture
Santa Fe National Forest
Forest Service
Los Alamos, New Mexico

Mary Elizabeth Hoinkes
Arms Control and Disarmament Agency
Washington, D.C.

John Bellinger
U.S. Army Corps of Engineers
Office of Environmental Policy
Washington, D.C.

Carol McKinney
U.S. Army Corps of Engineers
Albuquerque, New Mexico

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U.S. Army Corps of Engineers
Albuquerque, New Mexico

Assistant to the Secretary for
U.S. Department of Defense
Nuclear, Chemical, and Biological Defense Programs
Washington, D.C.

Albert G. Jordan
Defense Nuclear Facilities Safety Board
Washington, D.C.

Andrew Thibadeau
Defense Nuclear Facilities Safety Board
Washington, D.C.

Michael P. Jansky
U.S. Environmental Protection Agency
Dallas, Texas

Richard Sanderson
U.S. Environmental Protection Agency
Office of Federal Activities
Washington, D.C.

Bob Barker
U.S. Department of the Interior
Bureau of Indian Affairs
Albuquerque, New Mexico

Willie R. Taylor
U.S. Department of the Interior
Office of Environmental Policy and Compliance
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Jennifer Fowler-Propst
U.S. Department of the Interior
Fish and Wildlife Service
Albuquerque, New Mexico

Joel D. Lusk
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Fish and Wildlife Service
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Bandelier National Monument
Los Alamos, New Mexico

Brian Jacobs
U.S. Department of the Interior
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Roy Weaver
U.S. Department of the Interior
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William Cohen
U.S. Department of Justice
Washington, D.C.

Robert Fairweather
Office of Management and Budget
Washington, D.C.

Carl J. Paperiello
U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Washington, D.C.

NEW MEXICO STATE GOVERNMENT

Governor Gary Johnson
Santa Fe, New Mexico

Alletta Belin
Assistant Attorney General
Santa Fe, New Mexico

The Honorable Shannon Robinson
Albuquerque, New Mexico

Senator DeDe Feldman
Albuquerque, New Mexico

The Honorable Jeannette Wallace
State Representative
Los Alamos, New Mexico

Gedi Cibas
New Mexico Environment Department
Santa Fe, New Mexico

Michael Dale
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Los Alamos, New Mexico

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Regis Pecos
New Mexico Office of Indian Affairs
Santa Fe, New Mexico

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New Mexico State Land Office
Santa Fe, New Mexico

Steve Cary
Office of Natural Resources Trustee
Santa Fe, New Mexico

LANL SWEIS Cooperating Agency

Fred Brueggeman
Los Alamos County
Los Alamos, New Mexico

Denise Smith
Los Alamos County Council
Los Alamos, New Mexico

Lawry Mann
Los Alamos County Council
Los Alamos, New Mexico

Local Government

Mayor Ross Chavez
City of Española
Española, New Mexico

Mayor Larry Delgado
City of Santa Fe
Santa Fe, New Mexico

Companies and Institutions

Battelle
Evergreen, Colorado

Ann Berkley Rodgers
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Jicarilla Culture Center
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Los Alamos, New Mexico

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State Historic Preservation Officer
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Tribal Environmental Watch Alliance
Española, New Mexico

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Santa Fe, New Mexico

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Western Network
Santa Fe, New Mexico

Bob McNeil
WIPP Environmental Evaluation Group
Albuquerque, New Mexico

INDIVIDUALS

Gary Andrews
Albuquerque, New Mexico

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Wadena, Minnesota

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Santa Fe, New Mexico

Ray Armenta
Los Alamos, New Mexico

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Jemez Springs, New Mexico

Kelly Black
Los Alamos, New Mexico

Bonnie Bonneau
El Prado, New Mexico

Richard Browning
Los Alamos, New Mexico

Shelley Buonaiuto
Santa Fe, New Mexico

Bruce & Loraine Buvinger
Albuquerque, New Mexico

Jessica Caplan
Madrid, New Mexico

Pat Casados
Los Alamos, New Mexico

Mary Ray Cate, M.D.
Santa Fe, New Mexico

Peter Chestnut
Albuquerque, New Mexico

Jody Clark
Socorro, New Mexico

Frank Clinard
Los Alamos, New Mexico

Barbara Conroy
Santa Fe, New Mexico

Al Cucchiara
Los Alamos, New Mexico

Shirley G. Davis
Santa Fe, New Mexico

Bob Day
Los Alamos, New Mexico

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Los Alamos, New Mexico

Mike Dempseye
White Rock, New Mexico

Scott Denbaars
Los Alamos, New Mexico

Richard Deyo
Santa Fe, New Mexico

Elizabeth Dunham
Santa Fe, New Mexico

Gregg Eiesler
Los Alamos, New Mexico

John Eklund
Los Alamos, New Mexico

Eric Ericson
Santa Fe, New Mexico

Tom Farmer
Los Alamos, New Mexico

Eric Fern
Los Alamos, New Mexico

Geoff Fettos
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CHAPTER 10.0
GLOSSARY

This glossary lists terms of art or scientific expressions that may not be familiar to some readers of the SWEIS. The terms are defined as they are used in the SWEIS. Statutes or laws are defined and discussed in volume I of the SWEIS, chapter 7, Applicable Laws, Regulation, and Other Requirements.

Absorbed dose: The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray) (10 CFR 835.2).

Accident: Unexpected or undesirable event that leads to the release of hazardous material within a facility or into the environment, exposing workers or the public to hazardous materials or radiation.

Accord Pueblos: Four Pueblos that have each executed formal accord documents with DOE setting forth the government-to-government relationship between each of the Pueblos and DOE. The four Pueblos are Cochiti, San Ildefonso, Santa Clara, and Jemez.

Actinide: Any of a series of elements with atomic numbers ranging from actinium-89 through lawrencium-103.

Acute exposure: A single or short-term exposure to a toxic substance that may result in health effects.

Advisory Council of Historic Preservation (Council): An independent 19-member federal council created by the *National Historic Preservation Act of 1996*, Title II (16 U.S.C. §470 *et seq.*). The council meets quarterly to review and comment on National Register of Historic Places and Section 106 compliance cases.

Adverse effect: A change produced to an eligible cultural resource that results in demised integrity of location, setting, design, physical condition, materials, workmanship, feeling, or association. When applied to humans or animals, an undesirable health effect.

Air pollutant: Any substance in air that could, if in high enough concentration, harm humans, other animals, or vegetation.

Air quality standards: The level of pollutants in the air prescribed by regulations that may not be exceeded during a specified time in a defined area.

Alpha emitter: A radioactive substance that decays by releasing an alpha particle.

Alpha particle: A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air).

Alpha radiation: A strongly ionizing, but weakly penetrating, form of radiation consisting of positively charged alpha particles emitted spontaneously from the nuclei of certain elements during radioactive decay. Alpha radiation is the least penetrating of the four common types of ionizing radiation (alpha, beta, gamma, and neutron). Even the most energetic alpha particle generally fails to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha radiation is most hazardous when an alpha-emitting source resides inside an organism.

Ambient air: That portion of the atmosphere, external to buildings, to which the general public is exposed.

Americium: Americium is a manmade metal that is slightly heavier than lead. Americium-241 is produced by the radioactive decay of plutonium-241; in addition to being an alpha-emitter, it is an emitter of gamma rays. Americium-241 has a half-life of 433 years.

Aquifer: Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to conduct groundwater.

Archaeological sites (resources): Any location where humans have altered the terrain or discarded artifacts during either prehistoric or historic times.

Artifact: An object of archaeological or historical interest produced or shaped by human workmanship.

As low as reasonably achievable (ALARA): The approach to manage and control exposures (both individual and collective) to the workforce and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable (10 CFR 835.2).

Atomic Energy Commission (AEC): A five-member commission, established by the *Atomic Energy Act of 1946*, to supervise nuclear weapons design, development, manufacturing, maintenance, modification, and dismantlement. In 1974, the Atomic Energy Commission was abolished and all functions were transferred to the U.S. Nuclear Regulatory Commission and the Administrator of the Energy Research and Development Administration. The Energy Research and Development Administration was later terminated and its functions vested by law in the Administrator were transferred to the Secretary of Energy.

Atomic number: The number of positively charged protons in the nucleus of an atom or the number of electrons on an electrically neutral atom.

Attainment area: An area that the U.S. Environmental Protection Agency has designated as being in compliance with one or more of the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others.

Authorization/safety basis: Those aspects of the facility design basis and operational requirements relied upon by the DOE as necessary to authorize operation. These aspects are considered to be important to the safety of facility operations. The authorization basis is described in documents such as the facility Safety Analysis Report (SAR) and other safety analyses, hazard classification documents, the technical safety requirements (TSRs), DOE-issued safety evaluation reports, and facility-specific commitments made to comply with DOE orders or policies. Authorization basis is considered to be equivalent to safety basis. Authorization basis also is defined as a combination of authorization/safety basis, the environmental basis, and other regulatory basis documents.

Background radiation: Radiation from: (1) naturally occurring radioactive materials that have not been technologically enhanced, (2) cosmic sources, (3) global fallout as it exists in the environment (such as from the testing of nuclear explosive devices), (4) radon and its progeny in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or past human activities, and (5) consumer products containing nominal amounts of radioactive material or producing nominal levels of radiation (10 CFR 835.2).

Badged worker: A worker equipped with an individual dosimeter who has the potential to be exposed to radiation.

Baseline: A quantitative expression of conditions, costs, schedule, or technical progress to serve as a base or standard for measurement during the performance of an effort; the established plan against which the status of resources and the progress of a project can be measured. For the SWEIS, the environmental baseline is the site environmental conditions that are considered representative for the purpose of projecting future impacts.

Beryllium: An extremely lightweight, strong metal used in weapons systems.

Best available technology (BAT): Economically achievable pollution control methods that will allow point sources to comply with the effluent limitations required by the *Clean Water Act*. Factors to be taken into account in assessing what is the best available technology include the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, the cost of achieving such effluent reduction, environmental impacts other than water quality (including energy requirements), and such other factors as the U.S. Environmental Protection Agency Administrator deems appropriate.

Best management practices (BMPs): Structural, nonstructural, and managerial techniques, other than effluent limitations, to prevent or reduce pollution of surface water. They are the most effective and practical means to control pollutants that are compatible with the productive use of the resource to which they are applied. BMPs are used in both urban and agricultural areas. BMPs can include schedules of activities; prohibitions of practices; maintenance procedures; treatment requirements; operating procedures; and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Beta emitter: A radioactive substance that decays by releasing a beta particle.

Beta particle: A negatively charged particle emitted during the radioactive decay of many radionuclides. A beta particle is identical with an electron. It has a short range in air and a small ability to penetrate other materials.

Beta radiation: Ionizing radiation consisting of fast moving, positively or negatively charged elementary particles emitted from atomic nuclei during radioactive decay. Beta radiation is more penetrating but less ionizing than alpha radiation. Negatively charged beta particles are identical to electrons; positively charged beta particles are known as positrons. Both are stopped by clothing or a thin sheet of metal.

Biota: Living organisms including plants and animals.

Blast circle: The area wherein fragments from tests may fall and from which humans are excluded during tests.

Bound/bounding: To use simplifying assumptions and analytical methods in an analysis of impacts or risks such that the result overestimates or describes an upper limit on (i.e., "bounds") potential impacts or risks. A bounding analysis is an analysis designed to overestimate or determine an upper limit to potential impacts or risks. A bounding accident is a hypothetical accident for which the calculated consequences equal or exceed the consequences of all other potential accidents for a particular activity or facility.

Byproduct material: Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Byproduct material is exempt from regulation under the *Resource Conservation and Recovery Act*. However, the exemption applies only to the actual radionuclides dispersed or suspended in the waste substance. Any nonradioactive hazardous waste component of the waste is subject to regulation under the *Resource Conservation and Recovery Act*.

Caldera: A large crater formed by the collapse of the central part of a volcano.

Cancer: The name given to a group of diseases characterized by uncontrolled cellular growth with cells having invasive characteristics such that the disease can transfer from one organ to another.

Candidate species: Plants and animals native to the U.S. for which the U.S. Fish and Wildlife Service or the National Marine Fisheries Service has sufficient information on biological vulnerability and threats to justify proposing to add them to the threatened and endangered species list, but cannot do so immediately because other species have a higher priority for listing. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service determine the relative listing priority of candidate taxa in accordance with general listing priority guidelines published in the *Federal Register*.

Canned subassemblies: A component in certain nuclear explosives that may contain natural, depleted, or highly enriched uranium or lithium. The "secondary" in a nuclear weapon.

Capability: The combination of equipment, facilities, infrastructure, and expertise required to undertake types or groups of activities and implement mission element assignments.

Cavate Pueblo: Structure making use of natural rock to form the sides of a single structure or group of buildings, frequently by hollowing out the interior space.

Cesium: A silver-white alkali metal. A radioactive isotope of cesium, cesium-137, is a common fission product.

Characteristic waste: A solid waste defined as hazardous because it exhibits one of the following four characteristics: ignitibility, corrosivity, reactivity, or toxicity.

Cladding: A metal coating bonded onto another metal.

Climatology: The characteristics of the weather over a period of time. The science of climatology addresses the causes, distribution, and effects of weather on the environment and humans.

Code of Federal Regulations (CFR): All federal regulations in force are published in codified form in the Code of Federal Regulations.

Cold War period: The historic period from 1949 to 1989, characterized by international tensions and nuclear armament buildup, especially between the U.S. and the U.S.S.R. The era began approximately at the end of World War II when the *Atomic Energy Act* was passed, establishing the Atomic Energy Commission, and ended with the dissolution of the U.S.S.R. into separate republics and the ending of large-scale nuclear weapons production in the U.S.

Collective dose: The sum of the total effective dose equivalent (TEDE) values of all individuals in a specified population. Collective dose is expressed in units of person-rem (or person-sievert) (10 CFR 835).

Committed dose equivalent (CDE): The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert) (10 CFR 835.2).

Committed effective dose equivalent (CEDE): The sum of the committed dose equivalents to various tissues of the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert) (10 CFR 835).

Community (biotic): All plants and animals occupying a specific area and their relationships.

Conceptual design: Efforts to develop a project scope that will satisfy program needs; ensure project feasibility and attainable performance levels of the project for congressional consideration; develop project criteria and design parameters for all engineering disciplines; and identify applicable codes and standards, quality assurance requirements, environmental studies, construction materials, space allowances, energy conservation features, health and safety, safeguards, security requirements, and any other features or requirements necessary to describe the project.

Contact-handled waste: Radioactive waste or waste packages with an external dose rate low enough to permit contact handling by humans during normal waste management activities. Contact-handled transuranic waste means transuranic waste with a surface dose rate not greater than 200 millirem per hour.

Container: The metal envelope in a waste package that provides the primary containment function of the waste package and is designed to meet the containment requirements of 10 CFR 60.

Contamination: The deposition or discharge of chemicals, radionuclides, or particulate matter above a given threshold, usually associated with an effects level onto or into environmental media, structures, areas, objects, personnel, or nonhuman organisms.

Cooperating agency: As defined by the Council on Environmental Quality regulations for implementing NEPA, any federal agency other than a lead agency that has jurisdiction by law of special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major federal action. A state or local agency of similar qualifications or, when the effects are on a reservation, an Indian tribe, may by agreement with the lead agency become a cooperating agency (40 CFR 1508.5).

Credible accident: An accident that has a probability of occurrence greater than or equal to once in a million years.

Criteria of effect: Regulations in 36 CFR Parts 800.5(a) and 800.9(b) and Section 106 of the *National Historic Preservation Act* (16 U.S.C. §470 *et seq.*) that provide guidelines for determining the kind and intensity of effect to an eligible cultural resource.

Criteria pollutant: Six air pollutants for which National Ambient Air Quality Standards are established by the U.S. Environmental Protection Agency: sulfur dioxide, nitric oxides, carbon monoxide, ozone, particulate matter-10 (smaller than 10 microns in diameter), and lead.

Critical habitat: Habitat essential to the conservation of an endangered or threatened species that has been designated as critical by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures outlined in the *Endangered Species Act* and its implementing regulations (50 CFR 424). The lists of critical habitats can be found in 50 CFR 17.95 (fish and wildlife), 50 CFR 17.96 (plants), and 50 CFR 226 (marine species).

Criticality event or accident: The accidental creation of an uncontrolled, self-sustaining nuclear chain reaction, accompanied by highly damaging external ionizing radiation.

Cultural resources: Any prehistoric or historic sites, buildings, structures, districts, or other places or objects (including biota of importance) considered to be important to a culture, subculture, or community for scientific, traditional, or religious purposes or for any other reason. In the SWEIS, prehistoric cultural resources refer to any material remains and items used or modified by people before the establishment of a European presence in the upper Rio Grande Valley in the early 17th Century; historic cultural resources include all material remains and any other physical alteration of the landscape that has occurred since the arrival of Europeans in the region.

Cultural resource site: The specific place or location of regular human occupation or use, as indicated by one or more forms of physical evidence.

Cultural resources survey: Evaluating the significance of the resources and their eligibility for inclusion in the National Register of Historic Places.

Cumulative impacts: The impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal), private industry, or individuals undertake such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time (40 CFR 1508.7).

Curie (Ci): The conventional unit of activity in a sample of radioactive material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie also is a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

Decay (radioactive): The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous transformation of an unstable nuclide into a different nuclide or into a different energy state of the same nuclide; the emission of nuclear radiation (alpha, beta, or gamma radiation) is part of the process.

Decibel (dB): A unit of sound measurement. In general, a sound doubles in loudness for every increase of 10 decibels.

Decibel, A-weighted (dBa): A unit of weighted sound pressure level measured by the use of a metering characteristic and the “A” weighting specified by the American National Standards Institute (S1.4-1971[R176]).

Decommissioning: As used in this SWEIS, the process of decontamination, disassembly, and storage or disposal in a manner and state that assures future exposure of humans and the environment would be at acceptable levels.

Decontamination: The removal or reduction of radioactive or chemical contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

Depleted uranium (DU): Uranium containing less uranium-235 than the naturally occurring distribution of uranium isotopes.

Deposition: In geology, the laying down of potential rock-forming materials (sedimentation). In atmospheric sciences, the collection and retention of airborne particulates of gases on any solid or liquid surface (called dry deposition), or their removal from the air by precipitation (called wet deposition or precipitation scavenging).

Derived concentration guide (DCG): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for 1 year by one exposure mode (e.g., ingestion of water, submersion in air, or inhalation of air), would result in an effective dose equivalent equal to the annual dose limit for that group exposed. For the public, this would be a dose of 100 millirem to a reference human who inhales 296,000 cubic feet (8,400 cubic meters) of air and ingests 195 gallons (730 liters) of water in a year.

Design basis accident: An accident postulated for the purpose of establishing functional and performance requirements for safety structures, systems, and components.

Design laboratory (or weapons laboratory): DOE facilities involved in the design of nuclear weapons.

Detailed operating procedure (DOP): Approved and authorized procedures for conducting a task.

Detriment: Negative effects from exposure to ionizing radiation. Harmful effects on health are called "health detriment."

Deuterium: A nonradioactive isotope of the element hydrogen with one neutron and one proton in the atomic nucleus.

Direct economic effects: The initial increases in output from different sectors of the economy resulting from some new activity within a predefined geographic region.

Direct effect multiplier: The total change in regional earnings and employment in all related industries as a result of one-dollar changes in earnings and an on-the-job change in a given industry.

Dismantlement: The process of taking apart a nuclear weapon or nuclear weapon component. This process takes place at LANL.

Dispersion: The downwind spreading of a plume by turbulence and meander in wind direction, resulting in a plume of lower concentration over a larger area.

Disposal: The process of placing waste in a final repository.

Disposal cell: Trench for disposal of low-level waste.

Disposition: The ultimate fate or end use of a surplus nuclear material or DOE facility following the transfer of the facility to the Office of the Assistant Secretary for Environmental Waste Management or the Director of the Office of Fissile Materials Disposition.

DOE orders: DOE directives that promulgate requirements and policies to DOE employees and contractors, including requirements to comply with other laws and regulations.

Dose (or radiation dose): The amount of energy deposited in body tissue as a result of radiation exposure. Various technical terms, such as absorbed dose, collective dose, dose equivalent, and effective dose equivalent, are used to evaluate the amount of radiation an exposed person receives. Each of these terms is defined in this glossary.

Dose equivalent: The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert) (10 CFR 835.2).

Dosimeter: A device, instrument, or system that measures radiation dose (e.g., film badge or ionization chamber).

Drawdown: The height difference between the natural water level in a formation and the reduced water level in the formation caused by the withdrawal of groundwater.

Drinking-water standards: The prescribed level of constituents or characteristics in a drinking water supply that cannot be exceeded legally.

Ecology: A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment.

Ecosystem: Living organisms and their nonliving (abiotic) environment functioning together as a community.

Ecotone: Transition zone between two adjacent distinct plant or animal communities.

Effective dose equivalent (EDE): The summation of the products of the dose equivalent received by specified tissues or organs of the body and the appropriate weighting factor. It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem (or sievert) (10 CFR 835.2).

Effluent: A waste stream flowing into the atmosphere, surface water, groundwater, or soil. Most frequently the term applies to wastes discharged to surface waters.

Eligibility: The criteria of significance in American history, architecture, archeology, engineering, and culture. The criteria require integrity and association with lives or events, distinctiveness for any of a variety of reasons, or importance because of information the property does or could hold.

Eligible cultural resource: A cultural resource that has been evaluated and reviewed by an agency and the State Historic Preservation Office(r) and recommended as eligible for inclusion in the National Register of Historic Places, based on the criteria of significance.

Emission standards: Legally enforceable limits on the quantities and/or kinds of air contaminants that can be emitted into the atmosphere.

Endangered species: Plants and animals that are threatened with extinction, serious depletion, or destruction of critical habitat. Requirements for declaring a species endangered are contained in the *Endangered Species Act*.

Enduring stockpile: The U.S. nuclear stockpile of the future, consisting of fewer than 10 weapon systems (many of them older than their design lifetime), with no new systems added to the stockpile for the foreseeable future.

Energetic material: Generic term for high explosives and propellants.

Enriched uranium: A mixture of uranium isotopes that has greater amounts of the isotope uranium-235 than occur naturally. Naturally occurring uranium is nominally 0.720 percent uranium-235.

Environmental assessment (EA): A written environmental analysis that is prepared pursuant to the *National Environmental Policy Act* to determine whether a major federal action could significantly affect the environment and thus require preparation of an environmental impact statement. If the action would not significantly affect the environment, then a Finding of No Significant Impact is issued.

Environmental impact statement (EIS): A document required of federal agencies by the *National Environmental Policy Act* for proposals for legislation or major federal actions significantly affecting the quality of the human environment. A tool for decision making, it describes the positive and negative environmental impacts of the proposed action and alternative actions.

Environmental justice: A requirement of Executive Order 12898 for federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental impacts of federal programs, policies, and activities on minority and low-income populations.

Environmental monitoring: The process of sampling and analysis of environmental media in and around a facility being monitored for the purpose of: (1) confirming compliance with performance objectives and (2) early detection of any contamination entering the environment to facilitate timely remedial action.

Environmental Restoration (ER) Program: Program at LANL responsible for investigation and remediation of solid waste management units (SWMUs).

Ephemeral stream: A stream that flows only after a period of heavy precipitation.

Epicenter: The point on the Earth's surface directly above the focus of an earthquake.

Epidemiology: The science concerned with the study of events that determine and influence the frequency and distribution of disease, injury, and other health-related events and their causes in defined human populations.

Ethnographic: Information about cultural beliefs and practices.

Exposure limit: The legal limit of accumulated exposure (to ionizing radiation, nonionizing radiation, noise, chemicals, or other hazardous substances).

Exposure pathway: The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a mechanism by which chemicals or physical agents at or originating from a release site reach an individual or population. Each exposure pathway includes a source or release from a source, an exposure route, and an exposure point. If the exposure point differs from the source, a transport/exposure medium such as air or water also is included.

Fabrication: For the purpose of the SWEIS, the terms "fabrication" and "manufacturing" are synonymous. See "manufacturing."

Fault: A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred.

Finding of No Significant Impact (FONSI): A document by a federal agency briefly presenting the reasons why an action, not otherwise excluded, will not have a significant effect on the human environment and will not require an environmental impact statement.

Fissile material: Any material consisting of or containing one or more fissile radionuclides. Fissile radionuclides are plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides. The definition does not apply to unirradiated natural uranium and depleted uranium, and natural uranium or depleted uranium that has been irradiated in a thermal reactor (49 CFR 173.403). DOE Order 5480.3 also includes curium-244 and neptunium-237 as fissile materials.

Fission: The splitting of a heavy atomic nucleus into two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.

Fission products: Nuclei formed by the fission of heavy elements (primary fission products); also, the nuclei formed by the decay of the primary fission products, many of which are radioactive.

Floodplains: The lowlands and relatively flat areas adjoining inland and coastal waters and the flood-prone areas of offshore islands. Floodplains include, at a minimum, that area with at least a 1.0 percent chance of being inundated by a flood in any given year.

The "base floodplain" is defined as the area that has a 1.0 percent or greater chance of being flooded in any given year. Such a flood is known as a 100-year flood.

The "critical action floodplain" is defined as the area that has at least a 0.2 percent chance of being flooded in any given year. Such a flood is known as a 500-year flood. Any activity for which even a slight chance of flooding would be too great (e.g., the storage of highly volatile, toxic, or water reactive materials) should not occur in the critical action floodplain.

Formation: In geology, the primary unit of formal stratigraphic mapping or description. Most formations possess certain distinctive features.

Fugitive emissions: Emissions to the atmosphere from pumps, valves, flanges, seals, and other process points not vented through a stack. Also includes emissions from area sources such as ponds, lagoons, landfills, and piles of stored material.

Fusion: The combining of two light nuclei (such as hydrogen isotopes or lithium) to form a heavier nucleus. Fusion is accompanied by the release of large amounts of energy.

Gamma radiation: High-energy, short wavelength, electromagnetic radiation emitted from the nucleus of an atom during radioactive decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium. Gamma rays are similar to, but are usually more energetic than, x-rays.

Genetic effects: Changes in reproductive cells that may result in abnormal offspring of humans or animals (National Council on Radiation Protection [NCRP] 105).

Geology: The science that deals with the Earth: the materials, processes, environments, and history of the planet, including the rocks and their formation and structure.

Glovebox: An airtight box used to work with hazardous material, vented to a closed filtering system, having attached gloves that go into the box permitting work therein.

Groundwater: Water found beneath the Earth's surface.

Half-life (radiological): The time in which half the atoms of a radioactive substance undergo radioactive decay; this varies for specific radioisotopes from millionths of a second to billions of years.

Hazard analysis: The assessment of hazardous situations potentially associated with a process or activity. It includes the identification of material, system, process, and plant characteristics that can produce undesirable consequences. A safety analysis report hazard analysis examines the complete spectrum of potential accidents that could expose members of the public, on-site workers, facility workers, and the environment to hazardous materials. (See "Safety analysis report.")

Hazard category: Classification of nuclear facilities and operations for the potential of on-site and off-site effects from accidents. The criteria for distinguishing among hazard categories are found in DOE Order 5480.23, *Nuclear Safety Analysis Reports*.

Hazard index (HI): An indicator of the potential toxicological hazard from exposure to a particular substance; one such HI is the ratio of the estimated exposure to the estimated safe exposure. No toxicological effects would be expected where the HI is less than 1.0.

Hazardous air pollutants (HAPs): Air pollutants not covered by ambient air quality standards but that may present a threat of adverse human health effects or adverse environmental effects. Those specifically listed in 40 CFR 61.01 are asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. More broadly, HAPs are any of the 189 pollutants listed in or pursuant to Section 112(b) of the *Clean Air Act*. Very generally, HAPs are any air pollutants that may realistically be expected to pose a threat to human health or welfare.

Hazardous material: A material, including a hazardous substance, as defined by 49 CFR 171.8 that poses a risk to health, safety, and property when transported or handled.

Hazardous waste: A solid waste that, because of its quantity, concentration, or physical chemical or infectious characteristics, may significantly contribute to an increase in mortality; or may pose a potential hazard to human health or the environment when improperly treated, stored, or disposed. The *Resource Conservation and Recovery Act of 1980* defines a "solid" waste as including solid, liquid, semisolid, or contained gaseous material (42 U.S.C. 6901 *et seq.*). By definition, hazardous waste has no radioactive components.

Heredity effects: Changes that are passed on to succeeding generation of offspring. See "Genetic effects."

High-efficiency particulate air (HEPA) filter: A throwaway, extended media, dry-type filter with a rigid casing enclosing the full depth of the pleats. The filter exhibits a minimum efficiency of 99.97 percent when tested with an aerosol of essentially monodispersed 0.3 micrometer diameter test aerosol particles.

High explosives (HE): Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressure in the surrounding medium. Defined by 40 CFR 261.23 as any material that exhibits the characteristic of reactivity.

High explosives fabrication: The ability to fabricate any chemical compound or mechanical mixture that, when subjected to heat, impact, fraction, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium.

High-level waste (HLW): The highly radioactive waste that results from reprocessing spent nuclear fuel and irradiated targets from reactors and is liquid before it is treated and solidified. LANL has no HLW in its inventory.

Highly enriched uranium (HEU): A mixture of uranium isotopes in which the abundance of the isotope uranium-235 is increased to 20 percent or more by weight, well above normal (naturally occurring) levels.

Historic context: A planning unit that is based on a shared theme, specific time period, and geographical area. Historical contexts are developed for predicting the types of sites and activities that may have taken place and determining how the sites might fit into the context. The evaluation process using the historic context to identify data deficits as criteria for evaluation.

Historic district: A significant concentration, linkage, or continuity of sites, buildings, structures, or objects historically or aesthetically united by plan or physical development and eligible for inclusion in the National Register of Historic Places because of cultural significance.

Hydrodynamic test: High-explosives nonnuclear experiment to investigate hydrodynamic aspects of primary function up to mid to late stages of pit implosion.

Hydrodynamics: The study of the motion of a fluid and of the interactions of the fluid with its boundaries, especially in the case of an incompressible inviscid fluid.

Hydrology: The science dealing with the properties, distribution, and circulation of water on and below the Earth's surface and in the atmosphere.

Implosion: Sudden inward compression and reduction in volume.

Incident-free risk: The risk of effects during normal conditions, not including the additional risk posed by incidents and accidents.

Index: A selected recent data set that is considered representative of current conditions and serves as a baseline for projecting future changes.

Indirect economic effects: Indirect effects result from the need to supply industries experiencing direct economic effects with additional outputs to allow them to increase their production. The additional output from each directly affected industry requires inputs from other industries within a region (i.e., purchases of goods and services). This results in a multiplier effect to show the change in total economic activity resulting from a new activity in a region.

Inertial confinement fusion (ICF): A laser-initiated nuclear fusion using the inertial properties of the reactants as a confinement mechanism.

Infrastructure: The basic services, facilities and equipment needed for the functioning and growth of an area.

Interim (permit) status: Period during which treatment, storage, and disposal facilities coming under the *Resource Conservation and Recovery Act of 1980* are temporarily permitted to operate while awaiting denial or issuance of a permanent permit.

Intersite: Transportation or other activities involving other sites.

Intrasite: Transportation or activities occurring solely within the boundaries of a facility.

Ion: An atom or molecule that has gained or lost one or more electrons to become electrically charged.

Ion exchange: A unit physiochemical process that removes ions, including radionuclides, from liquid streams (usually water) for the purpose of purification or decontamination.

Ionizing radiation: Radiation with sufficient energy to displace electrons from atoms or molecules, thereby producing ions.

Isolated find: A single artifact with no verifiable association with other cultural resources or other elements that would enlarge the historic information it contains.

Isotope: Nuclei of the same element with different numbers of neutrons are isotopes of the element. Isotopes have the same chemical properties but may have different radioactive properties.

Joint test assembly: A nonnuclear test configuration, with diagnostic instrumentation, of a warhead or bomb.

Key facility: Certain LANL facilities that were selected for special attention in the SWEIS. Selection criteria for key facilities are discussed in volume I, section 2.2.2 of the SWEIS.

Kiva: In this SWEIS, one of the remote-controlled critical assembly buildings associated with the Los Alamos Critical Experiment Facility (LACEF).

Laser: A device that produces a beam of monochromatic (single-color) "light" in which the waves of light are all in phase. This condition creates a beam that has relatively little scattering and has a high concentration of energy per unit area.

Latent cancer fatality (LCF): Death from cancer resulting from, and occurring some years after, exposure to excess ionizing radiation or other carcinogens.

Limiting condition for operation (LCO): The lowest functional capability or performance levels of safety-related structures, systems, components, and their support systems required for normal, safe operation of the facility.

Lithic scatter: Concentrations of stones showing evidence of human manufacturing of stone tools, including finished artifacts, roughly formed artifacts, the cores of stone from which they were made, and the waste flakes from the tool manufacturing process.

Low-income population: Community in which 25 percent or more of the population is characterized as living in poverty. The SWEIS uses the U.S. Bureau of the Census 1990 data to establish poverty thresholds; the 1990 poverty threshold for unrelated individuals was a 1989 income of $6,451 for those under age 65; $5,947 for those age 65 and older; and $12,674 for a family of four.

Low-level radioactive mixed waste (LLMW): Waste that contains both hazardous and low-level radioactive components. The hazardous component in LLMW is subject to regulation under the *Resource Conservation and Recovery Act of 1980*.

Low-level radioactive waste (LLW): All radioactive waste that is not classified as high-level waste, transuranic waste, spent nuclear fuel, or "11e(2) by-product material" as defined by DOE Order 5820.2A, *Radioactive Waste Management*. Byproduct material includes the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as LLW, provided the concentration of transuranic waste is less than 100 nanocuries per gram.

Manufacturing: For the purpose of the SWEIS, the terms "fabrication" and "manufacturing" are synonymous. LANL has an existing capability to fabricate or manufacture plutonium parts. That is, the equipment, knowledge, supporting infrastructure, and administration procedures and controls exist at LANL to create plutonium metallic shapes to precise specifications. This capability is currently used in support of existing missions for research and development and to build prototypes of parts.

Maximally exposed individual (MEI): A hypothetical person whose location and habits result in the highest concentration or exposure and who takes no protective actions to lessen his or her exposure.

Maximum contaminant level (MCL): The MCL is the maximum permissible level of a contaminant in water that is delivered to any user of a public water system, as measured within the system or at entry points, depending upon the contaminant (40 CFR 141).

Megawatt (MW): A unit of power equal to 1 million watts. Megawatt thermal is commonly used to define heat produced, while megawatt electric defines electricity produced.

Meteorology: The science dealing with the atmosphere and its phenomena, especially as relating to weather.

Migration: The natural movement of a material through the air, soil, or groundwater; also, seasonal movement of animals from one area to another.

***Migratory Bird Treaty Act*:** This act states that it is unlawful to pursue, take, attempt to take, capture, possess, or kill any migratory bird, or any part, nest, or egg of any such bird other than permitted activities.

Minority population: Area where minority individuals comprise 25 percent or more of the population. Minority refers to people who classified themselves in the 1990 U.S. Census as African Americans, Asian or Pacific Islanders, American Indians, Hispanics of any race or origin, or other non-White races.

Mitigation: The alleviation of adverse impacts on resources by avoidance, by limiting the degree or magnitude of an action, by repair or restoration, by preservation and maintenance that reduces or eliminates the impact, or by replacing or providing substitute resources or environments.

Mixed oxide (MOX): A physical blend of uranium oxide and plutonium oxide that can be used as fuel in a nuclear reactor.

Mixed waste: See low-level radioactive mixed waste.

National Ambient Air Quality Standards (NAAQS): Air quality standards established by the *Clean Air Act*, as amended. The primary NAAQS are intended to protect the public health with an adequate margin of safety, and the secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National Emission Standards for Hazardous Air Pollutants (NESHAP): A set of national emission standards for listed hazardous pollutants emitted from specific classes or categories of new and existing sources. These standards were implemented in the *Clean Air Act Amendments of 1977*.

National Environmental Research Park (NERP): An outdoor laboratory set aside for ecological research to study the environmental impacts of energy developments. NERPs were established by DOE to provide protected land areas for research and education in the environmental sciences and to demonstrate the environmental compatibility of energy technology development and use.

National Pollutant Discharge Elimination System (NPDES): Federal permitting system required for hazardous effluents regulated through the *Clean Water Act*, as amended.

National Pollutant Discharge Elimination System Permit: Federal regulation (40 CFR Parts 122 and 125) requires permits for the discharge of pollutants from any point source into the waters of the U.S. regulated through the *Clean Water Act*, as amended.

National Register of Historic Places (NRHP): A list of districts, sites, buildings, structures, and objects of prehistoric or historic local, state, or national significance maintained by the Secretary of the Interior. The list is expanded as authorized by Section 2(b) of the *Historic Sites Act of 1935* (16 U.S.C. §462) and Section 101(a)(1)(A) of the *National Historic Preservation Act of 1966*, as amended.

Native American: A tribe, people, or culture that is indigenous to the U.S. Also referred to as American Indians.

Natural phenomena accidents: Accidents that are initiated by events such as earthquakes, tornadoes, floods, etc.

Neutron: An uncharged elementary particle with a mass slightly greater than that of the proton, found in the nucleus of every atom heavier than hydrogen-1. A free neutron is unstable and decays with a half-life of about 13 minutes into an electron and a proton.

Neutron flux: The product of neutron number density and velocity (energy) giving an apparent number of neutrons flowing through a unit area per unit time.

Noise: Unwanted or undesirable sound, usually characterized as being so loud as to interfere with, or be inappropriate to, normal activities such as communication, sleep, study, or recreation.

Noncriteria pollutant: A pollutant with an effects screening level guideline. Some noncriteria pollutants have a state standard as well.

Nonattainment area: An air quality control region (or portion thereof) in which the U.S. Environmental Protection Agency has determined that ambient air concentrations exceed National Ambient Air Quality Standards for one or more criteria pollutants.

Nondestructive evaluation: Test method that does not involve damage to or destruction of the test sample; this includes the use of ultrasonics, radiography, magnetic flux, and other techniques.

Nonnuclear component: Any one of the parts of a nuclear weapon that do not contain radioactive or fissile material.

Nonnuclear fabrication: Ability to fabricate nonnuclear components and perform nonnuclear component surveillance.

Nonproliferation: Preventing the spread of nuclear weapons, nuclear weapon materials, and nuclear weapon technology.

Nonproliferation Treaty: A treaty with the aim of controlling the spread of nuclear weapons technologies, limiting the number of nuclear weapons states, and pursuing, in good faith, effective measures relating to the cessation of the nuclear arms race. The treaty does not invoke stockpile reductions by nuclear states, and it does not address actions of nuclear states in maintaining their stockpiles.

Nuclear component: A part of a nuclear weapon that contains fissionable or fusionable material.

Nuclear facility: A facility with operations that involve radioactive materials in such form and quantity that a nuclear hazard potentially exists to the employees or the general public. Included are facilities that: produce, process, or store radioactive liquid or solid waste, fissionable materials, or tritium; conduct separations operations; or conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations. Incidental use of radioactive materials in a facility operation (e.g., check sources, radioactive sources, and x-ray machines) does not necessarily require a facility to be included in this definition.

Nuclear warhead: A warhead that contains fissionable and fusionable material; the nuclear assembly and nonnuclear components packaged as a deliverable weapon.

Nuclear weapons complex: The set of interrelated federal sites and government-owned/contractor-operated facilities supporting the research, development, design, manufacture, testing, and maintenance of the nation's nuclear weapons and the subsequent dismantlement of retired weapons.

Off site (also off-site): As used in the SWEIS, the term denotes a location, facility, or activity occurring outside of the boundary of the entire LANL site.

On site (also on-site): As used in the SWEIS, the term denotes a location or activity occurring somewhere within the boundary of the LANL site.

Operable unit (OU): A discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration or eliminates or mitigates a release, threat of release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units.

Outfall: The discharge point of a drain, sewer, or pipe as it empties into a body of water.

Packaging: The assembly of components necessary to ensure compliance with federal transportation regulations. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle tie-down system and auxiliary equipment may be designated as part of the packaging.

Paleontology: A science dealing with life of past geological periods as known from fossil remains.

Paleontological resources: Fossils including those of microbial, plant, or animal origin.

Particulate matter (PM), PM_{10}, $PM_{2.5}$: Any finely divided solid or liquid material other than uncombined (i.e., pure) water. A subscript denotes the upper limit of the diameter of particles included. Thus, PM_{10} includes only those particles equal to or less than 10 micrometers (0.0004 inch) in diameter; $PM_{2.5}$ includes only those particles equal to or less than 2.5 micrometers (0.0001 inch) in diameter.

Perched aquifer: Groundwater separated from the underlying main body of groundwater, or aquifer, by unsaturated rock.

Perched groundwater: A body of groundwater of small lateral dimensions lying above a more extensive aquifer.

Performance assessment (PA): An analysis that predicts the behavior of a system or system component under a given set of conditions. In the context of "waste management activities," a systematic analysis of the potential risks posed by waste management systems to the public and environment, and a comparison of those risks to established performance objectives.

Permeability: The degree to which, or rate at which a fluid or gas can pass through a substance.

Perennial: Acting or lasting throughout the year or through many years (perpetual).

Person-rem: A redundancy meaning a dose of 1 rem. When used with a collective dose or population dose, it is a unit for expressing the dose when integrated across all people in the population.

Physical setting: The land and water form, vegetation, and structures that compose the landscape.

Pit: An assembly at the center of a nuclear device containing a subcritical mass of fissionable material.

Plume: The elongated pattern of contaminated air or water originating at a point source, such as a smokestack or a hazardous waste disposal site.

Plutonium: A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially in a reactor by bombardment of uranium with neutrons and is used in the production of nuclear weapons.

Pollution prevention: Involves recycling or reduction of any hazardous substance, pollutant, or contaminate before generation, along with practices that protect natural resources through conservation or more efficient use.

Population dose: See "collective dose."

Potable: Suitable for drinking.

Pounds per square inch (psi): A measure of pressure. Atmospheric pressure is about 14.7 psi.

Prehistoric: Of, relating to, or existing in times antedating written history. In this SWEIS, prehistoric cultural resources refer to any material remains and items used or modified by people before the establishment of a European presence in the upper Rio Grande Valley in the early 17th Century.

Production: Fabrication or manufacturing of a relatively large quantity of items (as compared to the research and development and prototype capability). Production usually implies an effort to optimize material flows and improve efficiency and yield as well as the reliability of both the product and the process.

Programmatic environmental impact statement (PEIS): A broad-scope EIS prepared in accordance with the requirements of 102(2)(C) of NEPA that analyzes the environmental impacts of proposed federal policies or programs that involve multiple decisions potentially affecting the environment at one or more sites.

Project-specific environmental impact statement: An EIS prepared in accordance with the requirements of 102(2)(C) of NEPA that evaluates the environmental impacts of a single proposed action. See "Environmental impact statement."

Protected area: An area encompassed by physical barriers, subject to access controls, surrounding material access areas, and meeting the standards of DOE Order 5632.1C, *Protection and Control of Safeguards and Security Interests*.

Pueblo: The communal dwelling of an Indian village of Arizona, New Mexico, or adjacent areas consisting of contiguous flat-roofed stone or adobe houses in groups, sometimes several stories high; an Indian village of the southwestern U.S.; a member of a group of Indian peoples of the southwestern U.S.

Rad: See "Radiation absorbed dose."

Radiation: As used in the SWEIS, means ionizing radiation. The emitted particles or photons from the nuclei of radioactive atoms.

Radiation absorbed dose (rad): The basic unit of absorbed dose equal to the absorption of 0.01 joule per kilogram of absorbing material.

Radioactive: The state of emitting radiation energy in forms of waves (rays) or particles.

Radioactive waste: Materials from nuclear operations that are radioactive or are contaminated with radioactive materials, and for which use, reuse, or recovery are impractical.

Radioactivity: The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

Radioisotopes: See "Isotope."

Radionuclide: Any radioactive element.

Radon: A heavy gaseous, radioactive element with a half life of about 4 days from the decay of radium.

RADTRAN: A computer code combining user-determined meteorological, demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences and accident risk of transporting radioactive material.

Raptor: Birds of prey including various types of hawks, falcons, eagles, vultures, and owls.

Recharge: Replenishment of water to an aquifer.

Record of Decision (ROD): A document prepared in accordance with the requirements of 40 CFR 1505.2 that provides a concise public record of DOE's decision on a proposed action for which an EIS was prepared. A ROD identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by DOE in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not.

Region of influence (ROI): Region in which the principal direct and indirect socioeconomic effects of actions are likely to occur and are expected to be of consequence for local jurisdictions.

Reliability: The ability of a nuclear weapon, weapon system, or weapon component to perform its required function under stated conditions for a specified period of time (essentially equivalent to performance).

Rem (roentgen equivalent man): The conventional unit or radiation dose equivalent. A unit of individual dose of absorbed ionizing radiation used to measure the effect on human tissue. The dosage of an ionizing radiation that will cause the same biological effect as one roentgen of x-ray or gamma-ray exposure.

Remediation: The decontamination of facilities or sites to an acceptable level of contamination suitable for general or specified use.

Remote-handled waste: In general, refers to radioactive waste that must be handled at a distance to protect workers from unnecessary exposure. "Remote-handled transuranic waste" means transuranic waste with a dose rate of 200 millirem per hour or more at the surface of the waste package.

Risk: A quantitative or qualitative expression of possible loss that considers both the probability that a hazard will cause harm and the consequences of that event.

Risk assessment (chemical or radiological): The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific chemical or radiological materials.

Roentgen: A unit of exposure to ionizing x-ray or gamma radiation equal to 2.58×10^{-4} coulomb per kilogram. (A coulomb is a unit of electrical charge.) A roentgen is approximately equal to 1 rad.

Roentgen Equivalent Man (rem): See "Rem."

Runoff: The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and may eventually enter streams.

Safety analysis report (SAR): A safety document providing a concise but complete description and safety evaluation of a site, design, normal and emergency operation, potential accidents, predicted consequences of such accidents, and the means proposed to prevent such accidents or mitigate their consequences. A safety analysis report is designated as final when it is based on final design information; otherwise, it is designated as preliminary.

Safe secure transport (SST): A specially designed trailer, used for transporting nuclear weapons or nuclear weapon components.

Safeguards and security: Program or actions with the express goal of elimination or minimizing the likelihood of unauthorized access to or loss of custody of a nuclear weapon or weapon system, nuclear materials, or sensitive or classified information.

Sanitary wastes: Liquid or solid (includes sludge) wastes that are not hazardous or radioactive and that are generated by industrial, commercial, mining, or agricultural operations or from community activities.

Scope: In a document prepared pursuant to the *National Environmental Policy Act of 1969*, the range of actions, alternatives, and impacts to be considered.

Scoping: Involves the solicitation of comments from interested people, groups, and agencies at public meetings, public workshops, in writing, electronically, or via fax to assist DOE in defining the proposed action, identifying alternatives, and developing preliminary issues to be addressed in an environmental impact statement.

Secondary (assembly): The component of a nuclear weapon that contains elements needed to initiate the fusion reaction in a thermonuclear reaction.

Section 106 process: A *National Historic Preservation Act* (16 U.S.C. §470 *et seq.*) review process used to identify, evaluate, and protect cultural resources eligible for nomination to the National Register of Historic Places that may be affected by federal actions or undertakings.

Sedimentation: The settling out of soil and mineral solids from suspensions under the force of gravity.

Seismic: Pertaining to any earth vibration, especially an earthquake.

Seismic zone: Geographic region that is assumed to possess uniform earthquake potential throughout.

Seismicity: Occurrence of earthquakes in space and time.

Setting: The physical environment of a property.

Severe accident: An accident with a frequency rate of less then 10^{-6} per year that would have more severe consequences than a design-basis accident, in terms of damage to the facility, off-site consequences, or both.

Sewage: The total of organic waste and wastewater generated by an industrial establishment or a community.

Shielding: A material placed between a radiation source and a receptor that absorbs the radiation, thus reducing the exposure to the receptor.

Short-lived nuclides: Radioactive isotopes with half-lives no greater than about 30 years (e.g., cesium-137 and strontium-90).

Site-wide environmental impact statement (SWEIS): A type of programmatic EIS that analyzes the environmental impacts of all or selected functions at a DOE site. As part of its regulations for implementation of NEPA, DOE prepares site-wide EISs for certain large, multiple-facility DOE sites; it may prepare EISs or EAs for other sites to assess the impacts of all or selected functions at those sites (10 CFR 1021.330 [c]).

Socioeconomics: The social and economic condition in the study area.

Solid waste management unit (SWMU): Any unit from which hazardous constituents may migrate, as defined by the *Resource Conservation and Recovery Act.* A designated area that is or is suspected to be the source of a release of hazardous material into the environment that will require investigation and/or corrective action.

Source material: In general, material from which special nuclear material can be derived. Under the *Atomic Energy Act* and U.S. Nuclear Regulatory Commission regulations, "source material" means uranium and thorium in any physical or chemical form, as well as ores that contain 1/20 of 1 percent (0.05 percent) or more by weight of uranium or thorium.

Source term: The quantity of material released and parameters such as exhaust temperature that determine the downwind concentration, given a specific meteorological dispersion condition.

Special nuclear material (SNM): As defined in Section 11 of the *Atomic Energy Act of 1954*, special nuclear material means (1) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U.S. Nuclear Regulatory Commission determines to be special nuclear material or (2) any material artificially enriched by any of the foregoing.

Species of concern: Includes species that are considered to be potential candidates for addition to the List of Endangered Species (50 CFR 17) by the federal agency responsible for *Endangered Species Act* compliance oversight, the U.S. Fish and Wildlife Service. These are primarily species for which there is insufficient information on biological vulnerability and threat to warrant legal protection.

Stabilization: Actions taken to further confine or reduce the hazards associated with residues as necessary for safe management and responsible storage.

START I and II: Strategic Arms Reduction Talks (also Treaty) (START) refer to negotiations between the U.S. and the U.S.S.R. (the former Soviet Union during START I negotiations) aimed at limiting and reducing nuclear arms. START I discussions began in 1982 and eventually led to a ratified treaty in 1988. START II discussions, which are now in progress, will attempt to further reduce the acceptable levels of nuclear weapons ratified in START I.

State Historic Preservation Office(r) (SHPO): A position in each U.S. state that coordinates state participation in the implementation of the *National Historic Preservation Act* (16 U.S.C. §470 *et seq.*). The SHPO is a key participant in the Section 106 process, assisting in the steps of identification of eligible resources, evaluating effects of undertakings, and developing mitigation measures or management plans to reduce any adverse effects to eligible cultural resources.

Stockpile management: Operations associated with producing, maintaining, refurbishing, surveilling, and dismantling the nuclear weapons stockpile.

Stockpile stewardship: Activities associated with research, design, development, and testing of nuclear weapons and the assessment and certification of their safety and reliability.

Stockpile surveillance: Routine and periodic examination, evaluation, and testing of stockpile weapons and weapon components to ensure that they conform to performance specifications and to identify and evaluate the effect of unexpected or age-related requirements.

Strike: The direction or trend that a structural surface (e.g., a bedding or fault plane) takes as it intersects the horizontal.

Surface water: Water on the Earth's surface, as distinguished from water in the ground (groundwater).

Technical safety requirements (TSRs): Those requirements that define the conditions, the safe boundaries, and the management or administrative controls necessary to ensure the safe operation of a nuclear facility and to reduce the potential risk to the public and facility workers from uncontrolled releases of radioactive materials or from radiation exposures due to inadvertent criticality. TSRs consist of safety limits, operating limits, surveillance requirements, administrative controls, use and application instructions, and the basis thereof. TSRs were formerly known as "operational safety requirements" for nonreactor nuclear facilities and "technical specifications" for reactor facilities.

Threatened and endangered (T&E) species: Animals, birds, fish, plants, or other living organisms threatened with extinction by human-produced or natural changes in their environment. Requirements for declaring species threatened or endangered are contained in the *Endangered Species Act of 1973*.

Total effective dose equivalent (TEDE): The sum of the effective dose equivalent from external exposures and the committed effective dose equivalent from internal exposures (10 CFR 835).

Toxic waste: Individual chemical wastes (liquid or solid), such as polychlorinated biphenyls or asbestos, that are regulated by the *Toxic Substances Control Act*.

Transuranic (TRU) waste: Waste, without regard to source or form, that is contaminated with alpha-emitting radionuclides of atomic number greater than 92 (uranium) and with half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram.

Traditional cultural property (TCP): A significant place or object associated with historical and cultural practices or beliefs of a living community that is rooted in that community's history and is important in maintaining the continuing cultural identity of the community.

Tritium: A radioactive isotope of the element hydrogen with two neutrons and one proton. Common symbols for the isotope are H–3 and T.

Unreviewed safety question: A proposed change, test, or experiment is considered to involve an unreviewed safety question if: (1) the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety evaluated previously by safety analyses will be significantly increased or (2) a possibility for an accident or malfunction of a different type than any evaluated previously by safety analyses will be created that will result in significant safety consequences.

Uranium: A heavy, silvery-white metallic element (atomic number 92) with many radioactive isotopes. Uranium-235 is most commonly used as a fuel for nuclear fission. Another isotope, uranium-238, can be transformed into fissionable plutonium-239 by its capture of a neutron in a nuclear reactor.

Volatile organic compounds (VOCs): A broad range of organic compounds, often halogenated, that vaporize at ambient or relatively low temperatures, such as benzene, chloroform, and methyl alcohol.

War reserve: Operational weapons and materials designated as essential for national security needs.

Waste acceptance criteria (WAC): Requirements established by treatment, storage, and disposal facilities for the acceptance of waste into a facility.

Waste characterization: The identification of waste composition and properties by reviewing process knowledge, nondestructive examination, nondestructive assay, or sampling and analysis. Characterization provides the basis for determining appropriate storage, treatment, handling, transportation, and disposal requirements.

Waste generator: For the purpose of the SWEIS, any individual or group of individuals who generate radioactive, mixed, hazardous, or other types of wastes at LANL.

Waste Isolation Pilot Plant (WIPP): A DOE facility designed and authorized to permanently dispose of transuranic radioactive waste in a mined underground facility in deep geologic salt beds. It is located in southeastern New Mexico, 26 miles (42 kilometers) east of the City of Carlsbad.

Waste management: The planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated pollution prevention, surveillance, and maintenance activities.

Waste minimization: Actions that economically avoid or reduce the generation of waste by source reduction, by reducing the toxicity of hazardous waste, by improving energy usage, or by recycling.

Watershed: For the purposes of the SWEIS, a watershed was defined as that region contributing water to major identified stream channels, which ultimately become tributaries or drain into tributaries to an 11-mile (18-kilometer) segment of the Rio Grande between Otowi Bridge and Frijoles Canyon.

Weapon component: An item in a nuclear weapon that can be either an assembly or individual subset of an assembly. The word “component” can be used interchangeably with “part” or “subassembly.”

Weapons laboratories: Colloquial term for the three DOE national laboratories—Los Alamos, Lawrence Livermore, and Sandia—that are responsible for the design, development, and stewardship of U.S. nuclear weapons.

Weapon system: Collective term for the nuclear assembly and nonnuclear components, subsystems, and systems that compose a nuclear weapon.

Wetland: Land or areas exhibiting hydric (requiring considerable moisture) soil concentrations, saturated or inundated soil during some portion of the year, and plant species tolerant of such conditions.

Whole-body dose: Dose resulting from the uniform exposure of all organs and tissues in a human body.

Wind rose: A depiction of wind speed and direction frequency for a given period of time.

X-rays: Penetrating electromagnetic radiation having a wavelength much shorter than that of visible light. X-rays are identical to gamma rays, but originate outside the nucleus, either when the inner orbital electrons of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons.

CHAPTER 11.0
CONTRACTOR DISCLOSURE STATEMENTS

DE-AC04-94AL85382

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE LANL SWEIS FOR DOE NUCLEAR WEAPONS COMPLEX MODERNIZATION

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked *Questions Concerning CEQ's National Environmental Policy Act Regulations*", 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)". See 46 FR 18026-18031.

In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows: (check either (a) or (b) and list financial or other interest if (b) is checked).

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(b) ☐ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interest

1. NA
2.
3.

Certified by:

[signature]
Signature

Daniel M. Schwendenman
Name

Project Manager, EASI
Title

November 26, 1997
Date

Enterprise Advisory Services, Inc. Disclosure Statement

DE-AC0495AL99975

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE LANL SWEIS FOR DOE NUCLEAR
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Financial or Other Interest

1.

2.

3.

Certified by: [signature]
Signature

THOMAS E. MAGETTE
Name

VICE PRESIDENT
Title

8·25·97
Date

Tetra Tech, Inc. Disclosure Statement

DE-AC0495AL99975

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE LANL SWEIS FOR DOE NUCLEAR
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Financial or Other Interest

1.

2.

3.

Certified by:

[signature]
Signature

William R. Rhyne
Name

Vice President
Title

August 13, 1997
Date

H&R Technical Associates Disclosure Statement

DE-ACO495AL99975

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE LANL SWEIS FOR DOE NUCLEAR
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Financial or Other Interest

1.

2.

3.

Certified by:

[signature]

SIGNATURE

Krishan K. Wahi

NAME

President

TITLE

October 10, 1995

DATE

GRAM, Inc. Disclosure Statement

DE-ACO495AL99975

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE LANL SWEIS FOR DOE NUCLEAR
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Financial or Other Interest

1.

2.

3.

Certified by:

[signature]
SIGNATURE

Evaristo J. Bonano
NAME

President and CEO
TITLE

October 10, 1995
DATE

BETA Corporation Disclosure Statement

DE-ACO495AL99975

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE LANL SWEIS FOR DOE NUCLEAR
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Financial or Other Interest

1.

2.

3.

Certified by: R. Lee Norland
SIGNATURE

R. LEE NORLAND
NAME

GENERAL MGR. DOE PROGRAMS
TITLE

10/11/95
DATE

Dames & Moore Disclosure Statement

DE-ACO495AL99975

QUALIFICATION CRITERION NO. 1

NEPA DISCLOSURE STATEMENT FOR
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Financial or Other Interest

1.

2.

3.

Certified by: David B Winslow
SIGNATURE

David B. Winslow
NAME

Vice President
TITLE

24 oct 95
DATE

Parsons Brinckerhoff Energy Services, Inc Disclosure Statement

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THE LOS ALAMOS NATIONAL LABORATORY SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT PROCESS

The United States Department of Energy (DOE) has a policy (10 Code of Federal Regulations [CFR] 1021.330) of preparing a Site-Wide Environmental Impact Statement (SWEIS) for certain large, multiple-facility sites, such as the Los Alamos National Laboratory (LANL). The purpose of a SWEIS is to provide DOE and its stakeholders with an analysis of the environmental impacts resulting from ongoing and reasonably foreseeable new operations and facilities and reasonable alternatives at the DOE site. The SWEIS analyzes four alternatives for the continued operation of LANL to identify the potential effects that each alternative could have on the human environment.

The SWEIS Advance Notice of Intent, published in the *Federal Register* (FR) on August 10, 1994 (59 FR 40889), identified possible issues and alternatives to be analyzed. Based on public input received during prescoping, DOE published the Notice of Intent to prepare the SWEIS in the *Federal Register* on May 12, 1995 (60 FR 25697). DOE held a series of public meetings during prescoping and scoping to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the SWEIS. An Implementation Plan[1] was published in November 1995 to summarize the results of scoping, describe the scope of the SWEIS based on the scoping process, and present an outline for the draft SWEIS. The Implementation Plan also included a discussion of the issues reflected in public comments during scoping.

In addition to the required meetings and documents described above, the SWEIS process has included a number of other activities intended to enhance public participation in this effort. These activities have included:

- Workshops to develop the Greener Alternative described and analyzed in the SWEIS.
- Meetings with and briefings to representatives of federal, state, tribal, and local governments during prescoping, scoping, and preparation of the draft SWEIS.
- Preparation and submission to the Los Alamos Community Outreach Center of information requested by members of the public related to LANL operations and proposed projects.
- Numerous Open Forum public meetings in the communities around LANL to discuss LANL activities, the status of the SWEIS, and other issues raised by the public.

The draft SWEIS was distributed to interested stakeholders for comment. The comment period extended from May 15, 1998, to July 15, 1998. Public hearings on the draft SWEIS were announced in the *Federal Register*, as well as community newspapers and radio broadcasts. Public hearings were held in Los Alamos, Santa Fe, and Española, New Mexico, on June 9, 1998, June 10, 1998, and June 24, 1998, respectively.

Oral and written comments were accepted during the 60-day comment period for the draft SWEIS. All comments received, whether orally or in writing, were considered in preparation of the final SWEIS. The final SWEIS includes a new volume IV with responses to individual comments and a discussion of general major issues. DOE will prepare a Record of Decision no sooner than 30 days after the final SWEIS Notice of Availability is published in the *Federal Register*. The Record of Decision will describe the rationale used for DOE's selection of an alternative or portions of the alternatives. Following the issuance of the Record of Decision, a Mitigation Action Plan may also be issued to describe any mitigation measures that DOE commits to in concert with its decision.

---

1. DOE *National Environmental Policy Act* regulations (10 CFR 1021) previously required that an implementation plan be prepared; a regulation change (61 FR 64604) deleted this requirement. An implementation plan was prepared for this SWEIS.

COVER SHEET

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agency: Incorporated County of Los Alamos

Title: Site-Wide Environmental Impact Statement for the Continued Operation of the Los Alamos National Laboratory, Los Alamos, New Mexico (DOE/EIS-0238)

Contact: For further information concerning this Site-Wide Environmental Impact Statement (SWEIS), contact:

Corey Cruz, Project Manager
U.S. DOE, Albuquerque Operations Office
P.O. Box 5400, Albuquerque, NM 87185
Telephone: 505–845–4282 Fax: 505–845–6392

For general information on DOE's *National Environmental Policy Act* (NEPA) process, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance (EH–42)
U.S. DOE, 1000 Independence Avenue, SW, Washington, DC 20585
Telephone: 202–586–4600 or leave a message at 1–800–472–2756

Abstract: DOE proposes to continue operating the Los Alamos National Laboratory (LANL) located in Los Alamos County, in north-central New Mexico. DOE has identified and assessed four alternatives for the operation of LANL: (1) No Action, (2) Expanded Operations, (3) Reduced Operations, and (4) Greener. Expanded Operations is DOE's Preferred Alternative, with the exception that DOE would only implement pit manufacturing at a level of 20 pits per year. In the No Action Alternative, DOE would continue the historical mission support activities LANL has conducted at planned operational levels. In the Expanded Operations Alternative, DOE would operate LANL at the highest levels of activity currently foreseeable, including full implementation of the mission assignments from recent programmatic documents. Under the Reduced Operations Alternative, DOE would operate LANL at the minimum levels of activity necessary to maintain the capabilities to support the DOE mission in the near term. Under the Greener Alternative, DOE would operate LANL to maximize operations in support of nonproliferation, basic science, materials science, and other nonweapons areas, while minimizing weapons activities. Under all of the alternatives, the affected environment is primarily within 50 miles (80 kilometers) of LANL. Analyses indicate little difference in the environmental impacts among alternatives. The primary discriminators are: collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand.

Public Comment and DOE Decision: The draft SWEIS was released to the public for review and comment on May 15, 1998. The comment period extended until July 15, 1998, although late comments were accepted to the extent practicable. All comments received were considered in preparation of the final SWEIS[1]. DOE will utilize the analysis in this final SWEIS and prepare a Record of Decision on the level of continued operation of LANL. This decision will be no sooner than 30 days after the Notice of Availability of the final SWEIS is published in the *Federal Register*.

---

[1] Changes made to this SWEIS since publication of the draft SWEIS are marked with a vertical bar to the right or left of the text.

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(BOUND SEPARATELY FROM THIS VOLUME):

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MAIN REPORT

VOLUME III
APPENDIXES (2 PARTS)

VOLUME IV
COMMENT RESPONSE DOCUMENT

VOLUME II
ABBREVIATIONS AND ACRONYMS

ADT	average daily trip
ARIES	Advanced Recovery and Integrated Extraction System
BNM	Bandelier National Monument
CEDE	committed effective dose equivalent
CMIP	Capability Maintenance and Improvement Project
CMR	Chemistry and Metallurgy Research
dBA	decibels A-weighted frequency scale
DOE	U.S. Department of Energy
DOP	detailed operating procedure
EIS	environmental impact statement
EM	DOE Office of Environmental Management
ER	environmental restoration
FR	*Federal Register*
ft	feet
FWS	U.S. Fish and Wildlife Service
HE	high explosives
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiological Protection
JCI	Johnson Controls, Inc.
km	kilometer
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality

LLMW	low-level mixed waste
LLW	low-level radioactive waste
m	meter
MDA	Material Disposal Area
MEI	maximally exposed individual
mi	mile
MOX	mixed oxide (fuel)
NA	not applicable
NEPA	*National Environmental Policy Act of 1969*, as amended
NMED	New Mexico Environment Department
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
OEL	occupational exposure limit
OLE	Ojo (Transmission) Line Extension
OSHA	U.S. Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PF	Plutonium Facility
PEIS	programmatic environmental impact statement
PNM	Public Service Company of New Mexico
ppm	parts per million
PSSC	project-specific siting and construction
RCRA	*Resource Conservation and Recovery Act*
rem	roentgen equivalent man
RLWTF	Radioactive Liquid Waste Treatment Facility

ROD	Record of Decision
SHPO	State Historic Preservation Office(r)
SNM	special nuclear material
SOP	standard operating procedure
SSM	Stockpile Stewardship and Management
SWEIS	site-wide environmental impact statement
SWMU	solid waste management unit
T&E	threatened and endangered (species)
TA	technical area
TCE	1,1,1-trichloroethane
TCP	traditional cultural property
TRU	transuranic (waste)
TSCA	*Toxic Substances Control Act*
U.S.	United States
U.S.C.	United States Code
USGS	U.S. Geological Survey
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant
WM	waste management

VOLUME II
MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this SWEIS. Definitions of technical terms can be found in volume I, chapter 10, Glossary.

SCIENTIFIC NOTATION

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using scientific notation, as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either right (for a positive power of 10) or left (for a negative power of 10). If the value given is 2.0×10^3, move the decimal point three places (insert zeros if no numbers are given) to the right of its current location. The result would be 2,000. If the value given is 2.0×10^{-5}, move the decimal point five places to the left of its present location. The result would be 0.00002. An alternative way of expressing numbers, used primarily in the appendixes of this SWEIS, is exponential notation, which is very similar in use to scientific notation. For example, using the scientific notation for 1×10^9, in exponential notation the 10^9 (10 to the power of 9) would be replaced by E+09. (For positive powers, sometimes the "+" sign is omitted, and so the example here could be expressed as E09.) If the value is given as 2.0×10^{-5} in scientific notation, then the equivalent exponential notation is 2.0E-05.

UNITS OF MEASUREMENT

The primary units of measurement used in this report are English units with metric equivalents enclosed in parentheses.

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). The following list presents these metric prefixes:

giga	1,000,000,000 (10^9; E+09; one billion)
mega	1,000,000 (10^6; E+06; one million)
kilo	1,000 (10^3; E+03; one thousand)
hecto	100 (10^2; E+02; one hundred)
deka	10 (10^1; E+01; ten)
unit	1 (10^0; E+00; one)
deci	0.1 (10^{-1}; E-01; one tenth)
centi	0.01 (10^{-2}; E-02; one hundredth)
milli	0.001 (10^{-3}; E-03; one thousandth)

micro	0.000001 (10^{-6}; E-06; one millionth)
nano	0.000000001 (10^{-9}; E-09; one billionth)
pico	0.000000000001 (10^{-12}; E-12; one trillionth)

DOE Order 5900.2A, *Use of the Metric System of Measurement*, prescribes the use of this system in DOE documents. Table MC–1 lists the mathematical values or formulas needed for conversion between English and metric units. Table MC–2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

RADIOACTIVITY UNIT

Part of this report deals with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC–3). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit of mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of these.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually expressed in terms of effective dose equivalent and reported numerically in units of rem (Table MC–4). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in Table MC–5.

CHEMICAL ELEMENTS

A list of selected chemical elements, chemical constituents, and their nomenclature is presented in Table MC–6.

TABLE MC–1.—*Conversion Table*

MULTIPLY	BY	TO OBTAIN	MULTIPLY	BY	TO OBTAIN
ac	0.405	ha	ha	2.47	ac
°F	(°F -32) x 5/9	°C	°C	(°C x 9/5) + 32	°F
ft	0.305	m	m	3.28	ft
ft^2	0.0929	m^2	m^2	10.76	ft^2
ft^3	0.0283	m^3	m^3	35.3	ft^3
gal.	3.785	l	l	0.264	gal.
in.	2.54	cm	cm	0.394	in.
lb	0.454	kg	kg	2.205	lb
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
mi	1.61	km	km	0.621	mi
mi^2	2.59	km^2	km^2	0.386	mi^2
mi/h	0.447	m/s	m/s	2.237	mi/h
nCi	0.001	pCi	pCi	1,000	nCi
oz	28.35	g	g	0.0353	oz
pCi/l	10^{-9}	µCi/ml	µCi/ml	10^{9}	pCi/l
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
ppb	0.001	ppm	ppm	1,000	ppb
ton	0.907	metric ton	metric ton	1.102	ton

TABLE MC–2.—*Names and Symbols for Units of Measure*

LENGTH	
SYMBOL	**NAME**
cm	centimeter (1 x 10^{-2} m)
ft	foot
in.	inch
km	kilometer (1 x 10^{3} m)
m	meter
mi	mile
mm	millimeter (1 x 10^{-3} m)
µm	micrometer (1 x 10^{-6} m)
VOLUME	
SYMBOL	**NAME**
cm^3	cubic centimeter
ft^3	cubic foot
gal.	gallon
in.^{3}	cubic inch
l	liter
m^3	cubic meter
ml	milliliter (1 x 10^{-3} l)
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard
RATE	
SYMBOL	**NAME**
Ci/yr	curies per year
cm^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
kg/yr	kilograms per year
km/h	kilometers per hour
mg/l	milligrams per liter
MGY	million gallons per year
MLY	million liters per year
m^3/yr	cubic meters per year
mi/h or mph	miles per hour
µCi/l	microcuries per liter
pCi/l	picocuries per liter

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

NUMERICAL RELATIONSHIPS	
SYMBOL	**MEANING**
$<$	less than
$\leq$	less than or equal to
$>$	greater than
$\geq$	greater than or equal to
2σ	two standard deviations
TIME	
SYMBOL	**NAME**
d	day
h	hour
min	minute
nsec	nanosecond
s	second
yr	year
AREA	
SYMBOL	**NAME**
ac	acre (640 per mi^2)
cm^2	square centimeter
ft^2	square foot
ha	hectare (1 x 10^4 m^2)
in.^{2}	square inch
km^2	square kilometer
mi^2	square mile
MASS	
SYMBOL	**NAME**
g	gram
kg	kilogram (1 x 10^3 g)
mg	milligram (1 x 10^{-3} g)
µg	microgram (1 x 10^{-6} g)
ng	nanogram (1 x 10^{-9} g)
lb	pound
ton	metric ton (1 x 10^6 g)
oz	ounce

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

TEMPERATURE	
SYMBOL	**NAME**
°C	degrees Celsius
°F	degrees Fahrenheit
°K	degrees Kelvin
SOUND/NOISE	
SYMBOL	**NAME**
dB	decibel
dBA	A-weighted decibel

TABLE MC–3.—*Names and Symbols for Units of Radioactivity*

RADIOACTIVITY	
SYMBOL	**NAME**
Ci	curie
cpm	counts per minute
mCi	millicurie (1 x 10^{-3} Ci)
μCi	microcurie (1 x 10^{-6} Ci)
nCi	nanocurie (1 x 10^{-9} Ci)
pCi	picocurie (1 x 10^{-12} Ci)

TABLE MC–4.—*Names and Symbols for Units of Radiation Dose*

RADIATION DOSE	
SYMBOL	**NAME**
mrad	millirad (1 x 10^{-3} rad)
mrem	millirem (1 x 10^{-3} rem)
R	roentgen
mR	milliroentgen (1 x 10^{-3} R)
μR	microroentgen (1 x 10^{-6} R)

TABLE MC–5.—*Radionuclide Nomenclature*

SYMBOL	RADIONUCLIDE	HALF-LIFE	SYMBOL	RADIONUCLIDE	HALF-LIFE
Am-241	americium-241	432 yr	Pu-241	plutonium-241	14.4 yr
H-3	tritium	12.26 yr	Pu-242	plutonium-242	3.8×10^5 yr
Mo-99	molybdenum-99	66 hr	Pu-244	plutonium-244	8.2×10^7 yr
Pa-234	protactinium-234	6.7 hr	Th-231	thorium-231	25.5 hr
Pa-234m	protactinium-234m	1.17 min	Th-234	thorium-234	24.1 d
Pu-236	plutonium-236	2.9yr	U-234	uranium-234	2.4×10^5 yr
Pu-238	plutonium-238	87.7 yr	U-235	uranium-234	7×10^8 yr
Pu-239	plutonium-239	2.4×10^4 yr	U-238	uranium-238	4.5×10^9 yr
Pu-240	plutonium-240	6.5×10^3 yr			

TABLE MC–6.—*Elemental and Chemical Constituent Nomenclature*

SYMBOL	CONSTITUENT	SYMBOL	CONSTITUENT
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
Ar	argon	Pu	plutonium
B	boron	SF_6	sulfur hexafluoride
Be	beryllium	Si	silicon
CO	carbon monoxide	SO_2	sulfur dioxide
CO_2	carbon dioxide	Ta	tantalum
Cu	copper	Th	thorium
F	fluorine	Ti	titanium
Fe	iron	U	uranium
Kr	krypton	V	vanadium
N	nitrogen	W	tungsten
Ni	nickel	Xe	xenon
NO_2^-	nitrite ion	Zn	zinc
NO_3^-	nitrate ion		

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PART I
EXPANSION OF TA–54/AREA G LOW-LEVEL WASTE DISPOSAL AREA

I.1 ROLE OF THIS PROJECT-SPECIFIC SITING AND CONSTRUCTION ANALYSIS IN THE SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT

This Project-Specific Siting and Construction (PSSC) analysis addresses the proposed expansion of the Area G low-level radioactive waste (LLW)[1] disposal area in Technical Area (TA)–54. It examines the siting and construction alternatives specific to this project in greater detail than the description and analysis presented in volume I of the Los Alamos National Laboratory (LANL) Site-Wide Environmental Impact Statement (SWEIS). The preferred alternative from this PSSC analysis is then included as one of the activities within the Expanded Operations Alternative discussed in volume I.

This arrangement of information and analysis allows the U.S. Department of Energy (DOE) to "zoom" in on aspects of this project that warrant more detailed description and analysis, while maintaining the clarity of volume I of the SWEIS. The siting and construction impacts of the Preferred Alternative described in this PSSC analysis are included along with the operational impacts described for the Expanded Operations Alternative in volume I to provide a complete understanding of the impacts of that alternative. Any differences in impacts that would be expected if a different PSSC alternative were selected are discussed in chapter 5 of volume I (section 5.3).

Waste volumes and strategies for managing the various waste streams are discussed in *Waste Management Strategies for LANL* (LANL 1998a) and chapter 5 (sections 5.2.9.3, 5.3.9.3, 5.4.9.3, and 5.5.9.3) of volume I, and are summarized in section I.1.1.3. Operations within the existing Area G, including new disposal cell excavation, are discussed in the *Description of Technical Areas and Facilities at LANL* (LANL 1998b) and in chapter 2 (sections 2.1.2.1 and 2.2.2.15) of the SWEIS, volume I.

More information regarding the approaches for disposal of LANL's wastes across the SWEIS alternatives (shipment off the site, storage on the site, and treatment) is presented in chapter 3 (sections 3.1, 3.2, 3.3, and 3.4) of volume I. The SWEIS analyzes continued disposal of LLW on the site within the Expanded Operations Alternative. The SWEIS also analyzes the LLW management strategy of storing the waste on the site for some short period and then shipping it off the site for disposal elsewhere, as part of the No Action, Reduced Operations, and Greener Alternatives.

The environmental impacts of operating the LLW disposal area and of the post-closure period are included in chapter 5 of volume I. The volume of disposal cells excavated, emissions to air, worker doses, and certain other parameters associated with LLW disposal operations would depend on the volume of LLW to be disposed of and not on the disposal location. The consequences to members of the public (especially post-closure), however, would depend on location because distance from the LLW disposal operation to the public depends on the location selected, and the

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1. Waste that contains radioactivity but is not classified as high-level waste, transuranic waste, spent nuclear fuel, or "11e(2) by-product material" as defined by DOE Order 5820.2A, *Radioactive Waste Management*.

PSSC Alternatives for Expansion of Area G LLW Disposal

Develop Zone 4 at TA–54*—DOE would develop up to 24 acres (10 hectares) within Zone 4, which is immediately west of the existing active disposal area (see Figure I.2.5–1).*

Develop Zone 6 in TA–54*—DOE would develop up to 17 acres (7 hectares) within Zone 6, which is immediately to the west of Area L (Zone 5) and extends to Area J (see Figure I.2.5–1).*

Develop the North Site in TA–54*—DOE would develop up to 49 acres (20 hectares) within the North Site, which is immediately to the north of Zone 6 and Area J (see Figure I.2.5–1).*

Develop New Disposal Site at Another LANL TA*—DOE would establish a new LLW disposal facility at another location within LANL, presumed to be an undeveloped, undisturbed mesa. TA–67 is the specific TA examined as an example of the requirements and impacts associated with development of an undeveloped site for LLW disposal. The disposal site analyzed would develop up to 50 acres (20 hectares) plus roads and support areas at TA–67, which is located on Pajarito Mesa (see Figures I.1.1–1 and I.2.4.1–1).*

Preferred Alternative*—DOE's Preferred Alternative is to develop both Zones 4 and 6, proceeding westward in a step-by-step fashion from the existing footprint of Area G.*

magnitude of impacts decreases with distance. Post-closure impacts to the public are addressed for all alternative locations in chapter 5, section 5.3.3.5, of volume I.

In section I.2, this PSSC analysis identifies alternative locations at LANL where the additional LLW disposal capacity could be developed. Section I.2 also identifies alternative LLW management options not analyzed in this PSSC analysis because they are completely analyzed as part of the SWEIS alternatives in volume I. Section I.3 contains more detailed information about the environmental conditions at each of the alternative locations. Section I.4 presents the environmental consequences of development at each location. The SWEIS, including this PSSC analysis, is intended to provide a complete *National Environmental Policy Act of 1969* (NEPA) analysis of impacts regarding the proposed expansion of LLW disposal at LANL.

I.1.1 Background

DOE is considering the need to expand the LLW disposal area at LANL within the next 10 years. This PSSC analysis describes the alternatives for that development within LANL and their environmental consequences.

DOE and its predecessor agencies have operated LANL since 1943. Work at LANL produces LLW. Historically, DOE has disposed of this waste by burial in various designated sites within LANL. LANL's only currently active solid LLW disposal area is in the Material Disposal Area (MDA) G (referred to as Area G) at TA–54, shown in Figure I.1.1–1. TA–54 is located on Mesita del Buey, a narrow southeast-trending mesa about 2.5 miles (4 kilometers) long. Mesita del Buey is bordered by Cañada del Buey on the north and Pajarito Canyon on the south. San Ildefonso Pueblo land is located to the northeast of TA–54. The boundary between DOE land at TA–54 and San Ildefonso Pueblo land lies along the south edge of the top of the next mesa to the northeast of Cañada del Buey, an unnamed mesa south of Cedro Canyon. This boundary is about 650 feet (210 meters) northeast of the edge of Cañada del Buey at Area G.

Burial of LLW at TA–54, Area G, began in 1957 after the U.S. Atomic Energy Commission, with the assistance of the United States Geological Survey (USGS), selected

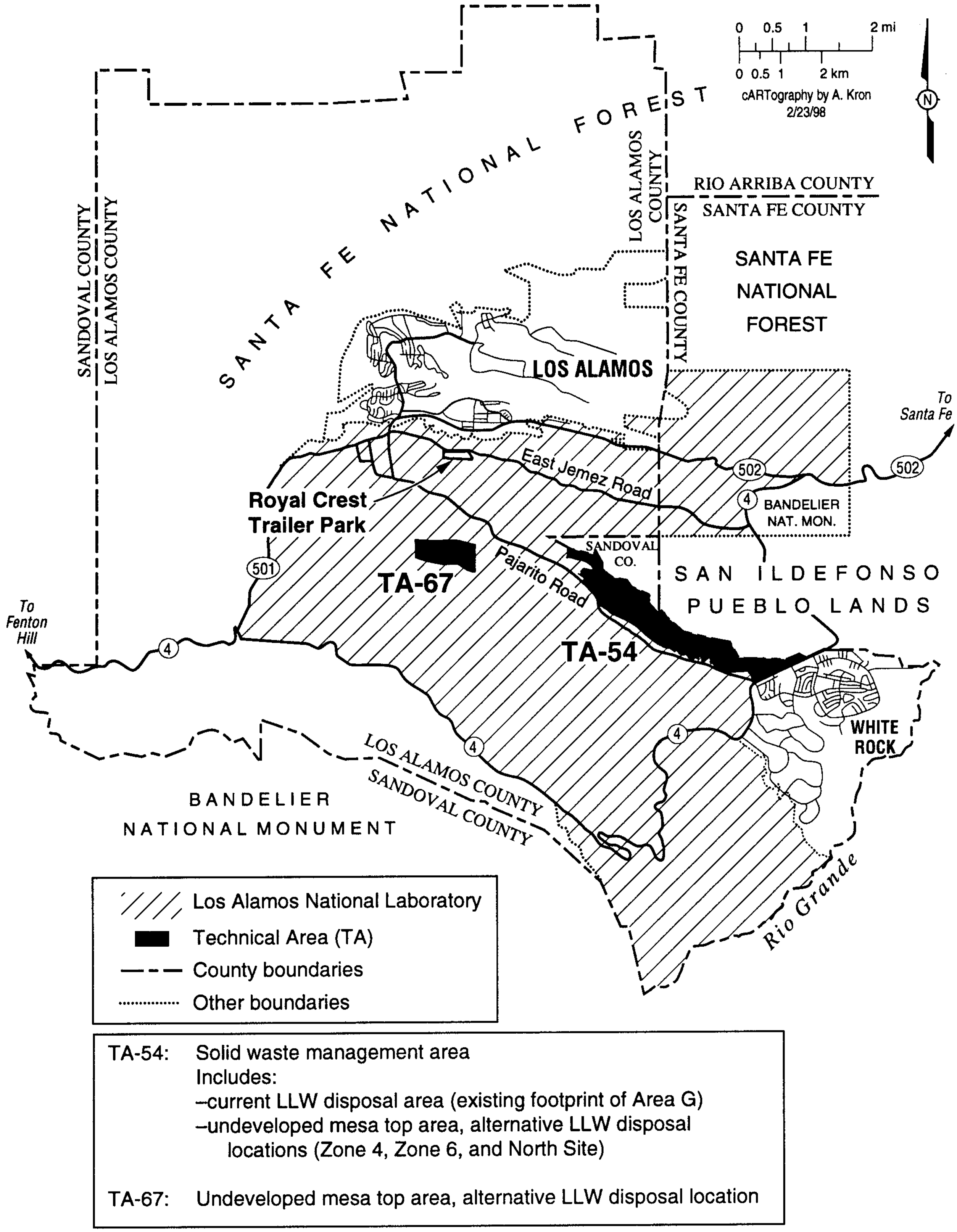

FIGURE I.1.1–1.—*Location of LANL, TA–54, and TA–67.*

Mesita del Buey as the disposal site for LANL's LLW. Area G was described in a historical report as one of the on-site land disposal facilities for radioactive wastes (Rogers 1977).

The previous (1979) SWEIS identified all of Mesita del Buey as an area for handling operational solid waste, including radioactive waste (DOE 1979). The 1979 SWEIS states, "The radioactive disposal area in use is Area G, located on Mesita del Buey. The dedicated waste disposal area contains a total of about 80 acres (32 hectares) of which approximately 37 acres (15 hectares) has been in active use since 1958. Based upon current waste generation rates, this area should provide an additional 15 or more years use. However, since the entire Mesita del Buey has been designated for the handling of operational solid waste, there will still be another 23 acres available for use beyond that time" (DOE 1979).

The original LLW disposal area at Area G was expanded once to reach its current size of 63 acres (25 hectares). This active area was referred to in the 1979 SWEIS as the "existing footprint." Waste management facilities at Area G include LLW disposal cells and shafts, a 200-ton (180-metric ton) compactor for LLW, soil-covered asphalt pads containing stacks of waste drums, temporary tension domes used to store drums of transuranic (TRU) waste[2] and low-level radioactive mixed waste[3] (LLMW), and a monofill disposal cell (a disposal cell containing a single waste type) for asbestos that has radioactive contamination.

A detailed description of the LLW streams and estimates of the volumes that might be produced under each of the SWEIS alternatives is provided in *Waste Management Strategies for LANL* (LANL 1998a) and chapter 5 of the SWEIS, volume I. Descriptions of the techniques by which LLW disposal cells are constructed, filled, and closed are found in the *Detailed Operating Procedure* (DOP) *54G–013*, (LANL 1996a). This DOP incorporates recommendations made by USGS (cited in Rogers 1977 and in Purtymun et al. 1980) and others (Koopman 1965) on disposal cell placement with regard to distances from canyon walls and bottoms. The Performance Assessment describes closure and post-closure requirements for the existing Area G (LANL 1998f).

I.1.1.1 *History of Expansion Plans at Area G*

Given the limited area within the existing footprint at Area G, DOE and LANL waste management personnel have recognized for several years the need to consider additional areas at LANL that would be suitable for burial of LLW (LANL 1982). The part of Mesita del Buey immediately to the west of Area L (Figure I.1.1.1–1) received the first and most thorough investigation because it is contiguous with the existing footprint and is within the area designated in 1957 for solid waste management operations. Expansion to Area L was regarded as logical but not imminent at the time the previous SWEIS was issued (DOE 1979). Specific planning and siting for the next LLW disposal area began about 1989.

I.1.1.2 *History of NEPA Reviews*

On October 20, 1990, DOE directed that NEPA review of an expansion of existing Area G be prepared. By 1994, no draft was considered ready for preapproval public review, in part because of questions about the need, arising from uncertainties in decontamination and decommissioning and environmental

2. TRU wastes contain a radionuclide with a half-life greater than 20 years and alpha activity of 100 nanocuries per gram (nCi/g) or greater at the time of measurement, excluding naturally occurring and depleted uranium, spent nuclear fuel, and high-level waste.

3. LLMW contains LLW, plus chemicals regulated as hazardous under the *Resource Conservation and Recovery Act* (RCRA) (42 United States Code [U.S.C.] §6901).

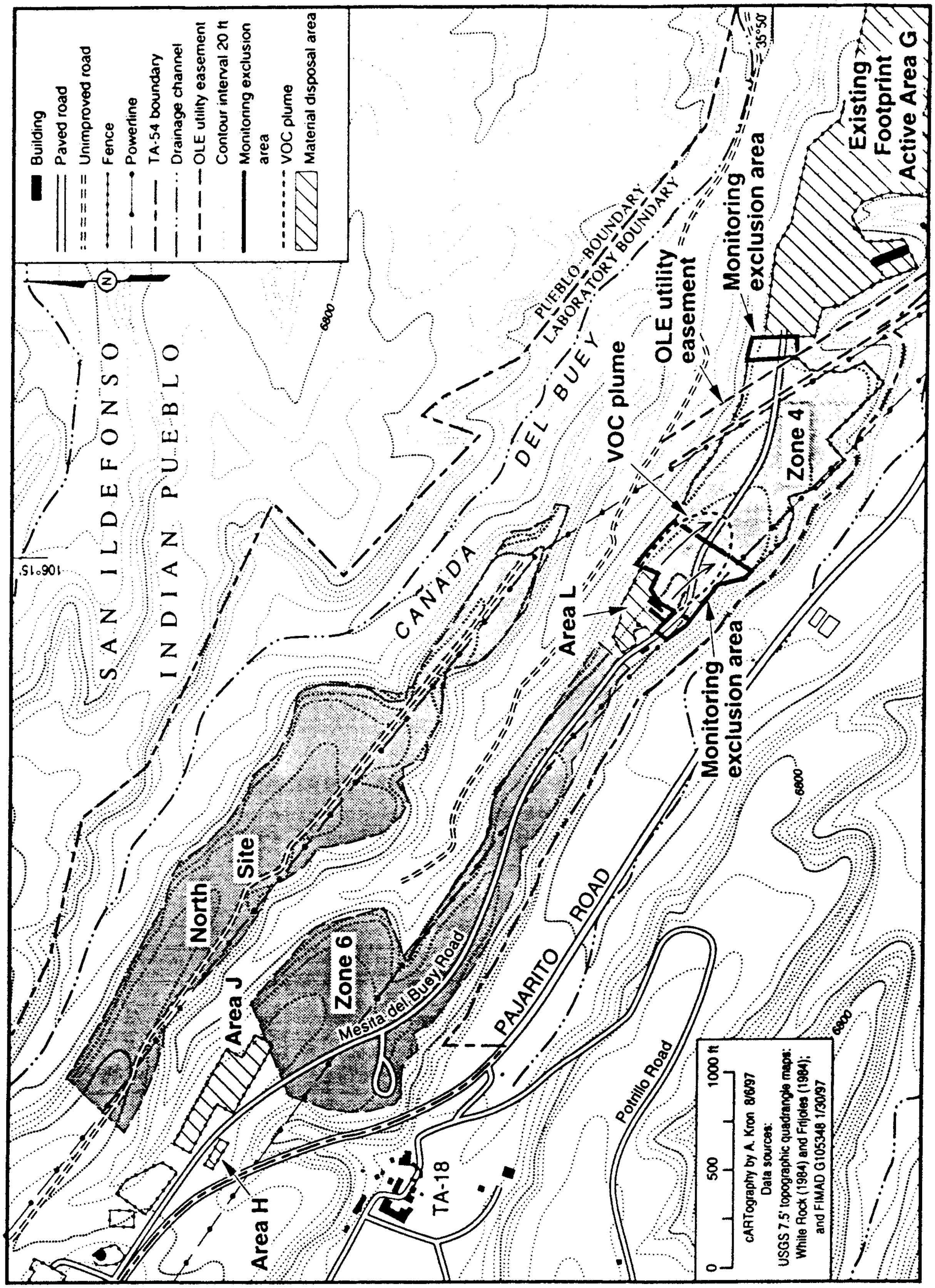

FIGURE I.1.1.1–1.—*Location Within TA–54 of Zones 4 and 6, Areas H, J, and L, and North Site.*

restoration (ER) waste volume projections. Several of the unresolved questions were discussed in a report prepared by a group named Our Common Ground (OCG 1993). (This was an unofficial group of LANL employees and members of the surrounding community that were asked by the LANL Director in 1993 to review the proposal for expansion of Area G.) In August 1994, the Advance Notice of Intent (NOI) to prepare a new SWEIS was published in the *Federal Register* (FR). Further development of disposal capacity outside the existing Area G footprint was specifically suggested for coverage in the new SWEIS. The NOI published in the FR on May 12, 1995 (60 FR 25697), made the commitment to include the NEPA review for this proposal in the SWEIS.

I.1.1.3 *Low-Level Radioactive Waste Generation and Anticipated Disposal Requirements at LANL*

Operations at LANL will continue to generate LLW that requires disposal by DOE. Waste volumes during the 10-year SWEIS timeframe will increase significantly over volumes generated in recent years (1990 through 1994). This increase stems primarily from clean-up projects planned under the ER Project. The assumptions used here are that the volume of LLW would vary by the SWEIS alternative, that regardless of alternative at least some of the LLW generated would be disposed of in disposal cells (trenches)[4] at Area G, and that the remaining LLW would need to be disposed of off site (except under the Expanded Operations Alternative, when on-site disposal capacity is expanded and all LLW is disposed of on site). The projected volumes of LANL's LLW by SWEIS alternative are summarized in Table I.1.1.3–1[5]. There is insufficient space within existing Area G to accommodate all LLW anticipated from LANL activities in the next 10 years, regardless of alternative.

4. LLW with high surface activity, tritium-contaminated LLW, and some other special wastes are disposed of in shafts drilled into tuff. There is sufficient space in the existing footprint to meet the 10-year shaft disposal requirements.

5. Volumes shown in tables in this document are presented in metric units (cubic meters) because this is the form used in volume I of the SWEIS, the *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997), and other documents on this subject. Also, exponential notation is used; 10^3 means "thousand."

TABLE I.1.1.3–1.—*LANL's LLW Volume to be Disposed of in Next 10 Years, by SWEIS Alternative (10^3 cubic meters)[a]*

LLW CATEGORY	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
LLW Generated[a]	95	117	84	97
LLW to be Disposed[b]	88	112	78	90
Currently Developed Area G Capacity	36	36	36	36
Waste Volume Above Currently Developed Area G Capacity[c]	52	76	42	54

[a] From volume I of the SWEIS, chapter 5 (sections 5.2.9.3, 5.3.9.3, 5.4.9.3, and 5.5.9.3).
[b] Volume after compaction and other treatments.
[c] Under the No Action, Reduced Operations, and Greener Alternatives, much of the waste volume would be shipped off the site for disposal. Under Expanded Operations, on-site disposal capacity would be expanded, and the waste would be disposed of on the site (volume I, chapter 3).

The volume of LLW disposal space that can be developed within the existing Area G is uncertain because the best terrain has been used. The excavated but unfilled disposal cell volume is 34,000 cubic yards (26,000 cubic meters). The surface of the remaining area is sloped and the subsurface features are unknown. New disposal cell volume is estimated at 13,000 cubic yards (10,000 cubic meters) but could be less.

In addition, in the final *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997), the Preferred Alternative for LLW designates LANL as one of six candidate sites from which DOE will choose two or three regional LLW disposal sites (DOE 1997)[6]. The options under which LANL may receive off-site LLW and the projected volumes are shown in Table I.1.1.3–2.

6. In addition, the WM PEIS Preferred Alternative for LLMW designates LANL as one of six candidate sites, from which DOE will choose two or three regional disposal sites. LANL does not currently dispose of such waste at Area G or elsewhere. If LANL is chosen as a regional disposal site for LLMW, the site-specific impacts of such disposal would be addressed in further NEPA review, tiered from the WM PEIS and this SWEIS.

DOE's decisions within the context of the WM PEIS are independent of the SWEIS but may, in and of themselves, force expansion of Area G. A reasonably foreseeable future and bounding case would be a combination of the WM PEIS Preferred Alternative—Regionalized (Regionalized 3, 4, 5) with the Expanded Operations Alternative in LANL's SWEIS, whereby the 10-year shortfall of LLW disposal space at LANL would be about 125,000 cubic yards (96,000 cubic meters). Such a decision from the WM PEIS would represent a substantial change in the approach to LLW disposal at LANL. This would be a long-term commitment (beyond the 10-year period addressed in the SWEIS) by DOE to utilize space at LANL as a regional LLW disposal site. (If LANL is chosen as a regional disposal site for LLW, the site-specific impacts of that decision would be addressed in further NEPA review tiered from the WM PEIS and this SWEIS.) Alternatively, DOE could decide to ship all LANL's LLW to one of the other regional disposal sites. (As discussed above, shipment of LANL's LLW for off-site disposal is analyzed in the No Action, Reduced Operations, and Greener Alternatives.)

TABLE I.1.1.3–2.—*Bounding LLW Volumes to be Disposed at LANL, Including LLW Potentially Shipped to LANL Based on WM PEIS over 10 Years (10^3 cubic meters)*

WM PEIS ALTERNATIVE	REGIONALIZED 1, 2	PREFERRED ALTERNATIVE: REGIONALIZED 3, 4, 5[a]	CENTRALIZED 3, 4
Off-Site LLW Volume for Disposal at LANL[b]	16	20	3
LANL LLW to be Disposed[c]	112	112	112
Maximum LLW Volume for Disposal at LANL	128	132	115
Available Capacity in Area G	36	36	36
Shortfall in Capacity at Area G	92	96	79

[a] The Preferred Alternative for LLW disposal in WM PEIS is regionalized, with LANL as a candidate for one of the two or three disposal sites for the complex.
[b] From Appendix I, Table I.3–4, WM PEIS (DOE 1997), adjusted to 10 years.
[c] Maximum volume, Expanded Operations Alternative, from Table I.1.1.3–1.

There are several sources of uncertainty in predictions about volume of the LLW to be disposed of at LANL over the next 10 years. One source of uncertainty is in predictions of waste to be generated at LANL under the four SWEIS alternatives. Although operations-related LLW volumes are reasonably predictable given the levels of operations, the volume of LLW to be produced by ER and decontamination and decommissioning activities is potentially very large but is tied to the level of funds allocated annually by DOE for the clean-up programs. The *Waste Management Strategies for LANL* LLW volume projections have been used here because they are bounding cases that include both operational and ER/ decontamination and decommissioning LLW estimates (LANL 1998a). This waste volume estimating method responds to one of the issues raised in the report by Our Common Ground (OCG 1993).

The volume of additional LLW disposal space needed over the next 10 years and into the future is not known at present. DOE's options to ship LLW from other locations for disposal at LANL, as developed in the WM PEIS, introduce another uncertainty into the space needed for LLW disposal.

This PSSC analysis presents various alternative locations at LANL that could be developed for LLW disposal. To preserve flexibility and as a bounding case for the next 10 years, this PSSC analysis assumes the LLW volume to be accommodated is that described for the SWEIS Expanded Operations Alternative (146,000 cubic yards [112,000 cubic meters]) from the *Waste Management Strategies for LANL* and in chapter 5 (section 5.3.9.3) of the SWEIS, volume I, plus the maximum quantity of LLW proposed to be moved to LANL from other DOE locations over 10 years (26,000 cubic yards [20,000 cubic meters]), as described in the WM PEIS (DOE 1997). The remaining 47,000 cubic yards (36,000 cubic meters) of disposal space in the existing footprint at Area G will be used prior to expansion of on-site LLW disposal capacity. Over the next 10 years, DOE could need to develop additional disposal space at LANL for up to 125,000 cubic yards (96,000 cubic meters) of LLW (the greatest foreseeable disposal capacity shortfall, as reflected in Table I.1.1.3–2).

I.2 ALTERNATIVES

This section identifies alternative locations that DOE could develop as disposal cells (trenches) to dispose of LLW that would be generated at LANL over the next 10 years, plus LLW that might be shipped to LANL for disposal from other DOE locations. This discussion is focused on construction and development of new LLW disposal areas. (Figures I.1.1–1 and I.1.1.1–1 illustrate the locations being considered.) Alternatives discussed include:

- Develop Zone 4 at TA–54.
- Develop Zone 6 at TA–54.
- Develop the North Site at TA–54.
- Develop an undisturbed site at another LANL TA. (TA–67 is used as an example.)
- Develop both Zones 4 and 6 in step-wise fashion (the Preferred Alternative).

Each of the five alternatives could provide more than enough space for potential LLW disposal needs (125,000 cubic yards [96,000 cubic meters]) for the next 10 years (Table I.1.1.3–2). The differences among alternatives follow from consequences of development at the different locations. The alternative of developing at an undisturbed location responds to one of the issues raised in the report by Our Common Ground (OCG 1993).

Additional alternatives for LLW management are not analyzed in detail in this PSSC analysis because they are analyzed within the SWEIS itself. The typical No Action Alternative (i.e., to continue burying LLW within the existing footprint at Area G) is discussed in chapter 3 of volume I as a part of normal operations; its consequences are presented in chapter 5. This activity is common to all the SWEIS alternatives up to the point that on-site disposal ends (for the No Action, Reduced Operations, and Greener Alternatives). Shipping LLW off the site for disposal elsewhere is a part of the SWEIS No Action, Reduced Operations, and Greener Alternatives, but not the Expanded Operations Alternative.

I.2.1 Develop Zone 4 at TA–54

Under this alternative, DOE would develop Zone 4 within Area G, immediately west of the active disposal area as shown in Figure I.1.1.1–1, for the additional LLW disposal capacity. The Zone 4 area is about 30 acres (12 hectares), but some of the area could not be developed for disposal cells because of groundwater monitoring wells and a utility easement. Two options will be discussed for developing Zone 4, the area north of the current road and the entire area, both north and south of the road. Developing just the area north of the road would avoid archaeological sites. Although the area to the south of the road is larger, it would be impractical to develop just that area because of the archaeological sites located there.

I.2.1.1 *Location Description*

Zone 4 is located on Mesita del Buey, within TA–54 (Figures I.1.1–1 and I.1.1.1–1). The upper portion of Mesita del Buey is of Bandelier Tuff. The Bandelier Tuff is composed primarily of volcanic ash. The tuff is a good material in which to dispose of LLW because it forms a natural barrier to fluid migration, primarily because of its generally low hydraulic conductivity (Purtymun and Kennedy 1971 and Rogers 1995). No geologic faults have been identified at Mesita del Buey.

Zone 4, an area of slightly less than 30 acres (12 hectares), runs westward from the existing footprint of Area G to Area L, where chemical wastes are managed. This area is fenced, and access is controlled by the gate at the westernmost end of the waste management area. The paved Mesita del Buey Road runs the length of the mesa into the developed area. The area is level and covered with second-growth pinyon[7] and juniper and an understory of shrubs and grasses. Zone 4 is within the foraging area of a peregrine falcon nest site, a site that has been unoccupied in recent years.

There are some constraints on developing LLW disposal space in Zone 4. Because Area L was once used for chemical waste disposal, there is a volatile organic compound (VOC) plume in the subsurface. LANL set aside monitoring exclusion zones on either side of Zone 4 to track the movement of the VOC plume. At the western edge of Zone 4, the monitoring zone is about 3 acres (1.2 hectares), and the eastern monitoring zone is about 1 acre (0.4 hectares). These features are shown in Figure I.1.1.1–1. The VOC plume is being monitored and has not moved appreciably in about 5 years. It extends in the pore gas space about 500 feet (150 meters) eastward into Zone 4 (LANL 1994). The organic compound of maximum concentration is 1,1,1-trichloroethane (TCE), at 5,540 parts per million (ppm), as detected in 1997 (LANL 1998e). The identity and concentrations of VOCs are listed in appendix I.B. A study of the human health risk posed by this plume will be performed under the ER Project at LANL during the 1997 to 1999 timeframe. Until the results are known, excavations will not be made in these exclusion zones. If disposal cells were to be excavated, administrative controls such as monitoring the air in the breathing area and supplying workers with respiratory protection could protect worker health.

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7. A cross-reference between the common and scientific names of the plants and animals noted in the text is found in appendix I.A.

Very small but measurable amounts of VOCs are being released into the atmosphere as a consequence of the VOC plume. Any effects that these emissions are having on fossorial (digging) animals as well as other area plants and animals are being assessed through ecological risk assessments.

An easement for the proposed Public Service Company of New Mexico (PNM) Ojo (Transmission) Line Extension (OLE) passes through this end of Zone 4; but, plans to construct the OLE have been suspended indefinitely. The need for additional electrical power at LANL has not been resolved yet. This easement area would be avoided until the electrical supply issue is settled.

Nine cultural resources, remains of prehistoric Native American habitation, have been identified within Zone 4. All except one is south of Mesita del Buey Road. The exception is located north of the road but within the ER monitoring zone. The site would not be excavated because this monitoring zone would not be disturbed. As discussed further in section I.3.6, an archeological data recovery plan has been approved by the New Mexico State Historic Preservation Office(r) (SHPO) for the sites in Zone 4 that are eligible for the National Register of Historic Places (NRHP). At Zone 4, the boundary of San Ildefonso Pueblo is 1,300 feet (400 meters) northeast of the north edge of the top of Mesita del Buey (Figure I.1.1.1–1). The traditional cultural property (TCP) study conducted for the SWEIS did not identify any TCPs in this area.

I.2.1.2 *Development*

If this alternative were implemented, a radiation control and monitoring zone would be placed adjacent to an active disposal cell so that waste disposal crews could be monitored as they prepared to leave the area. A decontamination facility, probably an impervious wash pad capable of accommodating a truck, would be added if needed. Decontamination water would be collected and transferred to the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA–50. These facilities would be connected to the existing utility lines. In addition, an air monitoring network would be installed. The existing waste management support facilities and infrastructure within the existing footprint area would continue to be used. No new roads or utilities would be required. The trees in the area, mainly pinyon and juniper, would be removed and the wood would be chipped and burned or used as mulch on the site (as discussed in section I.4.1.2).

DOE has identified two options for developing LLW disposal areas within Zone 4. Just the area to the north of Mesita del Buey Road could be developed, or the areas on both the north and south sides of the road could be developed together. Several archaeological sites would have to be excavated in order to proceed with development south of the road. If additional disposal area was limited to the north side of the road, avoiding the monitoring zones, no archeological sites need be excavated, and the VOC monitoring apparatus would not be disturbed. Engineering and administrative controls could be put in place to mitigate the potential for radiological contamination of archeological sites to the south of the road.

If the area on the both sides of Mesita del Buey Road were developed, the eight archaeological sites to the south of the road would be affected. Excavating waste disposal cells among unexcavated archaeological sites is not feasible for several reasons. Fencing around the surface features would reduce but not prevent the chance of their being run over by heavy excavation equipment and waste delivery trucks. The extent of a site cannot be accurately determined from remaining surface features alone, and the equipment used to excavate disposal cells (back hoe and front-end loader) could destroy subsurface features. Avoiding archaeological sites would greatly reduce the potential disposal volume per acre, thus expanding the number of acres needed for a dedicated LLW disposal area. Finally, there are concerns about the possibility of contamination migrating into the archaeological sites from buried radioactive wastes.

The areas that would be disturbed are summarized in Table I.2.1.2–1. The estimate of usable acreage takes into account the requirement for disposal cells to be 50 feet (15 meters) from the competent canyon wall (Rogers 1977 and Purtymun et al. 1980), avoiding the VOC plume, monitoring areas, and the OLE easement. The long-term impacts of disposal at this location were assessed in the Area G Performance Assessment (LANL 1998f) and are discussed further in volume I (section 5.3.3.5).

I.2.2 Develop Zone 6 at TA–54

Under this alternative, DOE would develop the area of Mesita del Buey that lies within TA–54 immediately to the west of Area L (Zone 5) and extends to Area J for the additional LLW disposal capacity. This area, referred to as Zone 6, is slightly less than 40 acres (16 hectares). The location is shown in Figure I.1.1.1–1. The location is not fenced, but access by road is controlled by the same gate referred to in section I.2.1.1.

I.2.2.1 *Location Description*

The soil and underlying tuff at Zone 6 are the same as those described for Zone 4 in section I.2.1.1.

The area is level and covered with second-growth pinyon and juniper and an understory of shrubs and grasses. The mesa top is quite narrow in part of this location, and Mesita del Buey Road runs down the middle of the mesa. These features would make about half the surface area difficult and inefficient to develop as disposal cells. Zone 6 is also within the foraging area of the peregrine falcon nest site noted in section I.2.1.1. Monitoring data indicate the presence of no ER locations. There are seven archaeological sites within Zone 6 that could be affected. Prior to developing this area, a recovery plan would be prepared, and the SHPO would be consulted. At Zone 6, the boundary of San Ildefonso Pueblo lies about 1,600 feet (500 meters) northeast of the north edge of the top of Mesita del Buey (Figure I.1.1.1–1). The TCP study conducted for the SWEIS did not result in the identification of specific TCPs in Zone 6.

I.2.2.2 *Development*

If this alternative were implemented, the same steps would be implemented as those discussed in section I.2.1.2. No new roads or utilities

TABLE I.2.1.2–1.—*Low-Level Waste Disposal Areas Within Zone 4 of TA–54*

OPTION	APPROXIMATE AREA DISTURBED	APPROXIMATE WASTE VOLUME (10^3 m^3)[a]
Option 1 – Designate approximately 7 acres (3 hectares) west of the existing footprint and east of the existing ER monitoring area as an MDA, north of the Mesita del Buey access road only.	7 acres (3 hectares)	260
Option 2 – Designate approximately 30 acres (12 hectares) west of the existing footprint and east of the existing ER monitoring zone as an MDA, both sides of Mesita del Buey access road.	24 acres (10 hectares)	800

[a] Waste capacity value calculated assuming disposal cell depth of 65 feet (20 meters) and a 40 percent fill efficiency.

would be required, but the present road could be relocated nearer to the canyon rim to free more contiguous space for disposal cell development. Here, fencing would not be placed around the entire zone; only the disposal cells being excavated and filled with LLW would be fenced. This fencing would prevent people and medium- to large-sized animals from entering open disposal cells. Fencing would be removed after the disposal cells are closed.

The trees in the mesa-top area, mainly pinyon and juniper, would be removed as necessary and managed as discussed in section I.2.1.2.

Zone 6 presents some constraints on efficient development because much of the area is located along a narrow part of the mesa. In the narrow area, it would be difficult to site disposal cells with the required 50 feet (15 meters) set back from the mesa edges and still avoid Mesita del Buey Road. Most of the disposal cells would be placed in the wider area at the west end of Zone 6. The area that could be disturbed and potential waste volume are shown in Table I.2.2.2–1.

While this site was not specifically analyzed regarding the long-term impacts of waste disposal at this location, the site characteristics at Zone 6 are essentially identical to those analyzed in the Area G Performance Assessment (LANL 1998f). Thus, the results of the Performance Assessment (discussed further in volume I, chapter 5, section 5.3.3.5) are considered to be applicable to this location (Newell 1998).

TABLE I.2.2.2–1.—*LLW Disposal Area Within Zone 6 of TA–54*

OPTION	APPROX. AREA DISTURBED	APPROX. WASTE VOLUME (10^3 m^3)
Designate 40 acres (16 hectares) Immediately West of Area L as an MDA	17 acres (7 hectares)	550

Waste capacity value calculated assuming disposal cell depth of 65 feet (20 meters) and a 40 percent fill efficiency.

I.2.3 Develop the North Site, TA–54

Under this alternative, DOE would develop the northern finger of Mesita del Buey that lies within TA–54 immediately to the north of Zones 6 and Area J for the additional LLW disposal capacity. The area is shown in Figure I.1.1.1–1. The mesa top in this area is undeveloped and relatively undisturbed. A 115-kilovolt electrical power line and an unimproved road run down its length. The location is not fenced, and access is not controlled. This area will be referred to in this document as the North Site, TA–54. The total area is about 63 acres (25 hectares), but not all is developable for disposal cells.

I.2.3.1 *Location Description*

The soil and underlying tuff at the North Site are the same as those described for Zone 4 in section I.2.1.1.

The mesa top at the North Site has an area suitable for disposal cell development of about 49 acres (20 hectares). The area is very similar to Zones 4 and 6, described in sections I.2.1.1 and I.2.2.1. At the North Site, the boundary of San Ildefonso Pueblo is about 300 feet (90 meters) northeast of the north edge of the top of Mesita del Buey (Figure I.1.1.1–1). The TCP study conducted for the SWEIS did not result in the identification of specific TCPs at the North Site.

Four archaeological sites are known to be present within the North Site, but the area has not been as rigorously surveyed as has the rest of Mesita del Buey. Additional sites may be present. Prior to developing this area, a recovery plan would be prepared and the SHPO would be consulted. No ER locations have been identified.

I.2.3.2 *Development*

If this alternative were implemented, the development would be the same as presented for Zone 6 (section I.2.2.2), except that the unpaved road down the mesa would be upgraded by topping it with asphalt. The support structures at Area G would continue to be used as the management center. However, due to the distance from the developed part of Mesita del Buey, some utility lines, including a 110/220-volt electrical line and telephone lines, may be installed aboveground. A decontamination facility, probably an impervious wash pad capable of accommodating a truck, could be added if needed. Decontamination water would be collected and transferred to the RLWTF by tank truck or through the existing pipeline from Area G. Here, fencing would not be placed around the entire zone; only the disposal cells being excavated and filled with LLW would be fenced. This fencing would prevent people and animals from entering open disposal cells. Fencing would be removed after the cells are closed.

The trees in the mesa top area, mainly pinyon and juniper, would be removed as needed and managed as discussed in section I.2.1.2.

The North Site may present some constraints on efficient development. A 115-kilovolt utility line runs the length of the mesa. Current practice precludes disposal cell construction under electrical lines for safety reasons. The electrical line could be relocated toward the edge of the mesa to maximize disposal space. In addition, the USGS specification is that the bottom of the disposal cell be a minimum of 10 feet (3 meters) above the adjacent canyon bottom; this limits the allowable depth of the disposal cells and requires longer or wider disposal cells to accommodate a given volume of waste. The acreage disturbed under this alternative takes this constraint into account.

While this site was not specifically analyzed regarding the long-term impacts of waste disposal at this location, the site characteristics at the North Site are essentially identical to those analyzed in the Area G Performance Assessment (LANL 1998f). Thus, the results of the Performance Assessment (discussed further in volume I, chapter 5, section 5.3.3.5) are considered to be applicable to this location (Newell 1998).

The potential area disturbed and approximate waste volume are summarized in Table I.2.3.2–1.

TABLE I.2.3.2–1.—*Low-Level Waste Disposal Area Within the North Site of TA–54*

OPTION	APPROX. ACREAGE DISTURBED	APPROX. WASTE VOLUME (10^3 m^3)
Designate 63 acres (25 hectares) Immediately North of Zone 6 and Area J as an MDA	49 acres (20 hectares)	1,600

Waste capacity value calculated assuming disposal cell depth of 65 feet (20 meters) or 10 feet above the adjacent canyon bottom (whichever is less) and a 40 percent fill efficiency.

I.2.4 Develop New Disposal Site at Another LANL Technical Area (TA–67)

Under this alternative, DOE would establish a new LLW disposal facility at another unspecified location at LANL. The new area is assumed to be an undeveloped, undisturbed mesa, not adjacent to the existing LLW disposal area. This alternative would require that the existing facilities at Area G be duplicated in another location at LANL. A good deal of information is known about Pajarito Mesa within TA–67 because this area was evaluated as a possible location for a mixed waste disposal facility, a proposal subsequently canceled. This location was chosen as an example of requirements for developing undeveloped mesas within LANL for LLW disposal. Other undeveloped mesa-top locations would present similar but not necessarily identical requirements for development (i.e., not all mesa tops are within potential habitat of threatened and endangered [T&E] species or possible existence of a fault, but virtually all contain archaeological sites).

I.2.4.1 *Location Description*

The representative undeveloped location selected is TA–67 on Pajarito Mesa because it is the best characterized area on an undeveloped mesa. This location is shown in Figures I.1.1–1 and I.2.4.1–1.

The upper portion of Pajarito Mesa is also of Bandelier Tuff, the properties of which are described in section I.2.1.1. Beneath TA–67, the tuff is a 295-foot (90-meter) thick bed of Bandelier Tuff (Broxton and Chipera 1994). The underlying layer is also of older sedimentary deposits and basalt flows. The Rendija Canyon fault may underlie the western portion of TA–67. (See chapter 4, section 4.2.2.2, Figure 4.2.2.2–1).

TA–67 is an undeveloped area of slightly less than 72 acres (29 hectares) atop Pajarito Mesa. To the north of the mesa lies Pajarito Canyon; to the south is Threemile Canyon. The mesa top is level and covered with ponderosa pine, pinyon, and juniper with an understory of shrubs and grasses. The site is within the buffer zone of a high explosives (HE) research and development area. It is also within the blast circles for active HE firing sites at TA–15 and TA–40 (LANL 1991). The blast circle defines an area wherein fragments from tests may fall and from which humans are excluded during tests. Access to TA–67 at present is via West Jemez Road (State Route 501) and then through a security gate via Anchor Ranch Road and east on R-Site Road.

TA–67 is within one-quarter mile of potential nesting habitat for the Mexican spotted owl, and is within potential roosting and foraging habitat for that species.

There are 11 cultural resources within TA–67 that might be affected by development of the site (LANL 1998c). The TCP study conducted for the SWEIS did not identify any specific TCPs in the area. The boundary of San Ildefonso Pueblo is about 1.5 miles (2.4 kilometers) east of TA–67 (Figure I.1.1–1).

I.2.4.2 *Development*

If this alternative were implemented, a set of waste management support facilities and infrastructure similar to that in the existing footprint area would be constructed and installed at TA–67, including office structures, personnel showers, equipment and supply storage lockers, control rooms, personnel monitoring stations, and the surface decontamination wash pad and structures. It would not be efficient to continue to use the support facilities at Area G because of the distance. Decontamination water would be collected in a tank and moved by tank truck to the RLWTF. Another 200-ton (180-metric ton) compactor may be installed, or the existing unit might be relocated. The infrastructure (consisting of roads, utility lines, and air monitoring network) would have to be installed. An access control gate and some fencing would be installed. The access road would require either a bridge over Threemile Canyon or an access road around the west end of the canyon. The installation in the existing footprint would remain active while the new location was being developed.

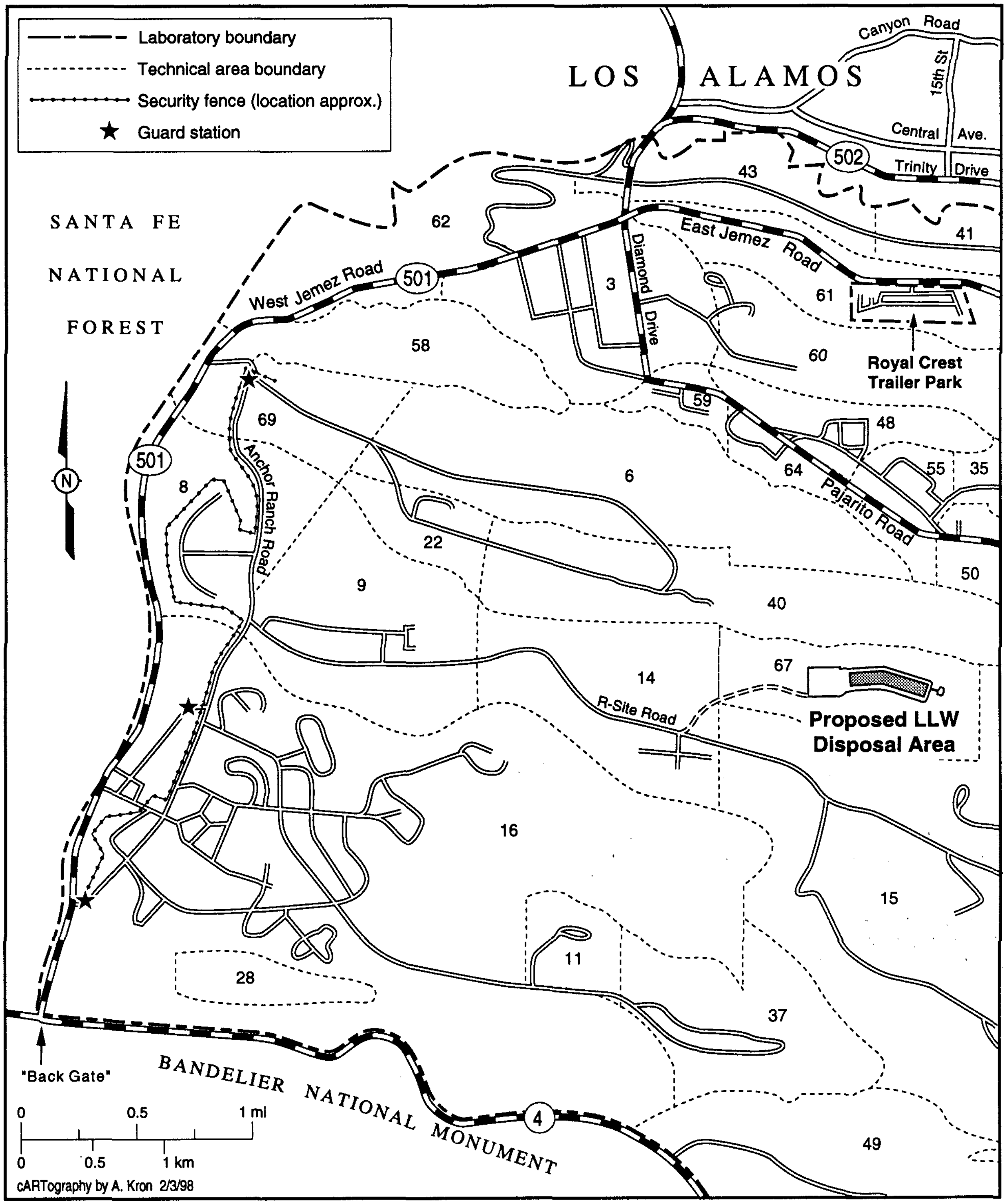

FIGURE I.2.4.1–1.—*Location of the Proposed LLW Disposal Area at TA–67.*[1]

[1] The TA numbers are included.

The trees in the mesa-top area, ponderosa pines, pinyons, and juniper, would be removed and managed as discussed in section I.2.1.2. The surface contour would be changed as needed to control runoff and protect the wetland north of the mesa. A data recovery plan would be developed, archaeological sites would be excavated as necessary, and data would be recovered, as discussed in sections I.3.6 and I.4.4.5.

Fencing would not be placed around the entire zone; only the disposal cells being excavated and filled with LLW would be fenced. This fencing would prevent people and animals from entering open cells. Fencing would be removed after the disposal cells are closed.

About 50 acres (24 hectares) is assumed for waste disposal cells, while the remainder of the area disturbed would be for roads and other infrastructure development. The potential area disturbed and waste volume are summarized in Table I.2.4.2–1.

While this site was not specifically analyzed regarding the long-term impacts of waste disposal at this location, the site characteristics at TA–67 (and many other mesa tops in the area) are sufficiently similar to those analyzed in the Area G Performance Assessment (LANL 1998f) in that the Performance Assessment results (discussed in volume I, chapter 5, section 5.3.3.5) are considered applicable to other mesa-top locations, such as TA–67 (Newell 1998). It is important to note that the possible existence of a fault beneath part of the TA–67 site introduces additional issues that do not exist at TA–54.

TABLE I.2.4.2–1.—*LLW Disposal Area Within TA–67*

OPTION	APPROX. ACREAGE DISTURBED	APPROX. WASTE VOLUME (10^3 m^3)
Designate 72 acres (29 hectares) at TA–67 on Pajarito Mesa as an MDA	50 acres (20 hectares)	1,600

Waste capacity value calculated assuming disposal cell depth of 65 feet (20 meters) and a 40 percent fill efficiency.

I.2.5 Preferred Alternative—Develop Zones 4 and 6 at TA–54

The Preferred Alternative is to develop both Zones 4 and 6, proceeding westward in a step-by-step fashion from the existing footprint of Area G. The majority of the area on top of Mesita del Buey (excluding the North Site) would effectively be designated for LLW management and disposal. The Preferred Alternative is shown in Figure I.2.5–1.

This alternative has been designated as preferred because it offers DOE several advantages. Because LLW disposal areas require long-term institutional control and LLW has been disposed of at both ends of Mesita del Buey (Area H and Area G, shown in Figure I.2.5–1), it would be more efficient to control the mesa top as one contiguous disposal area, continuing west from the existing Area G. Zones 4 and 6 on Mesita del Buey are not currently occupied or used by any T&E species. The space set aside might suffice for as long as 130 years. Setting aside an area that is more than adequate for the LLW disposal needs forecasted for 10 years gives DOE flexibility in case the needs have been underestimated. Finally, setting aside this entire area preserves DOE's flexibility to continue to dispose of LLW (north of the road in Zone 4) while addressing the issues of the archaeological sites in the remaining part of Zones 4 and 6.

Disposal cells would be excavated as needed. The development would ultimately be equivalent to the sum of that described individually for all of Zone 4 (section I.2.1.2)

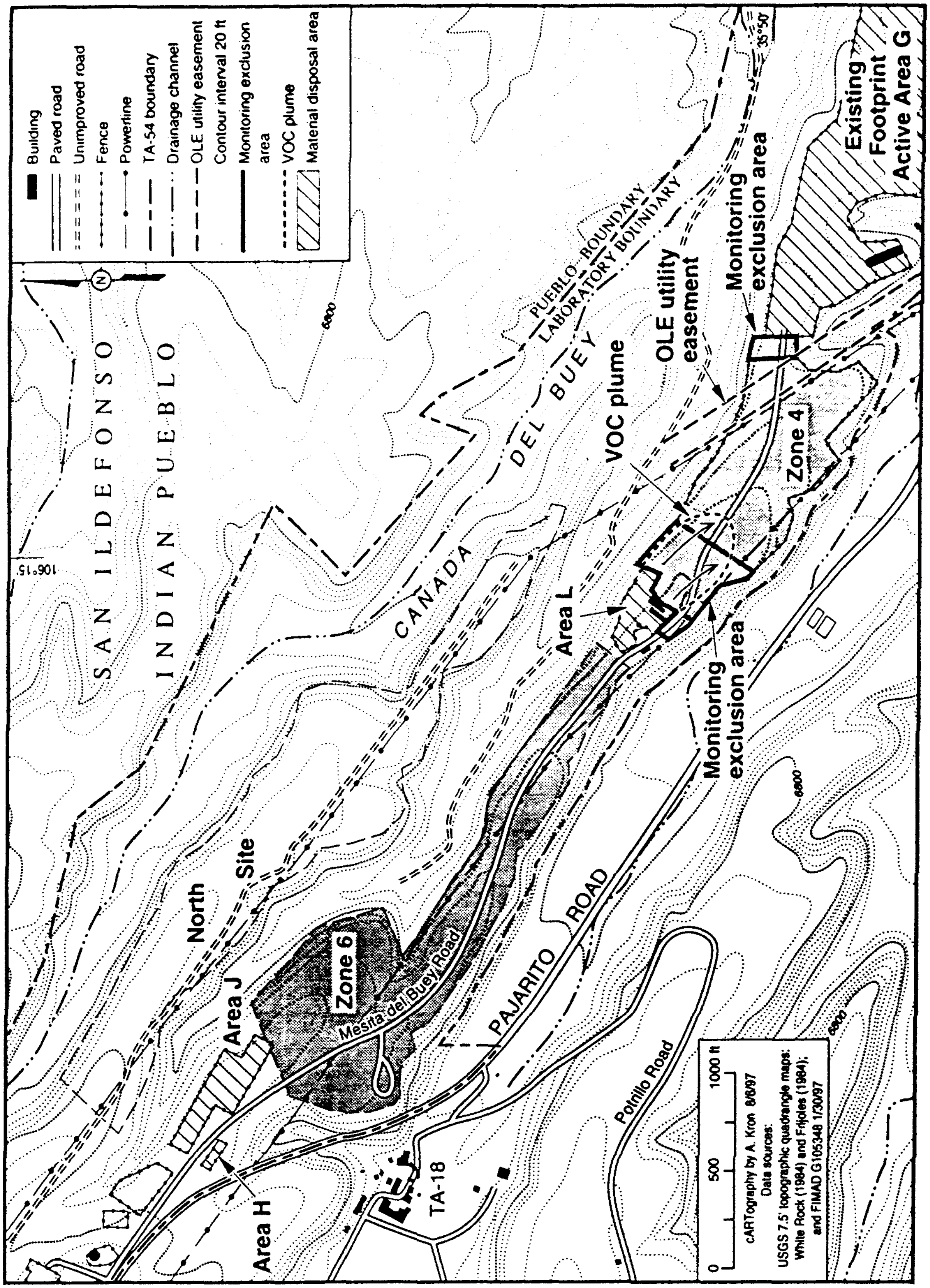

FIGURE I.2.5–1.—*Location of the Preferred Alternative Within TA–54.*

and Zone 6 (section I.2.2.2) added together, and as shown in Table I.2.5–1.

I.3 AFFECTED ENVIRONMENT

This section does not repeat information that is presented in volume I of the SWEIS; it focuses on alternative-specific information that is needed to illuminate the differences in alternatives. Table I.3–1 identifies the environmental resources common to this PSSC analysis and volume I of the SWEIS, along with their location in volume I and in this PSSC analysis. Table I.3–2 identifies environmental resources that are not discussed in this PSSC analysis, provides information about why they are not discussed further here, and identifies the locations of discussions in volume I of the SWEIS. Zones 4 and 6 and the North Site are on the top of the Mesita del Buey area at TA–54. The environmental conditions for the whole mesa top are described as a unit (as Mesita del Buey). TA–67, on Pajarito Mesa, is described separately.

I.3.1 Land Resources

Distances and directions from the residential areas, the San Ildefonso Pueblo boundary, and the Bandelier National Monument (BNM) boundary to the alternative locations are shown in Table I.3.1–1. The distances to these resources from existing Area G are included for comparison. Although the distances are shown to the nearest San Ildefonso Pueblo boundary, this is not the distance to a residential area at San Ildefonso. The mesa top on San Ildefonso Pueblo land nearest the DOE boundary may be used for other intermittent purposes, but no dwellings are located there. The nearest human habitations on pueblo land are at Totavi, some 3.6 miles (5.8 kilometers) northeast of Area G, and Otowi, which is farther away.

TABLE I.2.5–1.—*LLW Disposal Area Within the Preferred Alternative, Zones 4 and 6*

OPTION	APPROX. ACREAGE DISTURBED	APPROX. WASTE VOLUME (10^3 m^3)
Designate Zones 4 and 6 on Mesita del Buey, 70 acres (28 hectares)	41 acres (17 hectares)	1,350

Waste capacity value calculated assuming disposal cell depth of 65 feet (20 meters) and a 40 percent fill efficiency.
For Zone 4, option 2 (develop both north and south of the access road) is assumed.

I.3.1.1 *Land Use*

TA–54 is a designated waste management and disposal area and is not accessible to the general public. In contrast, TA–67 land is designated as an explosives test or storage area that is currently used as a safety buffer zone for nearby LANL explosives testing operations; LANL workers are excluded from TA–67 during tests.

I.3.1.2 *Visual Resources*

From Pajarito Road, motorists can see only the sides of support facilities and storage domes of the existing footprint of Area G on the edge of the mesa above, to the north of the road. The areas next to the structures at Area G are predominately grass-covered expanses (at closed disposal sites) surrounded by undeveloped areas that are forested with native shrubs and small trees. Mesita del Buey is not visible from the BNM Visitors' Center or developed campgrounds. It is visible from the nearest San Ildefonso Pueblo boundary, although not from the dwellings at Totavi and Otowi.

The easternmost end of TA–67 is visible from Pajarito Road but not from the BNM Visitors' Center, developed campgrounds, or San Ildefonso Pueblo land. The TA–67 area

TABLE I.3–1.—*Potential Environmental Resource Issues Addressed in Volume I and This PSSC*

ENVIRONMENTAL RESOURCE	LOCATIONS OF DISCUSSIONS
Land Use	Volume I, section 4.1.1 and PSSC Analysis, section I.3.1.1
Visual Resources	Volume I, section 4.1.2 and PSSC Analysis, section I.3.1.2
Noise	Volume I, section 4.1.3 and PSSC Analysis, section I.3.1.3
Air Quality	Volume I, section 4.4 and PSSC Analysis, section I.3.2
Ecological Resources	Volume I, section 4.5 and PSSC Analysis, section I.3.3
Threatened and Endangered Species	Volume I, section 4.5 and PSSC Analysis, section I.3.3.2
Human Health	Volume I, section 4.6 and PSSC Analysis, section I.3.4
Environmental Justice	Volume I, section 4.7 and PSSC Analysis, section I.3.5
Cultural Resources	Volume I, section 4.8 and PSSC Analysis, section I.3.6
Waste Management	Volume I, section 4.9 and PSSC Analysis, section I.3.7
Environmental Restoration	Volume I, section 2.1.2.5 and PSSC Analysis, section I.3.8
Traffic	Volume I, section 4.10 and PSSC Analysis, section I.3.9

TABLE I.3–2.—*Potential Environmental Resource Issues Addressed Only in Volume I of the SWEIS*

ENVIRONMENTAL RESOURCE	REASON NOT ADDRESSED IN THIS PSSC	LOCATION OF DISCUSSION
Parks, Forests, Conservation Areas, Areas of Recreational, Ecological, or Aesthetic Importance	Public access not permitted in any of the areas under consideration due to their present designated uses.	Volume I, section 4.1.1
Geology and Soils	Alternatives would involve the same types of surface soils and the same underlying Bandelier Tuff (Purtymun and Kennedy 1971, Nyhan et al. 1978, and Broxton and Chipera 1994).	Volume I, section 4.3
Water Resources	None of the alternatives would affect water resources. Any modifications to runoff patterns would be minor relocations. Surface water conditions are described in Reneau 1994, Banar 1996, and LANL 1996b.	Volume I, section 4.4
Wetlands	No wetlands present on mesa tops at TA–54 or TA–67 or in other locations that could be affected by any of the PSSC alternatives.	Volume I, section 4.5
Socioeconomics	The labor required to implement any of the alternatives is very small and well within the capacity of the local labor market.	Volume I, section 4.7

TABLE I.3.1–1.—*Distances to Residential Areas, Bandelier National Monument, and San Ildefonso Pueblo Boundaries from Each Alternative Location*

ALTERNATIVE LOCATION	FROM ROYAL CREST TRAILER PARK	FROM WHITE ROCK	FROM LOS ALAMOS TOWNSITE	FROM BANDELIER NATIONAL MONUMENT	FROM SAN ILDEFONSO PUEBLO BOUNDARY[a]
Zone 4	3.7 mi (5.9 km)	1.3 mi (2.1 km)	3.9 mi (6.2 km)	3.0 mi (4.8 km)	0.25 mi (0.4 km)
Zone 6	3.0 mi (4.8 km)	2.1 mi (3.4 km)	3.1 mi (5.0 km)	3.2 mi (5.1 km)	0.3 mi (0.5 km)
North Site, TA–54	2.9 mi (4.6 km)	2.1 mi (3.4 km)	3.0 mi (4.8 km)	3.2 mi (5.1 km)	0.05 mi (0.1 km)
TA–67	1.5 mi (2.4 km)	5.2 mi (8.3 km)	2.0 mi (3.2 km)	2.0 mi (3.2 km)	1.5 mi (2.4 km)
Area G Existing Footprint	1.6 mi (2.5 km)	1.0 mi (1.6 km)	4.2 mi (6.7 km)	3.2 mi (5.1 km)	0.13 mi (0.2 km)

[a] Distance to human habitation on the Pueblo lands at Totavi is 3.6 miles (mi) (5.8 kilometers [km]). Otowi is farther away.

presents a forested appearance with tall native trees.

I.3.1.3 *Noise*

Operations at TA–54 contribute to the overall background noise level generated by LANL activities primarily through the traffic into and away from the facilities located within the TA and from heavy machinery and equipment used to excavate the disposal cells and shafts and move waste containers. Actual operational noise heard outside of structures is mostly limited to the immediate vicinity of the activity; most of these noises are due to the routine movement of equipment and waste containers into and around the facilities. No measurements of environmental noise have been conducted within the TA–54 area; but the level of noise present there is fairly representative of other industrially developed sites around LANL.

TA–67 is undeveloped land covered with native vegetation. It is forested with native trees and contributes little to the overall background noise at LANL.

I.3.2 Air Quality

LANL maintains five meteorological towers around LANL, including one on Pajarito Road below the mesa-top location of TA–55 and Area G and one at TA–6 near TA–67 (LANL 1998b). These towers are instrumented to record temperature, relative humidity, wind direction, and wind velocity at 15-minute intervals. Statistics of wind measured 36 feet (11 meters) above ground level indicate that the prevailing daytime wind at TA–54 is from the southeast. At TA–6, the prevailing daytime wind is from the south.

On-site and off-site air monitoring stations collect samples from which the radionuclides in routine emissions and resuspended dust are analyzed. Eight such sampling stations are located around the developed footprint of Area G. LANL's annual surveillance reports document tritium, plutonium, uranium, and americium emissions in comparison with the DOE allowable concentration guides. These reports also contain a more thorough description of monitoring activities (LANL 1996b).

There are no monitoring stations in or bordering Zone 4, Zone 6, the North Site, or TA–67. Thus, there is no radioactive air quality information specific to any of the potential expansion areas.

The monitoring station nearest to these areas on Mesita del Buey, Station 36, is located at the west end of the developed footprint of Area G, just east of the monitoring exclusion area that separates the zone from the developed footprint of Area G (LANL 1996b). The air monitoring stations nearest to the TA–67 site are stations 76 and 78, approximately 5,000 feet (1.6 kilometers) to the east-southeast (LANL 1996b).

I.3.3 Ecological Resources

I.3.3.1 *Flora and Fauna*

Mesita del Buey

Most of Mesita del Buey, particularly Area G, is a high density area for LANL workers and traffic movement with continual disturbance related to waste disposal activities. The North Site is relatively undisturbed. The vegetation of the undisturbed portions of Mesita del Buey is primarily comprised of pinyon pine-juniper woodland with a ground cover of blue grama grass. In the disturbed areas, including the closed waste disposal cells, the vegetation is of mixed grasses and low-growing native plants (Usner 1996). The vegetation supports about 23 wildlife species that represent a broad diversity including insects, reptiles, amphibians, mammals, and birds. Some 95 species of birds, both resident and migratory varieties, have been identified in the general vicinity. Mule deer and elk are the most visible of the large mammals of the region. Other common species include black bear, mountain lion, bobcat, fox, and coyote. Small mammals known to inhabit the general area include species of voles, mice, and chipmunks (Banar 1996, Keller and Bennett 1996, Usner 1996).

TA–67

The TA–67 site is covered with the ponderosa pine habitat type, generally over the Pajarito Plateau's elevational ranges from 6,900 to 7,500 feet (2,100 to 2,300 meters). Overall, TA–67 is a fairly flat, wooded mesa top adjacent to moderately steep to very steep canyons; the north-facing canyon slope areas include fir and spruce species. The TA–67 area vegetation communities support about 90 wildlife species that represent a broad diversity, including insects, reptiles, amphibians, mammals, and birds.

Forty-nine species of birds, both resident and migratory varieties, have been identified in the general vicinity. Mule deer and elk are the most visible of the large mammals in the region. Other common species include black bear, mountain lion, fox, bobcat, and coyote (Cross and Usner 1996).

I.3.3.2 *Threatened and Endangered Species*

DOE analyzed existing available field information and used a preliminary model of nesting and roosting habitat for the Mexican spotted owl (*Strix occidentalis lucida*) to assess use of the TA–54 and TA–67 areas by species of animals and birds that are federally and state listed and protected as threatened or endangered. Three federally protected (also state listed) species of birds potentially use the surrounding area of TA–54 for habitat: the American peregrine falcon (*Falco peregrinus*), the Mexican spotted owl, and the southwestern willow flycatcher (*Empidonax traillii extimus*). However, species-specific field surveys located no T&E species habitat use for nesting or roosting purposes on Mesita del Buey itself, as well as none within 0.25 mile of the mesa top. The mesa top may provide some foraging habitat for the peregrine falcon. One federally protected species of bird, the Mexican spotted owl, potentially uses habitat in the TA–67 area for roosting and foraging purposes; potential nesting habitat is located next to TA–67 in the canyon area. No known use of this nesting habitat has occurred recently.

LANL conducted preliminary consultation with the U.S. Fish and Wildlife Service (FWS) concerning TA–67 development. According to the FWS, additional surveys would be needed in order to establish baseline information. Mitigation measures would be developed through consultations, in accordance with the *Endangered Species Act* (16 U.S.C. §1531), if the TA–67 alternative were to be implemented.

I.3.4 Human Health

I.3.4.1 *Radiological Dose*

Personnel at TA–54 are exposed to radiation from working with the various types of wastes managed there. Personnel are not exclusively assigned to one type of waste, so their doses represent an integration over all the jobs performed there. The LLW disposal cells are excavated by personnel who are part of the regular TA–54 workforce, so their doses cannot be partitioned to show only exposures received while excavating disposal cells. TRU and TRU mixed wastes (waste with both TRU and chemicals regulated as hazardous under the RCRA) produce the majority of the workers' doses. In 1995, of the 470 individuals working at Area G who wore dosimetry badges, 408 received no dose. In 1996, out of 228 badged personnel, 213 had no dose. The health effects of radiation are expressed as the increased risk or chance of dying from cancer at some point later in life (excess latent cancer fatality [LCF]). The average external doses of personnel assigned to TA–54 who wear dosimetry badges and received detectable (non-zero) doses in 1995 and 1996 with associated health effects are shown in Table I.3.4.1–1. Dose and health effect information on LANL personnel working in other locations under the Expanded Operations Alternative is presented in volume I of the SWEIS, chapter 5, section 5.3.6. (Long-term public health impacts from disposal operations are discussed in section 5.3.3.5 of volume I and the Area G Performance Assessment [LANL 1998f]).

Area development and disposal cell construction activities would not be expected to expose equipment operators to radioactive material, regardless of alternative location. Thus, there would be no worker dose associated with area development and cell construction. Any workers who are on the site for a short time to construct disposal cells and support facilities and do not work in the vicinity of TRU wastes should receive no work-related dose, regardless of alternative location.

TABLE I.3.4.1–1.—*Annual Individual Worker Dose (External Dose) and Health Effects at Area G (1995, 1996)*

TOTAL BADGED WORKERS AT AREA G	INDIVIDUALS WITH ZERO DOSE	AVERAGE DOSE FOR INDIVIDUALS WITH MEASURABLE DOSE	HEALTH EFFECT—CHANCE OF EXCESS LCF IN THE EXPOSED POPULATION
470 Individuals in 1995	408 (87 percent)	18 millirem (62 individuals)	less than 1—(0.00045 or 4 in 10 thousand)
228 Individuals in 1996	213 (93 percent)	38 millirem (15 individuals)	less than 1—(0.00023 or 2 in 10 thousand)
DOE Individual Annual Occupational Dose Limit	—	5,000 millirem[a] (5 rem)	less than 1—(0.0020 or 20 in 10 thousand)

[a] DOE 1994

I.3.4.2 *Construction Activities*

The regular workforce at Area G excavates new disposal cells as part of normal operations. Construction and relocation activities can expose workers to a variety of risks, such as being crushed beneath heavy equipment, back injuries, electrical hazards, and those related to working below grade. All work is performed according to facility procedures for each type of task and LANL-wide general standards. Worker health is protected by following administrative controls and wearing personal protective equipment such as hard hats and steel-toed boots, as needed. Information on safety and construction-related accidents that have occurred at LANL is found in chapter 4 of volume I.

I.3.5 Environmental Justice

The WM PEIS has identified a potential environmental justice issue because of the proximity of LLW disposal areas at LANL to minority and low-income populations, such as the Native Americans at San Ildefonso Pueblo and the Hispanic population in Española, Santa Fe, and the surrounding area (DOE 1997). As noted in section I.1.1, the northern boundary of LANL at TA–54 is San Ildefonso Pueblo land. However, the nearest human habitations on San Ildefonso Pueblo land are at Totavi, some 3.6 miles (5.8 kilometers) from Area G, and at Otowi, which is farther away. Distance is even farther to Española, the nearest town with a predominately Hispanic population. The distances to the residential areas from each of the proposed LLW disposal locations are presented in Table I.3.1–1. The environmental justice affected environment is discussed further in chapter 4, section 4.8, of volume I.

I.3.6 Cultural Resources

The presence of TCPs in the Mesita del Buey area and the TA–67 area is unknown. Cultural resource surveys have been conducted over most of TA–54 and over a portion of TA–67 to identify archeological sites within those areas.

Cultural resource surveys conducted over Mesita del Buey within the designated footprint of Area G have identified 20 archaeological sites in the area west and north of the existing Area G disposal area. Sixteen of these 20 sites have been evaluated for inclusion on the NRHP. Of the 16 sites evaluated for register inclusion, 8 are located in Zone 4 to the south of the roadway, and 1 is located to the north of the roadway in an ER monitoring zone. All 9 sites within Zone 4 are Coalition Period pueblo roomblocks (A.D. 1100 through A.D. 1325). An archeological data recovery plan on seven of the sites located south of the road in Zone 4 that are eligible for inclusion on the NRHP (Larson 1991b) has been approved by the New Mexico SHPO, and site work to implement the recovery plan has been initiated but not completed; the remaining site on the south side of the road is not eligible for NRHP inclusion. The single site located north of the roadway in Zone 4 is not included in the data recovery plan because there are no current plans to excavate this site since it is located within an ER monitoring zone. Seven of the 16 archaeological sites evaluated for NRHP inclusion were identified within the Zone 6 area of Mesita del Buey. All of these seven sites are pueblo roomblocks dating from the Coalition Period and the Classic Period (A.D. 1325 through A.D. 1600) (Larson 1997). Consultation with the SHPO and the four Accord Pueblos has not yet been initiated by DOE for these seven sites. The remaining 4 sites of the total of 20 sites located to the west and north of the existing Area G disposal area are not believed to be eligible for inclusion on the NRHP. Surveys of these sites were not comprehensive, however, and a rigorous survey and additional consultation with the SHPO and Accord Pueblos, together with site work to implement such a plan, have not yet been undertaken by DOE.

Cultural resource surveys of the TA–67 area of interest revealed the presence of 11 archaeological sites and these have been evaluated for eligibility for inclusion on the NRHP. These sites are from the Coalition and Classic Periods (LANL 1998c). Of the 11 sites, all but 1 are eligible for inclusion in the register. An archaeological data recovery plan on the 10 sites, together with consultation with the SHPO and Accord Pueblos, and site work to implement such a plan have not yet been undertaken by DOE.

I.3.7 Waste Management (Construction Refuse)

Uncontaminated wastes produced by operations at LANL, such as construction debris and office refuse, are collected by a subcontractor and recycled where feasible. The remaining uncontaminated wastes are disposed of in the Los Alamos County Landfill.

I.3.8 Environmental Restoration

I.3.8.1 *Mesita del Buey*

All of TA–54 has been placed in ER Operable Unit 1148. Eventual cleanup and site closure would follow ER procedures and other applicable regulations in place at that time.

Area L was historically used as a disposal site for hazardous chemical wastes and has a VOC vapor plume in its subsurface. Various chemicals are present in the plume; the one in highest concentration is TCE. Constituents and concentrations of the VOC plume are listed in appendix I.B. This plume extends about 55 feet (20 meters) east of Area L into Zone 4. Within Zone 4, there are two ER monitoring zones, as shown in Figure I.1.1.1–1. The first is located immediately east of Area L and covers about 4 acres (1.6 hectares). The second comprises about 1 acre (0.4 hectare) immediately west of the current disposal area at Area G. Monitor wells in both monitoring exclusion zones are being tested on a quarterly basis to determine movement of pore gas in the vadose zone. The plume has not expanded spatially in the last 5 years. There are no known areas of contamination in Zone 6 or the North Site.

I.3.8.2 *TA–67*

Because TA–67 is in the blast circles for active firing sites, it is possible that debris and airborne particulates from test activities have been deposited onto portions of TA–67. To date, no such debris or contamination has been identified at this site. In addition, TA–67 is not currently an ER operable unit area.

I.3.9 Traffic

Traffic to and from Los Alamos County and within LANL is discussed in volume I, chapter 4, section 4.10. At present, LLW is moved to Area G by truck. Construction materials are also moved to LANL and within LANL by truck. Access to Mesita del Buey is via Pajarito Road (State Route 4). Access to TA–67 is via West Jemez Road (State Route 501).

I.3.10 Comparison of Environmental Conditions at Alternative Locations

The environmental conditions at each of the identified alternative locations are summarized and compared in Table I.3.10–1.

The conditions for the Preferred Alternative are the sum of the individual conditions for Zones 4 and 6, except for distances and noise.

I.4 ENVIRONMENTAL CONSEQUENCES

The environmental consequences of developing new LLW disposal areas at LANL are presented

TABLE I.3.10–1.—*Comparison of Environmental Resource Conditions in Alternative Locations for Low-Level Radioactive Waste Disposal*

	PREFERRED ALTERNATIVE			
ENVIRONMENTAL RESOURCE CONDITION	**ZONE 4 (AREA G, TA–54)**	**ZONE 6 (TA–54)**	**NORTH SITE (TA–54)**	**TA–67**
Land Area Available	7 acres (3 hectares) north of road, 24 acres (10 hectares) both sides of road developable	41 acres (16 hectares), 17 acres (7 hectares) developable	63 acres (25 hectares), 49 acres (20 hectares) developable	72 acres (29 hectares), 50 acres (20 hectares) developable
- Current Identified Use	LLW disposal area	solid waste management area	solid waste management area	buffer zone, blast circle for HE testing
- Potential Waste Disposal Capacity (10^3 m^3)	260 north of road 800 both sides	550	1,600	1,600
Distance to - Nearest Residential Area	1.3 mi (2.1 km)	2.1 mi (3.4 km)	2.1 mi (3.4 km)	1.5 mi (2.4 km)
- Bandelier National Monument	3.0 mi (4.8 km)	3.2 mi (5.1 km)	3.2 mi (5.1 km)	2.0 mi (3.2 km)
- San Ildefonso Pueblo Boundary[a]	0.25 mi (0.4 km)	0.3 mi (0.5 km)	0.05 mi (0.1 km)	1.5 mi (2.4 km)
- Totavi	3.6 mi (5.8 km)	3.6 mi (5.8 km)	3.6 mi (5.8 km)	> 3.6 mi (5.8 km)
- Otowi	> 3.6 mi (5.8 km)	> 3.6 mi (5.8 km)	> 3.6 mi (5.8 km)	> 3.6 mi (5.8 km)
- Española	> 10 mi (16 km)	> 10 mi (16 km)	> 10 mi (16 km)	> 10 mi (16 km)
Visibility from - Public Areas - San Ildefonso Pueblo Boundary	not visible visible	not visible visible	not visible visible	visible not visible
Noise	< 80 dBA	< 80 dBA	< 80 dBA	< 80 dBA except during HE open air testing
Air Quality	no site-specific data available; nearest air monitor is on Pajarito Road below TA–54	no site-specific data available; nearest air monitor is on Pajarito Road below TA–54	no site-specific data available; nearest air monitor is on Pajarito Road below TA–54	no site-specific data available; nearest air monitor is at TA–6, near TA–67
Ecological Resources - Flora and Fauna	pinyon-juniper, small mammals and birds	pinyon-juniper, large and small mammals and birds	pinyon-juniper, large and small mammals and birds	ponderosa pine-mixed conifers, large and small mammals and birds

TABLE I.3.10–1.—*Comparison of Environmental Resource Conditions in Alternative Locations for Low-Level Radioactive Waste Disposal*-Continued

ENVIRONMENTAL RESOURCE CONDITION	PREFERRED ALTERNATIVE: ZONE 4 (AREA G, TA–54)	PREFERRED ALTERNATIVE: ZONE 6 (TA–54)	NORTH SITE (TA–54)	TA–67
- Threatened, Endangered, and Sensitive Species	within peregrine falcon foraging habitat	within peregrine falcon foraging habitat	within peregrine falcon foraging habitat	within potential Mexican spotted owl roosting and foraging habitat, next to potential nesting habitat
Human Health	no dose from construction activities	no dose from construction activities	no dose from construction activities	no dose from construction activities
Environmental Justice	adjacent to San Ildefonso Pueblo boundary, nearest populations not minority or low income	adjacent to San Ildefonso Pueblo boundary, nearest populations not minority or low income	adjacent to San Ildefonso Pueblo boundary, nearest populations not minority or low income	not adjacent to San Ildefonso Pueblo boundary, nearest populations not minority or low income
Cultural Resources - Archaeological Sites	one site north of road (avoidable), 8 sites south of road	7 sites	4 known sites	11 sites
- Traditional Cultural Properties	no information	no information	no information	no information
Waste Management	construction waste recycled or disposed at landfill	construction waste recycled or disposed at landfill	construction waste recycled or disposed at landfill	construction waste recycled or disposed at landfill
Environmental Restoration	part of Operable Unit 1148, adjacent to VOC plume	part of Operable Unit 1148, no contaminated areas known	part of Operable Unit 1148, no contaminated areas known	not part of an operable unit, no contaminated areas known
Traffic	access via Pajarito Road	access via Pajarito Road	access via Pajarito Road	access via west Jemez Road (State Route 501)

[a] Distance from the existing LLW disposal site in Area G to the San Ildefonso Pueblo boundary is 0.13 mi (0.2 km).
dBA = decibels A-weighted frequency scale

for each alternative and compared below. The differences among alternatives derive from development and construction activities at the different locations where LLW would be disposed. The primary differences among alternatives relate to current land use and surface features. All alternatives call for constructing and developing an LLW disposal area by excavating into the same underlying Bandelier Tuff. The disposal volume to be excavated and the consequences of excavating the tuff itself are assumed to be equivalent for all alternatives. The impacts of LLW management and disposal operations including post-closure are addressed in chapter 5 of volume I. The following siting, development, and construction impacts would be in addition to the operational impacts for LLW management, including disposal.

I.4.1 Develop Zone 4 at TA–54

I.4.1.1 *Land Resources*

Land Use

Because Area G (80 acres [32 hectares]) has been dedicated for LLW disposal, developing Zone 4 would represent no change in land use (DOE 1979). Land use for the entire TA–54 area has been designated for research and development and waste disposal (volume I, chapter 4, Figure 4.1.1.2–1).

Visual Resources

New disposal cells would not be visible from Pajarito Road. New disposal cells would be visible from the boundary of the San Ildefonso Pueblo, but not from the human habitations at White Rock, Los Alamos, Totavi, Otowi, or BNM.

Noise

Excavating new LLW disposal cells would produce the same noise at the point of excavation for all alternatives because the same type of tuff underlies all locations. As shown in Table I.4.1.1–1, cell construction in Zone 4 would be audible at the San Ildefonso Pueblo boundary, but not at the human habitations at Totavi and Otowi, which are much farther away than White Rock and the Los Alamos townsite. Disposal cell construction could be audible above background levels at the nearest point in White Rock. Noise levels at residential areas due to the excavation and construction activities could be audible but within normal levels in the

TABLE I.4.1.1–1.—*Sound Level Estimates[a] from Excavations/Construction in Zone 4 at Receptor Locations[b]*

ALTERNATIVE	(OPERATORS) 3 to 6 ft (1 to 2 m) DISTANCE, dBA	ON-SITE PERSONNEL, 50 ft (15 m) DISTANCE, dBA	WHITE ROCK, dBA	ROYAL CREST TRAILER PARK, dBA	LOS ALAMOS TOWNSITE, dBA	BANDELIER NATIONAL MONUMENT, dBA	SAN ILDEFONSO PUEBLO BOUNDARY, dBA
Zone 4 Disposal Cell Excavation	90 to 113[c]	72 to 95	30 to 53	20 to 43	17 to 40	22 to 45	45 to 68
Normal Background	NA	NA	38 to 51	no data (assume 38 to 51)	38 to 51	31 to 35	no data (assume 31 to 35)

[a] Values calculated from standard noise ranges at 50 feet (ft) (15 meters [m]) using the inverse square relationship: sound $level_1$ - sound $level_2 = 20 \log r_2 r_1^{-1}$ where 1 and 2 represent two locations.
[b] Distances from residential areas shown in Table I.3.1–1.
[c] Standard construction equipment noise ranges (from Canter 1996).
NA = Not applicable

Los Alamos townsite and at Royal Crest Trailer Park. Noise from cell construction could also be audible above background at the roadway boundary to BNM, but not at the Visitors' Center or in the developed campgrounds. The estimates presented are very conservative; in practice, the uneven terrain, intervening vegetation, and direction of air movement would further reduce the noise at receptor locations.

The sound levels at and near the excavation equipment are sufficiently high that operators would be provided with hearing protection. Hearing protection may be provided for other personnel in the vicinity of construction, as needed.

I.4.1.2 *Air Quality*

As LLW disposal cells are excavated, dust particles and vehicle exhaust fumes would be generated by bulldozers, back hoes, and similar construction equipment. LANL personnel would use standard dust suppression methods such as minimizing the area of ground disturbed and misting (LANL 1996c). Excavating disposal cells would not be expected to degrade the quality of air in residential areas.

If the VOC plume has spread from Area L into Zone 4 and the soil and tuff in that location are excavated, VOC components could be released into the air. Consequences to air quality have not been estimated, pending the outcome of the study on risk related to this VOC plume.

Part or all of the wood from trees cleared from Zone 4 would be chipped and burned or used as mulch on the site. Burning would be conducted, under an open burning permit obtained from the New Mexico Environment Department (NMED), such that the air quality standards would not be violated.

I.4.1.3 *Ecological Resources*

Flora and Fauna

Developing Zone 4 would require that most or all of the pinyon-juniper tree cover on 24 acres (10 hectares) be removed. The vegetative coverage of Zone 4 is comparable in density to the general forested area along the mesa top. The wood would be chipped and burned or used for mulch on the site. This would change or eliminate part of the habitat of birds and small mammals living in or around Zone 4. The habitat change would be small (24 acres [10 hectares]) compared to the available habitat remaining in the area (which is many hundreds of acres in size). Construction noise and activity would cause minor and short-term disturbance to wildlife utilizing adjacent habitat during the various development phases. Because the new cells would be within an area that is already fenced, no new impacts are anticipated to the large game animals that utilize the area.

Threatened and Endangered Species

A peregrine falcon nest site is located more than 3 miles (4.8 kilometers) from the proposed expansion areas at TA–54. Peregrine falcons have a wide foraging area, typically up to 12.3 miles (19.8 kilometers) from their nest. The total amount of foraging habitat for this nesting location is 126,805 acres (50,722 hectares), not including developed areas. Developing Zone 4 would require that trees be removed and result in a loss of about 24 acres (10 hectares) of possible foraging habitat (approximately 0.03 percent of available forage area) (Keller and Bennett 1996). The removal of less than 1 percent of available forage area would not result in an appreciable effect on this species.

I.4.1.4 *Environmental Justice*

Developing an LLW disposal area at any location on Mesita del Buey would place the development and subsequent operations adjacent to the San Ildefonso Pueblo boundary but not to the nearest human habitations on pueblo land, as shown in Table I.3.1–1. The development would be visible from the pueblo boundary, and the noise from disposal cell excavations would be audible, should anyone be present at the boundary. However, the noise is not in the range considered harmful to human health.

I.4.1.5 *Cultural Resources*

DOE lacks information regarding the presence of TCPs within TA–54. In the absence of specific information, the consequences of developing Zone 4 on such resources can only be estimated in a qualitative manner. If these resources are present in the Zone 4 area, they would either be destroyed by construction or diminished in value by alteration of the area. If none of these resources are present, no effect would be expected.

If only the area within Zone 4 on the north side of the road were developed and the monitoring exclusion zone were avoided, no archaeological sites would be disturbed. Eight archaeological sites within Zone 4 could be affected or destroyed by constructing an LLW disposal facility that includes the south side of Mesita del Buey Road. All of the eight sites are eligible for the NRHP (Larson 1991a). Two of the eligible sites have already been partially tested or excavated in accordance with a 1991 data recovery plan (Larson 1991b and Larson 1997). If the area on the south side of the road were to be developed, all of the sites would have to be excavated prior to the start of project activities. DOE would need to consult with the four Accord Pueblos and take their comments into consideration in the data recovery plan before the archaeological excavations at Zone 4 could be continued.

I.4.1.6 *Waste Management (Construction Refuse)*

Waste from disposal cell construction (i.e., rock and soil) would be managed at the location (used for fill and for cover or disposed of). No other construction would be needed.

I.4.1.7 *Environmental Restoration*

All of TA–54 is considered a part of ER Operable Unit 1148. If Zone 4 were to be developed, consideration would have to be given to the VOC plume originating in Area L. Possible effects of excavating cells in Zone 4 on the VOC plume and the contaminant source at Area L are not known at present. LANL personnel have initiated a study of the risks posed by the old waste disposal at Area L and the VOC plume, but there is no information at present.

I.4.1.8 *Traffic*

As noted in section I.2.1.2, no new construction (except for excavation of disposal cells) would be required to implement this alternative. Thus, developing Zone 4 would not require construction materials to be transported to the site nor generate construction wastes to be removed from the site. Developing Zone 4 would have no effect on the flow of traffic on public roads.

I.4.2 Develop Zone 6 at TA–54

I.4.2.1 *Land Resources*

Land Use

Because the whole of Mesita del Buey, including Area G, has been identified for management of solid wastes, developing Zone 6 would not represent a change in land use category (DOE 1979).

Visual Resources

New disposal cells would not be visible from Pajarito Road. New cells would be visible from the boundary of the San Ildefonso Pueblo, but not from the human habitations at White Rock, Los Alamos, Totavi, Otowi, or BNM.

Noise

The noise level to which people could be exposed varies with receptor location, as shown in Table I.4.2.1–1. Disposal cell construction in Zone 6 would be audible at the San Ildefonso Pueblo boundary but not at the human habitations at Totavi and Otowi, which are much farther away than White Rock and the Los Alamos townsite. Noise levels at residential areas due to the excavation and construction activities would be audible, but within normal levels in White Rock, the Los Alamos townsite, and at the Royal Crest Trailer Park. Noise from disposal cell construction could be audible above background at the roadway boundary to BNM, but not at the Visitors' Center nor in the developed campgrounds. The estimates presented are very conservative; in practice, the uneven terrain, intervening vegetation, and direction of air movement would further reduce the noise at receptor locations.

The sound levels at and near the excavation equipment are sufficiently high that operators would be provided with hearing protection. Hearing protection may be provided for other personnel in the vicinity of construction, as needed.

I.4.2.2 *Air Quality*

As discussed in section I.4.1.2, LANL personnel would use standard dust suppression methods. Excavating disposal cells would not be expected to degrade the quality of air in residential areas.

The wood from trees cleared from Zone 6 would be chipped and burned or used as mulch on the site. Burning would be conducted under an open burning permit obtained from NMED, such that the air quality standards would not be violated.

I.4.2.3 *Ecological Resources*

Flora and Fauna

Developing Zone 6 would require that most or all of the pinyon-juniper tree cover on 17 acres (7 hectares) be removed. The vegetative

TABLE I.4.2.1–1.—*Sound Level Estimates[a] from Excavations/Construction in Zone 6 at Receptor Locations[b]*

ALTERNATIVE	OPERATORS, 3 to 6 ft (1 to 2 m) DISTANCE, dBA	ON-SITE PERSONNEL, 50 ft (15 m) DISTANCE, dBA	WHITE ROCK, dBA	ROYAL CREST TRAILER PARK, dBA	LOS ALAMOS TOWNSITE, dBA	BANDELIER NATIONAL MONUMENT, dBA	SAN ILDEFONSO PUEBLO BOUNDARY, dBA
Zone 6 Disposal Cell Excavation	90 to 113[c]	72 to 95	24 to 47	22 to 45	22 to 45	22 to 45	42 to 65
Normal Background	NA	NA	38 to 51	no data (assume 38 to 51)	38 to 51	31 to 35	no data (assume 31 to 35)

[a] Values calculated from standard noise ranges at 50 ft (15 m), using the inverse square relationship: sound $level_1$ - sound $level_2 = 20 \log r_2 r_1^{-1}$ where 1 and 2 represent two locations.
[b] Distances from residential areas shown in Table I.3.1–1.
[c] Standard construction equipment noise ranges (from Canter 1996).
NA = Not applicable

coverage of Zone 6 is comparable in density to the general forested area along the mesa top. The wood would be chipped and burned or used for mulch on the site. This would change or eliminate part of the habitat for birds and small mammals living in and around Zone 6. The habitat change would be small (17 acres [7 hectares]) compared to the available habitat remaining in the area (which is many hundreds of acres in size). Construction noise and activity would cause minor and short-term disturbance to wildlife utilizing adjacent habitat during the various development phases. Because the new disposal cells and shafts would only be fenced during the time that they are active, and the whole area would not be fenced, no new impacts are anticipated to the large game animals that utilize the area.

Threatened and Endangered Species

A peregrine falcon nest site is located more than 3 miles (4.8 kilometers) from both proposed expansion areas at TA–54. Peregrine falcons have a wide foraging area, typically up to 12.3 miles (19.8 kilometers) from their nest. The total amount of foraging habitat for this nesting location is 126,805 acres (51,318 hectares), not including developed areas. Cutting the trees would remove some 17 acres (7 hectares, less than 0.02 percent) of possible foraging habitat for peregrine falcons, in the event that this alternative is chosen (Keller and Bennett 1996). The removal of less than 1 percent of available foraging habitat area would not result in an appreciable effect on this species.

I.4.2.4 *Environmental Justice*

The disposal area development would be visible from the pueblo boundary, and the noise from disposal cell excavations would be audible, should anyone be present at the boundary. However, the noise is not in the range considered harmful to human health.

I.4.2.5 *Cultural Resources*

DOE lacks information regarding the presence of TCPs within TA–54. In the absence of such information, the potential consequences of developing Zone 6 can only be estimated qualitatively. If these resources are present in Zone 6, they would either be destroyed by construction or diminished in value by alteration of the area. If no such resources are present, no effect would be expected.

Seven archaeological sites would be affected or destroyed by constructing an LLW disposal facility at Zone 6. The cultural resource report documenting the survey has not been submitted to the SHPO, and official eligibility determinations for the seven sites have not been made. In compliance with current regulations, adverse effects to the NRHP eligible sites could be successfully mitigated by conducting archaeological excavations designed to recover scientific data. If Zone 6 is selected as the location for an LLW facility, DOE would prepare a proposal for mitigation of adverse effects to the eligible sites (a data recovery plan) and incorporate the concerns of the Accord Pueblos. The New Mexico SHPO would review the document prior to implementation of mitigation measures and be requested to concur in a determination of no adverse effect before the start of project activities.

I.4.2.6 *Waste Management (Construction Refuse)*

Waste from disposal cell construction (i.e., rock and soil) would be managed at the location (used for fill and for cover or disposed of). No other construction would be needed.

I.4.2.7 *Environmental Restoration*

All of TA–54 is considered part of ER Operable Unit 1148. There would be no additional ER implications from disposing of LLW in Zone 6.

I.4.2.8 *Traffic*

As noted in section I.2.2.2, the only construction required to implement this alternative would be to fence cells being excavated and filled. Thus, developing Zone 6 would not require construction materials to be transported to the site nor generate construction wastes to be removed from the site. Developing Zone 6 would have no effect on the flow of traffic on public roads.

I.4.3 Develop the North Site at TA–54

I.4.3.1 *Land Resources*

Land Use

Because the whole of Mesita del Buey, including Area G, has been identified for management of solid wastes, developing the North Site would not represent a change in land use category (DOE 1979).

Visual Resources

New disposal cells would not be visible from Pajarito Road. New cells would be visible from the boundary of the San Ildefonso Pueblo, but not from the human habitations at White Rock, Los Alamos, Totavi, Otowi, or BNM.

Noise

The noise level to which people could be exposed varies with receptor location, as shown in Table I.4.3.1–1. Disposal cell construction at the North Site would be audible at the San Ildefonso Pueblo boundary, but not at the human habitations at Totavi and Otowi, which are much farther away than White Rock and the Los Alamos townsite. Noise levels at residential areas due to the excavation and construction activities would be audible but within normal levels in White Rock, the Los Alamos townsite, and at the Royal Crest Trailer Park. Noise from cell construction could be audible above background at the roadway boundary to BNM, but not at the Visitors' Center nor in the developed campgrounds. The estimates presented are very conservative; in practice, the uneven terrain, intervening vegetation, and direction of air movement

TABLE I.4.3.1–1.—*Sound Level Estimates[a] from Excavations/Construction in the North Site at Receptor Locations[b]*

ALTERNATIVE	OPERATORS, 3 to 6 ft (1 to 2 m) DISTANCE, dBA	ON-SITE PERSONNEL, 50 ft (15 m) DISTANCE, dBA	WHITE ROCK, dBA	ROYAL CREST TRAILER PARK, dBA	LOS ALAMOS TOWNSITE, dBA	BANDELIER NATIONAL MONUMENT, dBA	SAN ILDEFONSO PUEBLO BOUNDARY, dBA
North Site	90 to 113[c]	72 to 95	24 to 47	22 to 45	22 to 45	22 to 45	54 to 79
Normal Background	NA	NA	38 to 51	no data (assume 38 to 51)[d]	38 to 51	31 to 35	no data (assume 31 to 35)[d]

[a] Values calculated from standard noise ranges at 50 ft (15 m), using the inverse square relationship: sound level$_1$ - sound level $_2$ = 20 log r_2 r_1^{-1} where 1 and 2 represent two locations.
[b] Distances from residential areas shown in Table I.3.1–1.
[c] Standard construction equipment noise ranges (from Canter 1996).
[d] In these cases, noise levels were assumed to be the same as those measured in nearby locations. The noise level at the Royal Crest Trailer Park was assumed to be the same as that measured at the Los Alamos townsite, and the noise level at the San Illdefonso boundary is assumed to be the same as that at the adjacent BNM land (refer to Figure I.1.1–1).
NA = Not applicable

would further reduce the noise at receptor locations.

The sound levels at and near the excavation equipment are sufficiently high that operators would be provided with hearing protection. Hearing protection may be provided for other personnel in the vicinity of construction, as needed.

I.4.3.2 *Air Quality*

As discussed in section I.4.1.2, LANL personnel would use standard dust suppression methods. Excavating cells would not be expected to degrade the quality of air in residential areas.

Part or all of the wood from trees cleared from the North Site would be chipped and burned or used as mulch on the site. The burning would be conducted under an open burning permit obtained from NMED, such that the air quality standards would not be violated.

I.4.3.3 *Ecological Resources*

Flora and Fauna

Developing the North Site could also require that the pinyon-juniper tree cover on 49 acres (20 hectares) be removed. The vegetative coverage of the North Site is comparable to the general forested area along the mesa top. The wood would be chipped and burned or used for mulch on the site. This would change or eliminate part of the habitat for birds and small mammals living in or around the North Site. The habitat change would be small, compared to the available 49 acres (20 hectares) of habitat remaining in the area, which is many hundreds of acres in size. Construction noise and activity would cause minor and short-term disturbance to wildlife utilizing adjacent habitat during the various development phases. Because the new disposal cells and shafts would only be fenced during the time that they are active, and the whole area would not be fenced, no new impacts are anticipated to the large game animals that utilize the area.

Threatened and Endangered Species

Peregrine falcons have a wide foraging area, typically up to 12.3 miles (19.8 kilometers) from their nest, which is more than 3 miles (5 kilometers) away from the North Site. The total amount of forage habitat for this nesting location is 126,805 acres (50,722 hectares), not including developed areas. At the North Site, the loss of foraging habitat due to removing trees would be 40 acres (16 hectares), approximately 0.05 percent (Keller and Bennett 1996). The removal of less than 1 percent of available foraging habitat area would not result in an appreciable effect on this species.

I.4.3.4 *Environmental Justice*

The development would be visible from the pueblo boundary, and the noise from disposal cell excavations would be audible, should anyone be present at the boundary. However, the noise is not in the range considered harmful to human health.

I.4.3.5 *Cultural Resources*

Cultural resource surveys of the North Site identified four archaeological sites. The surveys were not comprehensive; a rigorous survey would be needed if this alternative were selected, and additional sites may be identified. As discussed in section I.4.2.5, if this alternative were selected, a cultural resource report would be submitted to the SHPO and Accord Pueblos, and their comments would be taken into consideration in developing a data recovery plan.

DOE lacks information regarding the presence of TCPs within TA–54. In the absence of such information, the potential consequences of developing the North Site can only be estimated qualitatively. If these resources are present within the North Site area, they would either be destroyed by construction or diminished in value by the alteration of the area. If none of these resources are present, then no effect would be expected.

I.4.3.6 *Waste Management (Construction Refuse)*

Waste from disposal cell construction (i.e., soil and rock) would be managed at the location (used for fill and for cover or disposed of). Any refuse from utility line construction would be disposed of in the Los Alamos County Landfill. The amount of refuse would be very small.

I.4.3.7 *Environmental Restoration*

All of TA–54 is considered a part of ER Operable Unit 1148. There would be no additional ER implications from disposing of LLW in the North Site.

I.4.3.8 *Traffic*

As noted in section I.2.3.2, the only construction required to implement this alternative would be to pave the unpaved road down the mesa top and install utility lines and a decontamination facility (wash pad for a truck). Fencing would be needed for disposal cells being excavated and filled. Developing the North Site would require perhaps a dozen truckloads of construction materials to be transported to the site. No construction wastes would be removed from the site. Developing the North Site would have no noticeable effect on the flow of traffic on public roads.

I.4.4 Develop a New Disposal Site at Another LANL Technical Area (TA–67)

I.4.4.1 *Land Resources*

Land Use

Currently, TA–67 is a secured area used as an inactive buffer zone for HE research and development. It is within the blast circles for active HE firing sites at TA–15 and TA–40. Its development for LLW disposal would require dual land use designation. Development of an LLW disposal site within TA–67 would require that disposal operations be suspended temporarily during HE open firing tests. It would result in a change in land use designation from Explosives Use to Explosives/Waste Disposal.

The possible presence of a geologic fault underlying the western edge of TA–67 could potentially disqualify this site from further consideration as a disposal area. Should development be pursued in the future, additional investigation would be required.

Visual Resources

New disposal cells would not be visible from Pajarito Road. If the TA–67 site was developed, the support structures would probably be visible from Pajarito Road and possibly from State Road 4 bordering BNM, but not from the San Ildefonso Pueblo land. If a bridge were constructed over Threemile Canyon, this might also be visible from Pajarito Road. None of these would be visible from the boundary of the San Ildefonso Pueblo, nor from the human habitations at White Rock, Los Alamos, Totavi, Otowi, or BNM.

Noise

If TA–67 were developed, the additional construction would cause noise generation intermittently for 1 to 2 years, in addition to the disposal cell excavation noise. Trenching for utility lines with a back hoe would produce the loudest of these operational noises. The noise level for back hoe operations (72 to 92 decibels A-weighted frequency scale [dBA]) is bounded by that for tractor operations (76 to 95 dBA) (Canter 1996).

The noise level to which people could be exposed varies with receptor location, as shown in Table I.4.4.1–1. Disposal cell construction at TA–67 could be audible above background level in White Rock, the Los Alamos townsite, and at the Royal Crest Trailer Park. Noise from cell construction could be audible above background at the roadway boundary to BNM, but not at the Visitors' Center nor in the developed campgrounds. The estimates presented are very conservative; in practice, the uneven terrain, intervening vegetation, and direction of air movement would further reduce the noise at receptor locations.

The sound levels at and near the excavation equipment are sufficiently high that operators would be provided with hearing protection. Hearing protection may be provided for other personnel in the vicinity of construction, as needed.

I.4.4.2 *Air Quality*

As discussed in section I.4.1.2, LANL personnel would use standard dust suppression methods. Excavating cells would not be expected to degrade the quality of air in residential areas.

Considerable additional construction would be required to develop the TA–67 site. These activities would also generate more dust particles and vehicle exhaust fumes. The consequences to air quality have not been estimated but would be comparable to other ground-breaking activities (less than highway construction) and of short duration.

Part or all of the wood from trees cleared from TA–67 would be chipped and burned or used as mulch on the site. The burning would be conducted under an open burning permit obtained from NMED, such that the air quality standards would not be violated.

TABLE I.4.4.1–1.—*Sound Level Estimates[a] from Excavations/Construction in TA–67 at Receptor Locations[b]*

ALTERNATIVE	OPERATORS, 3 to 6 ft (1 to 2 m) DISTANCE, dBA	ON-SITE PERSONNEL, 50 ft (15 m) DISTANCE, dBA	WHITE ROCK, dBA	ROYAL CREST TRAILER PARK, dBA	LOS ALAMOS TOWNSITE, dBA	BANDELIER NATIONAL MONUMENT dBA	SAN ILDEFONSO PUEBLO BOUNDARY, dBA
TA–67	90 to 113[c]	72 to 95	18 to 41	28 to 51	27 to 40	27 to 40	27 to 50
Normal Background	NA	NA	38 to 51	no data (assume 38 to 51)[d]	38 to 51	31 to 35	no data (assume 31 to 35)[d]

[a] Values calculated from standard noise ranges at 50 ft (15 m), using the inverse square relationship: sound $level_1$ - sound level $_2$ = 20 log r_2 r_1^{-1} where 1 and 2 represent two locations.
[b] Distances from residential areas shown in Table I.3.1–1.
[c] Standard construction equipment noise ranges (from Canter 1996).
[d] In these cases, noise levels were assumed to be the same as those measured in nearby locations. The noise level at the Royal Crest Trailer Park was assumed to be the same as that measured at the Los Alamos townsite, and the noise level at the San Illdefonso boundary is assumed to be the same as that at the adjacent BNM land (refer to Figure I.1.1–1).
NA = Not applicable

I.4.4.3 *Ecological Resources*

Flora and Fauna

Developing TA–67 could require that most or all of the ponderosa pine, pinyon, and juniper tree cover on 60 acres (24 hectares) be removed. The vegetative coverage of mostly mature trees over 40 feet (12 meters) tall is comparable in density to the general forested area along the mesa top. This wood would be chipped and burned or used as mulch on the site.

This development would change or eliminate part of the habitat for birds and small mammals living in and around the developed part of TA–67. The habitat change would be small because the disturbed area would be about 60 acres (24 hectares) within a more than 1,000-acre (greater than 400-hectares) relatively undisturbed area. Construction noise and activity would cause minor and short-term disturbance to wildlife utilizing adjacent habitat during the various development phases. Because the new disposal cells would only be fenced during the time that they are active, and the whole area would not be fenced, no new impacts are anticipated to the large game animals that utilize the area.

Threatened and Endangered Species

The Mexican spotted owl has been found to nest over 1 mile (1.6 kilometers) away from TA–67 within the general vicinity of the southern portion of TA–15; however, potential nesting habitat is present near TA–67 within 0.25 mile (0.4 kilometer) of the proposed disposal site. The TA–67 location is also within potential roosting and foraging habitat areas. Removing ponderosa pine trees at the site would decrease the potential foraging habitat for the Mexican spotted owl by about 1.3 percent and the potential roost-only habitat by about an equal amount (Keller and Bennett 1996). Potential nesting habitat may be adversely affected in that noise and light from the disposal site could reduce the desirability of the area and its future usefulness to the species.

I.4.4.4 *Environmental Justice*

The disposal area development would not be visible from the pueblo boundary, and the noise from disposal cell excavations would not be audible, should anyone be present at the boundary.

I.4.4.5 *Cultural Resources*

Eleven specific archaeological sites would be affected or destroyed by the construction of an LLW disposal facility at TA–67. In addition to these 11 sites, people working in the area may be able to reach and disturb other sites in close proximity to the construction area. One site has been determined not to be eligible for the NRHP. Adverse effects to the 10 NRHP-eligible sites could be mitigated by conducting archaeological excavations designed to recover scientific data. A survey report documenting the results of the 1992 to 1993 archaeological survey would be sent to the SHPO in order to begin the required consultation process. The procedure would be as described in section I.4.2.5 for Zone 6.

DOE lacks information regarding the presence of TCPs within TA–67. In the absence of specific information on such resources, the potential consequences of developing the TA–67 site on such resources can only be estimated qualitatively. If these resources are present within TA–67, they would either be destroyed by construction or diminished in value by the alteration of the area. If none of these resources are present, then no effect would be expected.

I.4.4.6 *Waste Management (Construction Refuse)*

Developing a new LLW disposal location at TA–67 would generate refuse from constructing the support facilities. The quantity is not known at present. This refuse would be recycled to the extent possible, and the remainder would be disposed of in the Los Alamos County Landfill. Waste from disposal cell construction would be managed at the location.

I.4.4.7 *Environmental Restoration*

Developing an LLW disposal area at TA–67 is not anticipated to have ER implications. However, developing in a new and uncontaminated location would create another area with permanent constraints on future uses due to waste buried there.

I.4.4.8 *Traffic*

If TA–67 were developed, the traffic would increase less than 1 percent for 1 to 2 years on Pajarito Road and West Jemez Road as construction materials and pre-engineered support structures were moved to the site and construction wastes were removed. Constructing new LLW disposal cells subsequently would have no impact on the flow of traffic on public roads.

I.4.5 Preferred Alternative—Develop Zones 4 and 6 at TA–54

The consequences of the Preferred Alternative, to develop Zones 4 and 6 in step-wise fashion moving westward from the present LLW disposal area in Area G, would be the additive consequences of those discussed separately for Zone 4 in section I.4.1 and Zone 6 in section I.4.2, except for noise. The consequences of noise are taken as the louder of the noise effects from Zone 4 or 6 at each of the receptor locations.

I.4.5.1 *Land Resources*

Land Use

Because the whole of Mesita del Buey has been identified for management of solid wastes, developing Zones 4 and 6 would not result in a change to the land use designation of research and development and waste disposal.

Visual Resources

New disposal cells would not be visible from Pajarito Road. The cells would be visible from the boundary of the San Ildefonso Pueblo, but not from the human habitations at White Rock, Los Alamos, Totavi, Otowi, or BNM.

Noise

The noise level to which people could be exposed varies with receptor location, as shown in Table I.4.5.1–1. The estimates shown represent the louder of the estimates from Tables I.4.1.1–1 (Zone 4) and I.4.2.1–1 (Zone 6) at each receptor location. Disposal cell construction in Zones 4 and 6 would be audible at the San Ildefonso Pueblo boundary, but not at the human habitations at Totavi and Otowi, which are much farther away than White Rock and the Los Alamos townsite. Noise levels at residential areas due to the excavation and construction activities would be audible, but within normal levels in White Rock, the Los Alamos townsite, and at the Royal Crest Trailer Park. Noise from cell construction could be audible above background at the roadway boundary to BNM, but not at the Visitors' Center nor in the developed campgrounds. The estimates presented are very conservative; in practice, the uneven terrain, intervening vegetation, and direction of air movement would further reduce the noise at receptor locations.

TABLE I.4.5.1–1.—*Sound Level Estimates[a] from Excavations/Construction in Zones 4 and 6 at Receptor Locations[b]*

ALTERNATIVE	OPERATORS, 3 to 6 ft (1 to 2 m) DISTANCE, dBA	ON-SITE PERSONNEL, 50 ft (15 m) DISTANCE, dBA	WHITE ROCK, dBA	ROYAL CREST TRAILER PARK, dBA	LOS ALAMOS TOWNSITE, dBA	BANDELIER NATIONAL MONUMENT, dBA	SAN ILDEFONSO PUEBLO BOUNDARY, dBA
Zones 4 and 6 Disposal Cell Excavation	90 to 113[c]	72 to 95	30 to 53	22 to 45	22 to 45	22 to 45	45 to 68
Normal Background	NA	NA	38 to 51	no data (assume 38 to 51)[d]	38 to 51	31 to 35	no data (assume 31 to 35)[d]

[a] Values calculated from standard noise ranges at 50 ft (15 m), using the inverse square relationship: sound level$_1$ - sound level $_2$ = 20 log r_2 r_1^{-1} where 1 and 2 represent two locations.
[b] Distances from residential areas shown in Table I.3.1–1.
[c] Standard construction equipment noise ranges (from Canter 1996).
[d] In these cases, noise levels were assumed to be the same as those measured in nearby locations. The noise level at the Royal Crest Trailer Park was assumed to be the same as that measured at the Los Alamos townsite, and the noise level at the San Illdefonso boundary is assumed to be the same as that at the adjacent BNM land (refer to Figure I.1.1–1).
NA = Not applicable

The sound levels at and near the excavation equipment are sufficiently high that operators would be provided with hearing protection. Hearing protection may be provided for other personnel in the vicinity of construction, as needed.

I.4.5.2 *Air Quality*

As discussed in section I.4.1.2, LANL personnel would use standard dust suppression methods. Excavating cells would not be expected to degrade the quality of air in residential areas.

The wood from trees cleared from Zones 4 and 6 would be chipped and burned or used as mulch on the site. The burning would be conducted under an open burning permit obtained from NMED, such that the air quality standards would not be violated. Trees would be cleared in a step-wise fashion, as disposal area becomes needed.

I.4.5.3 *Ecological Resources*

Flora and Fauna

Developing Zone 4 and then Zone 6 would require that most or all of the pinyon-juniper tree cover on the 41 acres (17 hectares) be removed; however, this would be done in a gradual manner as disposal space was needed. The wood would be chipped and burned or used as mulch on the site. This would change or eliminate bird and small mammal habitat in direct proportion to the acreage disturbed. The habitat change caused by removing 41 acres (17 hectares) of vegetative cover would be small compared to the available habitat remaining in the area, which measures hundreds of acres in size. Similar habitat is available at the North Site. Construction noise and activity would cause minor and short-term disturbance to wildlife utilizing adjacent habitat during the various development phases. Because the new disposal cells would only be fenced during the time that they are active, and the whole area would not be fenced, no new impacts are anticipated to the large game animals that utilize the area.

The cumulative impact of removing an additional 41 acres (17 hectares) of pinyon-juniper woodland when added to the 63 acres (25 hectares) removed (assuming comparable plant density) in achieving the current size of the Area G LLW disposal area should be small. Much of Mesita del Buey is likely part of the Pajarito Canyon watershed, which currently has approximately 1,900 acres (770 hectares) of pinyon-juniper woodland. This vegetation type is the most abundant on LANL, currently covering an estimated 13,000 acres (5,265 hectares), or slightly over 46 percent of LANL. The cumulative impact would be a decrease in about 104 acres (42 hectares) of pinyon-juniper habitat for the birds and small and large mammals that utilize this habitat type. This habitat is located in an area that has experienced fragmentation from past actions, and any contribution to fragmentation would be minor. When considering the abundance of this habitat on LANL as well as the region, cumulative biological and ecological effects would be small.

Threatened and Endangered Species

A peregrine falcon nest site is located more than 3 miles (4.8 kilometers) from both proposed expansion areas at TA–54. Peregrine falcons have a wide foraging area, typically up to 12.3 miles (19.8 kilometers) from their nest. The total amount of foraging habitat for this nesting location is 126,805 acres (50,722 hectares), not including developed areas. Some 41 acres (17 hectares), or less than 0.05 percent of possible foraging habitat for peregrine falcons could ultimately be lost due to tree removal, in the event that this Preferred Alternative is chosen (Keller and Bennett 1996). However, this loss would be gradual and would not result in an appreciable effect on this species. Cumulative effects would not change appreciably from current conditions.

I.4.5.4 *Environmental Justice*

The disposal area development would be visible from the pueblo boundary, and the noise from disposal cell excavations would be audible, should anyone be present at the boundary. However, the noise is not in the range considered harmful to human health.

I.4.5.5 *Cultural Resources*

DOE lacks information regarding the presence of TCPs on Mesita del Buey. In the absence of specific information on such resources, the potential consequences of developing Zones 4 and 6 on such resources can only be estimated qualitatively. If these resources are present within Zones 4 and 6, they would either be destroyed by construction or diminished in value by the alteration of the area. If none of these resources are present, then no effect would be expected.

A total of 15 archaeological sites would be affected or destroyed by constructing an LLW disposal facility at Zones 4 and 6. Although the cultural report and data recovery plan for Zone 4 has been accepted by the SHPO, that is not the case with Zone 6, as discussed in section I.4.2.5. The Zone 4 area north of the road, where there are no sites, could be developed first. Simultaneously, the approved excavation and data recovery plan could be initiated in Zone 4 south of the road. Before Zone 6 could be developed, DOE would prepare a proposal for mitigation of adverse effects to the eligible sites (a data recovery plan) and incorporate the concerns of the Accord Pueblos. The New Mexico SHPO would review the document prior to implementation of mitigation measures and be requested to concur in a determination of no adverse effect before the start of project activities.

I.4.5.6 *Waste Management (Construction Refuse)*

Waste from disposal cell construction (i.e., soil and rock) would be managed at the location (used for fill and for cover or disposed of). No other construction would be needed.

I.4.5.7 *Environmental Restoration*

All of TA–54 is considered a part of ER Operable Unit 1148. There would be no additional ER implications from disposing of LLW in Zones 4 and 6.

I.4.5.8 *Traffic*

As noted in section I.2.5, the only construction required to implement this alternative would be to fence cells being excavated and filled. Thus, developing the Preferred Alternative would not require construction materials to be transported to the site nor generate construction wastes to be removed from the site. There would be no effect on the flow of traffic on public roads.

I.4.6 Potential Accidents

The potential accidents identified are those that could take place during disposal cell construction and during support facility and infrastructure construction in the case of the TA–67 alternative. The consequences of construction accidents are injury or possibly death to one or more workers. The probability for such an accident is low where the amount of construction work required is small (i.e., disposal cell construction only), but increases with the increased amount of construction work. Thus, the probability of an accident would be greatest for the TA–67 development alternative, because it would require substantially more construction work.

During construction, the bounding case accident for a worker would be injury or death due to industrial accident. A piece of heavy equipment such as a crane could fall on a worker or a trench wall could collapse. Any industrial accident could cause injury or death to one or more involved workers. Uninvolved workers and members of the public would not be affected. The environment would not be contaminated. Working according to standard operating procedures, facility procedures, and worker training would decrease the probability of this accident.

Operational accidents and their consequences are analyzed in chapter 5 of volume I. Projected accident rates are also presented there.

I.4.7 Comparison of Environmental Consequences

The potential consequences of expanding LLW disposal in each of the alternative locations are summarized and compared in Table I.4.7–1. The consequences of the Preferred Alternative, developing both Zones 4 and 6, are the additive consequences of those associated with the two individual locations, except for noise where the louder of the noise estimates for Zone 4 and 6 is presented for each of the receptor locations. Similarly, the distance to various locations is taken as the closer of the two figures presented. The environmental consequences of the selected alternative, developing an additional area for LLW disposal, are included in chapter 5 (section 5.3) of volume I, along with the consequences of ongoing LANL operations in describing overall impacts of LANL operations.

TABLE I.4.7–1.—*Comparison of Environmental Consequences of Expanding Low-Level Waste Disposal in Alternative Locations*

	PREFERRED ALTERNATIVE			
FACTOR, MEASURE	**ZONE 4, TA–54**	**ZONE 6, TA–54**	**NORTH SITE, TA–54**	**TA–67**
Status (distance to and location of nearest residential area)	1.3 mi (2.1 km) White Rock	2.1 mi (3.4 km) White Rock	2.1 mi (3.4 km) White Rock	1.5 mi (2.4 km) Royal Crest Trailer Park
Distance to BNM Boundary	3.0 mi (4.8 km)	3.2 mi (5.1 km)	3.2 mi (5.1 km)	2.0 mi (3.2 km)
Distance to San Ildefonso Pueblo Boundary[a]	0.25 mi (0.4 km)	0.3 mi (0.5 km)	0.05 mi (0.1 km)	1.5 mi (2.4 km)
LANL Land Use Designation	no change in designation	no change in designation	no change in designation	designation changed to include LLW disposal
Visibility from Public Access Area	no change	no change	no change	increased visibility from Pajarito Road
Excavation and Construction Noise at Nearest Residential Area	may slightly exceed normal background level	may slightly exceed normal background level	may slightly exceed normal background level	equivalent to normal background level
Air Quality	dust and exhaust during disposal cell and shaft excavation, smoke from open burning of cleared trees	dust and exhaust during disposal cell and shaft excavation, smoke from open burning of cleared trees	dust and exhaust during disposal cell and shaft excavation, smoke from open burning of cleared trees	dust and exhaust during site and road development, then during disposal cell and shaft excavation, smoke from open burning of cleared trees
Ecological Resources (flora and fauna)	clear 24 acres (10 hectares), loss of pinyons and understory	clear 17 acres (7 hectares), loss of pinyons and understory	clear 49 acres (20 hectares), loss of pinyons and understory	clear 60 acres (24 hectares), loss of pinyon and ponderosa pine, juniper, and understory
Threatened, Endangered, and Sensitive Species	loss of < 0.1 percent foraging area; no appreciable effect on threatened peregrine falcon	loss of < 0.1 percent foraging area; no appreciable effect on threatened peregrine falcon	loss of < 0.1 percent foraging area; no appreciable effect on threatened peregrine falcon	loss of about 1.3 percent of roosting and foraging habitat; no appreciable effect on threatened Mexican spotted owl; may adversely affect potential nesting habitat desirability and usefulness to the species

TABLE I.4.7–1.—*Comparison of Environmental Consequences of Expanding Low-Level Waste Disposal in Alternative Locations*-Continued

FACTOR, MEASURE	PREFERRED ALTERNATIVE ZONE 4, TA–54	PREFERRED ALTERNATIVE ZONE 6, TA–54	NORTH SITE, TA–54	TA–67
Environmental Justice	development visible and noise audible at San Ildefonso Pueblo boundary	development visible and noise audible at San Ildefonso Pueblo boundary	development visible and noise audible at San Ildefonso Pueblo boundary	development not visible and noise not audible at San Ildefonso Pueblo boundary
Cultural Resources (archaeological sites)	1 site north side of road (avoidable), 8 sites affected if whole area developed	7 sites affected, data recovery plan needed	4 or more sites affected, data recovery plan needed	11 sites affected, data recovery plan needed
Traditional Cultural Properties	no information available, any sites present could be destroyed or degraded	no information available, any sites present could be destroyed or degraded	no information available, any sites present could be destroyed or degraded	no information available, any sites present could be destroyed or degraded
Waste Management	no change	no change	no change	some construction refuse
Environmental Restoration	need to avoid exclusion area	no change	no change	no change
Traffic	no change	no change	no change	increase for 1 to 2 years due to construction
Accidents (industrial)	probability is low, consequence is injury or death to a worker	probability is low, consequence is injury or death to a worker	probability is low, consequence is injury or death to a worker	probability is higher (additional construction), consequence is injury or death to a worker

[a] Distance from the existing LLW disposal site in Area G to the San Ildefonso Pueblo boundary is 0.13 mi (0.2 km). Distance to human habitations at San Ildefonso Pueblo (Totavi) is 5 mi (8 km).

The greatest differences among the PSSC alternatives are due to the differences between TA–54 and TA–67.[8] That is, the TA–54 PSSC alternatives (Zone 4, Zone 6, North Site, and Zones 4 and 6) have very similar impacts; but each is very different from the TA–67 alternative. This is due primarily to the need to replicate at TA–67 much of the infrastructure that already exists at TA–54, including office space, showers, locker rooms, control rooms, personnel monitoring stations, a decontamination wash pad, packaging and inspection areas, fencing, utilities, and roads. Such infrastructure development would require substantially more construction and land disturbance to provide a comparable area for waste disposal. This level of construction at TA–67 would result in (as compared to any of the TA–54 alternatives) additional dust and exhaust (from construction) and smoke (from burning cleared trees), substantially greater loss of bird habitat (including potential roosting and forage-only habitat for the Mexican spotted owl), the potential to adversely affect the Mexican spotted owl (no effect to federally protected species is expected at any of the TA–54 alternative sites), greater waste generation, increased traffic during construction to establish the site infrastructure, and a greater likelihood of construction accidents (due to the additional construction). While the TA–67 location is slightly closer to the nearest residential area and to the nearest BNM boundary, it is much farther from the San Ildefonso Pueblo boundary, as compared to any of the TA–54 alternatives. Under all alternatives, the disposal cells would not be visible from inhabited areas, but the support structures would be visible from public access areas (such as Pajarito Road); the principal difference in visual impacts is due to the fact that TA–67 is not currently developed. Areas of relatively minor difference between the TA–54 alternatives and the TA–67 alternative are: noise from any of the TA–54 sites would be slightly above normal background at the nearest residential area, while noise from TA–67 would be equivalent to normal background levels at the nearest residential area; all of the alternative sites contain archaeological sites that would require data recovery plans or avoidance; no information exists regarding specific TCPs at any of the alternative sites; none of the alternative sites would be expected to disturb the sites of ER projects; and TA–67 development and operations would not be visible or audible at the San Ildefonso Pueblo boundary, but would be visible and audible from this boundary for all of the TA–54 alternative sites (although not from any San Ildefonso Pueblo residential areas).

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8. TA–67 was selected to represent development of a new disposal site at LANL. While the specific characteristics of TA–67 may not be applicable to all potential sites, the majority of the differences in the impacts of TA–54 alternatives and the TA–67 alternatives are attributed to the need to establish an appropriate infrastructure to support waste disposal at TA–67 (as discussed in this section), and these types of differences would apply to other locations for a new disposal site. The possible existence of a fault in part of TA–67 may not be applicable to other sites.

APPENDIX I.A—*Scientific Names of Animals and Plants* (referred to by their common names in the text)

COMMON NAME	SCIENTIFIC NAME	STATUS
ANIMALS		
Black Bear	*Ursus americanus*	
Bobcat	*Felis rufus*	
Brush Mouse	*Peromyscus boylii*	
Colorado Chipmunk	*Eutamias quadrivittatus*	
Coyote	*Canis latrans*	
Elk	*Cervus elaphus* *Subspecies: candensis*	
Gray Fox	*Urocyon cinereoagenteus*	
Jemez Mountain Salamander	*Plethodon neomexicanus*	species of concern[a], state threatened[b]
Least Chipmunk	*Eutamias minimus*	
Little Brown Occult Bat	*Myotis occultus*	species of concern
Long-Tailed Vole	*Microtus longicaudus*	
New Mexican Meadow Jumping Mouse	*Zapus hudsonius luteus*	species of concern, state threatened
Mexican Spotted Owl	*Strix occidentalis lucida*	Federal threatened[c]
Montane Vole	*Microtus montanus*	
Mountain Lion	*Felis concolor*	
Mule Deer	*Odocoileus hemionus*	
Northern Goshawk	*Accipiter gentilis*	species of concern
Peregrine Falcon	*Falco peregrinus*	Federal endangered[d], state endangered[e]
Spotted Bat	*Euderma maculata*	species of concern, state threatened
Southwestern Willow Flycatcher	*Empidonax traillii*	Federal endangered, state endangered
VEGETATION		
Blue Grama	*Bouteloua gracilis* (H.B.K.) Lag.	
One-Seeded Juniper	*Juniperus monosperma* (Engelm.) Sarg.	
Pinyon Pine	*Pinus edulis* Engelm.	
Ponderosa Pine	*Pinus ponderosa* Laws. var. *scoparium* Engelm.	

[a] Species of local concern: Any species known to exist or potentially exist within the proximity of LANL lands and surrounding areas that are rare in numbers and/or occurrences and whose habitat requirements are very specific, rare to this area, or threatened in any way.
[b] State threatened: Any species whose prospects of survival or recruitment within the state are likely to become jeopardized in the near future.
[c] Federal threatened: Any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
[d] Federal endangered: Any species that is in danger of extinction throughout all or a significant portion of its range.
[e] State endangered: Any species listed in the New Mexico endangered list because it is rare in numbers and/or occurrences and, without protection, its further existence in the state is in serious jeopardy.

APPENDIX I.B.—*Volatile Organic Contaminant Plume Constituents*

TA–54 MDA L Volatile Organic Contaminant Plume: Observed Maximum Concentrations During May 1997[a] with Modified EPA Method TO–14[b]

COMPOUND	WELL NO.	PORT DEPTH (ft)	MAXIMUM CONCENTRATION (ppmv)[c]
Trichloroethane[1,1,1-]	54-02089	46	5,540
Trichloroethene	54-02089	46	679
Trichloro-1,2,2-trifluoroethane[1,1,2-]	54-02089	46	386
Dichloropropane[1,2-]	54-02089	46	144
Trichlorofluoromethane	54-02089	46	68
Dichloroethane[1,1-]	54-02089	46	48
Chloroform	54-02089	46	47
Dichloroethane[1,2-]	54-02089	46	36
Hexane	54-02089	46	33
Tetrahydrofuran	54-02089	46	30
Methylene Chloride	54-02089	46	23
Diethyl Ether	54-02089	46	22
Tetrachloroethene	54-02089	46	19
Cyclohexane	54-02089	46	9
Carbon Tetrachloride	54-02089	46	7
Butene[1-]	54-02089	46	3
Methylcyclohexane	54-02089	46	3
Dichloroethene[1,1-]	54-01004	124	2
Methylcyclopentane	54-02089	46	2
Toluene	54-01004	124	2
Pentane	54-02089	46	2
Acetone	54-01004	124	2
Methylpentane[2-]	54-02089	46	2
Methylpentane[3-]	54-02089	46	2
Chlorobenzene	54-02089	46	2
Benzene	54-02089	46	1
Isooctane	54-02089	46	1
Isobutane	54-02089	46	1
Butane[n-]	54-02089	46	1
Isopentane	54-02089	46	1
Methylhexane[3-]	54-02089	46	1
Dichlorodifluoromethane	54-01004	124	1

[a] Compendium Method TO–14, "The Determination of Volatile Organic Compounds in Ambient Air Using SUMMA® Passivated Canister Sampling and Gas Chromatography Analysis." Modified for collection of samples from pore gas sampling ports.
[b] *Source*: LANL 1998d
[c] Parts per million by volume

REFERENCES

Banar 1996	*Biological Assessment for Environmental Restoration Program Operable Unit 1148 TA–54 and TA–51.* A. Banar. Los Alamos National Laboratory. LA–UR–93–1054. Los Alamos, New Mexico. February 1996.
Broxton and Chipera 1994	*Stratigraphy, Mineralogy and Chemistry of Tuffs at Pajarito Mesa, Los Alamos National Laboratory, New Mexico.* D. E. Broxton and S. J. Chipera. Los Alamos National Laboratory. Los Alamos, New Mexico. 1994.
Canter 1996	*Environmental Impact Assessment*, second edition. L. W. Canter. McGraw-Hill Inc. New York, New York. 1996.
Cross and Usner 1996	*Biological Assessment for the Mixed Waste Storage and Disposal Facility, Technical Areas 67 and 15.* S. Cross and D. Usner. Los Alamos National Laboratory. LA–UR–94–1400. Los Alamos, New Mexico. January 1996.
DOE 1979	*Final Environmental Impact Statement, Los Alamos Scientific Laboratory Site, Los Alamos, New Mexico.* U.S. Department of Energy. DOE/EIS-0018. Washington, D.C. December 1979.
DOE 1994	*Radiological Control Manual.* U.S. Department of Energy. DOE/EH–0256T. April 1994.
DOE 1997	*Waste Management Programmatic Environmental Impact Statement.* U.S. Department of Energy, Office of Environmental Management. DOE/EIS-0200. Washington, D.C. May 1997.
Keller and Bennett 1996	Internal memorandum from D. Keller and K. Bennett, ESH–20, Los Alamos National Laboratory. Subject: Current status of threatened and endangered species at the TA–54 alternative waste disposal areas and the TA–67 alternative area. ESH–20/Ecol–97–0219. Los Alamos, New Mexico. December 18, 1996.
Koopman 1965	Letter from F. C. Koopman, United States Geological Survey, to S. E. Russo, Los Alamos Scientific Laboratory. Subject: Guidelines for Construction of Pits on Mesita del Buey. Eng–3. Los Alamos, New Mexico. June 1965.
LANL 1982	*Long-Range Site Development Plan, Los Alamos National Laboratory*. Report produced under the direction of Long-Range Facilities Planning Task Force, Engineering Division, Los Alamos National Laboratory, and Royston, Hanamoto, Alley and Abey. Mill Valley, California, and Los Alamos, New Mexico. 1982.
LANL 1991	*Cultural Resources Survey.* Los Alamos National Laboratory. Report No. 288. Los Alamos, New Mexico. 1991.

LANL 1994 — *Los Alamos National Laboratory Environmental Restoration: Quarterly Technical Report, July–September 1994*. Los Alamos National Laboratory. LA–UR–94–4147. Los Alamos, New Mexico. December 1994.

LANL 1996a — *Detailed Operating Procedure (DOP) 54G–013*. Los Alamos National Laboratory. Los Alamos, New Mexico. 1996.

LANL 1996b — *Environmental Surveillance at Los Alamos During 1995*. Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.

LANL 1996c — *Pit and Shaft Construction, Use, and Closure*. Los Alamos National Laboratory. Detailed Operating Procedure 54G-013, R.O. Los Alamos, New Mexico. April 19, 1996.

LANL 1998a — *Waste Management Strategies for LANL*. Los Alamos National Laboratory. LA-UR-97-4764. Los Alamos, New Mexico. April 1998.

LANL 1998b — *Description of Technical Areas and Facilities at LANL*. Los Alamos National Laboratory. LA-UR-97-4275. Los Alamos, New Mexico. March 1998.

LANL 1998c — Memorandum to file from Steve Hoagland, Los Alamos National Laboratory. Subject: Cultural Resource Survey for the Resource Conservation and Recovery Act Mixes Waste Disposal Facility. Los Alamos, New Mexico. March 1998.

LANL 1998d — *Quarterly Pore Gas Sampling Report*, Third Quarter FY 1997. Los Alamos National Laboratory. PMC-LA-98-003. Los Alamos, New Mexico. January 1998.

LANL 1998e — *EM/ER Field Unit 5 RFI Monitor/Characterization Studies*, draft Quarterly Report. D. Krier. Los Alamos National Laboratory. Los Alamos, New Mexico. January 16, 1997.

LANL 1998f — *Performance Assessment and Composite Analysis for the Los Alamos National Laboratory Low-Level Waste Material Disposal Area G*. Los Alamos National Laboratory. LA-UR-97-85. Los Alamos, New Mexico. Submitted to the U.S. Department of Energy March 1997. Approved October 1998.

Larson 1991a — *Area G, TA–54, New Pits*, Lab Job No. 9989/11994. B. Larson. Los Alamos National Laboratory. Cultural Resource Survey Report No. 288. Los Alamos, New Mexico. April 1991.

Larson 1991b	*Data Recovery Plan for Seven Coalition Period Pueblos on Mesita del Buey: Laboratory of Anthropology (LA) 4620, 4621, 4622, 4623, 4624, 4625, and 4626, Los Alamos National Laboratory, New Mexico.* B. Larson. Los Alamos National Laboratory. Cultural Resource Management Team Report No. 98 Los Alamos, New Mexico. May 1991.
Larson 1997	Update memorandum from B. Larson, Los Alamos National Laboratory. Subject: Current status of archaeological resources and cultural resource issues for the RLWTF PSSC Analysis (TA–50 area) and the LLW PSSC Analysis (TA–54 Zone 4 and 6, and TA–67). Los Alamos, New Mexico. 1997.
Newell 1998	*Application of the TA–54/Area G Radiological Performance Assessment to Alternatives Considered in the LANL SWEIS for Low-Level Waste Disposal*. D. Newell. Los Alamos National Laboratory. Los Alamos, New Mexico. January 7, 1998.
Nyhan et al. 1978	*Soil Survey of Los Alamos County, New Mexico.* J. W. Nyhan, L. W. Hacker, T. E. Calhoun, and D. L. Young, Los Alamos National Laboratory. LA–6779–MS. Los Alamos, New Mexico. 1978.
OCG 1993	*A Fresh Perspective on the Proposed Expansion of Area G at TA–54.* Our Common Ground. Los Alamos, New Mexico. October 1993.
Purtymun and Kennedy 1971	*Geology and Hydrology of Mesita del Buey*. W. D. Purtymun and W. R. Kennedy. Los Alamos Scientific Laboratory. LA–4660. Los Alamos, New Mexico. 1971.
Purtymun et al. 1980	*Guidelines for Construction and Use of Solid Waste Disposal Facilities at Area G, TA–54*. W. D. Purtymun, M. L. Wheeler, and W. A. Warren. Los Alamos Scientific Laboratory. LA–4660. Los Alamos, New Mexico. December 1980.
Reneau 1994	"Potential Mesa-Edge Instability at Pajarito Mesa, Los Alamos National Laboratory." S. Reneau. Los Alamos, New Mexico. Unpublished. 1994.
Rogers 1977	*History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T).* M. A. Rogers. Los Alamos Scientific Laboratory. LA–6848–MS, Vol. 1. Los Alamos, New Mexico. June 1977.
Rogers 1995	*The Unsaturated Hydraulic Characteristics of the Bandelier Tuff.* D. B. Rogers. Los Alamos National Laboratory. LA–12968–MS. Los Alamos, New Mexico. September 1995.

Usner 1996	*The Biological Environment at Area G, Los Alamos National Laboratory.* D. Usner. Los Alamos National Laboratory. LA–UR–95–3600. Los Alamos, New Mexico. May 1996.

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PART II
ENHANCEMENT OF PLUTONIUM PIT MANUFACTURING

II.1 INTRODUCTION

The draft SWEIS identified the Utilize Existing Unused Space in the Chemistry and Metallurgy Research (CMR) Building as the Project-Specific Siting and Construction (PSSC) Preferred Alternative for the proposed enhancement of plutonium pit manufacturing capability at LANL. However, as a result of delays in the implementation of the Capability Maintenance and Improvement Project (CMIP) and recent additional controls and operational constraints in the CMR Building (instituted to ensure that the risks associated with CMR operations are maintained at an acceptable level), the DOE has determined that additional study of methods for implementing the 50 pits per year production is warranted. In effect,

has postponed the decision to implement the pit manufacturing capability beyond a level of 20 pits per year (14 pits per year is the No Action level). The DOE believes it can expand the pit manufacturing capability to 20 pits per year at Technical Area (TA)–55 without significant infrastructure upgrades, as analyzed in this PSSC analysis, and still meet its near-term mission requirements. When any necessary additional studies are completed, DOE will provide the appropriate NEPA review, tiered from this SWEIS, to implement the pit manufacturing capability beyond the 20 pits per year capacity. This postponement does not modify the long-term goal announced in the Record of Decision (ROD) for the *Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (SSM PEIS) (DOE 1996) (up to 80 pits per year using multiple shifts). For completeness and to bound the impacts of implementing pit production at LANL, the "CMR Building Use" Alternative is still included in the Expanded Operations Alternative. However, the Preferred Alternative would only implement pit manufacturing at a level of 20 pits per year. Also, the ROD for the SWEIS would only include a decision regarding the operations to implement the pit production mission at LANL for up to 20 pits per year.

II.1.1 The Role of the Enhancement of Plutonium Pit Manufacturing Project-Specific Siting and Construction Analysis in the Site-Wide Environmental Impact Statement

This PSSC analysis addresses the proposed enhancement of plutonium pit manufacturing capability at LANL. It examines the siting and construction alternatives for this project, supplementing the description and analysis presented in volume I of this SWEIS. The Utilize Existing Unused Space in the CMR Building ("CMR Building Use") Alternative from this PSSC analysis is included as one of the activities in the Expanded Operations Alternative in volume I of the SWEIS. The differences between the impacts of this alternative for pit manufacturing and the impacts of the other alternatives considered are discussed in chapter 5, section 5.3, of volume I. For the key facilities involved, construction activities examined in this PSSC and the subsequent operations (described in volume I, chapter 3, section 3.2) form a substantial portion of the Expanded Operations Alternative of the SWEIS.

The focus of this PSSC analysis is the siting and construction related to the enhancement of pit

PSSC Alternatives for Enhancement of Plutonium Pit Manufacturing

- ***Utilize Existing Unused Space in the CMR Building****—DOE would make existing unused nuclear space in the CMR Building operational and would move some of the existing activities in TA–55–4 to the CMR Building in TA–3 to make adequate space in TA–55–4 for plutonium pit manufacturing activities. DOE also would establish a dedicated transportation corridor between TA–55 and TA–3.*
- ***Brownfield Plutonium Facility****—DOE would build a new plutonium-qualified facility in a developed area near TA–55–4 and within the existing fence line at TA–55. As with the "CMR Building Use" Alternative, activities currently located within TA–55–4 would be moved to this new facility to make space available in TA–55–4 for plutonium pit manufacturing. The transportation corridor also could be constructed under this alternative.*
- ***Add-on to the TA–55–4****—DOE would enlarge the existing TA–55–4 by adding new nuclear space onto this building. Because this adds space to TA–55–4, it may not be necessary to relocate activities currently located in TA–55–4 to this new nuclear space. Rather, this space may be designed specifically for, and house, the expanded pit manufacturing operations. The transportation corridor also could be constructed under this alternative.*

manufacturing. The environmental impacts of operating pit manufacturing facilities are included in chapter 5 of the SWEIS, volume I. The air emissions, worker doses, and certain other parameters associated with pit manufacturing operations would depend on the number of pits manufactured. The consequences to members of the public, however, are dominated by the location of the operations because distance from the operations to the public affects the magnitude of impacts. (Note that the operational impacts related to pit production are small relative to other operational impacts, as discussed in volume I, chapter 3, section 3.6.)

This arrangement of information and analysis allows DOE to "zoom in" on aspects of this project that require more detailed description and analysis, while maintaining the clarity of volume I. The organization of this PSSC is complementary to the organization of information in volume I. The siting and construction information presented here is additional to the operational information provided in volume I and is pertinent to understanding the actions and alternatives described in that portion of the SWEIS. The siting and construction consequences from the "CMR Building Use" Alternative described in this PSSC analysis are included in those described in volume I, chapter 5, for the Expanded Operations Alternative to provide a complete and bounding analysis of the impacts of those operations.

Section II.2 of this PSSC analysis identifies alternative locations at LANL where the additional pit manufacturing capacity could be developed. Section II.3 contains more detailed information about the environmental conditions at each of these locations than is presented in volume I, chapter 4, of the SWEIS. Section II.4 presents the environmental consequences of the construction phase only for enhanced pit manufacturing, and section II.5 addresses the consequences of a potential construction accident. Operational impacts, including operational accidents, are addressed in volume I. The entire SWEIS, including this PSSC analysis, is intended to provide a complete and bounding NEPA analysis of pit fabrication at LANL.

II.1.2 Background Information

In September 1996, DOE issued the SSM PEIS (DOE 1996). Based on this PEIS, DOE issued a ROD on December 19, 1996, that selected LANL as the site for the fabrication of weapon components referred to as pits. The SSM PEIS and its ROD established pit production at LANL. It is expected that up to 50 pits will be manufactured per year under routine operations with a maximum capacity that could produce up to 80 pits per year (with multiple-shift operations). For this reason, the Expanded Operations Alternative includes production of up to 80 pits per year, as well as all related support operations for this capability.

As noted in the description of the Expanded Operations Alternative, this production level of pit manufacturing necessitates operations that, together with other ongoing operations, cannot be accommodated within the available floorspace in the LANL Plutonium Facility at TA–55 (Building TA–55–4). DOE and LANL have identified that 15,300 square feet (1,425 square meters) of additional floorspace is needed to fully support this level of operation (LANL 1997). The Expanded Operations Alternative description and analysis includes the establishment and use of this needed floorspace. The establishment of this additional floorspace (through allocation of existing space or construction of new space) is addressed in detail in this PSSC analysis, as is the utilization of the space (including a discussion of functions that could be performed in this space).

II.1.3 Material Flows Associated with the Pit Manufacturing Capability

The relationship between the manufacture of pits and other related operations at LANL is presented in Figure II.1.3–1.[1] This diagram reflects the types of material flows associated with these operations. A more detailed description of these operations is presented in volume I, chapter 3, of the SWEIS. The manufacture of pits involves the generation of samples for analysis; generation of residues for stabilization or recovery; generation of waste for treatment, storage, and disposal; and storage and handling of plutonium in solid and liquid forms.

The following existing capabilities are essential to support pit manufacturing operations as well as other ongoing operations at LANL: TA–3 capabilities for analytical chemistry and nonnuclear parts; TA–50 and TA–54 waste treatment, storage, and disposal capabilities; TA–55 capability for residue processing, particularly aqueous and pyrochemical processing; TA–55 capability for storage and handling of plutonium in several forms; and TA–8 capability for radiography. The locations of the TAs that support pit manufacturing operations are shown in Figure II.1.3–2. These capabilities support ongoing operations throughout LANL, and therefore, their continued viability is essential to many missions and programs at LANL. DOE does not currently propose to replace these capabilities. The alternatives in this PSSC analysis maximize use of existing capabilities in order to minimize the environmental effects of establishing the pit production operations identified above. Construction and reconfiguration activities to enhance pit manufacturing are only anticipated to occur at TA–55 and, for a bounding analysis, at the CMR Building under the "CMR Building Use" Alternative.

II.1.4 Laboratory Floorspace Requirements

Increased nuclear materials processing floorspace and analytical chemistry space are

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1. In addition to pits returned from storage or the stockpile, feed material for pit production could also come from other portions of DOE's plutonium inventory. The diagram reflects only pit returns as feed material for the sake of simplicity.

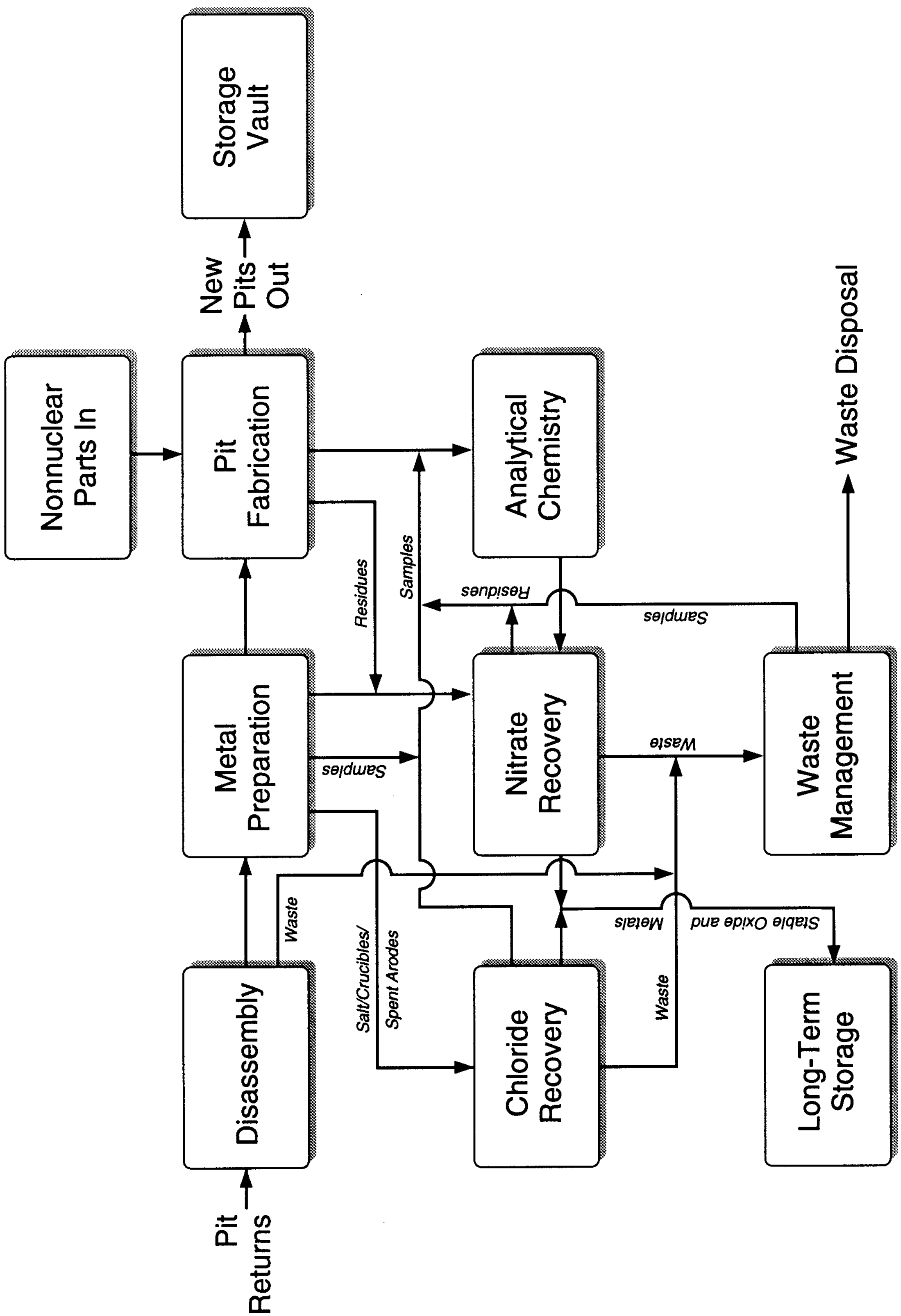
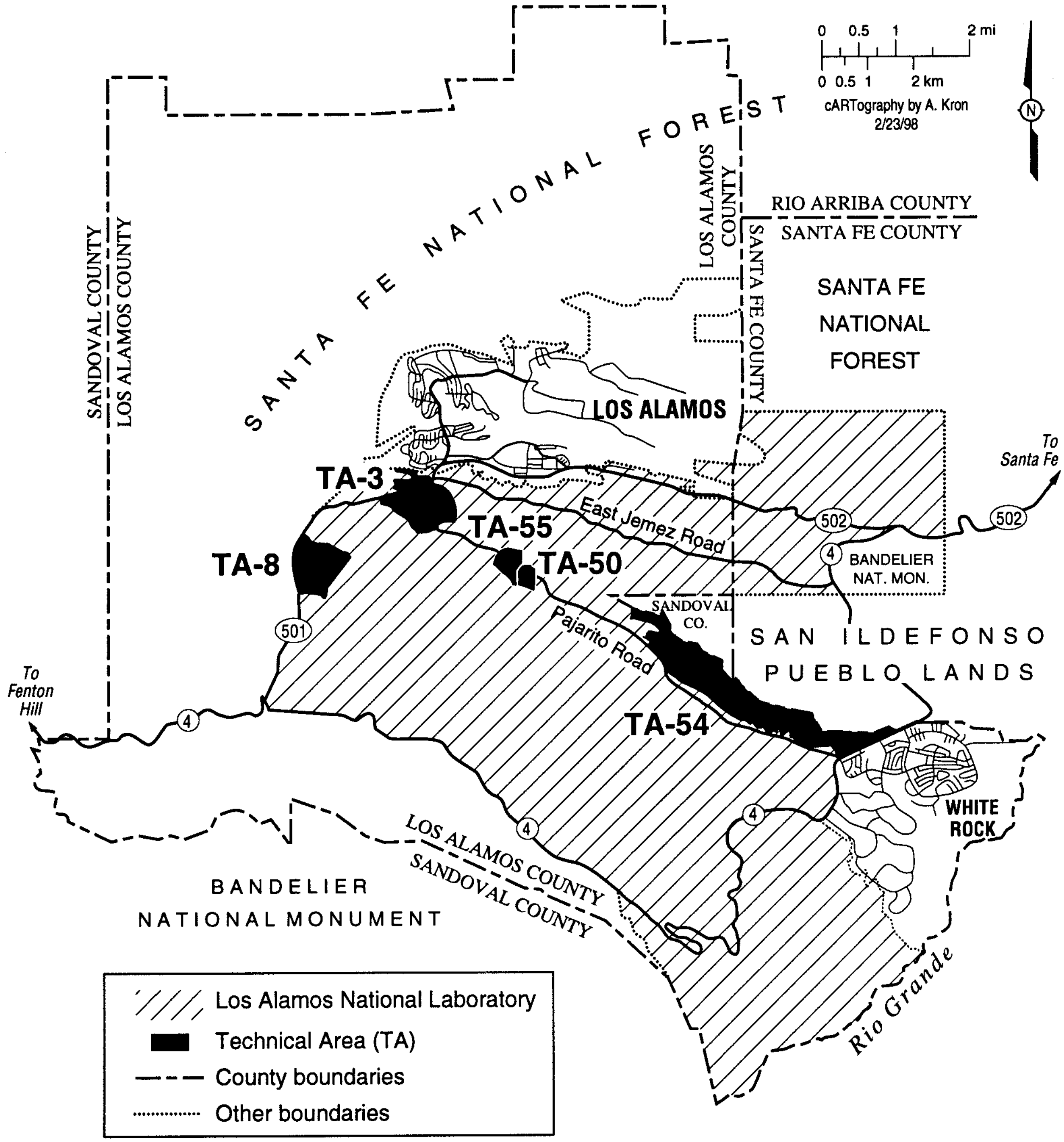


FIGURE II.1.3–1.—*Flow Diagram of Proposed Pit Manufacturing at Los Alamos.*



TA-3:	Analytical Chemistry and Non-Nuclear Parts
TA-8:	Radiography
TA-50:	Radioactive Liquid Waste Treatment
TA-54:	Solid Waste Handling and Low-Level Radioactive Waste Disposal
TA-55:	Processing, Handling, and Storage of Plutonium

FIGURE II.1.3–2.—*Location of LANL Operations that Support Pit Manufacturing.*

required to meet reasonably foreseeable pit manufacturing requirements. Two steps were involved in determining the floorspace requirements. First, subject matter experts provided the total floorspace that their capability would require based on the projected requirements, without regard to the final location of the program or function. Results of this analysis indicated that approximately 15,300 square feet (1,425 square meters) were required in addition to floorspace currently available in TA–55–4 (see Table II.1.4–1). Second, the following criteria were employed to select the functions that could be relocated from existing space in TA–55–4 in order to make space available for pit manufacturing:

- Total floorspace would fulfill anticipated functional requirements.
- Only liquid waste and residues generated in large volumes at the additional space facility would be low-level radioactive liquid waste. (This can be sent to TA–50 for treatment.)
- Major equipment that is integral to the TA–55–4 plutonium infrastructure would not be moved from TA–55–4.
- Both locations should dedicate space to materials handling and waste management functions.
- Functions, such as plutonium-238 operations, that would require extensive decontamination would not move.
- Additional support functions that specific capabilities require would be moved if the capability is moved.

These criteria are consistent with the following two basic concepts: (1) identifying capabilities that can most easily be separated from the current TA–55–4 infrastructure and remaining capabilities and (2) reconfiguring TA–55–4 to provide adequate contiguous space to accommodate the remaining capabilities such as the expanded pit manufacturing activities.

With the information and criteria above, the floorspace allocations for operations and support functions were determined and are shown in Table II.1.4–1. Under these criteria, all or part of the capabilities marked with a superscripted letter "a" in Table II.1.4–1 could be conducted in the additional space. The functions analyzed for potential relocation in this PSSC analysis were selected to be representative of the functions that could move and to bound the potential impacts of the Expanded Operations Alternative.

The risks and hazards associated with each of these functions that are candidates for the additional space are essentially identical. They are driven by the type and form of the material (plutonium oxide or metal in almost all cases), the nature of the operations (physical manipulation, destructive and nondestructive analytical work, solid chemistry, and aqueous chemistry in small quantities), and the nature of the facility and equipment (which is driven by current design and other safety-related standards associated with plutonium operations). The one exception to this statement is the Special Recovery Line, which includes the capability to handle small quantities of tritium contamination (a different radioactive material than is associated with the rest of the materials that could transfer to the additional space) of plutonium parts (LANL 1997). Because the hazards associated with them are essentially the same for all of the functions that are being considered, the question of exactly which process(es) might be moved is not important to the analysis within this document. In other words, the operational impacts of the alternatives addressed in this PSSC analysis (discussed in volume I, chapter 5) are driven by the location of the operations, not the differences between those operations being considered to move to that location. For the purposes of this document, it is assumed that pit surveillance (as well as metallography associated with this function), pit disassembly for manufacturing feedstock, about 50 percent

TABLE II.1.4–1.—*Laboratory Floorspace Requirements in Square Feet (Square Meters)*

FUNCTION	EXISTING TA–55–4 FLOORSPACE ft^2 (m^2)	ALLOCATION OF EXISTING FLOORSPACE AT TA–55–4 UNDER EXPANDED OPERATIONS ft^2 (m^2)	ADDITIONAL FLOORSPACE NEEDED UNDER EXPANDED OPERATIONS ft^2 (m^2)	TOTAL EXPANDED OPERATIONS FLOORSPACE REQUIREMENT ft^2 (m^2)
Manufacturing Plutonium Components[a]	11,400 (1,060)	15,300 (1,425)	3,200 (300)	18,500 (1,720)
Disassembly and Surveillance of Weapons Components[a]	2,300 (215)	0 (0)	4,500 (420)	4,500 (420)
Plutonium-238 Research, Development, and Applications	9,000 (835)	9,000 (835)	0 (0)	9,000 (835)
Actinide Materials Science and Processing Research and Development				
Actinide Research and Development—General[a]	3,400 (315)	3,400 (315)	1,000 (95)	4,400 (410)
Actinide Research and Development—Waste Management	800 (75)	0 (0)	0 (0)	0 (0)
Special Recovery Line[a]	700 (65)	0 (0)	1,200 (110)	1,200 (110)
Neutron Source Materials Recovery	800 (75)	800 (75)	0 (0)	800 (75)
Pit Disassembly and Material Conversion	1,000 (95)	1,500 (140)	0 (0)	1,500 (140)
Fabrication of Ceramic-Based Reactor Fuels	3,000 (280)	3,000 (280)	0 (0)	3,000 (280)
Plutonium Recovery	13,400 (1,250)	13,400 (1,250)	0 (0)	13,400 (1,250)
Support Activities				
Material Control and Accountability	0 (0)	0 (0)	0 (0)	0 (0)
Materials Management and Radiation Control[a]	4,400 (410)	4,400 (410)	2,000 (185)	6,400 (595)
Waste Management[a]	2,400 (225)	2,400 (225)	1,200 (110)	3,600 (335)
Analytical Chemistry—Metallography[a]	4,700 (435)	2,600 (240)	1,500 (140)	4,100 (380)
Contingency Space[a]	0 (0)	1,500 (140)	700 (65)	2,200 (205)
Total	57,300 (5,330)	57,300 (5,530)	15,300 (1,425)	72,600 (6,750)

[a] All or parts of these activities could be conducted in the additional space.
Metric totals may not sum due to rounding.

of the actinide research and development and the Special Recovery Line would constitute the functions that would be moved. Based on the quantities and types of materials involved, these processes bound the materials and risks for the functions being considered to move to the additional space.

The enhancement of pit manufacturing operations would require improvements in infrastructure, rearrangement of processes to optimize material flows, and equipment purchases so that LANL could provide a maximum capacity of up to 80 pits per year (using multiple shift operations) for the enduring nuclear weapons stockpile. However, pit manufacturing would not be the only function at LANL that requires dedicated floorspace in a nuclear materials facility. Other functions currently exist at TA–55–4 and must continue for the foreseeable future. These functions, their floorspace requirements in TA–55–4, and additional space are outlined in appendix II.A.

II.1.5 Capability Maintenance and Improvement Project

The CMIP is the name of the construction project under which the enhancement of pit manufacturing would occur. The CMIP is a construction project that consists of two parts. The capability maintenance activities within this project are necessary to provide for the continued viability of several facilities, as discussed in volume I. These include TA–55 and the Sigma Building. These activities are included in all of the SWEIS alternatives described in volume I because they are necessary to maintain existing capabilities. The SWEIS analyses of these aspects of the CMIP are addressed in chapter 5 of volume I for all alternatives.

Alternatives that DOE could develop for creation of adequate additional space to accommodate pit production are presented in section II.2 of this PSSC analysis. As described earlier, modifications to TA–55–4 would be consistent with the following concepts: (1) identifying for possible relocation those capabilities that can most easily be separated from the TA–55 infrastructure and remaining capabilities and (2) providing adequate space within TA–55 to accommodate the remaining capabilities, including the enhanced pit manufacturing activities.

II.2 SITING AND CONSTRUCTION ALTERNATIVES

This section discusses alternatives for the construction of adequate additional space to accommodate pit production in addition to the other activities described in the Expanded Operations Alternative. Because of the potential transportation and handling implications of moving materials from TA–55 to the CMR Building, options for transporting special nuclear materials (SNMs) are discussed also. The options for transporting SNMs are applicable to each of the alternatives.

The typical No Action Alternative regarding this project (that is, not enhancing the existing capability), is discussed in the SWEIS No Action Alternative in volume I, and that discussion is not repeated here.

Conceptual locations have been identified for the Brownfield Plutonium Facility and the Add-on to TA–55–4 alternatives based on the conceptual operational requirements of the pit manufacturing capability provided in the SSM PEIS. These conceptual requirements have been used to broadly define facility size and category, utility needs, and other possible infrastructure characteristics. This information has been generally reviewed in the context of LANL's siting criteria and construction codes. The resulting locations are the product of this conceptual analysis.

II.2.1 Alternatives Analyzed in Detail

The text box on page II–2 briefly describes the three alternatives analyzed in detail. This section provides further information on these alternatives. As noted in these descriptions, pit manufacturing would continue during these construction activities by phasing construction. This approach allows for continuous support of missions throughout the construction activities.

II.2.1.1 *Utilize Existing Unused Space in the CMR Building Alternative*

Only two existing facilities at LANL are qualified to undertake the types of operations described in appendix II.A of this PSSC analysis: TA–55–4 and the CMR Building in TA–3. As noted previously, TA–55–4 does not currently have adequate available space. However, the CMR Building has two wings available and another wing that may become available in time to support these needs. These three wings are essentially equivalent, and would have almost identical construction and operational impacts if utilized.

This alternative is distinct from the others in that it does not require construction of new nuclear facility floorspace; rather, the construction project would focus on making existing nuclear facility space operational. Additionally, the majority of the construction involved is within existing facilities (which substantially reduces disturbance of land beyond the existing disturbance). Given that current employee office space is very limited at TA–55 and makes extensive use of portable trailers, it is reasonably foreseeable that a new office support facility could be constructed; thus, creation of this office space is included in the analyses for this alternative. The size and location of such a facility would likely be limited to currently developed areas. Operationally, the potential for transportation on public roads, as well as material handling volume and risk, are more substantial for this alternative than the alternatives discussed in sections II.2.1.2 and II.2.1.3. This alternative poses minimal potential for biological or cultural effects, and there would be no addition to the potentially contaminated space in either TA–55 or the CMR Building (i.e., uses existing nuclear space). Additionally, facility modifications under this alternative would generate transuranic (TRU)[2] waste and low-level radioactive waste (LLW)[3] (because these modifications would occur within the nuclear facility), which would require treatment and disposal.

The above discussion reflects an endpoint achievement in pit manufacturing capacity at TA–55–4. DOE would achieve this capacity in a phased manner. First, additional maintenance and equipment procurement would be conducted in TA–55–4 to support continued pit manufacturing at the existing capacity of about 14 pits per year (this is part of all SWEIS alternatives). Secondly, construction would be initiated to complete refurbishment of TA–55–4 for long-term viability of the facility in support of all missions: replacement of aged analytical chemistry support equipment and improvements to nonnuclear support facilities. By completion of the second phase, it is expected that an intermediate pit manufacturing capability of 20 pits per year at TA–55–4 would be achieved through use of the upgraded facilities and efficiencies gained in manufacturing operations. The final phase would be transfer of activities to the CMR Building, followed by modification of TA–55–4

2. TRU wastes contain a transuranic radionuclide with a half-life greater than 20 years and alpha activity of 100 nanocuries per gram (nCi/g) or greater at the time of measurement, excluding naturally occurring and depleted uranium, spent nuclear fuel, and high-level waste.

3. LLW contains radioactivity, but is not classified as high-level waste, TRU waste, spent nuclear fuel, or "11e(2) byproduct material" as defined by DOE Order 5820.2A, *Radioactive Waste Management*.

to provide for pit manufacturing at TA–55–4, as described above. The analyses of the "CMR Building Use" Alternative bound the potential risk to workers and the public from this phased approach.

Transportation Corridor

Transportation of SNM among the facilities at LANL would increase under the Expanded Operations Alternative. The transportation of samples between the CMR Building and TA–55–4 would also increase substantially (as described in the Expanded Operations transportation analysis). These shipments typically would require specially designed packaging and vehicles or road closures. In this case, total shipments between TA–55 and the CMR Building would be expected to increase by approximately 500 shipments of SNM per year (see appendix F in volume III). Road closures would occur more frequently.

In order to minimize impacts to the public (ranging from transportation-related risks to inconvenience), a restricted-access road between TA–55 and TA–3 (Figures II.2.1.1–1 and II.2.1.1–2) is proposed. This road would be developed on an existing dirt road just off of the existing public road. It would be utilized for all SNM shipments between TA–55 and the CMR Building. In addition to removal of vegetation, filling the road bed and paving the road, fences, gates, lights, towers, and other physical security structures would be constructed within the corridor. This road would not be constructed for the 20 pits per year rate.

In order to ensure that the potential impacts of the Expanded Operations Alternative are bounded, the transportation analysis in volume I includes transportation of these materials on public roads utilizing appropriate packaging to minimize road closures. The Expanded Operations Alternative (volume I, chapter 5, section 5.3.10) also includes the impacts of building the dedicated road. The resulting analysis is thus conservative in terms of public risk due to transportation accidents and in terms of public radiation exposures associated with routine shipments.

Inclusion of the "CMR Building Use" Alternative in the SWEIS

The "CMR Building Use" Alternative from this PSSC analysis is included in the SWEIS Expanded Operations Alternative and its associated impacts analysis. The "CMR Building Use" Alternative for pit manufacturing is to utilize existing unused space in the CMR Building (moving activities from TA–55–4 to CMR to make adequate space in TA–55–4 for plutonium pit manufacturing activities) and use a dedicated restricted access road (with minimal environmental impacts) to mitigate the impacts to the public related to transportation between TA–55 and the CMR Building.

II.2.1.2 *Brownfield Plutonium Facility Alternative*

In this alternative, DOE would build a new plutonium-qualified facility in a developed area near the existing Plutonium Facility at TA–55, hence, the use of the term "Brownfield." This stand-alone facility would take about as long to build and start up as a facility at an undeveloped or "Greenfield" site. A Greenfield facility, however, would require additional nonnuclear space (staging and storage, measurement equipment, etc.) as well as nuclear space (operational space); whereas, the Brownfield facility would be able to take advantage of some infrastructure at the existing TA–55 facility and thus, would likely require slightly less total floorspace and less total acreage than a Greenfield site. The Brownfield Plutonium Facility would have a new parking lot, new cold laboratory, low-level radiography, and support space. Approximately 15,300 square feet (1,425 square meters) of new laboratory floorspace would be required for this facility. A new office support facility could be required in the future and is analyzed as part of this

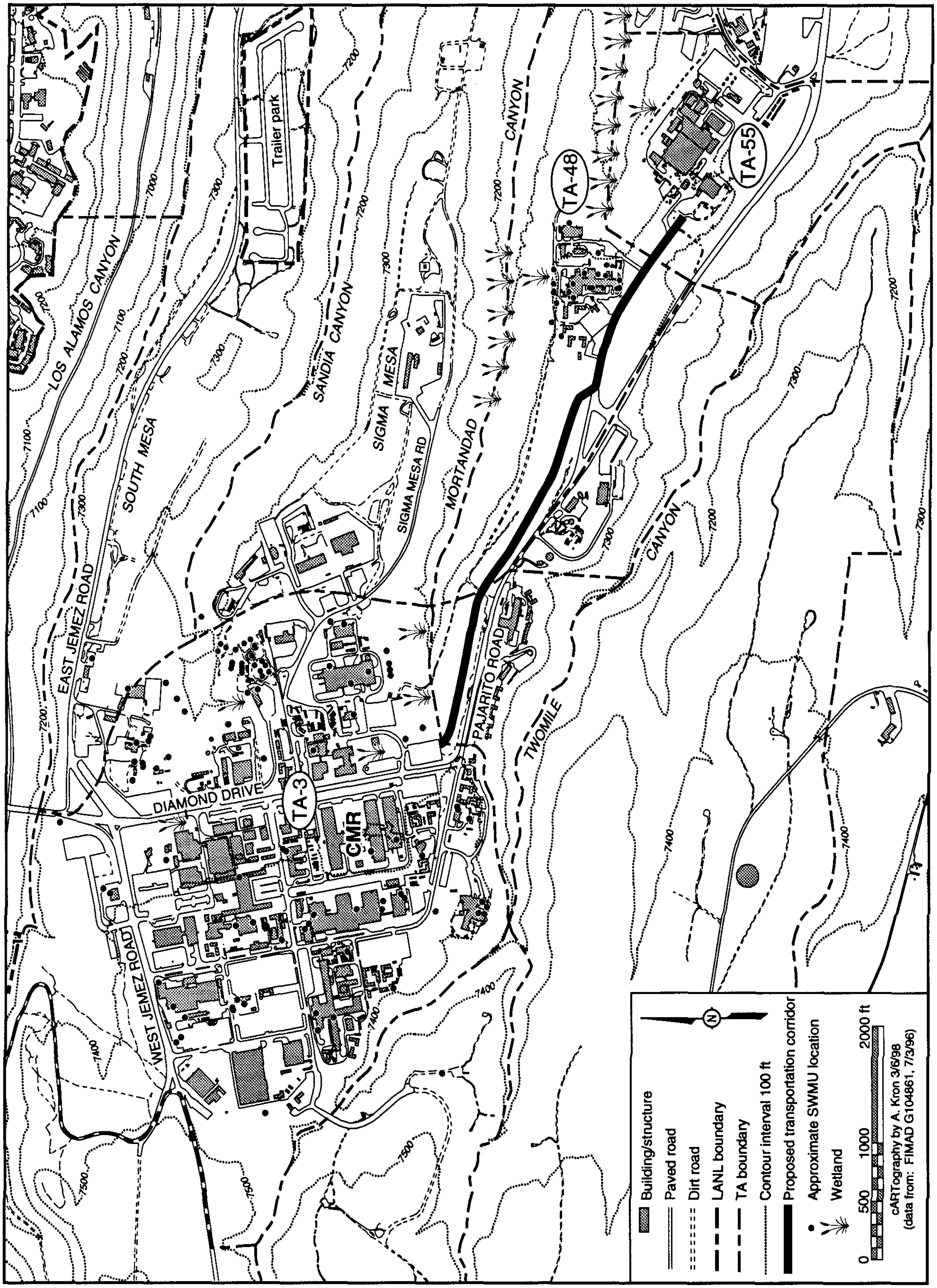


FIGURE II.2.1.1–1.—*Location of Proposed Transportation Corridor.*

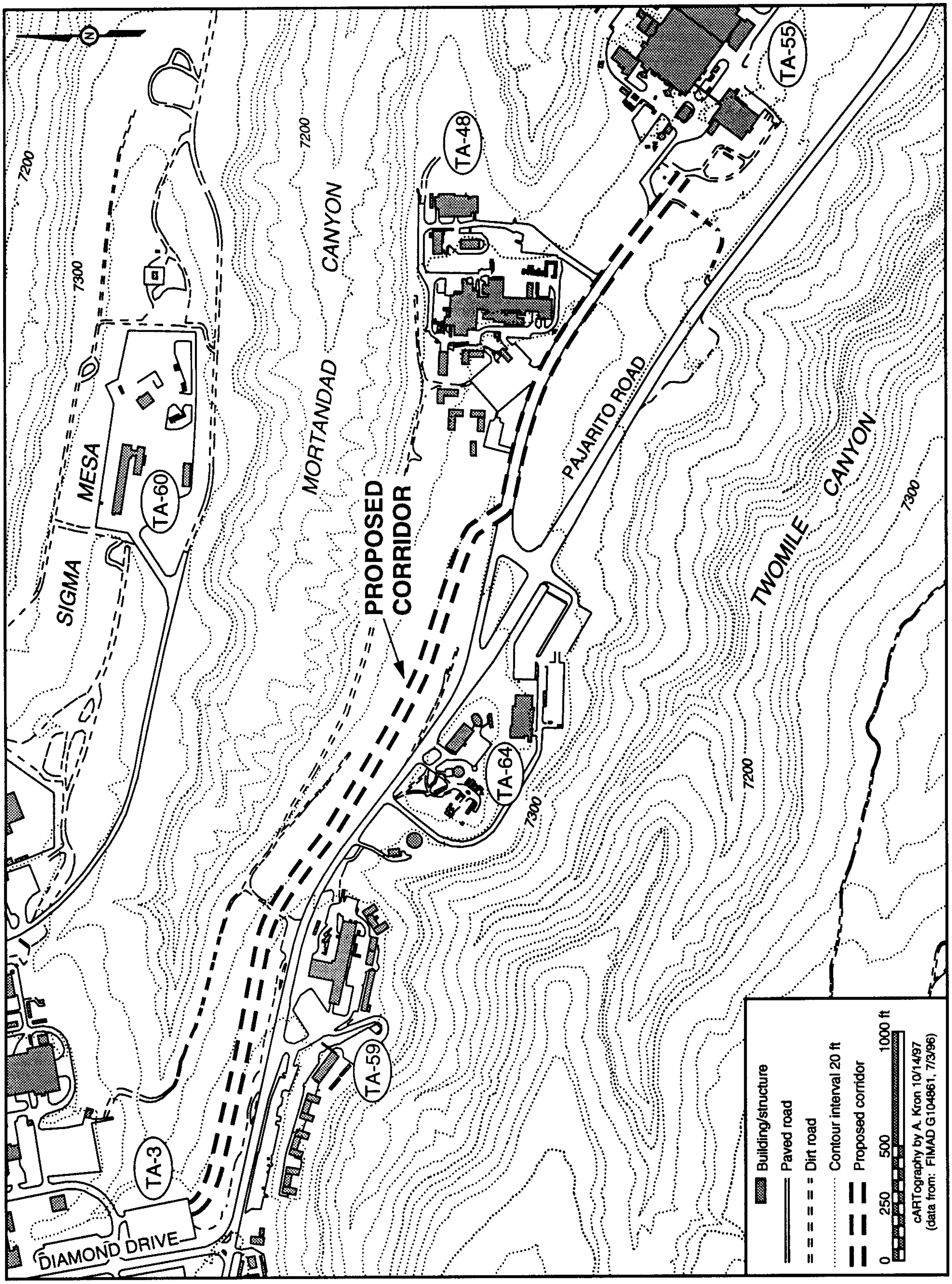


FIGURE II.2.1.1–2.—*Detailed Location of Proposed Transportation Corridor.*

alternative. This alternative includes a dedicated transportation corridor to be constructed between TA–55 and the CMR Building to provide analytical chemistry support to TA–55 pit manufacturing operations. The additional transportation options discussed in section II.2.1.1 also would be considered under this alternative.

As with the "CMR Building Use" Alternative for enhanced pit manufacturing, the increased pit manufacturing capacity would be phased under this alternative. The analysis of this alternative bounds the impacts of the phased implementation, and the operations impacts analyzed in volume I, chapter 5, bound the operational impacts of the phased implementation.

Conceptually, the Brownfield Plutonium Facility could be constructed just south and west of Buildings 1 and 2 within an existing protected area at TA–55 (Figure II.2.1.2–1). Although the facility itself is within the TA–55 fence line, the fencing and security system may have to be moved to provide adequate buffer between the building and the fence. In order to provide the operational space required (see Table II.1.4–1) under this alternative, this stand-alone facility would need to contain approximately 15,300 square feet (1,425 square meters) of designated nuclear laboratory space; it is assumed that this space would become contaminated during operations, creating a liability for eventual cleanup. The required utilities would be routed to this stand-alone facility from nearby utility corridors. The facility waste streams would be routed to nearby waste collection lines. Most transportation of materials would occur within the existing protected area at TA–55, and access control would be managed using existing or slightly modified security fencing and equipment. This alternative would minimize transportation of materials between the CMR Building and TA–55. Potential environmental advantages for this alternative would include minimizing transportation risks and minimizing development in currently undeveloped areas (less potential for cultural and biological impacts); however, it would create additional nuclear facility space that would potentially be contaminated (and have the liability for eventual decontamination and decommissioning).

II.2.1.3 *Add-On to the TA–55–4 Alternative*

Construction to add plutonium-qualified space to the existing plutonium facility at TA–55 is also considered reasonable. Because this alternative would take maximum advantage of the existing TA–55 facility infrastructure (i.e., utilities, structural support, vaults, alarm systems, etc.), it would require less total development than the Brownfield site to provide the same operational floorspace. This facility also may have low-level radiography as well as a new cold laboratory, and may require office support space (thus, construction of this office space is analyzed as part of this alternative).

Based on a conceptual siting, the TA–55 add-on plutonium facility could be located directly adjacent and along the northeastern wall of TA–55–4 between Buildings 42 and 8 (Figure II.2.1.3–1). The add-on plutonium facility would house approximately 15,300 square feet (1,425 square meters) of nuclear laboratory space. The infrastructure necessary to support the pit manufacturing capabilities under this alternative would be provided by the existing, or slightly modified, TA–55–4 Plutonium Facility. The utilities required for operations within the add-on facility would be provided by extending, and tying into, utility infrastructure already existing in TA–55–4. Material handling and movement would occur within TA–55–4, and the add-on facility and access control would be managed by using the existing TA–55–4 Plutonium Facility security systems.

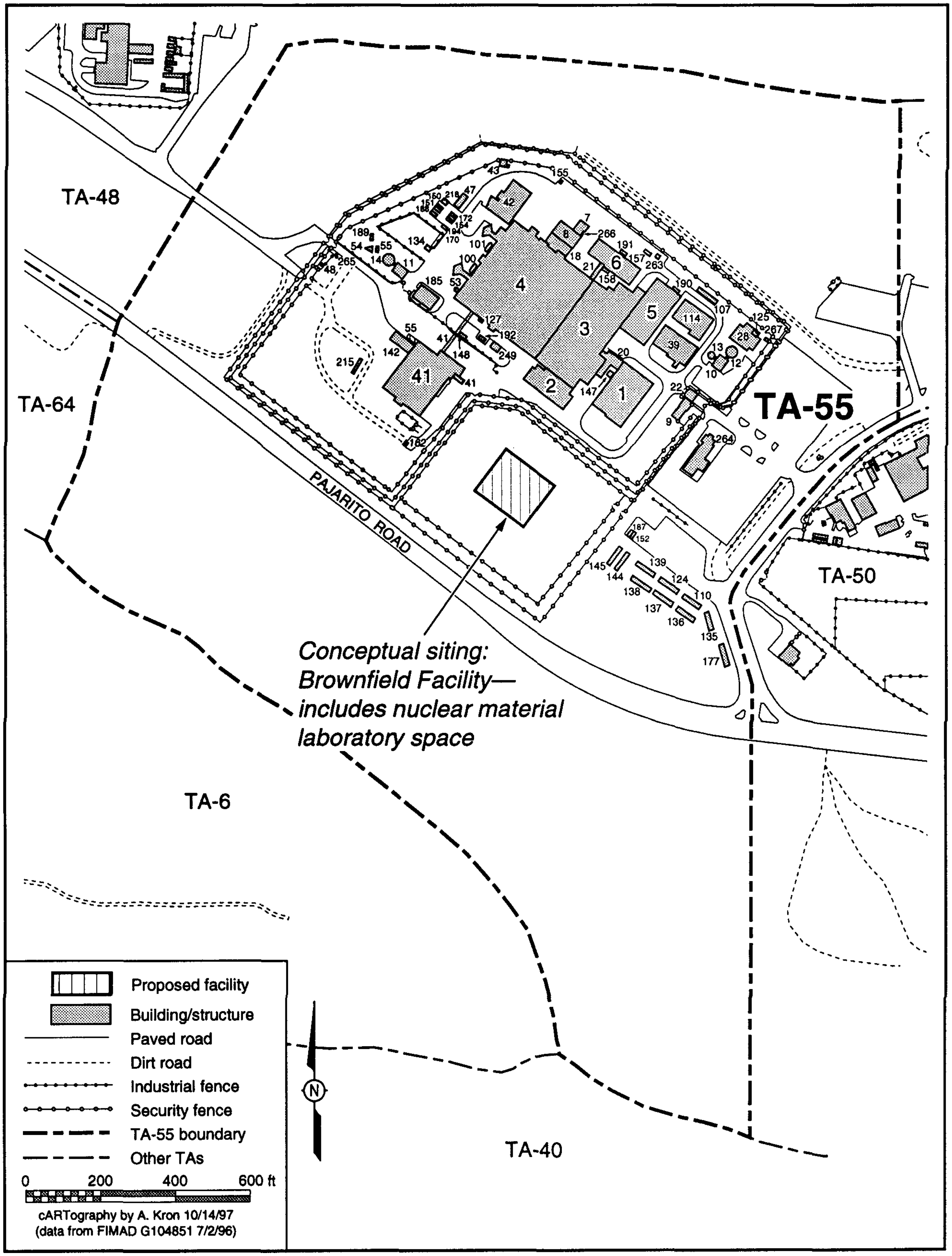


FIGURE II.2.1.2–1.—*Conceptual Location of the Brownfield Facility.*

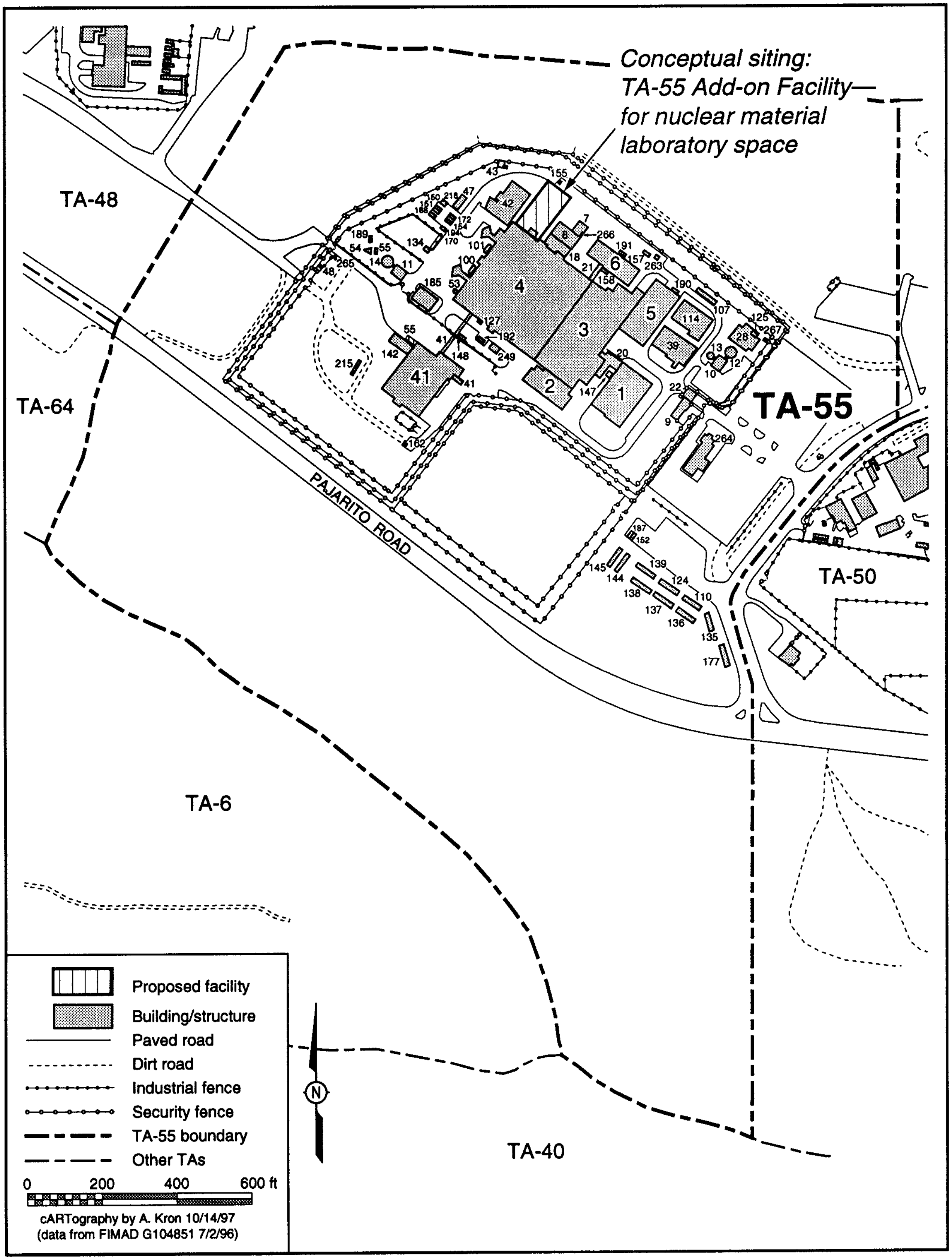


FIGURE II.2.1.3–1.—*Conceptual Location for the Add-On Facility.*

The add-on facility may not require relocation of current TA–55–4 operations. While this is an option that would be implemented in a phased manner (as discussed in the other two alternatives), it also is possible to maintain and operate existing activities in TA–55–4 as a new pit production facility is built within the add-on facility (again, this may also utilize a phased approach that increases the capacity of the existing capability up to 20 pits per year). Once the add-on facility was completed and functioning under this option, the activities in TA–55 would be expanded and rearranged within TA–55–4 to meet projected floorspace requirements. As with the other alternatives, the analysis includes all construction operations (under either of the alternative options), and the analysis of operations discussed in volume I, chapter 5, bounds the operations of the phased approach. This alternative would minimize transportation between TA–55 and the CMR Building (the same as for Brownfield). This alternative includes a dedicated transportation corridor to be constructed between TA–55 and TA–3 to provide analytical chemistry support to TA–55 pit manufacturing operations in the add-on facility. However, the additional transportation options discussed in section II.2.1.1 also would be considered under this alternative. This facility would create additional contaminated space. This alternative has essentially the same environmental impacts as the Brownfield facility.

II.2.2 Alternatives Not Examined in Detail

II.2.2.1 *Eliminate Existing Capabilities*

Existing plutonium facilities and capabilities at LANL are needed to support ongoing missions. Many of the capabilities that currently exist are essential to successfully support ongoing programmatic missions and implement the SSM PEIS decisions and cannot be eliminated (for example, aqueous and pyrochemical recovery and stabilization process, storage and handling of plutonium, plutonium metallurgy, analytical chemistry, and nondestructive analysis). Other nuclear facility capabilities are critical to ongoing missions at LANL, and there has been no DOE programmatic determination to cease or transfer these responsibilities to another site. Hence, the elimination of existing capabilities at LANL to make space available for enhanced pit manufacturing is not considered reasonable. For these reasons, an elimination alternative is not examined further.

II.2.2.2 *Greenfield Plutonium Facility*

An alternative to construct a new facility or facilities at an undeveloped location at LANL also was considered but dismissed from detailed evaluation. Such a facility would have to be largely self-sufficient and could take little advantage of existing infrastructure available at a developed site (replication of such infrastructure would mean a facility with far more total floorspace than the minimum required to perform the operations). Under such an alternative, site disturbance would be extensive (roads, parking areas, fences, utilities, administrative offices, etc.) with the potential for affecting biological, visual, and/or cultural resources. Such an action also would add substantially to the operating nuclear space in the weapons complex and at LANL at a time when DOE is trying to minimize this type of space (and thus, minimize the eventual liability for decommissioning of contaminated space). The time required to build and start up such a facility is extensive. There are no programmatic, environmental, or other advantages to undertaking this type of action beyond those represented in the alternatives described in section II.2.1. Transportation, material handling, and other issues are no different for this alternative than are represented in the other alternatives. Because there are no potential advantages to undertaking a

Greenfield Plutonium Facility, and there are additional unique environmental impacts associated with disturbing an undeveloped site, this alternative is not considered reasonable for detailed analysis.

II.2.2.3 *Other Existing Space*

While there may be other facilities with existing available space at LANL, with the exception of existing unused plutonium-qualified space at the CMR Building, this space does not meet current standards for supporting plutonium operations. Substantial upgrades to such facilities would be required to allow for their use in plutonium operations. By the nature of requirements for plutonium facilities, these upgrades would be so intrusive and complex that they would be similar in duration to the Brownfield Alternative. Additionally, such facilities are farther away from the existing infrastructure at TA–55 than is examined in the Brownfield Alternative, and so additional transportation risks would be incurred in this event (as compared to Brownfield). This alternative would have no programmatic or environmental advantages over the Brownfield Alternative. As such, this alternative is not considered to be distinct from the Brownfield Alternative and is not analyzed.

II.3 AFFECTED ENVIRONMENT

This section does not repeat information that is presented in volume I, chapter 4; it focuses on alternative-specific information that is needed to illuminate the differences among alternatives. Table II.3–1 identifies the environmental resources common to this PSSC analysis and volume I, along with their location in both documents. Table II.3–2 identifies environmental resources that are not discussed in this PSSC analysis, provides information about why they are not discussed, and identifies the locations of the discussions in volume I, chapter 4.

TABLE II.3–1.—*Potential Environmental Resource Issues Addressed in Volume I and This PSSC*

ENVIRONMENTAL RESOURCE	LOCATIONS OF DISCUSSIONS
Land Use	Volume I, section 4.1.1 and PSSC Analysis, section II.3.1.1
Noise	Volume I, section 4.1.3 and PSSC Analysis, section II.3.1.3
Air Quality	Volume I, section 4.4 and PSSC Analysis, section II.3.2
Ecological Resources	Volume I, section 4.5 and PSSC Analysis, section II.3.3
Cultural Resources	Volume I, section 4.8 and PSSC Analysis, section II.3.4
Traffic	Volume I, section 4.10 and PSSC Analysis, section II.3.5
Environmental Justice	Volume I, section 4.7 and PSSC Analysis, section II.3.6
Human Health	Volume I, section 4.6 and PSSC Analysis, section II.3.7
Environmental Restoration and Waste Management	Volume I, sections 2.1.2.5 and 4.9 and PSSC Analysis, section II.3.8

II.3.1 Land Resources

II.3.1.1 *Land Use*

TA–55 and TA–3 have been designated for research and development land use purposes, as has the land within the neighboring TAs, including TA–48, TA–60, and TA–59. The majority of the land within TA–55 and TA–3 is highly developed industrially. TA–55 is located on Mesita del Buey, which is a narrow southeast-trending mesa about 2.5 miles (4 kilometers) long. The CMR Building is located in TA–3 about 1.2 miles (2 kilometers) west of TA–55 on South Mesa. The locations of TA–55 and TA–3 are shown in Figure II.1.3–2. Currently undeveloped land within the vicinity of TA–55, including that along the proposed transportation corridor, is open to wildlife use. It is not considered to be the highest quality

TABLE II.3–2.—*Potential Environmental Resource Issues Addressed Only in Volume I*

ENVIRONMENTAL RESOURCE	REASON NOT ADDRESSED IN THIS DOCUMENT	LOCATION OF DISCUSSION
Visual Resources	Any major construction would occur in developed industrial areas.	Chapter 4, section 4.1.2
Parks; Forests; Conservation Areas; Wetlands; and Areas of Recreational, Ecological, or Aesthetic Importance	None of these resources is located in any of the areas under consideration.	Chapter 4, section 4.1
Geology and Soils	Alternatives would involve the same types of surface soils and the same underlying Bandelier Tuff (Nyhan et al. 1978).	Chapter 4, section 4.2
Water Resources	None of the alternatives would affect water resources. Any modifications to runoff patterns would be minor relocations.	Chapter 4, section 4.3
Socioeconomic Conditions	Fewer than 140 workers would be required to implement the Preferred Alternative during times of peak labor demand. Construction projects associated with any of the alternatives would be approximately 4 years in duration, and the number of potential workers is very small compared to the population base in northern New Mexico.	Chapter 4, section 4.9

habitat, however, due to its close proximity to highly developed areas with high levels of human activities and busy roadways.

II.3.1.2 *Visual Environment*

The visual environment around TA–55 is that of an industrially developed site with a backdrop of forested and grass covered areas. Similarly, the larger industrial development within TA–3 is set against a predominately silvan backdrop. The surrounding TAs are either sparsely developed and forested, or their development is clustered into one or two areas with forested areas within their boundaries.

II.3.1.3 *Noise Environment*

Operations at TA–55 and TA–3 contribute to the overall background noise level generated by LANL activities, primarily through the traffic into and away from the facilities located within these TAs. Actual operational noise heard outside of structures is limited to the immediate vicinity of the buildings; mostly these noises are due to occasional routine maintenance activities (such as grass mowing) and the movement of equipment and waste containers into and around the facilities. No measurements of environmental noise have been conducted within the TA–55 area, but the level of noise present there and around the TA–3 area is fairly representative of other industrially developed sites around LANL.

II.3.2 Air Quality

Air monitors in the stacks at TA–55–4 and the CMR Building collect data from routine emissions. The index used in this SWEIS for the CMR Building radioactive stack emissions is 0.0002 curies per year (see Table 3.6.1–4 in chapter 3, volume I). The index for TA–55 radioactive stack emissions is 0.00002 curies per year of plutonium-239, and about 1,100 curies per year of tritium (in the form of hydrogen and water vapor) (see Table 3.6.1–2, chapter 3, in volume I).

II.3.3 Ecological Resources

II.3.3.1 *Threatened or Endangered Species*

DOE utilized existing available field information and a preliminary model of nesting and roosting habitat for the Mexican spotted owl to assess use of the TA–55 and TA–3 areas by species of animals and birds that are federally listed and state listed and protected as threatened or endangered. Three federally protected (also state listed) species of birds potentially use the areas for foraging habitat: the bald eagle (*Haliaeetus leucocephalus*), the American peregrine falcon (*Falco peregrinus*), and the Mexican spotted owl (*Strix occidentalis lucida*) (Haarmann 1997).

II.3.3.2 *Flora and Fauna*

The areas within the fenced portion of TA–55 where TA–55–4, the Brownfield Plutonium Facility, and the add-on to the TA–55–4 alternatives are proposed for location, are not available for use by any but the smallest wildlife species. This also is the case with the fenced portion of TA–3 around the CMR Building. These areas within the TA security fences are grassed over with a mixture of native and nonnative grass species and have small landscaped areas that include low lying bushes and a few small trees, but no large-trunked trees. The mesa-top area along the proposed transportation corridor within TA–55, TA–48, and TA–59 is predominantly covered with ponderosa pine (*Pinus ponderosa* Laws. *var. scoparium* Engelm.), with small stands of Gambel oak (*Quercus gambelii* Nutt.) understory trees (*Quercus gambelii*) and a groundcover of mostly mountain muhly grass (*Muhlenbergia montana* (Nutt. (A.S. Hitchc.) and blue grama grass (*Bouteloua gracilis* (H.B.K.) Lag.)). Wildlife in the mesa-top area includes a variety of insects, reptiles, birds, and mammals. Small mammals known to inhabit the area include voles (*Microtus* spp.), brush mice (*Peromyscus boylii*), and chipmunks (*Eutamias* spp.). Large mammals known to use and inhabit the area include game animals such as elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*), as well as coyote (*Canis latrans*) and black bear (*Ursus americanus*). Field data suggest that many of these animals are attracted to and use surface water located in the upper portion of Mortandad Canyon to the northeast of TA–55.

II.3.4 Cultural Resources

Historic and archaeological sites are located in the vicinity of TA–55. These include a two-room pueblo (LA 12705) and historic wagon road (LA 71160) near the proposed corridor. LA 12705 has been determined eligible for the National Register of Historic Places (NRHP). LA 71160 has been determined ineligible for the NRHP (LANL 1996b). Other cultural properties are not expected to be found within the areas encompassed by the various alternatives because of the currently disturbed states of the potential alternative sites.

II.3.5 Traffic

Four publicly accessible vehicle routes convey traffic to and from LANL (Figure II.1.3–2). State Road 502 (Main Hill Road) and East Jemez Road are heavily used by commuter traffic from Santa Fe and Española. State Roads 4 and 501 (West Jemez Road) provide access to LANL for small communities to the west of LANL. Pajarito Road conveys traffic from White Rock to LANL. The four main portals to LANL convey about 40,000 average daily trips (ADTs). They are Los Alamos Canyon bridge (28,000 ADTs), Pajarito Road (8,000 ADTs), East Jemez Road (6,000 ADTs), and State Road 4 from the west (1,000 ADTs). East Jemez Road and Pajarito Road are DOE-owned and provide public access to many of the TAs at LANL.

In addition to private vehicles, government vehicles contribute to the volume of traffic on these roadways. Routine shipments of SNM are made across these roads in the DOE/U.S. Nuclear Regulatory Commission (NRC) Type B certified packaging. DOE has delegated the authority to LANL to temporarily close roads for the purpose of transporting hazardous or radioactive materials on DOE-owned roads. On average, the total number of on-site transfers of radioactive materials is approximately 950 per year. The number of hazardous or radioactive material shipments that actually require temporary road closures is approximately 80 per year. Road closures for on-site hazardous or radioactive material transfers are routinely conducted at one of three times: 5:00 a.m., 9:00 a.m., or 2:00 p.m. Road closures generally last less than 1 hour. Traffic is either held in place by security personnel or rerouted to the other available access roads at LANL. Because of the temporary and infrequent nature of the road closures and the ability to schedule road closures during off-peak hours, no discernible changes in routine traffic patterns are known to result from these actions at LANL.

II.3.6 Environmental Justice

Section 4.8, of chapter 4, volume I, discusses environmental justice and the populations near LANL. Because any of the alternative construction sites would have only local effects and the local populations are not minority or low-income populations, environmental justice considerations are complete in volume I, chapter 5.

II.3.7 Human Health

Work (including facility modification, maintenance and similar work) in the nuclear facilities at TA–55–4 and the CMR Building is presumed to involve exposure to radiation. Such work is conducted according to strict guidelines established by existing LANL standard operating procedures (SOPs). Under these SOPs, engineering and administrative controls are implemented to minimize worker and public exposure to radiation. Chapter 5 of volume I addresses projected worker doses at TA–55. Worker doses at the CMR Building are considerably lower than for TA–55.

Construction and relocation activities can expose workers to a variety of health risks and accidents, such as handling hazardous materials, being crushed beneath heavy equipment, back injuries, hidden electrical hazards, and working in a confined space. All work is performed according to SOPs for each type of task. In some cases, special work permits are required for work in secure areas or areas where radioactive or hazardous chemicals are present. Worker health is protected by the use of administrative controls and the wearing of personal protective equipment as needed and as specified in the special work permits.

II.3.8 Environmental Restoration and Waste Management

LANL has established procedures to be in compliance with all applicable laws and regulations for collecting, storing, treating, and disposing of waste. LANL's construction debris and nonhazardous solid waste are disposed of at the Los Alamos County Landfill on East Jemez Road. Typical radioactive wastes generated at TA–55 and the CMR Building include radioactive liquid waste, which is piped or trucked to the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA–50; solid LLW, which is managed and may be disposed of at TA–54, Area G; and TRU waste, which is packaged and stored at TA–54 pending ultimate disposal at the Waste Isolation Pilot Plant (WIPP). In addition, mixed waste (containing both a radioactive and a *Resource Conservation and Recovery Act* (RCRA)-regulated hazardous component) is generated at these facilities. TRU mixed waste is transported to TA–54, Area

G, and stored there pending disposal at the WIPP. Solid, low-level mixed waste (LLMW)[4] and liquid LLMW are transported to TA–54, Area G, and TA–54, Area L, respectively, and stored there until appropriate disposal options become available. These options may include shipment off site to a commercial or other DOE facility for treatment and disposal.

The Environmental Restoration (ER) Project was established to identify the extent of environmental contamination at LANL from past practices and the appropriate means of cleaning it up under RCRA (as described in chapter 2, section 2.1.2). No potential release sites are known to exist in the immediate vicinity or are expected to be disturbed by activities planned under any of the alternatives under consideration in this PSSC analysis.

II.4 Environmental Consequences

Routine air emissions, wastewater, and solid waste projections from operations and their associated impacts are discussed in volume I (chapters 4 and 5) and are associated with the locations of facilities under the "CMR Building Use" Alternative. Impacts from the operations located in TA–55 could potentially be less than the TA–3 location; but, because routine emissions are so low, changes in impacts between these locations are not identifiable. Some aspects of impacts do not have a location difference. For example, radioactive wastewater treatment and radioactive waste disposal have the same final disposal locations under each alternative.

Impacts from operational accidents could show a locational difference because the CMR Building is closer to more members of the public than TA–55–4. The accident analysis section of volume I considers that the location for the operations requiring the additional space is in the CMR Building. Impacts due to accidents from these same operations being located in the vicinity of TA–55 could potentially be less. It is noted however, that this change would manifest only in the overall consideration of risk due to accidents. Existing operations with radioactive materials in the CMR Building and TA–55 represent the same potential hazards as those proposed for the future. The frequency of the potential accident might increase with an increase in the amount of work, but the potential consequences of such accidents have been considered for both facilities in chapter 5.

Another distinction among the alternatives is the creation of new nuclear space. The "CMR Building Use" Alternative is the only alternative that does not create any new nuclear space. Operations in new nuclear space under the other alternatives are assumed to create contaminated space and the liability for eventual decontamination and decommissioning. This is a conservative assumption and presents a bounding analysis for the alternatives presented in this PSSC analysis.

Note that any impacts associated with the dedicated transportation corridor would not be incurred at the 20 pits per year production rate.

II.4.1 Utilize Existing Unused Space in the CMR Building Alternative

II.4.1.1 *Land Use*

The expansion and reconfiguration activities to enhance plutonium pit manufacturing under this alternative would involve existing structures in TA–55–4 and the CMR Building at TA–3. Land uses in TA–55 and the CMR Building would not change from the current classification of use for research and development.

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4. LLMW contains LLW, plus chemicals regulated as hazardous under the RCRA (42 United States Code [U.S.C.] §6901).

Under this alternative, a dedicated transportation corridor would be constructed to transport plutonium pits and various plutonium samples and components among the facilities at TA–55, the analytical chemistry operations at the CMR Building, and the nonnuclear support facilities in TA–3 (Figures II.2.1.1–1 and II.2.1.1–2). The corridor would be approximately 1 mile (1.6 kilometer) in length and 75 feet (23 meters) wide. It would occupy an area of approximately 7 acres (2.8 hectares). Development of the corridor would require road construction activities, including the removal of vegetation and the filling of a road bed. The dedicated corridor would cross Diamond Drive at its intersection with Sigma Road. At this intersection, a gate would be constructed to exclude public access during the movement of SNM into or out of the CMR Building. Public access to Pajarito Road would be allowed to continue unimpeded.

II.4.1.2 *Noise*

Implementation of the alternative to use existing CMR Building space would result in noise production both within the CMR Building and TA–55–4, as well as exterior to both structures in the case of the roadway and related construction actions. Noise produced from the construction activities conducted within both buildings and outside of structures would not likely affect the public. Involved workers would be exposed to levels of noise under normal working conditions, ranging from about 45 decibels A-weighted frequency scale (dBA) to 55 dBA for decontamination activities (May 1978) all the way up to slightly in excess of about 95 dBA for construction activities involving the use of heavy machinery (such as chainsaws, bulldozers, rock drills, and concrete mixers). At a distance of 50 feet (15 meters) from the work site, however, these noise levels would range from about 75 dBA to 95 dBA (Magrab 1975).

Most of the noise produced by the decontamination, construction, and reconfiguration activities at the CMR Building, TA–55, and the transportation corridor would fall below the occupational exposure limit (OEL) of the U.S. Occupational Safety and Health Administration (OSHA). Noise intensity would quickly decrease with distance from the source (Lipscomb and Taylor 1978). Any noise produced above 80 dBA would require the operators and nearby workers to participate in a personnel hearing conservation program (LANL 1993). The majority of the remodeling and construction activities would take place inside existing buildings, such as the CMR Building. The damping effect of building walls and greater than a 50-foot (15-meter) distance would reduce the noise levels below 80 dBA and to normal background levels (Canter 1996). The public would not be subjected to noise above 80 dBA at the closest public areas of Diamond Drive and Pajarito Road.

II.4.1.3 *Air Quality*

Radiological Emissions

Many proposed reconfiguration and associated activities would take place in the CMR Building. The decontamination and improvements would be conducted primarily indoors. The existing space to be remodeled would be physically segregated from the rest of the CMR Building. Normal operations would continue unhindered in the rest of the CMR Building. Engineering controls and SOPs would be in place to prevent radiological contaminants from leaving the work area. The room air would be filtered by the existing high-efficiency particulate air (HEPA) filters in the ventilation system during the reconfiguration. The CMR Building stack air exhaust would continue to be sampled. CMR Building improvements, such as installing a new heating, ventilation, and air conditioning (HVAC) system would be made only after appropriate decontamination procedures were followed.

Workers would wear appropriate protective gear and radiation dosimetry for performing decontamination. The applicable SOPs for decontaminating interior spaces and equipment would be followed. Radiological monitoring of the workers and work space would be conducted routinely to assure containment of any radioactive contamination. Under these administrative, engineering controlled, and closed systems, no radioactive material would be expected to be released into the environment. The radiological air quality outside the CMR Building would not be expected to vary from normal operations. The workers and public would not be affected, with respect to radiological air emissions, from these decontamination and improvement activities at the CMR Building because any contaminated air would be filtered before leaving the building. Any radioactive waste from the decontamination process would be transported to TA–54, Area G following the current SOPs, which call for closing public access to Diamond Drive and Pajarito Road during radioactive waste transport. The public would not be affected because of the road closure.

The construction of a new transportation corridor between TA–55 and the CMR Building at TA–3 would be along Mortandad Canyon and Pajarito Road. The stretch of land is comprised of developed areas and forest. No solid waste management units (SWMUs) or radioactively contaminated soils are present along the corridor route (LANL 1990). The ground leveling, road paving, and construction of guard stations and security fences would not contribute additional radioactive air emissions from the area. No facilities or operations exist along the corridor that would emit radioactive constituents to the atmosphere. The radiological air quality of this area would not be expected to change from the historical average for the area. No environmental impacts with respect to radiological air emissions would be expected for workers or the public from the construction of the transportation corridor.

Nonradiological Emissions

The air emissions of nitrogen oxides, carbon monoxide, sulfur oxides, and particulate matter from construction equipment exhaust only occur during the periods of active construction and are small compared to routine vehicle emissions associated with traffic in the area. Workers and the public would not be impacted by these emissions primarily because of the low volume of emissions and distance from the construction sites to the nearest public area.

II.4.1.4 *Ecological Resources*

Threatened or Endangered Species

Bald Eagle. LANL studies indicate that the bald eagle may occasionally forage in the areas proposed for the transportation corridor under the “CMR Building Use” Alternative. The bald eagle primarily occurs in habitats along permanent streams, rivers, and lakes. The areas proposed for use in the “CMR Building Use” Alternative do not contain permanent streams, rivers, or lakes. Therefore, these areas are considered only low-level use foraging habitat for the bald eagle. The loss of this small amount of low-level use foraging habitat would not have any appreciable effect on this species.

Peregrine Falcon. LANL studies indicate that the areas proposed for the transportation corridor constitute less than 0.05 percent of the total area available for potential foraging habitat for the peregrine falcon within the LANL boundary. Because this represents only a small portion of the total foraging habitat for the peregrine falcon, this would not have any appreciable effect on this species.

Mexican Spotted Owl. The area proposed for the transportation corridor has been analyzed using the preliminary model for Mexican spotted owl potential nesting and roosting habitat. The results of the analysis indicated that fragmented patches of potential nesting/ roosting habitat exist within 0.2 mile (322 meters) of the proposed corridor. This area is already considerably disturbed by noise and light from existing roads and buildings near the site. Given the fragmented nature of this potential habitat and the current level of disturbance, the "CMR Building Use" Alternative should not contribute additional disturbances to the potential habitats. The preliminary model also indicated that the corridor includes Mexican spotted owl foraging habitat. It is estimated that the loss of foraging habitat to the owl would represent roughly 0.06 percent of the total available foraging habitat within the LANL boundary. The loss of this foraging habitat would not have any appreciable effect on this species.

Flora and Fauna

The upgrades for the "CMR Building Use" Alternative are primarily indoor upgrades to existing facilities, with the exception of the transportation corridor. The transportation corridor could contain a security fence that would alter approximately 1 mile (1.6 kilometers) of large mammal and predator movement along Pajarito Road in the vicinity of TA–59 and TA–48, but would not restrict game animal movement within the immediate vicinity. The removal of about 7 acres (2.8 hectares) of overstory and understory vegetation within the proposed road corridor would displace small mammals and birds.

II.4.1.5 *Cultural Resources*

No adverse effects to cultural resources are expected to occur under this alternative. The NRHP-eligible site along the transportation corridor would be avoided, if possible. If the site cannot be avoided, appropriate mitigation measures, including data recovery, would be designed and implemented in consultation with the New Mexico State Historic Preservation Office(r) (SHPO) (LANL 1996b).

II.4.1.6 *Traffic*

This alternative is expected to increase the volume of traffic at the CMR Building on Diamond Drive and at TA–55 on Pajarito Road during the construction of facilities and operations that support enhanced pit manufacturing at LANL. Vehicles required to transport construction workers' materials would contribute to an increase in local traffic. This additional traffic load is anticipated to occur primarily within the first 3 years of the project. Pajarito Road currently averages about 8,000 vehicle trips per day and Diamond Drive about 13,000 vehicle trips per day. Assuming an additional 600 vehicle trips per day due to construction and a fairly even distribution to both roads, increases are projected to be about 2 to 5 percent. Effects of this increase would not be significant. Construction activities at TA–55 would not require the permanent or extended closure of any public roads or rerouting of traffic. Temporary closures could be required to accommodate certain construction activities.

Construction activities could temporarily decrease the number of available employee parking spaces and interfere with the existing employee parking situation in TA–3 and TA–55. Construction activities could adversely affect the traffic flow around TA–55 primarily at the start and end of each work day. At a minimum, the potential shortage of parking spaces would result in delays for both site workers and construction workers and could result in an increase in the number of vehicular accidents. Following completion of construction activities, sufficient parking would be available.

During peak operations, up to an additional 140 employees are anticipated to be on the site. Assuming 280 vehicle trips as a result, an increase of about 1 to 2 percent in traffic is projected for Diamond Drive and Pajarito Road. With the related construction traffic no longer present, the effect of this traffic increase would not be significant.

The construction and operation of a dedicated transportation corridor between TA–55 and TA–3 is proposed as part of this alternative. It would restrict vehicular access to TA–48, the Sigma Complex in TA–3, and public use of Diamond Drive because it would cross the access roads into each of these TAs and Diamond Drive. The construction and operation of railroad-type crossing gates at the intersection of Diamond Drive and Sigma Road and at the entrance of TA–48 off of Pajarito Road would restrict traffic movements during construction and would stop traffic when dedicated vehicles are using the corridor. Based on an estimated peak rate of 500 SNM shipments each year using the corridor and 220 working days per year, the number of road closures would average less than three per working day and last less than 15 minutes per closure. These closures would be coordinated to avoid peak traffic hours. No members of the public would be allowed access to the dedicated transportation corridor.

The use and operation of the transportation corridor would reduce the number of LANL vehicles that carry SNM on publicly accessible Pajarito Road and Diamond Drive by approximately 500 shipments per year or about three vehicles per work day. This decrease in traffic volume would result in a reduction in the potential for vehicular accidents involving SNM. However, radioactive materials from other LANL operations would continue to use publicly accessible roads. The dedicated transportation corridor also would provide for incremental improvements in the level of security and efficiency in transporting SNM between TA–55 and the CMR Building.

II.4.1.7 *Human Health*

Human health impacts may potentially result from decontamination of equipment, relocation of equipment and materials, and the construction and interior modifications that would be performed over the transition period. Radiological impacts may result from exposure to plutonium, uranium, tritium, and a variety of actinides when these materials are moved to new locations and as workers reconfigure radiological control areas.

Workers involved in construction of a new guard gate and the construction of a safe and secure transportation corridor would not be exposed to radioactivity at levels above background. Doses to construction workers are expected to be no higher than doses to permanent LANL workers. LANL worker doses are displayed in Table II.4.1.7–1 and discussed below.

Workers involved in decontamination and building modification activities at TA–55 and the CMR Building would be working in radiological control areas and in areas adjacent to ongoing operations, and therefore, would have a greater exposure to radioactivity than the workers mentioned in the preceding paragraph. Approximately 364,000 labor hours would be needed to accomplish the decontamination and reconfiguration activities within TA–55–4. In order to estimate potential health effects, the external dose to construction workers at TA–55 is assumed to be approximately the same as that received by radiological control technicians and by Johnson Controls, Inc. (JCI), workers performing routine maintenance and equipment installations at TA–55–4. As a group, these technicians and workers received about 0.12 millirem per hour. Therefore, the collective dose to workers performing the decontamination and building modifications is estimated to be about 45 person-rem. Using a risk conversion factor of 4×10^{-4} excess latent cancer fatality (LCF) per person-rem

TABLE II.4.1.7–1.—*Radiological Doses and Excess Latent Cancer Fatalities for Construction Activities Under the "CMR Building Use" Alternative*

WORKERS	HISTORICAL COLLECTIVE DOSE RATE (rem/hr)	EXPOSURE LENGTH (person-hours)	COLLECTIVE DOSE (person-rem)	EXCESS LATENT CANCER FATALITIES
Construction Worker at TA–55	0.00012[a]	364,000	43.68	0.018
Construction Worker at CMR Building	0.0000039[b]	305,000	1.19	0.00048

[a] Stokes 1997
[b] PC 1996

(International Commission on Radiological Protection [ICRP] 1991), this means that 1.8 x 10^{-2} excess LCF would be expected over the life of the "CMR Building Use" Alternative. In other words, it is unlikely that the decontamination and building modifications would result in any excess cancer fatalities among the construction worker population.

Approximately 305,000 labor hours would be needed to accomplish the decontamination and reconfiguration activities within the CMR Building. The external dose to construction workers at the CMR Building is assumed to be approximately the same as that received by radiological control technicians and by JCI workers performing routine maintenance and equipment installations at the CMR Building. Based on a review of their radiation exposures, these technicians and workers received on average about 0.0039 millirem per hour. Therefore, the collective dose to workers performing the decontamination and building modifications is estimated to be 1.2 person-rem. Using a risk conversion factor of 4 x 10^{-4} excess LCF per person-rem, this means that 4.8 x 10^{-4} excess LCF would be expected over the life of the "CMR Building Use" Alternative. In other words, it is highly unlikely that the decontamination and building modifications would result in any excess cancer fatalities among the worker population.

Worker exposures to radiation and radioactive materials in radiological control areas would be controlled under established procedures that require doses to be kept as low as reasonably achievable. Any potential hazards would be evaluated as part of the radiation worker and occupational safety programs at LANL. Nonroutine construction activities may require special work permits with worker protection measures given for specific locations and activities. Under the "CMR Building Use" Alternative, the public would not receive any additional radiological dose beyond the background level. Therefore, no adverse human health effects to the public are anticipated.

II.4.1.8 *Waste Management*

The "CMR Building Use" Alternative would produce waste from the construction of a new dedicated transportation corridor, interior building modifications, and the replacement of old equipment used to support pit manufacturing operations in TA–55–4 and the CMR Building. The types of waste that could be generated from these activities would include nonhazardous solid waste from construction activities, RCRA waste, *Toxic Substances Control Act* (TSCA) (15 U.S.C. §2601) polychlorinated biphenyl (PCB) waste, LLW, and LLMW from modifications to manufacturing operations. Sanitary wastes also would be generated from the construction activities. Table II.4.1.8–1 shows the estimated volumes of radioactive waste that would be generated from the construction activities. As shown in Table II.4.1.8–1, the total volume of radioactive waste that would be generated by construction and building modifications would be 2,685 cubic yards (77 cubic meters) over the 3 to 4 years of construction activity.

Nonhazardous wastes would be disposed of in the Los Alamos County Landfill, which has adequate capacity to handle the projected amount of waste. RCRA and PCB wastes would be sent off site for treatment and disposal at a commercial facility. Commercial treatment is readily available and currently used to treat most LANL RCRA wastes. LLW would be taken to TA–54, Area G or to a permitted off-site facility for disposal. LLMW would be stored at Area G pending the selection of an acceptable treatment and disposal option. Because of the relatively small amount of LLW and LLMW that would be produced, the "CMR Building Use" Alternative is not expected to adversely affect the disposal or storage capacity at Area G. Sanitary wastes could either be collected by subcontractors during construction operations or be put into the LANL sanitary sewer system. The anticipated volume of sanitary wastes would not be expected to have any effect on the existing capacity of the sanitary sewer system.

II.4.2 Brownfield Plutonium Facility Alternative

II.4.2.1 *Land Use*

The proposed activities would be conducted within areas that are already heavily disturbed for industrial use connected to research and development purposes. The new structure proposed under this alternative would be built within the fenced area of TA–55 that has already undergone heavy disturbance and clearing for security reasons related to TA–55–4. Implementation of the Brownfield Alternative would not result in a change to the land use classification currently assigned to TA–55.

As discussed in section II.4.1.1, under this alternative, a dedicated transportation corridor would be constructed to transport plutonium pits and various plutonium samples and components among the facilities at TA–55, the analytical chemistry operations at the CMR Building, and the nonnuclear support facilities in TA–3.

II.4.2.2 *Noise*

Implementation of the Brownfield Alternative would result in actions that create noise, both within TA–55–4 and outside the building. Noise produced from the construction activities conducted within TA–55–4 and outside the

TABLE II.4.1.8–1.—*Total Radioactive Waste Generation from Construction Under the "CMR Building Use" Alternative*[a]

WASTE TYPE	TA–55, PF–4 (yd^3/m^3)	CMR BUILDING (yd^3/m^3)	TA–55 PLUS CMR (yd^3/m^3)
TRU	300/229	258/197	558/426
TRU Mixed	—	377/288	377/288
LLW	300/229	1,410/1,077	1,710/1,306
LLMW	—	40/31	40/31
Total Waste	600/458	2,085/1,593	2,685/2,051

PF = Plutonium Facility, yd = yards, m = meters
[a] Time period is the entire period of construction, 3 to 4 years.

structure would not likely affect the public. Involved workers would be exposed to levels of noise under normal working conditions, ranging from about 45 dBA to 55 dBA for decontamination activities (May 1978), all the way up to slightly in excess of about 95 dBA for construction activities involving the use of heavy machinery (such as chainsaws, bulldozers, rock drills, and concrete mixers). At a distance of 50 feet (15 meters) from the work site, however, these noise levels would range from about 75 dBA to 95 dBA (Magrab 1975).

Most of the noise produced by the construction activities at TA–55 would fall below dBA OEL of the OSHA. The high-level noise generated would be localized at the work sites. Any noise produced above 80 dBA would require the operators and nearby workers to participate in a personnel hearing conservation program as per LANL administrative requirements. The public would not be subjected to noise above 80 dBA at the closest public areas of Diamond Drive and Pajarito Road.

Under this alternative, TA–55 workers not involved in the construction activity would not be subjected to excessive noise produced by construction activities because they are physically removed from the construction site. The public would not be affected by the construction- and improvement-generated noise, also due to the distance from the construction activities to the public.

II.4.2.3 *Air Quality*

Radiological Emissions

The construction of a new building at TA–55 would take place within the current boundary for the TA. The vacant ground within the TA–55 secured area has been previously disturbed but is not contaminated. The construction of a new building would not contribute additional radioactive air emissions above normal operations for TA–55. The radiological air quality would not be expected to change from the historical average for the area. Workers and the public at or along Pajarito Road would not be impacted by radiological air emissions because no such emissions would be generated by the construction.

Nonradiological Emissions

The air emissions of nitrogen oxides, carbon monoxide, sulfur oxides, and particulate matter from construction equipment exhaust only occur during the periods of active construction and are small compared to routine vehicle emissions associated with traffic in the area. Impacts to workers would be minimal because the emissions are of relatively low volume. The public would not be impacted for this reason as well because of the distance from the construction site to the public.

II.4.2.4 *Ecological Resources*

Threatened or Endangered Species

The construction of a Brownfield Plutonium Facility in a previously disturbed area near the TA–55 Plutonium Facility would result in the loss of less than 0.01 percent of the total LANL foraging habitat for the bald eagle, peregrine falcon, and Mexican spotted owl. Less than 0.05 percent of these species habitats would be affected by the proposed transportation corridor. This would not result in an appreciable effect on these species.

II.4.2.5 *Cultural Resources*

No adverse effects to cultural resources from construction of a new stand-alone facility within the current security fence at TA–55 are expected to occur under this alternative. If the facility were to be sited elsewhere at TA–55, cultural resources surveys would not likely be required to determine the effect of construction because of the disturbed nature of TA–55. As discussed in section II.4.1.5, the NRHP-eligible site located along the transportation corridor would not be disturbed in order to avoid having an impact on the site.

II.4.2.6 *Traffic*

This alternative is expected to increase the volume of traffic at nearby TA–55 during the construction of facilities and operations that support pit manufacturing at LANL. Vehicles required to transport construction materials and workers would contribute to an increase in local traffic. This additional traffic load is anticipated to occur primarily within the first 3 years of the anticipated 4-year project. Based on an average daily traffic rate of approximately 8,000 vehicle trips per day on Pajarito Road and assuming an additional 600 construction vehicle trips per day, the increase in vehicle traffic from construction activities is estimated to be no more than about 8 percent above routine traffic volumes. Effects of this increase would not be significant. Construction activities at TA–55 would not require the permanent or extended closure of any public roads or rerouting of traffic. Temporary closures of short duration could be required to accommodate certain construction activities.

Construction activities could decrease the number of available employee parking spaces and interfere with the existing employee parking situation in the area. The construction of new facilities near TA–55 could result in additional temporary loss of parking spaces if construction equipment and trailers are located in existing parking areas. Construction activities could adversely affect the traffic flow around TA–55, primarily at the start and end of each work day. At a minimum, the potential shortage of parking spaces would result in delays for both site workers and construction workers and could result in an increase in the number of vehicular accidents. Following completion of construction activities, sufficient parking would be provided for all workers at TA–55. Impacts from the construction of the dedicated transportation corridor would be the same under this alternative as under the Preferred Alternative.

During peak operations, up to an additional 140 employees are anticipated to be on the site. Assuming 280 vehicle trips per day as a result, an increase of about 3 percent in traffic is projected for Pajarito Road. With the related construction traffic no longer present, the effect of this traffic increase would not be significant.

II.4.2.7 *Human Health*

Human health impacts may potentially result from the construction of a Brownfield Plutonium Facility. Radiological impacts may result from exposure to plutonium, uranium, tritium, and a variety of actinides when these materials are moved to the new facility location. Workers involved in construction activities at TA–55 would not be exposed to radioactivity at levels above background. Workers involved in building modification activities at TA–55 would be working in radiological control areas and in areas adjacent to ongoing operations. Worker exposures to radiation and radioactive materials in radiological control areas would be controlled under established procedures that require doses to be kept as low as reasonably achievable. Any potential hazards would be evaluated as part of the radiation worker and occupational safety programs at LANL. Nonroutine construction activities may require special work permits with worker protection measures given for specific locations and activities. Doses to construction workers would be expected to be equal to or less than those received by workers under the "CMR Building Use" Alternative (Table II.4.1.7–1). Under this alternative, the public would not receive any additional radiological dose beyond the background level. Therefore, no adverse human health effects to the public are anticipated.

II.4.2.8 *Waste Management*

This alternative would produce waste from the construction of a new building at TA–55 that would include 15,300 square feet (1,425 square meters) of designated nuclear material laboratory space. The types of waste that could be generated from this activity would include nonhazardous solid waste from construction activities and possibly RCRA waste. Sanitary wastes also would be generated under this alternative. Small amounts of LLW could be generated in the process of relocating equipment to the new facility (this waste would have to be treated and disposed). The total volume of RCRA wastes also would be minimal. Nonhazardous wastes would be disposed of in the Los Alamos County Landfill, which has adequate capacity to handle the projected amount of waste. RCRA wastes would be sent off site for treatment and disposal at a commercial facility. Commercial treatment is readily available and currently used to treat most LANL RCRA wastes. Sanitary wastes could either be collected by subcontractors during construction operations or be put into the LANL sanitary sewer system. The anticipated volume of sanitary wastes would not be expected to have any effect on the existing capacity of the sanitary sewer system. This alternative also would create new nuclear space at LANL, which would imply a liability for future cleanup (and related waste generation).

II.4.3 Add-On to TA–55–4 Alternative

II.4.3.1 *Land Use*

The proposed activities would be conducted within areas that are already used for research and development purposes. Implementation of this alternative would not change the land use designations of TA–55 or adjacent areas.

As discussed in section II.4.1.1, under this alternative, a dedicated transportation corridor would be constructed to transport plutonium pits and various plutonium samples and components among the facilities at TA–55, the analytical chemistry operations at the CMR Building, and the nonnuclear support facilities in TA–3.

II.4.3.2 *Noise*

Implementation of the Add-on to TA–55–4 Alternative would result in actions that create noise, both within TA–55–4 and outside the building. Noise produced from the construction activities conducted within the TA–55–4 building and outside the structure would not likely affect the public. Involved workers would be exposed to levels of noise under normal working conditions ranging from about 45 dBA to 55 dBA for decontamination activities (May 1978) all the way up to slightly in excess of about 95 dBA for construction activities involving heavy machinery (such as chainsaws, bulldozers, rock drills, and concrete mixers). At a distance of 50 feet (15 meters) from the work site, however, these noise levels would range from about 75 dBA to 95 dBA (Magrab 1975).

Most of the noise produced by the construction activities at TA–55 would be below the OEL of OSHA. The noise generated would be confined to TA–55 and to the new transportation corridor. The high-level noise generated would be localized at the work sites. Any noise produced above 80 dBA would require the operators to participate in a personnel hearing conservation program as per LANL administrative requirements. The public at Pajarito Road would not be affected by the noise levels because the noise would fall below 80 dBA after 50 feet (15 meters) from the work site.

II.4.3.3 *Air Quality*

Radiological Emissions

The construction of a new add-on facility at TA–55–4 would take place within the current security boundary of the area. The vacant ground within the TA–55 secured area has been previously disturbed, but is not contaminated. No SWMUs or radioactively contaminated soils are present within the vacant area (LANL 1990). The construction, erection, and finishing of the add-on facility would not contribute additional radioactive air emissions above normal operations for TA–55. The radiological air quality would not be expected to change from the historical average for the area. Workers and the public would not be affected by the building construction.

Nonradiological Emissions

The air emissions of nitrogen oxides, carbon monoxide, sulfur oxides, and particulate matter from construction equipment exhaust only occur during the periods of active construction and are small compared to routine vehicle emissions associated with traffic in the area. Workers and the public would not be impacted by these emissions primarily because of the low volume of emissions and distance from the construction sites to the nearest public area.

II.4.3.4 *Ecological Resources*

Threatened or Endangered Species

Under this alternative, there would be negligible (less than 0.06 percent) loss of bald eagle, peregrine falcon, and Mexican spotted owl foraging habitat. This would not result in any appreciable effect on these species.

II.4.3.5 *Cultural Resources*

No adverse effects to cultural resources from construction of an addition to TA–55–4 within the current security fence are expected to occur under this alternative. As discussed in section II.4.1.5, the NRHP-eligible site along the transportation corridor would be avoided during construction of the corridor.

II.4.3.6 *Traffic*

Traffic patterns and volumes required to support new construction or the reconfiguration of existing facilities under this alternative would be increased at TA–55. Based on an average daily traffic rate of approximately 8,000 ADTs on Pajarito Road and assuming an additional 600 construction vehicle trips per day, the increase in vehicle traffic from construction activities is estimated to be no more than about 8 percent above routine traffic volumes. Effects of this increase would not be significant. Construction activities at TA–55 would not require the permanent or extended closure of any public roads or rerouting of traffic. Temporary closures of short duration could be required to accommodate certain construction activities.

Construction activities could decrease the number of available employee parking spaces and interfere with the existing employee parking situation in the area. The construction of new facilities at TA–55 could result in additional temporary loss of parking spaces if construction equipment and trailers are located in existing parking areas. Construction activities could adversely affect the traffic flow around TA–55 primarily at the start and end of each work day. At a minimum, the potential shortage of parking spaces would result in delays for both site workers and construction workers and could result in an increase in the number of vehicular accidents. Following completion of construction activities, sufficient parking would be provided for all workers at TA–55. Impacts from the construction of the dedicated transportation corridor would be the same under this alternative as under the Preferred Alternative.

During peak operations, up to an additional 140 employees are anticipated to be on the site. Assuming 280 vehicle trips as a result, an increase of about 3 percent in traffic is projected for Pajarito Road. With the related construction traffic no longer present, the effect of this traffic increase would not be significant.

II.4.3.7 *Human Health*

Workers involved in the construction of the add-on facility at TA–55–4 could be exposed to plutonium, uranium, tritium, and a variety of actinides when these materials are moved to new locations and as workers reconfigure existing radiological control areas. Some reconfiguration and remodeling work would be performed inside TA–55–4. Workers performing these activities are expected to receive about the same doses as workers performing the "CMR Building Use" Alternative. Doses to construction workers would be expected to be equal to or less than those received by workers under the "CMR Building Use" Alternative (Table II.4.1.7–1). Under this alternative, the public would not receive any additional radiological dose beyond the background level. Therefore, no adverse human health effects are anticipated under this alternative.

II.4.3.8 *Waste Management*

This alternative would produce waste from the construction of an add-on building at TA–55 that would include approximately 15,300 square feet (1,425 square meters) of laboratory space. The types of waste that could be generated from these activities would include nonhazardous solid waste from construction activities and possibly RCRA waste. Sanitary wastes would also be generated under this alternative. Some LLW could be generated in the process of relocating equipment to the new space. The total volume of nonhazardous waste and the amount of RCRA waste would be minimal. Nonhazardous wastes would be disposed of in the Los Alamos County Landfill, which has adequate capacity to handle the projected amount of waste. RCRA wastes would be sent off site for treatment and disposal at a commercial facility. Commercial treatment is readily available and currently used to treat most LANL RCRA wastes. Sanitary wastes could either be collected by subcontractors during construction operations or be put into the LANL sanitary sewer system. The anticipated volume of sanitary wastes would not be expected to have any effect on the existing capacity of the sanitary sewer system. This alternative also would create new nuclear space at LANL, which would imply a liability for future cleanup (and related waste generation).

II.4.4 Comparison of Alternatives

Table II.4.4–1 shows a summary of the potential impacts of the alternatives.

There are few differences in the construction impacts across the PSSC alternatives. Because all of the construction (except for the proposed transportation corridor) would occur within previously disturbed areas and would result in land use consistent with the existing use of land in these areas, no land use, cultural resource, or ecological resource impacts would be anticipated unless the proposed transportation corridor were constructed. Construction of this corridor under any of the alternatives would have an equal impact under any of the alternatives; but the land use, ecological resources, and cultural resources impacts of constructing the corridor would be minimal. Construction noise and construction traffic impacts would be minimal under any of the alternatives with or without the transportation corridor. If the corridor is constructed, it would mitigate operational impacts by substantially reducing the operational transport on public roads under the Expanded Operations Alternative. (This is true under all of the PSSC alternatives, but this mitigation is more important for the "CMR Building Use"

TABLE II.4.4–1.—*Summary of Potential Impacts of the Alternatives*

FACTOR, MEASURE	"CMR BUILDING USE" ALTERNATIVE[a]	BROWNFIELD ALTERNATIVE	ADD-ON TO TA–55–4 ALTERNATIVE
Land Use	No change in land use designations of research and development for TA–55 and TA–3. Development of the transportation corridor would change disturbed but undeveloped land to industrial land use.	No change in land use designations of research and development for TA–55 and TA–3. Development of the transportation corridor would change disturbed but undeveloped land to industrial land use.	No change in land use designations of research and development for TA–55 and TA–3. Development of the transportation corridor would change disturbed but undeveloped land to industrial land use.
Noise	Increased noise levels temporarily to 80 dBA and above for TA–3 and TA–55 construction workers. Noise levels not likely to affect the public.	Increased noise levels temporarily to 80 dBA and above for TA–55 construction workers. Noise levels not likely to affect the public.	Increased noise levels temporarily to 80 dBA and above for TA–55 construction workers. Noise levels not likely to affect the public.
Air Quality	Minor radiological emissions during construction phase. Nonradiological emissions expected during construction period.	No radiological emissions during construction phase. Nonradiological emissions expected during construction period.	No radiological emissions during construction phase. Nonradiological emissions expected during construction period.
Ecological Resources	Loss of < 0.1 percent of foraging habitat for individual threatened or endangered species due to the construction of the optional dedicated road; no appreciable effect to individual threatened or endangered (T&E) species.	Loss of < 0.05 percent of foraging habitat for individual threatened or endangered species due to the construction of the optional dedicated road; no appreciable effect to individual T&E species.	Loss of < 0.05 percent of foraging habitat for individual threatened or endangered species due to the construction of the optional dedicated road; no appreciable effect to individual T&E species.
Cultural Resources	No disturbance of archeological sites.	No disturbance of archeological sites.	No disturbance of archeological sites.
Traffic	Vehicular traffic on Pajarito Road, Diamond Drive, and West Jemez Road would increase by 5 percent or less during construction phase. Transport of SNM would increase.	Vehicular traffic on Pajarito Road would increase by about 8 percent during construction phase. Transport of SNM would increase.	Vehicular traffic on Pajarito Road would increase by about 8 percent during construction phase. Transport of SNM would increase.
Human Health	Potential physical and construction related hazards. Minimal worker radiation hazard (0.018 excess LCFs); no radiation risk to the public.	Potential physical and construction related hazards. Minimal worker radiation hazard (0.018 excess LCFs); no radiation risk to the public.	Potential physical and construction related hazards. Minimal worker radiation hazard (0.018 excess LCFs); no radiation risk to the public.

TABLE II.4.4–1.—*Summary of Potential Impacts of the Alternatives*-Continued

FACTOR, MEASURE	"CMR BUILDING USE" ALTERNATIVE[a]	BROWNFIELD ALTERNATIVE	ADD-ON TO TA–55–4 ALTERNATIVE
Waste Management	LLW disposed of at LANL disposal site or off site. Nonhazardous wastes disposed of at county landfill. RCRA and PCB waste disposed of at off-site commercial facility.	Nonhazardous wastes disposed of at county landfill. Any RCRA waste would be disposed of at off-site commercial facility. Creates additional nuclear space, which would constitute a future cleanup liability.	Nonhazardous wastes disposed of at county landfill. Any RCRA waste would be disposed of at off-site commercial facility. Creates additional nuclear space, which would constitute a future cleanup liability.
Accidents	Unlikely to occur with worker and public dose; accident would result in off-site maximally exposed individual (MEI) dose of about 8 rem (resulting in 0.005 excess LCFs). The worker involved would inhale plutonium; this would not result in an acute worker fatality, but would result in an incremental risk of death from cancer over the worker's lifetime. (Risk is dependent on several factors and cannot be quantified.)	Unlikely to occur with worker and public dose; accident would result in off-site MEI dose of about 8 rem (resulting in 0.005 excess LCFs). The worker involved would inhale plutonium; this would not result in an acute worker fatality, but would result in an incremental risk of death from cancer over the worker's lifetime. (Risk is dependent on several factors and cannot be quantified.)	Unlikely to occur with worker and public dose; accident would result in off-site MEI dose of about 8 rem (resulting in 0.005 excess LCFs). The worker involved would inhale plutonium; this would not result in an acute worker fatality, but would result in an incremental risk of death from cancer over the worker's lifetime. (Risk is dependent on several factors and cannot be quantified.)

[a] Utilize existing unused space in the CMR Building.

Alternative because it would result in the greatest operational transport between TA–55 and the CMR Building out of the three PSSC alternatives.)

The few differences in construction impacts across the PSSC alternatives are attributable to the difference between construction within an existing nuclear facility and construction to create additional nuclear facility space. Air emissions for construction within existing nuclear space (as proposed under the "CMR Building Use" Alternative) would include radiological emissions because of the radioactive material contamination (primarily in equipment) in the areas involved in the construction, in addition to the nonradioactive emissions from construction equipment exhaust. The creation of new nuclear facility space would not result in radioactive air emissions and would have comparable nonradioactive emissions from construction equipment exhaust. Similarly, construction under the "CMR Building Use" Alternative would result in construction workers receiving radiation doses due to the ongoing nuclear operations in the areas of the facility that are not involved in the construction activities, and the construction waste generated from within the existing facilities would include some LLW and TRU waste for disposal. These impacts would not be expected under the Brownfield or Add-on to TA–55–4 Alternatives (except for the relatively small exposures and waste quantities generated in moving existing contaminated equipment into the new facilities). Finally, the "CMR Building Use" Alternative utilizes existing nuclear space, which does not incur a new liability for cleanup of contaminated space. (The areas used under this alternative are presumed to be contaminated from past activities in these areas.) The Brownfield or Add-on to TA–55–4 Alternatives would result in the construction of about 15,000 square feet (about 1,400 square meters) of new nuclear space, which implies a liability for future cleanup and related radioactive waste generation.

II.5 POTENTIAL ACCIDENT SCENARIO

One additional accident with significant consequences was analyzed for the "CMR Building Use" Alternative. This accident involved construction activities only. Operational and transportation accidents are addressed in chapter 5 of volume I. The construction accident scenario was developed to evaluate potential impacts on the workers and the public in and around TA–55 and the dedicated transportation corridor development areas. The details of the accident analysis are described in the following text and, in more detail, in appendix II.B.

II.5.1 Construction Accident

This hypothetical accident scenario was developed for the TA–55 Safety Analysis Report (LANL 1996a) to evaluate the impact to individuals at a construction site. Construction workers and their management would be located in and around the TA–55 area where building modifications would be made in support of the enhanced pit manufacturing operations. Heavy equipment would be located and operated on site. During normal conditions, laboring construction workers and operating machinery would be present at the site.

The postulated accident would occur during the reconfiguration of a building. This scenario is based on a postulated accident during modifications or upgrades of structures, systems, or components at TA–55–4. The scenario is initiated by the accidental drop of a plutonium dioxide storage container during movement to or from storage in order to perform a building modification or upgrade activity. The container is assumed to rupture upon impact with the floor, resulting in an airborne release of particulate matter. A worker is exposed. The suspended particulate matter is processed through the ventilation system and released through the north exhaust stack, assuming that the ventilation system and HEPA filtration are not operable. (See appendix II.B for a discussion of this accident assuming these systems remain operable.)

An accident of this type would have an occurrence frequency that makes it an unlikely event (appendix II.B) under any of the SWEIS alternatives. “Unlikely” is defined as a frequency between 1 in 100 years and 1 in 10,000 years or at least once in 10,000 similar facilities operated for 1 year. Under this postulated accident, the worker who dropped the container would be exposed to a significant inhalation dose, but no acute worker fatality occurs. The risk to this worker is highly dependent on the type of protective measures taken at the time of the accident, the speed with which these measures are taken, and the effectiveness of medical treatment after exposure; as such, the risk to this worker cannot be predicted quantitatively or reliably. The dose to the off-site maximally exposed individual (MEI) is 8.1 rem, which corresponds to a risk of about 0.005 excess LCFs.

APPENDIX II.A CAPABILITIES AND FLOORSPACE REQUIREMENTS UNDER THE EXPANDED OPERATIONS ALTERNATIVE

This appendix provides more information about the TA–55–4 nuclear materials capabilities and their floorspace requirements to supplement the discussion in section II.1.4.

II.A.1 Manufacturing of Plutonium Components

Existing capabilities for pit manufacturing at LANL have developed and maintained the technology base required to build research and development pits and pits that can replace individual units removed from the stockpile for surveillance and other purposes. Current floorspace allocation for this capability, which includes general pit manufacture, disassembly, and assembly is 11,400 square feet (1,060 square meters). Based on the SSM PEIS (DOE 1996) and its ROD (61 FR 68014), DOE has chosen to meet its future pit production needs by expanding this existing manufacturing capability. With this expansion, DOE would be able to produce up to 50 pits per year (single shift) and 80 pits per year with multiple shifts. Floorspace allocation for this expanded capability is 15,300 square feet (1,425 square meters) of contiguous space in TA–55–4 and 3,200 square feet (298 square meters) for the additional space addressed in this PSSC analysis. This 3,200 square feet (298 square meters) would be used primarily to test new technologies outside of the production lines and to prepare components for testing.

II.A.2 Disassembly and Surveillance of Weapons Components

LANL conducts destructive and nondestructive evaluations on pits to evaluate stockpile reliability and staging safety. These pits also are disassembled, and the plutonium contained therein is converted to oxide for storage or other uses. Each destructive evaluation, depending on pit type, includes the following operations: leak testing, weighing, dimensional inspection, dye penetrant inspection, radiography, metallography, chemical analysis, and microtensile testing. Most of these disassembly and surveillance activities are performed at TA–55–4 and share equipment with pit manufacturing operations. Approximately 20 pits are examined each year. The disassembly capacity is greater than this, and is at times used to disassemble additional pits. The pit material remaining after the evaluation is stored in the TA–55–4 vault. These functions are candidates for transfer from TA–55–4 to the additional space addressed in this PSSC analysis. If transferred, these activities would no longer be able to use the pit manufacturing equipment at TA–55–4 (thus, additional equipment and floorspace would be required).

Under the Expanded Operations Alternative, LANL would disassemble and analyze 65 pits per year. Current floorspace allocation for the disassembly and surveillance of weapons components is 2,300 square feet (214 square meters). This would need to increase to 4,500 square feet (419 square meters) to support the levels of operations discussed in the Expanded Operations Alternative, including replication of the equipment in TA–55–4 that is necessary to support expanded operations.

II.A.3 Plutonium-238 Research, Development, and Applications

Plutonium-238 activities include research on radioisotopic thermoelectric generator design, fabrication, and testing, as well as plutonium oxide fuel recycle and processing, plutonium oxide heat-source recovery, disposition, and stabilization operations. The plutonium oxide removed from excess and retired radioisotopic thermoelectric generators and other heat sources received from Pantex, Sandia National Laboratories, and other facilities is processed at LANL. LANL would maintain the capability to conduct research, fabrication, and processing activities with plutonium-238 from both defense-related and nondefense-related heat sources. Because these are potentially high-dose operations, special glovebox lines are required. This function is not a candidate for transfer from TA–55–4 to the additional space because of the unique storage, handling, and processing requirements associated with this material, which could not be easily replicated. In addition, any space vacated by these activities in TA–55–4 would require equipment removal and decontamination prior to introducing other activities that could be compromised if contaminated with plutonium-238. Current floorspace allocation for the plutonium-238 processing activities is 9,000 square feet (837 square meters). This floorspace allocation would not change under the level of operations in the Expanded Operations Alternative.

II.A.4 Actinide Materials Science and Processing Research and Development

II.A.4.1 *Actinide Research and Development—General*

As part of the effort to better understand the material science aspects of nuclear materials and weapons aging and performance, various materials research activities are conducted at TA–55–4. Experiments also are conducted to evaluate the scientific underpinnings of stockpile activities, such as improved welding and bonding processes, development of special mold coatings, and fire-resistance tests. Some activities are related to dynamic experiments conducted by LANL and involve experiments at other sites as well as TA–55–4. Most of the actinide research and development involving aqueous materials would remain at TA–55–4. However, activities such as solid state synthesis and associated analyses (including both surface and bulk evaluations) could be transferred. Current floorspace allocation in TA–55–4 for general actinide research and development programs is 3,400 square feet (316 square meters) and would not change under the level of operations in the Expanded Operations Alternative in TA–55–4. However, some additional space would be needed. It is estimated that the space allocation for these actinide research and development activities would be 1,000 square feet (93 square meters) of contiguous space in addition to the 3,400 square feet (316 square meters) of space in TA–55–4.

II.A.4.2 *Actinide Research and Development—Environmental Management*

LANL provides continuing technical support to DOE's Office of Environmental Management (EM) regarding clean-up activities around the DOE complex, including process development for stabilization of residues. The efforts for EM are in three general areas, including: (1) issues associated with stabilization, chemical processing, storage shelf-life, surveillance, and skid-mounted processing techniques; (2) technology transfer to other sites or organizations involving mock-ups and operator training; and (3) stabilizing minor quantities of specialty items from other DOE sites. In effect, this effort builds on the capabilities of other TA–55–4 functions and demonstrates their application in these three areas. Because of its integral ties to other TA–55–4 functions, this is not a candidate to transfer to the additional space. Current floorspace allocations for EM technology support programs are 800 square feet (74 square meters).

II.A.4.3 *Special Recovery Line*

The Special Recovery Line supports the recovery of plutonium and other actinides from items that are potentially contaminated with tritium. LANL personnel would disassemble up to 40 items per year that are potentially contaminated with tritium. Current floorspace allocation for the Special Recovery Line is 700 square feet (65 square meters). Under the Expanded Operations Alternative, floorspace allocation for this would need to increase to 1,200 square feet (112 square meters). This function is a candidate for transfer from TA–55–4 to the additional space addressed in this PSSC analysis.

II.A.4.4 *Neutron Source Materials Recovery*

This function separates (recovers) radionuclides from light metals or light metal oxides to reduce the neutron radiation associated with excess neutron sources. Current and future floorspace allocation for neutron source material recovery programs is 800 square feet (74 square meters) in TA–55–4. Some of this work also is performed in the CMR Building at this time. Work performed in TA–55–4 depends extensively upon the unique plutonium processing and handling capability of TA–55–4. This is not a candidate for transfer from TA–55–4 to the additional space.

II.A.4.5 *Pit Disassembly and Material Conversion*

LANL has been tasked by DOE to develop and demonstrate pit disassembly and material conversion technologies. This is being done as part of the Advanced Recovery and Integrated Extraction System (ARIES). The ARIES can disassemble a pit by a cutting operation; convert the plutonium into plutonium metal or oxide; place the material in a welded storage container; and decontaminate and assay the container. This system currently exists in a series of gloveboxes in TA–55–4.

Under the Expanded Operations Alternative, LANL would conduct a one-time demonstration involving the disassembly of up to 250 pits and conversion of the plutonium to plutonium oxide as part of an integrated pit disassembly and conversion system, as opposed to a series of individual glovebox operations. This work would be done in TA–55–4 over a period of 4 years. The potential environmental impacts of this proposed action were analyzed in an environmental assessment (chapter 1, section 1.5.7, volume I) (DOE 1998).

The disassembly of pits, including those for surveillance and pit manufacturing purposes, would be an ongoing activity, at a level of up to 200 pit disassemblies per year, after the demonstration activities are completed. In order to accommodate the projected throughput for this process after demonstration, some expansion is anticipated. The disassembly portion of ARIES is very similar to the pit disassembly operations for surveillance. In this sense, these operations could be a candidate for transfer to the additional space. However, there are differences that make such a transfer very difficult. These include:

- The ARIES is still under development (as opposed to the disassembly for surveillance).
- The potential throughput of the integrated pit disassembly and conversion demonstration could make handling and packaging of the output materials between TA–55–4 and the additional space very costly.
- The space used for ARIES is not contiguous to the other space that would be made available by the other potential transfers. This means that if the ARIES space in TA–55–4 were made available, it would be difficult to use this space in an efficient manner.

All of these factors would make moving a portion of this capability to the additional space very costly and time consuming. For these reasons, DOE does not consider it reasonable to transfer this capability to the additional space. Note that some of the technologies used for pit disassembly in this project may be replicated and applied to disassembly and surveillance activities that are being considered for transfer (section II.A.2).

In summary, under the Expanded Operations Alternative, LANL would use ARIES in TA–55–4 for both the pit disassembly and conversion demonstration and for other pit disassembly needs at a level of up to 200 pit disassemblies per year. This alternative would result in the expansion of the ARIES space allocation from 1,000 square feet (93 square meters) to 1,500 square feet (140 square meters) in TA–55–4.

II.A.5 Fabrication of Ceramic-Based Reactor Fuels

LANL has been tasked by DOE to develop and demonstrate ceramic-based reactor fuels technology. A specific application of this function is to utilize output from pit disassembly and conversion (discussed under section II.A.4) for fabrication into mixed oxide (MOX) reactor fuel. Under the Expanded Operation Alternative, LANL personnel would demonstrate the ability to produce MOX fuel from older pits for use in nuclear reactors. Thus, for the next several years, this function is closely linked to the pit disassembly and material conversion function; DOE does not consider it appropriate to separate these two functions for the foreseeable future. Current floorspace allocation for the MOX demonstration activities is 3,000 square feet (280 square meters). This floorspace allocation would not change under the Expanded Operations Alternative. Similar to pit disassembly and conversion, this process would be a candidate for possible transfer to the additional space. The materials involved are metals and oxides, and the processes involved are not substantially different than those used for other processes considered for transfer. However, this process is closely linked to ARIES, and DOE does not consider it appropriate to separate these two functions. Therefore, as with ARIES, transfer of this process is not analyzed in this document.

II.A.6 Plutonium Recovery

Currently, LANL uses aqueous nitrate and chloride chemical techniques to extract plutonium from various residues. Processes include dissolution, ion exchange, solvent extraction, precipitation, pyrolysis, and carbonate oxidation/salt distillation. Pyrochemical recovery operations, or electrorefining, convert impure actinide metal to pure actinide metal. Plutonium recovery is a unique function in TA–55–4 that supports virtually all other activities in that facility. It is not feasible to transfer this function to the additional space. Current floorspace allocation for plutonium recovery is 13,400 square feet (1,246 square meters). No change in floorspace is anticipated for the Expanded Operations Alternative.

II.A.7 Support Activities

II.A.7.1 *Material Control and Accountability*

Material control and accountability is a support function for all operations at TA–55. Moreover, experience gained through this activity is directly applicable to the development and demonstration of nonproliferation technologies. The TA–55 nonproliferation technologies involve development of safeguards methodologies and instrumentation for plutonium nondestructive assay. A typical example is the development of nondestructive assay equipment for the ARIES program.

Plutonium nondestructive assay devices developed for nonproliferation purposes are routinely tested at TA–55–4. TA–55–4 provides LANL with a unique capability in the development of nonproliferation technology. TA–55 supports the development of safeguards instrumentation that contributes to nonproliferation technology. LANL would develop safeguards instrumentation for nonproliferation technologies; yet no dedicated floorspace would be allocated, because the equipment can be shared with various material management activities. This function is integral to other TA–55 functions and is not a candidate for transfer from TA–55 to the additional space.

II.A.7.2 *Materials Management and Radiation Control*

Materials management and radiation control include all support activities that track material movements to and from processing function spaces and storage areas, such as the TA–55–4 vault. Also, all facilities that process nuclear materials must allocate space for radiation measurement and control support staff. These support activities must be provided in facilities that handle nuclear materials. Current floorspace allocations for the material management and radiation control function are 4,400 square feet (409 square meters). No change to this floorspace allocation is anticipated for the level of operations addressed in the Expanded Operations Alternative in TA–55–4. It is also estimated that any functions transferred from TA–55–4 to the additional space would require similar support functions as well. It is estimated that the floorspace allocations for materials management and radiation control would require 2,000 square feet (186 square meters) in the additional space.

II.A.7.3 *Waste Management*

The plutonium processing and recovery programs produce waste materials that contain trace amounts of actinides. The presence of actinides requires that the waste materials be properly packaged and assayed prior to disposal. This is a support activity that must be provided for any facility handling nuclear materials. Current floorspace allocations for the waste management functions in TA–55 are 2,400 square feet (223 square meters). Floorspace allocations under the Expanded Operations Alternative for the waste management function are 2,400 square feet (223 square meters) in TA–55–4. It is estimated that the space allocation for this function in the additional space utilized would be 1,200 square feet (112 square meters).

II.A.7.4 *Analytical Chemistry—Metallography*

A core capability at TA–55 is the fundamental and applied analysis of plutonium using metallography. This supports the nuclear materials processing activities at TA–55–4. Current floorspace allocation for analytical chemistry metallography functions in TA–55–4 is 4,700 square feet (437 square meters). Future floorspace allocations for analytical chemistry metallography functions are 2,600 square feet (242 square meters) in TA–55–4. This reduction in floorspace is the result of including analytical chemistry functions that are specific to pit surveillance with the pit surveillance function and reduced floorspace requirements that result from improvement in analytical chemistry technologies. The analytical chemistry functions specific to pit surveillance are a candidate for transfer from TA–55 to the additional space, if pit surveillance is transferred also. This function would require 1,500 square feet (140 square meters) of floorspace in the additional space.

II.A.8 Contingency Space

Approximately 1,500 square feet (140 square meters) and 700 square feet (65 square meters) of contingency space would be allocated in TA–55–4 and the additional space facility, respectively. At this stage of design, contingency space is typically established to address the uncertainties in floorspace projections. This contingency amounts to about 3 percent of the total projected floorspace requirements.

APPENDIX II.B
ACCIDENT SCENARIO FOR BUILDING MODIFICATIONS AND UPGRADES OF STRUCTURES, SYSTEMS, OR COMPONENTS FOR THE ENHANCEMENT OF PIT MANUFACTURING OPERATIONS AT LANL

II.B.1 Preliminary Scenario Description

This scenario is based on a postulated accident during modifications or upgrades of structures, systems, or components at TA–55–4. The scenario is initiated by the accidental drop of a plutonium dioxide storage container during movement to or from storage, which is necessary to allow for building modification or upgrade activity. The container is assumed to rupture upon impact with the floor, resulting in an airborne release of particulate material. A worker is exposed. The suspended particulate material is processed through the ventilation system and released through the north exhaust stack.

II.B.1.1 *Scenario Description*

Description of the Activity

Storage containers, mostly metal, have been extensively used to package most of the radioactive material at TA–55 (LANL 1996a). It is postulated that prior to or during CMIP activities related to building modifications or upgrades at TA–55, some of these containers will be moved similar to routine movements that occur in TA–55–4 for operational purposes. Movements of this type present the potential for contamination spread in vaults and potential radiological exposures to personnel handling the containers (LANL 1996a). Although storage containers are typically intact, closed, and free of smearable contamination, some storage containers, after prolonged storage, may have been subjected to significant stresses as a result of chemical or physical changes in the stored material (LANL 1996a). Pages 3 through 135 of LANL 1996a may be consulted for additional details on the structural integrity of the various types of storage containers.

Frequency Range

This type of accident is expected to have a frequency of 0.1 to 0.01 per year assuming operation of ventilation and HEPA filtration, and a frequency of 10^{-2} to 10^{-4} per year in an unmitigated accident scenario (LANL 1996a). These are considered to be “anticipated” and “unlikely” events, respectively. Events necessary for the unmitigated version of this accident to occur and result in a release include: chance that the container is degraded, failure to follow procedures to inspect containers for visible signs of deterioration, failure of visual inspection to detect a deteriorated container, an accidental drop, breach of a degraded container upon impact with the floor, failure of the HVAC system, and failure or lack of HEPA filters. This assumes that, similar to operational requirements, activities related to building modifications or upgrades are restricted by procedure to inspect containers for visible signs of degradation or deformities. The frequency estimate of 10^{-2} to 10^{-4} per year for an unmitigated accident is conservative because: (1) the frequency of only a portion (accidental drop, maximum = 1×10^{-2} failure to follow an administrative procedure, maximum = 5×10^{-2} failure of visual inspection, maximum = 0.5) of the event sequence is 2.5×10^{-4}; therefore, quantification of additional events would likely place the sequence in a lower frequency; and

(2) it is likely that the ventilation system and associated filtration will be operable during upgrade activities (LANL 1998). On the other hand, the number of moves per year, if greater than 1.0, would increase the frequency.

Consequence Severity

A similar accident at TA–55–4 during normal operations has been estimated to result in a dose consequence to the MEI of 8.1 rem (committed effective dose equivalent [CEDE]) in the unmitigated scenario and a dose of 6.6×10^{-12} rem CEDE in a realistic scenario where the ventilation system and HEPA filtration are operable.

The worker who dropped the container would be exposed to a significant inhalation dose, but no acute worker fatality occurs. This inhalation dose would be expected to cause an increased risk of death from cancer over the worker's lifetime; however, this increase in risk is highly dependent on the following:

- The type of protective measures taken at the time of the accident
- The speed with which these measures are taken
- The effectiveness of medical treatment after the exposure

Thus, the risk to this worker cannot be predicted quantitatively or reliably.

REFERENCES

Canter 1996 — *Environmental Impact Assessment*, second edition. L. W. Canter. McGraw-Hill Inc. New York, New York. 1996.

DOE 1996 — *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*. U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. September 1996.

DOE 1998 — *Pit Disassembly and Conversion Demonstration Environmental Assessment and Research Development Activities.* U.S. Department of Energy. DOE/EA-1207. Washington, D.C. August 1998.

Haarmann 1997 — *A Study of the Threatened and Endangered Species of the Capability Maintenance and Improvement Project.* T. Haarmann. Los Alamos National Laboratory. LA-UR-96-3268. Los Alamos, New Mexico. June 1997.

ICRP 1991 — *1990 Recommendations of the International Committee on Radiological Protection.* Annals of the International Commission on Radiological Protection. Pergamon Press. ICRP Publication 60, Vol. 21, No.1-3. New York, New York. 1991.

LANL 1990 — *Los Alamos National Laboratory Site Development Plan–Technical Information, Facilities Engineering Planning Group.* Los Alamos National Laboratory. LA-CP-90-405. Los Alamos, New Mexico. September 1990.

LANL 1993 — "Administrative Requirements: Workspaces, Hearing Conservation." *Los Alamos National Laboratory Manual*. Los Alamos National Laboratory. AR8-2. Los Alamos, New Mexico. October 1, 1993.

LANL 1996a — *Final Safety Analysis Report for TA–55.* Los Alamos National Laboratory, Nuclear Materials Technology Division. Los Alamos, New Mexico. July 1996.

LANL 1996b — *Capability Maintenance and Improvements Project (CMIP),* Cultural Resources Survey Report No. 130. Los Alamos National Laboratory. LA-CP-96-222. Los Alamos, New Mexico. October 1996.

LANL 1997 — *Alternatives for Increasing the Nuclear Materials Processing Space at Los Alamos for Future Missions.* Los Alamos National Laboratory. LA-UR-97-1000. Los Alamos, New Mexico. April 1997.

LANL 1998 — *Enhanced Conceptual Design Report for Capability Maintenance and Improvement Project.* Los Alamos National Laboratory, Facilities Security and Safeguards Division. Los Alamos, New Mexico. 1998.

Lipscomb and Taylor 1978	*Noise Control, Handbook of Principles and Practices*. David M. Lipscomb and Arthur C. Taylor, eds. Van Nostrand Reinhold Environmental Engineering Series, Van Nostrand Reinhold Company. New York, New York. 1978.
Magrab 1975	*Environmental Noise Control.* Edward B. Magrab. A Wiley Interscience Publication, John Wiley & Sons. New York, New York. 1975.
May 1978	*Handbook of Noise Assessment*. D. M. May. Van Nostrand Reinhold Company. New York, New York. 1978.
Nyhan et al. 1978	*Soil Survey of Los Alamos County, New Mexico*. J. W. Nyhan, L. W. Hacker, T. E. Calhoun, D. L. Young. Los Alamos National Laboratory. LA-6779-MS. Los Alamos, New Mexico. 1978.
PC 1996	C. Olson, Los Alamos National Laboratory. Personal communication (electronic mail), regarding "External Dose Numbers for CMR." Los Alamos, New Mexico. October 11, 1996.
Stokes 1997	Memorandum from Bob Stokes, Los Alamos National Laboratory regarding "Rad Worker and Public Doses for Construction Phase of the CMIP at TA–55." Los Alamos, New Mexico. October 8, 1997.

ABOUT THE *NATIONAL ENVIRONMENTAL POLICY ACT*

The *National Environmental Policy Act* (NEPA) (42 United States Code [U.S.C.] §4321 *et seq.*) was enacted to ensure that federal decision makers consider the effects of proposed actions on the human environment and to lay their decisionmaking process open for public scrutiny. NEPA also created the President's Council on Environmental Quality (CEQ). The U.S. Department of Energy's (DOE's) NEPA regulations (10 Code of Federal Regulations [CFR] 1021) augment the CEQ regulations (40 CFR 1500 through 1508).

Under NEPA, an environmental impact statement (EIS) documents a federal agency's analysis of the environmental consequences that might be caused by major federal actions, defined as those proposed actions that may result in a significant impact to the environment. An EIS also:

- Explains the purpose and need for the agency to take action.
- Describes the proposed action and the reasonable alternative courses of action that the agency could take to meet the need.
- Describes what would happen if the proposed action were not implemented—the "No Action" (or status quo) Alternative.
- Describes what aspects of the human environment would be affected if the proposed action or any alternative were implemented.
- Analyzes the changes, or impacts, to the environment that would be expected to take place if the proposed action or an alternative were implemented, compared to the expected condition of the environment if no action were taken.

The DOE EIS process follows these steps:

- The Notice of Intent, published in the *Federal Register*, identifies potential EIS issues and alternatives and asks for public comment on the scope of the analysis.
- The public scoping period, with at least one public meeting, during which public comments on the scope of the document are collected and considered.
- The issuance of a draft EIS for public review and comment (for a minimum of 45 days), with at least one public hearing.
- The preparation and issuance of the final EIS, which incorporates the results of the public comment period on the draft EIS.
- Preparation and issuance of a Record of Decision, which states:
  - — The decision.
  - — The alternatives that were considered in the EIS and the environmentally preferable alternative.
  - — All decision factors, such as cost and technical considerations, that were considered by the agency along with environmental consequences.
  - — Mitigation measures designed to reduce adverse environmental impacts.
- Preparation of a Mitigation Action Plan, as appropriate, which explains how the mitigation measures will be implemented and monitored.

THE LOS ALAMOS NATIONAL LABORATORY SITE-WIDE ENVIRONMENTAL IMPACT STATEMENT PROCESS

The United States Department of Energy (DOE) has a policy (10 Code of Federal Regulations [CFR] 1021.330) of preparing a Site-Wide Environmental Impact Statement (SWEIS) for certain large, multiple-facility sites, such as the Los Alamos National Laboratory (LANL). The purpose of a SWEIS is to provide DOE and its stakeholders with an analysis of the environmental impacts resulting from ongoing and reasonably foreseeable new operations and facilities and reasonable alternatives at the DOE site. The SWEIS analyzes four alternatives for the continued operation of LANL to identify the potential effects that each alternative could have on the human environment.

The SWEIS Advance Notice of Intent, published in the *Federal Register* (FR) on August 10, 1994 (59 FR 40889), identified possible issues and alternatives to be analyzed. Based on public input received during prescoping, DOE published the Notice of Intent to prepare the SWEIS in the *Federal Register* on May 12, 1995 (60 FR 25697). DOE held a series of public meetings during prescoping and scoping to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the SWEIS. An Implementation Plan[1] was published in November 1995 to summarize the results of scoping, describe the scope of the SWEIS based on the scoping process, and present an outline for the draft SWEIS. The Implementation Plan also included a discussion of the issues reflected in public comments during scoping.

In addition to the required meetings and documents described above, the SWEIS process has included a number of other activities intended to enhance public participation in this effort. These activities have included:

- Workshops to develop the Greener Alternative described and analyzed in the SWEIS.
- Meetings with and briefings to representatives of federal, state, tribal, and local governments during prescoping, scoping, and preparation of the draft SWEIS.
- Preparation and submission to the Los Alamos Community Outreach Center of information requested by members of the public related to LANL operations and proposed projects.
- Numerous Open Forum public meetings in the communities around LANL to discuss LANL activities, the status of the SWEIS, and other issues raised by the public.

The draft SWEIS was distributed to interested stakeholders for comment. The comment period extended from May 15, 1998, to July 15, 1998. Public hearings on the draft SWEIS were announced in the *Federal Register*, as well as community newspapers and radio broadcasts. Public hearings were held in Los Alamos, Santa Fe, and Española, New Mexico, on June 9, 1998, June 10, 1998, and June 24, 1998, respectively.

Oral and written comments were accepted during the 60-day comment period for the draft SWEIS. All comments received, whether orally or in writing, were considered in preparation of the final SWEIS. The final SWEIS includes a new volume IV with responses to individual comments and a discussion of general major issues. DOE will prepare a Record of Decision no sooner than 30 days after the final SWEIS Notice of Availability is published in the *Federal Register*. The Record of Decision will describe the rationale used for DOE's selection of an alternative or portions of the alternatives. Following the issuance of the Record of Decision, a Mitigation Action Plan may also be issued to describe any mitigation measures that DOE commits to in concert with its decision.

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1. DOE *National Environmental Policy Act* regulations (10 CFR 1021) previously required that an implementation plan be prepared; a regulation change (61 FR 64604) deleted this requirement. An implementation plan was prepared for this SWEIS.

COVER SHEET

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agency: Incorporated County of Los Alamos

Title: Site-Wide Environmental Impact Statement for the Continued Operation of the Los Alamos National Laboratory, Los Alamos, New Mexico (DOE/EIS-0238)

Contact: For further information concerning this Site-Wide Environmental Impact Statement (SWEIS), contact:

Corey Cruz, Project Manager
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P.O. Box 5400, Albuquerque, NM 87185
Telephone: 505–845–4282 Fax: 505–845–6392

For general information on DOE's *National Environmental Policy Act* (NEPA) process, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance (EH–42)
U.S. DOE, 1000 Independence Avenue, SW, Washington, DC 20585
Telephone: 202–586–4600 or leave a message at 1–800–472–2756

Abstract: DOE proposes to continue operating the Los Alamos National Laboratory (LANL) located in Los Alamos County, in north-central New Mexico. DOE has identified and assessed four alternatives for the operation of LANL: (1) No Action, (2) Expanded Operations, (3) Reduced Operations, and (4) Greener. Expanded Operations is DOE's Preferred Alternative, with the exception that DOE would only implement pit manufacturing at a level of 20 pits per year. In the No Action Alternative, DOE would continue the historical mission support activities LANL has conducted at planned operational levels. In the Expanded Operations Alternative, DOE would operate LANL at the highest levels of activity currently foreseeable, including full implementation of the mission assignments from recent programmatic documents. Under the Reduced Operations Alternative, DOE would operate LANL at the minimum levels of activity necessary to maintain the capabilities to support the DOE mission in the near term. Under the Greener Alternative, DOE would operate LANL to maximize operations in support of nonproliferation, basic science, materials science, and other nonweapons areas, while minimizing weapons activities. Under all of the alternatives, the affected environment is primarily within 50 miles (80 kilometers) of LANL. Analyses indicate little difference in the environmental impacts among alternatives. The primary discriminators are: collective worker risk due to radiation exposure, socioeconomic effects due to LANL employment changes, and electrical power demand.

Public Comment and DOE Decision: The draft SWEIS was released to the public for review and comment on May 15, 1998. The comment period extended until July 15, 1998, although late comments were accepted to the extent practicable. All comments received were considered in preparation of the final SWEIS[1]. DOE will utilize the analysis in this final SWEIS and prepare a Record of Decision on the level of continued operation of LANL. This decision will be no sooner than 30 days after the Notice of Availability of the final SWEIS is published in the *Federal Register*.

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1. Changes made to this SWEIS since publication of the draft SWEIS are marked with a vertical bar to the right or left of the text.

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ABBREVIATIONS AND ACRONYMS

AAQS	Ambient Air Quality Control Standards
ACHP	Advisory Council on Historic Preservation
ACGIH	American Conference of Governmental Industrial Hygienists
ACIS	Automated Chemical Inventory System
ACL	administrative control level
AEC	U.S. Atomic Energy Commission
AIHA	American Industrial Hygiene Association
AIRFA	*American Indian Religious Freedom Act*
ALARA	as low as reasonably achievable
ALOHA™	Areal Locations of Hazardous Atmospheres (code)
ANSI	American National Standards Institute
ARF	airborne release fraction
ARMS	Archaeological Records Management System
ARPA	*Archaeological Resource Protection Act*
ARR	airborne release rate
ARTCC	Air Route Traffic Control Center
BIO	Basis for Interim Operation
BLEVE	boiling liquid expanding vapor explosion
BNL	Brookhaven National Laboratory
BNM	Bandelier National Monument
°C	degrees Celsius
CAA	*Clean Air Act*
CAM	continuous air monitor

CAP–88	Clean Air Act Assessment Package for 1988
CBD	chronic beryllium disease
CDC	Centers for Disease Control
CDP	Census Designated Place
CDR	Conceptual Design Report
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH	contact-handled (waste)
CH TRU	contact-handled transuranic (waste)
cm	centimeter
CMIP	Capability Maintenance and Improvement Project
CMR	Chemistry and Metallurgy Research
CRMT	Cultural Resources Management Team
CSA	Container Storage Area
DARHT	Dual Axis Radiographic Hydrodynamic Test (Facility)
DCG	derived concentration guide
DDE	deep dose equivalent
DNA	deoxyribonucleic acid
DNFSB	Defense Nuclear Facilities Safety Board
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DR	damage ratio

DU	depleted uranium
EA	environmental assessment
ECDR	Enhanced Conceptual Design Report
EIS	environmental impact statement
EM	DOE Office of Environmental Management
EM&R	emergency management and response
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
ES	emission stack
EU	enriched uranium
°F	degrees Fahrenheit
FAA	Federal Aviation Administration
FE	fan exhaust
FEMA	Federal Emergency Management Agency
FIMAD	Facility for Information Management, Analysis and Display
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FRP	fiberglass-reinforced plastic (or plywood)
FSAR	Final Safety Analysis Report
FS MEI	facility-specific maximally exposed individual
ft	feet
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram

g	acceleration of gravity (980 cm/sec2)
GEP	good engineering practice
GIS	geographic information system
GV	guideline value
ha	hectares
HA	hazard analysis
HAP	hazardous air pollutant
HAZMAT	hazardous material
HCLPF	high confidence in low probability of failure
HE	high explosives
HEFS	High Explosives Firing Site
HEPF	High Explosives Processing Facility
HEP	(mean) human error probability
HEPA	high efficiency particulate air (filter)
HEU	highly enriched uranium
HHS	U.S. Department of Health and Human Services
HI	hazard index
HRL	Health Research Laboratory
HVAC	heating, ventilation, and air conditioning
ICBM	intercontinental ballistic missile
ICRP	International Commission on Radiological Protection
IDLH	immediately dangerous to life or health
in.	inch
IP	industrial packaging
IPF	Isotope Production Facility

IRIS	Integrated Risk Information System
ISC–3	Industrial Source Complex (Model) Version 3
km	kilometer
LACEF	Los Alamos Critical Experiments Facility
LAM	Los Alamos Municipal Airport
LAMPF	Los Alamos Meson Physics Facility (former name for LANSCE)
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LASL	Los Alamos Scientific Laboratory
lb	pound
LCF	latent cancer fatality
LEDA	Low-Energy Demonstration Accelerator
LEL	lower explosive limit
LEU	low enriched uranium
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
LPF	leak path factor
LSA	low specific activity
m	meter
MAPs	mixed activation products
MAR	material-at-risk
MC&A	materials control and accountability
MCL	maximum contaminant level
MEI	maximally exposed individual

MFPs	mixed fusion products
MGY	million gallons per year
mi	mile
ML	Richter Magnitude
MLNSC	Manuel Lujan Neutron Scattering Center
MOA	memorandum of agreement
MOI	maximum off-site individual
MOX	mixed oxide (fuel)
MSL	Materials Science Laboratory
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NAGPRA	*Native American Graves and Repatriation Act*
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCI	National Cancer Institute
NCRP	National Council on Radiation Protection
NDA	nondestructive analysis
NDE	nondestructive examination
NDT	Nondestructive Testing (Facility)
NEPA	*National Environmental Policy Act of 1969*, as amended
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	*National Historic Preservation Act*
NIF	National Ignition Facility
NIH	National Institute of Health
NIOSH	National Institute for Occupational Safety and Health

NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMSA	New Mexico Statutes Annotated
NMSF	Nuclear Materials Storage Facility
NMTR	New Mexico Tumor Registry
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPH	natural phenomena hazard
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRDC	National Resources Defense Council
NRHP	National Register of Historic Places
NSC	National Safety Council
NTS	Nevada Test Site
NTU	nephelometric turbidity units
OEL	occupational exposure limit
OLM	Ozone Limiting Method
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PE-Ci	plutonium equivalent curie
PEIS	programmatic environmental impact statement

PF	Plutonium Facility
PGA	peak ground acceleration (horizontal)
pH	a measure of acidity and alkalinity
PHERMEX	Pulsed High-Energy Radiation Machine Emitting X-Ray (facility)
PL	public law
PM	particulate matter
PM 10	particulate matter equal to or less than 10 micrometers aerodynamic diameter
POC	point-of-contact
PPE	personal protective equipment
ppb	parts per billion
ppm	parts per million
PRA	probabilistic risk assessment
PrHA	process hazard analysis
PSHA	Probabilistic Seismic Hazard Analysis
psi	pounds per square inch
R&D	research and development
RAM	radioactive material
RAMROD	Radioactive Materials Research, Operations, and Demonstration (facility)
RANT	Radioactive Assay and Nondestructive Test (facility)
RAP	regulated air pollutant
RCRA	*Resource Conservation and Recovery Act*
rem	roentgen equivalent man
RF	radio frequency
RfCs	inhalation reference concentrations
RfD	reference dose

RFETS	Rocky Flats Environmental Technology Site
RFP	Rocky Flats Plant (former name of the Rocky Flats Environmental Technology Site)
RH	remote-handled (waste)
RH TRU	remote-handled transuranic (waste)
RLW	radioactive liquid waste
RLWTF	Radioactive Liquid Waste Treatment Facility
RMP	Risk Management Program (EPA)
ROD	Record of Decision
SA	safety assessment
SAR	Safety Analysis Report
SCAPA	Subcommittee of Consequence Analysis and Protective Actions (DOE)
SCO	surface-contaminated object
SEER	Surveillance, Epidemiology, and End Results
SHEBA	Solution High-Energy Burst Assembly
SHPO	State Historic Preservation Office(r)
SLEV	screening level emission value
SMAC	shipment mobility/accountability collection
SNL	Sandia National Laboratories
SNM	special nuclear material
SPCC	Spill Prevention, Control, and Countermeasures
SRS	Savannah River Site
SSM	Stockpile Stewardship and Management
SST	safe secure transport
START	Strategic Arms Reduction Talks (or Treaty)
STC	standard transportation container

SWB	standard waste box
SWSC	sanitary waste system consolidation
TA	Technical Area
TCP	traditional cultural property
TEDE	total effective dose equivalent
TEEL	temporary emergency exposure limit
TFF	Target Fabrication Facility
TI	transport index
TLV	threshold limit value
TRU	transuranic (waste)
TRUPACT	Transuranic Packaging Transporter
TSFF	Tritium Science and Fabrication Facility
TSP	total suspended particulates
TSTA	Tritium System Test Assembly (facility)
TWA	time-weighted average
TWISP	Transuranic Waste Inspectable Storage Project
UBC	Uniform Building Code
UC	University of California
UCL	upper confidence limit
UCNI	unclassified controlled nuclear information
UCRL	University of California Research Laboratory
UN	University of Nevada
UNM	University of New Mexico
URF	unit risk factor
U.S.	United States

U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USSR	Union of Soviet Socialist Republics
VOC	volatile organic compound
WAC	waste acceptance criteria
WCRR	Waste Characterization, Reduction, and Repackaging (facility)
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Plant
WNR	Weapons Neutron Research
WWTF	Waste Water Treatment Facility

VOLUME III
MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this SWEIS. Definitions of technical terms can be found in volume I, chapter 10, Glossary.

SCIENTIFIC NOTATION

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using scientific notation, as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either right (for a positive power of 10) or left (for a negative power of 10). If the value given is 2.0×10^3, move the decimal point three places (insert zeros if no numbers are given) to the right of its current location. The result would be 2,000. If the value given is 2.0×10^{-5}, move the decimal point five places to the left of its present location. The result would be 0.00002. An alternative way of expressing numbers, used primarily in the appendixes of this SWEIS, is exponential notation, which is very similar in use to scientific notation. For example, using the scientific notation for 1×10^9, in exponential notation the 10^9 (10 to the power of 9) would be replaced by E+09. (For positive powers, sometimes the "+" sign is omitted, and so the example here could be expressed as E09.) If the value is given as 2.0×10^{-5} in scientific notation, then the equivalent exponential notation is 2.0E-05.

UNITS OF MEASUREMENT

The primary units of measurement used in this report are English units with metric equivalents enclosed in parentheses.

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). The following list presents these metric prefixes:

giga	1,000,000,000 (10^9; E+09; one billion)
mega	1,000,000 (10^6; E+06; one million)
kilo	1,000 (10^3; E+03; one thousand)
hecto	100 (10^2; E+02; one hundred)
deka	10 (10^1; E+01; ten)
unit	1 (10^0; E+00; one)
deci	0.1 (10^{-1}; E-01; one tenth)
centi	0.01 (10^{-2}; E-02; one hundredth)
milli	0.001 (10^{-3}; E-03; one thousandth)

micro	0.000001 (10^{-6}; E-06; one millionth)
nano	0.000000001 (10^{-9}; E-09; one billionth)
pico	0.000000000001 (10^{-12}; E-12; one trillionth)

DOE Order 5900.2A, *Use of the Metric System of Measurement*, prescribes the use of this system in DOE documents. Table MC–1 lists the mathematical values or formulas needed for conversion between English and metric units. Table MC–2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

RADIOACTIVITY UNIT

Part of this report deals with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC–3). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit of mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of these.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually expressed in terms of effective dose equivalent and reported numerically in units of rem (Table MC–4). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in Table MC–5.

CHEMICAL ELEMENTS

A list of selected chemical elements, chemical constituents, and their nomenclature is presented in Table MC–6.

TABLE MC–1.—*Conversion Table*

MULTIPLY	BY	TO OBTAIN	MULTIPLY	BY	TO OBTAIN
ac	0.405	ha	ha	2.47	ac
°F	(°F -32) x 5/9	°C	°C	(°C x 9/5) + 32	°F
ft	0.305	m	m	3.28	ft
ft^2	0.0929	m^2	m^2	10.76	ft^2
ft^3	0.0283	m^3	m^3	35.3	ft^3
gal.	3.785	l	l	0.264	gal.
in.	2.54	cm	cm	0.394	in.
lb	0.454	kg	kg	2.205	lb
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
mi	1.61	km	km	0.621	mi
mi^2	2.59	km^2	km^2	0.386	mi^2
mi/h	0.447	m/s	m/s	2.237	mi/h
nCi	0.001	pCi	pCi	1,000	nCi
oz	28.35	g	g	0.0353	oz
pCi/l	10^{-9}	µCi/ml	µCi/ml	10^9	pCi/l
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
ppb	0.001	ppm	ppm	1,000	ppb
ton	0.907	metric ton	metric ton	1.102	ton

TABLE MC–2.—*Names and Symbols for Units of Measure*

LENGTH	
SYMBOL	**NAME**
cm	centimeter (1×10^{-2} m)
ft	foot
in.	inch
km	kilometer (1×10^{3} m)
m	meter
mi	mile
mm	millimeter (1×10^{-3} m)
µm	micrometer (1×10^{-6} m)
VOLUME	
SYMBOL	**NAME**
cm^3	cubic centimeter
ft^3	cubic foot
gal.	gallon
$in.^3$	cubic inch
l	liter
m^3	cubic meter
ml	milliliter (1×10^{-3} l)
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard
RATE	
SYMBOL	**NAME**
Ci/yr	curies per year
cm^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
kg/yr	kilograms per year
km/h	kilometers per hour
mg/l	milligrams per liter
MGY	million gallons per year
MLY	million liters per year
m^3/yr	cubic meters per year
mi/h or mph	miles per hour
µCi/l	microcuries per liter
pCi/l	picocuries per liter

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

NUMERICAL RELATIONSHIPS	
SYMBOL	**MEANING**
$<$	less than
$\leq$	less than or equal to
$>$	greater than
$\geq$	greater than or equal to
2σ	two standard deviations
TIME	
SYMBOL	**NAME**
d	day
h	hour
min	minute
nsec	nanosecond
s	second
yr	year
AREA	
SYMBOL	**NAME**
ac	acre (640 per mi^2)
cm^2	square centimeter
ft^2	square foot
ha	hectare (1×10^{4} m^2)
$in.^2$	square inch
km^2	square kilometer
mi^2	square mile
MASS	
SYMBOL	**NAME**
g	gram
kg	kilogram (1×10^{3} g)
mg	milligram (1×10^{-3} g)
µg	microgram (1×10^{-6} g)
ng	nanogram (1×10^{-9} g)
lb	pound
ton	metric ton (1×10^{6} g)
oz	ounce

TABLE MC–2.—*Names and Symbols for Units of Measure*-Continued

TEMPERATURE	
SYMBOL	**NAME**
°C	degrees Celsius
°F	degrees Fahrenheit
°K	degrees Kelvin
SOUND/NOISE	
SYMBOL	**NAME**
dB	decibel
dBA	A-weighted decibel

TABLE MC–3.—*Names and Symbols for Units of Radioactivity*

RADIOACTIVITY	
SYMBOL	**NAME**
Ci	curie
cpm	counts per minute
mCi	millicurie (1 x 10^{-3} Ci)
μCi	microcurie (1 x 10^{-6} Ci)
nCi	nanocurie (1 x 10^{-9} Ci)
pCi	picocurie (1 x 10^{-12} Ci)

TABLE MC–4.—*Names and Symbols for Units of Radiation Dose*

RADIATION DOSE	
SYMBOL	**NAME**
mrad	millirad (1 x 10^{-3} rad)
mrem	millirem (1 x 10^{-3} rem)
R	roentgen
mR	milliroentgen (1 x 10^{-3} R)
μR	microroentgen (1 x 10^{-6} R)

TABLE MC–5.—*Radionuclide Nomenclature*

SYMBOL	RADIONUCLIDE	HALF-LIFE	SYMBOL	RADIONUCLIDE	HALF-LIFE
Am-241	americium-241	432 yr	Pu-241	plutonium-241	14.4 yr
H-3	tritium	12.26 yr	Pu-242	plutonium-242	3.8×10^5 yr
Mo-99	molybdenum-99	66 hr	Pu-244	plutonium-244	8.2×10^7 yr
Pa-234	protactinium-234	6.7 hr	Th-231	thorium-231	25.5 hr
Pa-234m	protactinium-234m	1.17 min	Th-234	thorium-234	24.1 d
Pu-236	plutonium-236	2.9yr	U-234	uranium-234	2.4×10^5 yr
Pu-238	plutonium-238	87.7 yr	U-235	uranium-234	7×10^8 yr
Pu-239	plutonium-239	2.4×10^4 yr	U-238	uranium-238	4.5×10^9 yr
Pu-240	plutonium-240	6.5×10^3 yr			

TABLE MC–6.—*Elemental and Chemical Constituent Nomenclature*

SYMBOL	CONSTITUENT	SYMBOL	CONSTITUENT
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
Ar	argon	Pu	plutonium
B	boron	SF_6	sulfur hexafluoride
Be	beryllium	Si	silicon
CO	carbon monoxide	SO_2	sulfur dioxide
CO_2	carbon dioxide	Ta	tantalum
Cu	copper	Th	thorium
F	fluorine	Ti	titanium
Fe	iron	U	uranium
Kr	krypton	V	vanadium
N	nitrogen	W	tungsten
Ni	nickel	Xe	xenon
NO_2^-	nitrite ion	Zn	zinc
NO_3^-	nitrate ion		

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APPENDIX A
WATER RESOURCES

A.1 SURFACE WATER NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM VOLUMES

One of the primary sources of potential impacts to surface water at the Los Alamos National Laboratory (LANL) is the National Pollutant Discharge Elimination System (NPDES) outfalls. NPDES outfall flow projections were prepared by alternative. Table A.1–1 identifies each industrial outfall by facility, outfall number, and watershed. The index discharge as of August 1996 is also presented along with outfall projections for each alternative.

A.2 GROUNDWATER HYDRAULIC PROPERTIES

The nature and extent of groundwater bodies in the LANL region has not been fully characterized. To better understand the hydrogeologic characterization of Pajarito Plateau, LANL personnel have prepared a Hydrogeologic Workplan (LANL 1998). The workplan proposes the installation of new wells that will further investigate the recharge and cross-connection mechanisms to the main aquifer (section 4.3.2.3). Current data indicate that groundwater bodies occur near the surface of the earth in canyon bottoms, alluvium, perched at deeper levels (intermediate perched groundwater), and at deeper levels in the main aquifer. Table A.2–1 presents summary information on the hydraulic parameters of groundwater bodies in the LANL region.

A.3 MAIN AQUIFER VOLUME ESTIMATES

The main aquifer is the only groundwater body within the LANL region that is sufficiently saturated and permeable to transmit economic quantities of water to wells for public use. Recharge of the main aquifer is not fully understood nor characterized. Recent investigations suggest that the majority of water pumped to date from the main aquifer has been from storage, with minimal recharge (Rogers et al. 1996). Because this groundwater body is the only source of potable water within the region, the amount of water available for future use is of interest to many.

For the purposes of the Site-Wide Environmental Impact Statement (SWEIS), water storage calculations were made using a model developed by the United States (U.S.) Geological Survey (USGS). For modeling regional flow in the main aquifer, USGS subdivided the main aquifer into eight layers, which have a total thickness of 5,600 feet (1,707 meters) (Figure A.3–1). The model grid uses 25 columns and 33 rows spaced at 1-mile intervals. The volume of water stored in any given cell is equal to the storage coefficient multiplied by the volume of the cell. For all cells, a value of 0.1554 was used for the storage coefficient, which was based on a specific yield value of 0.15 and specific storage capacity of 1×10^{-6} per foot. The volume of water stored beneath any given region is the sum of water stored in the cells, bounded by the region, and extending to the total depth of the aquifer.

The volume for the main aquifer beneath the Española Basin is underestimated by this model, as the basin actually extends beyond the modeled region (Figure A.3–2). Table A.3–1 presents a summary of the values used to calculate the amount of water stored in the main aquifer beneath the Pajarito Plateau (which is a subset of the total area that USGS modeled), the area from which the Department of Energy (DOE) water is drawn. Table A.3–2 presents a

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
KEY FACILITIES											
HE Testing	04A–141	85	39	69	Light Gas Gun Fac.	Ancho	0.03				
HE Testing	04A–156	86	39	89	Gas Gun Shop	Ancho	0.09				
HRL	03A–040	08	43	01	HRL	Los Alamos	2.70	2.50	2.50	2.50	2.50
LANSCE	03A–047	18	53	60	Linac C-Tower	Los Alamos	2.64	4.70	7.10	2.30	7.10
LANSCE	03A–048	19	53	62	Linac C-Tower	Los Alamos	8.56	15.60	23.40	7.70	23.40
LANSCE	03A–049	20	53	64	Linac C-Tower	Los Alamos	4.15	7.50	11.30	3.70	11.30
Tritium	02A–129	11	21	155N,357	Steam Plant	Los Alamos	0.11	0.11	0.11	0.11	0.11
Tritium	03A–036	12	21	152, 155, 155N, 220	Lab., TSTA, C-Tower	Los Alamos	0.02				
Tritium	03A–158	14	21	209	TSFF	Los Alamos	0.22	0.22	0.22	0.11	0.11
Tritium	05S(STP)	15	21	227	Sewage treatment	Los Alamos	0.77				
CMR	03A–021	31	03	29	CMR	Mortandad	0.53	0.53	0.53	0.53	0.53
Plutonium	03A–181	38	55	06	Utility Bldg.	Mortandad	14.00	14.00	14.00	14.00	14.00
Radiochemistry	03A–045	37	48	01	RC-1	Mortandad	1.10	0.87	0.87	0.87	0.87
Radiochemistry	04A–016	34	48	01	RC-1	Mortandad	6.30				
Radiochemistry	04A–131	33	48	01	RC-1	Mortandad	0.95				
Radiochemistry	04A–152	36	48	28	RC-1	Mortandad	4.00				
Radiochemistry	04A–153	35	48	01	RC-1	Mortandad	3.20	3.20	3.20	3.20	3.20
RLWTF	EPA051	39	50	01	RLWTF	Mortandad	5.51	6.60	9.30	5.30	6.60
Sigma	03A–022	32	03	66,127,141	Sigma Complex	Mortandad	4.40	4.40	4.40	4.40	4.40
TFF	04A–127	40	35	213	TFF	Mortandad	2.00				
HE Processing	04A–115	49	08	70	NDT Facility	Pajarito	0.53				
HE Processing	05A–066	53	09	A,21,28	Lab, Shop	Pajarito	4.36	0.74	0.74	0.74	0.74
HE Processing	05A–067	51	09	B,41,42	Laboratory	Pajarito	0.33	0.33	0.33	0.33	0.33
HE Processing	05A–068	52	09	48	Machining Bldg.	Pajarito	1.16	0.06	0.06	0.06	0.06
HE Processing	06A–074	48	08	22	X-ray Bldg.	Pajarito	0.25				
HE Processing	06A–075	50	08	21	Laboratory	Pajarito	1.00				
HE Testing	04A–101	58	40	09	Firing Site	Pajarito	0.05				
HE Testing	04A–143	61	15	306	Hydrotest Bldg.	Pajarito	0.02	0.02	0.02	0.02	0.02

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]-Continued

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
HE Testing	06A–079	54	40	04	Firing Site	Pajarito	0.54	0.54	0.54	0.54	0.54
HE Testing	06A–080	55	40	05	Firing Site	Pajarito	0.03	0.03	0.03	0.03	0.03
HE Testing	06A–081	56	40	08	Firing Site	Pajarito	0.03	0.03	0.03	0.03	0.03
HE Testing	06A–082	59	40	12	Preparation Room	Pajarito	0.03				
HE Testing	06A–099	57	40	23	Laboratory	Pajarito	0.03				
HE Testing	06A–100	60	40	15	Firing Site	Pajarito	0.04	0.04	0.04	0.04	0.04
LANSCE	03A–113	21	53	293, 294, 1032	LEDA C-Towers	Sandia	0.90	39.70	39.80	12.30	39.80
LANSCE	03A–125	23	53	28	Proton Storage Ring	Sandia	0.18	0.18	0.18	0.18	0.18
LANSCE	03A–145	22	53	06	Orange Box Offices	Sandia	0.37				
Sigma	03A–024	30	03	35, 187	Press Bldg./ C. Tower	Sandia	2.90	2.90	2.90	2.90	2.90
HE Processing	02A–007	64	16	540	Steam Plant	Water	10.50	7.40	7.40	7.40	7.40
HE Processing	03A–130	81	11	30	Laboratory	Water	0.04	0.04	0.04	0.04	0.04
HE Processing	04A–070	65	16	220	X-ray Bldg.	Water	0.22				
HE Processing	04A–083	73	16	202	Shops	Water	0.20				
HE Processing	04A–092	80	16	370	Metal Forming	Water	1.57				
HE Processing	04A–157	75	16	460	Laboratory	Water	7.31				
HE Processing	05A–053	79	16	410	Assembly Bldg.	Water	0.12				
HE Processing	05A–054	68	16	340	HE Synthesis	Water	3.57	3.60	3.60	3.60	3.60
HE Processing	05A–055	78	16	401, 406	Pressure Tanks	Water	0.04	0.13	0.17	0.10	0.10
HE Processing	05A–056	67	16	260	Process Bldg.	Water	2.53				
HE Processing	05A–069	82	11	50	Drop Tower Sump	Water	0.00	0.00	0.00	0.00	0.00
HE Processing	05A–071	77	16	430	HE Pressing	Water	0.04	0.04	0.04	0.04	0.04
HE Processing	05A–072	74	16	460	Laboratory	Water	0.02				
HE Processing	05A–096	83	11	51	Drop Tower Sump	Water	0.00	0.00	0.00	0.00	0.00
HE Processing	05A–097	84	11	52	Drop Tower Sump	Water	0.00	0.00	0.00	0.00	0.00
HE Processing	06A–073	66	16	222	Dark Room	Water	0.08				
HE Testing	03A–028	72	15	184, 185, 202	Cooling Tower	Water	2.20	2.20	2.20	2.20	2.20
HE Testing	03A–185	70	15	184, 202	Cooling Tower	Water	0.73	0.73	0.73	0.73	0.73
HE Testing	04A–139	71	15	184	PHERMEX	Water	0.00				
HE Testing	06A–123	69	15	183	Laboratory	Water	0.13				

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]-Continued

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Tritium	04A–091	76	16	450	Process Bldg.	Water	0.22				
	Sum, Key Facilities				59 Outfalls[d]		104	119	136	76	133
NON-KEY FACILITIES											
S&T	03A–042	44	46	01	Laboratory	Cañada del Buey	5.30	5.30	5.30	5.30	5.30
S&T	04A–118	46	54	1013	Pajarito #4 Well	Cañada del Buey	1.10	1.10	1.10	1.10	1.10
S&T	04A–166	43	05	26	Pajarito #5 Well	Cañada del Buey	0.01	0.01	0.01	0.01	0.01
S&T	03A–038	87	33	114	Support Bldg.	Chaquehui	5.80				
S&T	04A–171	07	NF	01	Guaje #1 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–172	06	NF	01A	Guaje #1A Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–173	05	NF	02	Guaje #2 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–174	04	NF	04	Guaje #4 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–175	02	NF	05	Guaje #5 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–176	01	NF	06	Guaje #6 Well	Guaje	0.66	0.66	0.66	0.66	0.66
S&T	04A–177	03	NF	B1	Guaje Booster #1 Well	Guaje	0.06	0.06	0.06	0.06	0.06
S&T	03A–034	13	21	166	Equipment Bldg.	Los Alamos	0.26				
S&T	03A–035	10	21	210	Research Bldg.	Los Alamos	0.04				
S&T	04A–182	09	21	1003	Backflow Preventer	Los Alamos	0.00	0.00	0.00	0.00	0.00
S&T	04A–186	16	21	452	Otowi #4 Well	Los Alamos	0.18	0.18	0.18	0.18	0.18
S&T	03A–160	41	35	124	Antares Target Hall	Mortandad	5.10	5.10	5.10	5.10	5.10
S&T	06A–132	42	35	87	Laboratory	Mortandad	5.80				
S&T	03A–025	47	03	208	Equipment Bldg.	Pajarito	0.18	0.18	0.18	0.18	0.18
S&T	04A–164	63	18	252	Pajarito #2 Well	Pajarito	0.01	0.01	0.01	0.01	0.01
S&T	06A–106	62	36	01	Laboratory	Pajarito	0.58	0.58	0.58	0.58	0.58
S&T	04A–161	17	72	01	Otowi #1 Well	Pueblo	1.00	1.00	1.00	1.00	1.00
S&T	01A–001[c]	27	03	22	Power Plant	Sandia	77.9	113.90	113.90	113.90	113.90
S&T	03A–027	28	03	285	Cooling Tower	Sandia	5.80	5.80	5.80	5.80	5.80
S&T	03A–148	26	03	1498	Data Center	Sandia	6.30				
S&T	04A–094	29	03	170	Gas Facility	Sandia	5.30				
S&T	04A–163	25	72	04	Pajarito #1 Well	Sandia	6.20	6.20	6.20	6.20	6.20
S&T	04A–165	24	72	07	Pajarito #3 Well	Sandia	2.00	2.00	2.00	2.00	2.00

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]-Continued

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
	Sum, Non-Key Facilities				28 Outfalls[c,d]		130	261	142	142	142
	LANL Total						233	261	278	218	275

[a] NPDES Information Sources: Index information was provided by the Surface Water Data Team Reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997.
[b] When no discharge is indicated under the alternative, this means the outfall was eliminated. For outfalls with 0.00 flow, this means the outfall still remains but the projected flow is so small that it was rounded down to zero.
[c] All effluent from the TA–46 Sewage Treatment Facility Sanitary Waste System Consolidation (SWSC) is pumped to a re-use tank adjacent to the TA–3 power plant. When the power plant is in operation, water is drawn from the tank as make-up for the power plant cooling towers where it is either lost to the air through evaporation or discharged to Sandia Canyon via the power plant Outfall 01A-001. For the index flow, of the total 77.9 MGY flow for Outfall 01A-001, approximately 29.0 MGY is contributed by SWSC as make-up water. For the other four alternatives, of the total 113.9 million gallons per year (MGY) flow for Outfall 01A-001, approximately 65 MGY is contributed by SWSC as make-up water. Outfall 135 is located at the TA–46 SWSC facility but is not used. Outfall 13S, although not listed in the table, is added to the number of outfalls, making a total of 28 outfalls for the non-key facilities.
[d] Number of outfalls identified, 59 and 28, for key and non-key, respectively, are for the index outfalls. The number of outfalls for all the alternatives is 33 and 28 for key and non-key, respectively. This reduction in outfalls from the index for key facilities is due to LANL's ongoing Outfall Reduction Program. Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997.
[e] NF = National Forest
[f] HE = High explosives, HRC = Health Research Laboratory, LANSCE = Los Alamos Neutron Science Center, CMR = Chemistry and Metallurgy Research, RLWTF = Radioactive Liquid Waste Treatment Facility, TFF = Target Fabrication Facility, S&T = Science and Technology
[g] Legend numbers correspond to NPDES locations shown in Figure 4.3.1.3–1
[h] TSTA = Tritium System Test Assembly, TSFF = Tritium Science and Fabrication Facility, NDT = Nondestructive Testing, LEDA = Low-Energy Demonstration Accelerator, PHERMEX = Pulsed High-Energy Radiation Emitting X-Ray Facility

TABLE A.2–1.—*Hydraulic Characteristics of Groundwater Bodies, LANL Region*

	POROSITY (%)	HYDRAULIC CONDUCTIVITY (cm/sec)
Alluvium[a] (may contain alluvial groundwater)	43	4.00E-04
Tuff[a] (may contain intermediate perched groundwater)	48	2.00E-04
Main Aquifer Formations[b,c]		
Puye Formation		4.60E-04
Tesuque Formation		3.00E-04
Tschicoma Formation		9.00E-04

[a] Data from Rogers and Gallaher 1995.
[b] Data from Purtymun 1984. Hydraulic conductivity converted from gallons per day per square foot, cm/sec is centimeters per second.
[c] Porosity values for the main aquifer formations are not readily available from the published literature.

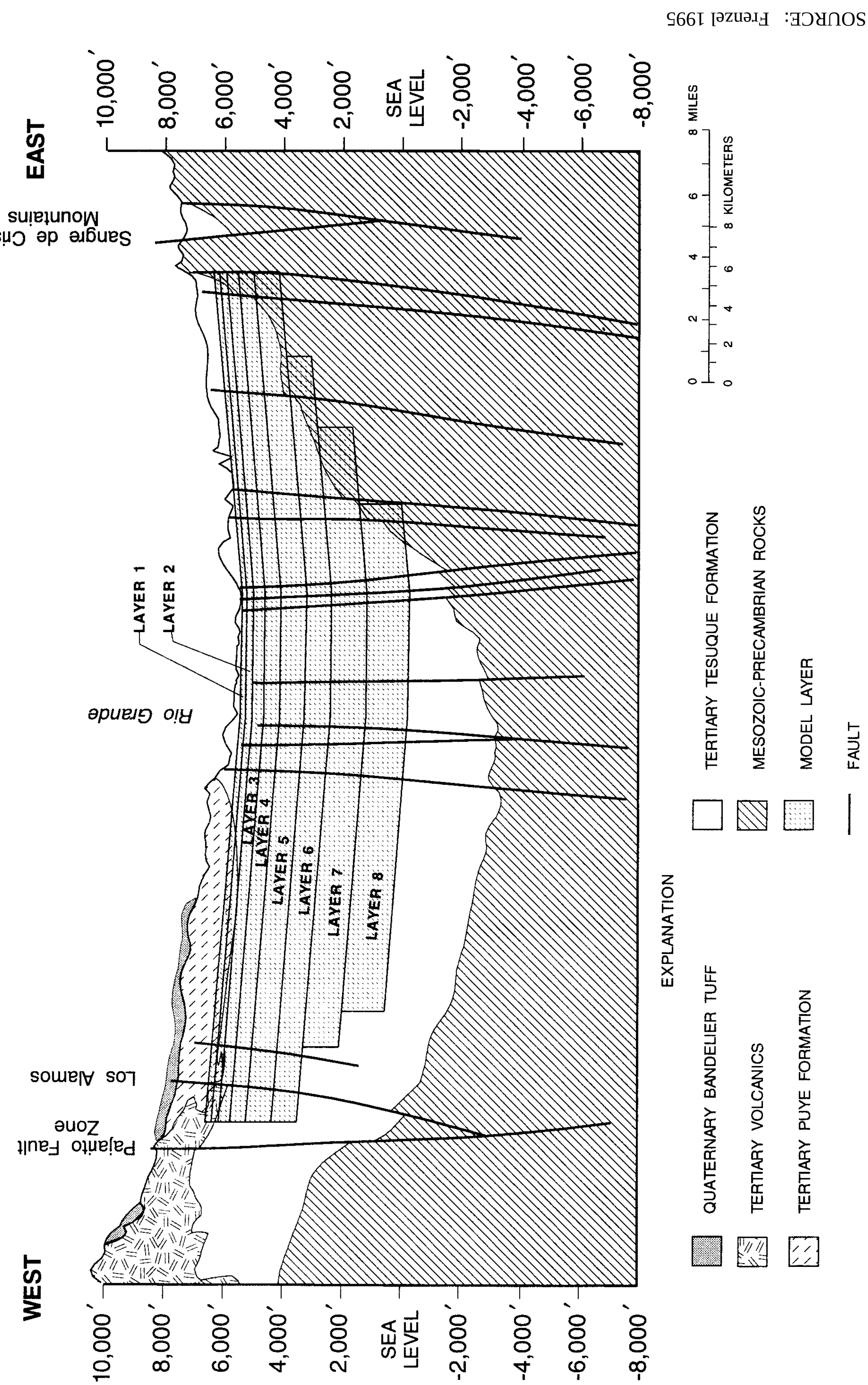
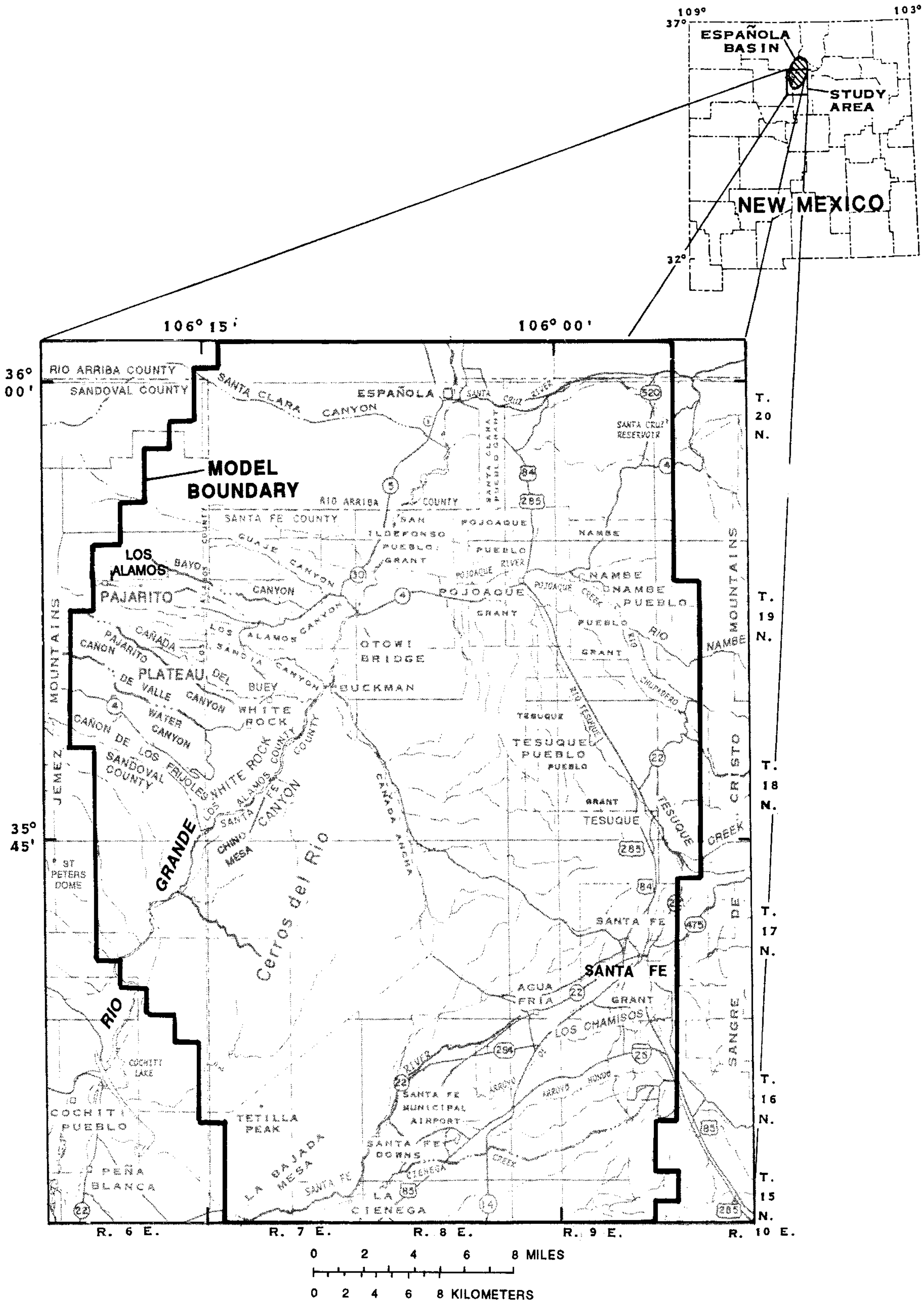


FIGURE A.3–1.—*Diagrammatic Section of Model Layers and Subsurface Geology.*



SOURCE: Frenzel 1995

FIGURE A.3–2.—*Area USGS Modeled.*

TABLE A.3–1.—*Estimated Water Storage of Main Aquifer Beneath Pajarito Plateau*

MODEL LAYER NO.	(A) LAYER THICKNESS (FEET)	(B) NUMBER OF ACTIVE CELLS IN REGION	(C) VOLUME OF AQUIFER IN THE LAYER (CUBIC FEET)	(D) STORAGE COEFFICIENT (CUBIC FEET OF WATER PER CUBIC FEET OF AQUIFER)	(E) VOLUME OF WATER WITHIN LAYER (CUBIC FEET)	(F) CUMULATIVE AQUIFER THICKNESS (FEET)	(G) CUMULATIVE WATER VOLUME (CUBIC FEET)	(H) CUMULATIVE WATER VOLUME (GALLONS)	(I) CUMULATIVE YEARS TO DEPLETE AT DOE WATER RIGHTS RATE (SEE TABLE A.3–3)
1	200	124	6.91384E+11	0.1554	1.07441E+11	200	1.07441E+11	$8.0376710^{+}11$	445
2	275	124	9.50653E+11	0.1554	1.47732E+11	475	2.55173E+11	$1.9089510^{+}12$	1,058
3	325	124	1.1235E+12	0.1554	1.74592E+11	800	4.29764E+11	$3.2150710^{+}12$	1,781
4	475	124	1.64204E+12	0.1554	2.55173E+11	1,275	6.84937E+11	$5.1240110^{+}12$	2,839
5	725	124	2.50627E+12	0.1554	3.89474E+11	2,000	1.07441E+12	$8.0376710^{+}12$	4,453
6	1,000	124	3.45692E+12	0.1554	5.37206E+11	3,000	1.61162E+12	$1.2056510^{+}13$	6,680
7	1,200	119	3.98104E+12	0.1554	6.18683E+11	4,200	2.23037E+12	$1.6684610^{+}13$	9,244
8	1,400	119	4.44939E+12	0.1554	6.91436E+11	5,600	2.92171E+12	$2.1857310^{+}13$	12,109

Formulas:
C = A x [(5,280 feet/mile)^2] x B
E = C x D
F = sum of current layer thickness plus thickness of all layers above
G = sum of current layer water volume plus water volumes of all layers above
H = G x 7.481 gallons per cubic foot
I = H/(1,805 million gallons per year); calculations are conservatively based on 100% usage of total DOE water rights.
Source: Frenzel 1995

TABLE A.3–2.—*Estimated Water Storage of Main Aquifer Within the Area USGS Modeled*

MODEL LAYER NO.	(A) LAYER THICKNESS (FEET)	(B) NUMBER OF ACTIVE CELLS IN REGION	(C) VOLUME OF AQUIFER IN THE LAYER (CUBIC FEET)	(D) STORAGE COEFFICIENT (CUBIC FEET OF WATER PER CUBIC FEET OF AQUIFER)	(E) VOLUME OF WATER WITHIN LAYER (CUBIC FEET)	(F) CUMULATIVE AQUIFER THICKNESS (FEET)	(G) CUMULATIVE WATER VOLUME (CUBIC FEET)	(H) CUMULATIVE WATER VOLUME (GALLONS)	(I) CUMULATIVE YEARS TO DEPLETE AT TOTAL WATER RIGHTS RATE (SEE TABLE A.3–3)
1	200	712	3.97×10^{12}	0.1554	6.169×10^{11}	200	6.169×10^{11}	4.61518×10^{12}	475
2	275	712	5.459×10^{12}	0.1554	8.483×10^{11}	475	1.465×10^{12}	1.0961×10^{13}	1,127
3	325	712	6.451×10^{12}	0.1554	1.002×10^{12}	800	2.468×10^{12}	1.84607×10^{13}	1,899
4	475	684	9.058×10^{12}	0.1554	1.408×10^{12}	1,275	3.875×10^{12}	2.89907×10^{13}	2,982
5	725	685	1.385×10^{13}	0.1554	2.152×10^{12}	2,000	6.027×10^{12}	4.50863×10^{13}	4,637
6	1,000	607	1.692×10^{13}	0.1554	2.63×10^{12}	3,000	8.656×10^{12}	6.47592×10^{13}	6,660
7	1,200	533	1.783×10^{13}	0.1554	2.771×10^{12}	4,200	1.143×10^{13}	8.54886×10^{13}	8,792
8	1,400	442	1.725×10^{13}	0.1554	2.681×10^{12}	5,600	1.411×10^{13}	1.05544×10^{14}	10,855

Formulas:
C = A x [(5,280 feet/mile)^2] x B
E = C x D
F = Sum of current layer thickness plus thicknesses of all layers above
G = Sum of current layer water volume plus water volumes of all layers above
H = G x 7.481 gallons per cubic foot
I = H/(9,723 million gallons per year); calculations are conservatively based on 100% usage of total water rights for the Española Basin.
Source: Frenzel 1995

summary of the values used to calculate the water stored in the main aquifer within the area studied by the USGS (Figure A.3–2). These two tables also reflect the number of years it would take to deplete the water stored beneath these areas for each level modeled based on 100 percent use of water rights by the major users who draw from these areas. The total water rights used for these calculations are reflected in Table A.3–3.

It should be noted that these calculations do not consider recharge to or discharge from the aquifer or pumping from wells outside the control volume (e.g., Española, Santa Fe, San Ildefonso wells). Also, the water level changes projected by the regional MODFLOW model represent average changes over a whole grid-cell (i.e., a square that is a mile on a side). They are for the most part not predictive of the water level changes at any single point within the cell (for example, a supply well). Pumping wells have characteristic "cones of depression" where the water surface reflects an inverted cone, and water levels at the well may be quite different from levels even a few ten's of feet away. Whether any individual well would exhibit water level changes consistent with the predicted grid-cell average change is a function of, for example, its location within the grid-cell; proximity to other pumped wells; and the individual well operation, construction, and hydraulics. Hence, the water level changes predicted by the model can only be considered qualitatively and not be considered as finite changes.

TABLE A.3–3.—*Water Rights for Española Basin*

USER	WATER RIGHTS (GAL/YR)	TOTAL
DOE	1.805E+09	18.6%
Santa Fe	7.012E+09	72.1%
Espanola	9.060E+08	9.3%
TOTAL (J)	9.723E+09	100.0%

Source: PC 1996

A.4 DEVELOPMENT OF GROUNDWATER MODEL INPUT FILES

A.4.1 Water Use Projections

Table A.4.1–1 presents annual water use projections. The following processes were used to generate the numbers shown in Table A.4.1–1:

- *LANL Water Use.* The SWEIS alternatives were reviewed to determine changes in water use across LANL. Because technical area (TA)–53 is a major user of water at LANL and is individually metered for water use, projections for this facility were made separate from the rest of LANL.

  While projections for maximum annual use were developed for the SWEIS under each alternative (for comparison to the DOE Water Rights in the Socioeconomic Analyses in chapter 5), use rates for each of the next 10 years were developed separately for the purposes of assessing drawdown of the main aquifer. These annual projections, were developed using the average annual LANL use from 1990 through 1994 (LANL 1992, LANL 1993, LANL 1994, LANL 1995, and LANL 1996). This baseline value was used for the 10-year projections, to which facilities use data (based on projected construction and operations in each alternative) were added or subtracted as appropriate. These projections include reductions of 26 million gallons (99 million liters) per year, due to the TA–16 steam plant upgrade, and 10 million gallons (38 million liters) per year, due to the High Explosives Wastewater Treatment Facility upgrade.
- *Los Alamos County Water Use.* Data from 1990 through 1994 indicate an average per

TABLE A.4.1–1.—*Annual Water Use Projections*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
TOTAL USE FOR LANL AND COUNTY (IN MILLION GALLONS)											
No Action	1,600	1,600	1,600	1,534	1,534	1,620	1,620	1,620	1,620	1,620	1,620
Expanded Operations	1,691	1,691	1,665	1,665	1,751	1,751	1,751	1,751	1,751	1,751	1,751
Reduced Operations	1,470	1,470	1,444	1,444	1,457	1,457	1,444	1,444	1,444	1,444	1,444
Greener	1,637	1,637	1,611	1,611	1,697	1,697	1,697	1,697	1,697	1,697	1,697
PERCENTAGE OF DOE WATER RIGHT (1,805 MILLION GALLONS)											
No Action	86%	86%	85%	85%	90%	90%	90%	90%	90%	90%	90%
Expanded Operations	94%	94%	92%	92%	97%	97%	97%	97%	97%	97%	97%
Reduced Operations	81%	81%	80%	80%	81%	81%	80%	80%	80%	80%	80%
Greener	91%	91%	89%	89%	94%	94%	94%	94%	94%	94%	94%

capita use of 155.8 gallons (589.7 liters) per day. This per capita use was applied to conservative projections (these are considered conservative because limited land availability would likely prevent the population from growing anywhere near the maximum projection) for the county population as follows: No Action, 18,969; Expanded Operations, 19,924; Reduced Operations, 17,394; and Greener, 18,969. These numbers were assumed constant through the entire 10-year period, effective January 1, 1996. These numbers were multiplied by the average per capita use figure to obtain the total Los Alamos County use figures shown. Bandelier water use is included in these calculations, because the per capita use factor included data from Bandelier.

The total use from DOE Water Rights was calculated by adding the results of the LANL use calculations and the Los Alamos County calculations.

- *Santa Fe County Water Use*. The Santa Fe County population figures used to calculate water use (Table A.4.1–2) were based on projected populations at 5-year intervals, prepared by the University of New Mexico's (UNM's) Bureau of Business and Economic Research (UNM 1994). A second-order polynomial was fit to the data to calculate the annual numbers shown in the second column. The number of new consumers for the public system was calculated based on estimates from Sangre de Cristo Water Company, because new developments are expected to use less water (142 gallons [540 liters] per day per person) than existing users (172 gallons [654 liters] per day per person). The per capita figure averages include irrigation and industrial use. To calculate the total public system water use, the percentage of Santa Fe County served by the Sangre de Cristo Water Company (57 percent) was assumed constant. For years 1996 through 2006, the projected water increases based on per

TABLE A.4.1–2.—*Estimated Annual Water Use for Santa Fe County*

YEAR	SANTA FE COUNTY POPULATION PROJECTION	NEW CONSUMERS	TOTAL WATER USE (gal./yr)	TOTAL WATER USE (acft/yr)
1993	105,089		3,741,505,919	11,481.5
1994	107,194		3,816,442,704	11,711.5
1995	109,326		3,892,360,000	11,944.4
1996	111,486	2,160	3,955,845,398	12,139.2
1997	113,674	4,347	4,020,140,288	12,336.5
1998	115,889	6,562	4,085,244,669	12,536.3
1999	118,131	8,805	4,151,158,542	12,738.6
2000	120,401	11,075	4,217,881,905	12,943.4
2001	122,699	13,372	4,285,414,760	13,150.6
2002	125,024	15,697	4,353,757,106	13,360.3
2003	127,376	18,050	4,422,908,944	13,572.5
2004	129,376	20,430	4,492,870,273	13,787.2
2005	132,164	22,838	4,563,641,093	14,004.4
2006	134,599	25,273	4,635,221,404	14,224.0

gal./yr = gallons per year
acft/yr = acre-feet per year

capita increases were added to the actual water use value for 1995.

A.4.2 Other Input Files and Information

Frenzel's model (1995) for north-central New Mexico, was used with no changes to any hydraulic parameters and no additional calibration. Data on water use from individual DOE and Santa Fe wells from 1993 through 1995 were obtained from the state engineers office and added to Frenzel's well input file, which used pumping data through 1992 (Frenzel 1995). Changes were made only to well pumping rates calculated from the water use projections. The process below describes the procedure for reducing annual total well field production to pumping from each model layer for each individual well. This process was performed for each alternative.

- To allocate the total use for the DOE and Santa Fe supply systems among individual wells, a spreadsheet was developed to calculate average percentage of the total produced by each well field from 1993 through 1995. In turn, the average proportion of the total well field production supplied by each individual well within the field was calculated from 1993 through 1995.
- For projected pumping rates for each well based on water use projections, a spreadsheet was developed based on Frenzel's (1995) Table 11. Frenzel's Table 11 allocates the percentage of pumping from layers one through five for each well. These percentages were multiplied by each well's total annual projected pumping to obtain the proper flow rate from each layer.
- Based on conversations with representatives of the Sangre de Cristo Water Company (Santa Fe County's public supplier) in 1995, Santa Fe plans to start taking their San Juan-Chama water right (5,605 acre-feet [or 1,827 million gallons (6,913 million liters)] per year) from the Rio Grande through a diversion pipeline (Santa Fe Diversion). When the collection system for the Rio Grande is on-line, Santa Fe will shut down the Buckman well field and use it only for supply emergencies.

A.5 MODEL RESULTS

Based on the Frenzel model, the total approximate volume of water within the 5,600-foot (1,707-meter) thickness of the main aquifer below the Pajarito Plateau is estimated to be 21.8 trillion gallons (82,513 million cubic meters). Water quality will generally become increasingly poor with increasing depth. Therefore, the amount of potable water may be far less than the total volume available. Available data are insufficient to model water quality degradation with depth; but, water supply wells screened as deep as 1,830 feet (558 meters) into the main aquifer produce potable water that meets *Safe Drinking Water Act* standards (42 United States Code [U.S.C.] §300).

A similar water storage analysis for the main aquifer beneath the entire USGS modeled area shows that 106 trillion gallons (401 trillion liters) of water are stored. This estimate of storage volume is conservative, as the USGS model does not include the entire Española Basin. Use of groundwater from the Española Basin at combined annual water rights rates for DOE (1,805 million gallons [6,832 million liters] per year); Santa Fe (7,012 million gallons [26,540 million liters] per year); and Española (906 million gallons [3,429 million liters] per year) indicates that if the upper 1,275 feet (389 meters) of the Basin were used, a water supply would be available for 2,982 years and if the upper 2,000 feet (610 meters) of the Basin were used, a water supply would be available for 4,637 years.

A.5.1 Changes in Water Levels and Storage in the Main Aquifer

The model results reflect water level changes at the top of the main aquifer across the alternatives, given continued draw from the aquifer by DOE, Española, and Santa Fe. Table A.5.1–1 shows predicted water level changes at the surface of the main aquifer during the period from 1996 through 2006 for each of the SWEIS alternatives. Although the water use modeled includes water use in Española and Santa Fe, the differences between the alternatives are due only to LANL operations.

The groundwater model indicates that no springs in White Rock Canyon are likely to go dry. Springs in White Rock Canyon in the vicinity of the Buckman well field may actually increase in flow due to rising groundwater levels (from 0.1 to 3.8 feet [0.03 to 1.2 meters]). The rising water levels result from the continuing recovery in the vicinity of the Los Alamos well field, which was shut down in 1992, and recovery in the vicinity of Santa Fe's Buckman well field, which is planned for shut down in 1999. Operations of both well fields are independent of the alternatives and significantly affect water levels in the main aquifer in the vicinity of the Rio Grande.

TABLE A.5.1–1.—*Maximum Water Level Changes at the Top of the Main Aquifer Due to All Users Combined (1996 Through 2006)*

	WATER LEVEL CHANGE IN FEET[a]			
	NO ACTION	**EXPANDED**	**REDUCED**	**GREENER**
AREA OF CONCERN ON-SITE				
Pajarito Well Field	-13.2	-15.6	-10.7	-14.5
Otowi Well Field (Well 0–4)	-12.9	-15.2	-10.3	-14.2
AREA OF CONCERN OFF-SITE				
DOE - Guaje Well Field	-8.7	-9.3	-8.1	-9.0
Santa Fe Water Supply				
Buckman Well Field	+21.6	+21.6	+21.7	+21.6
Santa Fe Well field	-20.6	-20.6	-20.6	-20.6
San Juan Chama Diversion	0.0	0.0	0.0	0.0
Springs				
White Rock Canyon Springs, maximum drop	0.0	0.0	0.0	0.0
White Rock Canyon Springs, maximum rise	+1.0	+1.0	+1.0	+1.0
Other Springs (Sacred, Indian)	+3.8	+3.8	+3.8	+3.8
San Ildefonso Pueblo Supply Wells				
West of Rio Grande:				
Household, Community Wells	+0.6	+0.6	+0.6	+0.6
Los Alamos Well Field	+3.8	+3.8	+3.8	+3.8
East of Rio Grande:				
Household, Community Wells	0.0	0.0	0.0	0.0

[a] Negative value (-) indicates water level drop; positive value (+) indicates water level rise.

In comparison to the thicknesses of the eight model layers (total equals 5,600 feet [1,707 meters]), the maximum drawdown predicted over the next 10 years for DOE well fields (15.6 feet [4.8 meters] for the Pajarito well field) represents a reduction of main aquifer saturated thickness of 0.28 percent. Water use projections indicate that the maximum total volume of water to be withdrawn from DOE well fields from 1996 through 2006 is 19 billion gallons (72 billion liters), which is 0.09 percent of the main aquifer volume (22 trillion gallons [83 trillion liters]) of water in storage beneath the Pajarito Plateau. In summary, the drawdowns in DOE well fields are minimal relative to the total thickness of the main aquifer, and the volume of water to be used over the period from 1996 through 2006 is negligible relative to the volume of water in storage.

The water level declines reflected here could have an impact on the water levels in off-site wells that are used by other entities, which would require these entities to drill deeper wells into the aquifer.

A.6 MODEL UNCERTAINTIES AND LIMITATIONS

The following uncertainties and limitations associated with the use of this model should be noted:

- The model only includes a portion of the main aquifer. No model or method exists to predict changes of water levels in the vicinity of springs emanating from intermediate perched groundwater bodies (Basalt Spring, S-Site (TA–16) Springs, Water Canyon Gallery).
- The model's mile-square grid spacing underestimates drawdowns at individual wells. The grid spacing is also too large to precisely model changes in water levels in the main aquifer adjacent to the Rio Grande in response to the Santa Fe diversion. A finer-scale model is under development by the Sangre de Cristo Water Company.
- No additional calibration was performed, even though Otowi-4 pumping, initiated after Frenzel's model was calibrated, may make additional calibration technically desirable.
- Because water levels at the Pueblo of San Ildefonso are not available, modeled water level changes are the only data available.
- The remainder of Santa Fe County is served by approximately 16,000 domestic wells, each of which has rights to 3 acre-feet (0.98 million gallons [3.7 million liters]) per year. These are far more private wells than were included in the model (200). This factor probably does not significantly change model drawdown results for the following reasons: most private users probably use much less than 3 acre-feet (0.98 million gallons [3.7 million liters]) per year, the private wells extract only from layer one or shallower perched zones (public supply wells pump from layers two through five), and private wells are sufficiently spread out so that impacts from one location are not observed at other nearby wells.

REFERENCES

Bradford 1996 — Memorandum from W. Bradford, ESH-EIS, to Doris Garvey, ESH/M889. Subject: NPDES Outfalls and Annual Volume Discharges for Other than Key Facilities. August 28, 1996.

Frenzel 1995 — *Geohydrology and Simulation of Groundwater Flow Near Los Alamos, North-Central New Mexico*. Water Resources Investigations Report 95-4091. U.S. Geological Survey. Washington, D.C. 1995.

Garvey 1997 — Memorandum from D. Garvey, ESH-EIS, to Corey Cruz, DOE Albuquerque Operations Office. Subject: NPDES outfalls. December 19, 1997.

LANL 1992 — *Environmental Surveillance at Los Alamos During 1990.* Los Alamos National Laboratory. LA-12271-M8. UC-902. Los Alamos, New Mexico. March 1992.

LANL 1993 — *Environmental Surveillance at Los Alamos During 1991.* Los Alamos National Laboratory. LA-12572-ENV. UC-902. Los Alamos, New Mexico. August 1993.

LANL 1994 — *Environmental Surveillance at Los Alamos During 1992.* Los Alamos National Laboratory. LA-12764-MS. UC-902. Los Alamos, New Mexico. July 1994.

LANL 1995 — *Environmental Surveillance at Los Alamos During 1993.* Los Alamos National Laboratory. LA-12973-ENV. UC-902. Los Alamos, New Mexico. October 1995.

LANL 1996 — *Environmental Surveillance at Los Alamos During 1994.* Los Alamos National Laboratory. LA-13047-ENV. UC-902. Los Alamos, New Mexico. July 1996.

LANL 1998 — *Los Alamos National Laboratory Hydrogeologic Workplan*. Los Alamos National Laboratory. Los Alamos, New Mexico. May 1998.

PC 1996 — E. Rogoff, GRAM, Inc. Personal communication with T. Thompson, New Mexico State Engineer, regarding information on water rights for Española and Santa Fe. June 11, 1996.

Purtymun 1984 — *Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Ground Water Supplies.* W. D. Purtymun. Los Alamos National Laboratory. LA-9957-MS. Los Alamos, New Mexico. 1984.

Rogers and Gallaher 1995	*The Unsaturated Hydraulic Characteristics of the Bandelier Tuff.* D. B. Rogers and B. M. Gallaher. Los Alamos National Laboratory. LA-12968-MS. UC-903. Los Alamos, New Mexico. September 1995.
Rogers et al. 1996	"Recharge to the Pajarito Plateau Aquifer System." D. B. Rogers, A. K. Stoker, S. G. McLin, and B. M. Gallaher. *1996 Guidebook, Geology of the Los Alamos—Jemez Mountains Region.* Los Alamos National Laboratory. LA-UR-96-486. New Mexico Geological Society. Los Alamos, New Mexico. 1996.
UNM 1994	*Population Projections for the State of New Mexico by Age and Sex, 1990–2020.* University of New Mexico, Bureau of Business and Economic Research. Albuquerque, New Mexico. May 1994.

APPENDIX B
AIR QUALITY

This appendix provides supplemental information regarding the air quality analyses presented in chapter 5. This appendix addresses aspects of both radiological air emissions and nonradiological air emissions.

B.1 RADIOLOGICAL AIR QUALITY

B.1.1 Methodology

The radiological air quality analyses address:

- *Facility-Specific Maximally Exposed Individual (FS MEI)*—The FS MEI represents a location near a facility that is modeled as having the greatest dose to a hypothetical public individual from all modeled emissions under a given SWEIS alternative.
- *LANL Site-Wide Maximally Exposed Individual*—The LANL MEI represents the location of the single highest modeled dose to a hypothetical public individual. Under a given alternative, the highest FS MEI becomes the LANL MEI for that alternative.
- Collective dose to the population within a 50-mile (80-kilometer) radius from LANL.

In addition to these receptors, isodose maps were developed that show the estimated committed effective dose equivalents (CEDEs) at any location within the 50-mile (80-kilometer) radius. These maps were developed to allow individuals within the 50-mile (80-kilometer) radius to estimate their modeled CEDE.

In order to enable these analyses, a review of historical emissions was undertaken for the period 1990 through 1994. The data were largely derived from past National Emission Standards for Hazardous Air Pollutants (NESHAP) reports. The data reviewed are summarized in Table B.1.1–1. The data show the CEDE to the LANL MEI. Although valid, these data were only available for the LANL MEI, not for the FS MEI.

MEIs are hypothetical individuals who do not leave and do not take protective actions to avoid exposure. The risk from ionizing radiation consists mostly of some number of excess latent cancer fatalities (LCFs). These are cancers resulting from, and that develop well after, the exposure to ionizing radiation. These represent an increase in the number of fatal cancers that occur from other causes. The excess LCF is the product of the dose and the risk factor of 5×10^{-4} excess LCF per person-rem. The reader should recognize that these estimates are intended to provide a conservative measure of the potential impacts to be used in the decision-making process and do not necessarily portray an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated impacts form an upper bound and that actual consequences could be less, but probably would not be worse. This is discussed in the primer on the effects of radiation in section D.1 of appendix D, Human Health.

B.1.1.1 *Modeled Facilities*

Several facilities at LANL emit radioactive materials to the ambient air through stacks, vents, or diffuse emissions. Not all of the facilities listed in Table B.1.1–1 were modeled for this SWEIS. Those facilities not modeled were eliminated from such detailed analysis because they have historically low emission rates or because they are not expected to operate during the period analyzed in the SWEIS. The facilities modeled include 16 emission points from 12 facilities within 10 TAs. These facilities are listed in Table B.1.1.1–1. These

TABLE B.1.1–1.—*Historical Summary of Dose Estimates to LANL's Maximally Exposed Individual from Radioactive Air Emissions (1990 Through 1994)*

MODELED EFFECTIVE DOSE EQUIVALENT (mrem/yr) TO LANL'S MEI FROM AIRBORNE RELEASES							
	1990[a]	1991[a]	1992	1993	1994	AVERAGE[b]	PERCENT
EDE (mrem/yr) from point and nonpoint sources	15.3	6.5	7.9	5.6	7.6	7.33	
POINT SOURCES							
LA–1: TA–2 (Omega West Reactor)	NA	NA	0.0061	0.000061	0.0000255	0.00206	0.028
TA–41 (Weapons Material Fabrication)							
LA–2: TA–3 (CMR Laboratory, Van de Graff)	NA	NA	0.00164	0.00277	0.00188	0.00210	0.029
LA–4: TA–33 (Old Tritium Handling Facility)	NA	NA	9.00×10^{-6}	0.0000100	0.000014	0.0000110	0.002
LA–5: TA–21, TA–35, TA–43, TA–48, TA–50, TA–55	NA	NA	0.0012	0.0244	0.0173	0.0176	0.241
LA-5a: TA–21					0.0167		
LA-5b: TA–35, TA–50, TA–55					0.0000528		
LA-5c: TA–43					4.11×10^{-6}		
LA-5d: TA–48					0.000528		
LA–6: TA–53 (LANSCE)	NA	NA	7.83	4.57	6.74	6.38	87.0
LA–7: TA–54 (Waste Disposal Site)	NA	NA	4.08×10^{-8}	0	6.54×10^{-8}	3.54×10^{-8}	0.00000
Total Point Source			7.85	4.597	6.78	6.40	87.3
NONPOINT SOURCES							
LA–3: TA–15 (PHERMEX), TA–36 (Open-Air Explosive Tests Sites)	NA	NA	0.009	0.066	0.16	0.030	0.414
LA–8: TA–54 (Active Storage and Disposal Site)	NA	NA	NA	0.0007	0.0000540	0.0000610	0.001
LA–9: TA–6, TA–21, TA–33, TA–49, TA–54 (Inactive Storage and Disposal Sites)	NA	NA	NA	NA	NA		
LA–11: TA–14, TA–15, TA–36, TA–39 (Residual Materials at Inactive Firing Sites)	NA	NA	NA	NA	NA		

TABLE B.1.1–1.—*Historical Summary of Dose Estimates to LANL's Maximally Exposed Individual from Radioactive Air Emissions (1990 Through 1994)*-Continued

MODELED EFFECTIVE DOSE EQUIVALENT (mrem/yr) TO LANL'S MEI FROM AIRBORNE RELEASES							
	1990[a]	**1991[a]**	**1992**	**1993**	**1994**	**AVERAGE[b]**	**PERCENT**
LA–12:TA–53 (Effluent Release to Holding Ponds)	NA	NA	0.00083	1.90×10^{-7}	0.0088	0.003	0.044
LA–13:TA–53 (Residual Radionuclides in Ponds)	NA	NA	NA	NA	NA		
LA–14: TA–50 (Liquid Release to Canyon)	NA	NA	0.00014	0.00210	1.80×10^{-7}	0.001	0.01
LA–15:TA–2, TA–41, TA–45, TA–50 (Residual Radionuclides in Canyon)	NA	NA	NA	NA	NA		
LA–16:TA–53 (Fugitive Emissions)	NA	NA	NA	1.0	0.8	0.900	12.28
LA–17:TA–21, TA–33 (Fugitive Emissions from Decontamination and Decommissioning Facilities)	NA	NA	NA	0.014	NA		
Total from Nonpoint Sources			0.00997	1.07	0.82	0.934	12.7

Notes:

NA = Not available (data were not available for that site that year), LANSCE = Los Alamos Neutron Science Center, PHERMEX = Pulsed High-Energy Radiation Machine Emitting X-Ray Facility

[a] The effective dose equivalent to the LANL MEI was not reported from individual facilities in 1990 and 1991. The only value reported in those years was the total dose (from all facilities combined) to the LANL MEI.

[b] Because the detailed individual source contributions are not available for 1990 and 1991, this average has been calculated for the 3-year period from 1992 to 1994.

TABLE B.1.1.1–1.—*List of Facilities Modeled for Radionuclide Air Emissions from LANL*

FACILITIES	
TA–3–29	CMR Building
TA–3–66	Sigma Building
TA–3–102	Machine Shops
TA–11	High Explosives (HE) Testing
TA–15/36	Firing Sites
TA–16	WETF
TA–18	Pajarito Site: LACEF
TA–21	TSTA and TSFF
TA–48	Radiochemistry Laboratory
TA–53	LANSCE[a]
TA–54	Area G
TA–55	Plutonium Facility

Notes:
[a] Five specific sources were modeled from TA–53. These include the TA–53 Exhaust Stack-2 (ES–2), Exhaust Stack-3 (ES–3), Isotope Production Facility (IPF), Low- Energy Demonstration Accelerator (LEDA), and combined diffuse emissions.
CMR = Chemistry and Metallurgy Research, WETF = Weapons Engineering Tritium Facility, LACEF = Los Alamos Critical Experiments Facility, TSTA = Tritium System Test Assembly, TSFF = Tritium Science Fabrication Facility

facilities historically have emitted the majority of radioactive materials to the air or were affected by the SWEIS alternatives.

Emission projections were made by alternative for each of these facilities. These estimates were based on historical activity levels and emissions and the SWEIS alternative descriptions. These estimates served as the basis for modeling the consequences of LANL radiological air emissions.

B.1.1.2 *Selection of the CAP–88 Model*

Based on estimated emission rates under various alternatives, air dispersion modeling was performed to evaluate the radiation doses (CEDEs) from these emissions. The *Clean Air Act* Assessment Package-1988 (CAP–88) (EPA 1992a) is one such air dispersion model. It was selected to perform dose calculations. CAP–88 contains a modified Gaussian plume model that estimates the average dispersion of radionuclides released from up to six sources simultaneously. The model may be run on individual sources as well. The sources may be elevated stacks or uniform area (diffuse) sources. The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food from radionuclides emitted to the air, and intake rates for people from ingestion of food produced in the assessment area. The model calculates the CEDE resulting from these air emissions and resulting exposure pathways.

CAP–88 was chosen for the following reasons:

- CAP–88 is approved by the U.S. Environmental Protection Agency (EPA) for demonstrating compliance with the NESHAP (40 Code of Federal Regulations [CFR] 61, Subpart H) and is used by LANL and other DOE facilities for that purpose. Consequently, DOE and LANL have experience with this code, and it is acceptable to other regulatory agencies.
- CAP–88 is known to compare favorably with other models for producing results that generally agree with experimental data.
- To support NESHAP estimates, the LANL mainframe version of CAP–88 was previously modified to include special radionuclides emitted by the Los Alamos Neutron Science Center (LANSCE). Those radionuclides are mainly activation products that are not modeled by the personal computer version or by other air dispersion models, such as the Generation II (GENII) model prepared for DOE by Pacific Northwest Laboratory.
- CAP–88 adequately accounts for both point sources and diffuse sources, which are both present at LANL.

- Other models (such as GENII) do not have any significant advantages over CAP–88 that would negate its use.

B.1.1.3 *Limitations of the CAP–88 Model*

As in all computer models, there are some limitations in the CAP–88 model. These limitations were considered prior to the use of this model but were dismissed. The most important limitations are described below.

- While up to six sources can be modeled in a single run, all the sources are assumed to be at the same geographic point during the modeling run. This was overcome by performing separate model runs for each source.
- CAP–88 assumes a flat terrain during the radionuclide transport. Complex terrain cannot be modeled by CAP–88. This effect was considered negligible when the distance to the exposed individuals is large compared to the stack height, area, or facility size. The flat terrain model is customary and used elsewhere to model LANL emissions.
- The model assumes that individuals remain at locations 24 hours a day, 365 days a year, when estimating the dose for that specific location. This is obviously unlikely but provides worst-case bounding conditions.
- CAP–88 calculates the dose from external radiation from radionuclides in the air that envelops the receptor. However, if the radionuclide cloud is only overhead and not in touch with the ground, the radiation dose is not calculated. This is not regarded as a serious shortcoming because of the absorption of the radiation in air and CAP–88's overestimate of the dose once the cloud has touched down. In most past years, environmental monitors have shown lower exposures than were calculated using CAP–88.

B.1.1.4 *Model Input Parameters*

The CAP–88 model requires many input parameters in order to perform dose calculations. Most of these parameters are built into the model and require no input from the user. However, some parameters (such as the amount of radionuclide emitted) must be introduced by the user. These user-defined inputs are discussed below, along with how the data were derived.

Radionuclide Emission Rate Data

Radionuclide emission rate projections for each alternative were introduced into the CAP–88 model. Some modeled facilities have more than one emission point, depending on the operations within the facilities. For example, TA–53 has five emission points, which were modeled separately. The radionuclides emitted and their modeled emission rates for each facility are summarized in Tables B.1.1.4–1 through B.1.1.4–17.

All radionuclide emissions were modeled using the personal computer version of CAP–88, except when the radionuclides contain mixed activation products (MAPs). In those cases, the LANL mainframe version of CAP–88 was used for modeling. The only two modeled facilities that required the use of LANL mainframe computers were TA–48 and TA–53.

Some assumptions had to be made while modeling some radionuclide emissions from LANL. In all cases, the most conservative assumption was selected for use, resulting in an overestimation of the committed effective dose equivalents. These assumptions are:

- Actinide and particulate emissions from the Chemistry and Metallurgy
- Research (CMR) Building and TA–55 were not modeled by radionuclide. All actinide and particulate emissions from these facilities were assumed to be plutonium-239.

TABLE B.1.1.4–1.—*Radiological Air Emissions from TA–3–29 (CMR)*

STACK NUMBER	WING 2	WING 4	WING 9
	ES–14	ES–24	ES–46
STACK PARAMETERS			
Height (meters)	15.9	15.9	21.5
Diameter (meters)	1.1	1.1	2.1
Exit Velocity (meters per second)	6.8	14.6	1.9
EMISSION RATE PER STACK (CURIES PER YEAR)			
No Action Alternative			
Actinides (plutonium-239)[a]	0.000420		
Expanded Operations Alternative			
Actinides (plutonium-239)[a]	0.000760		
Fission Products[b]			
Krypton-85			100
Xenon-131m			23,480
Xenon-133			1,500
Tritium[c]		1,000	
Reduced Operations Alternative[d]			
Actinides (plutonium-239)[a]	0.000380		
Greener Alternative[d]			
Actinides (plutonium-239)[a]	0.000420		

Notes:
[a] Actinides were not broken down by isotope; therefore, they were represented by plutonium-239. Actinides are emitted from Wings 2, 3, 4, 5, 6, 7, and 9, but no stacks were specified. The most conservative stack was chosen (ES–14 at Wing 2) to model emissions from all these wings.
[b] Fission product emissions apply only to the Expanded Operations Alternative. Fission products are emitted from Wing 9. The most conservative stack (ES–46) was chosen for modeling.
[c] Tritium emissions apply only to the Expanded Operations Alternative. Tritium is emitted from Wing 4. A new stack will be installed for it; no information on the stack parameters is available. The most conservative stack (ES–24) was chosen to model all tritium emissions from Wing 4.
[d] The No Action and Greener Alternatives are the same. The Reduced Operations Alternative is 90 percent of the No Action Alternative.

TABLE B.1.1.4–2.—*Radiological Air Emissions from TA–3–66 (Sigma)*

STACK NUMBER						
	ES–1	**ES–8**	**ES–9**	**ES–13[a]**	**ES–24[a]**	**ES–25/26[b,c]**
Percent Emissions[d] Uranium-238	2	2	2	45	45	4
STACK PARAMETERS						
Height (meters)	19.8	16.8	15.4	13.7	15.9	12.2
Diameter (meters)	1.2	2.8	1.8	0.4	1.1	0.3
Exit Velocity (meters per second)	14.4	1.1	4.9	51.8	14.6	1.8
EMISSION RATE PER STACK (CURIES PER YEAR)[e]						
No Action Alternative						
Uranium-234	0	0	0	0	0	0.0000220
Uranium-238	0.0000122	0.0000122	0.0000122	0.000275	0.000275	0.0000244
Expanded Operations Alternative						
Uranium-234	0	0	0	0	0	0.0000660
Uranium-238	0.0000360	0.0000360	0.0000360	0.000810	0.000810	0.0000720
Reduced Operations Alternative						
Uranium-234	0	0	0	0	0	0.0000220
Uranium-238	0.0000122	0.0000122	0.0000122	0.000275	0.000275	0.0000244
Greener Alternative						
Uranium-234	0	0	0	0	0	0.0000220
Uranium-238	0.0000122	0.0000122	0.0000122	0.000275	0.000275	0.0000244

Notes:

[a] 90 percent of the depleted uranium (DU) (e.g., uranium-238) comes out of ES–13 and ES–24 (i.e., 45% each).

[b] No stack information is available for enriched uranium (EU) emissions; therefore, the most conservative emission stack (ES) is considered for emissions (stack ES–25).

[c] Stack ES–26 is added to stack ES–25 for similarity of parameters.

[d] All uranium-238 is assumed to be in equilibrium with thorium-234 and protactinium-234m. All DU is considered as uranium-238, and all EU is considered as uranium-234.

[e] The No Action, Greener, and Reduced Operations Alternatives are the same. The Expanded Operations Alternative is three times higher than the No Action Alternative.

TABLE B.1.1.4–3.—*Radiological Air Emissions from TA–11 (High Explosives Testing)*

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Uranium-238[a]	3.98×10^{-7}	9.96×10^{-7}	2.32×10^{-7}	2.32×10^{-7}
Uranium-235[b]	7.56×10^{-9}	1.89×10^{-8}	4.41×10^{-9}	4.41×10^{-9}
Uranium-234[c]	1.49×10^{-7}	3.71×10^{-7}	8.67×10^{-8}	8.67×10^{-8}

Notes:
[a] Protactinium-234m and thorium-234 are in equilibrium with uranium-238.
[b] Thorium-231 is in equilibrium with uranium-235.
[c] No stack emissions. This is an area source. An area of 10,000 square meters (m^2) was used. Areas of 100 and 1,000 m^2 were also used, with no difference in the results.

TABLE B.1.1.4–4.—*Radiological Air Emissions from TA–16 (Tritium Facility)*

RADIONUCLIDE[a,b]	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Tritium (gaseous)	100	300	100	100
Tritium (water vapor)	300	500	300	300
Total	400	800	400	400

Notes:
[a] Tritium is emitted in the gaseous form (HT) as well as in the water vapor form (HTO). CAP–88 uses the water vapor form of tritium for modeling for a conservative result because the vapor form produces the highest dose. It was assumed that all tritium is in the vapor form.
[b] Tritium is emitted from fan exhaust (FE)–4 in Building 205 (the only stack for tritium emissions at TA–16). The stack parameters are: Height = 18.3 meters, Diameter = 0.5 meter, and Exit Velocity = 19.3 meters per second.

TABLE B.1.1.4–5.—*Radiological Air Emissions from TA–18 (Pajarito Site)*

RADIONUCLIDE[a,b]	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Argon-41	101	126	101	101

Notes:
[a] No stack emissions. This is an area source. An area of 45,200 square meters (m^2) was calculated based on the air volume used by LANL to calculate the emission rates.
[b] Argon-41 is the only significant radionuclide emitted from TA–18. Others are present in quantities too small to consider in this analysis.

TABLE B.1.1.4–6.—*Radiological Air Emissions from TA–21 (Tritium Facility)*

RADIONUCLIDE[a]	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
TA–21–155[b]				
Tritium (gaseous)	100	100	100	100
Tritium (water vapor)	100	100	100	100
Total	200	200	200	200
TA–21–209[c]				
Tritium (gaseous)	640	640	640	640
Tritium (water vapor)	860	860	860	860
Total	1,500	1,500	1,500	1,500

Notes:
[a] Tritium is emitted in the gaseous form (HT) as well as in the water vapor form (HTO). CAP–88 uses the water vapor form of tritium for modeling for a conservative result, because the vapor form produces the highest dose. It was assumed that all tritium is in the vapor form.
[b] The ES–5 stack parameters for TA–21–155 are: Height = 29.9 meters (m), Diameter = 0.8 m, Exit Velocity = 7.8 meters per second (m/s).
[c] The ES–1 stack parameters for TA–21–209 are: Height = 23.2 m, Diameter = 1.2 m, Exit Velocity = 10.3 m/s.

TABLE B.1.1.4–7.—*Radiological Air Emissions from TA–3–102 (Shops)*

RADIONUCLIDE[a,b]	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Uranium-238	0.00005	0.00015	0.00005	0.00005

Notes:
[a] Protactinium-234m and thorium-234 are in equilibrium with uranium-238.
[b] The ES–22 stack parameters are: Height = 11.9 meters, Diameter = 0.9 meter, Exit Velocity = 0.8 meters per second.

TABLE B.1.1.4–8.—*Radiological Air Emissions from TA–48 (Radiochemistry Laboratory)*

FAN EXHAUST (FE) NUMBER (STACK NUMBER)				
	FE–15 (16)	**FE–4 (11)[a]**	**FE–45/46**	**FE–51/54**
FAN EXHAUST PARAMETERS				
Height (meters)	19.8	20.1	15.2	13.1
Diameter (meters)	1.5	1.8	1.8	0.9
Velocity (meters per second)	13.5	9.9	8.2	7.9
EMISSION RATE PER FAN EXHAUST (CURIES PER YEAR)				
No Action Alternative				
Mixed Fission Product[b]	0.000015	0.00008	0.0000126	1.10×10^{-6}
Plutonium-239	4.50×10^{-6}	4.70×10^{-7}	4.70×10^{-7}	6.20×10^{-8}
Expanded Operations Alternative				
Mixed Fission Product[b]	0.000033	0.000088	0.000018	2.20×10^{-6}
Plutonium-239	9.60×10^{-6}	5.20×10^{-7}	6.50×10^{-7}	1.20×10^{-7}
Reduced Operations Alternative				
Mixed Fission Product[b]	0.000015	0.00004	0.000013	5.30×10^{-7}
Plutonium-239	4.50×10^{-6}	2.40×10^{-7}	4.60×10^{-7}	3.10×10^{-8}
Greener Alternative				
Mixed Fission Product[b]	0.000033	0.00008	0.000018	1.10×10^{-6}
Plutonium-239	9.60×10^{-6}	4.70E $\times 10^{-7}$	6.50×10^{-7}	6.20×10^{-8}

Notes:
[a] Fan exhaust FE–4 exits through Stack 11.
[b] The mixed fission products are represented by strontium-90/yttrium-90 in equilibrium.

TABLE B.1.1.4–9.—*Radiological Air Emissions from TA–48 (Radiochemistry Laboratory)*[a]

ALTERNATIVE	NO ACTION		EXPANDED OPERATIONS		REDUCED OPERATIONS		GREENER	
FAN EXHAUST NUMBER	FE–60	FE–63/64	FE–60	FE–63/64[b]	FE–60	FE–63/64	FE–60	FE–63/64
FAN EXHAUST PARAMETERS								
Height (meters)	12.4	10.3	12.4	10.3	12.4	10.3	12.4	10.3
Diameter (meters)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Exit Velocity (meters per second)	9.4	12.5	9.4	12.5	9.4	12.5	9.4	12.5
EMISSION RATE PER FAN EXHAUST (CURIES PER YEAR)								
Emission:								
Mixed Activation Products[c]	1.60 x 10^{-7}	1.40 x 10^{-6}	3.20 x 10^{-7}	2.80 x 10^{-6}	8.00 x 10^{-8}	7.00 x 10^{-7}	1.60 x 10^{-7}	1.40 x 10^{-6}
Arsenic-72	0	0.000056	0	0.00011	0	0.000028	0	0.000056
Arsenic-73	0	0.000095	0	0.00019	0	0.0000475	0	0.000095
Arsenic-74	8.50 x 10^{-7}	0.000019	1.70 x 10^{-6}	0.000038	4.25 x 10^{-7}	9.50 x 10^{-6}	8.50 x 10^{-7}	0.000019
Beryllium-7	7.30 x 10^{-6}	6.10 x 10^{-8}	0.000015	1.20 x 10^{-7}	3.65 x 10^{-6}	3.05 x 10^{-8}	7.30 x 10^{-6}	6.10 x 10^{-8}
Bromine-77	0.00031	0.00012	0.00062	0.00024	0.000155	0.00006	0.00031	0.00012
Germanium-68	0	8.50 x 10^{-6}	0	0.000017	0	4.25 x 10^{-6}	0	8.50 x 10^{-6}
Rubidium-86	0	1.40 x 10^{-7}	0	2.80 x 10^{-7}	0	7.00 x 10^{-8}	0	1.40 x 10^{-7}
Selenium-75	0.000044	0.00012	0.000089	0.00024	0.000022	0.00006	0.000044	0.00012

Notes:
[a] These isotopes were modeled using LANL’s mainframe computer.
[b] Fan exhausts FE–63/64 exit through Stack 7.
[c] The mixed activation products are represented by strontium-90/yttrium-90 in equilibrium.

TABLE B.1.1.4–10.—*Radiological Air Emissions from TA–55 (Plutonium Facility)*

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
ES–15 (North Stack)[a]	1.52 x 10^{-6}	2.50 x 10^{-6}	1.38 x 10^{-6}	2.00 x 10^{-6}
ES–16 (South Stack)[b]				
Particulates (plutonium-239)[c]	0.0000162	0.000026	7.91 x 10^{-6}	0.0000157
Tritium	1,000	100	100	100

Notes:
[a] The ES–15 stack parameters are: Height = 14 meters (m), Diameter = 1.1 m, and Exit Velocity = 6.8 meters per second (m/s).
[b] The ES–16 stack parameters are: Height = 14 m, Diameter = 1.1 m, and Exit Velocity = 10.8 m/s.
[c] No isotopic breakdown of particulates is available; therefore, all particulates are represented by plutonium-239.

TABLE B.1.1.4–11.—*Radiological Air Emissions from TA–15 and TA–36 (Firing Sites)*

ALTERNATIVE	RADIONUCLIDE (CURIES PER YEAR)[a,b]		
	URANIUM-238	URANIUM-235	URANIUM-234
NO ACTION			
TA–15	0.0226	0.000437	0.00842
TA–36	0.012	0.000233	0.00449
Total	0.0346	0.00067	0.0129
EXPANDED OPERATIONS			
TA–15	0.0693	0.00134	0.0258
TA–36	0.0346	0.00067	0.0129
Total	0.104	0.00201	0.0387
REDUCED OPERATIONS			
TA–15	0.0226	0.000437	0.00842
TA–36	0.012	0.000233	0.00449
Total	0.0346	0.00067	0.0129
GREENER			
TA–15	0.0226	0.000437	0.00842
TA–36	0.012	0.000233	0.00449
Total	0.0346	0.00067	0.0129

Notes:
[a] No stack emissions. This is an area source. An area of 100 square meters was used. This value was used based on information obtained from LANL personnel regarding the area of pads used for firing experiments.
[b] These values are for the resuspendable and/or respirable portion of the product used during the tests and as such are the values used as the source parameter in the CAP–88 PC Model.

TABLE B.1.1.4–12.—*Radiological Air Emissions from TA–54 (Area G—Waste Management)*

RADIONUCLIDE[b]	ALTERNATIVE (CURIES PER YEAR)[a]			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Tritium	21	21	21	21
Americium-241	6.60×10^{-7}	6.60×10^{-7}	6.60×10^{-7}	6.60×10^{-7}
Plutonium-238	4.80×10^{-6}	4.80×10^{-6}	4.80×10^{-6}	4.80×10^{-6}
Plutonium-239	6.80×10^{-7}	6.80×10^{-7}	6.80×10^{-7}	6.80×10^{-7}
Uranium-234	8.00×10^{-6}	8.00×10^{-6}	8.00×10^{-6}	8.00×10^{-6}
Uranium-235	4.10×10^{-7}	4.10×10^{-7}	4.10×10^{-7}	4.10×10^{-7}
Uranium-238	4.00×10^{-6}	4.00×10^{-6}	4.00×10^{-6}	4.00×10^{-6}

Notes:
[a] No change in emissions is expected among the SWEIS alternatives. These emissions were back-calculated using the CAP–88 model and are conservatively based on the average, plus two standard deviations of nearby environmental concentration measurements.
[b] No stack emissions. This is an area source. An area of 5,000 square meters was used. This value was used based on information obtained from LANL personnel regarding the area of waste disposal.

TABLE B.1.1.4–13.—*Radiological Air Emissions from TA–53 (LANSCE—ES–2 Stack)[a,b]*

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)[c]			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Argon-41	55.2	69.0	27.6	69.0
Carbon-10	2.12	2.65	1.06	2.65
Carbon-11	2,240	2,790	1,120	2,790
Nitrogen-13	348	434	174	434
Oxygen-14	5.29	6.61	2.65	6.61
Oxygen-15	464	581	233	581

Notes:
[a] TA–53 emissions were divided into five sources: ES–2 stack emissions, ES–3 stack emissions, LEDA emissions, IPF–2 emissions, and diffuse emissions.
[b] ES–2 stack emissions: evacuation from the Manuel Lujan Neutron Scattering Center (MLNSC), Weapons Neutron Research (WNR), and Line D-South. Parameters are: Height = 13 meters (m), Diameter = 0.9 m, Exit Velocity = 7 meters per second.
[c] Increased by factor of 200/70 to account for increased beam current.

TABLE B.1.1.4–14.—*Radiological Air Emissions from TA–53 (LANSCE—ES–3 Stack)*[a,b]

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Argon-41	345	862	172	862
Carbon-11	3,100	7,760	1,550	7,760

Notes:
[a] TA–53 emissions were divided into five sources: ES–2 stack emissions, ES–3 stack emissions, LEDA emissions, IPF–2 emissions, and diffuse emissions.
[b] ES–3 stack emissions: evacuation from experimental areas A, B, and C, and associated lines B and C tunnels. Parameters are: Height = 30.5 meters (m), Diameter = 0.9 m, Exit Velocity = 12.5 meters per second.

TABLE B.1.1.4–15.—*Radiological Air Emissions from TA–53 (LANSCE—LEDA)*[a,b]

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Argon-41		2.29	2.29	2.29
Nitrogen-13	0.163	0.163	0.163	0.163
Nitrogen-16	0.0285	0.0285	0.0285	0.0285
Oxygen-15	0.00177	0.00177	0.00177	0.00177
Oxygen-19	0.00216	0.00216	0.00216	0.00216
Sulfur-37	0.00181	0.00181	0.00181	0.00181
Chlorine-39	0.00047	0.00047	0.00047	0.00047
Chlorine-40	0.00219	0.00219	0.00219	0.00219
Krypton-83m	0.00221	0.00221	0.00221	0.00221
Others	0.00111	0.00111	0.00111	0.00111

Notes:
[a] TA–53 emissions were divided into five sources: ES–2 stack emissions, ES–3 stack emissions, LEDA emissions, IPF–2 emissions, and diffuse emissions.
[b] LEDA emissions: evacuation from the Low Energy Demonstration Accelerator. Emissions were assumed to exit through the ES–3 stack with parameters: Height = 30.5 meters (m), Diameter = 0.9 m, Exit Velocity = 12.5 meters per second.

TABLE B.1.1.4–16.—*Radiological Air Emissions from TA–53 (LANSCE—IPF–2)*[a,b]

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Carbon-11	70	87.5	35	87.5
Nitrogen-13	80	100	40	100
Oxygen-15	20	25	10	25

Notes:
[a] TA–53 emissions were divided into five sources: ES–2 stack emissions, ES–3 stack emissions, LEDA emissions, IPF–2 emissions, and diffuse emissions.
[b] IPF–2 emissions: evacuation from the Isotope Production Facility 2. Emissions were assumed to exit through the ES–3 stack with parameters: Height = 30.5 meters (m), Diameter = 0.9 m, Exit Velocity = 12.5 meters per second.

TABLE B.1.1.4–17.—*Radiological Air Emissions from TA–53 (LANSCE—Diffuse)*[a,b]

RADIONUCLIDE	ALTERNATIVE (CURIES PER YEAR)			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Argon-41	2.56	3.2	1.28	3.2
Carbon-11	61.44	76.8	30.72	76.8

Notes:
[a] TA–53 emissions were divided into five sources: ES–2 stack emissions, ES–3 stack emissions, LEDA emissions, IPF–2 emissions, and diffuse emissions.
[b] Diffuse emissions: escape from the area around the high intensity beam line (Line A). No stack emissions.

- All uranium-238 emissions were assumed to be in equilibrium with its decay daughters, thorium-234 and protactinium-234m.
- Unidentified mixed fission products (MFPs) or MAPs are modeled as strontium-90/yttrium-90 in equilibrium. This was done for some unidentified MAPs from the Low Energy Demonstration Accelerator (LEDA) emissions at the LANSCE and for some MAPs and MFPs from TA–48.
- Tritium can exist in gaseous (elemental tritium) or water vapor (tritium oxide) forms. The oxide form is used in CAP–88 to ensure conservative results because it produces a higher dose. All tritium emissions were modeled as oxides from TA–16 and TA–21 (the tritium facilities).

Source Parameters

LANL emission sources include individual stacks and large area (diffuse) sources. For stack emissions, the actual stack heights, diameters, and exit velocities were used. These stack parameters are reflected in Tables B.1.1.4–1 through B.1.1.4–17.

The sizes of area sources were calculated based on site information. Because the sizes of area sources could not always be precisely determined, a sensitivity analysis was performed using various area sizes. This analysis was performed by changing the sizes of the areas modeled while fixing all other parameters. Areas of 1,075, 10,750, and 107,500 square feet (100, 1,000, and 10,000 square meters) were used in separate model runs for the same case, and the results in all three runs were exactly the same. The conclusion was that the resultant dose was independent of the size of the area source if the radionuclide emission rates was the same due to the distance of the modeled MEI or member of the population from the area source. Despite this sensitivity analysis, the best estimate of an area's size was used in all cases for the actual modeling.

Agricultural Data

Radionuclides emitted to the air and subsequently ingested with food crops is one pathway of exposure used by CAP–88. The immediate region surrounding the LANL site does not have any major agricultural production activities; however, the agricultural data used in the modeling effort are reflected in Table B.1.1.4–18 (EPA 1992a).

These agricultural data were provided in the CAP–88 database for the State of New Mexico. Using these parameters may have resulted in an overestimate of the dose to individuals living in close proximity to the LANL site.

Meteorological Data

Meteorological data are used in conjunction with the CAP–88 model to estimate air dispersion of emitted nuclides. There were four meteorological towers distributed over the LANL sites used for this purpose. The meteorological data used for each tower were the average of 3 years of actual meteorological data. The tower nearest to the modeled facility was used for input data, as reflected below.

TABLE B.1.1.4–18.—*Fraction of Agricultural Products Produced in the Home, Assessment Area, and Imported*

	VEGETABLE	MILK	MEAT
Fraction Home Produced	0.7	0.399	0.442
Fraction Assessment Area Produced	0.3	0.601	0.558
Fraction Imported	0	0	0

- *TA–6 Tower*—Used for modeling emissions from TA–3, TA–16, TA–48, and TA–55
- *TA–49 Tower*—Used for modeling emissions from TA–15 and TA–36
- *TA–53 Tower*—Used for modeling emissions from TA–21 and TA–53
- *TA–54 Tower*—Used for modeling emissions from TA–18 and TA–54

The use of 3 years' data for modeling purposes is due to the fact that these towers have existed in these locations for that period of time. The use of average meteorological data over this period is expected to reflect future conditions more accurately than data from any individual year.

Other meteorological data needed as input to CAP–88 are:

- Annual precipitation = 19 inches (48 centimeters) per year (Bowen 1990)
- Annual ambient temperature = 48°F (8.8°C) (Bowen 1990)
- Height of lid = 5,000 feet (1,525 meters) The lid height (vertical extent of mixing of air emissions) was obtained from the weather center in Albuquerque and was verified by the National Oceanographic and Atmospheric Administration.

Distances Between Emission Points and Receptors

The distances between the emission sources and the specific location modeled must be introduced as input parameters for CAP–88 to calculate the nuclide concentration and subsequent doses at that location. Map coordinates for each source at LANL and each receptor location were determined using large maps and Geographic Information System (GIS) graphics. The distances were then calculated using these coordinate points. The distances and direction between each modeled facility and the facility-specific MEI location are listed in Table B.1.1.4–19.

Population Data

Data regarding the population distribution within a 50-mile (80-kilometer) radius around LANL are needed by CAP–88 for the calculation of the collective population dose. LANL has been using a population data file that was prepared based on the 1990 Census (DOC 1991). A new population data file was prepared by the University of Nevada (UN) in 1995, using data from the New Mexico Bureau of Business and Economic Research (BBER 1995). The UN data file was used for all CAP–88 population runs, consistent with the socioeconomic data used for the SWEIS. There are no significant differences between the LANL data file and the UN data file.

The input parameters described above were input into the CAP–88 model to generate the estimated radionuclide concentrations and resulting radiation dose equivalents. Various receptors were modeled as bounding estimates. These receptors are discussed individually below.

B.1.1.5 *Facility-Specific Maximally Exposed Individual Doses*

CAP–88 runs were made using each modeled facility's air emissions to determine the CEDE at various locations. The results were examined, and a single point at the LANL boundary where the highest dose occurs was identified. The distance and direction to these points were determined. These points are the locations of the facility-specific MEIs. The distances and directions of all facility-specific MEIs are listed in Table B.1.1.5–1. The distances and directions for all MEIs, with respect to all modeled facilities, are presented in Table B.1.1.4–19, as noted above. The dose commitment from all facility emissions were then calculated for each FS MEI location and summed to provide the total dose at that location. The contribution from each modeled

TABLE B.1.1.4–19.—*Distances (Meters) and Directions Between the Modeled Facilities and the Facility-Specific MEI*

MODELED FACILITY	MEI		TA–3–29 CMR; TA–3–66 SIGMA	TA–48 RADIO-CHEMISTRY LAB; TA–55 PLUTONIUM FACILITY	TA–3–102 MAIN SHOPS	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–53 LANSCE	TA–54 AREA G[a]	TA–54 AREA G[b]	TA–15/36 FIRING SITES	TA–11 HIGH EXPLOSIVES TESTING
	NORTHING	EASTING	1775900	1,773,300	1,775,500	1,758,500	1,763,900	1,775,200	1,774,100	1,758,600	1,754,700	1,766,400	1,757,400
			1,619,600	1,624,900	1,618,100	1,611,100	1,636,900	1,634,200	1,638,700	1,645,600	1,649,200	1,632,900	1,615,100
TA–3–29 (CMR)	1772369	1619014	3,575	5,955	3,265	15,960	19,785	15,455	19,765	29,940	34,975	15,110	15,420
			N	E	NNW	SSW	ESE	E	E	ESE	ESE	ESE	SSW
TA–3–66 (Sigma)	1772352	1619258	3,560	5,725	3,345	16,075	19,570	15,205	19,520	29,710	34,760	14,880	15,520
			N	E	NW	SW	ESE	E	E	ESE	ESE	ESE	SSW
TA–3–102 (Shops)	1772127	1618300	3,990	6,710	3,380	15,420	20,340	16,190	20,490	30,460	35,480	15,680	15,075
			NNE	E	N	SSW	ESE	E	E	ESE	ESE	ESE	SSW
TA–16 (Tritium Facility)	1760866	1609447	18,145	19,835	16,995	2,885	27,625	28,610	32,105	36,220	40,225	24,100	6,625
			NE	NE	NNE	SSE	ESE	ENE	ENE	ESE	ESE	ENE	ESE
TA–18 (Pajarito Site)	1761900	1634900	20,735	15,155	21,620	24,050	2,820	13,320	12,780	11,205	16,010	4,920	20,310
			NW	NW	NW	W	NE	N	NNE	ESE	ESE	NNW	W
TA–21 (Tritium Facility)	1774175	1633991	14,500	9,135	15,940	27,730	10,675	1,050	4,705	19,420	24,700	7,855	25,255
			W	W	W	WSW	SSE	N	E	SE	SE	S	SW
TA–48 (Radiochemistry Laboratory)	1770639	1623684	6,660	2,920	7,395	17,480	14,825	11,465	15,400	24,995	30,080	10,135	15,775
			NW	NNE	NW	SW	ESE	ENE	E	ESE	SE	ESE	SW
TA–53 (LANSCE)	1771546	1638133	19,025	13,350	20,420	30,010	7,740	5,365	2,625	14,940	20,155	7,345	27,025
			WNW	W	WNW	WSW	SSE	NW	NNE	SSE	SSE	SW	WSW
TA–54 (Area G)	1757700	1644800	31,080	25,270	32,080					1,195			
			NW	NW	NW	W	NW	NNW	NNW	NE	SE	NW	W
TA–55 (Plutonium Facility)	1769609	1624860	8,200	3,690	33,700	17,680	13,315	10,890	14,545	23,470	28,535	8,660	15,630
			NW	N	NW	SW	ESE	ENE	ENE	ESE	ESE	ESE	SW
TA–15/36 (Firing Sites)	1759700	1629700	19,090	14,415	19,600	18,630	8,330	16,140	16,975	15,940	20,125	7,415	14,775
			NNW	NNW	NW	W	ENE	ENE	NE	ESE	ESE	NE	W

TABLE B.1.1.4–19.—*Distances (Meters) and Directions Between the Modeled Facilities and the Facility-Specific MEI*-Continued

MODELED FACILITY	MEI		TA–3–29 CMR; TA–3–66 SIGMA	TA–48 RADIO-CHEMISTRY LAB; TA–55 PLUTONIUM FACILITY	TA–3–102 MAIN SHOPS	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–53 LANSCE	TA–54 AREA G[1]	TA–54 AREA G[2]	TA–15/36 FIRING SITES	TA–11 HIGH EXPLOSIVES TESTING
TA–11 (High Explosives Testing)	1761700	1615300	14,825	15,055	14,070	5,280	21,715	23,220	26,470	30,455	34,605	18,205	4,300
			NNW	NE	NNW	SW	E	NE	ENE	ESE	ESE	ENE	S

Note: This table identifies the distance and direction from each modeled facility to each facility's MEI. These values were used as input parameters for CAP–88 model runs and to calculate the dose contribution from each modeled facility to each MEI. As an example, the LANSCE MEI is located about 4,705 feet east of TA–21. Northings and Eastings in the first two rows pertain to the MEIs; Northings and Eastings in the columns pertain to the modeled facilities.

[a] Hypothetical site at boundary of LANL and San Ildefonso Pueblo.

[b] Actual MEI in the town of White Rock.

TABLE B.1.1.5–1.—*Distance and Directions to Facility-Specific Maximally Exposed Individuals*

FACILITY	MEI DISTANCE FEET (METERS)	DIRECTION
TA–3–29 (CMR)	3,575 (1,090)	North
TA–3–66 (Sigma Building)	3,560 (1,085)	North
TA–3–102 (Machine Shops)	3,380 (1,030)	North
TA–11 (High Explosives Testing)	4,300 (1,310)	South
TA–15/36 (Firing Sites)	7,415 (2,260)	Northeast
TA–16 (WETF)	2,885 (880)	South-Southeast
TA–18 (Pajarito Site: LACEF)	2,820 (860)	Northeast
TA–21 (TSTA and TSFF)	1,050 (320)	North
TA–48 (Radiochemistry Laboratory)	2,920 (890)	North-Northeast
TA–53 (LANSCE)	2,625 (800)	North-Northeast
TA–54 (Area G)	1,195 (365)	Northeast—LANL Boundary
	5,330 (1,625)	Southeast—White Rock
TA–55 (Plutonium Facility)	3,690 (1,125)	North

Note: This table lists the facility-specific MEI location from each modeled facility. These data are also contained in Table B.1.1.4–19.

facility to each MEI was calculated for each of the four SWEIS alternatives.

The MEI locations do not necessarily represent actual residences or individuals. They are merely points at the LANL boundary where the highest potential dose occurs. Some points at the LANL boundary do have residences close to them. This is especially true for those TAs located in the northern part of the LANL site, such as TA–3 and TA–53.

Two FS MEI locations were considered for Area G because it borders San Ildefonso Pueblo land. The first location is at the LANL boundary, 1,197 feet (365 meters) northeast of Area G next to San Ildefonso land. No one currently lives in that location. The second location is in the town of White Rock, approximately 5,331 feet (1,625 meters) southeast of Area G.

Some modeled facilities share the same MEI location. TA–3–29 (CMR) and TA–3–66 (Sigma) share the same MEI location, as do TA–48 (Radiochemistry Facility) and TA–55 (Plutonium Facility).

B.1.1.6 *LANL Site-Wide Maximally Exposed Individual Dose*

The LANL site-wide MEI dose was determined by examining the total dose to each FS MEI. The FS MEI with the highest total dose is considered to be the LANL site-wide MEI for that alternative. For every FS MEI location, the total dose is the dose contributed by that specific facility, plus any doses contributed by other modeled facilities.

B.1.1.7 *Population Dose*

The dose to the population living within a 50-mile (80-kilometer) radius from LANL was calculated by CAP–88 using the UN population data prepared from BBER data (BBER 1995). For each modeled facility, a population run was made for each of the four alternatives. The results from each modeled facility for each alternative were added to obtain the total population dose for that alternative.

B.1.1.8 *Isodose Maps*

Isodose maps (maps showing lines of equal dose) were generated for the region within a 50-mile (80-kilometer) radius from LANL. The isodose maps show contour lines representing the annual individual dose at the points where the lines pass through. Four CAP–88 runs were made for each emission source for each alternative in order to generate data points sufficient to create the isodose maps. The following distances (in meters) were introduced as an input to CAP–88 runs to generate these maps:

- *Run No. 1*—300, 400, 500, 600, 700, 800, 900, 1,000, 1,100, 1,200, 1,300, 1,400, 1,500, 1,600, 1,800, 2,000, 2,200, 2,400, 2,600, and 2,800
- *Run No. 2*—3,000, 3,200, 3,400, 3,600, 3,800, 4,000, 4,200, 4,400, 4,600, 4,800, 5,000, 5,500, 6,000, 6,500, 7,000, 7,500, 8,000, 8,500, 9,000, and 9,500
- *Run No. 3*—10,000, 11,000, 12,000, 13,000, 14,000, 15,000, 16,000, 17,000, 18,000, 19,000, 20,000, 22,000, 24,000, 26,000, 28,000, 30,000, 32,000, 34,000, 36,000, and 38,000
- *Run No. 4*—40,000, 42,000, 44,000, 46,000, 48,000, 50,000, 52,000, 54,000, 56,000, 58,000, 60,000, 62,000, 64,000, 66,000, 68,000, 70,000, 72,500, 75,000, 77,500, and 80,000

Dose calculations were made at each distance in 16 directions around the emission source for each alternative. The results were then used to generate the isodose maps using GIS overlays. The results of the runs for all emission sources were summed to obtain the isodose maps for all of LANL operations. Two sets of isodose maps were generated. The first set of four maps (one map per alternative) covers the region around LANL with an average individual dose higher than 1 millirem per year. The second set of four maps (one map per alternative) covers the rest of the 50-mile (80-kilometer) region where average individual doses were less than 1 millirem per year.

B.1.2 Results of Consequence Analyses

B.1.2.1 *Doses to Facility-Specific Maximally Exposed Individuals*

For each FS MEI, the total dose at the MEI location was calculated by adding the contributions from each modeled facility. The highest dose for an alternative is the LANL MEI for that alternative.

The contribution of each modeled facility to the FS MEIs for the four SWEIS alternatives are included in Tables B.1.2.1–1 through B.1.2.1–4. The totals shown on these tables are summarized in Table B.1.2.1–5.

B.1.2.2 *Dose to the LANL Site-Wide Maximally Exposed Individual*

As noted above, the LANL site-wide MEI is determined by identifying the FS MEI with the highest total dose. The location of and modeled dose to the LANL site-wide MEI for each alternative is summarized in Table B.1.2.2–1.

The NESHAP requires that the dose resulting from air emissions to the LANL MEI not exceed 10 millirem per year. As shown in Table B.1.2.2–1, this regulatory limit would not be exceeded under any of the SWEIS alternatives. In fact, the highest MEI dose was 5.44 millirem per year for the Expanded Operations Alternative, which is 54.4 percent of the

TABLE B.1.2.1–1.—*Doses to Facility-Specific MEIs from LANL Operations for the No Action Alternative (millirems per year)*

MEI SOURCE	TA–3–29/ TA–3–66 CMR AND SIGMA	TA–3–102 SHOPS	TA–11 HIGH EXPLOSIVES	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–48/55 RADIO-CHEMISTRY LABORATORY AND PLUTONIUM FACILITY	TA–53 LANSCE[a]	TA–54 AREA G (LANL BOUNDARY)	TA–54 AREA G (WHITE ROCK)	TA–15/36 FIRING SITES
TA–3–29 (CMR)	6.43E-02	4.67E-02	4.16E-03	3.93E-03	1.12E-02	1.48E-02	5.51E-02	1.12E-02	1.12E-03	5.12E-03	1.60E-02
TA–3–66 (Sigma)	3.41E-02	2.29E-02	2.30E-03	2.14E-03	6.62E-03	8.42E-03	2.96E-02	6.64E-03	3.74E-03	3.08E-03	9.28E-03
TA–3–102 (Shops)	2.93E-03	1.98E-03	1.72E-04	1.59E-04	4.79E-04	6.35E-04	3.04E-03	4.83E-04	2.62E-04	2.11E-04	6.98E-04
TA–11 (High Explosives Testing)	3.14E-06	4.56E-06	3.41E-05	1.26E-05	3.02E-06	2.25E-06	4.15E-06	1.90E-06	1.87E-06	1.38E-06	3.63E-06
TA–15/36 (Firing Sites)	1.04E-01	7.71E-02	1.21E-01	8.40E-02	1.05E+00	3.27E-01	1.62E-01	3.17E-01	4.24E-01	2.40E-01	1.16E+00
TA–16 (Tritium Facility)	1.68E-02	1.78E-02	8.18E-02	1.44E-01	1.32E-02	1.19E-02	1.54E-02	8.08E-03	7.01E-03	5.88E-03	1.41E-02
TA–18 (Pajarito Site)	3.50E-04	3.39E-04	5.41E-04	3.04E-04	8.63E-02	2.76E-03	6.90E-04	5.49E-03	1.42E-02	7.98E-03	7.30E-03
TA–21 (Tritium Facility)	4.72E-02	4.47E-02	4.04E-02	3.62E-02	1.07E-01	6.50E-01	1.56E-01	3.66E-01	5.33E-02	4.43E-02	2.53E-01
TA–48 (Gram calculation)	1.88E-04	1.58E-04	5.51E-05	4.25E-05	2.20E-04	2.06E-04	1.01E-03	1.73E-04	1.19E-04	8.99E-05	3.44E-04
TA–48 (LANL calculation)	1.53E-01	1.17E-01	5.05E-02	3.71E-02	2.20E-01	2.12E-01	1.22E+00	1.66E-01	1.02E-01	7.67E-02	3.60E-01
TA–53 Diffuse	7.27E-05	6.47E-05	5.06E-05	3.28E-05	2.84E-03	2.52E-03	2.43E-04	4.48E-02	4.88E-04	2.59E-04	2.29E-03
ES–2	2.53E-03	2.21E-03	1.75E-03	1.10E-03	1.07E-01	8.55E-02	8.71E-03	1.34E+00	1.87E-02	9.78E-03	8.17E-02
ES–3	4.61E-03	4.25E-03	3.54E-03	2.38E-03	1.20E-01	8.63E-02	1.40E-02	7.50E-01	2.75E-02	1.56E-02	9.46E-02
IPF–2	8.02E-05	7.12E-05	5.65E-05	3.47E-05	3.55E-03	2.52E-03	2.80E-04	3.00E-02	6.63E-04	3.52E-04	2.69E-03
LEDA	1.27E-04	1.28E-04	9.73E-05	7.32E-05	6.04E-04	4.41E-04	2.06E-04	2.12E-03	2.63E-04	1.95E-04	5.29E-04
TA–54 (Area G)	4.36E-04	4.00E-04	5.40E-04	2.11E-04	3.11E-03	6.04E-04	5.37E-04	6.46E-04	8.90E-02	2.21E-02	6.52E-04
TA–55 (Plutonium Facility)	1.45E-01	1.32E-01	2.69E-02	2.51E-02	9.05E-02	9.54E-02	3.37E-01	6.17E-02	5.18E-02	4.27E-02	2.59E-01
Total	0.58	0.47	0.33	0.34	1.82	1.50	2.00	3.11	0.08	0.47	2.26

[a] This is also the LANL site-wide MEI because it has the highest dose among the facility-specific MEIs.

TABLE B.1.2.1–2.—*Doses to Facility-Specific MEIs from LANL Operations for the Expanded Operations Alternative (millirems per year)*

MEI SOURCE	TA–3–29/ TA–3–66 CMR AND SIGMA	TA–3–102 SHOPS	TA–11 HIGH EXPLOSIVES	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–48/55 RADIO-CHEMISTRY LABORATORY AND PLUTONIUM FACILITY	TA–53 LANSCE[a]	TA–54 AREA G (LANL BOUNDARY)	TA–54 AREA G (WHITE ROCK)	TA–15/36 FIRING SITES
TA–3–29 (CMR)	4.95E-01	3.86E-01	4.13E-02	3.98E-02	9.00E-02	1.11E-01	4.22E-01	9.00E-02:	5.70E-02	4.38-02	1.19E-01
TA–3–66 (Sigma)	1.02E-01	6.87E-02	6.90E-03	6.43E-03	1.99E-02	2.53E-02	8.89E-02	1.99E-02	1.12E-02	9.23E-03	2.78E-02
TA–3–102 (Shops)	8.36E-03	9.33E-03	5.97E-04	5.14E-04	1.35E-03	1.76E-03	6.93E-03	1.35E-03	7.60E-04	6.14E-04	1.92E-03
TA–11 (High Explosives Testing)	1.03E-05	1.14E-05	8.52E-05	3.16E-05	7.54E-06	5.62E-06	1.04E-05	4.76E-06	4.68E-06	3.46E-06	9.08E-06
TA–15/36 (Firing Sites)	3.13E-01	2.31E-01	3.64E-01	2.52E-01	3.15E+00	9.8lE-01	4.86E-01	9.52E-01	1.27E+00	7.20E-01	3.48E+00
TA–16 (Tritium Facility)	3.36E-02	3.56E-02	1.64E-01	2.87E-01	2.65E-02	2.38E-02	3.07E-02	1.62E-02	1.40E-02	1.18E-02	2.81E-02
TA–18 (Pajarito Site)	4.37E-04	4.24E-04	6.76E-04	3.80E-04	1.08E-01	3.45E-03	8.63E-04	6.86E-03	1.77E-02	9.98E-03	9.13E-03
TA–21 (Tritium Facility)	4.72E-02	4.47E-02	4.04E-02	3.62E-02	1.07E-01	6.50E-0I	1.56E-01	3.66E-01	5.33E-02	4.43E-02	2.53E-01
TA–48 (GRAM calculation)	3.23E-04	2.66E-04	9.75E-05	7.39E-05	4.09E-04	3.88E-04	1.83E-03	3.19E-04	2.18E-04	1.64E-04	6.33E-04
TA–48 (LANL calculation)	3.07E-01	2.33E-01	1.01E-01	7.42E-02	4.40E-01	4.24E-01	2.43E+00	3.32E-01	2.03E-01	1.53E-01	7.2lE-01
TA–53 Diffuse	9.08E-05	8.09E-05	6.33E-05	4.10E-05	3.55E-03	3.15E-03	3.04E-04	5.60E-02	6.10E-04	3.24E-04	2.86E-03
ES–2	3.16E-03	2.76E-03	2.19E-03	1.37E-03	1.33E-01	1.07E-01	1.09E-02	1.68E+00	2.33E-02	1.22E-02	1.02E-01
ES–3	1.15E-02	1.06E-02	8.85E-03	5.95E-03	2.99E-01	2.16E-01	3.49E-02	1.88E+00	6.89E-02	3.89E-02	2.37E-01
IPF–2	1.00E-04	8.90E-05	7.07E-05	4.34E-05	4.44E-03	3.15E-03	3.50E-04	3.75E-02	8.28E-04	4.40E-04	3.36E-03
LEDA	1.27E-04	1.28E-04	9.73E-05	7.32E-05	6.04E-04	4.41E-04	2.06E-04	2.12E-03	2.63E-04	1.95E-04	5.29E-04
TA–54 (Area G)	4.36E-04	4.00E-04	5.40E-04	2.11E-04	3.11E-03	6.04E-04	5.37E-04	6.46E-04	8.90E-02	2.21E-02	6.52E-04
TA–55 (Plutonium Facility)	1.48E-02	1.37E-02	2.88E-03	2.68E-03	1.01E-02	1.05E-02	3.67E-02	6.90E-03	5.74E-03	4.67E-03	2.80E-02
Total	1.32	1.02	0.73	0.70	4.39	2.55	3.67	5.44	1.81	1.07	4.99

[a] This is also the LANL site-wide MEI because it has the highest dose among the facility-specific MEIs.

TABLE B.1.2.1–3.—*Doses to Facility-Specific MEIs from LANL Operations for the Reduced Operations Alternative (millirems per year)*

MEI SOURCE	TA–3–29/ TA–3–66 CMR AND SIGMA	TA–3–102 SHOPS	TA–11 HIGH EXPLOSIVES	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–48/55 RADIO-CHEMISTRY LABORATORY AND PLUTONIUM FACILITY	TA–53 LANSCE	TA–54 AREA G (LANL BOUNDARY)	TA–54 AREA G (WHITE ROCK)	TA–15/36 FIRING SITES[a]
TA–3–29 (CMR)	5.79E-02	4.20E-02	3.75E-03	3.54E-03	1.00E-02	1.33E-02	4.96E-02	1.01E-02	5.68E-03	4.61E-03	1.44E-02
TA–3–66 (Sigma)	3.41E-02	2.29E-02	2.30E-03	2.14E-03	6.62E-03	8.42E-03	2.96E-02	6.64E-03	3.74E-03	3.08E-03	9.28E-03
TA–3–102 (Shops)	2.79E-03	3.11E-03	1.99E-04	1.71E-04	4.48E-04	5.86E-04	2.31E-03	4.50E-04	2.53E-04	2.05E-04	6.40E-04
TA–11 (High Explosives Testing)	2.48E-06	2.74E-06	2.04E-05	7.58E-06	1.81E-06	1.35E-06	2.49E-06	1.14E-06	1.12E-06	8.30E-07	2.18E-06
TA–15/36 (Firing Sites)	1.04E-01	7.71E-02	1.21E-01	8.40E-02	1.05E+00	3.27E-01	1.62E-01	3.17E-01	4.24E-01	2.40E-01	116E+00
TA–16 (Tritium Facility)	1.97E-02	2.12E-02	1.08E-01	6.91E-02	1.60E-02	1.37E-02	1.95E-02	1.27E-02	1.18E-02	8.21E-03	1.79E-02
TA–18 (Pajarito Site)	3.50E-04	3.39E-04	5.41E-04	3.04E-04	8.63E-02	2.76E-03	6.90E-04	5.49E-03	1.42E-02	7.98E-03	7.30E-03
TA–21 (Tritium Facility)	4.72E-02	4.47E-02	4.04E-02	3.62E-02	1.07E-01	6.50E-01	1.56E-01	3.66E-01	5.33E-02	4.43E-02	2.53E-01
TA–48 (GRAM calculation)	1.56E-04	1.28E-04	4.72E-05	3.55E-05	1.98-04	1.86E-04	8.97E-04	1.54E-04	1.06E-04	7.98E-05	3.06E-04
TA–48 (LANL calculation)	7.66E-02	5.83E-02	2.53E-02	1.85E-02	1.10E-01	1.06E-01	6.08E-01	8.31E-02	5.08E-02	3.84E-02	1.80E-01
TA–53 Diffuse	3.63E-05	3.24E-05	2.53E-05	1.64E-05	1.42E-03	1.26E-03	1.22E-04	2.24E-02	2.44E-04	1.30E-04	1.14E-03
ES–2	1.23E-03	1.08E-03	8.52E-04	5.32E-04	5.18E-02	4.15E-02	4.23E-03	6.52E-01	9.07E-03	4.75E-03	3.98E-02
ES–3	2.31E-03	2.12E-03	1.77E-03	1.19E-03	5.99E-02	4.32E-02	6.98E-03	3.75E-01	1.38E-02	7.78E-03	4.73E-02
IPF–2	4.01E-05	3.56E-05	2.83E-05	1.74E-05	1.78E-03	1.26E-03	1.40E-04	1.50E-02	3.31E-04	1.76E-04	1.34E-03
LEDA	1.27E-04	1.28E-04	9.73E-05	7.32E-05	6.04E-04	4.41E-04	2.06E-04	2.12E-03	2.63E-04	1.95E-04	5.29E-04
TA–54 (Area G)	4.36E-04	4.00E-04	5.40E-04	2.11E-04	3.11E-03	6.04E-04	5.37E-04	6.46E-04	8.90E-02	2.2E-02	6.52E-04
TA–55 (Plutonium Facility)	1.46E-02	1.37E-02	2.73E-03	2.56E-03	9.41E-03	9.80E-03	3.47E-02	6.39E-03	5.36E-03	4.39E-03	2.60E-02
Total	0.36	0.29	0.31	0.22	1.51	1.22	1.08	1.88	0.68	0.39	1.76

Note: 6.43E-02 = 6.43×10^{-2}

[a] This is also the LANL site-wide MEI because it has the highest dose among the facility-specific MEIs.

TABLE B.1.2.1–4.—*Doses to Facility-Specific MEIs from LANL Operations for the Greener Alternative (millirems per year)*

MEI SOURCE	TA–3–29/ TA–3–66 CMR AND SIGMA	TA–3–102 SHOPS	TA–11 HIGH EXPLOSIVES	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–48/55 RADIO-CHEMISTRY LABORATORY AND PLUTONIUM FACILITY	TA–53 LANSCE[a]	TA–54 AREA G (LANL BOUNDARY)	TA–54 AREA G (WHITE ROCK)	TA–15/36 FIRING SITES
TA–3–29 (CMR)	6.43E-02	4.67E-02	4.16E-03	3.93E-03	1.12E-02	1.48-02	5.51E-02	1.12E-02	6.31E-03	5.12E-03	1.60E-02
TA–3–66 (Sigma)	3.41E-02	2.29E-02	2.30E-03	2.14E-03	6.62E-03	8.42E-03	2.96E-02	6.64E-03	3.74E-03	3.08E-03	9.28E-03
TA–3–102 (Shops)	2.79E-03	3.11E-03	1.99E-04	1.71E-04	4.48E-04	5.86E-04	2.31E-03	4.50E-04	2.53E-04	2.05E-04	6.40E-04
TA–11 (High Explosives Testing)	2.48E-06	2.74E-06	2.04E-05	7.58E-06	1.81E-06	1.35E-06	2.49E-06	1.14E-06	1.12E-06	8.30E-07	2.18E-06
TA–15/36 (Firing Sites)	1.04E-01	7.71E-02	1.21E-01	8.40E-02	1.05E+00	3.27E-01	1.62E-01	3.17E-01	4.24E-01	2.40E-01	1.16E+00
TA–16 (Tritium Facility)	1.68E-02	1.78E-02	8.18E-02	1.44E-01	1.32E-02	1.19E-02	1.54E-02	8.08E-03	7.01E-03	5.88E-03	1.41E-02
TA–18 (Pajarito Site)	3.50E-04	3.39E-04	5.41E-04	3.04E-04	8.63E-02	2.76E-03	6.90E-04	5.49E-03	1.42E-02	7.98E-03	7.30E-03
TA–21 (Tritium Facility)	4.72E-02	4.47E-02	4.04E-02	3.62E-02	1.07E-01	6.50E-01	1.56E-01	3.66E-01	5.33E-02	4.43E-02	2.53E-01
TA–48 (GRAM calculation)	3.13E-04	2.56E-04	9.63E-05	7.22E-05	4.05E-04	3.78E-04	1.81E-03	3.12E-04	2.12E-04	1.62E-04	6.22E-04
TA–48 (LANL calculation)	1.53E-01	1.17E-01	5.05E-02	3.71E-02	2.20E-01	2.12E-01	1.22E+00	1.66E-01	1.02E-01	7.67E-02	3.60E-01
TA–53 Diffuse	9.08E-05	8.09E-05	6.33E-05	4.10E-05	3.55E-03	3.15E-03	3.04E-04	5.60E-02	6.10E-04	3.24E-04	2.86E-03
ES–2	3.16E-03	2.76E-03	2.19E-03	1.37E-03	1.33E-01	1.07E-01	1.09E-02	1.68E+00	2.33E-02	1.22E-02	1.02E-01
ES–3	1.15E-02	1.06E-02	8.85E-03	5.95E-03	2.99E-01	2.16E-01	3.49E-02	1.88E+00	6.89E-02	3.89E-02	2.37E-01
IPF–2	I.00E-04	8.90E-05	7.07E-05	4.34E-05	4.44E03	3.15E-03	3.50E-04	3.75E-02	8.28E-04	4.40E-04	3.36E-03
LEDA	1.27E-04	1.28E-04	9.73E-05	7.32E-05	6.04E-04	4.41E-04	2.06E-04	2.12E-03	2.63E-04	1.95E-04	5.29E-04
TA–54 (Area G)	4.36E-04	4.00E-04	5.40E-04	2.11E-04	3.11E-03	6.04E-04	5.37E-04	6.46E-04	8.90E-02	2.21E-02	6.52E-04
TA–55 (Plutonium Facility)	1.48E-02	1.37E-02	2.80E-03	2.61E-03	9.74E-03	1.02E-02	3.57E-02	6.64E-03	5.53E-03	4.51E-03	2.70E-02
Total	0.35	0.28	0.31	0.31	1.93	1.54	1.64	4.52	0.79	0.45	2.17

[a] This is also the LANL site-wide MEI because it has the highest dose among the facility-specific MEIs.

TABLE B.1.2.1–5.—*Total Doses to the Facility-Specific Maximally Exposed Individuals from LANL Operations (millirems per year)*

MEI ALTERNATIVE	TA–3–29 CMR; TA–3–66 SIGMA	TA–3–102 MACHINE SHOPS	TA–11 HIGH EXPLOSIVES TESTING	TA–16 TRITIUM FACILITY	TA–18 PAJARITO SITE	TA–21 TRITIUM FACILITY	TA–48 RADIO-CHEMISTRY LABORATORY TA–55 PLUTONIUM FACILITY	TA–53 LANSCE	TA–54 AREA-G (LANL BOUNDARY)	TA–54 AREA-G (WHITE ROCK)	TA–15/36 FIRING SITES
No Action	0.43	0.34	0.31	0.31	1.73	1.41	1.66	3.11	0.75	0.43	2.26
Expanded Operations	1.32	1.02	0.73	0.70	4.39	2.55	3.67	5.44	1.81	1.07	4.99
Reduced Operations	0.36	0.29	0.31	0.22	1.51	1.22	1.08	1.88	0.68	0.39	1.76
Greener	0.35	0.28	0.31	0.31	1.93	1.54	1.64	4.52	0.79	0.45	2.17

TABLE B.1.2.2–1.—*Doses to the LANL Site-Wide Maximally Exposed Individual for Each of the SWEIS Alternatives*

ALTERNATIVE	DOSE (mrem/yr)	PERCENT OF NESHAP LIMIT	LOCATION
No Action	3.11	31.1	2,625 feet (800 meters) north-northeast of LANSCE
Expanded Operations	5.44	54.4	2,625 feet (800 meters) north northeast of LANSCE
Reduced Operations	1.88	18.8	2,625 feet (800 meters) north northeast of LANSCE
Greener	4.52	45.2	2,625 feet (800 meters) north-northeast of LANSCE

NESHAP = National Emissions Standards for Hazardous Air Pollutants (40 CFR 61, Subpart H).

regulatory limit. The LANL MEI is the LANSCE FS MEI under all alternatives.

B.1.2.3 *Collective Population Dose*

The collective dose to the population living within a 50-mile (80-kilometer) radius from LANL has been calculated for emissions from all modeled facilities. The population doses from each source for all four alternatives are presented in Table B.1.2.3–1, while the total collective population doses for the four SWEIS alternatives are presented in Table B.1.2.3–2.

An examination of Table B.1.2.3–1 reveals that most of the population dose comes from emissions from the Firing Sites. The Firing Sites emit long-lived uranium isotopes that can travel long distances without any significant decay. The emissions from LANSCE are mainly short-lived activation products that decay away in a matter of minutes or even seconds. Thus, the LANSCE emissions are important contributors to doses to individuals near LANL, but these emissions are less important to the doses for individuals farther away from LANL.

TABLE B.1.2.3–1.—*Collective Population Dose to Residents Within a 50-mile Radius from LANL (person-rem/year)*

	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
CMR	0.195	1.76	0.1755	0.195
Sigma	0.122	0.366	0.122	0.122
TA–11 (HE)	0.0000817	0.000204	0.000049	0.000049
TA–16 (Tritium)	0.276	0.552	0.276	0.276
TA–18	0.0720	0.900	0.0720	0.0720
TA–21 (Tritium)	0.977	0.977	0.977	0.977
Main Shops	0.0101	0.0303	0.0101	0.0101
TA–48 (GRAM)	0.00267	0.00508	0.00244	0.0051
TA–48 (LANL)	3.03	6.06	1.515	3.03
TA–55	0.81	0.0934	0.0845	0.0884
TA–15/–36 (Firing Sites)	7.07	21.21	7.07	7.07
TA–53				
ES–3	0.538	1.345	0.269	1.345
ES–2	0.429	0.536	0.209	0.536
LEDA	0.00327	0.00327	0.00327	0.00327
IPF–2	0.0145	0.0181	0.0073	0.0181
Diffuse	0.0118	0.0148	0.0059	0.0148
TA–54 (Waste Management)	0.0288	0.0288	0.0288	0.0288
Total[a]	13.59	33.09	10.83	13.79

[a] The values reported for population doses for this alternative, as well as the other alternatives, is higher than has been reported in the recent Annual Environmental Reports. It is important to recognize that the alternatives analyzed represent increased operations when compared to recent history. The material throughput at the different facilities under the various alternatives is presented in section 3.6.

TABLE B.1.2.3–2.—*Total Collective Population Doses for Each of the SWEIS Alternatives*

ALTERNATIVE	DOSE (PERSON-REM/YR)
No Action	13.59
Expanded Operations	33.09
Reduced Operations	10.83
Greener	13.79

B.1.2.4 *Isodose Maps*

Individual doses have been calculated for people living within a 50-mile (80-kilometer) radius from LANL. The highest individual dose for an alternative is the dose given to the LANL site-wide MEI for that alternative. For the 50-mile (80-kilometer) region, an individual's doses are shown on the isodose maps in Figures B.1.2.4–1 through B.1.2.4–8. Figures B.1.2.4–1 through B.1.2.4–4 show doses that are more than 1 millirem per year for each of the four alternatives. Only lines that represent a dose larger than 1 millirem per year and extend (at least in part) outside the LANL boundary are shown on the isodose maps. Figures B.1.2.4–5 through B.1.2.4–8 show doses that are less than 1 millirem per year for each alternative. To estimate their doses, individuals need only find their locations on the isodose map and identify the bounding doses nearest that location. A dose of 1 millirem per year is not considered significant

B.1.2.5 *Uncertainties*

There are many factors that introduce uncertainties into the process of projecting future doses to the public from radioactive air emissions from LANL. Some of these factors are listed below.

- The radionuclide emission rates estimated by each modeled facility are based on current knowledge regarding future operations at the facility. However, the level of funding, exact activities, and exact conditions associated with future operations cannot be predicted with certainty. Therefore, the emission rate estimates cannot be viewed as accurate or precise values.
- The LANL site-wide MEI dose is sensitive to the assumptions and operations associated with LANSCE. Procedures are in place to monitor the modeled MEI dose and ensure that the 10 millirem per year limit is not exceeded. Population doses, on the other hand, are more sensitive to the assumptions and operations associated with the Firing Sites. For example, a 25 percent change in uranium use (which is assumed to mean a 25 percent change in uranium emissions) would change the population dose by about 20 percent.
- The parameters introduced into the CAP–88 model cannot be exact, especially the meteorological data. The average meteorology for a 3-year period was used in the modeling, which is a reasonable and good prediction for future years. However, any single, future year could be anomalous, resulting in a collective dose estimate different from that presented in this report. Again, active monitoring and control of atmospheric releases is conducted to ensure that the public dose limits are not exceeded.
- The modeled dose is also very sensitive to the assumed period of exposure. For the purposes of this analysis, the very conservative assumption is made that the MEI is a person who stays in the same location 24 hours a day, 365 days a year. Furthermore, it is assumed that this person is not shielded from the emissions by clothing or shelter (e.g., a building, auto, home, etc.).
- The area source term for TA–54 was calculated from AIRNET monitoring data.

There are uncertainties in those data for tritium in its water vapor form due to a recent discovery that the silica gel samplers are not collecting water with a high efficiency. It is estimated that the underestimation, which is being quantified, will represent only a very small addition to the collective population dose and LANL MEI doses.

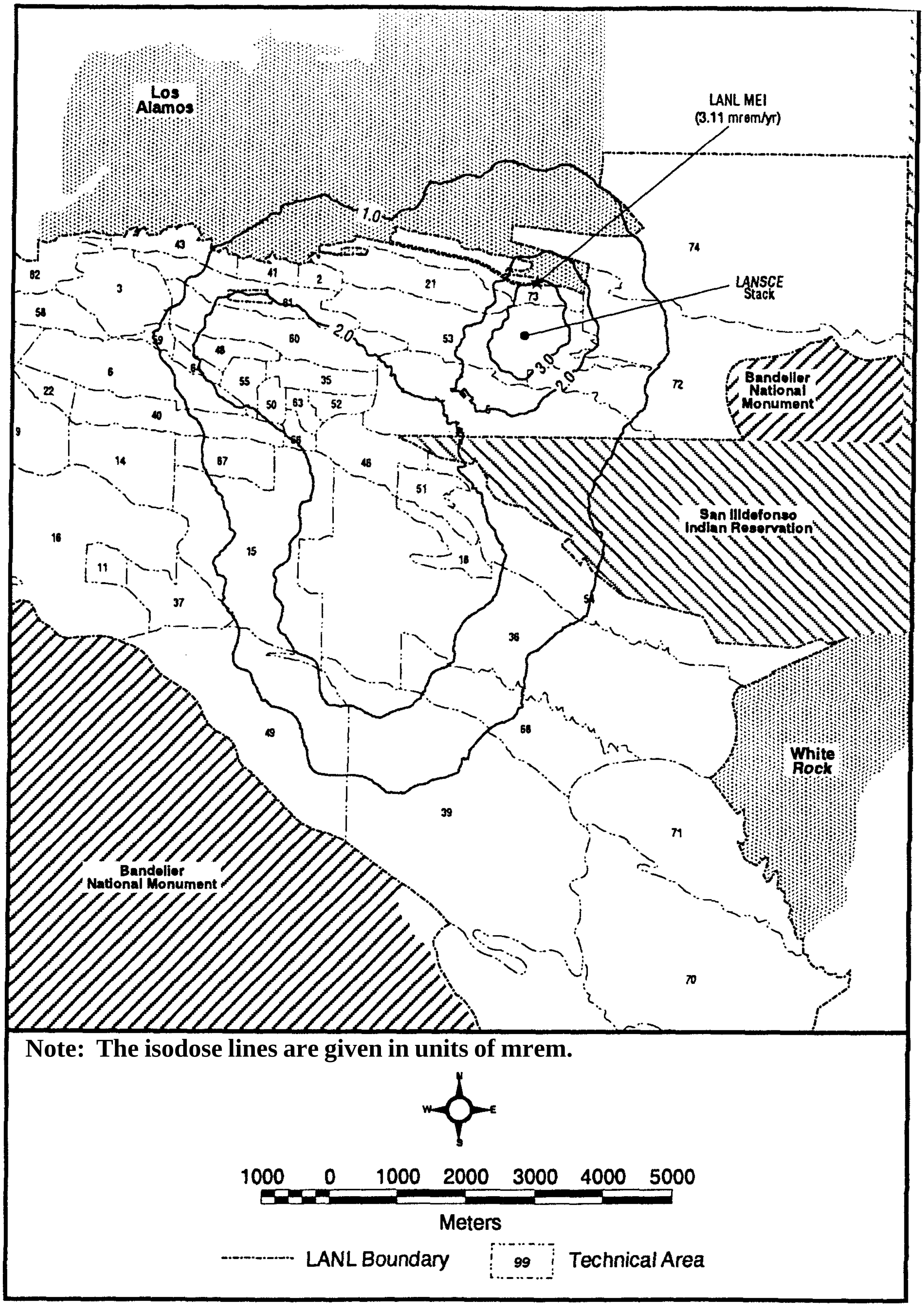
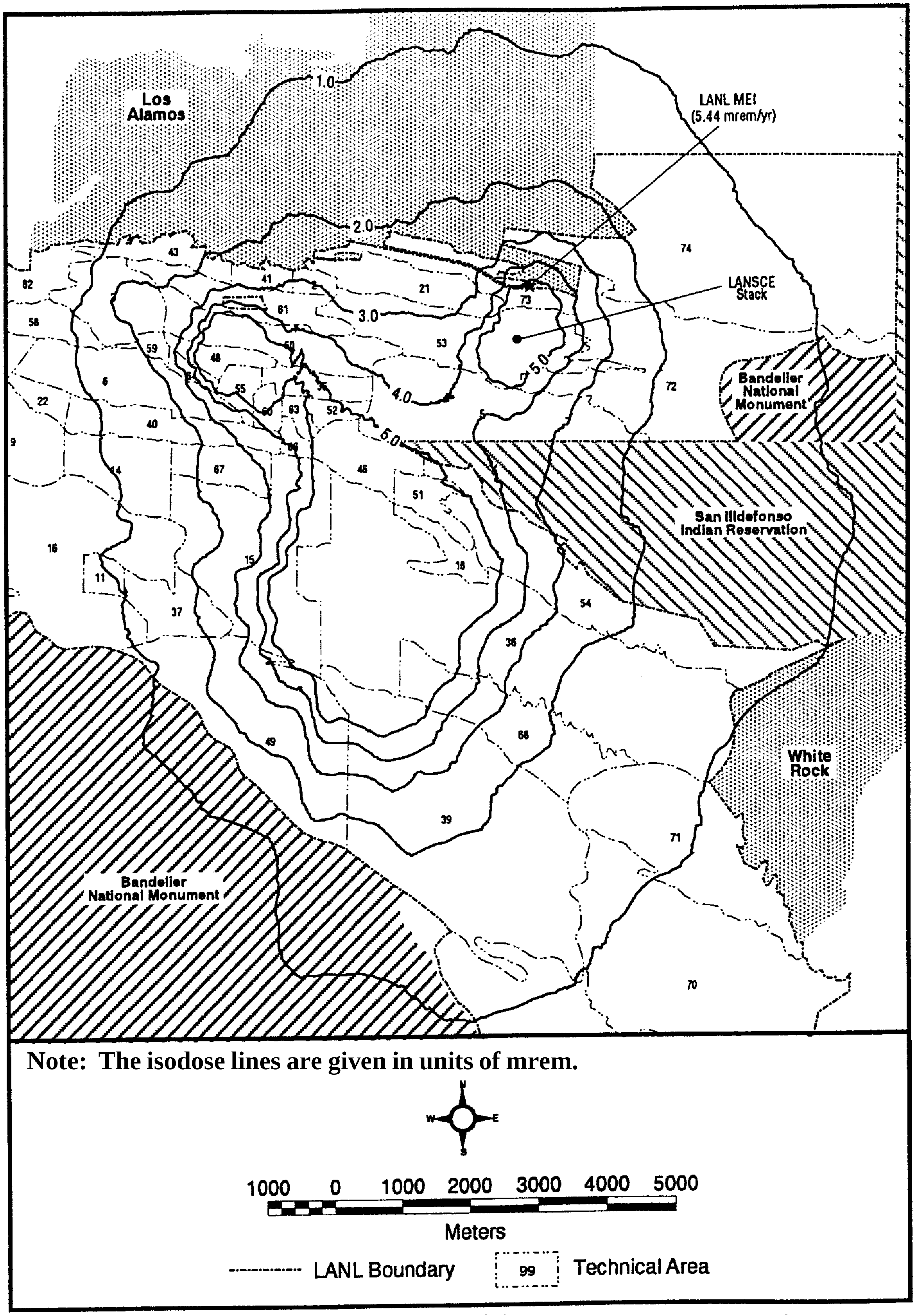


FIGURE B.1.2.4–1.—*Annual Average Individual Doses Higher Than 1 Millirem per Year for the No Action Alternative.*



Note: The isodose lines are given in units of mrem.

FIGURE B.1.2.4–2.—*Annual Average Individual Doses Higher Than 1 Millirem per Year for the Expanded Operations Alternative.*

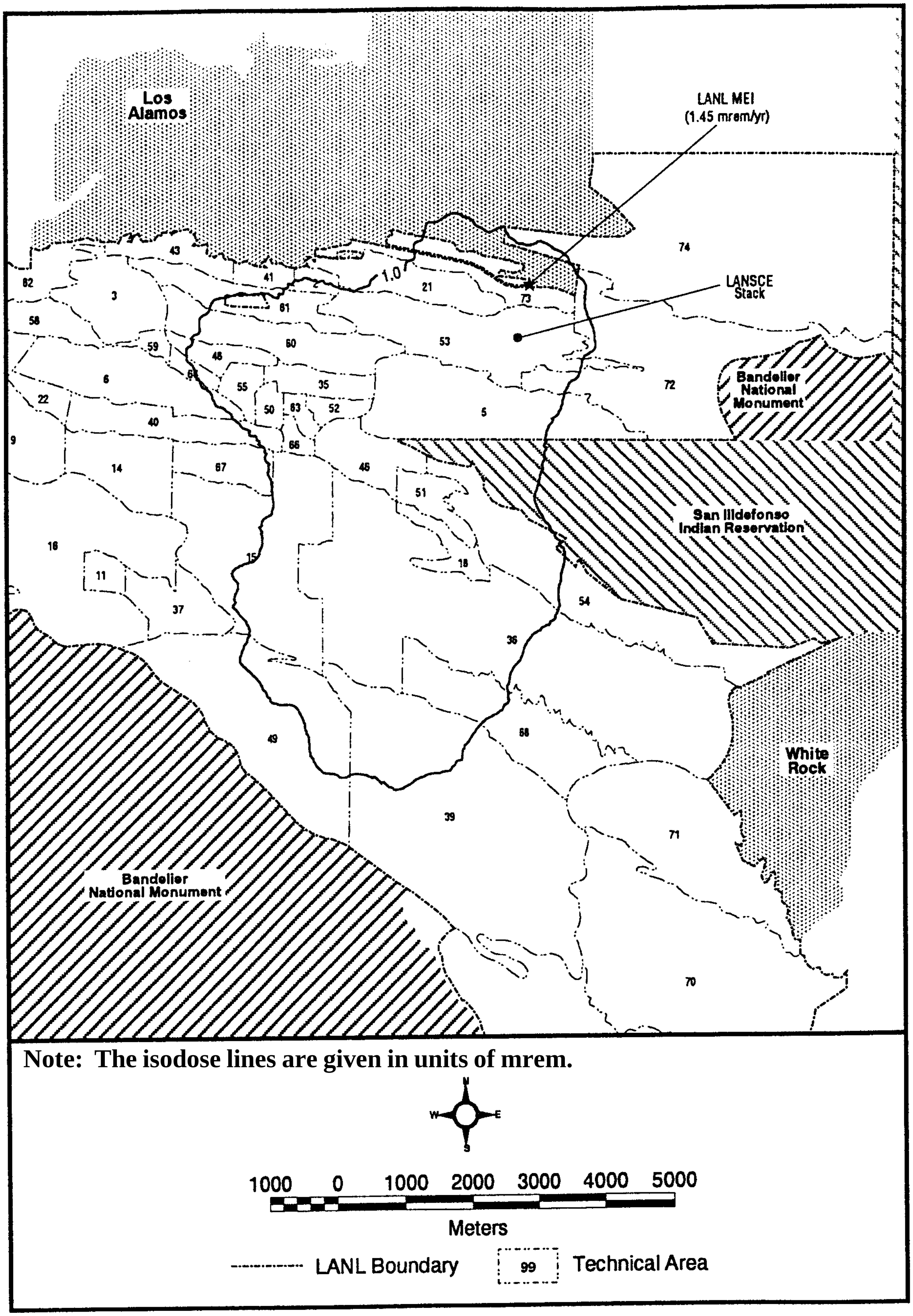


FIGURE B.1.2.4–3.—*Annual Average Individual Doses Higher Than 1 Millirem per Year for the Reduced Operations Alternative.*

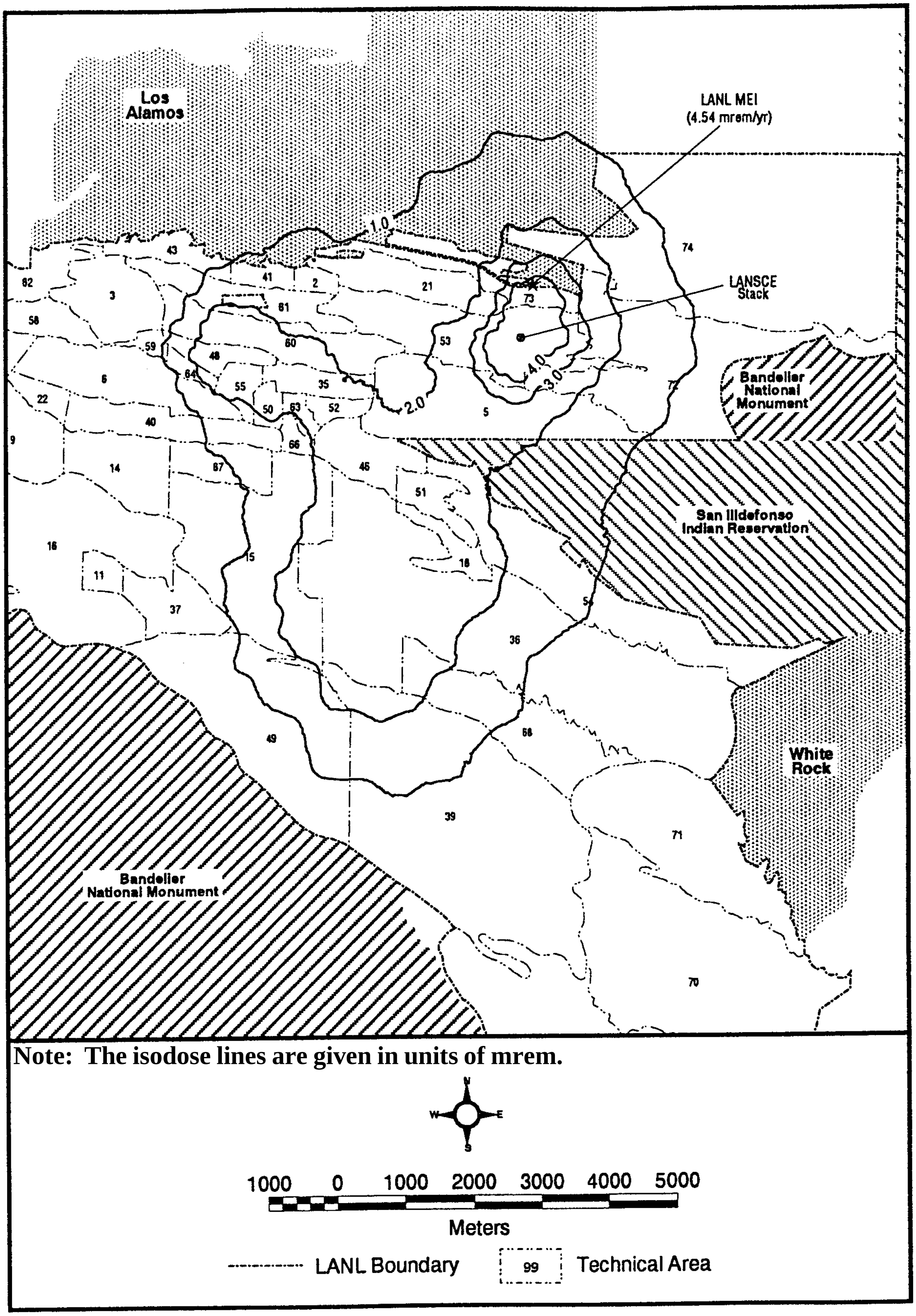


FIGURE B.1.2.4–4.—*Annual Average Individual Doses Higher Than 1 Millirem per Year for the Greener Alternative.*

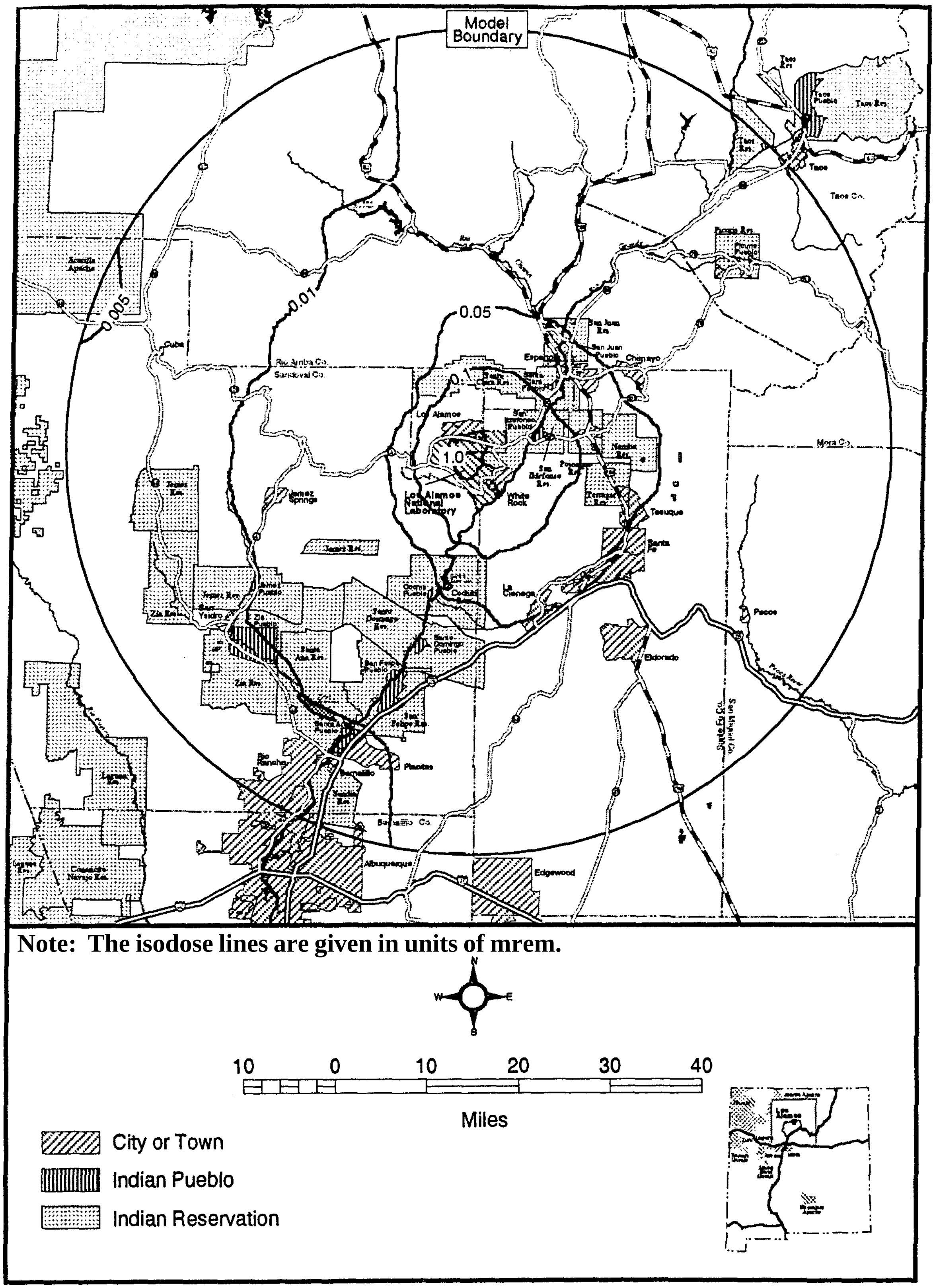
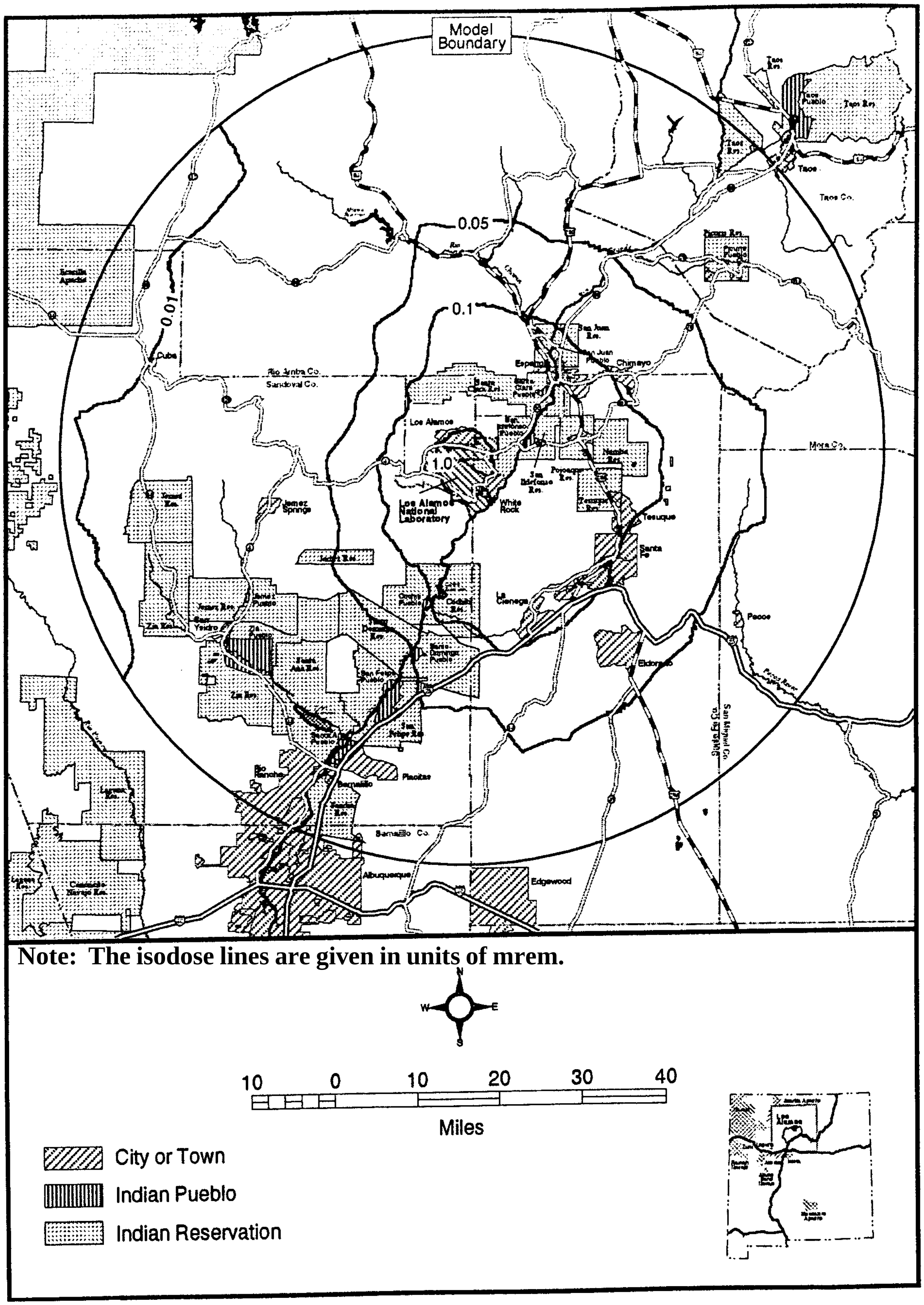


FIGURE B.1.2.4–5.—*Annual Average Individual Doses Less Than 1 Millirem per Year for the No Action Alternative.*



Note: The isodose lines are given in units of mrem.

FIGURE B.1.2.4–6.—*Annual Average Individual Doses Less Than 1 Millirem per Year for the Expanded Operations Alternative.*

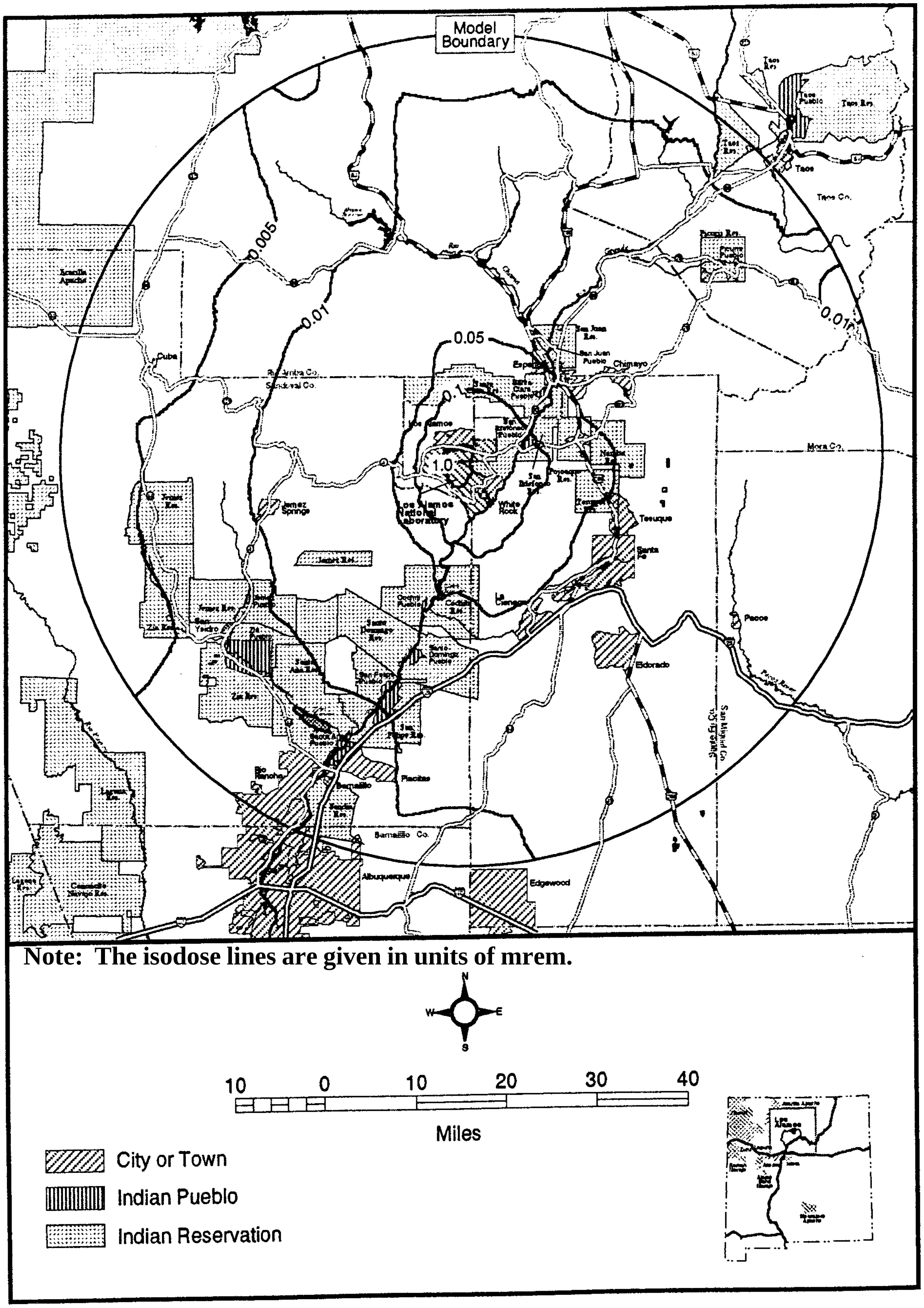


FIGURE B.1.2.4–7.—*Annual Average Individual Doses Less Than 1 Millirem per Year for the Reduced Operations Alternative.*

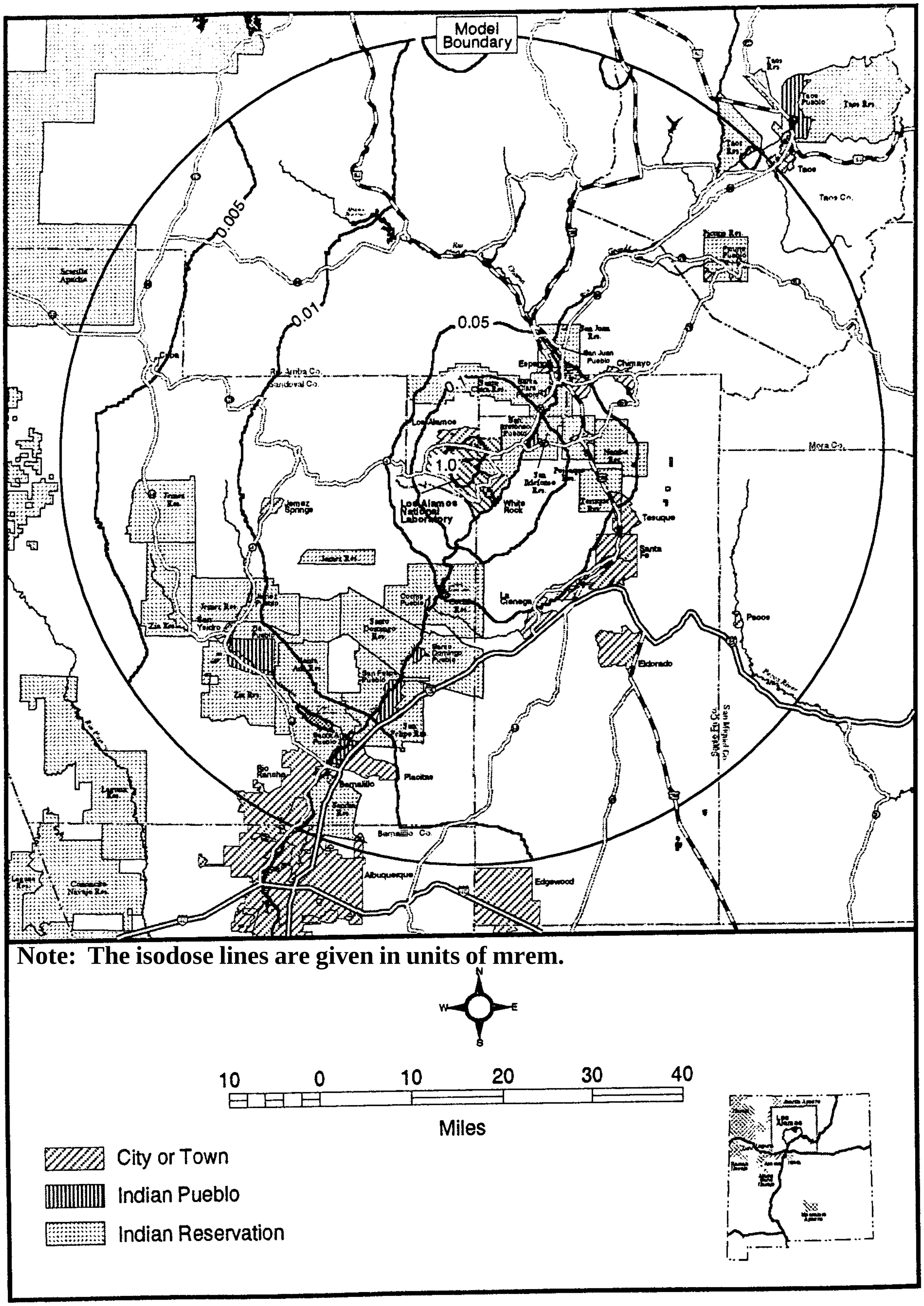


FIGURE B.1.2.4–8.—*Annual Average Individual Doses Less Than 1 Millirem per Year for the Greener Alternative.*

B.2 NONRADIOLOGICAL AIR QUALITY

The methodology description and the analysis results presented in chapter 5 are supplemented in this appendix with details on each aspect of modeling and analysis for criteria pollutants and toxic chemical emissions.

B.2.1 Assumptions, Data Sources, Standards, and Models

B.2.1.1 *Applicable Guidelines/ Standards and Emission Sources*

Criteria Pollutants

The *Clean Air Act* mandates that the EPA establish primary and secondary National Ambient Air Quality Standards (NAAQS) for pollutants of concern nationwide. These pollutants, known as criteria pollutants, are carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, lead, and particulate matter smaller than 10 microns in aerodynamic size (PM_{10}). As of September 16, 1997, in addition to the PM_{10} NAAQS, a new NAAQS became effective for particulate matter equal to or less than 2.5 microns (micrometers) in aerodynamic diameter ($PM_{2.5}$). These new standards will not require imposition of local area controls until 2005, and compliance determinations will not be required until 2008. Additionally, EPA revised the NAAQS and associated reference method for determining ozone attainment on July 18, 1997. This standard also will be applicable to LANL.

The State of New Mexico also has established ambient air quality standards for carbon monoxide, sulfur dioxide, total suspended particulates, hydrogen sulfide, and total reduced sulfur (New Mexico Administrative Code [NMAC], Title 20, Chapter 2, Part 3). State of New Mexico ambient air quality standards are more restrictive than the national standards and are listed in attachment 1.

Criteria pollutants released into the atmosphere from LANL operations are emitted primarily from combustion facilities such as boilers, emergency generators, and motor vehicles.

Toxic Air Pollutants

Chemicals are currently used at LANL in separately located groups of operations or laboratory complexes (TAs) that are spread out over a large geographic area (43 square miles [11,140 hectares]). Toxic air pollutants from these TAs may be released into the atmosphere from many different ongoing activities, including laboratory, maintenance, and waste management operations. Two types of toxic air pollutants are considered in this analysis: noncarcinogenic and carcinogenic.

The two database information systems used primarily in this analysis are the 1995 Automatic Chemical Inventory System (ACIS) (LANL 1995a) purchase data and the Regulated Air Pollutants (RAP) Report data (LANL 1990).

ACIS is a listing of chemicals purchased at each LANL facility in each calendar year. The 1995 ACIS list identified more than 2,000 chemicals. This list was reduced to 382 chemicals by eliminating from consideration those that do not have adequate vapor pressure in a liquid state to be evaporated during chemical operations or have very low toxicity. Fifty-one of these 382 chemicals are considered by EPA to be carcinogenic. For the purpose of this analysis, it was assumed that air emissions could result from the use of any of the 382 chemicals from any of the 30 separate TAs that purchased these chemicals. A list of these chemicals is provided in attachment 2.

RAP is a LANL site-wide nonradiological air emissions inventory that was conducted at LANL in 1990. This inventory, however, was prepared more than 7 years ago when LANL operations were significantly different from current operations. Because these data are not current, RAPS information was used in this analysis only to supplement ACIS data and other information gathered for this study.

Noncarcinogens. *Short-Term Guideline Values.* While no national or State of New Mexico standards have been established for noncarcinogens, the New Mexico Environment Department (NMED) has developed guideline values (GVs) for determining whether a new or modified source emitting a toxic air pollutant would be issued a construction permit (NMED/AQCRs, revised November 17, 1994). These GVs are 8-hour concentrations that are 1/100 of the Occupational Exposure Limits (OELs) established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997) or the National Institute of Occupational Safety and Health (NIOSH). The State of New Mexico listing was supplemented with the most current information on the lowest values for OELs from these sources. These GVs were used in this analysis in screening for potential short-term impacts of toxic releases from LANL operations.

Annual Average Guideline Values. The GVs used in this analysis are the inhalation reference concentrations (RfCs) from EPA's Integrated Risk Information System (IRIS) (EPA 1993b). RfCs are daily exposure levels to the human population (including sensitive subgroups) during a lifetime (70 years) that could occur without appreciable risk of deleterious effects.

Carcinogens. The GVs used in this analysis to estimate potential impacts of carcinogenic toxic air pollutants from LANL operations are based on an incremental cancer risk of one in a million (1.0×10^{-6}) (i.e., one person in a million would develop cancer if exposed to this concentration over a lifetime), a level of concern established in the *Clean Air Act*.

This value was used in the screening for the estimated combined incremental cancer risk associated with all of the carcinogenic pollutants emitted from LANL facilities at any location. For the purpose of screening individual carcinogens, a cancer risk of 1.0×10^{-8} was established as the GV.

B.2.1.2 *Receptors and Receptor Sets*

Two sets of receptors (i.e., locations where air quality levels were estimated) were considered for the analyses of criteria and toxic air pollutants.

- The first set of receptors includes nearby identified actual locations of human activity that might be affected from the emissions from LANL facilities. These include: (1) schools, hospitals, parks and playgrounds within Los Alamos; (2) residences (including those in trailer parks) in all directions surrounding all of LANL facilities in Los Alamos County; and (3) towns, cities, and sensitive national and cultural areas within approximately 50 miles (80 kilometers) of LANL. These receptors, which are listed in attachment 3, are referred to as sensitive receptors.
- The second set of receptors includes all of the closest off-site (i.e., fence line) locations (in 10-degree increments) around each TA to which the public could have access. These receptors are referred to as fence line receptors.

The potential impacts of air pollutants on workers employed at the LANL facilities were not considered as part of this analysis. Different regulations apply to an occupational setting, and the controlled nature of the work, along with surveillance systems associated with these controls, restricts routine exposures for workers. This analysis is focused on exposure to the public, and is based on a methodology that initially assumes that chemicals that are purchased are entirely available for release to the atmosphere outside the facility in which the chemicals are used.

Air quality standards have been established by the State of New Mexico for criteria pollutants for both short-term (i.e., 1-hour, 3-hour, 8-hour, and 24-hour) and long-term (e.g., 30-day, quarterly, and annual) time periods. In addition, GVs also were developed for toxic pollutants for both short-term (8-hour) and long-term (annual) time periods. Using these standards and GVs, the potential impacts of the pollutant emissions from LANL operations on these receptor sets were analyzed as discussed in the following paragraphs.

Criteria Pollutants

Short-term and long-term impacts for CO, NO_2, and SO_2, TSP, PM_{10}, and lead were estimated at the sensitive receptors, and the results were compared with applicable air quality standards. Both time frames were analyzed to address the potential short-term (acute) and long-term (chronic) impacts of these pollutants at locations where the public could have both short-term and long-term exposure to emissions from LANL facilities. Hydrogen sulfide and total reduced sulfur emissions are associated mostly with oil and gas industry; therefore, analysis for these pollutants was not necessary at LANL.

Short-term impacts also were analyzed at the fence line receptors surrounding TA–3, TA–16, and TA–21 in order to account for potential short-term exposure near the locations with relatively large combustion sources. The combustion sources at the other TAs are minor (primarily small boiler units and emergency generators) relative to the larger combustion units found at TA–3, TA–16, and TA–21, and are mostly for emergency back-up. The potential impacts at the fence line receptors of these minor sources were not considered.

Toxic Air Pollutants

Noncarcinogens. The potential short-term (acute) and long-term (chronic) impacts of these pollutants at locations where the public could have both short-term and long-term exposure to emissions from LANL facilities were considered.

Short-term impacts were analyzed at the fence line receptors. Long-term impacts were not considered at these receptors because, although it is possible that the public could have access to fence line areas for short periods of time, the fence line locations are not places where visitors can freely walk around, nor is pedestrian traffic at these locations encouraged or actually encountered on a regular (long-term) basis.

Carcinogens. The annual impacts from the emissions of carcinogenic toxic air pollutants were analyzed at the sensitive receptors. Although GVs for short-term exposure were used in the screening steps, the more meaningful comparisons were to long-term GVs for sensitive receptors.

B.2.1.3 *Air Quality Dispersion Models*

The EPA's Industrial Source Complex Air Quality Dispersion Model (ISC–3) was used for both the criteria and toxic pollutant analyses. ISC–3 is a versatile model that is often used to predict pollutant concentrations from continuous point, area, volume, and open disposal cell sources (EPA 1992b). This versatile model is often preferred by the EPA because of the many features that enable the user to estimate concentrations from nearly any type of source emitting nonreactive pollutants.

EPA's PUFF model was used for a screening level analysis of emissions from LANL's High Explosives Firing Sites (HEFSs) at TA–14, TA–15, TA–36, TA–39, and TA–40. The PUFF model is designed to estimate downwind concentrations from instantaneous releases of pollutants (EPA 1992d).

The HOTSPOT code was used in combination with the ISC–3 model for a detailed analysis of emissions from HEFF in order to provide a more readily usable input data file to the health effects analysis used in this SWEIS than provided by PUFF. The HOTSPOT code is designed for detonation of high explosives, and was used specifically to provide input data to the ISC–3 model (ORNL-LLNL 1996).

B.2.2 Criteria Pollutants—General Approach

The combustion sources that were evaluated in the analysis of criteria pollutants are listed in attachment 1. An atmospheric dispersion modeling analysis was conducted to estimate the combined potential air quality impacts of the emissions from each of these emission sources.

No quantitative analysis of vehicular-related emissions was performed as part of this analysis, but this emission source was included in the assumed background. Although the project alternatives may have different effects on the travel patterns in the study area as a result of changes in the number of LANL employees who would commute to Los Alamos, the future population of Los Alamos is expected to be the same under all of the alternatives. Therefore, the change in regional emissions under any of the future project alternatives are not expected to be more than a few (less than 5) percent. Because the study area is in attainment for the pollutants that are released primarily from motor vehicles (carbon monoxide and ozone precursors and nitrogen oxides [NO_x]) and because there are no nearby heavily congested traffic areas or major sources or ozone precursors (i.e., hydrocarbons and nitrogen oxides), no potentially significant air quality impacts are expected from the project alternatives.

B.2.2.1 *Criteria Pollutants—Methodology*

The analysis of combustion-related pollutants used standard analytical modeling techniques based on atmospheric dispersion modeling and emissions estimated under peak and actual annual average operating conditions of each major combustion unit. This information, together with stack locations and exhaust parameters (i.e., heights, diameters, flow rates), was available from LANL's air quality permit applications. Estimates of future emission rates were based on the operations anticipated under the Expanded Operations Alternative—the worst-case alternative with respect to emission rates from the combustion sources. These emissions were modeled using the ISC–3 model and meteorological data collected at TA–6. The methodology and procedures used are provided in attachment 1.

B.2.2.2 *Results of Criteria Pollutant Analysis*

The results of the analysis of criteria pollutants from LANL's combustion sources are presented in attachment 1. As shown, the highest estimated concentration of each pollutant is below the appropriate ambient air quality standard. None of the project alternatives, therefore, are predicted to significantly impact criteria pollutant levels.

B.2.3 Toxic Air Pollutants—General Approach

Unlike a production facility with well-defined operational processes and schedules, LANL is a research and development facility with great fluctuations in both the types of chemicals emitted and their emission rates. Because LANL's toxic air pollutant emission rates are relatively low (compared to releases from production facilities), vary greatly, are released from hundreds of sources spread out over a large geographic area, and are well below the state's permitting threshold limits, toxic air pollutant emissions are not monitored. Current emission rates and stack parameter information necessary to conduct a conventional air quality analysis of the releases of toxic air pollutants are therefore not available.

An alternative approach was developed specifically for this analysis to estimate the potential air quality impacts of these pollutants. This approach is based on the use of screening level emission values (SLEVs). SLEVs are conservatively estimated hypothetical emission rates for each of the toxic air pollutants that could potentially be emitted from each of LANL's TAs and that would not result in air quality levels harmful to human health under current or future conditions. These SLEVs were compared with conservatively estimated pollutant emission rates on a TA-by-TA basis to determine potential air quality impacts of toxic air pollutants from LANL operations. This process consisted of the following steps:

- From over 2,000 chemical compounds listed as being used at LANL, 382 toxic air pollutants (including 51 carcinogens) were selected for consideration based on chemical properties, volatility, and toxicity.
- A methodology based on SLEVs was used to estimate the potential worst-case impacts of the toxic air pollutants. SLEVs for each chemical for each TA were compared with emission rates conservatively estimated from chemical use rates. If a conservatively estimated emission rate for a given pollutant from a given TA was less than SLEV, that pollutant emission source was deemed not to have the potential to cause significant air quality impacts, and, as such, no detailed analyses was required; if SLEV was less than the estimated emission rate for a given pollutant from a given TA, a more detailed analysis was conducted.
- An additive impact analysis was conducted to estimate the potential total impact from the emissions of each pollutant from more than one TA and the total incremental cancer risk from all of the carcinogenic pollutants combined at any of the sensitive receptor locations considered.

The methodology used in this analysis followed modeling guidelines for toxic pollutants established by the EPA (EPA 1988, EPA 1992c, EPA 1992e, and EPA 1992f) in that it first uses screening level evaluations based on conservative assumptions and resulting in maximum potential impacts, followed by more detailed analyses based on more realistic assumptions. The overall procedure used for this air quality assessment, including the development of SLEVs, is summarized in Figures B.2.3–1 and B.2.3–2. Also shown on these figures are the procedures used to compare SLEVs with the available emission data and the steps taken to evaluate the pollutants with potentially significant impacts. Each pollutant with the potentially significant impacts (as a result of the screening-level analyses) was subjected to progressively more detailed and more realistic evaluations.

B.2.3.1 *Toxic Pollutants—Methodology for Individual Pollutants*

Screening Level Analysis

Once SLEVs (both short-term and long-term) were established for each of the toxic air pollutants on a TA-specific basis (attachment 4, Methodology), a comparison was made between these values and conservatively estimated emission rates based on the Expanded Operations Alternative. A ratio was developed for each chemical by dividing the SLEV by the estimated emission rate (SLEV/Q).

These results, in the form of worksheets (an example for TA–3 is provided in attachment 5),

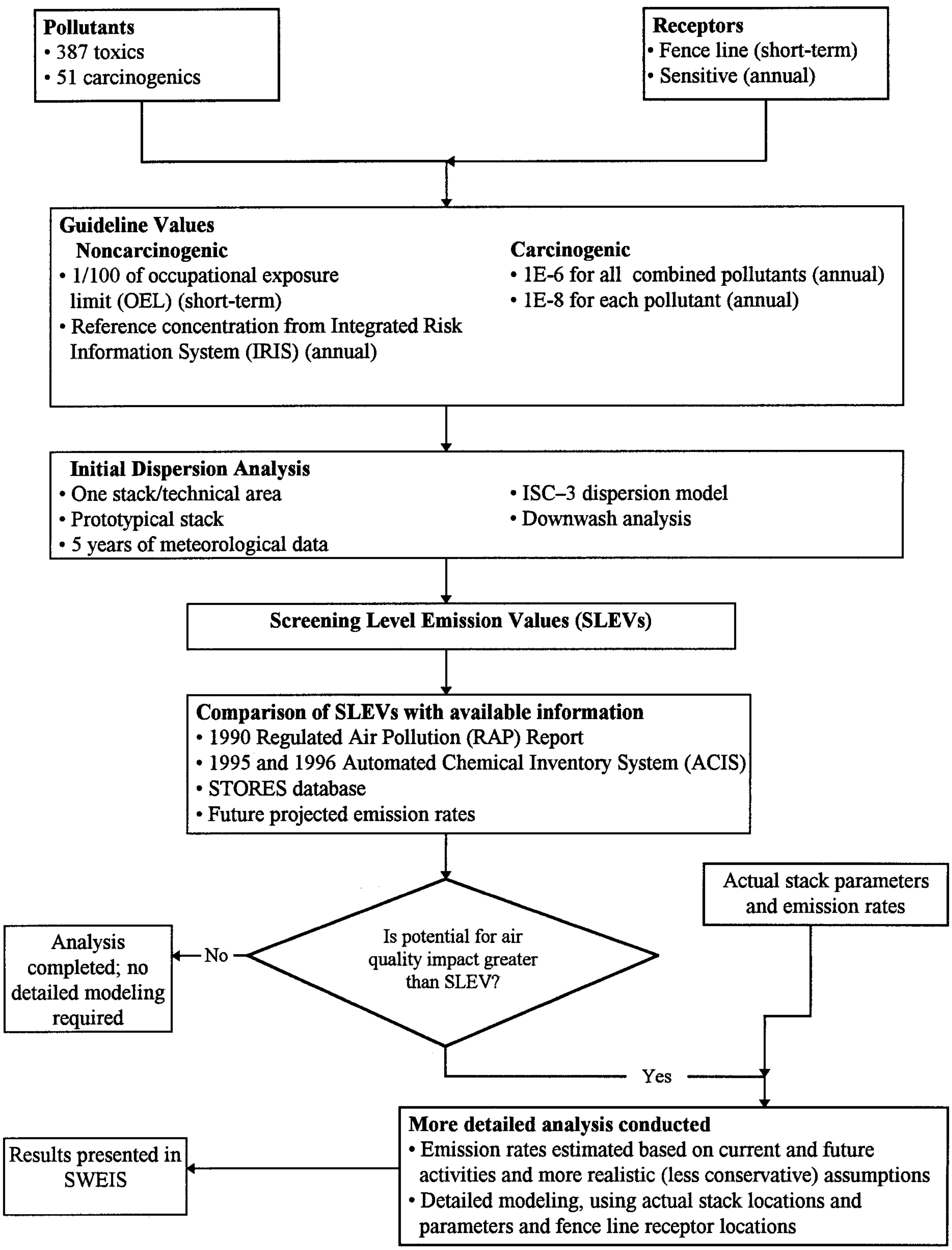


FIGURE B.2.3–1.—*Process Used for Evaluating Toxic Air Pollutants.*

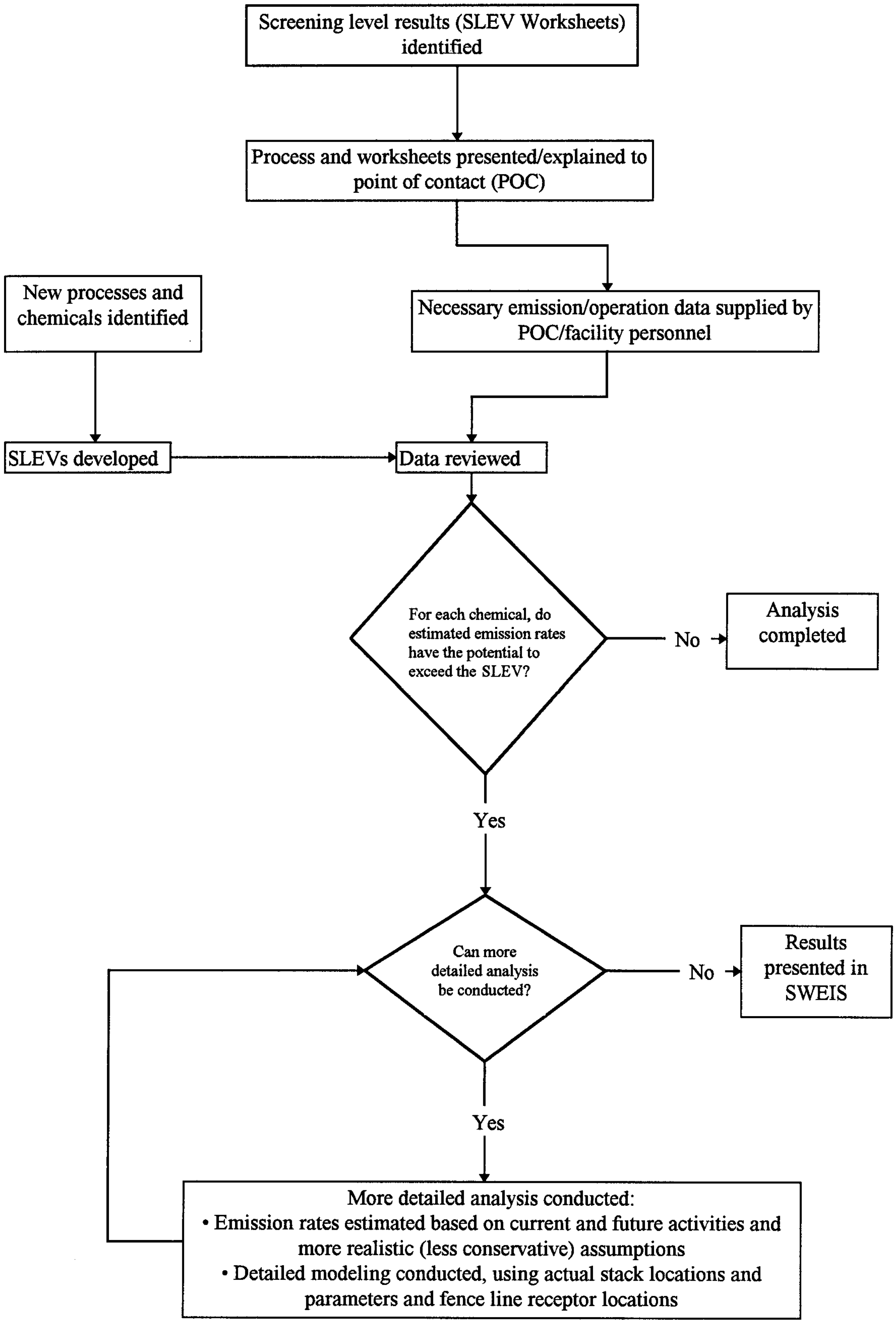


FIGURE B.2.3–2.—*Procedures for Evaluating Potential Impacts of Toxic Air Pollutant Emissions from Each Technical Area.*

were presented to knowledgeable site personnel who are aware of the activities and processes that are currently occurring at each TA as well as those that might occur in the future. In order to streamline the process, the relationship between SLEVs and the estimated emission rates for each TA were presented in two data sets.

The first data set included those chemicals with SLEV/Q ratios greater than 100. For each of these chemicals, a determination was made as to whether the utilization of that chemical would increase by more than one hundred times under future operation(s) of LANL under any of the project alternatives considered. Essentially, this meant that for each TA a determination had to be made as to whether the utilization of a chemical would increase over current use rates by a factor of 100. If a determination could be made that the future use of that chemical would not increase by this factor, no further evaluation of that chemical was required. If such a determination was not possible, a more detailed analysis was conducted.

The second data set included all the chemicals with a SLEV/Q ratio less than 100, and included those chemicals with a SLEV/Q ratio greater than 1 but less than 100, as well as those chemicals with a ratio less than 1. For each chemical with a ratio greater than 1 but less than 100, an evaluation was made as to whether the estimated emissions under any of the future alternatives would exceed the SLEV. Essentially, this meant that for each TA a determination had to be made as to whether the utilization of that chemical would increase over current use rates by a factor greater than the SLEV/Q ratio. If a determination could be made that the future use of that chemical would not increase by this factor, no further evaluation of that chemical was required. If such a determination was not possible, a more detailed analysis was conducted. For those chemicals with a SLEV/Q ratio less than 1 (i.e., SLEVs were potentially being exceeded under current conditions), more detailed analyses were conducted.

Two exceptions to the details associated with this approach were made. Information on the TAs for high explosives operations were derived using a model more appropriate for screening short-term exposure concentrations under those conditions (attachment 13). The second involved screening the emissions of chemicals from The Health Research Laboratory (HRL) at TA–43. Because of the proximity of HRL to actual receptors, all analyses for carcinogens as well as noncarcinogens were performed for actual receptors rather than fence line receptors (attachment 14).

Detailed Analysis

The detailed air quality analysis consisted of one or both of the following steps:

- Development of emission rates and source terms parameters using actual process knowledge
- Dispersion modeling using actual stack parameters and receptor locations

Two consequences may result from the detailed analysis for each chemical from each TA: (1) either there is no potential to contravene a GV (in which case no additional analyses were required), or (2) there is a potential to contravene a GV (in which case additional analyses were required). A pollutant with the potential to contravene a GV was subject to evaluation in the health and ecological risk assessment process for this SWEIS.

B.2.3.2 *Results of the Toxic Pollutant Analysis—Individual Pollutants*

Screening Level

The first data set considered those chemicals with SLEV/Q ratios greater than 100. For more than 90 percent of the toxic air pollutants, a determination was made (based on current and proposed operations of the TAs) that the utilization of these chemicals would not increase by more than 100 times under any of the project alternatives. The second data set included chemicals with SLEV/Q ratios greater than 1 but less than 100, and ratios less than 1. A determination was made as to whether the utilization of that chemical would increase over current use rates by a factor greater than the SLEV/Q ratio. The list of carcinogens also was reduced from 51 to 35 because some of the chemicals are no longer used and are not projected for future use. Based on worksheets for the chemicals in these data sets, and information on potential future use, operations at 13 locations were identified with the potential to exceed a GV.

Detailed Analysis

Detailed analyses were conducted for the following emission sources:

- Methylene chloride emissions at TA–3 (attachment 7)
- Beryllium emissions at TA–3 (attachment 8)
- Nickel dust emissions at TA–3 (attachment 9)
- Paint booth (primarily volatile organic compound) emissions at TA–3 and TA–60 (attachment 10)
- Incinerator emissions (primarily metals and volatile organics) at TA–16 (attachment 11)
- Emissions (primarily volatile organic compounds) from open burning operations at the High Explosives Treatment and Disposal Facility at TA–16 (attachment 12)
- Emissions (primarily metals) from High Explosives Firing Site (HEFS) operations at TA–14, TA–15, TA–36, TA–39, and TA–40 (attachment 13)
- Emissions (primarily volatile organic compounds) from the Health Research Laboratory at TA–43 (attachment 14)
- Chloroform emissions at TA–53 (attachment 15)
- Beryllium emissions at TA–55 (attachment 16)
- Nitric and hydrochloric acid emissions at TA–55 (attachment 17)
- Nitric and hydrochloric acid emissions at TA–59 (attachment 18)
- Ozone Emissions at TA–53 (attachment 19)

Detailed Analyses—Results

Emissions from two sources were referred to the health and ecological risk analysis process. The analysis for TA–43 showed the potential to exceed the GVs for four chemical carcinogens from HRL: chloroform, trichloroethylene, formaldehyde, and acrylamide.

The detailed analysis for HEFF indicated that the same chemicals that had the potential to exceed a GV in the previous screening step, would also have the potential to exceed their respective GVs using somewhat different parameters and a different model than used in the screening analysis. A different model was used in the detailed analysis in order to provide output data in a form more readily usable for the health risk analysis. Additional information on the following chemicals was referred to the health and ecological risk assessment process for this SWEIS:

- Depleted uranium, beryllium, and lead from TA–15
- Depleted uranium, beryllium, and lead from TA–36

- Beryllium and lead from TA–39
- Depleted uranium and lead from TA–14

B.2.3.3 *Toxic Pollutants—Methodology for Combined Impacts Analyses*

The following analyses were conducted to ensure that the combined effects from the releases of all of the chemicals from all the TAs would not exceed the GVs.

Noncarcinogens

An analysis of potential short-term impacts at a TA's fence line receptors showed that the 8-hour impacts from the releases of that TA were significantly greater (i.e., more than two orders of magnitude) than the impacts from the releases of a nearby TA. This is because the TAs are relatively far apart in comparison to the distances between the emission sources of a TA and its fence line receptors. Therefore, it is unlikely that the additive short-term impacts of noncarcinogenic pollutants at the fence line receptors of a TA would be significantly different from the maximum concentrations previously estimated for that TA.

An analysis of annual potential impacts at sensitive receptors showed that these impacts were significantly less (i.e., less then two orders of magnitude) relative to the appropriate GVs than the corresponding short-term impacts at the fence line receptors. Therefore, it is unlikely that the additive annual impacts of the noncarcinogenic pollutants at the sensitive receptors would be significant.

Carcinogens

Two different versions of additive impacts for carcinogens are presented. Both consider impacts at sensitive receptors based on annual ambient concentrations of pollutants. Short-term additive impacts for carcinogens at fence line receptors were not considered for the same reasons as for noncarcinogens. However, long-term impacts at sensitive receptors were considered because EPA considers in their standard setting process that risk from carcinogens can be additive for all carcinogenic chemicals.

The first version considered whether emissions of the same chemical from all TAs (whether of not it was actually used at that TA), at the SLEV rate (whether or not that maximum rate was actually projected at that TA) would exceed the total guideline risk value of 1×10^{-6}. The risk due to exposure at the maximum concentration over a lifetime for any receptor for each of the TAs was added to the separately calculated maximum concentration for any receptor for each of the other TAs, regardless of whether the same receptor was indicated.

The second version modeled simultaneous emissions of the same chemical at actual projected rates for each of the TAs, and recorded the maximum concentration at any receptor location. The risk due to exposure at that concentration over a lifetime was then added to the risks calculated in a similar fashion for each of the other chemicals. Risks were added regardless of whether or not the same receptor was involved. That total risk was also compared to the guideline risk value of 1×10^{-6} of any excess cancer from a lifetime of exposure.

B.2.3.4 *Toxic Pollutants—Results of Combined Impact Analysis*

Releases of Each Carcinogenic Pollutant from All TAs

The estimated combined cancer risk associated with releases of each of these pollutants from all TAs is 1.23×10^{-7}, which is below the GV of 1.0×10^{-6}. As such, no potentially significant air quality impacts were estimated.

Releases of All Carcinogenic Pollutants from All TAs

Results of this analysis are presented in attachment 6. As shown, the potential combined incremental cancer risk associated with releases of all carcinogenic pollutants from all TAs is slightly above the GV of 1.0 x 10^{-6}.

The major contributors to the estimated combined cancer risk values are chloroform, formaldehyde, and trichloethylene from HRL at TA–43 and multiple sources for methylene chloride. The estimated maximum cancer risk for each of these individual pollutants is 8.74 x 10^{-7}, 5.17 x 10^{-8}, 6.73 x 10^{-8}, and 6.84 x 10^{-8}, respectively. Of these, the relative contribution of chloroform emissions alone to the combined cancer risk value is more than 87 percent. The impacts of TA–43 emissions are due to a combination of relatively high emission rates, close proximity between receptors and sources, and the elevation of the receptors.

Because the result of this analysis was slightly above the specified GV of 1.0 x 10^{-6} and a simplifying but conservative approach was used that added the maximum risk from each chemical even though different receptors may have been involved, a more detailed analysis that considered the impact at each specific receptor location was conducted. This more refined analysis estimated the combined cancer risk at each of the 180 sensitive receptor locations.

As shown in attachment 6, the combined incremental cancer risks associated with releases of all carcinogenic pollutants from all TAs at the receptor locations where these impacts actually occur are slightly above the GV of 1.0 x 10^{-6} at the two locations within the LANL medical center: 1.17 x 10^{-6} at a receptor in an air intake duct and 1.07 x 10^{-6} at an operable window. Because the estimated cancer risk at these two receptor locations is slightly above the GV of 1.0 x 10^{-6}, these results were referred to the health and ecological risk assessment processes for this SWEIS.

ATTACHMENT 1
ANALYSIS OF CRITERIA POLLUTANTS FROM COMBUSTION SOURCES

Technical Areas: TA–3, TA–8, TA–15, TA–16, TA–18, TA–21, TA–22, TA–33, TA–35, TA–39, TA–41, TA–43, TA–46, TA–48, TA–49, TA–50, TA–53, TA–54, TA–55, TA–58, TA–59, TA–61, TA–63, and TA–64.

Emission Sources

The sources of criteria pollutant emissions at LANL are mostly combustion facilities. The largest contributors are steam plants and an asphalt plant. There are also several smaller sources. The following emission sources were considered:

MAJOR SOURCES	LOCATION	FUEL
Steam Plant	TA–3–22–1	Natural gas/oil # 2
Steam Plant	TA–21–357–1	Natural gas/oil # 2
Replacement Boiler	TA–16–4	Natural gas
Replacement Boiler	TA–16–5	Natural gas
Replacement Boiler	TA–16–6	Natural gas
Replacement Boiler	TA–16–13	Natural gas
Asphalt Heater	TA–3–73–2	Oil #2
Water Pump	TA–54–1013	Natural gas
Incinerator	TA–16	Solid waste/waste oil

Note:

Emissions from the following smaller combustion sources also were considered.

- 62 miscellaneous boilers located at various TAs
- 149 standby emergency generators (7 natural gas, 50 diesel, and 92 gasoline fueled)

Pollutants Considered

As required by the *Clean Air Act*, NAAQS have been established for six major air pollutants: CO, NO_2, ozone (O_3), particulate matter smaller than 10 microns (PM_{10}), SO_2, and lead (Pb). Each of these pollutants was considered.

Emission Rates

Major Assumptions

1. For the dual-fueled boilers, fuel oil emission rates were used to estimate short-term concentrations, and natural gas emission rates were used to estimate annual emission rates.

2. Emission factors were obtained from EPA's Compilation of Air Pollution Emission Factors (AP-42) (EPA 1995).

3. Peak load emission rates ($ER_{peak\ load}$) were estimated based on the capacity of each unit.

$$ER_{peak\ load} = \frac{\text{Unit Capacity / Design Capacity x Emission Factor}}{\text{Heating Value of Fuel}}$$

   See Tables A and B of this attachment.

4. Annual average emission rates (ER_{annual}) were based on the annual fuel consumption rates (assuming that a 100 percent capacity was used).

$$ER_{annual} = \text{Emission Factor x Fuel Usage}$$

   See Table C of this attachment.

5. PM_{10} emissions during the combustion of diesel and gasoline fuels or fuel oil were conservatively assumed to be half of the total suspended particulate (TSP) emissions. Particulates emitted during the combustion of natural gas are less than 1 micron (1 micrometer) in diameter; hence, for natural gas combustion, PM_{10} emissions were considered equal to TSP emissions.

6. It was conservatively assumed, as per New Mexico Air Quality Bureau's guidelines, that 40 percent of exhausted NO was converted to NO_2 when the exhaust plume reached fence line receptors a few hundred meters away from the source. Conversion to NO_2 depends on the presence of ozone in the surface atmospheric layer. It usually takes several hours for full conversion.

7. Based on the LANL information, it was assumed that emergency and standby generators operate a maximum of four continuous hours a day.

Dispersion Modeling Analysis

The EPA Industrial Source Complex model, Version 3 (ISC–3) was applied in the analysis of criteria pollutants. ISC–3 is a steady-state Gaussian dispersion model validated to be used in a short- and a long-term mode in regulatory and nonregulatory applications. The model is capable of handling multiple point sources, stack-tip downwash calculation, buoyancy-induced dispersion, as well as having an algorithm to account for the aerodynamic downwash due to the nearby buildings. The actual options that were used to analyze emissions from combustion sources are as follows:

- In the ISC–3 short-term mode:
  - Stack-tip downwash
  - Buoyancy-induced dispersion

— Final plume rise
— Calm winds processing
— Default wind profile exponents and potential temperature gradients
— Simple terrain
— Rural dispersion
— Aerodynamic downwash (where applicable)
— Constant emission rates throughout the modeling period
— No precipitation scavenging

Other assumptions include:

- All chemicals are released to the atmosphere rather than used in process or product, or sent to waste disposal or recycling after use.
- There is no time spent indoors or inside automobiles; whereas, people actually spend more than 80 percent of their time indoors. Being inside would cut the concentration by half as a minimum.

Modeling Procedures

1. TA–3, TA–21 and TA–16 boiler plants were modeled using actual emission locations and actual stack parameters, as provided by LANL. Wake effects of the boiler buildings and buildings in the immediate vicinity of the emission sources were considered.

2. The waste incinerator at TA–16, the water pump at TA–54, and the asphalt plant heaters at TA–3 were modeled using actual locations and stack parameters, as obtained from LANL. Wake effects of the incinerator building were considered.

3. The emission rates of the other combustion sources considered (i.e., small boilers and standby and emergency generators—natural gas, diesel and gasoline fueled) were summed up by TA and modeled as if their combined emissions were released from the center of the TA where they are located. The following prototypical stack and stack parameters were assumed for each of these sources.

    - Stack height: 6 meters
    - Stack diameter: 0.5 meters
    - Stack exit velocity: 9 meters per second
    - Stack temperature: 127°C

4. Impacts from combustion sources were considered for both peak and normal (annual average) operating conditions. Peak load emissions were used to estimate short-term impacts and annual average emissions were used to estimate long-term impacts.

5. Emergency and standby generators were modeled to estimate short-term impacts only.

6. Five years of Los Alamos meteorological on-site observations for years 1991 through 1995 were used in dispersion analysis. These 5 years of data were obtained by using the EPA PC RAMMET program, with surface observations and morning and afternoon mixing heights data as inputs. The

surface observations were collected at the TA–6 meteorological tower at LANL. Mixing heights data were estimated based on the Albuquerque upper air observations and Santa Fe surface data.

7. Lead emissions from incinerator and oil-fired asphalt heaters (the two combustion sources that continuously emit lead) were modeled using actual source parameters. Concentrations at the sensitive receptors were found 5 orders of magnitude lower than the NAAQS quarterly standard for lead of 1.5 micrograms per cubic meter.

8. Background concentrations were conservatively assumed to be 20 percent of the corresponding standard.

Results:

Nitrogen Dioxide Modeling Analysis for Combustion Sources at LANL

Initial modeling of NO_x concentrations resulted in a modeled 24-hour concentration of 519.76 micrograms per cubic meter (based on ISCST3 modeling). The applicable 24-hour standard, per New Mexico Ambient Air Quality Control Standards (AAQS) is 147 micrograms per cubic meters (adjusted for temperature and pressure [elevation]). Thus, based on the preliminary analysis, NO_x modeled concentrations are above the New Mexico AAQS. Therefore, the following methodology was used to evaluate the NO_2 concentrations.

New Mexico Air Quality Bureau—NO_2 Modeling Methodology. The Bureau has approved two screening techniques for estimating NO_2 concentrations from NO_x point sources. The first technique is a partial conversion rate of 40 percent, which is only applicable to 24-hour concentrations. Therefore, if the NO_x concentration is 200 micrograms per cubic meter, the NO_2 concentration can be assumed to be 80 micrograms per cubic meter. The second technique is that some sources will need to examine the atmospheric chemistry in a more rigorous manner. The guidance provides for using Ozone Limiting Method (OLM) to more accurately determine NO_2 concentrations. OLM should be used to resolve, if possible, any NO_2 standard exceedances at each receptor that shows a violation.

Modeling Analysis. Using this partial conversion rate of 40 percent, the acceptable 24-hour standard for LANL would be 368 micrograms per cubic meter [147 micrograms per cubic meter per 0.40] for NO_x. For the annual concentration analysis, no conversion was used, and the full modeled values were considered while comparing the results with the applicable ambient air standards.

All the receptors above the 24-hour threshold NO_x value of 368 micrograms per cubic meter were identified from the output table listing of 50-maximum 24-average concentration values. The resulting 50-maximum value table includes several header records identifying the concentration, date for the modeled concentration (ending hour of the averaging period), and the receptors (X and Y coordinates).

Based on the ISCST3 output file, there are only two 24-hour concentrations above 368 micrograms per cubic meter. To demonstrate compliance with the ambient air standard, OLM analysis was conducted for these two receptors.

Estimation of NO_2 Concentrations Resulting from NO_x Point Sources

- The first step is to use a screening technique (a standard Gaussian dispersion model [ISCST3]) to estimate the maximum NO_x concentrations.
- The second step involves estimating the fraction of this NO_x concentration occurring as NO_2.

Although NO_2 may be emitted directly to the atmosphere, most of it is formed as a result of reactions between NO and various other gases. The reaction with ozone is an effective means of converting NO to NO_2. In heavily polluted areas, reaction between NO and organic radicals provides an additional source of NO_2. A third source of NO_2 is the thermal conversion process:

$$2NO + O_2 = 2NO_2.$$

Ozone Limiting Method. The Ozone Limiting Method (OLM) involves an initial comparison of the estimated maximum NO_x concentration, (NO_x)max and the ambient O_3 concentration to determine which is the limiting factor to NO_2 formation.

If the O_3 concentration is greater than (NO_x)max, total conversion is assumed. If (NO_x)max is greater than the O_3 concentration, the formation of NO_2 is limited by the ambient O_3 concentration.

<u>The following expressions detail the procedure</u>:

1. A standard dispersion model ISCST3 is used to calculate (NO_x)max.

2. (NO_x)max is separated into two components:

   - Thermal conversion portion. For combustion sources, this is estimated to be equal to $0.10(NO_x)$max.
   - The remaining NO subject to conversion by O_3 equal to $0.90\ (NO_x)$max.

3. If (O_3)ambient is greater than $0.90(NO_x)$max, then assume that all of the NO is converted to NO_2, i.e., (NO_2)max = (NO_x)max.

   If $0.90(NO_x)$max is greater than (O_3)ambient, then set (NO_2)max = (O_3)ambient + $0.10(NO_x)$max.

4. (NO_2)max computed for the source is added to the NO_2 background.

The OLM program used for this analysis was BEE-LINE Software Inc., Version 2.5 (1995). In the OLM analysis, the default value for the NO_2 factor, micrograms per cubic meter to parts per million, is 1882.8091. This is one of the required input values by the OLM model. The corrected value (according to Bureau's Dispersion Modeling Guidelines) at an elevation of 7,000 feet is 1,473.4 micrograms per cubic meter, which was used in this OLM analysis.

Based on this OLM run, none of the receptors was found to exceed the NO_2 ambient air 24-hour standard of 147 micrograms per cubic meter. The maximum ozone corrected NO_2 value was only 90 micrograms per cubic meter. Therefore, maximum modeled NO_2 concentrations are below the applicable standards.

As shown in the following table, estimated criteria pollutant concentrations from combustion sources at LANL were within (i.e., less than) all national or State of New Mexico AAQS.

Results of Criteria Pollutants Analysis—Expanded Operations Alternative

POLLUTANT	TIME PERIOD	MAXIMUM ESTIMATED LANL IMPACTS (µg/m^3)	ASSUMED BACKGROUND CONCENTRATIONS[a] (µg/m^3)	TOTAL POLLUTANT CONCENTRATIONS (µg/m^3)	CONTROLLING AMBIENT AIR QUALITY STANDARDS (µg/m^3)[b]
Carbon Monoxide	1 hour	2,712	2,350	5,062	11,750
	8 hours	1,436	1,560	2,996	7,800
Nitrogen Dioxide[c]	24 hours	90[c]	29	119	147
	Annual	9	15	24	74
Sulfur Dioxide	3 hours	254	205	459	1,025
	24 hours	130	41	171	205
	Annual	18	8	26	41
Total Suspended Particulates	24 hours	18	30	48	150
	Annual	2	12	14	60
PM_{10}	24 hours	9	30	39	150
	Annual	1	10	11	50
Lead	3 months (calendar quarter)	0.7×10^{-4}	0.30	0.30	1.5

[a] No data exists for background values. It was conservatively assumed that background concentrations were 20 percent of the corresponding standard. Because there are almost no other combustion sources in and around LANL, the background concentrations would be much less than the 20 percent assumed concentrations.

[b] New Mexico Ambient Air Quality standards for some of the pollutants are stated in parts per million (ppm). These values were converted to micrograms per cubic meter (µg/m^3), with appropriate corrections for temperature and pressure (elevation) following New Mexico Dispersion Modeling Guidelines (revised January 1996).

[c] New Mexico Air Quality Bureau accepts OLM to more accurately determine NO_2 concentrations. The 24-hour maximum modeled concentration for NO_x was 520 µg/m^3. This concentration, when modeled using OLM, is only 90 µg/m^3 for NO_2.

Note: Ozone Analysis: Hourly ozone monitoring data from the BNM monitoring station for 1992 to 1994 were analyzed. The 1-hour of the fourth-highest values for the years 1992, 1993, and 1994 are 0.070 ppm, 0.066 ppm, and 0.072 ppm, respectively. The 3-year average of the annual fourth-highest maximum 1-hour concentration is 0.069 ppm. This value is about 58 percent of the 1-hour standard of 0.120 ppm. Therefore, DOE believes that when 8-hour data are analyzed in the future, these would show lower values than the new 8-hour standard of 0.08 ppm.

TABLE A.—*Peak Load Emission Rates Used for the Combustion Sources Analysis (Boilers, Incinerator, and Natural Gas Fired Emergency Generators)*

SOURCE	FUEL	HEATING VALUE Btu/gal. (OR Btu/ scf)	UNIT CAPACITY million Btu/ hr (HP)	CO EF lb/10^3gal. ($10^6 ft^3$) (OR lb/ million scf)	CO ER g/sec	NO_2 EF lb/10^3gal. (OR lb/ million scf)	NO_2 ER g/sec	SO_2 EF lb/10^3gal. (OR lb/ million scf)	SO_2 ER g/sec	PM_{10} EF lb/10^3gal. (OR lb/ million scf)	PM_{10} ER g/sec	TSP EF lb/10^3gal. (OR lb/ million scf)	TSP ER g/sec
TA–3–22–1	oil #2	140,000	210	5	0.95	20	3.78	48	9.07	1.00	0.19	2	0.38
TA–21–357–1	oil #2	140,000	12	5	0.05	20	0.22	48	0.52	1.00	0.01	2	0.02
TA–16–4	nat. gas	1,050	4.29	0.01854	0.02	0.01854	0.02	0.0003	0.0003	0.006	0.01		0.01
TA–16–5	nat. gas	1,050	6.13	0.01854	0.03	0.01854	0.03	0.0003	0.0004	0.006	0.01		0.01
TA–16–6	nat. gas	1,050	7.60	0.01854	0.03	0.01854	0.03	0.0003	0.0005	0.006	0.01		0.01
TA–16–13	nat. gas	1,050	5.12	0.01854	0.02	0.01854	0.02	0.0003	0.0004	0.006	0.01		0.01
TA–16 Prototypical	nat. gas	1,050	26.53	0.01854	0.12	0.01854	0.12	0.0003	0.0019	0.006	0.038		0.038
Misc. Prototypical Boiler TA–15	nat. gas	1,050	11.13	21	0.03	100	0.13	0.6	0.001	12	0.02		0.02
Misc. Prototypical Boiler TA–18	nat. gas	1,050	4.18	21	0.01	100	0.05	0.6	0.0003	12	0.01		0.01
Misc. Prototypical Boiler TA–22	nat. gas	1,050	6.69	21	0.02	100	0.08	0.6	0.0005	12	0.01		0.01
Misc. Prototypical Boiler TA–33	nat. gas	1,050	3.00	21	0.01	100	0.04	0.6	0.0002	12	0.004		0.004
Misc. Prototypical Boiler TA–35	nat. gas	1,050	37.25	21	0.09	100	0.45	0.6	0.003	12	0.05		0.05
Misc. Prototypical Boiler TA–41	nat. gas	1,050	6.69	21	0.02	100	0.08	0.6	0.0005	12	0.01		0.01

TABLE A.—*Peak Load Emission Rates Used for the Combustion Sources Analysis (Boilers, Incinerator, and Natural Gas Fired Emergency Generators)*-Continued

SOURCE	FUEL	HEATING VALUE Btu/gal. (OR Btu/ scf)	UNIT CAPACITY million Btu/ hr (HP)	CO EF lb/10^3gal. (10^6ft^3) (OR lb/ million scf)	CO ER g/sec	NO_2 EF lb/10^3gal. (OR lb/ million scf)	NO_2 ER g/sec	SO_2 EF lb/10^3gal. (OR lb/ million scf)	SO_2 ER g/sec	PM_{10} EF lb/10^3gal. (OR lb/ million scf)	PM_{10} ER g/sec	TSP EF lb/10^3gal. (OR lb/ million scf)	TSP ER g/sec
Misc. Prototypical Boiler TA–46	nat. gas	1,050	5.47	21	0.01	100	0.07	0.6	0.0004	12	0.01		0.01
Misc. Prototypical Boiler TA–48	nat. gas	1,050	38.89	21	0.10	100	0.47	0.6	0.003	12	0.06		0.06
Misc. Prototypical Boiler TA–50	nat. gas	1,050	15.78	21	0.04	100	0.19	0.6	0.001	12	0.02		0.02
Misc. Prototypical Boiler TA–52	nat. gas	1,050	12.00	21	0.03	100	0.14	0.6	0.001	12	0.02		0.02
Misc. Prototypical Boiler TA–53	nat. gas	1,050	42.49	21	0.11	100	0.51	0.6	0.003	12	0.06		0.06
Misc. Prototypical Boiler TA–55	nat. gas	1,050	20.10	21	0.05	100	0.24	0.6	0.001	12	0.03		0.03
Misc. Prototypical Boiler TA–58	nat. gas	1,050	11.51	21	0.03	100	0.14	0.6	0.001	12	0.02		0.02
TA–3–73–1	nat. gas	1,050	10	21	0.025	100	0.12	0.6	0.001	12	0.014		0.014
TA–3–73–2	oil #2	140,000	10	5	0.05	20	0.18	48	0.43	1	0.01	2	0.02
Nat. Gas EG TA–3	nat. gas	1,050	0.15	21	0.0004	100	0.002	0.6	0.00001	12	0.0002		0.0002
Nat. Gas EG TA–16	nat. gas	1,050	0.25	21	0.001	100	0.003	0.6	0.00002	12	0.0004		0.0004
Nat. Gas EG TA–35	nat. gas	1,050	0.20	21	0.001	100	0.002	0.6	0.00001	12	0.0003		0.0003

TABLE A.—*Peak Load Emission Rates Used for the Combustion Sources Analysis (Boilers, Incinerator, and Natural Gas Fired Emergency Generators)*-Continued

SOURCE	FUEL	HEATING VALUE Btu/gal. (OR Btu/ scf)	UNIT CAPACITY million Btu/ hr (HP)	CO EF lb/10^3gal. (10^6ft^3) (OR lb/ million scf)	CO ER g/sec	NO_2 EF lb/10^3gal. (OR lb/ million scf)	NO_2 ER g/sec	SO_2 EF lb/10^3gal. (OR lb/ million scf)	SO_2 ER g/sec	PM_{10} EF lb/10^3gal. (OR lb/ million scf)	PM_{10} ER g/sec	TSP EF lb/10^3gal. (OR lb/ million scf)	TSP ER g/sec
Nat.Gas EG TA–50	nat. gas	1,050	0.20	21	0.001	100	0.002	0.6	0.00001	12	0.0003		0.0003
Nat. Gas EG TA–53	nat. gas	1,050	0.25	21	0.001	100	0.003	0.6	0.00002	12	0.0004		0.0004
Nat. Gas Water Pump	nat. gas	1,050	700	1.60	0.311	5	0.972	0	0.000	0.003	0.001		0.001
Incinerator	waste				0.015		0.007		0.055		0.007		0.007

Notes:
[1] TA–16 emission factors in tons/MMSCF for the low NO_x boilers were provided by boiler manufacturer (Sellers Engineering Co., Danville, Kentucky, July 1995).
[2] TA–16 prototypical boiler unit capacity is a total capacity of all TA–16 boilers, except replacement (package) boilers, which were modeled separately.
[3] Miscellaneous prototypical boiler output capacity is a total capacity of boilers at each TA. Unit capacity is obtained from output capacity using the boiler efficiency of 72%.
[4] All miscellaneous boilers and replacement boilers at TA–16 are natural gas fired (Title V application) (LANL 1995b).
[5] Water pump engine has capacity of 700 hp, emission factors for water pump are in g/hp-hr.
[6] According to AP-42 (EPA 1995) particulate matter from the natural gas combustion is less than 1 μm in size, so ER(PM_{10}) = ER(TSP).
[7] TSP EF from the fuel oil #2 is the same as in Title V application (LANL 1995b); PM_{10} EF is obtained from Table 1.3–5 for size-specific EF from industrial boilers (EPA 1995).
[8] Waste oil and solid waste are burned. 8-hour CO and 24-hour SO_2 concentrations were conservatively estimated with 1-hour (CO) and 3-hours (SO_2) average emission rates.
[9] The second stacks at steam plants at TA–3 and TA–21 are used for standby or emergency operations only and were not taken into account (LANL 1995b).
EF = Emission Factor, EG = Emergency Generators, ER = Emission Rate, HP = horse power, SCF = standard cubic foot, TSP = Total Suspended Particulates

TABLE B.—*Peak Load Emission Rates Used for the Combustion Sources Analysis (Diesel and Gasoline Fired Emergency Generators)*[d]

SOURCE[a,b]	FUEL	HEATING VALUE Btu/gal. (OR Btu/scf)	DESIGN CAPACITY kw	CO EF g/kw-hr	CO ER g/sec	NO_2 EF g/kw-hr	NO_2 ER g/sec	SO_2 EF g/kw-hr	SO_2 ER g/sec	PM_{10} EF[c] g/kw-hr (OR lb/million Btu)	PM_{10} ER g/sec	TSP EF g/kw-hr (OR lb/million Btu)	TSP ER g/sec
Diesel EG TA–3	diesel	137,000	1344.97	4.06	1.52	18.8	7.02	1.25	0.47	1.34	0.50	2.68	1.00
Diesel EG TA–3*	diesel	137,000	1100	3.2	0.98	14	4.28		0.00	0.0573	0.027	0.0697	0.033
Diesel EG TA–8	diesel	137,000	59.66	4.06	0.07	18.8	0.31	1.25	0.02	1.34	0.02	2.68	0.04
Diesel EG TA–15	diesel	137,000	19.39	4.06	0.02	18.8	0.10	1.25	0.01	1.34	0.01	2.68	0.01
Diesel EG TA–16	diesel	137,000	250	4.06	0.28	18.8	1.31	1.25	0.09	1.34	0.09	2.68	0.19
Diesel EG TA–18	diesel	137,000	286.93	4.06	0.32	18.8	1.50	1.25	0.10	1.34	0.11	2.68	0.21
Diesel EG TA–21*	diesel	137,000	750	3.2	0.67	14	2.92		0.00	0.0573	0.018	0.0697	0.022
Diesel EG TA–21	diesel	137,000	140.19	4.06	0.16	18.8	0.73	1.25	0.05	1.34	0.05	2.68	0.10
Diesel EG TA–33	diesel	137,000	59.66	4.06	0.07	18.8	0.31	1.25	0.02	1.34	0.02	2.68	0.04
Diesel EG TA–35	diesel	137,000	79.79	4.06	0.09	18.8	0.42	1.25	0.03	1.34	0.03	2.68	0.06
Diesel EG TA–41	diesel	137,000	150	4.06	0.17	18.8	0.78	1.25	0.05	1.34	0.06	2.68	0.11
Diesel EG TA–43	diesel	137,000	150	4.06	0.17	18.8	0.78	1.25	0.05	1.34	0.06	2.68	0.11
Diesel EG TA–46	diesel	137,000	300	4.06	0.34	18.8	1.57	1.25	0.10	1.34	0.11	2.68	0.22
Diesel EG TA–50*	diesel	137,000	1,700	3.2	1.51	14	6.61		0.00	0.0573	0.042	0.0697	0.051

TABLE B.—*Peak Load Emission Rates Used for the Combustion Sources Analysis (Diesel and Gasoline Fired Emergency Generators)*[d]-Continued

SOURCE[a,b]	FUEL	HEATING VALUE Btu/gal. (OR Btu/ scf)	DESIGN CAPACITY kw	CO EF g/kw-hr	CO ER g/sec	NO_2 EF g/kw-hr	NO_2 ER g/sec	SO_2 EF g/kw-hr	SO_2 ER g/sec	PM_{10} EF[c] g/kw-hr (OR lb/ million Btu)	PM_{10} ER g/sec	TSP EF g/kw-hr (OR lb/ million Btu)	TSP ER g/sec
Diesel EG TA–53	diesel	137,000	59.66	4.06	0.07	18.8	0.31	1.25	0.02	1.34	0.02	2.68	0.04
Diesel EG TA–55*	diesel	137,000	600	3.2	0.53	14	2.33		0.00	0.0573	0.015	0.0697	0.018
Diesel EG TA–55	diesel	137,000	200	4.06	0.23	18.8	1.04	1.25	0.07	1.34	0.07	2.68	0.15
Diesel EG TA–59	diesel	137,000	238.62	4.06	0.27	18.8	1.25	1.25	0.08	1.34	0.09	2.68	0.18
Diesel EG TA–61	diesel	137,000	35.05	4.06	0.04	18.8	0.18	1.25	0.01	1.34	0.01	2.68	0.03
Diesel EG TA–64	diesel	137,000	264.91	4.06	0.30	18.8	1.38	1.25	0.09	1.34	0.10	2.68	0.20
Diesel EG 6th Str.	diesel	137,000	300	4.06	0.34	18.8	1.57	1.25	0.10	1.34	0.11	2.68	0.22
Diesel EG Rover	diesel	137,000	80.54	4.06	0.09	18.8	0.42	1.25	0.03	1.34	0.03	2.68	0.06
Gasoline EG TA–3	gasoline	130,000	181.95	267	13.49	6.92	0.35	0.359	0.02	0.439	0.02	0.878	0.04
Gasoline EG TA–8	gasoline	130,000	46.98	267	3.48	6.92	0.09	0.359	0.005	0.439	0.01	0.878	0.01
Gasoline EG TA–15	gasoline	130,000	0.75	267	0.06	6.92	0.001	0.359	0.0001	0.439	0.0001	0.878	0.0002
Gasoline EG TA–16	gasoline	130,000	10.44	267	0.77	6.92	0.02	0.359	0.001	0.439	0.001	0.878	0.003
Gasoline EG TA–21	gasoline	130,000	10.44	267	0.77	6.92	0.02	0.359	0.001	0.439	0.001	0.878	0.003
Gasoline EG TA–39	gasoline	130,000	2.24	267	0.17	6.92	0.004	0.359	0.0002	0.439	0.0003	0.878	0.0005

TABLE B.—*Peak Load Emission Rates Used for the Combustion Sources Analysis (Diesel and Gasoline Fired Emergency Generators)*[d]-Continued

SOURCE[a,b]	FUEL	HEATING VALUE Btu/gal. (OR Btu/scf)	DESIGN CAPACITY kw	CO EF g/kw-hr	CO ER g/sec	NO_2 EF g/kw-hr	NO_2 ER g/sec	SO_2 EF g/kw-hr	SO_2 ER g/sec	PM_{10} EF[c] g/kw-hr (OR lb/million Btu)	PM_{10} ER g/sec	TSP EF g/kw-hr (OR lb/million Btu)	TSP ER g/sec
Gasoline EG TA–46	gasoline	130,000	8.95	267	0.66	6.92	0.02	0.359	0.001	0.439	0.001	0.878	0.002
Gasoline EG TA–49	gasoline	130,000	5.97	267	0.44	6.92	0.01	0.359	0.001	0.439	0.001	0.878	0.001
Gasoline EG TA–50	gasoline	130,000	32.07	267	2.38	6.92	0.06	0.359	0.003	0.439	0.004	0.878	0.008
Gasoline EG TA–53	gasoline	130,000	49.96	267	3.71	6.92	0.10	0.359	0.005	0.439	0.01	0.878	0.01
Gasoline EG TA–54	gasoline	130,000	27.59	267	2.05	6.92	0.05	0.359	0.003	0.439	0.003	0.878	0.007
Gasoline EG TA–55	gasoline	130,000	3.73	267	0.28	6.92	0.01	0.359	0.0004	0.439	0.0005	0.878	0.0009
Gasoline EG TA–59	gasoline	130,000	11.19	267	0.83	6.92	0.02	0.359	0.001	0.439	0.001	0.878	0.003
Gasoline EG TA–63	gasoline	130,000	21.63	267	1.60	6.92	0.04	0.359	0.002	0.439	0.003	0.878	0.005
Gasoline EG TA–64	gasoline	130,000	26.10	267	1.94	6.92	0.05	0.359	0.003	0.439	0.003	0.878	0.006

Notes:
[a] All emergency generators design capacities at a particular TA are total capacity of all of the same fuel fired generators.
[b] Emission factors for the diesel fired generators differ depending on the size of the generator; industrial generators are those with capacity up to 457 kW (600 hp) generators above this limit are considered large stationary diesel engines (in the table they are marked with an asterisk). If industrial generators are in the same TA as smaller generators, ER for industrial generators are presented separately.
[c] Particulate emissions for gasoline fueled generators and small industrial generators in size distribution were not available. It was assumed that ER(TSP) = 2 x ER(PM_{10}).
[d] Insignificant sources like small movable generators or TA–57 emergency generators were not included in this analysis. Emissions from Rover Street PA40 generator and 6th Street Cummins generator were added to the TA–3 diesel generator emissions.

TABLE C.—*Annual Average Emission Rates Used for the Combustion Source Analysis*

SOURCE[d]	FUEL	FUEL USAGE (million cf/yr) (OR gal./yr)	CO EF lb/10^3gal. (OR lb/ million scf)	CO ER[c] g/sec	NO_2 EF lb/ 10^3gal. (OR lb/ million scf)	NO_2 ER g/sec	SO_2 EF lb/10^3gal. (OR lb/ million scf)	SO_2 ER[c] g/sec	PM_{10} EF[a] lb/10^3gal. (OR lb/ million scf)	PM_{10} ER g/sec	TSP EF[b] lb/10^3gal. (OR lb/ million scf)	TSP ER g/sec
TA–3–22–1	nat. gas	1,500	40	0.86	163	3.52	0.6	0.01	5	0.11	5	0.11
TA–21–357–1	nat. gas	82	35	0.04	140	0.17	0.6	0.001	5	0.01	5	0.01
TA–16–4	nat. gas	45.56	0.01854	0.02	0.01854	0.02	0.0003	0.0004	0.006	0.01	0.006	0.01
TA–16–5	nat. gas	65.13	0.01854	0.03	0.01854	0.03	0.0003	0.001	0.006	0.01	0.006	0.01
TA–16–6	nat. gas	80.8	0.01854	0.04	0.01854	0.04	0.0003	0.001	0.006	0.01	0.006	0.01
TA–16–13	nat. gas	54.46	0.01854	0.03	0.01854	0.03	0.0003	0.0005	0.006	0.01	0.006	0.01
TA–16 Prototypical	nat. gas	294.23	0.01854	0.16	0.01854	0.16	0.0003	0.003	0.006	0.05	0.006	0.05
Misc. Prototypical Boiler TA–15	nat. gas	40.9	21	0.01	100	0.06	0.6	0.0004	12	0.01	12	0.01
Misc. Prototypical Boiler TA–18	nat. gas	15.88	21	0.005	100	0.02	0.6	0.0001	12	0.003	12	0.003
Misc. Prototypical Boiler TA–22	nat. gas	25.4	21	0.01	100	0.04	0.6	0.0002	12	0.004	12	0.004
Misc. Prototypical Boiler TA–33	nat. gas	11.38	21	0.003	100	0.02	0.6	0.0001	12	0.002	12	0.002
Misc. Prototypical Boiler TA–35	nat. gas	116.94	21	0.04	100	0.17	0.6	0.001	12	0.02	12	0.02
Misc. Prototypical Boiler TA–41	nat. gas	19.02	21	0.01	100	0.03	0.6	0.0002	12	0.003	12	0.003
Misc. Prototypical Boiler TA–46	nat. gas	15.55	21	0.005	100	0.02	0.6	0.0001	12	0.003	12	0.003

TABLE C.—*Annual Average Emission Rates Used for the Combustion Source Analysis*-Continued

SOURCE[d]	FUEL	FUEL USAGE (million cf/yr) (OR gal./yr)	CO EF lb/10^3gal. (OR lb/ million scf)	CO ER[c] g/sec	NO_2 EF lb/ 10^3gal. (OR lb/ million scf)	NO_2 ER g/sec	SO_2 EF lb/10^3gal. (OR lb/ million scf)	SO_2 ER[c] g/sec	PM_{10} EF[a] lb/10^3gal. (OR lb/ million scf)	PM_{10} ER g/sec	TSP EF[b] lb/10^3gal. (OR lb/ million scf)	TSP ER g/sec
Misc. Prototypical Boiler TA–48	nat. gas	103.44	21	0.03	100	0.15	0.6	0.001	12	0.02	12	0.02
Misc. Prototypical Boiler TA–50	nat. gas	21.56	21	0.01	100	0.03	0.6	0.0002	12	0.004	12	0.004
Misc. Prototypical Boiler TA–52	nat. gas	28.69	21	0.01	100	0.04	0.6	0.0002	12	0.005	12	0.005
Misc. Prototypical Boiler TA–53	nat. gas	95.68	21	0.03	100	0.14	0.6	0.001	12	0.02	12	0.02
Misc. Prototypical Boiler TA–55	nat. gas	48.28	21	0.01	100	0.07	0.6	0.0004	12	0.01	12	0.01
Misc. Prototypical Boiler TA–58	nat. gas	28.05	21	0.01	100	0.04	0.6	0.0002	12	0.005	12	0.005
TA–3–73–1	nat. gas	13.6	21	0.004	100	0.02	0.6	0.0001	12	0.002	12	0.002
TA–3–73–2	oil #2	7,000	5	0.001	20	0.002	48	0.005	2	0.0002	2	0.0002
Nat. Gas Water Pump	nat. gas	700	1.6	0.31	5	0.97	0	0.00	0.003	0.001	0.003	0.001
Incinerator	waste			0.00002		0.0002		0.0002		0.0002		0.0002

Notes:
[a] According to AP-42 (EPA 1995), particulate matter from the natural gas combustion is less than 1µm in size, so ER(PM_{10}) = ER(TSP).
[b] TSP EF from the fuel oil #2 is the same as in Title V application; PM_{10} EF is obtained from Table 1.3–5 for size-specific EF from industrial boilers (EPA 1995).
[c] Waste oil and solid waste was burned. 8-hour CO and 24-hour SO_2 concentrations were conservatively estimated using 1-hour (CO) and 3-hours (SO_2) emission rates.
[d] In the first column, a miscellaneous prototypical boiler is a boiler that sums up emissions from all boilers at this TA.

ATTACHMENT 2
TOXIC CHEMICALS CONSIDERED FOR THE ANALYSIS

Toxic Chemicals Considered for the Analysis

NO.	TOXIC AIR POLLUTANTS
	NONCARCINOGENIC POLLUTANTS
1	1,1-Dichloroethane
2	1,1,2-Trichloro-1,2,2-Trifluoroethane
3	1,1-Dichloro-Nitroethane
4	1,4-Dioxane
5	1,1,1-Trichloroethane
6	1,2,4-Trimethylbenzene
7	1,2-Dichloroethylene
8	1,3,5-Trimethylbenzene
9	1-Chloro-1-Nitropropane
10	1-Nitropropane
11	2,4,6-Trinitrotoluene (TNT)
12	2-Aminopyridine
13	2-Butoxyethanol
14	2-Butoxyethanol Acetate
15	2-Diethylaminoethanol
16	2-Ethoxyethanol (EGEE)
17	2-Ethoxyethyl Acetate (EGEEA)
18	2-Hydroxypropyl Acrilate
19	2-Methoxyethanol (EGME)
20	2-Methoxyethyl Acetate
21	2-Methyl-Cyclopent. Mang.Tricarbonyl
22	4-Methoxyphenol
23	a-Methyl Styrene
24	Acetic Acid
25	Acetic Anhydride
26	Acetone
27	Acetonitrile
28	Acetophenone
29	Acetylene
30	Acetylene Tetrabromide

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
31	Acrolein
32	Acrylic Acid
33	Adiponitrile
34	Allyl Alcohol
35	Allyl Glycidyl Ether (AGE)
36	Aluminum, Metal Dust, as Al
37	Aluminum Alkyls not otherwise classified
38	Aluminum Pyro Powders, as Al
39	Aluminum, Welding Fumes, as Al
40	Amitrole
41	Ammonia
42	Ammonium Chloride (Fume)
43	Aniline and Homologues
44	Anisidine (o-, p-isomers)
45	Antimony and Compounds, as Sb
46	Arsine
47	Asphalt (Petroleum) Fumes
48	Benzenethiol
49	Benzoyl Peroxide
50	Biphenyl
51	Bismuth Telluride
52	Boron Oxide
53	Boron Trifluoride
54	Bromine
55	Bromine Pentafluoride
56	Bromoform
57	Butyl Mercaptan
58	Carbon Black
59	Carbon Disulfide
60	Carbon Tetrabromide
61	Catechol
62	Cesium Hydroxide

Toxic Chemicals Considered for the Analysis-Continued

NO.	TOXIC AIR POLLUTANTS
63	Chlorinated Camphene
64	Chlorine
65	Chlorine Trifluoride
66	Chloroacetaldehyde
67	Chloroacetyl Chloride
68	Chlorobenzene
69	Chlorodifluoromethane
70	Chromium III comp., as Cr
71	Cobalt Carbonyl, as Co
72	Cobalt Hydrocarbonyl, as Co
73	Cobalt, el. & inorg. comp., as Co
74	Copper, Dusts & Mists, as Cu
75	Copper, Fume, as Cu
76	Cresol (all isomers)
77	Crotonaldehyde
78	Cumene
79	Cyanamide
80	Cyanogen
81	Cyanogen Chloride
82	Cyclohexane
83	Cyclohexanol
84	Cyclohexanone
85	Cyclohexene
86	Cyclohexylamine
87	Cyclopentadiene
88	Cyclopentane
89	Decaborane
90	Di-sec, Octyl Phthalate
91	Diacetone Alcohol
92	Diazinon
93	Diazomethane
94	Dibutyl Phosphate

Toxic Chemicals Considered for the Analysis-Continued

NO.	TOXIC AIR POLLUTANTS
95	Dibutyl Phthalate
96	Dichlorodifluoromethane
97	Dichlorofluoromethane
98	Dichlorovos
99	Dicyclopentadiene
100	Dicyclopentadienyl Iron
101	Diethyl Ketone
102	Diethyl Phthalate
103	Diethylamine
104	Diethylene Triamine
105	Diisoproprylamine
106	Dimethoxymethane
107	Dimethyl Amine
108	Dimethyl Phthalate
109	Dimethyl Sulfate
110	Dinitro-o-Cresol
111	Dinitrobenzene (all isomers)
112	Dinitrotoluene
113	Diphenylamine
114	Dipropyl Ketone
115	Diprop. Glycol Methyl Ether
116	Divinyl Benzene
117	Endrin
118	Enflurane
119	Ethanol
120	Ethanolamine
121	Ethion
122	Ethyl Acetate
123	Ethyl Benzene
124	Ethyl Bromide
125	Ethyl Chloride
126	Ethyl Ether

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
127	Ethyl Formate
128	Ethyl Mercaptan
129	Ethylamine
130	Ethylene Chlorohydrin
131	Ethylene Diamine
132	Fibrous Glass Dust
133	Fluorides, as F
134	Fluorine
135	Formamide
136	Formic Acid
137	Furfural
138	Furfuryl Alcohol
139	Gasoline
140	Germanium Tetrahydride
141	Glutaraldehyde
142	Hafnium
143	Hexafluoroacetone
144	Hexamethylene Diisocyanate
145	Hexane (other isomers)*
146	Hexylene Glycol
147	Hydrogen Bromide
148	Hydrogen Chloride
149	Hydrogen Cyanide
150	Hydrogen Fluoride, as F
151	Hydrogen Peroxide
152	Hydrogen Sulfide
153	Hydroquinone
154	Indene
155	Indium & compounds, as In
156	Iodine
157	Iodoform
158	Iron Oxide Fume, as Fe

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
159	Iron Pentacarbonyl, as Fe
160	Iso-Amyl Acetate
161	Iso-Amyl Alcohol
162	Isobutane
163	Isobutyl Acetate
164	Isobutyl Alcohol
165	Isobutyronitrile
166	Isooctyl Alcohol
167	Isophorone
168	Isophorone Diisocyanate
169	Isopropoxyethanol
170	Isopropyl Acetate
171	Isopropyl Alcohol
172	Isopropyl Ether
173	Isopropylamine
174	Kerosene
175	Lead, el. & inorg. compounds, as Pb
176	Lithium Hydride
177	m-Cresol
178	m-Phenylenediamine
179	m-Toluidine
180	Magnesium Oxide Fume
181	Maleic Anhydride
182	Malononitrile
183	Manganese Comp., as Mn
184	Manganese as Mn Fume
185	Mercury (in. forms, incl. m.Hg)
186	Mercury Alkyl Compounds
187	Mercury Aryl Compounds
188	Methacrylic Acid
189	Methoxychlor
190	Methyl 2-Cyanoacrylate

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
191	Methyl Acetate
192	Methyl Acetylene
193	Methyl Acrylate
194	Methyl Alcohol
195	Methyl Cyclohexane
196	Methyl Ethyl Ketone (MEK)
197	Methyl Formate
198	Methyl Hydrazine
199	Methyl Iodide
200	Methyl Isobutyl Carbinol
201	Methyl Isobutyl Ketone
202	Methyl Isocyanate
203	Methyl Mercaptan
204	Methyl Methacrylate
205	Methyl n-Amyl Ketone
206	Methyl n-Butyl Ketone
207	Methyl Propyl Ketone
208	Methyl Silicate
209	Methylacrylonitrile
210	Methylamine
211	Methylene Bisphenyl Isocyanate
212	Molybdenum as Mo Insol. Comp.
213	Molybdenum as Mo Sol. Comp.
214	Morpholine
215	n,n-Dimethyl Acetamide
216	n,n-Dimethylaniline
217	n,n-Dimethylformamide
218	n-Amyl Acetate
219	n-Butyl Acetate
220	n-Butyl Acrylate
221	n-Butyl Alcohol
222	n-Butyl Glycidyl Ether (BGE)

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
223	n-Butylamine
224	n-Heptane
225	n-Hexane
226	n-Methylaniline
227	n-Propyl Acetate
228	Naphtalene
229	Nickel Carbonyl, as Ni
230	Nickel Sol. & In. Comp., as Ni
231	Nicotine
232	Nitric Acid
233	Nitric Oxide
234	Nitrobenzene
235	Nitroethane
236	Nitromethane
237	Nitrotoluene
238	Nitrous Oxide
239	Nonane
240	o-Chlorostyrene
241	o-Chlorotoluene
242	o-Dichlorobenzene
243	o-Methylcyclohexanone
244	o-Phenylenediamine
245	o-Toluidine
246	Octane
247	Oil Mist, Mineral
248	Osmium Tetroxide, as Os
249	Oxalic Acid
250	p-Nitroaniline
251	p-Nitrochlorobenzene
252	p-Phenylenediamine
253	p-Toluidine
254	Paraffin Wax Fume

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
255	Paraquat Dichloride
256	Paraquat Respirable Sizes
257	Particulate Matter, Resp. Dust
258	Pentachlorophenol
259	Pentaerythritol
260	Pentane (all isomers)
261	Perchloromethyl Mercaptan
262	Phenol
263	Phenothiazine
264	Phenylhydrazine
265	Phenylphosphine
266	Phosgene
267	Phosphoric Acid
268	Phosphorus
269	Phosphorus Oxychloride
270	Phosphorus Pentachloride
271	Phosphorus Trichloride
272	Picric Acid
273	Platinum Metal
274	Potassium Hydroxide
275	Propane
276	Propargyl Alcohol
277	Propionic Acid
278	Propionitrile
239	Propyl Alcohol
280	Propylene Glycol Monomethyl Ether
281	Pyridine
282	Rhodium Metal
283	sec-Butyl Acetate
284	sec-Butyl Alcohol
285	Selenium Compounds, as Se
286	Silica, Cristobalite

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
287	Silica, Quartz
288	Tridymite, Respirable Dust
289	Silica, Fused (respirable)
290	Silicon Tetrahydride
291	Silver (met. dust & sol. comp., as Ag)
292	Stoddard Solvent
293	Sulfur Hexafluoride
294	Sulfuric Acid
295	Sulfuryl Fluoride
296	Tantalum Metal
297	Tellurium & Compounds, as Te
298	Terphenyls
299	tert-Butyl Alcohol
300	Tetraethyl Lead
301	Tetrahydrofuran
302	Tetranitromethane
303	Tetrasodium Pyrophosphate
304	Thioglycolic Acid
305	Thionyl Chloride
306	Tin, metal
307	Tin Organic Compounds, as Sn
308	Tin Oxide & Inorg. Comp., as Sn
309	Toluene
310	Toluene-2,4-diisocyanate (TDI)
311	Tributyl Phosphate
312	Trichloroacetic Acid
313	Triethylamine
314	Trimethyl Benzene
315	Trimethyl Phosphite
316	Trimethylamine
317	Triphenylamine
318	Triphenylphosphate

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
319	Tungsten as W insoluble Compounds
320	Turpentine
321	Uranium (nat.) Sol. & Unsol. Comp. as U
322	Vanadium, Respirable Dust & Fume
323	Vinyl Acetate
324	Vinyl Toluene
325	Vinylidene Fluoride
326	VM & P Naphtha
327	Welding Fumes not otherwise listed
328	Wood Dust (certain hard woods)
329	Xylene (o-, m-, p-Isomers)
330	Yttrium
331	Zinc Chloride Fume
332	Zinc Oxide Fume
333	Zinc Chromate, as Cr
334	Zirconium Compounds, as Zr
CARCINOGENIC POLLUTANTS	
335	Acetaldehyde
336	Acrylamide
337	Acrylonitrile
338	Allyl Chloride
339	Aldrin
340	Arsenic, el. & inorg., exc. Arsine, as As
341	Asbestos
342	Benzene
343	Benzidine
344	Benzo(a)pyrene
345	Benzyl Chloride
346	Beryllium
347	Bis(Chloromethyl)Ether (BCME)
348	1,3-Butadiene

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
349	Cadmium, el. & compounds, as Cd
350	Carbon Tetrachloride
351	Chloroform
352	Chlordane
353	Chromium VI
354	Diethanolamine
355	3,3-Dichlorobenzidine
356	Epichlorohydrin
357	Ethyl Acrylate
358	Ethylene Dibromide
359	Ethylene Dichloride
360	Ethylene Oxide
361	Formaldehyde
362	Hexachlorobenzene
363	Hexachlorobutadiene
364	Hexachloroethane
365	Hydrazine
366	Lindane
367	Methyl Chloride
368	Methylene Chloride
369	Nickel, metal (dust)
370	Polychlorinated Biphenyl (PCB)
371	Propylene Dichloride
372	Propylene Oxide
373	Styrene
374	Tetrachlorethylene
375	Trichloroethylene
376	Vinyl Chloride
377	1,1-Dichloethylene
378	1,1,2,2-Tetrachloroethane
379	1,1,1,2-Tetrachloroethane

***Toxic Chemicals Considered for the Analysis*-Continued**

NO.	TOXIC AIR POLLUTANTS
380	1,1,2-Trichloroethane
381	1,2-Dibromo-3-Chloropropane
382	2-Nitropropane

ATTACHMENT 3
SET OF SENSITIVE RECEPTORS FOR NONRADIOLOGICAL AIR QUALITY ANALYSIS

Set of Sensitive Receptors for Nonradiological Air Quality Analysis

RECEPTOR ID	RECEPTOR NAME
1	Entrance Park
2	Airport
3	East Park
4	Sombrillo Facility
5	Canyon School Park
6	Canyon Elementary School
7	Furr's Supermarket
8	Canyon Road Park
9	Pine Street Playlot
10	YMCA
11	Post Office
12	Community Shopping Center
13	Community Center Park
14	Masonic Temple
15	Unitarian Fellowship Church and Sage Montessori School
16	Church of Latter Day Saints
17	Fuller Lodge and Park
18	Ashley Pond
19	Mesa Public Library
20	Senior Center
21	United Church of Los Alamos and Canyoncito Montessori School
22	Jewish Center
23	Orange Street Playlot
24	Larry Walkup Aquatic Center
25	Immaculate Heart of Mary Catholic Church
26	Los Alamos High School
27	Episcopal Church
28	Los Alamos Medical Center
29	Methodist Church and ARK Daycare Center
30	Sullivan Field
31	Mesa Complex
32	Ed's Food Market
33	Western Area Park

Set of Sensitive Receptors for Nonradiological Air Quality Analysis-Continued

RECEPTOR ID	RECEPTOR NAME
34	Ridgeway Playlot
35	Pueblo Complex
36	37^{th} Street Playlot
37	Aspen Elementary School
38	Walnut Street Playlot
39	Urban Park
40	Mountain School
41	Church of Christ
42	Fantasy Playlot
43	Golf Course
44	Guaje Pines Cemetery
45	Park
46	Picnic Area
47	Los Alamos Middle School
48	North Mesa Picnic Grounds
49	Rodeo Arena
50	Playlot
51	Barranca School
52	Barranca Mesa Park
53	Park
54	Overlook Park
55	Chamisa Elementary School
56	Mountain Meadow Playlot
57	Teddy Bear Junction
58	WR Shopping Center
59	Piñon Park
60	Piñon Elementary School
61	Grand Canyon Park
62	Jeffrey Playlot
63	Rover Park
64	Sage Montessori School
65	Park
66	Park
67	Community Club
68	Park
69	Park
70	Park

***Set of Sensitive Receptors for Nonradiological Air Quality Analysis*-Continued**

RECEPTOR ID	RECEPTOR NAME
71	First Baptist Church and Busy Bee Daycare and Playschool
72	Little Forest Daycare
73	North Mesa Ballfields
74	36th Street Tennis Courts
75	Covenant Christian School
76	Hilltop Christian Academy
77	Los Alamos Sportman's Club
78	Royal Crest RV and Mobile Home Park
79	Camp May
80	Pajarito Ski Area
81	Los Alamos Reservoir
82	Duchess Castle Ruins
83	Tsankawi Ruins
84	Mortandad Cave
85	Otowi Ruins
86	Puye Cliffs
87	Two-Mile Mesa Trail
88	LANL Fitness Trail
89	Cuba
90	Jemez Springs
91	Coyote
92	Abiquiu
93	Chimayo
94	San Ysidro
95	Bernalillo
96	Corrales
97	Cedar Crest
98	Golden
99	Madrid
100	Lamy
101	Village of Agua Fria
102	Santa Fe
103	Tesuque
104	Española
105	Santa Cruz

***Set of Sensitive Receptors for Nonradiological Air Quality Analysis*-Continued**

RECEPTOR ID	RECEPTOR NAME
106	El Rancho
107	Jaconita
108	Pojoaque
109	Nambe
110	Cuyamungue
111	Eldorado
112	Gallina
113	Alcalde
114	Ojo Caliente
115	Dixon
116	Taos
117	Picuris Pueblo
118	Nambe Pueblo
119	Tesuque Pueblo
120	Santa Clara Pueblo
121	San Juan Pueblo
122	San Ildefonso Pueblo
123	Cochiti Pueblo
124	San Felipe Pueblo
125	Santa Ana Pueblo
126	Jemez Pueblo
127	Jemez Pueblo
128	Jemez Pueblo
129	Sandia Pueblo
130	Taos Pueblo
131	Jicarilla Apache Indian Reservation
132	Acoma Pueblo
133	Isleta Pueblo
134	Mescalero Apaches
135	Abiquiu Lake
136	Cochiti Lake
137	Fenton Lake
138	Las Cumbres Learning Services
139	Zia Pueblo
140	Zia Pueblo
141	Zia Pueblo
142	Bandelier National Monument

***Set of Sensitive Receptors for Nonradiological Air Quality Analysis*-Continued**

RECEPTOR ID	RECEPTOR NAME
143	Santo Domingo Pueblo
144	Crownpoint Navajo Indian Reservation
145	Taos Pueblo
146	Taos Pueblo
147	Trail on North Side of White Rock
148	White Rock Canyon Rim Trail
149	Red Dot Trail
150	Trail on West Side of Pajarito Acres
151	Trail on East Side of LANL
152	Trail on East Side of LANL
153	Fey Trail
154	Trail West of Frey Trail
155	Lower Frijoles Canyon Trail
156	Trail on North Side of Bandelier National Monument
157	North Side of Bandelier National Monument
158	Burnt Mesa Trail
159	Burnt Mesa Trail
160	Trail South of Burnt Mesa Trail
161	Burnt Mesa Trail
162	Burnt Mesa Trail
163	Burnt Mesa Trail
164	Upper Frijoles Crossing Trail
165	Water Canyon Trail 281
166	Canyon de Valle Trail
167	Trail South of Pajarito Canyon Trail 280
168	Nature Loop
169	Pueblo Canyon Trail
170	Pueblo Canyon Trail
171	Pueblo Canyon Trail
172	Pueblo Canyon Trail
173	Pueblo Canyon Trail
174	Pueblo Canyon Trail
175	Elevated Receptors at TA–43
176	Elevated Receptors at TA–43

***Set of Sensitive Receptors for Nonradiological Air Quality Analysis*-Continued**

RECEPTOR ID	RECEPTOR NAME
177	Elevated Receptors at TA–43
178	Elevated Receptors at TA–43
179	Elevated Receptors at TA–43
180	Elevated Receptors at TA–43

ATTACHMENT 4
DISPERSION MODELING METHODOLOGY USED TO DEVELOP SCREENING LEVEL EMISSION VALUES

Dispersion Modeling Analysis

The EPA's Industrial Source Complex Air Quality Dispersion Model (ISC–3) was used for the dispersion analyses conducted for this study. The ISC–3 model, which applies a steady-state Gaussian plume equation for a continuous source, is a validated model that is often used to estimate air quality impacts from existing and proposed sources of air pollutants. The ISC–3's short-term algorithm was used to estimate 8-hour and annual concentrations at each of the receptor locations. Flat terrain was assumed. An emission rate of 1 gram per second was used to establish the relationship between emission rate and concentration at the maximum receptor location for each TA.

The regulatory default options that were used include:

- Rural dispersion algorithm
- Final plume rise
- Stack-tip downwash
- Building downwash
- Buoyancy-induced dispersion
- Default wind speed and vertical temperature profiles
- Terrain receptors, equal to and below the height of the lowest stack

The land use within or near Los Alamos (using the EPA-recommended Auer's technique [Auer 1978]) was considered to be rural. As such, the Pasquill-Gifford rural dispersion coefficients were used for all dispersion analyses.

Five years of Los Alamos meteorological on-site observations for years 1991 through 1995 were used in dispersion analysis for nonradiological air emissions. These 5 years of data were obtained by using the EPA PC RAMMET program, with surface observations and morning and afternoon mixing heights data as inputs. The surface observations were collected at the TA–6 meteorological tower at LANL. Mixing heights were estimated based on the Albuquerque upper air observations and Santa Fe surface data.

Because the TA stacks and nearby buildings may be subject to building downwash (i.e., stack heights may be less than good-engineering practice [GEP] stack heights), the controlling prototypical building dimensions were entered as input into the dispersion analysis. Trinity Consultants' Breeze Air™ (TCI 1996) BPIP (Building Profile Input Program [EPA 1993a]) computer software were used to determine direction-specific building dimensions (height, projected width, and GEP stack height).

Because there are no other significant sources of toxic air pollutants near LANL facilities, background air toxin levels were assumed to be zero.

The ISC–3-estimated maximum 8-hour and annual pollutant concentrations associated with LANL TAs, for a test case of 1 gram per second, using 1991 through 1995 meteorological data, are provided in Table A of this attachment.

TABLE A.—*The ISC–3 Estimated 8-Hour and Annual Concentrations Associated with LANL Technical Areas Using 1991–1995 Meteorological Data*

8-HOUR ESTIMATED CONCENTRATIONS (µg/m^3)[a]					
METEOROLOGICAL DATA[c]					
TA	**1991**	**1992**	**1993**	**1994**	**1995**
00	279.49560	229.43240	276.49660	248.43500	**287.41440**
2	513.64450	473.75730	**568.91710**	509.66990	560.53440
3	163.81105	**198.62587**	155.75540	164.33449	155.43233
5	149.90700	162.09580	128.37780	138.83980	**183.12160**
8	**324.95227**	305.07642	251.05130	273.90700	321.50980
9	**310.63486**	244.58514	245.01843	262.47159	260.73364
11	353.89670	**481.48288**	365.60450	346.11150	285.51890
15	290.83716	**292.22995**	225.39305	219.32697	200.88281
16	123.92935	**179.15591**	150.07620	113.51302	122.97661
18	910.98451	665.79895	842.05798	787.37677	**946.91431**
21	**432.78125**	312.27692	427.35263	372.58060	403.49457
22	488.72080	**524.60850**	435.44110	446.54640	523.14040
33	177.21200	112.63840	120.58750	**139.54990**	118.77170
35	576.44983	557.09857	**612.55536**	610.81940	592.49658
36	282.37897	204.94788	295.61194	219.22858	**389.92822**
39	233.96115	**285.91559**	159.50490	249.67120	276.70010
40	322.70642	296.88312	323.19415	**479.85321**	367.77228
41	490.36520	657.47140	676.38990	**709.29850**	666.62910
46	318.06880	**460.12480**	297.29060	341.28820	299.20180
48	488.90000	534.90000	568.60000	**589.30000**	556.10000
50	456.40000	453.60000	484.60000	**593.56396**	478.00000
51	359.90330	430.70670	**562.89490**	421.93490	494.20170
53	190.86334	150.54651	147.59128	**220.65263**	209.51642
54	147.87006	207.02702	169.36514	**219.19812**	141.96089
55	860.71283	739.73020	968.98750	821.74750	**1017.25200**
59	684.99225	769.20410	730.56140	653.36480	**769.62010**
60	223.43800	250.81170	176.93660	**274.93510**	179.31870
61	234.10380	177.12100	218.73490	196.43460	**253.92700**
64	615.90990	**784.60700**	499.29060	462.26250	613.96380

TABLE A.—*The ISC–3 Estimated 8-Hour and Annual Concentrations Associated with LANL Technical Areas Using 1991–1995 Meteorological Data*-Continued

ANNUAL ESTIMATED CONCENTRATIONS (µg/m³)[b]					
METEOROLOGICAL DATA[c]					
TA	**1991**	**1992**	**1993**	**1994**	**1995**
00	**2.19354**	1.76703	2.02104	1.69840	1.95963
2	4.48941	4.29066	**4.98455**	4.54396	4.59531
3	2.15460	1.96920	2.45068	**2.46536**	2.30553
5	0.74664	**0.76824**	0.73882	0.72562	0.67348
8	1.37394	1.26414	1.25554	1.22274	**1.40186**
9	0.60227	0.60095	**0.71872**	0.61262	0.56950
11	**0.86231**	0.81774	0.52535	0.45393	0.53742
15	0.29479	**0.31361**	0.28034	0.28057	0.26807
16	0.60160	**0.78717**	0.48017	0.61480	0.43183
18	0.46945	0.46511	0.43969	**0.50015**	0.45972
21	3.49665	2.61230	3.90596	3.67452	**3.96519**
22	0.51278	0.54939	**0.58868**	0.55958	0.52204
33	1.07322	0.99352	0.97370	1.06143	**1.11189**
35	0.55983	0.54803	**0.65824**	0.64655	0.60591
36	0.37314	**0.39786**	0.35679	0.34646	0.37540
39	2.55763	2.26826	**3.05966**	2.88462	2.97997
40	0.56740	0.54473	0.54502	**0.60511**	0.52467
41	5.10670	4.54171	5.34982	**5.40181**	5.26285
46	**0.66202**	0.54784	0.55816	0.52594	0.57425
48	2.69000	2.25000	2.88000	**2.94752**	2.82000
50	0.56421	0.59867	**0.64865**	0.57143	0.57586
51	0.52689	0.57286	0.62493	**0.71755**	0.66236
53	2.13802	2.31454	**2.42821**	2.31592	2.25865
54	0.68160	0.61071	0.69577	**0.78755**	0.68274
55	0.58653	0.65019	**0.67169**	0.63840	0.57909
59	1.61045	1.49807	1.86697	1.76562	**1.87894**
60	3.53892	**3.61417**	3.45185	3.48662	3.48484
61	3.79212	4.02321	**4.07485**	4.00865	3.79064
64	1.51835	1.34770	1.40558	1.43161	**1.54660**

Notes:
[a] 8-hour pollutant concentrations were estimated at the fence line receptors located around each TA.
[b] Annual pollutant concentrations were estimated at the sensitive receptors.
[c] Bold entries indicate that the highest concentration occurs for this year of the meteorological event.

ATTACHMENT 5
EIGHT-HOUR SCREENING LEVEL EMISSION VALUES (TABLE 1) AND ANNUAL SCREENING LEVEL EMISSION VALUES FOR CHEMICALS (TABLE 2) TA–3 EXAMPLE WORKSHEETS

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
	NONCARCINOGENIC POLLUTANTS											
1	1,1 Dichloroethane	75-34-3	400,000	4,000	2.01E+01	1.60E+02						
2	1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	7,600,000	76,000	3.83E+02	3.04E+03						
3	1,1-Dichloro-Nitroethane	594-72-9	10,000	100	5.03E-01	4.00E+00						
4	1,4-Dioxane	123-91-1	90,000	900	4.53E+00	3.60E+01	8.44E-04	4.26E+04	9.08E+00	7.95E-03	4.52E+03	4.52E+03
5	1,1,1-Trichloroethane	71-55-6	1,900,000	19,000	9.57E+01	7.59E+02			1.51E+03	1.32E+00	5.74E+02	5.74E+02
6	1,2,4-Trimethylbenzene	95-63-6	123,000	1,230	6.19E+00	4.91E+01						
7	1,2-Dichloroethylene	540-59-0	790,000	7,900	3.98E+01	3.16E+02						
8	1,3,5-Trimethylbenzene	108-67-8	123,000	1,230	6.19E+00	4.91E+01						
9	1-Chloro-1-Nitropropane	600-25-9	10,000	100	5.03E-01	4.00E+00						
10	1-Nitropropane	108-03-2	90,000	900	4.53E+00	3.60E+01						
11	2,4,6-Trinitrotoluene	118-96-7	500	5	2.52E-02	2.00E-01						
12	2-Aminopyridine	504-29-0	2,000	20	1.01E-01	7.99E-01						
13	2-Butoxyethanol	111-76-2	121,000	1,210	6.09E+00	4.83E+01	5.11E-01	9.47E+01				9.47E+01
14	2-Butoxyethanol Acetate	112-07-2	33,000	330	1.66E+00	1.32E+01						
15	2-Diethylaminoethanol	100-37-8	9,600	96	4.83E-01	3.84E+00						
16	2-Ethoxyethanol	110-80-5	18,000	180	9.06E-01	7.19E+00						
17	2-Ethoxyethyl Acetate	111-15-9	27,000	270	1.36E+00	1.08E+01						
18	2-Hydroxypropyl Acrylate	999-61-1	2,800	28	1.41E-01	1.12E+00						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
19	2-Methoxyethanol	109-86-4	16,000	160	8.06E-01	6.39E+00						
20	2-Methoxyethyl Acetate	110-49-6	24,000	240	1.21E+00	9.59E+00						
21	2-Methyl Cyclopentadienyl Manganese Tricarbonyl	12108-13-3	200	2	1.01E-02	7.99E-02						
22	4-Methoxyphenol	150-76-5	5,000	50	2.52E-01	2.00E+00						
23	a-Methyl Styrene	98-83-9	242,000	2,420	1.22E+01	9.67E+01						
24	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	2.84E+00	3.51E+00	1.62E+01	1.42E-02	7.04E+02	3.51E+00
25	Acetic Anhydride	108-24-7	20,000	200	1.01E+00	7.99E+00	--					
26	Acetone	67-64-1	1,780,000	17,800	8.96E+01	7.11E+02	2.41E+00	2.95E+02	5.64E+02	4.93E-01	1.44E+03	2.95E+02
27	Acetonitrile	75-05-8	67,000	670	3.37E+00	2.68E+01	--		2.41E+01	2.11E-02	1.27E+03	1.27E+03
28	Acetophenone	98-86-2	49,000	490	2.47E+00	1.96E+01	--					
29	Acetylene	74-86-2	2,662,000	26,620	1.34E+02	1.06E+03			9.09E+02	7.95E-01	1.34E+03	1.34E+03
30	Acetylene Tetrabromide	79-27-6	14,000	140	7.05E-01	5.59E+00	--					
31	Acrolein	107-02-8	230	2	1.16E-02	9.19E-02						
32	Acrylic Acid	79-10-7	5,900	59	2.97E-01	2.36E+00			6.95E-01	6.08E-04	3.88E+03	1.34E+03
33	Adiponitrile	111-69-3	8,800	88	4.43E-01	3.52E+00						
34	Allyl Alcohol	107-18-6	4,800	48	2.42E-01	1.92E+00	--					
35	Allyl Glycidyl Ether	106-92-3	23,000	230	1.16E+00	9.19E+00						
36	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.03E-01	4.00E+00	4.09E-02	9.78E+01	2.20E+00	1.93E-03	2.08E+03	9.78E+01
37	Aluminum Alkyls not otherwise classified	7429-90-5	2,000	20	1.01E-01	7.99E-01						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
38	Aluminum Pyro Powders, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00						
39	Aluminum, Welding Fumes, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00	6.04E-01	3.31E+00				3.31E+00
40	Amitrole	61-8-5	200	2	1.01E-02	7.99E-02						
41	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	7.09E-01	9.59E+00				9.59E+00
42	Ammonia Chloride (Fume)	12125-02-9	10,000	100	5.03E-01	4.00E+00						
43	Aniline & Homologues	62-53-3	7,600	76	3.83E-01	3.04E+00	2.81E-04	1.08E+04				1.08E+04
44	Anisidine (o-, p-isomers)	29191-52-4	500	5	2.52E-02	2.00E-01						
45	Antimony and Compounds, as Sb	7440-36-0	500	5	2.52E-02	2.00E-01			2.47E-01	2.16E-04	9.25E+02	9.25E+02
46	Arsine	7784-42-1	160	2	8.06E-03	6.39E-02						
47	Asphalt (Petroleum) Fumes	8052-42-4	5,000	50	2.52E-01	2.00E+00						
48	Benzenethiol	108-98-5	500	5	2.52E-02	2.00E-01						
49	Benzoyl Peroxide	94-36-0	5,000	50	2.52E-01	2.00E+00						
50	Biphenyl	92-52-4	1,000	10	5.03E-02	4.00E-01						
51	Bismuth Telluride	1304-82-1	5,000	50	2.52E-01	2.00E+00						
52	Boron Oxide	1303-86-2	10,000	100	5.03E-01	4.00E+00	7.25E-04	5.51E+03				5.51E+03
53	Boron Trifluoride	7637-07-2	3,000	30	1.51E-01	1.20E+00	3.50E-04	3.42E+03				3.42E+03
54	Bromine	7726-95-6	660	7	3.32E-02	2.64E-01	5.00E-04	5.27E+02				5.27E+02
55	Bromine Pentafluoride	7789-30-2	700	7	3.52E-02	2.80E-01						
56	Bromoform	75-25-2	5,000	50	2.52E-01	2.00E+00						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
57	Butyl Mercaptan	109-79-5	1,500	15	7.55E-02	5.99E-01						
58	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	1.47E-02	9.49E+01	1.10E+00	9.63E-04	1.45E+03	9.49E+01
59	Carbon Disulfide	75-15-0	31,000	310	1.56E+00	1.24E+01						
60	Carbon Tetrabromide	558-13-4	1,400	14	7.05E-02	5.59E-01						
61	Catechol	120-80-9	23,000	230	1.16E+00	9.19E+00						
62	Cesium Hydroxide	21351-79-1	2,000	20	1.01E-01	7.99E-01						
63	Chlorinated Camphene	8001-35-2	500	5	2.52E-02	2.00E-01						
64	Chlorine	7782-50-5	1,500	15	7.55E-02	5.99E-01	1.40E-04	4.28E+03				4.28E+03
65	Chlorine Trifluoride	7790-91-2	400	4	2.01E-02	1.60E-01						
66	Chloroacetaldehyde	107-20-0	3,000	30	1.51E-01	1.20E+00						
67	Chloroacetyl Chloride	79-04-9	200	2	1.01E-02	7.99E-02						
68	Chlorobenzene	108-90-7	46,000	460	2.32E+00	1.84E+01	1.88E-03	9.80E+03				9.80E+03
69	Chlorodifluoromethane	75-45-6	3,540,000	35,400	1.78E+02	1.41E+03						
70	Chromium, Metal & Cr III Compounds, as Cr	7440-47-3	500	5	2.52E-02	2.00E-01	4.46E-04	4.48E+02	1.10E+00	9.63E-04	2.08E+02	2.08E+02
71	Cobalt Carbonyl, as Co	10210-68-1	100	1	5.03E-03	4.00E-02						
72	Cobalt Hydrocarbonyl, as Co	16842-03-8	100	1	5.03E-03	4.00E-02						
73	Cobalt, elemental & inorg. comp., as Co	7440-48-4	20	0	1.01E-03	7.99E-03	2.80E-06	2.85E+03				2.85E+03
74	Copper, Dusts & Mists, as Cu	7440-50-8	1,000	10	5.03E-02	4.00E-01	7.07E-04	5.66E+02	1.30E+00	1.14E-03	3.51E+02	3.51E+02
75	Copper, Fume, as Cu	7440-50-8	200	2	1.01E-02	7.99E-02	5.48E-04	1.46E+02				1.46E+02
76	Cresol (all isomers)	1319-77-3	22,000	220	1.11E+00	8.79E+00						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
77	Crotonaldehyde	4170-30-3	5,700	57	2.87E-01	2.28E+00						
78	Cumene	98-28-8	245,000	2,450	1.23E+01	9.79E+01						
79	Cyanamide	420-04-2	2,000	20	1.01E-01	7.99E-01						
80	Cyanogen	460-19-5	20,000	200	1.01E+00	7.99E+00						
81	Cyanogen Chloride	506-77-4	750	8	3.78E-02	3.00E-01						
82	Cyclohexane	110-82-7	1,030,000	10,300	5.19E+01	4.12E+02	4.53E-02	9.10E+03				9.10E+03
83	Cyclohexanol	108-93-0	200,000	2,000	1.01E+01	7.99E+01						
84	Cyclohexanone	108-94-1	100,000	1,000	5.03E+00	4.00E+01						
85	Cyclohexene	110-83-8	1,010,000	10,100	5.08E+01	4.04E+02						
86	Cyclohexylamine	108-91-8	40,000	400	2.01E+00	1.60E+01						
87	Cyclopentadiene	542-92-7	200,000	2,000	1.01E+01	7.99E+01						
88	Cyclopentane	287-92-3	1,720,000	17,200	8.66E+01	6.87E+02						
89	Decaborane	17702-41-9	250	3	1.26E-02	9.99E-02						
90	Di-sec, Octyl Phthalate	117-81-7	5,000	50	2.52E-01	2.00E+00						
91	Diacetone Alcohol	123-42-2	238,000	2,380	1.20E+01	9.51E+01						
92	Diazinon	333-41-5	100	1	5.03E-03	4.00E-02						
93	Diazomethane	334-88-3	340	3	1.71E-02	1.36E-01						
94	Dibutyl Phosphate	107-66-4	5,000	50	2.52E-01	2.00E+00						
95	Dibutyl Phthalate	84-74-2	5,000	50	2.52E-01	2.00E+00						
96	Dichlorodifluoromethane	75-71-8	4,950,000	49,500	2.49E+02	1.98E+03	7.95E-03	2.49E+05				2.49E+05
97	Dichlorofluoromethane	75-43-4	42,000	420	2.11E+00	1.68E+01						
98	Dichlorovos	62-73-7	900	9	4.53E-02	3.60E-01						
99	Dicyclopentadiene	77-73-6	27,000	270	1.36E+00	1.08E+01						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS g/sec	8-HOUR SLEVS lb/hr	RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	ACIS 1995 DATA: RATIO SLEVS/ Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
1	2	3	4	5	6	7	8	9	10	11	12	13
100	Dicyclopentadienyl Iron	102-54-5	10,000	100	5.03E-01	4.00E+00						
101	Diethyl Ketone	96-22-0	705,000	7,050	3.55E+01	2.82E+02	1.00E-03	2.82E+05				2.82E+05
102	Diethyl Phthalate	84-66-2	5,000	50	2.52E-01	2.00E+00						
103	Diethylamine	109-89-7	15,000	150	7.55E-01	5.99E+00	1.00E-04	5.99E+04				5.99E+04
104	Diethylene Triamine	111-40-0	1,000	10	5.03E-02	4.00E-01			6.05E+00	5.30E-03	7.55E+01	7.55E+01
105	Diisopropylamine	108-18-9	21,000	210	1.06E+00	8.39E+00						
106	Dimethoxymethane	109-87-5	3,100,000	31,000	1.56E+02	1.24E+03						
107	Dimethyl Acetamide	127-19-5	35,000	350	1.76E+00	1.40E+01						
108	Dimethyl Amine	124-40-3	9,200	92	4.63E-01	3.68E+00						
109	Dimethyl Phthalate	131-11-3	5,000	50	2.52E-01	2.00E+00						
110	Dimethyl Sulfate	77-78-1	520	5	2.62E-02	2.08E-01						
111	Dinitro-o-Cresol	534-52-1	200	2	1.01E-02	7.99E-02						
112	Dinitrobenzene (all isomers)	99-65-0	1,000	10	5.03E-02	4.00E-01						
113	Dinitrotoluene	25321-14-6	150	2	7.55E-03	5.99E-02						
114	Diphenylamine	122-39-4	10,000	100	5.03E-01	4.00E+00						
115	Dipropyl Ketone	123-19-3	233,000	2,330	1.17E+01	9.31E+01						
116	Dipropylene Glycol Methyl Ether	34590-94-8	600,000	6,000	3.02E+01	2.40E+02						
117	Divinyl Benzene	1321-74-0	50,000	500	2.52E+00	2.00E+01						
118	Endrin	72-20-8	100	1	5.03E-03	4.00E-02						
119	Enflurane	13838-16-9	566,000	5,660	2.85E+01	2.26E+02						
120	Ethanol	64-17-5	1,880,000	18,800	9.47E+01	7.51E+02			6.52E+02	5.70E-01	1.32E+03	1.32E+03
121	Ethanolamine	141-43-5	6,000	60	3.02E-01	2.40E+00			2.25E+00	1.97E-03	1.22E+03	1.22E+03

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
122	Ethion	563-12-2	400	4	2.01E-02	1.60E-01						
123	Ethyl Acetate	141-78-6	1,400,000	14,000	7.05E+01	5.59E+02	2.78E-03	2.02E+05	5.06E+01	4.43E-02	1.26E+04	1.26E+04
124	Ethyl Benzene	100-41-04	434,000	4,340	2.19E+01	1.73E+02						
125	Ethyl Bromide	74-96-4	22,000	220	1.11E+00	8.79E+00						
126	Ethyl Chloride	75-00-3	264,000	2,640	1.33E+01	1.05E+02	1.50E-04	7.03E+05				7.03E+05
127	Ethyl Ether	60-29-7	1,200,000	12,000	6.04E+01	4.79E+02	7.50E-03	6.39E+04	6.26E+00	5.48E-03	8.75E+04	6.39E+04
128	Ethyl Formate	109-94-4	300,000	3,000	1.51E+01	1.20E+02						
129	Ethyl Mercaptan	75-08-1	1,300	13	6.54E-02	5.19E-01						
130	Ethylamine	75-04-7	9,200	92	4.63E-01	3.68E+00						
131	Ethylene Chlorohydrin	107-07-3	3,000	30	1.51E-01	1.20E+00						
132	Ethylene Diamine	107-15-3	25,000	250	1.26E+00	9.99E+00						
133	Fibrous Glass Dust	NA	10,000	100	5.03E-01	4.00E+00						
134	Fluorides, as F	NA	2,500	25	1.26E-01	9.99E-01	1.33E-02	7.49E+01				7.49E+01
135	Fluorine	7782-41-4	200	2	1.01E-02	7.99E-02						
136	Formamide	75-12-7	18,000	180	9.06E-01	7.19E+00	2.38E-02	3.03E+02				3.03E+02
137	Formic Acid	64-18-6	9,000	90	4.53E-01	3.60E+00	2.56E-04	1.41E+04	1.35E+00	1.18E-03	3.06E+03	3.06E+03
138	Furfural	98-01-1	800	8	4.03E-02	3.20E-01						
139	Furfuryl Alcohol	98-00-0	40,000	400	2.01E+00	1.60E+01			4.95E+01	4.33E-02	3.69E+02	3.69E+02
140	Gasoline	8006-61-9	890,000	8,900	4.48E+01	3.56E+02						
141	Germanium Tetrahydride	7782-65-2	600	6	3.02E-02	2.40E-01	1.10E-07	2.18E+06				2.18E+06
142	Glutaraldehyde	111-30-8	700	7	3.52E-02	2.80E-01	5.00E-07	5.59E+05	7.28E-01	6.37E-04	4.39E+02	4.39E+02
143	Hafnium	7440-58-6	500	5	2.52E-02	2.00E-01	1.25E-05	1.60E+04	1.33E+00	1.16E-03	1.72E+02	1.72E+02
144	Hexafluoroacetone	684-16-2	680	7	3.42E-02	2.72E-01						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS g/sec	8-HOUR SLEVS lb/hr	RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	ACIS 1995 DATA: RATIO SLEVS/ Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
1	2	3	4	5	6	7	8	9	10	11	12	13
145	Hexamethylene Diisocyanate	822-06-0	34	0.3	1.71E-03	1.36E-02						
146	Hexane (other isomers)*	110-54-3	1,760,000	17,600	8.86E+01	7.03E+02	2.63E-02	2.68E+04				2.68E+04
147	Hexylene Glycol	107-41-5	121,000	1,210	6.09E+00	4.83E+01						
148	Hydrogen Bromide	10035-10-6	9,900	99	4.98E-01	3.96E+00	8.70E-03	4.55E+02	1.97E+01	1.72E-02	2.29E+02	2.29E+02
149	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	5.36E-01	5.22E+00	5.27E+02	4.61E-01	6.07E+00	5.22E+00
150	Hydrogen Cyanide	74-90-8	5,000	50	2.52E-01	2.00E+00						
151	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01	1.20E-02	7.67E+01	2.74E+01	2.39E-02	3.84E+01	3.84E+01
152	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	1.28E-02	4.37E+01	7.47E+01	6.53E-02	8.56E+00	8.56E+00
153	Hydrogen Sulfide	7783-06-4	1,400	14	7.05E-02	5.59E-01	1.00E-07	5.59E+06				5.59E+06
154	Hydroquinone	123-31-9	2,000	20	1.01E-01	7.99E-01	1.07E-05	7.50E+04				7.50E+04
155	Indene	95-13-6	45,000	450	2.27E+00	1.80E+01						
156	Indium & compounds, as In	7440-74-6	100	1	5.03E-03	4.00E-02			6.00E-01	5.25E-04	7.61E+01	7.61E+01
157	Iodine	7553-56-2	1,000	10	5.03E-02	4.00E-01			3.00E-01	2.63E-04	1.52E+03	1.52E+03
158	Iodoform	75-47-8	10,000	100	5.03E-01	4.00E+00						
159	Iron Oxide Fume, as Fe	1309-37-1	5,000	50	2.52E-01	2.00E+00						
160	Iron Pentacarbonyl, as Fe	13463-4--6	800	8	4.03E-02	3.20E-01						
161	Iso-Amyl Acetate	123-92-2	525,000	5,250	2.64E+01	2.10E+02						
162	Iso-Amyl Alcohol	123-51-3	360,000	3,600	1.81E+01	1.44E+02	6.25E-04	2.30E+05				2.30E+05
163	Isobutane	75-28-5	1,936,000	19,360	9.75E+01	7.74E+02						
164	Isobutyl Acetate	110-19-0	700,000	7,000	3.52E+01	2.80E+02	2.28E-03	1.23E+05				1.23E+05
165	Isobutyl Alcohol	78-83-1	150,000	1,500	7.55E+00	5.99E+01	1.29E-03	4.66E+04				4.66E+04
166	Isobutyronitrile	78-82-0	22,000	220	1.11E+00	8.79E+00						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
167	Isooctyl Alcohol	26952-21-6	266,000	2,660	1.34E+01	1.06E+02	1.25E-04	8.50E+05				8.50E+05
168	Isophorone	78-59-1	23,000	230	1.16E+00	9.19E+00						
169	Isophorone Diisocyanate	4098-71-9	45	0	2.27E-03	1.80E-02						
170	Isopropoxyethanol	109-59-1	106,000	1,060	5.34E+00	4.24E+01						
171	Isopropyl Acetate	108-21-4	950,000	9,500	4.78E+01	3.80E+02						
172	Isopropyl Alcohol	67-63-0	980,000	9,800	4.93E+01	3.92E+02	1.93E+00	2.03E+02	6.22E+02	5.44E-01	7.20E+02	2.03E+02
173	Isopropyl Ether	108-20-3	1,040,000	10,400	5.24E+01	4.16E+02	2.50E-04	1.66E+06				1.66E+06
174	Isopropylamine	75-31-0	12,000	120	6.04E-01	4.79E+00						
175	Kerosene	8008-20-6	100,000	1,000	5.03E+00	4.00E+01	9.75E-01	4.10E+01	1.00E+02	8.75E-02	4.57E+02	4.10E+01
176	Lead, el. & inorg. compounds, as Pb	7439-92-1	50	0.5	2.52E-03	2.00E-02						
177	Lithium Hydride	7580-67-8	25	0.25	1.26E-03	9.99E-03	1.02E-02	9.82E-01				9.82E-01
178	m-Cresol	108-39-4	10,000	100	5.03E-01	4.00E+00						
179	m-Phenylenediamine	108-45-2	100	1	5.03E-03	4.00E-02						
180	m-Toluidine	108-44-1	8,800	88	4.43E-01	3.52E+00						
181	Magnesium Oxide Fume	1309-48-4	10,000	100	5.03E-01	4.00E+00	3.60E-02	1.11E+02				1.11E+02
182	Maleic Anhydride	108-31-6	1,000	10	5.03E-02	4.00E-01						
183	Malononitrile	109-77-3	8,000	80	4.03E-01	3.20E+00						
184	Manganese as Dust & Compounds, as Mn	7439-96-5	200	2	1.01E-02	7.99E-02	5.00E-05	1.60E+03				1.60E+03
185	Manganese as Mn Fume	7439-96-5	200	2	1.01E-02	7.99E-02	2.75E-06	2.91E+04				2.91E+04
186	Mercury (inorganic forms, incl. metallic Hg)	7439-97-6	25	0.25	1.26E-03	9.99E-03						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
187	Mercury Alkyl Compounds	7439-97-6	10	0.1	5.03E-04	4.00E-03						
188	Mercury Aryl Compounds	7439-97-6	100	1	5.03E-03	4.00E-02						
189	Methacrylic Acid	79-41-4	70,000	700	3.52E+00	2.80E+01						
190	Methoxychlor	72-43-5	10,000	100	5.03E-01	4.00E+00						
191	Methyl 2-Cyanoacrylate	137-05-3	8,000	80	4.03E-01	3.20E+00	1.95E-03	1.64E+03				1.64E+03
192	Methyl Acetate	79-20-9	606,000	6,060	3.05E+01	2.42E+02						
193	Methyl Acetylene	74-99-7	1,640,000	16,400	8.26E+01	6.55E+02						
194	Methyl Acrylate	96-33-3	35,000	350	1.76E+00	1.40E+01						
195	Methyl Alcohol	67-56-1	260,000	2,600	1.31E+01	1.04E+02	6.60E-01	1.57E+02	5.80E+02	5.08E-01	2.05E+02	1.57E+02
196	Methyl Cyclohexane	108-87-2	1,610,000	16,100	8.11E+01	6.43E+02						
197	Methyl Ethyl Ketone	78-93-3	590,000	5,900	2.97E+01	2.36E+02	8.62E-01	2.73E+02	1.00E+01	8.78E-03	2.69E+04	2.73E+02
198	Methyl Formate	107-31-3	246,000	2,460	1.24E+01	9.83E+01						
199	Methyl Hydrazine	60-34-4	19	0	9.57E-04	7.59E-03						
200	Methyl Iodide	74-88-4	12,000	120	6.04E-01	4.79E+00						
201	Methyl Isobutyl Carbinol	108-11-2	100,000	1,000	5.03E+00	4.00E+01						
202	Methyl Isobutyl Ketone	108-10-1	205,000	2,050	1.03E+01	8.19E+01	1.71E-02	4.80E+03	1.76E+00	1.54E-03	5.31E+04	4.80E+03
203	Methyl Isocyanate	624-83-9	47	0.47	2.37E-03	1.88E-02						
204	Methyl Mercaptan	74-93-1	980	10	4.93E-02	3.92E-01						
205	Methyl Methacrylate	80-62-6	410,000	4,100	2.06E+01	1.64E+02	3.30E-06	4.96E+07				4.96E+07
206	Methyl n-Amyl Ketone	110-43-0	233,000	2,330	1.17E+01	9.31E+01						
207	Methyl n-Butyl Ketone	591-78-6	20,000	200	1.01E+00	7.99E+00	5.00E-03	1.60E+03				1.60E+03
208	Methyl Propyl Ketone	107-87-9	6,000	60	3.02E-01	2.40E+00	2.50E-04	9.59E+03				9.59E+03

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
209	Methyl Silicate	681-84-5	6,000	60	3.02E-01	2.40E+00						
210	Methylacrylonitrile	126-98-7	2,700	27	1.36E-01	1.08E+00						
211	Methylamine	74-89-5	6,400	64	3.22E-01	2.56E+00						
212	Methylene Bisphenyl Isocyanate	101-68-8	51	1	2.57E-03	2.04E-02						
213	Molybdenum as Mo Insoluble Compounds	7439-98-7	10,000	100	5.03E-01	4.00E+00	1.31E-04	3.04E+04	1.00E-01	8.75E-05	4.57E+04	3.04E+04
214	Molybdenum as Mo Soluble Compounds	7439-98-7	5,000	50	2.52E-01	2.00E+00	2.50E-11	7.99E+10	1.00E-01	8.75E-05	2.28E+04	2.28E+04
215	Morpholine	110-91-8	70,000	700	3.52E+00	2.80E+01						
216	n,n-Dimethyl Acetamide	127-19-5	35,000	350	1.76E+00	1.40E+01						
217	n,n-Dimethylaniline	121-69-7	25,000	250	1.26E+00	9.99E+00						
218	n,n-Dimethylformamide	68-12-2	30,000	300	1.51E+00	1.20E+01			1.26E+01	1.10E-02	1.09E+03	1.09E+03
219	n-Amyl Acetate	628-63-7	525,000	5,250	2.64E+01	2.10E+02	6.25E-03	3.36E+04				3.36E+04
220	n-Butyl Acetate	123-86-4	710,000	7,100	3.57E+01	2.84E+02	3.35E-03	8.47E+04				8.47E+04
221	n-Butyl Acrylate	141-32-2	52,000	520	2.62E+00	2.08E+01						
222	n-Butyl Alcohol	71-36-3	150,000	1,500	7.55E+00	5.99E+01	2.08E-03	2.89E+04				2.89E+04
223	n-Butyl Glycidyl Ether	2426-08-6	133,000	1,330	6.70E+00	5.31E+01	1.27E-04	4.18E+05				4.18E+05
224	n-Butylamine	109-73-9	15,000	150	7.55E-01	5.99E+00						
225	n-Heptane	142-82-5	1,640,000	16,400	8.26E+01	6.55E+02	3.98E-03	1.65E+05				1.65E+05
226	n-Hexane	110-54-3	176,000	1,760	8.86E+00	7.03E+01	4.77E-02	1.48E+03	2.04E+01	1.78E-02	3.94E+03	1.48E+03
227	n-Methylalinine	100-61-8	2,000	20	1.01E-01	7.99E-01						
228	n-Propyl Acetate	109-60-4	835,000	8,350	4.20E+01	3.34E+02						
229	Naphtalene	91-20-3	50,000	500	2.52E+00	2.00E+01						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
230	Nickel Carbonyl, as Ni	13463-39-3	7	0.1	3.52E-04	2.80E-03						
231	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02	7.53E-06	5.31E+03	1.70E+00	1.49E-03	2.69E+01	2.69E+01
232	Nicotine	54-11-5	500	5	2.52E-02	2.00E-01						
233	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	4.87E-01	4.10E+00	6.20E+02	5.43E-01	3.68E+00	3.68E+00
234	Nitric Oxide	10102-43-9	30,000	300	1.51E+00	1.20E+01	1.02E-02	1.17E+03				1.17E+03
235	Nitrobenzene	98-95-3	5,000	50	2.52E-01	2.00E+00						
236	Nitroethane	79-24-3	3,070,000	30,700	1.55E+02	1.23E+03	1.20E-08	1.02E+11				1.02E+11
237	Nitromethane	75-52-5	50,000	500	2.52E+00	2.00E+01	1.20E-08	1.66E+09				1.66E+09
238	Nitrotoluene	99-99-0	11,000	110	5.54E-01	4.40E+00						
239	Nitrous Oxide	10024-97-2	90,000	900	4.53E+00	3.60E+01	1.50E-03	2.39E+04				2.39E+04
240	Nonane	111-84-2	1,050,000	10,500	5.29E+01	4.20E+02						
241	o-Chlorostyrene	2039-87-4	283,000	2,830	1.42E+01	1.13E+02						
242	o-Chlorotoluene	95-49-8	250,000	2,500	1.26E+01	9.99E+01						
243	o-Dichlorobenzene	95-50-1	150,000	1,500	7.55E+00	5.99E+01			2.87E+00	2.51E-03	2.39E+04	2.39E+04
244	o-Methylcyclohexanone	583-60-8	234,000	2,340	1.18E+01	9.35E+01						
245	o-Phenylenediamine	95-54-5	100	1	5.03E-03	4.00E-02						
246	o-Toluidine	95-53-4	8,800	88	4.43E-01	3.52E+00						
247	Octane	111-65-9	1,400,000	14,000	7.05E+01	5.59E+02	2.50E-03	2.24E+05				2.24E+05
248	Oil Mist, Mineral	NA	5,000	50	2.52E-01	2.00E+00	2.45E-02	8.16E+01				8.16E+01
249	Osmium Tetroxide, as Os	20816-12-0	2	0.02	8.06E-05	6.39E-04						
250	Oxalic Acid	144-62-7	1,000	10	5.03E-02	4.00E-01	5.25E-04	7.61E+02	3.30E+00	2.89E-03	1.38E+02	1.38E+02
251	p-Nitroaniline	100-01-6	3,000	30	1.51E-01	1.20E+00						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS g/sec	8-HOUR SLEVS lb/hr	RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	ACIS 1995 DATA: RATIO SLEVS/ Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
1	2	3	4	5	6	7	8	9	10	11	12	13
252	p-Nitrochlorobenzene	100-00-5	640	6	3.22E-02	2.56E-01						
253	p-Phenylenediamine	106-50-3	100	1	5.03E-03	4.00E-02						
254	p-Toluidine	106-49-0	8,800	88	4.43E-01	3.52E+00						
255	Paraffin Wax Fume	8002-74-2	2,000	20	1.01E-01	7.99E-01	2.50E-05	3.20E+04				3.20E+04
256	Paraquat Dichloride	1910-42-5	100	1	5.03E-03	4.00E-02						
257	Paraquat Respirable Sizes	4685-14-7	100	1	5.03E-03	4.00E-02						
258	Particulate Matter, Respirable Dust	NA	3,000	30.00	1.51E-01	1.20E+00	3.08E-03	3.89E+02				3.89E+02
259	Pentachlorophenol	87-86-5	500	5	2.52E-02	2.00E-01						
260	Pentaerythritol	115-77-5	5,000	50	2.52E-01	2.00E+00						
261	Pentane (all isomers)	109-66-0	1,770,000	17,700	8.91E+01	7.07E+02	6.25E-04	1.13E+06	5.56E+00	4.86E-03	1.45E+05	1.45E+05
262	Perchloromethyl Mercaptan	594-42-3	760	8	3.83E-02	3.04E-01						
263	Phenol	108-95-2	19,000	190	9.57E-01	7.59E+00	1.25E-04	6.07E+04				6.07E+04
264	Phenothiazine	92-84-2	5,000	50	2.52E-01	2.00E+00						
265	Phenyl Mercaptan	108-98-5	2,300	23	1.16E-01	9.19E-01						
266	Phenylhydrazine	100-63-0	440	4	2.22E-02	1.76E-01	2.50E-06	7.03E+04				7.03E+04
267	Phenylphosphine	638-21-1	230	2	1.16E-02	9.19E-02						
268	Phosgene	75-44-5	400	4	2.01E-02	1.60E-01						
269	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01	2.39E-03	1.67E+02	1.82E+01	1.59E-02	2.51E+01	2.51E+01
270	Phosphorus	7723-14-0	100	1	5.03E-03	4.00E-02			1.00E-01	8.75E-05	4.57E+02	4.57E+02
271	Phosphorus Oxychloride	10025-87-3	600	6	3.02E-02	2.40E-01	1.25E-03	1.92E+02				1.92E+02
272	Phosphorus Pentachloride	10026-13-8	850	9	4.28E-02	3.40E-01	2.50E-04	1.36E+03				1.36E+03
273	Phosphorus Trichloride	7719-12-2	1,100	11	5.54E-02	4.40E-01						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
274	Picric Acid	88-89-1	100	1	5.03E-03	4.00E-02						
275	Platinum Metal	7440-06-4	1,000	10	5.03E-02	4.00E-01	2.50E-06	1.60E+05				1.60E+05
276	Potassium Hydroxide	1310-58-3	2,000	20	1.01E-01	7.99E-01	7.80E-04	1.02E+03	3.96E+01	3.47E-02	2.31E+01	2.31E+01
277	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			2.11E+04	1.85E+01	3.89E+01	3.89E+01
278	Propargyl Alcohol	107-19-7	2,000	20	1.01E-01	7.99E-01						
279	Propionic Acid	79-09-4	30,000	300	1.51E+00	1.20E+01						
280	Propionitrile	107-12-0	14,000	140	7.05E-01	5.59E+00						
281	Propyl Alcohol	71-23-8	492,000	4,920	2.48E+01	1.97E+02	2.50E-02	7.87E+03				7.87E+03
282	Propylene Glycol Monomethyl Ether	107-98-2	369,000	3,690	1.86E+01	1.47E+02	5.50E-09	2.68E+10				2.68E+10
283	Pyridine	110-86-1	15,000	150	7.55E-01	5.99E+00			6.48E+00	5.67E-03	1.06E+03	1.06E+03
284	Rhodium Metal	7440-16-6	100	1	5.03E-03	4.00E-02						
285	sec-Butyl Acetate	105-46-4	950,000	9,500	4.78E+01	3.80E+02						
286	sec-Butyl Alcohol	78-92-2	300,000	3,000	1.51E+01	1.20E+02	6.25E-04	1.92E+05				1.92E+05
287	Selenium Compounds, as Se	7782-49-2	200	2	1.01E-02	7.99E-02	5.00E-10	1.60E+08				1.60E+08
288	Silica, Cristobalite	14464-64-1	50	0.5	2.52E-03	2.00E-02	2.50E-05	7.99E+02				7.99E+02
289	Silica, Quartz	14808-60-7	100	1	5.03E-03	4.00E-02	2.50E-04	1.60E+02	2.64E+01	2.31E-02	1.73E+00	1.73E+00
290	Tridymite, Respirable Dust	15468-32-3	50	0.5	2.52E-03	2.00E-02	2.50E-06	7.99E+03				7.99E+03
291	Silica, Fused (respirable)	60676-86-0	100	1	5.03E-03	4.00E-02	2.56E-03	1.56E+01	1.00E-01	8.75E-05	4.57E+02	1.56E+01
292	Silicon Tetrahydride	7803-62-5	6,600	66	3.32E-01	2.64E+00						
293	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.03E-03	4.00E-02	5.11E-05	7.82E+02	1.10E+00	9.63E-04	4.15E+01	4.15E+01

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R¹) OR (R²) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R¹)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R²)	
1	2	3	4	5	6	7	8	9	10	11	12	13
294	Stoddard Solvent	8052-41-3	525,000	5,250	2.64E+01	2.10E+02	2.44E-01	8.59E+02				8.59E+02
295	Sulfur Hexafluoride	2551-62-4	5,970,000	59,700	3.01E+02	2.39E+03			1.27E+03	1.11E+00	2.15E+03	2.15E+03
296	Sulfuric Acid	7664-93-9	1,000	10	5.03E-02	4.00E-01	7.91E-02	5.05E+00	1.57E+02	1.37E-01	2.92E+00	2.92E+00
297	Sulfuryl Fluoride	2699-79-8	20,000	200	1.01E+00	7.99E+00						
298	Tantalum Metal	7440-25-7	5,000	50	2.52E-01	2.00E+00	1.13E-04	1.77E+04				1.77E+04
299	Tellurium & Compounds, as Te	13494-80-9	200	2	1.01E-02	7.99E-02						
300	Terphenyls	26140-60-3	5,000	50	2.52E-01	2.00E+00						
301	tert-Butyl Alcohol	75-65-0	300,000	3,000	1.51E+01	1.20E+02	1.05E-04	1.14E+06				1.14E+06
302	Tetraethyl Lead	78-00-2	75	1	3.78E-03	3.00E-02						
303	Tetrahydrofuran	109-99-9	590,000	5,900	2.97E+01	2.36E+02	4.50E-04	5.24E+05	3.92E+00	3.43E-03	6.86E+04	6.86E+04
304	Tetranitromethane	509-14-8	40	0	2.01E-03	1.60E-02						
305	Tetrasodium Pyrophosphate	7722-88-5	5,000	50	2.52E-01	2.00E+00						
306	Thioglycolic Acid	68-11-1	3,800	38	1.91E-01	1.52E+00						
307	Thionyl Chloride	7719-09-7	4,900	49	2.47E-01	1.96E+00			3.62E-01	3.16E-04	6.19E+03	6.19E+03
308	Tin, metal	7440-31-5	2,000	20	1.01E-01	7.99E-01	1.60E-04	4.99E+03				4.99E+03
309	Tin Organic Compounds, as Sn	7440-31-5	100	1	5.03E-03	4.00E-02						
310	Tin Oxide & Inorganic Compounds, as Sn	7440-31-5	2,000	20	1.01E-01	7.99E-01	5.00E-10	1.60E+09	1.97E+00	1.72E-03	4.63E+02	4.63E+02
311	Toluene	108-88-3	188,000	1,880	9.47E+00	7.51E+01	1.36E-02	5.54E+03	2.01E+01	1.76E-02	4.26E+03	4.26E+03
312	Toluene-2,4-diisocyanate	584-84-9	20	0.20	1.01E-03	7.99E-03			2.00E-01	1.75E-04	4.57E+01	4.57E+01
313	Tributyl Phosphate	126-73-8	2,200	22	1.11E-01	8.79E-01	2.50E-03	3.52E+02	2.16E-01	1.89E-04	4.65E+03	3.52E+02

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
314	Trichloroacetic Acid	76-03-9	6,700	67	3.37E-01	2.68E+00	2.53E-04	1.06E+04				1.06E+04
315	Triethylamine	121-44-8	4,100	41	2.06E-01	1.64E+00			4.83E-01	4.23E-04	3.88E+03	3.88E+03
316	Trimethyl Benzene	25551-13-7	123,000	1,230	6.19E+00	4.91E+01						
317	Trimethyl Phosphite	121-45-9	10,000	100	5.03E-01	4.00E+00						
318	Trimethylamine	75-50-3	12,000	120	6.04E-01	4.79E+00						
319	Triphenylamine	603-34-9	5,000	50	2.52E-01	2.00E+00						
320	Triphenylphosphate	115-86-6	3,000	30	1.51E-01	1.20E+00						
321	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	6.02E-01	3.32E+00				3.32E+00
322	Turpentine	8006-64-2	556,000	5,560	2.80E+01	2.22E+02	4.35E-02	5.11E+03				5.11E+03
323	Uranium (natural) Sol. & Unsol. Comp. as U	7440-61-1	50	1	2.52E-03	2.00E-02	5.00E-10	4.00E+07	1.98E-01	1.74E-04	1.15E+02	1.15E+02
324	Vanadium, Respirable Dust & Fume	1314-62-1	50	1	2.52E-03	2.00E-02	2.50E-10	7.99E+07	1.10E+00	9.63E-04	2.08E+01	2.08E+01
325	Vinyl Acetate	108-05-4	35,000	350	1.76E+00	1.40E+01	2.50E-03	5.59E+03				5.59E+03
326	Vinyl Toluene	25013-15-4	242,000	2,420	1.22E+01	9.67E+01						
327	Vinylidene Fluoride	75-38-7	2,660	27	1.34E-01	1.06E+00						
328	VM & P Naphtha	8032-32-4	1,370,000	13,700	6.90E+01	5.47E+02	3.52E-02	1.56E+04	1.65E+00	1.45E-03	3.78E+05	1.56E+04
329	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	1.95E+00	1.03E+00				1.03E+00
330	Wood Dust (certain hard woods)	NA	1,000	10	5.03E-02	4.00E-01	2.51E+00	1.60E-01				1.60E-01
331	Xylene (o-,m-,p-Isomers)	1330-20-7	434,000	4,340	2.19E+01	1.73E+02	1.20E-01	1.45E+03	1.31E+01	1.14E-02	1.51E+04	1.45E+03
332	Yttrium	7440-65-5	1,000	10	5.03E-02	4.00E-01	9.63E-04	4.15E+02	1.00E-01	8.75E-05	4.57E+03	4.15E+02

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
333	Zinc Chloride Fume	7646-85-7	1,000	10	5.03E-02	4.00E-01	5.05E-03	7.91E+01	6.00E-01	5.25E-04	7.61E+02	7.91E+01
334	Zinc Oxide Fume	1314-13-2	5,000	50	2.52E-01	2.00E+00	3.65E-04	5.48E+03				5.48E+03
335	Zinc Chromate, as Cr	13530-65-9	10	0.1	5.03E-04	4.00E-03						
336	Zirconium Compounds, as Zr	7440-67-7	5,000	50	2.52E-01	2.00E+00	9.00E-04	2.22E+03				2.22E+03
	CARCINOGENIC POLLUTANTS											
337	Acrylamide	79-06-1	30	0.3	1.51E-03	1.20E-02			6.00E-01	5.25E-04	2.28E+01	2.28E+01
338	Acrylonitrile	107-13-1	4,300	43	2.16E-01	1.72E+00						
339	Allyl Chloride	107-05-1	3,000	30	1.51E-01	1.20E+00						
340	Aldrin	309-00-2	250	3	1.26E-02	9.99E-02						
341	Arsenic, el. & inorg., exc. Arsine, as As	7440-38-2	10	0.1	5.03E-04	4.00E-03	5.00E-10	7.99E+06				7.99E+06
342	Benzene	71-43-2	3,000	30	1.51E-01	1.20E+00						
343	Benzyl Chloride	100-44-7	2,800	28	1.41E-01	1.12E+00						
344	Beryllium	7440-41-7	2	0.02	1.01E-04	7.99E-04	3.01E-06	2.66E+02				2.66E+02
345	Bromoform	75-25-2	5,000	50	2.52E-01	2.00E+00						
346	1,3-Butadiene	106-99-0	4,400	44	2.22E-01	1.76E+00						
347	Cadmium, el. & compounds, as Cd	7440-43-9	2	0.02	1.01E-04	7.99E-04	6.60E-05	1.21E+01				1.21E+01
348	Carbon Tetrachloride	56-23-5	31,000	310	1.56E+00	1.24E+01	4.01E-02	3.09E+02				3.09E+02
349	Chloroform	67-66-3	49,000	490	2.47E+00	1.96E+01	4.55E-02	4.30E+02	1.44E+02	1.26E-01	1.56E+02	1.56E+02
350	Chromic acids & chromates	1333-82-0	1	0.01	5.03E-05	4.00E-04	8.06E-04	4.96E-01	3.00E-01	2.63E-04	1.52E+00	4.96E-01
351	Diethanolamine	111-42-2	200	2	1.01E-02	7.99E-02						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS g/sec	8-HOUR SLEVS lb/hr	RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	ACIS 1995 DATA: RATIO SLEVS/ Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
1	2	3	4	5	6	7	8	9	10	11	12	13
352	Epichlorohydrin	106-89-8	7,600	76	3.83E-01	3.04E+00						
353	Ethyl Acrylate	140-88-5	20,000	200	1.01E+00	7.99E+00			6.09E-01	5.33E-04	1.50E+04	1.50E+04
354	Ethylene Dichloride	107-06-2	40,000	400	2.01E+00	1.60E+01						
355	Ethylene Oxide	75-21-8	1,800	18	9.06E-02	7.19E-01						
356	Hexachlorobenzene	118-74-1	25	0.25	1.26E-03	9.99E-03						
357	Hexachlorobutadiene	87-68-3	210	2	1.06E-02	8.39E-02						
358	Hexachloroethane	67-72-1	9,700	97	4.88E-01	3.88E+00						
359	Hydrazine	302-01-2	13	0.1	6.54E-04	5.19E-03			2.00E-01	1.75E-04	2.97E+01	2.97E+01
360	Lindane	58-89-9	500	5	2.52E-02	2.00E-01						
361	Methyl Chloride	74-87-3	103,000	1,030	5.19E+00	4.12E+01	1.10E-01	3.74E+02				3.74E+02
362	Methylene Chloride	75-09-2	174,000	1,740	8.76E+00	6.95E+01	3.76E-02	1.85E+03	1.73E+02	1.51E-01	4.59E+02	4.59E+02
363	Nickel, metal (dust)	7440-02-0	1,000	10	5.03E-02	4.00E-01	3.01E-01	1.33E+00				1.33E+00
364	Pentachlorophenol	87-86-5	500	5	2.52E-02	2.00E-01						
365	Polychlorinated Biphenyl (PCB)	11097-69-1	500	5	2.52E-02	2.00E-01						
366	Propylene Dichloride	78-87-5	347,000	3,470	1.75E+01	1.39E+02	1.38E-02	1.01E+04				1.01E+04
367	Propylene Oxide	75-56-9	48,000	480	2.42E+00	1.92E+01						
368	Styrene	100-42-5	213,000	2,130	1.07E+01	8.51E+01						
369	Toxaphene	8001-35-2	500	5	2.52E-02	2.00E-01						
370	Tetrachlorethylene	127-18-4	170,000	1,700	8.56E+00	6.79E+01	2.50E-03	2.72E+04				2.72E+04
371	Trichloroethylene	79-01-6	269,000	2,690	1.35E+01	1.07E+02	1.40E-01	7.68E+02	2.25E+00	1.97E-03	5.45E+04	7.68E+02
372	Vinyl Chloride	75-01-4	13,000	130	6.54E-01	5.19E+00						
373	1,1-Dichloethylene	75-35-4	20,000	200	1.01E+00	7.99E+00						

TABLE 1 (PART A).—*8-Hour SLEVs of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	HOURLY EMISSION RATE FROM RAPS (Q^{hr}) lb/hr	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS lb/year	ESTIMATED HOURLY EMISSION RATES (Q^{ha}) lb/hr	RATIO SLEVS/ Q^{ha} (R^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13
374	1,1,2,2-Tetrachloroethane	79-34-5	6,900	69	3.47E-01	2.76E+00						
375	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	3.10E+00	5.81E+00				5.81E+00
376	2-Nitropropane	79-46-9	36,000	360	1.81E+00	1.44E+01						

Note: The highest ISC–3 estimated concentration at fence line receptors around TA–3 was found to be 198.63 µg/m^3 when emission rate is 1 g/sec.
NA = Not applicable, OELs = occupational exposure limits, RAPS = regulated air pollutants (reports), ACIS = Automated Chemical Inventory System

TABLE 1 (PART B).—*8-Hour SLEVs of the Potentially Sensitive Toxic Air Pollutants (Noncarcinogenic and Carcinogenic) from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/ Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
					NONCARCINOGENIC POLLUTANTS							
1	2-Butoxyethanol	111-76-2	121,000	1,210	6.09E+00	4.83E+01	5.11E-01	9.47E+01				9.47E+01
2	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	2.84E+00	3.51E+00	1.62E+01	1.42E-02	7.04E+02	3.51E+00
3	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.03E-01	4.00E+00	4.09E-02	9.78E+01	2.20E+00	1.93E-03	2.08E+03	9.78E+01
4	Aluminum, Welding Fumes, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00	6.04E-01	3.31E+00				3.31E+00
5	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	7.09E-01	9.59E+00				9.59E+00
6	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	1.47E-02	9.49E+01	1.10E+00	9.63E-04	1.45E+03	9.49E+01
7	Diethylene Triamine	111-40-0	1,000	10	5.03E-02	4.00E-01			6.05E+00	5.30E-03	7.55E+01	7.55E+01
8	Fluorides, as F	NA	2,500	25	1.26E-01	9.99E-01	1.33E-02	7.49E+01				7.49E+01
9	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	5.36E-01	5.22E+00	5.27E+02	4.61E-01	6.07E+00	5.22E+00
10	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01	1.20E-02	7.67E+01	2.74E+01	2.39E-02	3.84E+01	3.84E+01
11	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	1.28E-02	4.37E+01	7.47E+01	6.53E-02	8.56E+00	8.56E+00
12	Indium & compounds, as In	7440-74-6	100	1	5.03E-03	4.00E-02			6.00E-01	5.25E-04	7.61E+01	7.61E+01
13	Kerosene	8008-20-6	100,000	1,000	5.03E+00	4.00E+01	9.75E-01	4.10E+01	1.00E+02	8.75E-02	4.57E+02	4.10E+01
14	Lithium Hydride	7580-67-8	25	0.25	1.26E-03	9.99E-03	1.02E-02	9.82E-01				9.82E-01
15	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02	7.53E-06	5.31E+03	1.70E+00	1.49E-03	2.69E+01	2.69E+01
16	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	4.87E-01	4.10E+00	6.20E+02	5.43E-01	3.68E+00	3.68E+00
17	Oil Mist, Mineral	NA	5,000	50	2.52E-01	2.00E+00	2.45E-02	8.16E+01				8.16E+01

TABLE 1 (PART B).—*8-Hour SLEVs of the Potentially Sensitive Toxic Air Pollutants (Noncarcinogenic and Carcinogenic) from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R¹) OR (R²) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/ Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
18	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01	2.39E-03	1.67E+02	1.82E+01	1.59E-02	2.51E+01	2.51E+01
19	Potassium Hydroxide	1310-58-3	2,000	20	1.01E-01	7.99E-01	7.80E-04	1.02E+03	3.96E+01	3.47E-02	2.31E+01	2.31E+01
20	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			2.11E+04	1.85E+01	3.89E+01	3.89E+01
21	Silica, Quartz	14808-60-7	100	1	5.03E-03	4.00E-02	2.50E-04	1.60E+02	2.64E+01	2.31E-02	1.73E+00	1.73E+00
22	Silica, Fused (respirable)	60676-86-0	100	1	5.03E-03	4.00E-02	2.56E-03	1.56E+01	1.00E-01	8.75E-05	4.57E+02	1.56E+01
23	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.03E-03	4.00E-02	5.11E-05	7.82E+02	1.10E+00	9.63E-04	4.15E+01	4.15E+01
24	Sulfuric Acid	7664-93-9	1,000	10	5.03E-02	4.00E-01	7.91E-02	5.05E+00	1.57E+02	1.37E-01	2.92E+00	2.92E+00
25	Toluene-2,4-diisocyanate	584-84-9	20	0.20	1.01E-03	7.99E-03			2.00E-01	1.75E-04	4.57E+01	4.57E+01
26	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	6.02E-01	3.32E+00				3.32E+00
27	Vanadium, Respirable Dust & Fume	1314-62-1	50	1	2.52E-03	2.00E-02	2.50E-10	7.99E+07	1.10E+00	9.63E-04	2.08E+01	2.08E+01
28	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	1.95E+00	1.03E+00				1.03E+00
29	Wood Dust (certain hard woods)	NA	1,000	10	5.03E-02	4.00E-01	2.51E+00	1.60E-01				1.60E-01
30	Zinc Chloride Fume	7646-85-7	1,000	10	5.03E-02	4.00E-01	5.05E-03	7.91E+01	6.00E-01	5.25E-04	7.61E+02	7.91E+01

TABLE 1 (PART B).—*8-Hour SLEVs of the Potentially Sensitive Toxic Air Pollutants (Noncarcinogenic and Carcinogenic) from TA–3 Facilities Based on RAPS–90 (LANL 1990) and ACIS 1995 (LANL 1995a) Data*-Continued

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/ Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
						CARCINOGENIC POLLUTANTS						
31	Acrylamide	79-06-1	30	0.3	1.51E-03	1.20E-02			6.00E-01	5.25E-04	2.28E+01	2.28E+01
32	Cadmium, el. & compounds, as Cd	7440-43-9	2	0.02	1.01E-04	7.99E-04	6.60E-05	1.21E+01				1.21E+01
33	Chromic acids & chromate's	1333-82-0	1	0.01	5.03E-05	4.00E-04	8.06E-04	4.96E-01	3.00E-01	2.63E-04	1.52E+00	4.96E-01
34	Hydrazine	302-01-2	13	0.1	6.54E-04	5.19E-03			2.00E-01	1.75E-04	2.97E+01	2.97E+01
35	Nickel, metal (dust)	7440-02-0	1,000	10	5.03E-02	4.00E-01	3.01E-01	1.33E+00				1.33E+00
36	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	3.10E+00	5.81E+00				5.81E+00

NA = Not applicable

TABLE 1 (PART C).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 1 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/ Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hour		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.81E+02	1.59E-01	4.53E+03	4.53E+03

TABLE 1 (PART D).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 16 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
NONCARCINOGENIC POLLUTANTS												
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	3.13E-04	3.20E+04				3.20E+04
2	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	5.00E-06	5.59E+05				5.59E+05
3	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	5.00E-04	4.00E+03				4.00E+03
4	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	1.20E-04	1.67E+04				1.67E+04
CARCINOGENIC POLLUTANTS												
5	Chromic Acids & Chromates	1333-82-0	1	0.01	5.03E-05	4.00E-04	5.00E-05	7.99E+00				7.99E+00

TABLE 1 (PART E).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 29 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
	NONCARCINOGENIC POLLUTANTS											
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	1.25E-03	7.99E+03	1.27E+01	1.11E-02	8.97E+02	8.97E+02
2	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	8.80E-04	7.72E+03				7.72E+03
3	Fluorides, as F	NA	2,500	25	1.26E-01	9.99E-01	1.33E-02	7.49E+01				7.49E+01
4	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	5.13E-01	5.46E+00	2.33E+02	2.04E-01	1.37E+01	5.46E+00
5	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01	1.76E-03	5.21E+02	1.37E+01	1.20E-02	7.68E+01	7.68E+01
6	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	1.12E-02	4.99E+01	3.79E+01	3.32E-02	1.69E+01	1.69E+01
7	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	3.13E-03	1.28E+04				1.28E+04
8	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	3.82E-01	5.23E+00	3.77E+02	3.30E-01	6.06E+00	5.23E+00
9	Oil Mist, Mineral	NA	5,000	50	2.52E-01	2.00E+00	2.43E-03	8.23E+02				8.23E+02
10	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01	3.98E-04	1.01E+03	1.01E+01	8.83E-03	4.53E+01	4.53E+01
11	Potassium Hydroxide	1310-58-31	2,000	20	1.01E-01	7.99E-01	6.50E-04	1.23E+03				1.23E+03
12	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.21E+02	1.06E-01	6.79E+03	6.79E+03
13	Silica, Fused (respirable)	60676-86-0	100	1	5.03E-03	4.00E-02			1.00E-01	8.75E-05	4.57E+02	4.57E+02
14	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.04E-03	4.00E-02	1.25E-07	3.20E+05				3.20E+05
15	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01	6.29E-02	6.35E+00	1.34E+02	1.17E-01	3.41E+00	6.35E+00
16	Vanadium, Respirable Dust & Fume	1314-62-1	50	1	2.52E-03	2.00E-02	2.50E-10	7.99E+07				7.99E+07
17	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	9.44E-03	2.12E+02				2.12E+02

TABLE 1 (PART E).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 29 of TA–3-*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha})	ACIS 1995 DATA: RATIO SLEVS/Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
	CARCINOGENIC POLLUTANTS											
18	Acrylamide	79-06-1	30	0.3	1.51E-03	1.20E-02			6.00E-01	5.25E-04	2.28E+01	2.28E+01
19	Cadmium, el.&compounds, as Cd	7440-43-9	2	0.02	1.01E-04	7.99E-04	6.60E-05	1.21E+01				1.21E+01
21	Chromic acids & chromate's	1333-82-0	1	0.01	5.03E-05	4.00E-04	6.31E-04	6.33E-01	2.00E-01	1.75E-04	2.28E+00	6.33E-01
22	Nickel, metal (dust)	7440-02-0	1,000	10	5.03E-02	4.00E-01	2.75E-06	1.45E+05				1.45E+05
23	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	4.51E-03	3.99E+03				3.99E+03

TABLE 1 (PART F).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 22 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha})	ACIS 1995 DATA: RATIO SLEVS/Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01			1.62E+00	1.42E-03	2.81E+02	2.81E+02

TABLE 1 (PART G).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 30 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	2-Butoxyethanol	111-76-2	121,000	1,210	6.09E+00	4.84E+01	9.68E-03	5.00E+03				5.00E+03
2	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	1.58E-03	4.31E+03				4.31E+03
3	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.02E+04	8.94E+00	8.05E+01	8.05E+01
4	Wood Dust (certain hard woods)	NA	1,000	10	5.04E-02	4.00E-01	2.50E+00	1.60E-01				1.60E-01

TABLE 1 (PART H).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 25 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			2.82E+02	2.47E-01	2.91E+03	2.91E+03

TABLE 1 (PART I).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 32 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00			2.32E+00	2.03E-03	4.93E+03	4.93E+03
2	Kerosene	8008-20-6	100,000	1,000	5.03E+00	4.00E+01	2.25E-03	1.78E+04				1.78E+04
3	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	1.13E-03	1.78E+03				1.78E+03

TABLE 1 (PART J).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 34 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
	NONCARCINOGENIC POLLUTANTS											
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	1.25E-04	7.99E+04	1.16E+00	1.01E-03	9.86E+03	9.86E+03
2	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.04E-01	4.00E+00	6.25E-05	6.39E+04	1.10E+00	9.63E-04	4.15E+03	4.15E+03
3	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	2.53E-04	5.54E+03				5.54E+03
4	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	3.75E-04	7.46E+03	1.04E+01	9.11E-03	3.07E+02	3.07E+02
5	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01			3.54E+00	3.09E-03	2.97E+02	2.97E+02
6	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	2.50E-04	2.24E+03	2.45E+00	2.14E-03	2.61E+02	2.61E+02
7	Indium & Compounds, as In	7440-74-6	100	1	5.04E-03	4.00E-02			6.00E-01	5.25E-04	7.61E+01	7.61E+01
8	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	8.45E-04	4.73E+04	4.29E+01	3.75E-02	1.07E+03	1.07E+03
9	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02			1.60E+00	1.40E-03	2.85E+01	2.85E+01
10	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	5.18E-03	3.86E+02	3.31E+01	2.89E-02	6.90E+01	6.90E+01
11	Potassium Hydroxide	1310-58-31	2,000	20	1.01E-01	7.99E-01			3.41E+01	2.98E-02	2.68E+01	2.68E+01
11	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.04E-03	4.00E-02			1.10E+00	9.63E-04	4.15E+01	4.15E+01
12	Zinc Chloride Fume	7646-85-7	1,000	10	5.04E-02	4.00E-01	5.00E-05	7.99E+03				7.99E+03
13	Toluene-2,4-diisocyanate	584-84-9	20	0.20	1.01E-03	7.99E-03			2.00E-01	1.75E-04	4.57E+01	4.57E+01
14	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	6.25E-05	3.20E+04				3.20E+04
	CARCINOGENIC POLLUTANTS											
15	Chromic acids & chromate's	1333-82-0	1	0.01	5.03E-05	4.00E-04			1.00E-01	8.75E-05	4.57E+00	4.57E+00
16	Hydrazine	302-01-2	13	0.1	6.54E-04	5.19E-03			2.00E-01	1.75E-04	2.97E+01	2.97E+01
17	Nickel, metal (dust)	7440-02-0	1,000	10	5.03E-02	4.00E-01	6.25E-05	6.39E+03				6.39E+03

TABLE 1 (PART K).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 35 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R¹) OR (R²) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R¹)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R²)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	1.25E-05	1.12E+05				1.12E+05
2	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.81E+02	1.59E-01	4.53E+03	4.53E+03

TABLE 1 (PART L).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 35 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R¹) OR (R²) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R¹)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R²)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Aluminum, Welding Fumes, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00	9.00E-04	2.22E+03				2.22E+03
2	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	7.75E-04	3.61E+03	7.81E+01	6.83E-02	4.10E+01	4.10E+01
3	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			6.44E+02	5.63E-01	1.28E+03	1.28E+03
4	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	1.05E+00	1.91E+00				1.91E+00

TABLE 1 (PART M).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 39 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
NONCARCINOGENIC POLLUTANTS												
2	Aluminum, Welding Fumes, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00	6.03E-01	3.31E+00				3.31E+00
3	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	1.96E-02	1.43E+02				1.43E+02
4	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	1.05E-03	3.81E+04				3.81E+04
5	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	2.42E-02	8.27E+01				8.27E+01
6	Oil Mist, Mineral	NA	5,000	50	2.52E-01	2.00E+00	1.25E-02	1.60E+02				1.60E+02
7	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			3.63E+02	3.18E-01	2.26E+03	2.26E+03
8	Silica, Fused (respirable)	60676-86-0	100	1	5.04E-03	4.00E-02	2.50E-03	1.60E+01				1.60E+01
9	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	6.01E-01	3.33E+00				3.33E+00
10	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	8.56E-01	2.33E+00				2.33E+00
11	Zinc Chloride Fume	7646-85-7	1,000	10	5.04E-02	4.00E-01	5.00E-03	7.99E+01				7.99E+01
CARCINOGENIC POLLUTANTS												
1	Nickel, metal (dust)	7440-02-0	1,000	10	5.03E-02	4.00E-01	3.00E-01	1.33E+00				1.33E+00

TABLE 1 (PART N).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 40 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
	NONCARCINOGENIC POLLUTANTS											
1	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.03E-01	4.00E+00	1.25E-02	3.19E+02				3.19E+02
2	Aluminum, Welding Fumes, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00	2.25E-05	8.88E+04				8.88E+04
3	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	2.50E-05	5.59E+04				5.59E+04
4	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	1.52E-03	1.85E+03	2.08E+01	1.82E-02	1.54E+02	1.54E+02
5	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01	8.25E-03	1.11E+02	1.27E+00	1.11E-03	8.29E+02	1.11E+02
6	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	1.18E-03	4.76E+02	1.71E+01	1.50E-02	3.73E+01	3.73E+01
7	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	8.94E-02	4.47E+02	5.72E+01	5.00E-02	7.99E+02	4.47E+02
8	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	3.59E-02	5.57E+01	2.15E+01	1.88E-02	1.06E+02	5.57E+01
9	Oil Mist, Mineral	NA	5,000	50	2.52E-01	2.00E+00	5.28E-03	3.79E+02				3.79E+02
10	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01	6.25E-04	6.39E+02				6.39E+02
11	Potassium Hydroxide	1310-58-31	2,000	20	1.01E-01	7.99E-01	1.25E-04	6.39E+03	5.50E+00	4.81E-03	1.66E+02	1.66E+02
12	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.95E+02	1.71E-01	4.21E+03	4.21E+03
13	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01	1.26E-02	3.17E+01	1.83E+01	1.60E-02	2.50E+01	2.50E+01
14	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	3.63E-05	5.51E+04				5.51E+04
15	Wood Dust (certain hard woods)	NA	1,000	10	5.04E-02	4.00E-01	1.13E-03	3.55E+02				3.55E+02
	CARCINOGENIC POLLUTANTS											
16	Nickel, Metal (dust)	7440-02-0	1,000	10	5.03E-02	4.00E-01	1.19E-04	3.36E+03				3.36E+03
17	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	3.88E-02	4.64E+02				4.64E+02

TABLE 1 (PART O).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 43 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
2	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	8.03E-03	1.24E+03				1.24E+03
3	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	5.55E-01	1.22E+01				1.22E+01
4	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	6.95E-03	2.01E+02				2.01E+02
5	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	1.00E-02	4.00E+03				4.00E+03
6	Potassium Hydroxide	1310-58-31	2,000	20	1.01E-01	7.99E-01	3.13E-06	2.56E+05				2.56E+05
7	Wood Dust (certain hard woods)	NA	1,000	10	5.04E-02	4.00E-01	1.25E-03	3.20E+02				3.20E+02
8	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	2.50E-02	7.19E+02				7.19E+02

TABLE 1 (PART P).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 66 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/ Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
					NONCARCINOGENIC POLLUTANTS							
2	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	1.38E-03	7.27E+03				7.27E+03
3	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.04E-01	4.00E+00	2.81E-02	1.42E+02				1.42E+02
4	Aluminum, Welding Fumes, as Al	7429-90-5	5,000	50	2.52E-01	2.00E+00	1.50E-04	1.33E+04				1.33E+04
5	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	5.50E-03	1.24E+03				1.24E+03
6	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	5.00E-03	2.80E+02				2.80E+02
7	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	7.12E-04	3.93E+03	1.03E+02	8.99E-02	3.11E+01	3.11E+01
8	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01	1.88E-03	4.90E+02	1.27E+00	1.11E-03	8.29E+02	4.90E+02
9	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	1.50E-04	3.73E+03				3.73E+03
10	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	2.92E-02	1.37E+03				1.37E+03
11	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02	7.53E-06	5.31E+03				5.31E+03
12	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	1.05E-02	1.90E+02	1.04E+02	9.12E-02	2.19E+01	2.19E+01
13	Oil Mist, Mineral	NA	5,000	50	2.52E-01	2.00E+00	4.28E-03	4.67E+02				4.67E+02
14	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01	1.37E-03	2.92E+02				2.92E+02
15	Potassium Hydroxide	1310-58-31	2,000	20	1.01E-01	7.99E-01	3.20E-07	2.50E+06				2.50E+06
16	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			5.14E+02	4.49E-01	1.60E+03	1.60E+03
17	Silica, Quartz	14808-60-7	100	1	5.03E-03	4.00E-02	2.50E-04	1.60E+02	2.64E+01	2.31E-02	1.73E+00	1.73E+00
18	Silica, Fused (respirable)	60676-86-0	100	1	5.04E-03	4.00E-02	6.25E-05	6.39E+02				6.39E+02
19	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.04E-03	4.00E-02	5.00E-05	7.99E+02				7.99E+02
20	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01	3.35E-03	1.19E+02	2.03E+00	1.78E-03	2.25E+02	1.19E+02

TABLE 1 (PART P).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 66 of TA–3-*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/ Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
21	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	1.50E-04	1.33E+04				1.33E+04
22	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	3.13E-02	6.38E+01				6.38E+01
	CARCINOGENIC POLLUTANTS											
23	Chromic acids & chromates	1333-82-0	1.00	0.01	5.03E-05	4.00E-04	1.25E-04	3.20E+00				3.20E+00
24	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	4.15E-03	4.33E+03				4.33E+03

TABLE 1 (PART Q).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 70 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			2.51E+03	2.19E+00	3.28E+02	3.28E+02

TABLE 1 (PART R).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 142 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.09E+03	9.53E-01	7.55E+02	7.55E+02

TABLE 1 (PART S).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 102 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Lithium Hydride	7580-67-8	25	0.25	1.26E-03	9.99E-03	1.02E-02	9.82E-01				9.82E-01

TABLE 1 (PART T).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 102 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	5.00E-04	5.59E+03				5.59E+03
2	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	2.80E-02	7.14E+01				7.14E+01
3	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01	2.50E-04	1.60E+03				1.60E+03
4	Welding Fumes not otherwise listed	NA	5,000	50	2.52E-01	2.00E+00	2.06E-03	9.70E+02				9.70E+02

TABLE 1 (PART U).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 132 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	2.79E+00	3.58E+00				3.58E+00

TABLE 1 (PART V).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 141 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
					NONCARCINOGENIC POLLUTANTS							
1	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00	2.50E-03	5.59E+02				5.59E+02
2	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	7.50E-04	2.66E+03				2.66E+03
3	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	1.25E-03	1.60E+03				1.60E+03
					CARCINOGENIC POLLUTANTS							
4	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02	1.25E-04	3.20E+02				3.20E+02

TABLE 1 (PART W).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 170 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS		RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha})	ACIS 1995 DATA: RATIO SLEVS/Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			4.49E+03	3.93E+00	1.83E+02	1.83E+02

TABLE 1 (PART X).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic and Carcinogenic Pollutants from Building 223 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS		RAPS 1990 DATA: HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RAPS 1990 DATA: RATIO SLEVS/Q^{hr} (R^1)	ACIS 1995 DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ACIS 1995 DATA: ESTIMATED HOURLY EMISSION RATES (Q^{ha})	ACIS 1995 DATA: RATIO SLEVS/Q^{ha} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
NONCARCINOGENIC POLLUTANTS												
1	2-Butoxyethanol	111-76-2	121,000	1,210	6.09E+00	4.84E+01	5.01E-01	9.66E+01				9.66E+01
2	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	8.36E-01	4.78E+01				4.78E+01
3	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01			8.11E-01	7.10E-04	5.63E+02	5.63E+02
CARCINOGENIC POLLUTANTS												
4	1,1,2-Trichloroethane	79-00-5	45,000	450	2.27E+00	1.80E+01	3.03E+00	5.94E+00				5.94E+00

TABLE 1 (PART Y).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 287 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.04E-01	4.00E+00	2.50E-04	1.60E+04				1.60E+04
2	Kerosene	8008-20-6	100,000	1,000	5.04E+00	4.00E+01	3.00E-03	1.33E+04				1.33E+04

TABLE 1 (PART Z).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 316 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.21E+02	1.06E-01	6.79E+03	6.79E+03

TABLE 1 (PART AA).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 409 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	1.17E-02	8.51E+02				8.51E+02

TABLE 1 (PART BB).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 425 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			3.86E+01	3.37E-02	2.13E+04	2.13E+04

TABLE 1 (PART CC).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 494 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m³	1/100 OF THE OELS µg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	1.06E-05	9.40E+05				9.40E+05
2	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.04E-01	4.00E+00	2.50E-06	1.60E+06				1.60E+06
3	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	1.25E-04	5.43E+04				5.43E+04
4	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00	4.63E-05	6.05E+04	4.29E+01	3.76E-02	7.45E+01	7.45E+01
5	Hydrogen Fluoride, as F	7664-39-3	2,300	23	1.16E-01	9.19E-01	1.00E-04	9.19E+03	7.61E+00	6.66E-03	1.38E+02	1.38E+02
6	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01	3.75E-06	1.49E+05				1.49E+05
7	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02	1.25E-10	3.20E+08				3.20E+08
8	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00	1.75E-04	1.14E+04	5.46E+01	4.78E-02	4.18E+01	4.18E+01
9	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01	5.00E-07	7.99E+05	4.04E+00	3.53E-03	1.13E+02	1.13E+02
10	Potassium Hydroxide	1310-58-31	2,000	20	1.01E-01	7.99E-01	1.25E-06	6.39E+05				6.39E+05
11	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.04E-03	4.00E-02	5.00E-12	7.99E+09				7.99E+09
12	Sulfuric Acid	7664-93-9	1,000	10	5.04E-02	4.00E-01	9.50E-06	4.21E+04				4.21E+04
13	Tungsten as W insoluble Compounds	7440-33-7	5,000	50	2.52E-01	2.00E+00	5.00E-10	4.00E+09				4.00E+09

TABLE 1 (PART DD).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 495 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Silver (metal dust & soluble comp., as Ag)	7440-22-4	100	1	5.04E-03	4.00E-02	9.50E-07	4.21E+04				4.21E+04

TABLE 1 (PART EE).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 502 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			1.21E+02	1.06E-01	6.79E+03	6.79E+03

TABLE 1 (PART FF).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 562 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Hydrogen Chloride	7647-01-0	7,000	70	3.52E-01	2.80E+00			3.90E+01	3.41E-02	8.19E+01	8.19E+01

TABLE 1 (PART GG).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 43/510 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μG/M^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Acetic Acid	64-19-7	25,000	250	1.26E+00	9.99E+00	2.97E-02	3.37E+02				3.37E+02
2	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	2.07E-02	3.28E+02				3.28E+02

TABLE 1 (PART HH).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 1498 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Propane	74-98-6	1,800,000	18,000	9.06E+01	7.19E+02			6.05E+01	5.30E-02	1.36E+04	1.36E+04

TABLE 1 (PART II).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 1559 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Ammonia	7664-41-7	17,000	170	8.56E-01	6.79E+00	1.25E-01	5.43E+01				5.43E+01

TABLE 1 (PART JJ).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 1698 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01			2.45E+00	2.14E-03	2.61E+02	2.61E+02
2	Nickel, soluble & inorg. comp., as Ni	7440-02-0	100	1	5.03E-03	4.00E-02			1.00E-01	8.75E-05	4.57E+02	4.57E+02
3	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00			1.65E+01	1.45E-02	1.38E+02	1.38E+02
4	Vanadium, Respirable Dust & Fume	1314-62-1	50	1	2.52E-03	2.00E-02			1.10E+00	9.63E-04	2.08E+01	2.08E+01
5	Zinc Chloride Fume	7646-85-7	1,000	10	5.04E-02	4.00E-01			6.00E-01	5.25E-04	7.61E+02	7.61E+02

TABLE 1 (PART KK).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 1701 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS µg/m^3	1/100 OF THE OELS µg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Wood Dust (certain hard woods)	NA	1,000	10	5.04E-02	4.00E-01	2.50E-03	1.60E+02				1.60E+02

TABLE 1 (PART LL).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 2202 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Nitric Acid	7697-32-2	5,000	50	2.52E-01	2.00E+00			1.32E+01	1.16E-02	1.73E+02	1.73E+02
2	Phosphoric Acid	7664-38-2	1,000	10	5.03E-02	4.00E-01			4.04E+00	3.53E-03	1.13E+02	1.13E+02

TABLE 1 (PART MM).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 2203 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m³	1/100 OF THE OELS μg/m³	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Aluminum, Metal Dust, as Al	7429-90-5	10,000	100	5.04E-01	4.00E+00			1.10E+00	9.63E-04	4.15E+03	4.15E+03
2	Carbon Black	1333-86-4	3,500	35	1.76E-01	1.40E+00			1.10E+00	9.63E-04	1.45E+03	1.45E+03

TABLE 1 (PART NN).—*8-Hour SLEVs of Potentially Sensitive Noncarcinogenic Pollutants from Building 2010 of TA–3*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OELS μg/m^3	1/100 OF THE OELS μg/m^3	8-HOUR SLEVS		RAPS 1990 DATA		ACIS 1995 DATA			THE SMALLER (R^1) OR (R^2) RATIO
							HOURLY EMISSION RATE FROM RAPS (Q^{hr})	RATIO SLEVS/Q^{hr} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED HOURLY EMISSION RATES (Q^{ha})	RATIO SLEVS/Q^{ha} (R^2)	
					g/sec	lb/hr	lb/hr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Hydrogen Peroxide	7722-84-1	1,400	14	7.05E-02	5.59E-01			1.47E+01	1.28E-02	4.35E+01	4.35E+01

TABLE 2 (PART A).—*Annual SLEVs of the Carcinogenic Pollutants from TA–3 Facilities*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Acetaldehyde	75-07-0	B2	2.20E-06	5.42E-06	1.84E-03	2.93E+01			4.00E-01	1.40E-01	2.09E+02	2.09E+02
2	Acrylamide	79-06-1	B2	1.30E-03	3.20E-03	3.12E-06	4.95E-02						
3	Acrylonitrile	107-13-1	B1	6.80E-05	1.68E-04	5.97E-05	9.47E-01						
4	Allyl Chloride	107-05-1	C	5.50E-08	1.36E-07	7.37E-02	1.17E+03						
5	Aldrin	309-00-2	B2	4.90E-03	1.21E-02	8.28E-07	1.31E-02						
6	Arsenic, el. & in., exc. Arsine, as As	7440-38-2	A	4.30E-03	1.06E-02	9.43E-07	1.50E-02	2.00E-07	7.49E+04				7.49E+04
7	Asbestos	1332-21-4	A	6.90E+00	1.70E+01	5.88E-10	9.33E-06						
8	Benzene	71-43-2	A	8.30E-06	2.05E-05	4.89E-04	7.76E+00				2.37E+00	3.27E+00	3.27E+00
9	Benzidine	92-87-5	A	6.70E-02	1.65E-01	6.05E-08	9.61E-04						
10	Benzo(a)pyrene	50-32-8	B2	1.70E-03	4.19E-03	2.39E-06	3.79E-02						
11	Benzyl Chloride	100-44-7	B2	1.20E-05	2.96E-05	3.38E-04	5.37E+00						
12	Beryllium	7440-41-7	B2	2.40E-03	5.92E-03	1.69E-06	2.68E-02				1.10E-01	2.44E-01	2.44E-01
13	Bis (Chloromethyl) Ether (BCME)	542-88-1	A	6.20E-02	1.53E-01	6.54E-08	1.04E-03						
14	Bromoform	75-25-2	B2	1.10E-06	2.71E-06	3.69E-03	5.85E+01						
15	1,3-Butadiene	106-99-0	B2	2.80E-04	6.90E-04	1.45E-05	2.30E-01						
16	Cadmium, el.l&comp., as Cd	7440-43-9	B1	1.80E-03	4.44E-03	2.25E-06	3.58E-02						
17	Carbon Tetrachloride	56-23-5	B2	1.50E-05	3.70E-05	2.70E-04	4.29E+00	5.00E-01	8.58E+00	1.41E+01	4.94E+00	8.70E-01	8.70E-01
18	Chloroform	67-66-3	B2	2.30E-05	5.67E-05	1.76E-04	2.80E+00	4.50E-01	6.22E+00		4.52E+00	6.19E-01	6.19E-01
19	Chlordane	57-74-9	B2	3.70E-04	9.12E-04	1.10E-05	1.74E-01						
20	Chromium VI	18540-29-9	A	1.20E-02	2.96E-02	3.38E-07	5.37E-03						
21	Diethanolamine	111-42-2	--	1.10E-07	2.71E-07	3.69E-02	5.85E+02						
22	3,3-Dichlorobenzidine	91-94-1	B2	4.80E-04	1.18E-03	8.45E-06	1.34E-01						
23	Epichlorohydrin	106-89-8	B2	1.20E-06	2.96E-06	3.38E-03	5.37E+01						
24	Ethyl Acrylate	140-88-5	B2	5.00E-07	1.23E-06	8.11E-03	1.29E+02			6.09E-01	2.13E-01	6.05E+02	6.05E+02

TABLE 2 (PART A).—*Annual SLEVs of the Carcinogenic Pollutants from TA–3 Facilities*-Continued

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
25	Ethylene Dibromide	106-93-4	B2	2.20E-04	5.42E-04	1.84E-05	2.93E-01						
26	Ethylene Dichloride	107-06-2	B2	2.60E-05	6.41E-05	1.56E-04	2.48E+00			2.60E+00	9.10E-01	2.72E+00	2.72E+00
27	Ethylene Oxide	75-21-8	B1	1.00E-04	2.47E-04	4.06E-05	6.44E-01						
28	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	5.46E+00	9.07E-01				9.07E-01
29	Hexachlorobenzene	118-74-1	B2	4.60E-04	1.13E-03	8.82E-06	1.40E-01						
30	Hexachlorobutadiene	87-68-3	C	2.20E-05	5.42E-05	1.84E-04	2.93E+00						
31	Hexachloroethane	67-72-1	C	4.00E-06	9.86E-06	1.01E-03	1.61E+01						
32	Hydrazine	302-01-2	B2	4.90E-03	1.21E-02	8.28E-07	1.31E-02						
33	Lindane	58-89-9	B2-C	3.80E-04	9.37E-04	1.07E-05	1.69E-01						
34	Methyl Chloride	74-87-3	C	1.80E-06	4.44E-06	2.25E-03	3.58E+01						
35	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	1.50E+01	9.11E+00		7.42E+02	1.85E-01	1.85E-01
36	Nickel, metal (dust)	NA	A	2.40E-04	5.92E-04	1.69E-05	2.68E-01	7.36E-02	3.65E+00	5.25E+01	1.58E-03	1.70E+02	3.65E+00
37	Pentachlorophenol	87-86-5	B2	3.90E-07	9.61E-07	1.04E-02	1.65E+02						
38	Polychlorinated Biphenyl (PCB)	11097-69-1	B2	1.20E-03	2.96E-03	3.38E-06	5.37E-02						
39	Propylene Dichloride	78-87-5	B2	7.20E-07	1.78E-06	5.63E-03	8.94E+01	5.50E+00	1.63E+01				1.63E+01
40	Propylene Oxide	75-56-9	B2	3.70E-06	9.12E-06	1.10E-03	1.74E+01						
41	Styrene	100-42-5	B2	5.70E-07	1.41E-06	7.12E-03	1.13E+02			1.00E-01	3.50E-02	3.23E+03	3.23E+03
42	Toxaphene	8001-35-2	B2	3.20E-04	7.89E-04	1.27E-05	2.01E-01						
43	Tetrachlorethylene	127-18-4	B2	1.40E-05	3.45E-05	2.90E-04	4.60E+00	1.00E+00	4.60E+00				4.60E+00
44	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00	4.15E+00	1.55E+00		1.12E-01	5.75E+01	1.55E+00
45	Vinyl Chloride	75-01-4	A	8.40E-05	2.07E-04	4.83E-05	7.66E-01						
46	1,1-Dichloethylene	75-35-4	C	5.00E-05	1.23E-04	8.11E-05	1.29E+00						
47	1,1,2,2-Tetrachloroethane	79-34-5	C	5.80E-05	1.43E-04	6.99E-05	1.11E+00						
48	1,1,1,2-Tetrachloroethane	630-20-6	C	7.40E-06	1.82E-05	5.48E-04	8.70E+00						
49	1,1,2-Trichloroethane	79-00-5	C	1.60E-05	3.94E-05	2.54E-04	4.02E+00	1.66E+00	2.42E+00				2.42E+00
50	1,2-Dibromo-3-Chloropropane	96-12-8	B2	6.90E-07	1.70E-06	5.88E-03	9.33E+01						

TABLE 2 (PART A).—*Annual SLEVs of the Carcinogenic Pollutants from TA–3 Facilities*-Continued

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA: ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RAPS 1990 DATA: RATIO SLEVS/ Q^{aR} (R^1)	NEW EMISSION RATE DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	NEW EMISSION RATE DATA: ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	NEW EMISSION RATE DATA: RATIO SLEVS/Q^{aA} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
				(µg/m^3)$^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
51	2-Nitropropane	79-46-9	B2	2.70E-03	6.66E-03	1.50E-06	2.38E-02						

Note: The highest ISC–3 estimated annual concentration at sensitive receptors set was found to be 2.465 µg/m3 when emission rate is 1 g/sec.
Note: ACIS and RAPS databases (LANL 1995a and LANL 1990) indicated that 51 carcinogens had been used in the past. Site information now shows 35 carcinogens in use (Attachment 6, Table C).

TABLE 2 (PART B).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Benzene	71-43-2	A	8.30E-06	2.05E-05	4.89E-04	7.76E+00				2.37E+00	3.27E+00	3.27E+00
2	Beryllium	7440-41-7	B2	2.40E-03	5.92E-03	1.69E-06	2.68E-02				1.10E-01	2.44E-01	2.44E-01
3	Carbon Tetrachloride	56-23-5	B2	1.50E-05	3.70E-05	2.70E-04	4.29E+00	5.00E-01	8.58E+00	1.41E+01	4.94E+00	8.70E-01	8.70E-01
4	Chloroform	67-66-3	B2	2.30E-05	5.67E-05	1.76E-04	2.80E+00	4.50E-01	6.22E+00		4.52E+00	6.19E-01	6.19E-01
5	Ethylene Dichloride	107-06-2	B2	2.60E-05	6.41E-05	1.56E-04	2.48E+00			2.60E+00	9.10E-01	2.72E+00	2.72E+00
6	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	5.46E+00	9.07E-01				9.07E-01
7	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	1.50E+01	9.11E+00		7.42E+02	1.85E-01	1.85E-01
8	Nickel, metal (dust)	NA	A	2.40E-04	5.92E-04	1.69E-05	2.68E-01	7.36E-02	3.65E+00	5.25E+01	1.58E-03	1.70E+02	3.65E+00
9	Propylene Dichloride	78-87-5	B2	7.20E-07	1.78E-06	5.63E-03	8.94E+01	5.50E+00	1.63E+01				1.63E+01
10	Tetrachlorethylene	127-18-4	B2	1.40E-05	3.45E-05	2.90E-04	4.60E+00	1.00E+00	4.60E+00				4.60E+00
11	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00	4.15E+00	1.55E+00		1.12E-01	5.75E+01	1.55E+00
12	1,1,2-Trichloroethane	79-00-5	C	1.60E-05	3.94E-05	2.54E-04	4.02E+00	1.66E+00	2.42E+00				2.42E+00

TABLE 2 (PART C).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 16 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Chloroform	67-66-3	B2	2.30E-05	5.67E-05	1.76E-04	2.80E+00	4.50E-01	6.22E+00				6.22E+00
2	Chromium VI	18540-29-9	A	1.20E-02	2.96E-02	3.38E-07	5.37E-03	2.00E-02	2.68E-01				2.68E-01
3	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	6.00E-01	8.25E+00				8.25E+00

TABLE 2 (PART D).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 29 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Beryllium	7440-41-7	B2	2.40E-03	5.92E-03	1.69E-06	2.68E-02				3.60E-06	7.45E+03	7.45E+03
2	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	1.00E-02	4.95E+02				4.95E+02
3	Methylene Chloride	75-09-2	B2	4.70E-07	3.24E-07	3.09E-02	4.90E+02				7.00E+02	7.00E-01	7.00E-01
4	Nickel, metal (dust)	NA	A	2.40E-04	5.92E-04	1.69E-05	2.68E-01	1.10E-03	2.44E+02				2.44E+02

TABLE 2 (PART E).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 30 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				(μg/m^3)$^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	8.25E+00	1.66E+01			1.66E+01	1.66E+01

TABLE 2 (PART F).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 34 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				(μg/m^3)$^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	1.56E-01	3.17E+01				3.17E+01
2	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02			8.21E+01	2.87E+01	4.77E+00	4.77E+00
3	Nickel, metal (dust)	NA	A	2.40E-04	5.92E-04	1.69E-05	2.68E-01	2.50E-02	1.07E+01				1.07E+01

TABLE 2 (PART G).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 37 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA: ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RAPS 1990 DATA: RATIO SLEVS/ Q^{aR} (R^1)	NEW EMISSION RATE DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	NEW EMISSION RATE DATA: ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	NEW EMISSION RATE DATA: RATIO SLEVS/ Q^{aA} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
				($\mu g/m^3$)$^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Tetrachlorethylene	127-18-4	B2	1.40E-05	3.45E-05	2.90E-04	4.60E+00	1.00E+00	4.60E+00				4.60E+00

TABLE 2 (PART H).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 38 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA: ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RAPS 1990 DATA: RATIO SLEVS/ Q^{aR} (R^1)	NEW EMISSION RATE DATA: PURCHASED AMOUNT OF CHEMICALS FROM ACIS	NEW EMISSION RATE DATA: ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	NEW EMISSION RATE DATA: RATIO SLEVS/ Q^{aA} (R^2)	THE SMALLER (R^1) OR (R^2) RATIO
				($\mu g/m^3$)$^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Benzene	71-43-2	A	8.30E-06	2.05E-05	4.89E-04	7.76E+00				2.28E+00	3.40E+00	3.40E+00
2	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	2.78E+00	4.94E+01				4.94E+01
3	Propylene Dichloride	78-87-5	B2	7.20E-07	1.78E-06	5.63E-03	8.94E+01	5.50E+00	1.63E+01				1.63E+01
4	Tetrachlorethylene	127-18-4	B2	1.40E-05	3.45E-05	2.90E-04	4.60E+00	1.48E-08	3.11E+08				3.11E+08
5	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00	4.50E-02	1.43E+02				1.43E+02

TABLE 2 (PART I).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 39 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Benzene	71-43-2	A	8.30E-06	2.05E-05	4.89E-04	7.76E+00				9.10E-02	8.52E+01	8.52E+01
2	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	1.00E-02	4.95E+02				4.95E+02

TABLE 2 (PART J).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 40 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Carbon Tetrachloride	56-23-5	B2	1.50E-05	3.70E-05	2.70E-04	4.29E+00	5.00E-01	8.58E+00				8.58E+00
2	Chromium VI	18540-29-9	A	1.20E-02	2.96E-02	3.38E-07	5.37E-03	5.75E-02	9.33E-02				9.33E-02
3	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	3.06E-01	1.62E+01				1.62E+01
4	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	5.00E-01	2.74E+02	2.93E+01	1.03E+01	1.33E+01	1.33E+01
5	Nickel, metal (dust)	NA	A	2.40E-04	5.92E-04	1.69E-05	2.68E-01	4.75E-02	5.65E+00				5.65E+00
6	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00	2.50E+00	2.58E+00				2.58E+00

TABLE 2 (PART K).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 43 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	5.20E-01	9.52E+00				9.52E+00
2	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	3.00E+00	4.57E+01				4.57E+01

TABLE 2 (PART L).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 43 510 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	2.17E+00	2.28E+00				2.28E+00

TABLE 2 (PART M).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 65 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00	1.60E+00	4.02E+00				4.02E+00

TABLE 2 (PART N).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 66 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Carbon Tetrachloride	56-23-5	B2	1.50E-05	3.70E-05	2.70E-04	4.29E+00			1.06E+01	3.71E+00	1.16E+00	1.16E+00
2	Chloroform	67-66-3	B2	2.30E-05	5.67E-05	1.76E-04	2.80E+00			6.60E+01	6.60E-01	4.24E+00	4.24E+00
3	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	5.00E-02	9.91E+01				9.91E+01
4	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02	5.00E-01	2.74E+02				2.74E+02
5	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00			3.20E-01	1.12E-01	5.75E+01	5.75E+01
6	1,1,2-Trichloroethane	79-00-5	C	1.60E-05	3.94E-05	2.54E-04	4.02E+00	1.66E+00	2.42E+00				2.42E+00

TABLE 2 (PART O).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 70 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	1.93E-01	2.57E+01				2.57E+01

TABLE 2 (PART P).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 73 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	5.84E-01	8.49E+00				8.49E+00

TABLE 2 (PART Q).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 102 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				($\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Beryllium	7440-41-7	B2	2.40E-03	5.92E-03	1.69E-06	2.68E-02				1.40E-04	1.92E+02	1.92E+02
2	Nickel, metal (dust)	NA	A	2.40E-04	5.92E-04	1.69E-05	2.68E-01			5.25E+01	1.58E-03	1.70E+02	1.70E+02

TABLE 2 (PART R).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 105 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				($\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	2.50E-01	1.98E+01				1.98E+01

TABLE 2 (PART S).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 103 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Beryllium	7440-41-7	B2	2.40E-03	5.92E-03	1.69E-06	2.68E-02				1.10E-01	2.44E-01	2.44E-01

TABLE 2 (PART T).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 218 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Trichloroethylene	79-01-6	B2	1.00E-05	2.47E-05	4.06E-04	6.44E+00	5.38E-04	1.20E+04				1.20E+04

TABLE 2 (PART U).—*Annual SLEVs of Potentially Sensitive Carcinogenic Potentials from Building 287 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	3.00E-01	1.65E+01				1.65E+01

TABLE 2 (PART V).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 1698 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Carbon Tetrachloride	56-23-5	B2	1.50E-05	3.70E-05	2.70E-04	4.29E+00			3.50E+00	1.23E+00	3.50E+00	3.50E+00
2	Chloroform	67-66-3	B2	2.30E-05	5.67E-05	1.76E-04	2.80E+00			1.15E+02	1.38E+00	2.03E+00	2.03E+00
3	Ethylene Dichloride	107-06-2	B2	2.60E-05	6.41E-05	1.56E-04	2.48E+00			2.60E+00	9.10E-01	2.72E+00	2.72E+00
4	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02			5.80E+00	2.03E+00	6.75E+01	6.75E+01
5	Styrene	100-42-5	B2	5.70E-07	1.41E-06	7.12E-03	1.13E+02			1.00E-01	3.50E-02	3.23E+03	3.23E+03

TABLE 2 (PART W).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 495 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/ Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Formaldehyde	50-00-0	B1	1.30E-05	3.20E-05	3.12E-04	4.95E+00	3.00E-01	1.65E+01				1.65E+01

TABLE 2 (PART X).—*Annual SLEVs of Potentially Sensitive Carcinogenic Pollutants from Building 1819 of TA–3*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} X URF)	ANNUAL SLEVS		RAPS 1990 DATA		NEW EMISSION RATE DATA			THE SMALLER (R^1) OR (R^2) RATIO
								ANNUAL EMISSION RATE FROM RAPS (Q^{aR})	RATIO SLEVS/Q^{aR} (R^1)	PURCHASED AMOUNT OF CHEMICALS FROM ACIS	ESTIMATED ANNUAL EMISSION RATES (Q^{aA})	RATIO SLEVS/ Q^{aA} (R^2)	
				$(\mu g/m^3)^{-1}$		g/sec	lb/yr	lb/yr		lb/year	lb/hr		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Chloroform	67-66-3	B2	2.30E-05	5.67E-05	1.76E-04	2.80E+00			1.16E+02	2.48E+00	1.13E+00	1.13E+00
2	Methylene Chloride	75-09-2	B2	4.70E-07	1.16E-06	8.63E-03	1.37E+02			2.93E+00	1.03E+00	1.33E+02	1.33E+02

ATTACHMENT 6
ADDITIVE IMPACT ANALYSIS ASSOCIATED WITH THE COMBINED RELEASES OF CARCINOGENIC POLLUTANTS FROM ALL TECHNICAL AREAS

Technical Area(s): TA–00, TA–2, TA–3, TA–5, TA–8, TA–9, TA–11, TA–15, TA–16, TA–18, TA–21, TA–22, TA–33, TA–35, TA–36, TA–39, TA–40, TA–41, TA–43, TA–46, TA–48, TA–50, TA–51, TA–53, TA–54, TA–55, TA–59, TA–60, TA–61, and TA–64

Emission Sources

Releases of Noncarcinogenic and Carcinogenic Air Pollutants From All LANL TAs

Title III of the *Clean Air Act* (CAA) Amendments of 1990 sets a framework for regulating sources of toxic air pollutants. According to the provisions of the CAA, "after the implementation of the maximum achievable control technology, it is necessary to assess the residual risks due to toxic air emissions to the population near each source of emissions."

This assessment includes the determination of noncancer health effects of noncarcinogenic air pollutants based on the estimation of long-term and short-term ambient concentrations of these pollutants, and the determination of lifetime cancer risk exposure of carcinogenic air pollutants based on the estimation of long-term ambient concentrations of these pollutants. The determination involves performing analytical (modeling) simulations of the air pollutants dispersion for all emission sources of concern. Such simulations are then coupled with health effects information and compared to available population data to quantify human exposure, noncancer health risk, cancer risk, and ecological risks.

For carcinogenic air pollutants, the level of concern is the risk of an individual contracting cancer by being exposed to ambient concentrations of that pollutant over the course of a lifetime, or lifetime cancer risk. The criteria specified in the CAA is 1.0×10^{-6} (1 in 1,000,000) lifetime cancer risk for the individual exposed to the highest predicted concentration of a pollutant. Lifetime cancer risk is estimated by multiplying the predicted annual ambient concentration (in micrograms per cubic meter) of a specific pollutant by the unit risk factor for that pollutant, where the unit risk factor is equal to the upper bound lifetime cancer risk associated with inhaling a unit concentration (1 microgram per cubic meter) of that pollutant.

EPA has developed unit risk factors for a number of possible, probable, or known human carcinogens, which are available from its Integrated Risk Information System (IRIS) database.

According to EPA 1992f, "cancer risks resulting from exposure to mixtures of multiple carcinogenic pollutants are to be assessed by summing the incremental cancer risks due to each individual pollutant, regardless of the type of cancer that may be associated with any particular carcinogen. Thus, this approach assumes that all cancer risks are additive and all worst-case impacts occur at the same location. While this assumption may not be very realistic, it does help to insure that results are conservative, and, therefore protective to the public."

Pollutant(s) Considered

Noncarcinogenic Pollutants

An analysis of potential short-term impacts at a TA's fence line receptors showed that the 8-hour impacts from the releases of that TA were significantly greater (i.e., more then two orders of magnitude) than the impacts from the releases of a nearby TA. This is because the TAs are relatively far apart in comparison to the distances between the emission sources of a TA and its fence line receptors. Therefore, it is unlikely that the additive short-term impacts of noncarcinogenic pollutants at the fence line receptors of a TA would be significantly different from the maximum concentrations previously estimated for that TA.

An analysis of annual potential impacts at sensitive receptors showed that these impacts were significantly less (i.e., less then two orders of magnitude) relative to the appropriate Guideline Values (GVs) than the corresponding short-term impacts at the fence line receptors. Therefore, it is unlikely that the additive annual impacts of the noncarcinogenic pollutants at the sensitive receptors would be significant.

Carcinogenic Pollutants

All carcinogenic air pollutants that are currently being used at LANL or are anticipated to be used under the future alternatives were included in the additive impact analysis.

TA–2, TA–5, TA–11, TA–36, TA–40, TA–41, and TA–64 do not currently use carcinogenic pollutants and do not anticipate using them under the future alternatives. As such, these TAs were not included in the additive impact evaluation.

Emission Rates of Pollutants Considered

Annual emission rates of the carcinogenic pollutants used were those developed for both key and non-key facilities for each pollutant that had an SLEV/Q ratio less than one, based on process knowledge and chemical usage for the Expanded Operations Alternative. For those carcinogenic pollutants released from key or non-key facilities, within both key and non-key TAs, for which such emission data were not specifically developed for this analysis, emission rates were estimated based on data either from the RAPS Report or ACIS database, or were assumed to be at SLEV levels.

Beryllium emissions from all LANL sources (i.e., TA–3 CMR Building 29, TA–3 Machine Shops Complex, TA–35 Building 213, and TA–55 Building 15 Chemical Laboratory) were modeled using LANL's permitted emission rates.

Estimated emission rates of each of the carcinogenic pollutants considered in the additive impacts analysis for releases of all carcinogenic pollutants from all TAs are presented in Table A.

Dispersion Modeling Analysis

The additive impact analysis was conducted with the EPA's ISC–3 Model using 5 years of on-site meteorological data. All buildings near emission sources within the zone of influence at each TA were included in the downwash effects evaluation.

The incremental cancer risk from the release of a pollutant was estimated by multiplying the maximum ISC–3-estimated annual average concentration of that pollutant by its unit risk factor.

Major Assumptions Used in the Dispersion Analysis

- Emissions would be released simultaneously from LANL operations over 8,760 hours a year.
- Incremental cancer risks are additive.
- There is no reduction of the ambient concentrations by entry into buildings and deposition within them.

Results

Releases of Each Carcinogenic Pollutant from All TAs

The potential additive impact of the emissions of each of the carcinogenic pollutants from all of the TAs was estimated by assuming that each pollutant was emitted from all of the TAs at the SLEV levels. The maximum receptor for the release from each TA was added to the maximum receptor from each of the other TAs. This analysis was conducted for one of the pollutants, and the results were applied to each of the other pollutants. This approach is legitimate because the relationship between SLEVs and GVs are identical for all of the pollutants for each TA due to the fact that they are based on the same dispersion-related X/Q (concentration related to the emissions) ratio.

Results of the analysis are presented in Table B. For illustrational purposes, the cancer risk associated with the releases of three pollutants (arsenic, benzene, and formaldehyde) at their SLEV release rates are shown in Table B.

As shown, the combined cancer risk associated with releases of each of these pollutants from all TAs is 1.23×10^{-7}, which is below the GV of 1.0×10^{-6}.

Releases of All Carcinogenic Pollutants from All TAs

A total of 35 carcinogenic pollutants were considered in the additive impacts analysis of emissions of all carcinogenic pollutants from all of the TAs. These are the carcinogenic pollutants that are currently being used at LANL or are anticipated to be used under the site's future alternatives. The annual average concentrations of each pollutant were estimated assuming that all pollutants were emitted simultaneously from all of the TAs.

The maximum concentration of each pollutant from the simultaneous release from all TAs was determined by modeling the emission rates from Table A and recording the highest concentration from a listing of 180 receptors. The combined cancer risk was then estimated by summing up the cancer risk of each individual pollutant at these (maximum) concentrations, even though the receptors may have been different. This value was then compared with an allowable incremental cancer risk of 1.0×10^{-6}. Results of this analysis are presented in Table C. As shown, the potential combined incremental cancer risk associated with releases of all carcinogenic pollutants from all TAs is above the GV of 1.0×10^{-6}.

Because the predicted combined additive impact of all carcinogenic pollutants released from all TAs is above the specified GV of 1.0×10^{-6}, a more detailed analysis that considered the impact at each receptor locations was conducted. This more refined analysis estimated the combined cancer risk at each of the 180 sensitive receptor locations with a focus on the pollutants with the greatest contribution to the combined cancer risk from the previous step.

For each of these critical pollutants (chloroform, formaldehyde, methylene chloride, and trichloethylene), the maximum cancer risk was estimated at each of the 180 receptor locations using the highest values of the annual concentrations estimated using 5 years of meteorological data for that receptor. Cancer risk values at receptors #28 and #175 through #180 (the highest values) were computed for all the other chemicals, also using the highest value of the annual concentration estimated using 5 years of meteorological data for those receptors. For receptors other than those just mentioned, default values of the maximum concentration of any of the receptors were recorded in Table D for each of the chemicals other than the four critical pollutants.

As shown in Table D, the combined incremental cancer risk associated with releases of all carcinogenic pollutants from all TAs at the receptor locations where these impacts actually occur are above the GV of 1.0×10^{-6} at the two locations within the LANL Medical Center, 1.17×10^{-6} at Receptor #175 (air intake duct at a height of 3.7 feet [12.2 meters]) and 1.07×10^{-6} at Receptor #180 (an operable window at a height of 0.46 feet [1.5 meters]).

The major contributors to the estimated combined cancer risk values are pollutants primarily released from TA–43, the Health Research Laboratory (HRL). The critical pollutants are chloroform, formaldehyde, and trichloethylene from the HRL and methylene chloride from multiple sources (TA–3, TA–9, TA–16, TA–35, TA–46, and TA–48). The estimated maximum cancer risk for each of these individual pollutants is 8.74×10^{-7}, 5.17×10^{-8}, 6.73×10^{-8}, and 6.84×10^{-8}, respectively. Of these, the relative contribution of chloroform emissions alone to the combined cancer risk value is more than 87 percent.

The impacts of TA–43 emissions are due to a combination of relatively high emission rates, close proximity between receptors and sources, and the elevation of the receptors. Receptors at or near the Medical Center, where these impacts are estimated, are #28 and #175 through 180 in attachment 3, Sensitive Receptors. Receptor #28 is a ground level receptor. Receptors #175 through 180 are elevated (i.e., air intakes at a height of up to 3.7 feet [12 meters] and operable windows at a height of 0.46 feet [1.5 meters] above the ground) and are at the distance of less than 30.5 feet (100 meters) from the nearest stack on the roof of the HRL.

Because the estimated cancer risk at these two receptor locations is above the GV of 1.0×10^{-6}, these results are subject to a risk assessment analysis.

TABLE A (PART 1).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*

NO.	POLLUTANTS	KEY BUILDINGS OF THE TA–3 FACILITY															
		TA–3 SIGMA (BLDG. 66)				TA–3 CMR (BLDG. 29)				TA–3 MSL (BLDG. 1698)				TA–3 SHOP COMPLEX (BLDG. 102 & 141)			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		EMISSION RATES USED IN THE ANALYSIS			
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	BLDG. 102	BLDG. 141		
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec	g/sec	g/sec		
1	1,1,1,2-Tetrachloroethane																
2	1,1,2,2-Tetrachloroethane																
3	1,1,2-Trichloroethane																
4	1,3-Butadiene																
5	2,3,7,8-Tetrachlorodibenzo(p)dioxin																
6	2-Nitropropane																
7	Acetaldehyde																
8	Acrylamide																
9	Allyl Chloride																
10	Arsenic																
11	Benzene																
12	Benzo(p)pyrene																
13	Benzyl Chloride																
14	Beryllium[a]								5.18E-11					2.02E-09	1.58E-06		
15	Cadmium																
16	Carbon Tetrachloride	3.23E-01	1.16E+00		5.34E-05						3.50E+00		1.77E-05				
17	Chloroform	3.06E-01	4.23E+00		9.50E-06						2.00E+00		1.99E-05				
18	Chromium VI																
19	Diethanolamine																
20	Epichlorhydrin																
21	Ethyl Acrylate																
22	Ethylene Dichloride										2.70E+00		1.31E-05				
23	Ethylene Oxide																
24	Formaldehyde																
25	Hexachlorobutadiene																
26	Hexachloroethane																
27	Hydrazine																
28	Methyl Chloride																

TABLE A (PART 1).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*-Continued

NO.	POLLUTANTS	KEY BUILDINGS OF THE TA–3 FACILITY															
		TA–3 SIGMA (BLDG. 66)				TA–3 CMR (BLDG. 29)				TA–3 MSL (BLDG. 1698)				TA–3 SHOP COMPLEX (BLDG. 102 & 141)			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		EMISSION RATES USED IN THE ANALYSIS			
		ORIGINAL	REVISED	AT THE SLEV LEVEL g/sec	USED IN THE ANALYSIS g/sec	ORIGINAL	REVISED	AT THE SLEV LEVEL g/sec	USED IN THE ANALYSIS g/sec	ORIGINAL	REVISED	AT THE SLEV LEVEL g/sec	USED IN THE ANALYSIS g/sec	BLDG. 102 g/sec	BLDG. 141 g/sec		
29	Methylene Chloride					8.34E+00	7.03E-01		1.01E-02	3.34E+01	6.70E+01		2.92E-05				
30	Nickel, metal (dust)													2.27E-08			
31	Propylene Dichloride																
32	Styrene																
33	Tetrachlorethylene																
34	Trichloroethylene	1.71E-01	5.75E+01		1.61E-06												
35	Vinyl Chloride																
19	Diethanolamine																
20	Epichlorhydrin																
21	Ethyl Acrylate			8.11E-03													
22	Ethylene Dichloride													3.61E+00	--	5.35E-04	5.35E-04
23	Ethylene Oxide																
24	Formaldehyde			7.86E-05	15 Bldgs.					1.16E+02	--	5.49E-04	5.49E-04				
25	Hexachlorobutadiene																
26	Hexachloroethane																
27	Hydrazine													4.51E-02	2.04E+01		3.17E-08
28	Methyl Chloride																
29	Methylene Chloride			7.85E-04	7 Bldgs.	7.70E+01	--	9.70E-03	9.70E-03					6.66E+01	--	2.96E-02	2.96E-02
30	Nickel, metal (dust)			1.06E-06	3 Bldgs.												
31	Propylene Dichloride			5.63E-03													
32	Styrene			7.12E-03													
33	Tetrachlorethylene		--	2.90E-04													
34	Trichloroethylene			5.97E-05	4 Bldgs.									2.21E+02	--	1.39E-03	1.39E-03
35	Vinyl Chloride																

TABLE A (PART 2).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*

NO.	POLLUTANTS	NON-KEY BUILDINGS TA–3				TA–00				TA–8				TA–9			
		EMISSION RATES USED IN THE ANALYSIS				SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		BY BUILDING	BY BUILDING	TA TOTAL	BUILDING(S) CONSIDERED	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
		g/sec	g/sec	g/sec				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
1	1,1,1,2-Tetrachloroethane																
2	1,1,2,2-Tetrachloroethane																
3	1,1,2-Trichloroethane			2.39E-05	Bldg. 66									1.38E+02	--	8.70E-04	8.70E-04
4	1,3-Butadiene																
5	2,3,7,8-Tetrachlorodibenzo(p) dioxin																
6	2-Nitropropane																
7	Acetaldehyde			1.84E-03													
8	Acrylamide																
9	Allyl Chloride																
10	Arsenic			9.43E-07													
11	Benzene	3.2825E-05	1.3101E-06	3.4135E-05	Bldg. 38[b] Bldg. 39[c]									1.06E+04	--	1.68E-03	1.68E-03
12	Benzo(p)pyrene																
13	Benzyl Chloride																
14	Beryllium[a]																
15	Cadmium																
16	Carbon Tetrachloride	7.20E-06			Bldg. 40									2.94E+04	--	9.28E-04	9.28E-04
17	Chloroform	6.48E-06	3.57E-05	4.2183E-05	Bldg. 16[b] Bldg. 1819[c]									1.40E+00	--	6.05E-04	6.05E-04
18	Chromium VI																
19	Diethanolamine																
20	Epichlorhydrin																
21	Ethyl Acrylate			8.11E-03													
22	Ethylene Dichloride													3.61E+00	--	5.35E-04	5.35E-04
23	Ethylene Oxide																
24	Formaldehyde			7.86E-05	15 Bldgs.					1.16E+02	--	5.49E-04	5.49E-04				
25	Hexachlorobutadiene																
26	Hexachloroethane																
27	Hydrazine													4.51E-02	2.04E+01		3.17E-08

TABLE A (PART 2).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*-Continued

NO.	POLLUTANTS	NON-KEY BUILDINGS TA–3				TA–00				TA–8				TA–9			
		EMISSION RATES USED IN THE ANALYSIS				SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		BY BUILDING	BY BUILDING	TA TOTAL	BUILDING(S) CONSIDERED	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
		g/sec	g/sec	g/sec				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
28	Methyl Chloride																
29	Methylene Chloride			7.85E-04	7 Bldgs.	7.70E+01	--	9.70E-03	9.70E-03					6.66E+01	--	2.96E-02	2.96E-02
30	Nickel, metal (dust)			1.06E-06	3 Bldgs.												
31	Propylene Dichloride			5.63E-03													
32	Styrene			7.12E-03													
33	Tetrachlorethylene		--	2.90E-04													
34	Trichloroethylene			5.97E-05	4 Bldgs.									2.21E+02	--	1.39E-03	1.39E-03
35	Vinyl Chloride																

TABLE A (PART 3).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*

NO.	POLLUTANTS	TA–15				TA–16				TA–21				TA–22			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
1	1,1,1,2-Tetrachloroethane																
2	1,1,2,2-Tetrachloroethane									1.42E+02	--	4.35E-05	4.35E-05				
3	1,1,2-Trichloroethane						new pol.		2.16E-05					3.37E+00	--	1.06E-03	1.06E-03
4	1,3-Butadiene																
5	2,3,7,8-Tetrachlorodibenzo(p)dioxin						new pol. fr. incinerator		4.68E-11								
6	2-Nitropropane																
7	Acetaldehyde											1.15E-03					
8	Acrylamide																
9	Allyl Chloride											4.59E-02					
10	Arsenic							1.06E-08									
11	Benzene									9.65E+00	--	3.04E-04	3.04E-04				
12	Benzo(p)pyrene								4.61E-07								
13	Benzyl Chloride																

TABLE A (PART 3).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*-Continued

NO.	POLLUTANTS	TA–15				TA–16				TA–21				TA–22			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
14	Beryllium[a]																
15	Cadmium						new pol. fr. incinerator		3.83E-08								
16	Carbon Tetrachloride									2.67E+01	--	1.68E-04	1.68E-04				
17	Chloroform					3.07E+00	--	5.52E-04	5.52E-04	8.70E+00	--	1.10E-04	1.10E-04				
18	Chromium VI						new pol. fr. incinerator		1.58E-08								
19	Diethanolamine																
20	Epichlorhydrine																
21	Ethyl Acrylate											5.04E-03					
22	Ethylene Dichloride	9.73E+00	--	1.23E-03	1.23E-03					1.54E+01	--	9.70E-05	9.70E-05				
23	Ethylene Oxide											2.52E-05					
24	Formaldehyde					7.57E+00	--	9.77E-04	9.77E-04	5.13E+01	--	1.94E-04	1.94E-04				
25	Hexachlorobutadiene																
26	Hexachloroethane																
27	Hydrazine									4.08E+00	--	5.15E-07	5.15E-07				
28	Methyl Chloride																
29	Methylene Chloride					1.12E+01	--	2.70E-02	2.70E-02	2.84E+01	--	5.37E-03	5.37E-03				
30	Nickel, metal (dust)						new pol. fr. incinerator		8.75E-08								
31	Propylene Dichloride											3.50E-03					
32	Styrene																
33	Tetrachlorethylene																
34	Trichloroethylene	3.37E+00	--	3.19E-03	3.19E-03					4.21E+01	--	2.52E-04	2.52E-04				
35	Vinyl Chloride																

TABLE A (PART 4).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*

NO.	POLLUTANTS	TA–35				TA–39				TA–43				TA–46			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		EMISSION RATES USED IN THE ANALYSIS				SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	BLDG. 247	BLDG. 124/126	N.SIDE	S.SIDE	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec	g/sec	g/sec	g/sec	g/sec			g/sec	g/sec
1	1,1,1,2-Tetrachloroethane																
2	1,1,2,2-Tetrachloroethane	2.08E+01	--	2.62E-04	2.62E-04												
3	1,1,2-Trichloroethane																
4	1,3-Butadiene	new pol.	8.61E+01		1.44E-07									2.72E+00	--	5.39E-05	5.39E-05
5	2,3,7,8-Tetrachlorodibenzo(p)dioxin																
6	2-Nitropropane	new pol.	4.47E+01		2.88E-08									1.16E+00	--	5.59E-06	5.59E-06
7	Acetaldehyde																
8	Acrylamide	new pol.			6.62E-08					8.44E-08	8.44E-08	8.44E-08	8.44E-08				
9	Allyl Chloride																
10	Arsenic			3.53E-06													
11	Benzene	1.45E+02	-	1.83E-03	1.83E-03									4.25E+02	--	1.82E-03	1.82E-03
12	Benzo(p)pyrene																
13	Benzyl Chloride			1.27E-03													
14	Beryllium[a]				1.15E-08												
15	Cadmium																
16	Carbon Tetrachloride	1.61E+02	--	1.01E-03	1.01E-03									1.30E+01	--	1.01E-03	1.01E-03
17	Chloroform	5.36E-01	1.95E+01		7.75E-06	1.41E+02	--	1.42E-04	1.42E-04	3.17E-05	3.07E-04	3.07E-04	3.07E-04	6.29E-01	2.21E+01		6.80E-06
18	Chromium VI																
19	Diethanolamine															1.37E-01	
20	Epichlorohydrin																
21	Ethyl Acrylate																
22	Ethylene Dichloride	1.94E+00	--	5.84E-04	5.84E-04									9.64E+00	--	5.81E-04	5.81E-04
23	Ethylene Oxide																
24	Formaldehyde									2.49E-06	2.42E-05	2.42E-05	2.42E-05	1.48E+01	--	1.16E-03	1.16E-03
25	Hexachlorobutadiene																
26	Hexachloroethane																
27	Hydrazine																
28	Methyl Chloride					1.87E+04	--	6.95E-03	6.95E-03					8.33E+02	--	8.39E-03	8.39E-03
29	Methylene Chloride	2.04E+01	--	3.23E-02	3.23E-02							1.36E-05	1.36E-05	1.66E+01	--	3.21E-02	3.21E-02
30	Nickel, metal (dust)													2.27E+05	--	6.29E-05	6.29E-05

TABLE A (PART 4).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*-Continued

NO.	POLLUTANTS	TA–35				TA–39				TA–43				TA–46			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		EMISSION RATES USED IN THE ANALYSIS				SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	BLDG. 247	BLDG. 124/126	N.SIDE	S.SIDE	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec	g/sec	g/sec	g/sec	g/sec			g/sec	g/sec
31	Propylene Dichloride																
32	Styrene			2.67E-02													
33	Tetrachlorethylene	1.72E+02	--	1.09E-03	1.09E-03												
34	Trichloroethylene	5.62E-01	3.05E+00		5.27E-05	8.30E+01	--	3.27E-04	3.27E-04				1.47E-04	1.08E+01	--	1.51E-03	1.51E-03
35	Vinyl Chloride			1.81E-04													

TABLE A (PART 5).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*

NO.	POLLUTANTS	TA–48				TA–50				TA–53				TA–54			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
1	1,1,1,2-Tetrachloroethane			4.58E-04													
2	1,1,2,2-Tetrachloroethane		1.47E+02		9.07E-08												
3	1,1,2-Trichloroethane	7.22E+01	--	2.21E-04	2.21E-04												
4	1,3-Butadiene		8.74E+00		3.17E-07												
5	2,3,7,8-Tetrachlorodibenzo(p)dioxin																
6	2-Nitropropane																
7	Acetaldehyde																
8	Acrylamide																
9	Allyl Chloride																
10	Arsenic																
11	Benzene	9.55E-01	3.34E+01		2.79E-06					7.73E-01	5.41E+00		2.10E-05	5.96E+00	--	1.53E-03	1.53E-03
12	Benzo(p)pyrene																
13	Benzyl Chloride																
14	Beryllium[a]																

TABLE A (PART 5).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*-Continued

NO.	POLLUTANTS	TA–48				TA–50				TA–53				TA–54			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
15	Cadmium					1.70E+01	--	8.56E-06	8.56E-06								
16	Carbon Tetrachloride		2.93E+00		1.77E-05					1.74E+02	--	2.75E-04	2.75E-04	2.19E+01	--	8.47E-04	8.47E-04
17	Chloroform	2.56E-01	8.97E+00		3.76E-06					2.24E-01	--		2.35E-04	1.92E-01	5.48E+00		2.30E-05
18	Chromium VI																
19	Diethanolamine																
20	Epichlorohydrin											3.43E-03					
21	Ethyl Acrylate																
22	Ethylene Dichloride	4.33E+00	--	1.30E-04	1.30E-04					5.25E+00	--	1.58E-04	1.58E-04	8.10E+00	--	4.88E-04	4.88E-04
23	Ethylene Oxide																
24	Formaldehyde	1.03E+01	--	2.61E-04	2.61E-04												
25	Hexachlorobutadiene			1.54E-04													
26	Hexachloroethane			8.48E-04													
27	Hydrazine																
28	Methyl Chloride																
29	Methylene Chloride	1.15E+03	--	7.22E-03	7.22E-03					3.87E+00	--	8.76E-03	8.76E-03	8.36E-01	3.57E+03		1.73E-06
30	Nickel, metal (dust)	2.34E-01	3.74E+01		8.78E-08					1.45E+00	--	1.72E-05	1.72E-05				
31	Propylene Dichloride																
32	Styrene			5.95E-03													
33	Tetrachlorethylene	3.08E+01	--	2.42E-04	2.42E-04												
34	Trichloroethylene	4.78E+01	--	3.39E-04	3.39E-04	1.63E+01	--	1.54E-03	1.54E-03								
35	Vinyl Chloride																

TABLE A (PART 6).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*

NO.	POLLUTANTS	TA–55				TA–59				TA–60				TA– 61			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
1	1,1,1,2-Tetrachloroethane																
2	1,1,2,2-Tetrachloroethane																
3	1,1,2-Trichloroethane	3.88E+01	--	9.30E-04	9.30E-04												
4	1,3-Butadiene																
5	2,3,7,8-Tetrachlorodibenzo(p)dioxin																
6	2-Nitropropane																
7	Acetaldehyde																
8	Acrylamide	8.24E+02	--	1.15E-05	1.15E-05												
9	Allyl Chloride																
10	Arsenic																
11	Benzene	8.38E+01	2.94E+04		1.40E-08					new. pol			1.73E-05				
12	Benzo(p)pyrene																
13	Benzyl Chloride																
14	Beryllium[a]				1.04E-07												
15	Cadmium	3.97E+03	--	8.27E-06	8.27E-06					2.03E+00	--	1.54E-06	1.54E-06				
16	Carbon Tetrachloride	1.54E+01	1.29E+01		1.77E-05	5.63E+01	--	3.55E-04	3.55E-04								
17	Chloroform	5.62E-01	8.90E+00		1.67E-05												
18	Chromium VI	8.93E+00	--	1.24E-06	1.24E-06												
19	Diethanolamine																
20	Epichlorohydrin																
21	Ethyl Acrylate																
22	Ethylene Dichloride					3.40E+01	--	2.05E-04	2.05E-04								
23	Ethylene Oxide																
24	Formaldehyde	1.82E+04	--	1.15E-03	1.15E-03	1.62E+01	--	4.09E-04	4.09E-04								
25	Hexachlorobutadiene																
26	Hexachloroethane																
27	Hydrazine	4.33E+00	--	3.04E-06	3.04E-06												
28	Methyl Chloride													7.87E+00	--	1.36E-03	1.36E-03
29	Methylene Chloride	3.06E+01	4.95E+02		1.47E-05	8.64E-02	1.53E+03		1.68E-06								
30	Nickel, metal (dust)	3.28E+04	--	6.20E-05	6.20E-05												

TABLE A (PART 6).—*Emission Rates of the Carcinogenic Pollutants Considered in the Additive Impact Analysis*-Continued

NO.	POLLUTANTS	TA–55				TA–59				TA–60				TA– 61			
		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES		SLEV/Q RATIOS		EMISSION RATES	
		ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS	ORIGINAL	REVISED	AT THE SLEV LEVEL	USED IN THE ANALYSIS
				g/sec	g/sec			g/sec	g/sec			g/sec	g/sec			g/sec	g/sec
31	Propylene Dichloride																
32	Styrene																
33	Tetrachlorethylene	1.13E+01	1.34E+01		1.81E-05												
34	Trichloroethylene	9.23E-02	2.11E+01		1.61E-05	5.63E+00	--	5.32E-04	5.32E-04	4.39E+00	--	2.77E-04	2.77E-04				
35	Vinyl Chloride																

Notes: TA–2, TA–5, TA–11, TA–36, TA–40, TA–41, and TA–64, which are not currently using any of the carcinogenic pollutants or are anticipated to use them under future alternatives, were not included in the analysis.

[a] Beryllium emissions from all sources (i.e., TA–3 CMR Building 29, TA–3 Shop Complex, TA–35 Building 213, and TA–55 Building 15 Chemical Lab.), were modeled using LANL's permitted emission rates.

[b] Annual emission rates of carcinogenic pollutants were estimated based on detailed evaluation of actual operating conditions. These revised emission rates were developed for both key and non-key buildings, within key and non-key TAs, for each pollutant that had an SLEV/Q ratio less than 1. For those pollutants released from key or non-key buildings, within both key and non-key TAs, for which such emission data were not developed, emission rates were estimated based on data either from the RAPS–90 (LANL 1990) Report or ACIS 1996 database (LANL 1995a), or were assumed to be at SLEV levels.

[c] It was assumed that emissions would be released simultaneously over 8,760 hours a year.

TABLE B.—*Results of the Additive Impact Analysis of the Cancer Risk Associated with Releases of Each Carcinogenic Pollutant from All TAs Combined*

NO.	LANL TAs	ANNUAL SLEVS[a]		
		ARSENIC	BENZENE	FORMALDEHYDE
		g/sec	g/sec	g/sec
1	TA–00	1.06E-06	5.49E-04	3.15E-04
2	TA–2	4.67E-07	2.42E-04	1.54E-04
3	TA–3	9.43E-07	4.89E-04	3.12E-04
4	TA–5	3.03E-06	1.57E-03	1.00E-03
5	TA–8	1.66E-06	8.59E-04	5.49E-04
6	TA–9	3.24E-06	1.68E-03	1.07E-03
7	TA–11	2.70E-06	1.40E-03	8.92E-04
8	TA–15	7.42E-06	3.84E-03	2.45E-03
9	TA–16	2.95E-06	1.53E-03	9.77E-04
10	TA–18	4.68E-06	2.41E-03	1.54E-03
11	TA–21	5.86E-07	3.04E-04	1.94E-04
12	TA–22	3.95E-06	2.05E-03	1.31E-03
13	TA–33	2.09E-06	1.08E-03	6.92E-04
14	TA–35	3.53E-06	1.83E-03	1.17E-03
15	TA–36	5.85E-06	3.03E-03	1.93E-03
16	TA–39	7.60E-07	3.94E-04	2.51E-04
17	TA–40	3.84E-06	1.99E-03	1.27E-03
18	TA–41	4.31E-07	2.23E-04	1.42E-04
19	TA–43	1.38E-08	7.13E-06	4.55E-06
20	TA–46	3.51E-06	1.82E-03	1.16E-03
21	TA–48	7.89E-07	4.09E-04	2.61E-04
22	TA–50	3.59E-06	1.86E-03	1.19E-03
23	TA–51	3.24E-06	1.68E-03	1.07E-03

TABLE B.—*Results of the Additive Impact Analysis of the Cancer Risk Associated with Releases of Each Carcinogenic Pollutant from All TAs Combined*-Continued

NO.	LANL TAs	ANNUAL SLEVS[a]		
		ARSENIC	BENZENE	FORMALDEHYDE
		g/sec	g/sec	g/sec
24	TA–53	9.58E-07	4.96E-04	3.17E-04
25	TA–54	2.95E-06	1.53E-03	9.77E-04
26	TA–55	3.46E-06	1.79E-03	1.15E-03
27	TA–59	1.24E-06	6.41E-04	4.09E-04
28	TA–60	6.43E-07	3.33E-04	2.13E-04
29	TA–61	5.71E-07	2.96E-04	1.89E-04
30	TA–64	1.50E-06	7.79E-04	4.97E-04
SUMMARY				
Estimated Annual Concentration[b] from Releases of Each Pollutant from All TAs, (C_{an}), μg/m^3		2.82E-05	1.49E-02	9.49E-03
Unit Risk Factors[c] (URF), (μg/m^3)$^{-1}$		4.35E-03	8.30E-06	1.30E-05
Maximum Incremental Cancer Risk[d] (C_{an} x URF)		1.23E-07	1.23E-07	1.23E-07
Guideline Value[e]		1.00E-06	1.00E-06	1.00E-06

Major Assumptions:

[a] Annual emission rates at the SLEV levels were used in the additive impacts analysis.

[b] Annual average concentration (C_{an}) is the highest concentration estimated by the ISC–3model at any of the sensitive receptor locations using 5 years of on-site meteorological data.

[c] Unit risk factors are from the EPA's Integrated Risk Information System (IRIS) database (EPA 1993b).

[d] Maximum cancer risk of each pollutant was estimated by multiplying the annual concentration of that pollutant by its unit risk factor (EPA 1992f and EPA 1993b). Total combined incremental cancer risk was estimated by summing the cancer risks due to each individual pollutant released from all TAs.

[e] The guideline value of 1.0E-06 (1.0 x 10^{-6}), established by Title III of the *Clean Air Act Amendments of 1990* (CAAA) as a level of concern, is associated with a life time exposure to carcinogenic pollutants (EPA 1992f).

TABLE C.—*Total Combined Cancer Risks of All Carcinogenic Pollutants from All TAs (Regardless of the Receptor Locations Where Maximum Values Are Estimated)*

NO.	CARCINOGENIC POLLUTANTS[a]	ISC–3 ESTIMATED HIGHEST ANNUAL POLLUTANT CONCENTRATION (C_{an})[b]	UNIT RISK FACTORS (URF)[c]	MAXIMUM CANCER RISK DUE TO EACH POLLUTANT (C_{an} x URF)[d]
		μg/m^3	(μg/m^3)$^{-1}$	
1	1,1,1,2-Tetrachloroethane	1.32E-03	7.40E-06	9.77E-09
2	1,1,2,2-Tetrachloroethane	3.10E-04	5.80E-05	1.80E-08
3	1,1,2-Trichloroethane	2.44E-03	1.60E-05	3.90E-08
4	1,3-Butadiene	3.00E-05	2.80E-04	8.40E-09
5	2-Nitropropane	4.00E-05	2.70E-03	1.08E-07
6	Acetaldehyde	5.16E-03	2.20E-06	1.14E-08
7	Acrylamide	1.56E-05	1.30E-03	2.02E-08
8	Allyl Chloride	1.79E-01	5.50E-08	9.86E-09
9	Arsenic	2.84E-06	4.30E-03	1.22E-08
10	Benzene	3.67E-03	8.30E-06	3.05E-08
11	Benzo(p)pyrene	1.70E-07	1.70E-03	2.89E-10
12	Benzyl Chloride	8.40E-04	1.20E-05	1.01E-08
13	Beryllium	1.10E-06	2.40E-03	2.64E-09
14	Cadmium	1.59E-05	1.80E-03	2.86E-08
15	Carbon Tetrachloride	2.56E-03	1.50E-05	3.84E-08
16	2,3,7,8-tetrachlorodibezo(p)dioxin	1.70E-11	3.30E+01	5.61E-10
17	Chloroform	3.80E-02	2.30E-05	8.74E-07
18	Chromium VI	8.35E-07	1.20E-02	1.00E-08
19	Diethanolamine	7.64E-02	1.10E-07	8.40E-09
20	Epichlorohydrin	8.33E-03	1.20E-06	1.00E-08
21	Ethyl Acrylate	2.73E-02	5.00E-07	1.37E-08
22	Ethylene Dichloride	1.83E-03	2.60E-05	4.76E-08

TABLE C.—*Total Combined Cancer Risks of All Carcinogenic Pollutants from All TAs (Regardless of the Receptor Locations Where Maximum Values Are Estimated)*-Continued

NO.	CARCINOGENIC POLLUTANTS[a]	ISC–3 ESTIMATED HIGHEST ANNUAL POLLUTANT CONCENTRATION (C_{an})[b]	UNIT RISK FACTORS (URF)[c]	MAXIMUM CANCER RISK DUE TO EACH POLLUTANT (C_{an} x URF)[d]
		$\mu g/m^3$	$(\mu g/m^3)^{-1}$	
23	Ethylene Oxide	1.00E-04	1.00E-04	1.00E-08
24	Formaldehyde	3.98E-03	1.30E-05	5.17E-08
25	Hexachlorobutadiene	4.30E-04	2.20E-05	9.46E-09
26	Hexachloroethane	2.45E-03	4.00E-06	9.80E-09
27	Hydrazine	3.30E-06	4.90E-03	1.62E-08
28	Methyl Chloride	2.22E-02	1.80E-06	3.99E-08
29	Methylene Chloride	1.45E-01	4.70E-07	6.84E-08
30	Nickel, metal (dust)	9.95E-05	2.40E-04	2.39E-08
31	Propylene Dichloride	1.57E-02	7.20E-07	1.13E-08
32	Styrene	3.45E-02	5.70E-07	1.97E-08
33	Tetrachloroethylene	1.41E-03	1.40E-05	1.97E-08
34	Trichloroethylene	6.73E-03	1.00E-05	6.73E-08
35	Vinyl Chloride	1.20E-04	8.40E-05	1.01E-08
Total Combined Cancer Risk of All Pollutants[e]				1.67E-06
Guideline Value[f]				1.00E-06

Notes:
Major Assumptions:
[a] The total of 35 carcinogenic pollutants that have the potential to be released from LANL operations were considered in the additive impact analysis. Emission rates of these pollutants are presented in Table A.
[b] ISC–3 estimated annual concentration is the highest concentration at any of the sensitive receptor locations using 5 years on-site of meteorological data.
[c] Unit risk factors are from the EPA's Integrated Risk Information System (IRIS) database (EPA 1993b).
[d] Maximum cancer risk was obtained by multiplying of the estimated annual concentration of a specific pollutant by its unit risk factor (EPA 1992f and EPA 1993b).
[e] The total potential combined cancer risks were estimated by summing the cancer risks due to each individual pollutant released from LANL operations, regardless of the location where maximum values are estimated.
[f] The guideline value of 1.0E-06 (1.0×10^{-6}), established by Title III of the *Clean Air Act Amendments of 1990* (CAAA) as a level of concern, is associated with a life time exposure to carcinogenic pollutants (EPA 1992f).

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
1	2.58E-08	2.09E-08	2.70E-08	3.48E-08	7.37E-10	6.59E-09	3.82E-08	3.12E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
2	2.55E-08	2.87E-08	3.49E-08	3.52E-08	1.03E-09	6.66E-09	3.28E-08	2.73E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
3	2.05E-08	2.18E-08	2.91E-08	2.98E-08	1.15E-09	5.92E-09	2.78E-08	2.01E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
4	2.19E-08	2.09E-08	2.88E-08	2.89E-08	1.25E-09	5.18E-09	2.47E-08	1.79E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
5	2.39E-08	2.26E-08	3.12E-08	3.15E-08	1.35E-09	5.31E-09	2.60E-08	1.86E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
6	2.53E-08	2.17E-08	3.03E-08	3.01E-08	1.40E-09	5.04E-09	2.39E-08	1.70E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
7	2.90E-08	2.41E-08	3.37E-08	3.39E-08	1.56E-09	5.22E-09	2.55E-08	1.76E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
8	2.69E-08	2.04E-08	2.82E-08	2.96E-08	1.37E-09	4.68E-09	2.24E-08	1.52E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
9	2.74E-08	1.87E-08	2.55E-08	2.67E-08	1.30E-09	4.30E-09	2.05E-08	1.38E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
10	3.45E-08	2.12E-08	2.99E-08	3.89E-08	1.61E-09	4.97E-09	2.16E-08	1.44E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
11	4.12E-08	2.04E-08	3.01E-08	4.87E-08	1.68E-09	5.44E-09	2.13E-08	1.37E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
12	3.80E-08	1.96E-08	2.87E-08	4.23E-08	1.60E-09	5.04E-09	2.03E-08	1.31E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
13	3.66E-08	1.79E-08	2.61E-08	3.38E-08	1.48E-09	4.57E-09	1.85E-08	1.20E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
14	3.17E-08	1.66E-08	2.40E-08	2.66E-08	1.34E-09	4.48E-09	1.77E-08	1.16E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
15	3.29E-08	1.65E-08	2.38E-08	2.65E-08	1.36E-09	4.48E-09	1.74E-08	1.14E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
16	3.45E-08	1.65E-08	2.40E-08	2.91E-08	1.38E-09	4.52E-09	1.74E-08	1.14E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
17	4.07E-08	1.95E-08	2.84E-08	4.79E-08	1.66E-09	5.22E-09	2.00E-08	1.29E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
18	4.67E-08	2.13E-08	3.15E-08	6.22E-08	1.83E-09	6.14E-09	2.24E-08	1.46E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
19	4.69E-08	1.90E-08	2.80E-08	6.84E-08	1.70E-09	5.56E-09	1.95E-08	1.31E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
20	4.49E-08	1.87E-08	2.74E-08	5.34E-08	1.66E-09	5.26E-09	1.92E-08	1.25E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
21	4.74E-08	1.70E-08	2.53E-08	4.45E-08	1.66E-09	5.06E-09	1.82E-08	1.25E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
22	4.58E-08	1.64E-08	2.44E-08	3.52E-08	1.65E-09	4.84E-09	1.74E-08	1.19E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
23	3.84E-08	1.43E-08	2.09E-08	2.19E-08	1.53E-09	3.74E-09	1.51E-08	1.04E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
24	5.98E-08	1.79E-08	2.71E-08	3.05E-08	1.89E-09	6.19E-09	1.79E-08	1.26E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
25	1.13E-07	1.72E-08	2.41E-08	1.76E-08	1.87E-09	9.09E-09	1.38E-08	1.07E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
26	9.94E-08	1.50E-08	2.09E-08	1.49E-08	1.50E-09	5.92E-09	1.17E-08	9.15E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
27	2.22E-07	2.24E-08	2.87E-08	1.80E-08	1.83E-09	9.95E-09	1.35E-08	1.08E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
28	5.17E-07	3.61E-08	4.42E-08	2.03E-08	1.78E-09	1.07E-08	1.43E-08	1.14E-08	3.16E-08	7.47E-09	1.01E-08	8.92E-09
29	2.67E-07	2.29E-08	2.98E-08	1.67E-08	1.39E-09	5.76E-09	1.25E-08	9.60E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
30	1.87E-07	1.85E-08	2.42E-08	1.61E-08	1.27E-09	4.90E-09	1.20E-08	9.15E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
31	1.15E-07	1.47E-08	1.99E-08	1.52E-08	1.14E-09	4.10E-09	1.12E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
32	1.13E-07	1.50E-08	2.07E-08	1.49E-08	1.39E-09	5.15E-09	1.12E-08	8.70E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
33	3.82E-08	1.00E-08	1.33E-08	1.30E-08	6.26E-10	1.73E-09	1.09E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
34	4.81E-08	1.07E-08	1.53E-08	1.18E-08	1.08E-09	3.28E-09	9.88E-09	7.20E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
35	3.20E-08	8.58E-09	1.24E-08	1.02E-08	8.74E-10	2.32E-09	8.84E-09	6.75E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
36	2.94E-08	8.71E-09	1.26E-08	9.91E-09	8.86E-10	2.38E-09	9.36E-09	6.75E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
37	2.44E-08	9.62E-09	1.36E-08	1.10E-08	9.96E-10	2.65E-09	9.62E-09	6.75E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
38	2.83E-08	1.25E-08	1.84E-08	1.79E-08	1.28E-09	3.10E-09	1.35E-08	9.15E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
39	2.00E-08	7.41E-09	9.90E-09	9.05E-09	5.74E-10	1.49E-09	8.06E-09	6.00E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
40	1.56E-08	6.37E-09	8.80E-09	7.98E-09	5.04E-10	1.35E-09	7.02E-09	5.10E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
41	1.63E-08	6.50E-09	9.10E-09	7.85E-09	5.88E-10	1.40E-09	7.02E-09	5.25E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
42	1.01E-08	5.20E-09	7.30E-09	6.32E-09	3.74E-10	1.01E-09	6.24E-09	4.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
43	1.61E-08	7.28E-09	1.07E-08	8.78E-09	7.22E-10	1.80E-09	8.06E-09	5.70E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
44	1.13E-08	7.28E-09	1.06E-08	9.10E-09	6.82E-10	1.89E-09	8.58E-09	5.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
45	1.27E-08	8.71E-09	1.24E-08	1.09E-08	7.87E-10	2.25E-09	1.01E-08	6.60E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
46	1.54E-08	1.03E-08	1.43E-08	1.28E-08	8.57E-10	2.43E-09	1.17E-08	7.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
47	1.89E-08	1.18E-08	1.68E-08	1.53E-08	9.48E-10	2.84E-09	1.33E-08	8.85E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
48	1.54E-08	1.08E-08	1.56E-08	1.39E-08	7.99E-10	2.75E-09	1.27E-08	8.70E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
49	1.40E-08	1.34E-08	1.80E-08	1.68E-08	7.42E-10	3.76E-09	1.77E-08	1.29E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
50	1.15E-08	8.58E-09	1.19E-08	1.06E-08	6.65E-10	2.20E-09	1.01E-08	6.75E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
51	1.08E-08	9.36E-09	1.33E-08	1.14E-08	5.86E-10	2.88E-09	1.22E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
52	1.08E-08	9.49E-09	1.36E-08	1.18E-08	6.00E-10	2.93E-09	1.25E-08	8.85E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
53	1.10E-08	1.04E-08	1.41E-08	1.37E-08	5.30E-10	3.35E-09	1.43E-08	1.02E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
54	6.44E-09	8.32E-09	1.21E-08	1.04E-08	3.29E-10	4.21E-09	1.48E-08	1.07E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
55	7.13E-09	9.49E-09	1.37E-08	1.19E-08	3.67E-10	4.75E-09	1.69E-08	1.23E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
56	7.13E-09	9.88E-09	1.42E-08	1.23E-08	3.86E-10	4.88E-09	1.74E-08	1.28E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
57	7.36E-09	1.07E-08	1.51E-08	1.30E-08	4.10E-10	5.02E-09	1.85E-08	1.35E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
58	7.59E-09	1.08E-08	1.54E-08	1.33E-08	4.18E-10	5.04E-09	1.92E-08	1.41E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
59	7.82E-09	1.20E-08	1.70E-08	1.41E-08	4.37E-10	5.63E-09	2.05E-08	1.52E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
60	7.82E-09	1.17E-08	1.77E-08	1.38E-08	4.37E-10	6.17E-09	2.03E-08	1.52E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
61	7.36E-09	1.09E-08	1.66E-08	1.28E-08	4.10E-10	6.23E-09	1.85E-08	1.40E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
62	6.90E-09	9.23E-09	1.37E-08	1.12E-08	3.58E-10	4.72E-09	1.51E-08	1.10E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
63	6.90E-09	9.62E-09	1.49E-08	1.14E-08	3.74E-10	5.47E-09	1.61E-08	1.20E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
64	6.90E-09	9.88E-09	1.54E-08	1.16E-08	3.79E-10	5.67E-09	1.66E-08	1.23E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
65	7.59E-09	1.11E-08	1.73E-08	1.27E-08	4.13E-10	6.53E-09	1.87E-08	1.35E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
66	7.13E-09	9.36E-09	1.51E-08	1.08E-08	3.65E-10	6.43E-09	1.59E-08	1.07E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
67	7.82E-09	9.75E-09	1.62E-08	1.15E-08	3.62E-10	7.04E-09	1.61E-08	1.05E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
68	8.05E-09	1.07E-08	1.78E-08	1.26E-08	3.91E-10	7.24E-09	1.82E-08	1.17E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
69	7.13E-09	7.67E-09	1.49E-08	8.85E-09	2.83E-10	8.89E-09	1.43E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
70	6.67E-09	6.89E-09	1.35E-08	7.95E-09	2.59E-10	8.71E-09	1.25E-08	7.50E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
71	1.84E-08	6.89E-09	9.50E-09	8.32E-09	6.17E-10	1.51E-09	7.28E-09	5.40E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
72	1.96E-08	7.28E-09	1.03E-08	8.69E-09	6.94E-10	1.75E-09	8.06E-09	6.15E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
73	1.54E-08	1.25E-08	1.78E-08	1.60E-08	8.21E-10	3.53E-09	1.56E-08	1.10E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
74	1.56E-08	6.63E-09	9.30E-09	7.73E-09	5.93E-10	1.53E-09	7.54E-09	5.40E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
75	7.13E-09	1.03E-08	1.48E-08	1.24E-08	3.89E-10	5.20E-09	1.72E-08	1.25E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
76	2.21E-08	2.25E-08	3.01E-08	3.05E-08	1.24E-09	5.53E-09	2.68E-08	1.94E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
77	8.28E-09	7.80E-09	1.11E-08	9.55E-09	4.58E-10	2.36E-09	1.04E-08	7.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
78	5.13E-08	3.93E-08	5.76E-08	4.01E-08	2.65E-09	6.05E-09	3.77E-08	2.31E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
79	1.61E-09	1.56E-09	2.10E-09	1.77E-09	8.16E-11	2.70E-10	2.08E-09	1.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
80	1.84E-09	1.43E-09	2.00E-09	1.81E-09	9.36E-11	3.06E-10	1.82E-09	1.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
81	5.75E-09	4.81E-09	5.30E-09	5.77E-09	1.97E-10	5.40E-10	5.20E-09	3.90E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
82	9.89E-09	1.11E-08	1.54E-08	1.47E-08	3.98E-10	4.39E-09	1.92E-08	1.44E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
83	1.01E-08	1.17E-08	1.67E-08	1.52E-08	3.79E-10	5.09E-09	2.16E-08	1.64E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
84	2.44E-08	2.37E-08	3.05E-08	3.53E-08	5.86E-10	9.86E-09	4.76E-08	3.84E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
85	1.17E-08	1.17E-08	1.62E-08	1.63E-08	4.70E-10	4.10E-09	1.79E-08	1.37E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
86	2.30E-09	2.34E-09	3.40E-09	2.93E-09	1.22E-10	9.36E-10	3.64E-09	2.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
87	1.75E-08	1.24E-08	1.46E-08	1.67E-08	4.27E-10	9.90E-10	1.33E-08	1.16E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
88	1.06E-08	1.57E-08	1.04E-08	1.09E-08	2.28E-10	7.20E-10	1.01E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
89	2.30E-10	1.30E-10	2.00E-10	1.65E-10	9.60E-12	3.60E-11	2.60E-10	1.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
90	2.30E-10	3.90E-10	5.00E-10	4.23E-10	1.68E-11	1.08E-10	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
91	2.30E-10	1.30E-10	3.00E-10	2.40E-10	1.20E-11	5.40E-11	2.60E-10	1.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
92	4.60E-10	5.20E-10	9.00E-10	6.72E-10	2.64E-11	2.16E-10	7.80E-10	4.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
93	9.20E-10	1.04E-09	1.60E-09	1.27E-09	5.28E-11	5.22E-10	1.56E-09	1.05E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
94	2.30E-10	2.60E-10	4.00E-10	3.34E-10	9.60E-12	5.40E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
95	2.30E-10	3.90E-10	5.00E-10	4.14E-10	9.60E-12	7.20E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
96	2.30E-10	2.60E-10	4.00E-10	3.34E-10	9.60E-12	7.20E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
97	4.60E-10	3.90E-10	5.00E-10	4.28E-10	9.60E-12	9.00E-11	5.20E-10	4.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
98	4.60E-10	3.90E-10	6.00E-10	4.79E-10	1.92E-11	1.08E-10	7.80E-10	4.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
99	4.60E-10	5.20E-10	9.00E-10	6.77E-10	2.40E-11	1.98E-10	7.80E-10	6.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
100	6.90E-10	7.80E-10	1.20E-09	9.45E-10	3.12E-11	4.32E-10	1.04E-09	7.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
101	1.38E-09	1.56E-09	2.50E-09	1.89E-09	6.96E-11	9.54E-10	2.34E-09	1.50E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
102	1.38E-09	1.82E-09	2.80E-09	2.18E-09	8.16E-11	7.56E-10	2.60E-09	1.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
103	1.61E-09	1.69E-09	2.60E-09	2.12E-09	7.92E-11	7.38E-10	2.60E-09	1.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
104	1.38E-09	1.56E-09	2.10E-09	1.85E-09	7.68E-11	6.48E-10	2.34E-09	1.50E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
105	1.38E-09	1.43E-09	2.10E-09	1.76E-09	7.20E-11	5.22E-10	2.08E-09	1.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
106	2.76E-09	3.12E-09	4.40E-09	3.91E-09	1.37E-10	1.17E-09	4.94E-09	3.75E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
107	2.53E-09	2.86E-09	4.20E-09	3.61E-09	1.25E-10	1.15E-09	4.68E-09	3.30E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
108	2.07E-09	2.47E-09	3.50E-09	2.99E-09	1.03E-10	9.90E-10	3.90E-09	2.85E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
109	1.84E-09	2.08E-09	3.00E-09	2.51E-09	8.88E-11	7.92E-10	3.38E-09	2.40E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
110	1.84E-09	2.08E-09	3.20E-09	2.61E-09	9.84E-11	9.18E-10	3.64E-09	2.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
111	9.20E-10	9.10E-10	1.40E-09	1.14E-09	4.56E-11	5.04E-10	1.30E-09	9.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
112	4.60E-10	5.20E-10	7.00E-10	5.64E-10	2.16E-11	1.98E-10	7.80E-10	6.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
113	9.20E-10	7.80E-10	1.20E-09	1.02E-09	4.32E-11	3.24E-10	1.30E-09	7.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
114	4.60E-10	3.90E-10	6.00E-10	4.98E-10	2.16E-11	1.80E-10	5.20E-10	4.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
115	4.60E-10	5.20E-10	8.00E-10	6.11E-10	2.40E-11	1.80E-10	7.80E-10	6.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
116	2.30E-10	2.60E-10	4.00E-10	3.34E-10	1.20E-11	1.08E-10	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
117	4.60E-10	5.20E-10	7.00E-10	5.55E-10	2.16E-11	1.80E-10	5.20E-10	4.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
118	1.61E-09	1.82E-09	2.80E-09	2.24E-09	8.40E-11	7.20E-10	3.38E-09	2.10E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
119	1.61E-09	1.82E-09	2.80E-09	2.17E-09	7.92E-11	9.18E-10	3.12E-09	2.10E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
120	1.61E-09	1.82E-09	2.70E-09	2.23E-09	8.88E-11	6.66E-10	2.60E-09	1.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
121	2.30E-10	3.90E-10	5.00E-10	3.95E-10	1.44E-11	1.44E-10	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
122	3.22E-09	3.64E-09	5.30E-09	4.54E-09	1.56E-10	1.44E-09	5.98E-09	4.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
123	1.15E-09	1.17E-09	1.90E-09	1.44E-09	3.84E-11	2.70E-10	2.08E-09	1.20E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
124	4.60E-10	5.20E-10	8.00E-10	6.44E-10	1.92E-11	1.26E-10	7.80E-10	6.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
125	2.30E-10	2.60E-10	5.00E-10	3.90E-10	1.20E-11	7.20E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
126	2.30E-10	2.60E-10	3.00E-10	2.49E-10	9.60E-12	7.20E-11	2.60E-10	1.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
127	2.30E-10	2.60E-10	4.00E-10	3.29E-10	9.60E-12	5.40E-11	2.60E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
128	4.60E-10	6.50E-10	9.00E-10	7.33E-10	2.16E-11	1.08E-10	1.04E-09	6.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
129	2.30E-10	2.60E-10	5.00E-10	3.81E-10	9.60E-12	7.20E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
130	2.30E-10	2.60E-10	4.00E-10	3.06E-10	1.20E-11	1.08E-10	2.60E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
131	0.00E+00	1.30E-10	1.00E-10	8.46E-11	2.40E-12	3.60E-11	0.00E+00	0.00E+00	2.39E-08	3.05E-08	1.14E-08	1.37E-08
132	0.00E+00	1.30E-10	2.00E-10	1.27E-10	2.40E-12	1.80E-11	2.60E-10	1.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
133	2.30E-10	2.60E-10	3.00E-10	2.44E-10	4.80E-12	5.40E-11	2.60E-10	1.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
134	0.00E+00	1.30E-10	1.00E-10	8.93E-11	2.40E-12	1.80E-11	0.00E+00	0.00E+00	2.39E-08	3.05E-08	1.14E-08	1.37E-08
135	2.30E-10	3.90E-10	5.00E-10	4.75E-10	1.44E-11	1.08E-10	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
136	1.15E-09	1.30E-09	2.10E-09	1.60E-09	5.04E-11	4.14E-10	2.34E-09	1.50E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
137	2.30E-10	2.60E-10	5.00E-10	3.85E-10	1.68E-11	9.00E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
138	7.59E-09	1.11E-08	1.57E-08	1.32E-08	4.15E-10	5.17E-09	1.87E-08	1.38E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
139	2.30E-10	2.60E-10	3.00E-10	2.44E-10	7.20E-12	5.40E-11	2.60E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
140	2.30E-10	2.60E-10	4.00E-10	3.29E-10	9.60E-12	5.40E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
141	4.60E-10	3.90E-10	7.00E-10	5.45E-10	1.44E-11	1.08E-10	7.80E-10	4.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
142	4.83E-09	5.59E-09	1.05E-08	6.77E-09	2.04E-10	2.20E-09	1.07E-08	6.45E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
143	6.90E-10	7.80E-10	1.30E-09	9.64E-10	3.12E-11	2.34E-10	1.30E-09	9.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
144	0.00E+00	1.30E-10	1.00E-10	8.46E-11	2.40E-12	1.80E-11	0.00E+00	0.00E+00	2.39E-08	3.05E-08	1.14E-08	1.37E-08
145	2.30E-10	2.60E-10	4.00E-10	2.91E-10	9.60E-12	9.00E-11	2.60E-10	1.50E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
146	2.30E-10	2.60E-10	4.00E-10	3.62E-10	1.44E-11	9.00E-11	5.20E-10	3.00E-10	2.39E-08	3.05E-08	1.14E-08	1.37E-08
147	7.13E-09	9.10E-09	1.31E-08	1.14E-08	3.38E-10	4.39E-09	1.59E-08	1.14E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
148	7.36E-09	1.09E-08	1.66E-08	1.28E-08	4.13E-10	6.19E-09	1.85E-08	1.40E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
149	6.67E-09	8.45E-09	1.37E-08	9.72E-09	3.31E-10	5.92E-09	1.38E-08	9.15E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
150	7.82E-09	8.45E-09	1.61E-08	9.72E-09	3.10E-10	1.03E-08	1.56E-08	9.60E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
151	9.89E-09	9.23E-09	1.95E-08	1.14E-08	3.00E-10	1.43E-08	1.79E-08	1.05E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
152	1.59E-08	7.67E-09	2.17E-08	9.11E-09	2.45E-10	3.99E-08	1.25E-08	7.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
153	5.98E-09	6.37E-09	1.10E-08	7.75E-09	2.28E-10	3.42E-09	1.20E-08	7.20E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
154	6.44E-09	7.93E-09	1.38E-08	9.42E-09	2.47E-10	2.39E-09	1.46E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
155	5.52E-09	6.63E-09	1.19E-08	7.91E-09	2.09E-10	2.30E-09	1.17E-08	7.05E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
156	5.75E-09	6.89E-09	1.16E-08	7.84E-09	2.06E-10	1.57E-09	1.20E-08	6.45E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08

TABLE D (PART 1).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	1	2	3	4	5	6	7	8	9	10	11	12
REC. #	CHLF	FORM	TRCE	MECH	Be	MTCH	ETDC	CCL4	Ni	BENZ	ACAL	ETAC
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
157	6.44E-09	7.15E-09	1.24E-08	8.24E-09	2.38E-10	1.51E-09	1.27E-08	6.45E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
158	7.82E-09	8.84E-09	1.74E-08	1.02E-08	2.86E-10	1.62E-09	1.77E-08	7.95E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
159	8.97E-09	9.49E-09	1.73E-08	1.06E-08	2.93E-10	1.17E-09	1.69E-08	7.35E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
160	8.05E-09	8.45E-09	1.31E-08	1.01E-08	2.45E-10	1.06E-09	1.17E-08	6.00E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
161	1.22E-08	1.12E-08	1.86E-08	1.32E-08	2.83E-10	1.22E-09	1.72E-08	7.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
162	1.31E-08	1.31E-08	1.58E-08	1.57E-08	3.00E-10	1.10E-09	1.56E-08	7.95E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
163	1.59E-08	1.57E-08	1.61E-08	1.95E-08	3.07E-10	8.64E-10	1.46E-08	8.55E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
164	5.06E-09	4.42E-09	5.40E-09	5.10E-09	1.22E-10	5.04E-10	5.46E-09	3.75E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
165	4.37E-09	4.55E-09	5.90E-09	5.76E-09	1.37E-10	5.76E-10	4.68E-09	3.30E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
166	5.06E-09	5.46E-09	7.00E-09	6.68E-09	1.46E-10	5.58E-10	5.20E-09	3.90E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
167	5.98E-09	5.46E-09	6.30E-09	6.13E-09	1.94E-10	6.12E-10	6.24E-09	4.80E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
168	1.79E-08	9.36E-09	1.20E-08	1.24E-08	3.91E-10	1.15E-09	1.09E-08	8.85E-09	2.39E-08	3.05E-08	1.14E-08	1.37E-08
169	4.58E-08	1.56E-08	2.32E-08	2.70E-08	1.64E-09	4.57E-09	1.64E-08	1.13E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
170	2.53E-08	1.70E-08	2.28E-08	2.21E-08	1.15E-09	4.07E-09	1.77E-08	1.20E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
171	1.91E-08	1.82E-08	2.47E-08	2.45E-08	1.01E-09	5.22E-09	2.39E-08	1.71E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
172	1.84E-08	2.04E-08	2.55E-08	2.49E-08	8.50E-10	5.94E-09	2.47E-08	2.00E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
173	1.66E-08	1.85E-08	2.36E-08	2.38E-08	7.13E-10	5.71E-09	2.55E-08	2.00E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
174	1.61E-08	1.48E-08	1.99E-08	2.11E-08	5.76E-10	5.20E-09	2.52E-08	2.01E-08	2.39E-08	3.05E-08	1.14E-08	1.37E-08
175	8.74E-07	5.17E-08	6.73E-08	1.94E-08	1.71E-09	8.08E-09	1.38E-08	1.08E-08	3.06E-09	7.22E-09	9.50E-09	8.53E-09
176	6.90E-07	4.34E-08	5.94E-08	2.02E-08	1.91E-09	1.18E-08	1.43E-08	1.14E-08	3.14E-09	7.47E-09	9.46E-09	8.82E-09
177	5.65E-07	3.76E-08	4.93E-08	1.97E-08	1.89E-09	1.12E-08	1.40E-08	1.11E-08	3.07E-09	7.39E-09	9.09E-09	8.37E-09
178	5.96E-07	3.94E-08	4.93E-08	1.97E-08	1.71E-09	8.96E-09	1.40E-08	1.11E-08	3.11E-09	7.39E-09	9.79E-09	8.65E-09
179	4.51E-07	3.28E-08	4.33E-08	2.05E-08	1.98E-09	1.36E-08	1.46E-08	1.17E-08	3.19E-09	7.64E-09	9.48E-09	9.31E-09
180	7.71E-07	4.80E-08	5.39E-08	2.13E-08	1.80E-09	1.01E-08	1.46E-08	1.16E-08	3.26E-09	7.72E-09	1.12E-08	9.87E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
1	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
2	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
3	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
4	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
5	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
6	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
7	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
8	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
9	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
10	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
11	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
12	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
13	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
14	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
15	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
16	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
17	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
18	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
19	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
20	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
21	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
22	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
23	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
24	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
25	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
26	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
27	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
28	1.11E-08	1.01E-08	1.10E-08	3.30E-11	1.08E-08	4.04E-09	1.70E-10	1.28E-09	1.16E-08	0.00E+00	0.00E+00	5.18E-10
29	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
30	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
31	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
32	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
33	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
34	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
35	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
36	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
37	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
38	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
39	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
40	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
41	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
42	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
43	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
44	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
45	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
46	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
47	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
48	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
49	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
50	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
51	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
52	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
53	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
54	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
55	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
56	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
57	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
58	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
59	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
60	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
61	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
62	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
63	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
64	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
65	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
66	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
67	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
68	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
69	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
70	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
71	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
72	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
73	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
74	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
75	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
76	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
77	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
78	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
79	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
80	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
81	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
82	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
83	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
84	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
85	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
86	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
87	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
88	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
89	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
90	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
91	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
92	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
93	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
94	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
95	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
96	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
97	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
98	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
99	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
100	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
101	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
102	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
103	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
104	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
105	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
106	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
107	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
108	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
109	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
110	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
111	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
112	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
113	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
114	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
115	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
116	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
117	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
118	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
119	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
120	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
121	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
122	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
123	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
124	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
125	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
126	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
127	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
128	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
129	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
130	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
131	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
132	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
133	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
134	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
135	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
136	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
137	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
138	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
139	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
140	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
141	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
142	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
143	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
144	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
145	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
146	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
147	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
148	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
149	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
150	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
151	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
152	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
153	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
154	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
155	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
156	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09

TABLE D (PART 2).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	13	14	15	16	17	18	19	20	21	22	23	24
REC. #	TECE	PRDI	STYR	CDDF	As	Cd	BNZP	Cr Vi	ACAM	1,3-BUT	2-NTP	1,1,1,2-TCE
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR
157	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
158	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
159	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
160	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
161	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
162	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
163	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
164	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
165	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
166	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
167	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
168	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
169	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
170	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
171	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
172	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
173	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
174	1.97E-08	1.13E-08	1.97E-08	5.61E-10	1.22E-08	2.86E-08	2.89E-10	1.00E-08	2.02E-08	8.40E-09	1.08E-07	9.77E-09
175	1.04E-08	9.53E-09	1.03E-08	2.97E-10	9.55E-09	3.76E-09	1.53E-10	1.24E-09	1.92E-08	0.00E+00	0.00E+00	5.18E-10
176	1.08E-08	9.47E-09	1.07E-08	3.30E-11	1.03E-08	4.17E-09	1.70E-10	1.30E-09	1.51E-08	0.00E+00	0.00E+00	5.18E-10
177	1.04E-08	9.10E-09	1.03E-08	3.33E-11	9.89E-09	4.19E-09	1.70E-10	1.28E-09	1.34E-08	0.00E+00	0.00E+00	5.18E-10
178	1.06E-08	9.79E-09	1.06E-08	2.97E-10	9.98E-09	3.87E-09	1.53E-10	1.26E-09	1.38E-08	0.00E+00	0.00E+00	5.18E-10
179	1.11E-08	9.50E-09	1.10E-08	3.30E-11	1.02E-08	4.46E-09	1.70E-10	1.33E-09	9.49E-09	0.00E+00	0.00E+00	5.92E-10
180	1.20E-08	1.12E-08	1.20E-08	6.60E-11	1.19E-08	3.90E-09	1.70E-10	1.27E-09	2.02E-08	0.00E+00	0.00E+00	5.18E-10

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
1	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.67E-07
2	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.73E-07
3	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.38E-07
4	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.31E-07
5	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.42E-07
6	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.36E-07
7	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.52E-07
8	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.30E-07
9	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.20E-07
10	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.48E-07
11	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.64E-07
12	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.50E-07
13	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.32E-07
14	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.15E-07
15	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.16E-07
16	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.20E-07
17	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.58E-07
18	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.88E-07
19	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.83E-07
20	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.64E-07
21	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.53E-07
22	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.39E-07
23	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.08E-07
24	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.55E-07
25	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.89E-07
26	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.60E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
27	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	8.08E-07
28	1.74E-09	2.35E-08	5.20E-10	4.40E-10	8.40E-10	5.56E-10	1.20E-10	1.64E-10	0.00E+00	8.40E-10	1.45E-09	8.05E-07
29	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	8.47E-07
30	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	7.54E-07
31	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.72E-07
32	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.71E-07
33	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.78E-07
34	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.89E-07
35	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.63E-07
36	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.61E-07
37	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.60E-07
38	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.85E-07
39	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.44E-07
40	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.34E-07
41	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.35E-07
42	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.22E-07
43	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.41E-07
44	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.36E-07
45	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.46E-07
46	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.57E-07
47	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.70E-07
48	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.62E-07
49	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.79E-07
50	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.44E-07
51	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.50E-07
52	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.52E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
53	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.59E-07
54	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.49E-07
55	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.58E-07
56	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.60E-07
57	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.65E-07
58	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.67E-07
59	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.74E-07
60	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.74E-07
61	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.68E-07
62	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.54E-07
63	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.58E-07
64	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.60E-07
65	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.69E-07
66	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.57E-07
67	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.61E-07
68	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.68E-07
69	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.52E-07
70	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.45E-07
71	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.39E-07
72	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.44E-07
73	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.74E-07
74	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.36E-07
75	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.61E-07
76	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.39E-07
77	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.39E-07
78	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	7.39E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
79	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.92E-07
80	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.92E-07
81	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.13E-07
82	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.71E-07
83	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.79E-07
84	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.92E-07
85	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.73E-07
86	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.00E-07
87	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.69E-07
88	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.49E-07
89	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
90	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
91	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
92	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
93	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.89E-07
94	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
95	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
96	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
97	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
98	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
99	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.86E-07
100	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.87E-07
101	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.94E-07
102	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.95E-07
103	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.95E-07
104	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.93E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
105	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.92E-07
106	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.06E-07
107	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.04E-07
108	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.00E-07
109	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.97E-07
110	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.98E-07
111	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.88E-07
112	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
113	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.88E-07
114	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
115	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
116	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
117	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
118	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.96E-07
119	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.96E-07
120	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.95E-07
121	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
122	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.10E-07
123	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.91E-07
124	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
125	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
126	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
127	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
128	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.86E-07
129	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
130	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
131	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.82E-07
132	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.82E-07
133	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
134	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.82E-07
135	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
136	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.92E-07
137	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
138	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.67E-07
139	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
140	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
141	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.85E-07
142	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.29E-07
143	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.88E-07
144	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.82E-07
145	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.83E-07
146	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	4.84E-07
147	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.54E-07
148	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.68E-07
149	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.49E-07
150	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.59E-07
151	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.74E-07
152	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.96E-07
153	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.35E-07
154	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.45E-07
155	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.35E-07
156	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.34E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
157	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.37E-07
158	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.53E-07
159	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.53E-07
160	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.40E-07
161	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.63E-07
162	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.64E-07
163	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.73E-07
164	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.11E-07
165	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.11E-07
166	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.15E-07
167	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.17E-07
168	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	5.54E-07
169	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.27E-07
170	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.03E-07
171	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.15E-07
172	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.22E-07
173	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.16E-07
174	2.03E-08	3.90E-08	9.80E-09	9.46E-09	1.01E-08	8.41E-09	1.00E-08	9.85E-09	1.00E-08	1.01E-08	1.62E-08	6.04E-07
175	1.74E-09	2.19E-08	5.20E-10	4.40E-10	8.40E-10	5.40E-10	1.20E-10	1.61E-10	0.00E+00	8.40E-10	1.40E-09	1.17E-06
176	1.74E-09	2.30E-08	5.60E-10	4.40E-10	8.40E-10	5.59E-10	1.20E-10	1.65E-10	0.00E+00	8.40E-10	1.46E-09	9.73E-07
177	1.74E-09	2.24E-08	5.20E-10	4.40E-10	8.40E-10	5.62E-10	1.20E-10	1.65E-10	0.00E+00	8.40E-10	1.45E-09	8.26E-07
178	1.74E-09	2.26E-08	5.20E-10	4.40E-10	8.40E-10	5.48E-10	1.20E-10	1.62E-10	0.00E+00	8.40E-10	1.42E-09	8.59E-07

TABLE D (PART 3).—*Total Combined Cancer Risk of All Pollutants from All TAs*-Continued

NO.	25	26	27	28	29	30	31	32	33	34	35	TOTAL COMBINED CR
REC. #	1,1,2,2-TCE	1,1,2-TCE	HECE	HECB	VINC	DIEA	EPCH	ALCH	ETOX	BNCH	HDRZ	
	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	Max. CR	
179	1.74E-09	2.32E-08	5.60E-10	4.40E-10	8.40E-10	5.74E-10	1.20E-10	1.68E-10	0.00E+00	8.40E-10	1.49E-09	7.07E-07
180	1.74E-09	2.50E-08	5.20E-10	4.40E-10	8.40E-10	5.43E-10	1.20E-10	1.62E-10	0.00E+00	8.40E-10	1.45E-09	1.07E-06

Receptor ID Numbers:
1. CHLF = Chloroform; 2. FORM = Formaldehyde; 3. TRCE = Trichloethylene; 4. MECH = Methylene Chloride; 5. Be = Beryllium; 6. MTCH = Methyl Chloride; 7. ETDC = Ethylene Dichloride; 8. CCL4 = Carbon Tetrachloride; 9. NI = Nickel; 10. BENZ = Benzene; 11. ACAL = Acetaldehyde; 12. ETAC = Ethyl Acrylate; 13. TECE = Tetrachloethylene; 14. PRDI = Propylene Dichloride; 15. STYR = Styrene; 16. CDDF = 2,3,7,8-Tetrachlorodibenzo(p)dioxin; 17. As = Arsenic; 18. Cd = Cadmium; 19. BNZP = Benzo(p)pyrene; 20. Cr VI = Hexavalent Chromium; 21. ACAM = Acrylamide; 22. 1.3-BUT = 1,3-Butadiene; 23. 2-NTP = 2-Nitropropane; 24. 1,1,1,2-TCE = 1,1,1,2-Tetrachloroethane; 25. 1,1,2,2-TCE = 1,1,2,2-Tetrachloroethane; 26. 1,1,2-Trichloroethane; 27. HECE = Hexachloroethane; 28. HECB = Hexachlobutadiene; 29. VINC = Vinyl Chloride; 30. DIEA = Diethanolamine; 31. EPCH = Epichlorhydrine; 32. ALCH = Allyl Chloride; 33. ETOX = Ethylene Oxide; 34. BNCH = Benzyl Chloride; 35. HDRZ = Hydrazine.

Notes:
Max. CR = Maximum cancer risk due to each pollutant.
Total Combined CR = total estimated cancer risk of all pollutants combined.

Dispersion Analysis:
- The additive impact analysis was conducted with the EPA's ISC–3 model using 5 years of on-site meteorological data.
- The total of 35 carcinogenic pollutants that have the potential to be released from LANL operations were considered in the analysis. Emission rates of these pollutants and the appropriate unit risk factors are presented in Tables A and C.
- Maximum cancer risk was obtained by multiplying of the estimated annual concentration of a specific pollutant by its unit risk factor (EPA 1992f and EPA 1993b).
- The total potential combined cancer risks were estimated by summing the cancer risks due to each individual pollutant at each of the 180 receptor locations.

Major Assumptions:
- Emissions would be released simultaneously from LANL operations over 8,760 hours a year.
- Incremental cancer risks are additive.

Other Assumptions Include:
- All chemicals are released to the atmosphere, rather than used in process or product or sent to waste disposal or recycling after use.
- There is no time spent indoors or inside automobiles; whereas, people actually spend more than 80% of their time indoors. Being inside would cut the concentration by half as a minimum.

ATTACHMENT 7
AIR QUALITY IMPACT ASSESSMENT OF THE TA–3 CHEMICAL AND METALLURGY RESEARCH FACILITY (CMR) METHYLENE CHLORIDE EMISSIONS

Technical Area: TA–3, CMR Facility

Emission Source(s)

An emission source of methylene chloride is located at the CMR Facility, Building 29 (Stack ID FE–20). Methylene chloride is used for analysis of soil samples. During the concentrating phase, the extracted methylene chloride is evaporated and emitted to the atmosphere.

Source Term Parameters

Stack parameters and their locations are provided in Table A.

Emission Rates of Pollutants Considered

The annual emission rate of methylene chloride was estimated to be 700 pounds a year under the Expanded Operations Alternative operating schedule (Table A). It was assumed that these emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

Air quality impacts analysis was conducted with the EPA's ISC–3 Model using 5 years of on-site meteorological data. All nearby buildings within the zone of plume influence were considered in the downwash analysis. The highest annual average concentration estimated by the ISC–3 Model at any of sensitive receptors was used to estimate the incremental cancer risk of the methylene chloride release using its unit risk factor.

Results

Results of the analysis are presented in Tables B and C. As shown in Table C, the maximum cancer risk associated with release of methylene chloride from Building 29 of the TA–3 CMR facility is below the Guideline Value of 1.0×10^{-8}.

TABLE A.—*Stack Parameters and Emission Rate of the Methylene Chloride Associated with the TA–3 CMR Facility (Building 29)*

NO.	EMISSION SOURCE	STACK ID	STACK PARAMETERS				ESTIMATED ANNUAL EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/year	g/sec
1	TA–3 CMR Facility (Building 29)	Bldg 29 (FE–20)	380752; 3970257	15.90	17.20	1.10	700.0	0.0101

TABLE B.—*ISC–3 Estimated Annual Concentration of the Methylene Chloride Associated with Emission Source of the TA–3 CMR Facility Using 1991-1995 Meteorological Data*

EMISSION SOURCE	ISC–3 ESTIMATED ANNUAL AVERAGE CONCENTRATION ($\mu g/m^3$)				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–3 CMR Facility (Building 29)	6.80E-03	6.02E-03	7.35E-03	7.31E-03	6.91E-03

TABLE C.—*Results of the Dispersion Modeling Analysis of the Methylene Chloride Emissions from the CMR Facility of the TA–3*

NO.	EMISSION SOURCE	METHYLENE CHLORIDE UNIT RISK FACTOR (URF)	ISC–3 ESTIMATED ANNUAL CONCENTRATION (C_{an})	MAXIMUM CANCER RISK (C_{an} X URF)	GUIDELINE VALUE
		$(\mu g/m^3)^{-1}$	$\mu g/m^3$		
1	**2**	**3**	**4**	**5**	**6**
1	TA–3 CMR Facility (Building 29)	4.70E-07	7.35E-03	3.45E-09	1.00E-08

ATTACHMENT 8
AIR QUALITY IMPACT ASSESSMENT OF THE TA–3 BERYLLIUM EMISSIONS

Technical Area: TA–3, Buildings 102 and SM141

Emission Source(s)

Beryllium process development and machining operations at TA–3 are conducted in support of ongoing beryllium research and are currently being refurbished. Beryllium machining operations conducted at TA–3–39 will be relocated to the new Sigma beryllium TA–3–141 in order to consolidate the majority of the beryllium processing conducted at LANL. The permitted beryllium operations conducted at TA–3–102, TA–35–213, and TA–55, and the registered beryllium sources at TA–3–29 and TA–66 will remain in place. The modified SM141 beryllium facility also will incorporate operations and equipment from other DOE complexes.

Emissions from the two stacks, one on the TA–3 Building 102, and the other on the Building SM141, were considered in the analysis.

Source Term Parameters

Stack parameters and their locations are shown in Table A.

Emission Rates of Pollutants Considered

Annual emission rates of beryllium were estimated based on the draft permit application for SM141 and the existing air quality permit for the TA–3–102 facility. Emissions from these facilities are released to the atmosphere through a high efficiency particulate air (HEPA) filtration system, with a removal efficiency of 99.95 percent. Controlled emission rates are estimated to be 0.11 pounds per year for SM141 facility, and 1.4×10^{-4} pounds per year for the TA–3–102 facility.

Estimated annual emission rates of beryllium that were used in the analysis are shown in Table A. It was assumed that emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA’s ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings, including Buildings 102 and SM141, within the zone of stack plume influence were considered in the downwash analysis. The highest annual concentration estimated by the ISC–3 Model (Table B) was used to compute the maximum combined cancer risk of beryllium releases using its unit risk factor.

Results

Results of the analysis are presented in Tables B and C. As shown in Table C, the combined cancer risk associated with releases of beryllium from Buildings 102 and SM141 of the TA–3 facility is 2.41×10^{-9}, which is below the Guideline Value of 1.0×10^{-8}.

TABLE A.—*Stack Parameters and Beryllium Annual Emission Rate Associated with Buildings 102 and SM141 of the TA–3 Facility*

NO.	SOURCE	STACK ID	STACK PARAMETERS				ANNUAL PERMITTED EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/year	g/sec
1	TA–3 Building 102	B102	380476; 3970171	13.70	5.88	0.91	1.40E-04	2.02E-09
2	TA–3 Building 141	B141	381219; 3970330	15.24	14.30	1.52	1.10E-01	1.58E-06

TABLE B.—*TA–3 ISC–3 Estimated Annual Average Concentration of the Beryllium Using 1991 to 1995 Meteorological Data*

EMISSION SOURCE	ISC–3 ESTIMATED ANNUAL AVERAGE CONCENTRATION (µg/m^3)				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–3 Buildings 102 & SM141	7.82E-07	8.48E-07	1.00E-06	8.88E-07	8.87E-07

TABLE C.—*Results of the Dispersion Modeling Analysis of the Beryllium Emissions from TA–3*

NO.	EMISSION SOURCE	BERYLLIUM UNIT RISK FACTOR (URF)	ISC–3 ESTIMATED ANNUAL CONC.[1] (C_{an})	COMBINED MAXIMUM CANCER RISK (C_{an} x URF)	GUIDELINE VALUE
		(µg/m^3)$^{-1}$	µg/m^3		
1	2	3	4	5	6
1	TA–3 Buildings 102 & SM141	2.40E-03	1.00E-06	2.41E-09	1.00E-08

ATTACHMENT 9
AIR QUALITY IMPACT ASSESSMENT OF THE TA–3 SHOPS COMPLEX NICKEL DUST EMISSIONS

Technical Area: TA–3, Shops Complex

Emission Source(s)

The Shops Complex contains machining and inspection equipment to support LANL. The missions supported include nuclear weapons technology, stockpile management, nuclear materials production, and general fabrication. Nickel is machined in Building 102 of the Shops Complex facility.

Source Term Parameters

Stack parameters and locations are provided in Table A.

Emission Rates of Pollutants Considered

The nickel dust generated from the machining process is exhausted through a series of in-line high efficiency particulate air (HEPA) filters before entering a common shops baghouse control system and exiting to the atmosphere. The HEPA filter has a rated control efficiency of 99.97 percent, and the baghouse has a measured control efficiency of 80 percent. The amount of nickel currently being machined is approximately 10 percent of what was machined in 1990. The estimated annual emission rate of the nickel dust used in the dispersion analysis is shown in Table A. It was assumed that annual emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted with EPA's ISC–3 Model using 5 years of on-site meteorological data. All nearby buildings within the zone of plume influence were considered in the downwash analysis. The highest annual average concentration estimated by the ISC–3 Model at any of sensitive receptors was used to estimate the incremental cancer risk of the nickel release using its unit risk factor.

Results

Results of the analysis are presented in Tables B and C. As shown in Table C, the maximum cancer risk associated with release of the nickel dust from Shops Complex Building 102 of the TA–3 facility is below the Guideline Value of 1.0×10^{-8}.

TABLE A.—*Stack Parameters and Emission Rate of the Nickel Dust Associated with TA–3 Shops Complex (Building 102)*

NO.	EMISSION SOURCE	STACK ID	STACK PARAMETERS				ESTIMATED ANNUAL EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/year	g/sec
1	TA–3 Shops Complex (Building 102)	Building 102	380476; 3970171	13.70	5.88	0.91	1.58×10^{-3}	2.27×10^{-8}

TABLE B.—*ISC–3 Estimated Annual Concentration of the Nickel Dust Associated with Emission Source of the TA–3 Shops Complex Using Meteorological Data (1991 to 1995)*

EMISSION SOURCE	ISC–3 ESTIMATED ANNUAL AVERAGE CONCENTRATION (µg/m^3)				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–3 Shops Complex (Building 102)	2.70×10^{-8}	2.40×10^{-8}	3.00×10^{-8}	2.60×10^{-8}	2.70×10^{-8}

TABLE C.—*Results of the Dispersion Modeling Analysis of the Nickel Dust Emissions from Shops Complex (Building 102) of TA–3*

NO.	EMISSION SOURCE	NICKEL UNIT RISK FACTOR (URF)	ISC–3 ESTIMATED ANNUAL CONCENTRATION (C_{an})	MAXIMUM CANCER RISK (C_{an} X URF)	GUIDELINE VALUE
		(µg/m^3)$^{-1}$	µg/m^3		
1	TA–3 Shops Complex (Building 102)	2.40×10^{-4}	3.00×10^{-8}	7.20×10^{-12}	1.00×10^{-8}

ATTACHMENT 10
AIR QUALITY IMPACT ASSESSMENT OF PAINT BOOTH EMISSIONS

Technical Areas: TA–3, Building 38; TA–3, Building 39; and TA–60, Building 17

Emission Source: Paint Booth Operations

Paint booth operations occur at TA–3–38, TA–3–39, and TA–60–17.

Pollutant(s) Considered

There are seven toxic, noncarcinogenic pollutants and one carcinogenic air pollutant that have the potential to be released into the atmosphere from the paint booth located at TA–3–38. The noncarcinogenic pollutants are 2-butoxyethanol, isobutyl acetate, isopropyl alcohol, toluene, trimethyl benzene, xylene, and particulate matter. The carcinogenic pollutant is benzene. These chemicals are constituents of oil-based paint and paint thinner. Of these, toluene, trimethyl benzene, xylene, and benzene are constituents of oil-based paint. Isopropyl alcohol, 2-butoxyethanol, isobutyl acetate, and toluene are constituents of the paint thinner.

Because the chemical composition of the paints and thinner at TA–3–39 and TA–60–17 were not provided, it was assumed that paints and thinner compositions to be used at paint booths at TA–3–39 and TA–60–17 are similar to those used at the TA–3–38 paint booth.

Emission Rates of Pollutants Considered

To estimate annual emissions from painting operations from the paint booths, the information giving the quantity of paints and thinner used annually at each TA and their density was obtained. This information is presented in Tables A through E for each TA in the footnotes. It was assumed that type and duration of painting operations conducted at TA–60–17 in 1994 (i.e., 528 hours per year of operations consisted of 240 hours per year of rack painting, plus 288 hours per year of maintenance painting) would apply to all painting activities conducted at the TA–3–38 and TA–3–39 paint booths. Hourly emission rates were estimated for 528 hours of operations per year using a correction factor of five to approximate maximum hourly emission rates. That is, the hourly emission rates were estimated by dividing annual emission rates by 528 hours and then multiplying this value by five.

Estimated hourly and annual emission rates of toxic (noncarcinogenic and carcinogenic) air pollutants from paint booths at TA–3–38, TA–3–39, and TA–60–17 are presented in Tables A through F.

Emissions were modeled with EPA's ISC–3 Model as point sources located on specified buildings (TA–3 Buildings 38 and 39, TA–60 Building 17). The source terms were estimated based on engineering judgment (stack height = 32.8 feet [10 meters], building height = 31.17 feet [9.5 meters], stack diameter = 1.15 feet [0.35 meters], exit velocity = 16.41 feet per second [5 meters per second], and exit temperature = 293°K).

Two paint booth impact analyses were conducted, one to estimate short-term (8-hour) impacts of noncarcinogenic and carcinogenic pollutants, and one to estimate long-term annual impacts of carcinogenic pollutants.

Major Assumptions Used in the Analysis

- All paints and thinners used at TA–3–39 and TA–60–17 have similar composition and constituents as those identified for paints and thinner at TA–3–38.
- The type and duration of painting operations conducted at TA–60–17 would apply to all painting activities conducted at TA–3–38 and TA–3–39 paint booths.
- Content of fine particles (less than 10 micrometers in size) is 50 percent of the total particulate matter content.
- Five percent of PM_{10} content would be released into the atmosphere through the emission control equipment.

Results

Analysis of short-term (8-hour) impacts of noncarcinogenic air pollutants that have the potential to be released into the atmosphere under baseline conditions and under future alternatives show no impacts on ambient air quality. The $SLEV/Q^h$ ratios for all pollutants considered are all greater than one (Tables A, C, and E). That is, the estimated pollutant levels are below the established Guideline Values (GVs).

Results of the annual impacts analysis of the carcinogenic pollutant presented in Tables B, D, and F show that benzene emitted from TA–3–38 and TA–60–17 failed the analysis with an $SLEV/Q^{an}$ ratio less than one. That is, the estimated benzene level is greater then the established GV. This pollutant was further evaluated in the additive impact analysis.

TABLE A.—*8-Hour SLEV/Q Ratios of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3–38 Paint Booth*[1]

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OEL[6]	1/100 OF THE OEL[7]	8-HR SLEV[8]		ESTIMATED HOURLY EMISSION RATE (Q^h)[2]	SLEV/Q^h RATIO
			μg/m³	μg/m³	g/sec	lb/hr	lb/hr	
1	2	3	4	5	6	7	8	9
NONCARCINOGENIC POLLUTANTS								
1	2-Butoxyethanol	111-76-2	120,000	1,200	4.54	36.1	0.366	98.5
2	Isobutyl Acetate	110-19-0	700,000	7,000	26.5	210.0	1.28	164.0
3	Isopropyl Alcohol	67-63-0	980,000	9,800	37.1	294.0	0.732	402.0
4	Particulate Matter, Respirable Dust[3,4,5]	NA	3,000	30.0	0.114	0.901	0.200	45.1
5	Toluene	108-88-3	188,000	1,880	7.12	56.5	1.44	39.1
6	Trimethyl Benzene	25551-13-7	125,000	1,250	4.73	37.6	1.08	34.9
7	Xylene (o-,m-,p-Isomers)	1330-20-7	434,000	4,340	16.4	130.0	6.46	20.2
CARCINOGENIC POLLUTANTS								
8	Benzene	71-43-2	32,000	320	1.21	9.62	0.0215	446.0

TABLE A.—*8-Hour SLEV/Q Ratios of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3–38 Paint Booth*[1]

Site Operations Data:

- The amount of oil-based paint used annually is 250 gal./year.
- The constituents of the paint are toluene (5% by weight), trimethyl benzene (5% by weight), xylene (30% by weight), and benzene (0.1% by weight).
- The highest density of the paint is 9.1 lb/gal.
- The amount of paint thinner used annually with a density of 6.9 lb/gal. is 56 gal.
- The constituents of the thinner are toluene (10% by weight), isopropyl alcohol (20% by weight), 2-Butoxyethanol (10% by weight), and isobutyl acetate (35% by weight).

Notes:

Major Assumptions:

[1] Type and duration of painting operations conducted at TA–60–17 in 1994 (528 hours of operation consisted of 240 hours/year of rack painting, plus 288 hours/year of maintenance painting) would apply to all painting activities conducted at TA–3–38 paint booth.

[2] Hourly emission rates were estimated based upon 528 hours/year of operation using a correction factor of five to approximate the maximum potential hourly emission rate.

[3] Particulate emissions of 10 micrometers in size (PM_{10}) were estimated based upon the solids content of a paint and amount of total particulates emitted from TA–3–38 paint booth (844 lb/year).

[4] Content of fine particles PM_{10} is 50% of the total particulate matter content.

[5] 5% of the PM_{10} content would be released into the atmosphere.

Guideline Value(s):

[6] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).

[7] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term impacts of the toxic air pollutants.

Dispersion Analysis Results:

[8] 5 years of meteorological data were used in the dispersion modeling analysis. The highest ISC–3 estimated 8-hour concentration at fence line receptors was found to be 264.1 $\mu g/m^3$ when emission rate is 1 g/sec.

NA = Not applicable

TABLE B.—*Annual SLEV/Q Ratios of the Carcinogenic Pollutants from TA–3–38 Paint Booth*

NO.	CARCINOGENIC POLLUTANT	CAS NUMBER	CAR CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} x URF)[3]	ANNUAL SLEV[1]		ANNUAL EMISSION RATE (Q^a)[2]	RATIO SLEV/Q^a
				$(\mu g/m^3)^{-1}$		g/sec	lb/year	lb/year	
1	2	3	4	5	6	7	8	9	10
1	Benzene	71-43-2	A	8.30E-06	2.35E-05	4.25E-04	1.78E+00	2.28E+00	7.84E-01

Site Operations Data:
- The amount of oil-based paint used annually is 250 gal./year.
- The benzene content of the paint is 0.1% by weight.
- The highest density of the paint is 9.1 lb/gal.

Notes:
Major Assumptions:
[1] Type and duration of painting operations conducted at TA–60–17 in 1994 (528 hours of operation consisted of 240 hours/year of rack painting, plus 288 hours/year of maintenance painting) would apply to all painting activities conducted at TA–3–38 paint booth.
[2] Emission rate was estimated based upon amount of paint used annually and benzene content of the paint.
Dispersion Analysis Results:
[3] 5 years of meteorological data were used in the dispersion modeling analysis. The highest ISC–3 estimated annual concentration at sensitive receptors was found to be 2.83 $\mu g/m^3$ when emission rate is 1 g/sec.

TABLE C.—*8-Hour SLEV/Q Ratios of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3–38 Paint Booth*[1]

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OEL[7]	1/100 OF THE OEL[8]	8-HR SLEV[9]		ESTIMATED HOURLY EMISSION RATE (Q^h)[2,6]	SLEVs/Q^h RATIO
			µg/m³	µg/m³	g/sec	lb/hr	lb/hr	
1	2	3	4	5	6	7	8	9
				NONCARCINOGENIC POLLUTANTS				
1	2-Butoxyethanol	111-76-2	120,000	1,200	4.78	38.0	0.0327	1,160.0
2	Isobutyl Acetate	110-19-0	700,000	7,000	27.9	221.0	0.114	1,940.0
3	Isopropyl Alcohol	67-63-0	980,000	9,800	39.1	310.0	0.0653	4,740.0
4	Particulate Matter, Respirable Dust[3,4,5]	NA	3,000	30.0	0.120	0.949	0.00805	118.0
5	Toluene	108-88-3	188,000	1,880	7.49	59.5	0.0758	785.0
6	Trimethyl Benzene	25551-13-7	125,000	1,250	4.98	39.5	0.0431	918.0
7	Xylene (o-,m-,p-Isomers)	1330-20-7	434,000	4,340	17.3	137.0	0.259	531.0
				CARCINOGENIC POLLUTANTS				
8	Benzene	71-43-2	32,000	320	1.28	10.0	0.000862	11,700.0

TABLE C.—*8-Hour SLEV/Q Ratios of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–3–38 Paint Booth*[1]-Continued

Site Operations Data:
- The amount of oil-based paint used annually is 10 gal./year.
- The constituents of the paint are toluene (5% by weight), trimethyl benzene (5% by weight), xylene (30% by weight), and benzene (0.1% by weight).
- The highest density of the paint is 9.1 lb/gal.
- The amount of paint thinner used annually with a density of 6.9 lb/gal. is 5 gal.
- The constituents of the thinner are toluene (10% by weight), isopropyl alcohol (20% by weight), 2-Butoxyethanol (10% by weight), and isobutyl acetate (35% by weight).

Notes:
Major Assumptions:
[1] Type and duration of painting operations conducted at TA–60–17 in 1994 (528 hours of operation consisted of 240 hours/year of rack painting, plus 288 hours/year of maintenance painting) would apply to all painting activities conducted at TA–3–39 paint booth.
[2] Hourly emission rates were estimated based upon 528 hours/year of operation using a correction factor of five to approximate the maximum potential hourly emission rate.
[3] Particulate emissions of 10 micrometers in size (PM_{10}) were estimated based upon the solids content of a paint and amount of total particulates emitted from TA–3–38 paint booth (844 lb/year).
[4] Content of fine particles PM_{10} is 50% of the total particulate matter content.
[5] 5% of the PM_{10} content would be released into the atmosphere.
[6] The constituents of the paint and the thinner used at TA–3–39 paint booth are the same as for the paint booth at TA–3–38.
Guideline Value(s):
[7] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).
[8] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term impacts of the toxic air pollutants.
Dispersion Analysis Results:
[9] 5 years of meteorological data were used in the dispersion modeling analysis. The highest ISC–3 estimated 8-hour concentration at fence line receptors was found to be 250.9 µg/m^3 when emission rate is 1 g/sec.

TABLE D.—*Annual SLEV/Q Ratios of the Carcinogenic Pollutants from TA–3–38 Paint Booth*

NO.	CARCINOGENIC POLLUTANT	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} x URF)[4]	ANNUAL SLEV[1]		ESTIMATED ANNUAL EMISSION RATE (Q^a)[2,3]	SLEV/Q^a RATIO
				$(\mu g/m^3)^{-1}$		g/sec	lb/year	lb/year	
1	2	3	4	5	6	7	8	9	10
1	Benzene	71-43-2	A	8.30E-06	1.59E-05	6.28E-04	2.63E+00	9.10E-02	2.89E+01

Site Operations Data:

- The amount of oil-based paint used annually is 10 gal./year.
- The highest density of the paint is 9.1 lb/gal.

Notes:

Major Assumptions:

[1] Type and duration of painting operations conducted at TA–60–17 in 1994 (528 hours of operation consisted of 240 hours/year of rack painting, plus 288 hours/year of maintenance painting) would apply to all painting activities conducted at TA–3–39 paint booth.

[2] Emission rate was estimated based upon amount of paint used annually and benzene content of the paint.

[3] The benzene content of the paint is the same as for the paint booth at TA–3–38 (0.1% by weight).

Dispersion Analysis Results:

[4] 5 years of meteorological data were used in the dispersion modeling analysis. The highest ISC–3 estimated annual concentration at sensitive receptors was found to be 1.92 $\mu g/m^3$ when emission rate is 1 g/sec.

TABLE E.—*8-Hour SLEV/Q Rations of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–60–17 Paint Booth*[1]

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OEL[7]	1/100 OF THE OEL[8]	8-HR SLEV[9]		ESTIMATED HOURLY EMISSION RATE (Q^h)[2,6]	SLEVs/Q^h RATIO
			µg/m³	µg/m³	g/sec	lb/hr	lb/hr	
1	2	3	4	5	6	7	8	9
NONCARCINOGENIC POLLUTANTS								
1	2-Butoxyethanol	111-76-2	120,000	1,200	8.46	67.1	0.288	233.0
2	Isobutyl Acetate	110-19-0	700,000	7,000	49.3	392.0	1.01	389.0
3	Isopropyl Alcohol	67-63-0	980,000	9,800	69.1	548.0	0.575	953.0
4	Particulate Matter, Respirable Dust[3,4,5]	NA	3,000	30.0	0.211	1.68	0.106	15.9
5	Toluene	108-88-3	188,000	1,880	13.3	105.0	0.856	123.0
6	Trimethyl Benzene	25551-13-7	125,000	1,250	8.81	69.9	0.569	123.0
7	Xylene (o-,m-,p-Isomers)	1330-20-7	434,000	4,340	30.6	243.0	3.41	71.1
CARCINOGENIC POLLUTANTS								
8	Benzene	71-43-2	32,000	320	2.26	17.9	0.114	1,570.0

TABLE E.—*8-Hour SLEV/Q Rations of the Toxic (Noncarcinogenic and Carcinogenic) Air Pollutants from TA–60–17 Paint Booth*[1]-Continued

Site Operations Data:

- The amount of oil-based paint used annually is 132 gal./year.
- The constituents of the paint are toluene (5% by weight), trimethyl benzene (5% by weight), xylene (30% by weight), and benzene (0.1% by weight).
- The highest density of the paint is 9.1 lb/gal.
- The amount of paint thinner used annually with a density of 6.9 lb/gal. is 44 gal.
- The constituents of the thinner are toluene (10% by weight), isopropyl alcohol (20% by weight), 2-Butoxyethanol (10% by weight), and isobutyl acetate (35% by weight).

Notes:

Major Assumptions:

[1] Type and duration of painting operations conducted at TA–60–17 in 1994 (528 hours of operation consisted of 240 hours/year of rack painting, plus 288 hours/year of maintenance painting) would apply to all current painting activities.

[2] Hourly emission rates were estimated based upon 528 hours/year of operation using a correction factor of five to approximate the maximum potential hourly emission rate.

[3] Particulate emissions of 10 micrometers in size (PM_{10}) were estimated based upon the solids content of a paint and amount of total particulates emitted from TA–3–38 paint booth (844 lb/year).

[4] Content of fine particles PM_{10} is 50% of the total particulate matter content.

[5] 5% of the PM_{10} content would be released into the atmosphere.

[6] The constituents of the paint and the thinner used at TA–60–17 paint booth are the same as for the paint booth at TA–3–38.

[7] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).

Guideline Value(s):

[8] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term impacts of the toxic air pollutants.

Dispersion Analysis Results:

[9] 5 years of meteorological data were used in the dispersion modeling analysis. The highest ISC–3 estimated 8-hour concentration at fence line receptors was found to be 141.9 $\mu g/m^3$ when emission rate is 1 g/sec.

TABLE F.—*Annual SLEV/Q Ratios of the Carcinogenic Pollutants from TA–60–17 Paint Booth*

NO.	CARCINOGENIC POLLUTANT	CAS NUMBER	CAR. CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} x URF)[4]	ANNUAL SLEV[1]		ESTIMATED ANNUAL EMISSION RATE (Q^a)[2,3]	SLEV/Q^a RATIO
				($\mu g/m^3)^{-1}$		g/sec	lb/year	lb/year	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Benzene	71-43-2	A	8.30E-06	4.03E-05	2.48E-04	1.04E+00	1.20E+00	8.66E-01

Site Operations Data:

- The amount of oil-based paint used annually is 132 gal./year.
- The highest density of the paint is 9.1 lb/gal.

Notes:

Major Assumptions:

[1] Type and duration of painting operations conducted at TA–60–17 in 1994 (528 hours of operation consisted of 240 hours/year of rack painting, plus 288 hours/year of maintenance painting) would apply to all current painting activities.

[2] Emission rate was estimated based upon amount of paint used annually and benzene content of the paint.

[3] The benzene content of the paint is the same as for the paint booth at TA–3–38 (0.1% by weight).

Dispersion Analysis Results:

[4] 5 years of meteorological data were used in the dispersion modeling analysis. The highest ISC–3 estimated annual concentration at sensitive receptors was found to be 4.85 $\mu g/m^3$ when emission rate is 1 g/sec.

ATTACHMENT 11
AIR QUALITY IMPACT ASSESSMENT OF INCINERATOR EMISSIONS

Technical Area: TA–16

Emission Source(s): Incineration of HE-Contaminated Paper and Oil

Two incinerator impact analyses were conducted, one for burning high explosives (HE)-contaminated paper waste and one for burning HE-contaminated oil.

Incineration of HE-Contaminated Paper Waste

Maximum Firing Rate

The maximum HE-contaminated paper waste firing rate was estimated to be 2,204.6 pounds (1,000 kilograms) per year in order to reflect the maximum amount of paper waste currently burned under baseline conditions and the expected maximum amount that is anticipated to be burned under any of the future alternatives.

Source Term Parameters (from incinerator specifications)

- Incinerator stack height above ground level = 28.15 feet (8.58 meters)
- Stack inner diameter = 1.83 feet (0.559 meters)
- Stack exit velocity = 22.97 feet per second (7 meters per second) (assumed based on engineering judgment)
- Stack exit temperature = 800°F (427°C) (assumed based on engineering judgment)
- Stack location = south-east corner of Building 1409 of TA–16

Pollutant(s) Considered

Pollutants usually associated with the combustion of paper and wood waste are metals, acid gases, toxic organics such as CDD/CDF (i.e., groups of chlorinated homologs of dioxins and furans), and criteria pollutants (CO, NO_x, SO_2, and PM_{10}). For conservativeness, only toxic pollutants with the highest toxicity and carcinogenicity, such as arsenic, hexavalent chromium, cadmium, nickel, and CDD/CDF were selected for evaluation.

Emission Rates of Pollutants Considered

Emission factors for toxic and criteria pollutants considered were obtained from EPA's "Compilation of Air Pollutant Emissions Factors" (EPA 1995) (Table 2.1-9) for modular starved air combustors burning solid waste. Emission factors for criteria pollutants were used for estimating long-term emission rates because they are based only on long-term monitoring data.

Estimated annual emission rates of the toxic and criteria pollutants that are based on the most recent AP–42 emission factors are shown in Tables A and B, respectively.

Major Assumptions

- Incinerator would operate 250 hours a year (one burn per day, 5 days per week, and 50 weeks per year).
- 30 percent of the total chromium would be released in the form of hexavalent chromium.
- Emissions would be released over 8,760 hours of operation per year.
- The content of fine particulates (less than 10 micrometers in size) is 50 percent of the total particulate matter emitted.

Results

Toxic Air Pollutants. Because all of the toxic pollutants to be considered in the analysis are carcinogenic and annual impacts from these pollutants on ambient air are much more significant than the short-term (8-hour) impacts, only annual impacts were considered. As shown in Table A, only one of the pollutants considered (CDD/CDF) had an estimated pollutant level greater than the established Guideline Value (GV) (i.e., the SLEV/Q^a ratio is less than 1). This pollutant will therefore be further evaluated as a part of the additive impact analysis. None of the releases of other toxic pollutants would result in air quality impacts.

Criteria Air Pollutants. As shown in Table C, estimated annual concentrations of the criteria pollutants (C^{an}) are below the NAAQS. That is, the NAAQS/C^{an} ratios are always greater than 1. None of the releases of criteria pollutants would result in air quality impacts.

Incineration of HE-Contaminated Oil

Maximum Firing Rate

The maximum HE-contaminated oil firing rate is 1,200 gallons (4,542.48 liters) annually and 10 gallons (37.85 liters) hourly.

Source Term Parameters

The source term parameters are the same as were used in the analysis of HE-contaminated paper waste.

Pollutant(s) Considered

HE-contaminated oil generated by the High Explosives Processing Facility (HEPF) is not a "traditional waste oil," and many of the toxic air pollutants (such as metals) are not constituents of HE-contaminated oil. Therefore, metals were not considered in this analysis. The composition of VOCs were determined using EPA data (EPA 1995). Based on these data, it was assumed that, with the exception of metals, some specified organic compounds from VOCs, such as phenol, dichlorobenzene, naphthalene, and benzo(p)pyrene, may be formed as products of incomplete combustion. There also are acid gases, such as hydrogen chloride that are usually detected in flue gases from waste oil combustion. Based on these findings, toxic pollutants from waste oil burning were considered.

Emission Rates of Pollutants Considered

Emission factors for toxic and criteria air pollutants were obtained from Tables 1.11-1, -2, -3, and -5 of EPA 1995 for waste oil combustors. Estimated maximum hourly emission rates of the toxic noncarcinogenic and criteria air pollutants are presented in Table D. Estimated annual emission rates of the toxic carcinogenic pollutants and criteria pollutants are shown in Tables E and F, respectively.

Major Assumptions

- Incinerator would operate 250 hours a year (one burn per day, 5 days per week, and 50 weeks per year).
- Emissions would be released over 8,760 hours of operation per year.
- Percent of chlorine in oil is 0.1 percent by weight.
- Percent of ash in oil is 1 percent by weight.
- Sulfur content in oil is 1 percent by weight.

Results

Toxic Air Pollutants. Both short-term (8-hour) and long-term (annual) impacts of the toxic (carcinogenic and noncarcinogenic) air pollutants from waste oil incineration were considered. No pollutants failed the analysis (i.e., the estimated pollutant levels are below the established GV). As shown in Tables D and E, the SLEV/Q ratios are always greater than 1. None of the releases of toxic pollutants would result in air quality impacts.

Criteria Air Pollutants. As shown in Table G, estimated annual concentrations of the criteria pollutants (C^{an}) are below the NAAQS (i.e., the NAAQS/C^{an} ratios are always greater than 1). None of the releases of criteria pollutants would result in air quality impacts.

TABLE A.—*Annual SLEV/Q Ratios for the Toxic Carcinogenic Air Pollutants from TA–16 Incinerator Burning HE-Contaminated Paper Waste*

NO.	CARCINOGENIC AIR POLLUTANT	CAS NUMBER	CAR CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} x URF)[5]	ANNUAL SLEVs[3]		EMISSION FACTORS[1]	ANNUAL AVERAGE EMISSION RATES (Q^a)[2]	SLEV/Q^a RATIO
				($\mu g/m^3$)$^{-1}$		g/sec	lb/year	lb/ton	lb/year	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Arsenic, el. & inorg., exc. Arsine, as As	7440-38-2	A	4.30E-03	1.57E-03	6.38E-06	1.27E-02	6.69E-04	7.37E-04	1.72E+01
2	Cadmium, el. & compounds, as Cd	7440-43-9	B1	1.80E-03	6.56E-04	1.53E-05	3.03E-02	2.41E-03	2.66E-03	1.14E+01
3	Chromium (Vl)[4]	18540-29-9	A	1.20E-02	4.37E-03	2.29E-06	4.54E-03	3.31E-03	1.09E-03	4.15E+00
4	Nickel, metal (dust)	NA	A	2.40E-04	8.74E-05	1.14E-04	2.27E-01	5.52E-03	6.08E-03	3.37E+01
5	2,3,7,8-Tetrachlorodibenzo(p) dioxin (CDD/CDF)	1746-01-6	B2	3.30E+01	1.20E+01	8.32E-10	1.65E-06	2.94E-06	3.24E-06	5.09E-01

Source Term Parameters:
Source term parameters obtained from incinerator specification were as follows:
- Incinerator stack height above ground level is 8.58 m.
- Stack inner diameter is 0.559 m.
- Stack exit velocity is 7 m/sec (assumed).
- Stack exit temperature is 427°C.
- Stack location is southeast corner of Building 1409 of TA–16.

Maximum Firing Emission Rate:
Maximum amount of the material burned is 1,000 kilograms on an annual basis.
Notes:
Major Assumptions:
[1] Emission factors were obtained from EPA's AP–42 (EPA 1995), Tables 2.1–9 for modular starved air combustors burning solid waste.
[2] Annual average emission rates were estimated based on EPA's AP–42 emission factors and the maximum amount of material burned annually (EPA 1995).
[3] Annual SLEVs (lb/yr) were estimated assuming that incinerator would be operating 250 hours/year (one burn/day, 5 days/week, and 50 weeks/year).
[4] 30% of the total chromium was assumed to be released in the form of hexavalent chromium.
Disperion Analysis Results:
[5] 5 years of meteorological data (1991 to 1995) were used in the dispersion modeling analysis. The highest annual concentration of 0.36 $\mu g/m^3$ was found to occur during 1991.

TABLE B.—*Annual Emission Rates for the Criteria Pollutants from TA–16 Incinerator Burning HE-Contaminated Paper Waste*

NO.	CRITERIA AIR POLLUTANTS	AMOUNT OF WASTE BURNED ANNUALLY[a]	EPA'S AP–42 EMISSION FACTORS[b]		ANNUAL EMISSION RATE[c]	
		lb/year	lb/ton	lb/lb	lb/year	g/sec
1	2	5	3	4	6	7
1	Particulate Matter (PM_{10})[d]	2.20E+03	3.43E+00	1.72E-03	1.89E+00	2.72E-05
2	Nitrogen Oxide	2.20E+03	3.16E+00	1.58E-03	3.48E+00	5.01E-05
3	Sulfur Dioxide	2.20E+03	3.23E+00	1.62E-03	3.56E+00	5.13E-05

Notes:
Maximum Firing Annual Emission Rate:
[a] Maximum amount of material burned is 1,000 kilograms on an annual basis.
Major Assumptions:
[b] Emission factors for criteria pollutants were obtained from EPA's AP–42 (EPA 1995), Tables 2.1–9 for modular starved air combustors burning solid waste. These emission factors are intended to be used for estimating long-term emission levels only.
[c] Annual average emission rates were estimated based on EPA's AP–42 emission factors, maximum amount of material burned annually, and assumption that the emissions would be released over 8,760 hours of operation per year (EPA 1995).
[d] The fraction of fine particulates (PM_{10}) is 50% of the total particulate matter.

TABLE C.—*Annual Impact Analysis of the Criteria Pollutants from TA–16 Incinerator Burning HE-Contaminated Paper Waste*

NO.	CRITERIA AIR POLLUTANTS	AVERAGING TIME PERIOD	ANNUAL EMISSION RATE[a]	ICS–3 ESTIMATED ANNUAL POLLUTANT CONCENTRATION (C^{an})[b]	NATIONAL AMBIENT AIR QUALITY STANDARD (NAAQS)	(NAAQS)/(C^{an}) RATIO
			g/sec	µg/m³	µg/m³	
1	**2**	**3**	**4**	**5**	**6**	**7**
1	Particulate Matter (PM_{10})	Annual	2.72E-05	1.00E-05	50	5.00E+06
2	Nitrogen Oxide	Annual	5.01E-05	2.00E-05	100	5.00E+06
3	Sulfur Dioxide	Annual	5.13E-05	2.00E-05	80	4.00E+06

Source Term Parameters:

Source term parameters obtained from incinerator specification were as follows:

- Incinerator stack height above ground level is 8.58 m.
- Stack inner diameter is 0.559 m.
- Stack exit velocity is 7 m/sec (assumed).
- Stack exit temperature is 427°C (assumed).
- Stack location is southeast corner of Building 1409 of TA–16.

Notes:

Annual Emission Rate:

[a] As presented in Table B, item 3.

Dispersion Analysis Results:

[b] 5 years of meteorological data (1991 to 1995) were used in the dispersion modeling analysis. The highest ISC–3 estimated annual concentration (C^{an}) was found to occur during 1991.

TABLE D.—*8-Hour SLEV/Q Ratios for the Toxic and Criteria Air Pollutants from TA–16 Incinerator Burning HE-Contaminated Oil*

NO.	TOXIC AND CRITERIA AIR POLLUTANTS	CAS NUMBER	OELs	1/100 OF THE OELs	8-HR SLEVs[f]		EMISSION FACTORS[a]	MAXIMUM HOURLY EMISSION RATE (Q^h)[e]	SLEVs/Q^h RATIO
			μg/m³	μg/m³	g/sec	lb/hr	lb/gal.	lb/hr	
1	2	3	4	5	6	7	8	10	11
				TOXIC POLLUTANTS					
1	Hydrogen Chloride[b]	7647-01-0	7,000	70	5.91E-01	4.69E+00	6.60E-03	6.60E-02	7.11E+01
2	o-Dichlorobenzene	95-50-1	300,000	3,000	2.53E+01	2.01E+02	6.70E-09	6.70E-08	3.00E+09
3	Naphthalene	91-20-3	52,000	520	4.39E+00	3.48E+01	1.30E-05	1.30E-04	2.68E+05
4	Phenol	108-95-2	19,000	190	1.60E+00	1.27E+01	2.40E-06	2.40E-05	5.30E+05
				CRITERIA POLLUTANTS					
5	Carbon Monoxide	638-08-1	29,000	290	2.45E+00	1.94E+01	5.00E-03	5.00E-02	3.89E+02
6	Nitrogen Dioxide	10102-44-0	5,600	56	4.73E-01	3.75E+00	1.90E-02	1.90E-01	1.98E+01
7	Particulate Matter (PM_{10})[c]	NA	3000	30	2.53E-01	2.01E+00	5.10E-02	5.10E-01	3.94E+00
8	Sulfur Dioxide[d]	7446-09-5	5,200	52	4.39E-01	3.48E+00	1.47E-01	1.47E+00	2.37E+00

NA = Not applicable

Source Term Parameters:

Source term parameters obtained from incinerator specification were as follows:

- Incinerator stack height above ground level is 8.58 m.
- Stack inner diameter is .559 m.
- Stack exit velocity is 7 m/sec (assumed).
- Stack exit temperature is 427°C (assumed).
- Stack location is southeast corner of Building 1409 of TA–16.

TABLE D.—*8-Hour SLEV/Q Ratios for the Toxic and Criteria Air Pollutants from TA–16 Incinerator Burning HE-Contaminated Oil*-Continued

Maximum Firing Emission Rate:
Maximum amount of oil burned (i.e.,10 gallons on an hourly basis) was obtained from EPA 1992f.
Notes:
Major Assumptions:
[a] Emission factors were obtained from EPA's AP–42, Tables 1.11–1, 2, 3, and 5 for waste oil combustors (EPA 1995). Toxic metal compounds such as arsenic, cadmium, chromium, etc., that are usually emitted from waste oil combustion, are not constituents of HE-contaminated oil. Therefore, toxic metals were not considered.
[b] Percent of chlorine in oil is 0.1% by weight,
[c] Percent of ash in oil is 1% by weight, and
[d] Sulfur content in oil is 1% by weight.
[e] Maximum hourly emission rates were estimated based on EPA's AP–42 emission factors and maximum amount of oil burned (EPA 1995).
Dispersion Analysis Results:
[f] 5 years of meteorological data (1991 to 1995) were used in the dispersion modeling analysis. The estimated maximum 8-hour concentration of 118.4 $\mu g/m^3$ was found to occur during 1992.

TABLE E.—*Annual SLEV/Q for the Toxic Carcinogenic Air Pollutants from TA–16 Incinerator Burning HE-Contaminated Oil*

NO	TOXIC CARCINOGENIC AIR POLLUTANTS	CAS NUMBER	CAR CLASS	UNIT RISK FACTOR (URF)	MAXIMUM CANCER RISK (C_{an} x URF)[e]	ANNUAL SLEVs[d]		EMISSION FACTORS[b]	AMOUNT OF OIL BURNED ON ANNUAL BASIS[a]	ANNUAL EMISSION RATE (Q_a)[c]	SLEVs/Q_a RATIO
				$(\mu g/m^3)^{-1}$		g/sec	lb/year 3	lb/gal.	gal./year	lb/year	
1	2	3	4	5	6	7	8	9	10	11	12
1	Benzo(a)pyrene	50-32-8	B2	1.70E-03	6.19E-04	1.62E-05	3.20E-02	4.00E-06	1.20E+03	4.80E-03	6.68E+00

Source Term Parameters:
Source term parameters obtained from incinerator specification were as follows:

- Incinerator stack height above ground level is 8.58 m.
- Stack inner diameter is 0.559 m.
- Stack exit velocity is 7 m/sec (assumed).
- Stack exit temperature is 427°C (assumed).
- Stack location is southeast corner of Building 1409 of TA–16.

Notes:
Maximum Firing Emission Rate:
[a] Maximum amount of oil burned (i.e., 1,200 gallons on an annual basis) was obtained from EPA 1992c.
Major Assumptions:
[b] Emission factors for benzo(p)pyrene were obtained from EPA's AP–42, Table 1.11–5 for waste oil combustors (EPA 1995).
[c] Annual average emission rate was estimated based on EPA's AP–42 (EPA 1995) emission factors and the maximum amount of oil burned annually (1,200 gallons), according to EPA 1992c.
[d] Annual SLEVs was estimated assuming that incinerator would be operating 250 hours/year (one burn/day, 5 days/week, and 50 weeks/year), according to EPA 1992f.
Dispersion Analysis Results:
[e] 5 years of meteorological data were used in the dispersion modeling analysis. The highest annual concentration of 0.36 $\mu g/m^3$ was found to occur during 1991.

TABLE F.—*Annual Emission Rates of the Criteria Pollutants from TA–16 Incinerator Burning HE-Contaminated Oil*

NO.	CRITERIA AIR POLLUTANTS	AMOUNT OF OILS BURNED ON AN ANNUAL BASIS[a]	EPA'S AP–42 EMISSION FACTORS[b]	ANNUAL EMISSION RATE[c]	
		lb/year	lb/gal.	lb/year	g/sec
1	**2**	**3**	**4**	**5**	**6**
1	Particulate Matter (PM_{10})[d]	1.20E+03	5.10E-02	6.12E+01	8.81E-04
2	Nitrogen Oxide	1.20E+03	1.90E-02	2.28E+01	3.28E-04
3	Sulfur Dioxide[e]	1.20E+03	1.47E-01	1.76E+02	2.54E-03

Notes:
Maximum Firing Annual Emission Rate:
[a] The maximum amount of oil burned (i.e., 1,200 gallons on an annual basis) was obtained from Table K of EPA 1992c.
Major Assumptions:
[b] Emission factors for air pollutants considered in the analysis (lb/gal.) were obtained from EPA's AP–42, Table 2.1–9 for waste oil combustors (EPA 1995).
[c] Annual average emission rates were estimated based on EPA's AP–42 emission factors, maximum amount of material burned annually, and assumption that the emissions would be released over 8,760 hours of operation per year (EPA 1995).
[d] Percent of the ash in oils is 1% by weight.
[e] Sulfur content in oil is 1% by weight.

TABLE G.—*Annual Impact Analysis of the Criteria Pollutants from TA–16 Incinerator Burning HE-Contaminated Oil*

NO.	CRITERIA AIR POLLUTANTS	AVERAGING TIME PERIOD	ANNUAL EMISSION RATE[a]	ICS–3 ESTIMATED ANNUAL POLLUTANT CONCENTRATION (C^{an})[b]	NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)	(NAAQS)/(C^{an}) RATIO
			g/sec	µg/m^3	µg/m^3	
1	2	3	4	5	6	7
1	Particulate Matter (PM_{10})	Annual	8.81E-04	3.19E-04	50	1.57E+05
2	Nitrogen Oxide	Annual	3.28E-04	1.20E-04	100	8.33E+05
3	Sulfur Dioxide	Annual	2.54E-03	9.30E-04	80	8.60E+04

Source Term Parameters:
Source term parameters obtained from incinerator specification were as follows:

- Incinerator stack height above ground level is 8.58 m.
- Stack inner diameter is 0.559 m.
- Stack exit velocity is 7 m/sec (assumed).
- Stack exit temperature is 427°C (assumed).
- Stack location is southeast corner of Building 1409 of TA–16.

Notes:
Annual Emission Rate:
[a] As presented in Table F, item 3.
Dispersion Analysis Results:
[b] 5 years of meteorological data (1991 to 1995) were used in the dispersion modeling analysis. The highest ISC–3 estimated annual concentration (C^{an}) was found to occur during 1991.

ATTACHMENT 12
AIR QUALITY IMPACT ASSESSMENT OF OPEN BURNING OPERATIONS AT HIGH EXPLOSIVES TREATMENT AND DISPOSAL FACILITY

Technical Area: TA–16

Emission Source: Open Burning Operations at High Explosives Treatment and Disposal Facility

There are three open burning emission sources at the High Explosive Processing Facilities (HEPF). These are all located at TA–16, High Explosives Treatment and Disposal Facility, and include the open burning of HE-contaminated solvents and oil, the open burning of scrap HE, and the flashing of HE-contaminated materials that cannot be burned.

Open Burning of HE-Contaminated Solvents and Oil at the Burn Pit Located at TA–16–394

Pollutant(s) Considered

There are two groups of emissions from open-burning operations of solvents and oil. These include toxic pollutants specified as volatile organics/hazardous air pollutants (VOC/HAP), and criteria pollutants—primarily carbon monoxide and PM_{10}. There are no significant NO_x emissions as a result of these activities because the relatively low temperatures associated with open burning suppress emissions of NO_x.

According to Tewerson (1985), some of the highly volatile chemicals associated with the burning solvents or oil include acetone, cyclohexane, ethanol, ethyl acetate, methyl alcohol, methyl ethyl ketone, butyl acetate, and toluene. These chemicals were therefore selected for evaluation.

Emission Rates of Pollutants Considered

Appropriate emission factors and fuel constituents were obtained from Tewerson (1985). The maximum amount of solvents and oil in a burn of 300 gallons (1,135.62 liters) and 1,200 gallons (4,542.48 liters) per year, respectively, was obtained from site data. Based on these values, the density of the fuel, and the assumption that the facility will operate 50 hours per year, an hourly emission rates of toxic and criteria air pollutants were estimated. They are presented in Tables A and B, respectively.

Major Assumptions

- 50 hours of burn operations a year (50 burns per year at 1-hour length of burn.
- Content of fine particulates (less than 10 micrometers in size) is 50 percent of the total particulate matter content.
- Emissions were modeled as surface-based volume sources using the EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate burn tray dimensions.

- Following the conservative technique used for estimating short-term impacts from all emission sources, all fence line receptor locations, regardless of whether the public has access to these locations, were considered.
- Actual receptors will be considered for those sources where potential air quality impacts are likely to occur.

Results

Toxic Air Pollutants. Analysis of short-term (8-hour) impacts of the individual components comprising VOC/HAP emissions were considered at nearby fence line receptors. The analysis shows no impacts on ambient air quality; the SLEV/Q^h ratios are all greater than one (Tables C and D). That is, the estimated pollutant levels are below the established Guideline Values (GVs).

Criteria Air Pollutants. Two analyses were performed to estimate 8-hour SLEVs from open burning of HE-contaminated solvents and oil at the burn pit at TA–16–394.

Because potential impacts were predicted at all fence line receptors, including locations to which the public does not have access, the locations where the public does have access were considered. These locations are along the south border of TA–16 near State Road 4, bordering Bandelier National Monument, at 5,905.8 to 6,562 feet (1,800 to 2,000 meters) from the emission source. At these locations, the estimated 8-hour SLEV/Q^h ratios were all greater than one (Tables E and F).

Annual impacts of criteria pollutants from open burning of HE-contaminated solvents and oil at the burn pit at TA–16–394 were not considered due to the fact that the annual estimated emission rates (Tewerson 1985, Tables E and F) were too small to cause impacts.

Open Burning of Scrap HE at the Burn Pit Located at TA–16–388

Pollutant(s) Considered

The chemical constituents were selected for analysis based on information provided by Carter (1978). Due to uncertainty in identifying these constituents and their amounts in the scrap HE, chemicals of different toxicities were selected to represent the range of toxic emissions that may be emitted. These include hydrogen chloride, hydrogen fluoride, ammonia, ethanol, methyl alcohol, and acetylene.

Emission Rates of Pollutants Considered

Appropriate emission factors for selected VOC/HAP constituents were obtained from Table 3-5 of a document entitled "Air Emissions from Burning of Explosives" (Carter 1978). The maximum total amount of scrap HE burned per year, 106,526 pounds (48,320 kilograms), and the total estimated amount of VOC/HAP emissions per year (257 pounds [116.57 kilograms]) were obtained from site data. In order to estimate emissions associated with the burning of individual VOC/HAP components, it was assumed that the content of explosive components in scrap material is 1 percent. The major combustible components in scrap that account for at least 90 percent of composition are usually lumber or wood pallets. Estimated hourly and annual emission rates of toxic VOC/HAP pollutants, with the corresponding emission factors, are presented in Table G.

Major Assumptions

- The same assumptions that were used in the analysis of open-burning HE-contaminated solvents and oil at the Burn Pit Located at TA–16–394 are also made for this analysis.
- The content of explosive components in scrap material is 1 percent by weight.
- Emissions would be released over 8,760 hours of operations per year.

Results

Toxic Air Pollutants. Two analyses were performed to estimate 8-hour SLEVs of the toxic pollutants from open burning of scrap HE. Because potential impacts were predicted at fence line receptors to which the public does not have access, the locations where the public does have access were considered. The highest estimated 8-hour SLEV/Q ratios at receptor locations along the south border of TA–16 near State Road 4, bordering Bandelier National Monument, were found to be greater than one for all pollutants considered (Table H). That is, the estimated pollutant levels are below the established GV.

Annual impact analysis of toxic air pollutants from burning of HE scrap was performed at the sensitive receptor locations. Two toxic air pollutants for which inhalation reference concentrations (RfC) have been established were considered: hydrogen chloride and ammonia. The SLEV/Q^{an} ratios were found to be greater than 1 for these toxic air pollutants (Table I). That is, the estimated pollutant levels are below the established GV. None of the releases of toxic pollutants would result in air quality impacts.

Criteria Pollutants. The same methodology that was used to estimate potential annual impact of the toxic air pollutants was utilized to evaluate annual impacts of criteria pollutants. Three criteria pollutants were considered in the analysis, PM_{10}, CO, and NO_2. Annual emission rates for these pollutants were obtained directly from site data. The NAAQS/Q^{an} ratios were greater than one for all pollutants (Table J). That is, the estimated pollutant levels are below the NAAQS.

Annual impacts of criteria pollutants from the flashing of unburnable HE-contaminated materials were not considered because the quantities of emissions from these operations on an annual basis are much smaller than those from scrap HE-burning operations, and were too small to cause any impacts.

TABLE A.—*Emissions of HE-Contaminated Solvents from Open Burn at TA–16*

NO.	FUEL CONSTITUENTS	AMOUNT OF SOLVENTS BURNED[b,d]		AMOUNT OF FUEL CONSTITUENTS IN BURN	TOXIC POLLUTANTS		CRITERIA POLLUTANTS: CARBON MONOXIDE		CRITERIA POLLUTANTS: PARTICULATE MATTER $(PM_{10})^{e}$	
					YIELD OF COMPOUND[c]	HOURLY EMISSION RATE[a]	YIELD OF COMPOUND[c]	HOURLY EMISSION RATE[a]	YIELD OF COMPOUND[c]	HOURLY EMISSION RATE[a]
		gal./hr	lb/hr	lb/lb	lb/lb	lb/hr	lb/lb	lb/hr	lb/lb	lb/hr
1	2	3	4	5	6	7	8	9	10	11
1	Acetone	6.0	41.3	0.1196	0.0130	0.0642	0.0014	0.0069	0.0137	0.0338
2	Cyclohexane	6.0	41.3	0.1179	0.0460	0.2238	0.0100	0.0486	0.0369	0.0898
3	Ethanol	6.0	41.3	0.1195	0.0050	0.0247	0.0012	0.0059	0.0110	0.0271
4	Ethyl Acetate	6.0	41.3	0.1363	0.0069	0.0388	0.0024	0.0135	0.0120	0.0337
5	Methyl Alcohol	6.0	41.3	0.1198	0.0050	0.0247	0.0009	0.0044	0.0079	0.0195
6	Methyl Ethyl Ketone	6.0	41.3	0.1220	0.0060	0.0302	0.0031	0.0156	0.0153	0.0385
7	Butyl Acetate	6.0	41.3	0.1336	0.0465	0.2563	0.0051	0.0281	0.0199	0.0548
8	Toluene	6.0	41.3	0.1313	0.1070	0.5797	0.0639	0.3462	0.1735	0.4700
	Total							**0.4693**		**0.7673**

Emission Source:
Open burning of HE-contaminated solvents was considered at the pit located at TA–16–394.
Notes:
Hourly Emission Rate:
[a] Hourly emission rates in pounds per hour of each compound from burning fuel constituents were estimated using applicable emission factors, fuel constituents, and its amount in a burn.
[b] The maximum amount of solvents in a burn of 300 gallons per year was obtained from Tewerson 1985.
[c] Yield of compound is expressed in lb/lb of material combusted (Carter 1978).
Major Assumptions:
[d] 50 hours of burn operations a year (50 burns per year at 1 hour length of burn), according to Carter 1978.
[e] Content of fine particles PM_{10} (less than 10 micrometers in size) is 50% of the total particulate matter content.

TABLE B.—*Emissions of HE-Contaminated Oil from Open Burning at TA–16*

NO.	FUEL CON-STITUENTS	AMOUNT OF SOLVENTS BURNED[b,d]		AMOUNT OF FUEL CONSTITUENTS IN BURN	TOXIC POLLUTANTS		CRITERIA POLLUTANTS: CARBON MONOXIDE		CRITERIA POLLUTANTS: PARTICULATE MATTER (PM_{10})[e]	
					YIELD OF COMPOUND[c]	HOURLY EMISSION RATE[a]	YIELD OF COMPOUND[c]	HOURLY EMISSION RATE[a]	YIELD OF COMPOUND[c]	HOURLY EMISSION RATE[a]
		gal./hr	lb/hr	lb/lb	lb/lb	lb/hr	lb/lb	lb/hr	lb/lb	lb/hr
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Acetone	24.0	165.0	0.1196	0.0130	0.2566	0.0014	0.0276	0.0137	0.1352
2	Cyclohexane	24.0	165.0	0.1179	0.0460	0.8951	0.0100	0.1946	0.0369	0.3590
3	Ethanol	24.0	165.0	0.1195	0.0050	0.0986	0.0012	0.0237	0.0110	0.1085
4	Ethyl Acetate	24.0	165.0	0.1363	0.0069	0.1552	0.0024	0.0540	0.0120	0.1350
5	Methyl Alcohol	24.0	165.0	0.1198	0.0050	0.0989	0.0009	0.0178	0.0079	0.0781
6	Methyl Ethyl Ketone	24.0	165.0	0.1220	0.0060	0.1208	0.0031	0.0624	0.0153	0.1540
7	Butyl Acetate	24.0	165.0	0.1336	0.0465	1.0253	0.0051	0.1125	0.0199	0.2194
8	Toluene	24.0	165.0	0.1313	0.1070	2.3187	0.0639	1.3847	0.1735	1.8799
	Total							**1.8772**		**3.0690**

Emission Source:
Open burning of HE-contaminated solvents was considered at the pit located at TA–16–394.
Notes:
Hourly Emission Rate:
[a] Hourly emission rates in pounds per hour of each compound from burning fuel constituents were estimated using applicable emission factors, fuel constituents, and its amount in a burn.
[b] The maximum amount of solvents in a burn of 300 gallons per year was obtained from Tewerson 1985.
[c] Yield of compound is expressed in lb/lb of material combusted (Carter 1978).
Major Assumptions:
[d] 50 hours of burn operations a year (50 burns per year at 1 hour length of burn), according to Carter 1978.
[e] Content of fine particles PM_{10} (less than 10 micrometers in size) is 50% of the total particulate matter content.

TABLE C.—*8-Hour SLEV/Q Ratios of the Toxic Air Pollutants from Open Burning of HE-Contaminated Solvents at TA–16*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OEL[c]	1/100 OF THE OEL[d]	8-HOUR SLEV[b]		ESTIMATED HOURLY EMISSION RATE[a] (Q^h)	SLEV/Q^h RATIO
			μg/m³	μg/m³	g/sec	lb/hr	lb/hr	
1	2	3	4	5	6	7	8	9
1	Acetone	67-64-1	1,780,000	17,800	3.89E+01	3.09E+02	0.0642	4.81E+03
2	Cyclohexane	110-82-7	1,050,000	10,500	2.29E+01	1.82E+02	0.2238	8.13E+02
3	Ethanol	64-17-5	1,880,000	18,800	4.11E+01	3.26E+02	0.0247	1.32E+04
4	Ethyl Acetate	141-78-6	1,400,000	14,000	3.06E+01	2.43E+02	0.0388	6.25E+03
5	Methyl Alcohol	67-56-1	262,000	2,620	5.72E+00	4.54E+01	0.0247	1.84E+03
6	Methyl Ethyl Ketone	78-93-3	590,000	5,900	1.29E+01	1.02E+02	0.0302	3.39E+03
7	n-Butyl Acetate	123-86-4	710,000	7,100	1.55E+01	1.23E+02	0.2563	4.80E+02
8	Toluene	108-88-3	188,000	1,880	4.11E+00	3.26E+01	0.5797	5.62E+01

Emission Source:
Open burning of HE-contaminated solvents was considered at the pit located at TA–16–394.
Notes:
Major Assumptions:
[a] Emission rates are presented in Table A. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3) Dispersion Model, Volume 1 (EPA 1992b).
Dispersion Analysis Results:
[b] The highest ISC–3 estimated concentration at fence line receptors was found to be 457.9 μg/m³ when emission rate is 1 g/sec.
Guideline Values
[c] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).
[d] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term (8-hour) impacts of the toxic air pollutants.

TABLE D.—*8-Hour SLEV/Q Ratios of the Toxic Air Pollutants from Open Burning of HE-Contaminated Oil at TA–16*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OEL[c]	1/100 OF THE OEL[d]	8-HOUR SLEV[b]		ESTIMATED HOURLY EMISSION RATE[a] (Q^h)	SLEV/Q^h RATIO
			μg/m^3	μg/m^3	g/sec	lb/hr	lb/hr	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Acetone	67-64-1	1,780,000	17,800	3.89E+01	3.09E+02	0.2566	1.20E+03
2	Cyclohexane	110-82-7	1,050,000	10,500	2.29E+01	1.82E+02	0.8951	2.03E+02
3	Ethanol	64-17-5	1,880,000	18,800	4.11E+01	3.26E+02	0.0986	3.30E+03
4	Ethyl Acetate	141-78-6	1,400,000	14,000	3.06E+01	2.43E+02	0.1552	1.56E+03
5	Methyl Alcohol	67-56-1	262,000	2,620	5.72E+00	4.54E+01	0.0989	4.59E+02
6	Methyl Ethyl Ketone	78-93-3	590,000	5,900	1.29E+01	1.02E+02	0.1208	8.46E+02
7	n-Butyl Acetate	123-86-4	710,000	7,100	1.55E+01	1.23E+02	1.0253	1.20E+02
8	Toluene	108-88-3	188,000	1,880	4.11E+00	3.26E+01	2.3187	1.41E+01

Emission Source:
Open burning of HE-contaminated oil was considered at the pit located at TA–16–394.
Notes:
Major Assumptions:
[a] Emission rates are presented in Table B. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3) Dispersion Model, Volume 1 (EPA 1992b).
Dispersion Analysis Results:
[b] The highest ISC–3 estimated concentration at fence line receptors was found to be 457.9 μg/m^3 when emission rate is 1 g/sec.
Guideline Values
[c] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).
[d] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term (8-hour) impacts of the toxic air pollutants.

TABLE E.—*8-Hour SLEV/Q Ratios of the Criteria Pollutants from Open Burning of HE-Contaminated Solvents at TA–16*

NO.	CRITERIA AIR POLLUTANTS[a]	CAS NUMBER	OEL[d]	1/100 OF THE OEL[e]	8-HOUR SLEV[c]		ESTIMATED HOURLY EMISSION RATE[b] (Q^h)	SLEV/Q^h RATIO
			μg/m³	μg/m³	g/sec	lb/hr	lb/hr	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Particulate Matter (PM_{10})	NA	3,000	30	3.65	29.0	0.77	37.8
2	Carbon Monoxide	630-08-0	29,000	290	35.3	280.0	0.47	597.0

Emission Source:

Open burning of HE-contaminated oil was considered at the pit located at TA–16–394.

Notes:

Major Assumptions:

[a] The same modeling procedure that was used to estimate the air quality impacts of toxic air pollutants was applied to criteria pollutants that have the potential to be released from open burning operations at TA–16 under future alternatives. Two criteria pollutants (CO and PM_{10}) were considered from open burning operations of HE-contaminated oil at the burn pit located at TA–16–394. According to Tewerson 1985, there is no significant NO_x emissions as a result of these activities.

[b] Emission rates are presented in Table A. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3), Dispersion Model, Volume 1 (EPA 1992b).

Dispersion Analysis Results:

[c] In this analysis, receptor locations to where the public could have access were considered. These are locations along the south border of TA–16 near State Road 4, bordering Bandelier National Monument. The highest ISC–3 estimated concentration at these receptor locations was found to be 8.2 μg/m³ when emission rate is 1 g/sec.

Guideline Values

[d] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).

[e] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term (8-hour) impacts of the toxic air pollutants.

NA = Not applicable

TABLE F.—*8-Hour SLEV/Q Ratios of the Criteria Pollutants from Open Burning of HE-Contaminated Oil at TA–16*

NO.	CRITERIA AIR POLLUTANTS[a]	CAS NUMBER	OEL[d]	1/100 OF THE OEL[e]	8-HOUR SLEV[c]		ESTIMATED HOURLY EMISSION RATE[b] (Q^h)	SLEV/Q^h RATIO
			µg/m³	µg/m³	g/sec	lb/hr	lb/hr	
1	2	3	4	5	6	7	8	9
1	Particulate Matter (PM_{10})	NA	3,000	30	3.65	29.0	3.07	9.44
2	Carbon Monoxide	630-08-0	29,000	290	35.3	280.0	1.88	149.0

Emission Source:
Open burning of HE-contaminated oil was considered at the pit located at TA–16–394.
Notes:
Major Assumptions:
a The same modeling procedure that was used to estimate the air quality impacts of toxic air pollutants was applied to criteria pollutants that have the potential to be released from open burning operations at TA–16 under future alternatives. Two criteria pollutants (CO and PM_{10}) were considered from open burning operations of HE-contaminated oil at the burn pit located at TA–16–394. According to Tewerson 1985, there is no significant NO_x emissions as a result of these activities.
[b] Emission rates are presented in Table B. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3), Dispersion Model, Volume 1 (EPA 1992b).
Dispersion Analysis Results:
[c] In this analysis, receptor locations where the public could have access to were considered. These are locations along the south border of TA–16 near State Road 4, bordering Bandelier National Monument. The highest ISC–3 estimated concentration at any of these receptor locations was 8.2 µg/m³, when emission rate is 1 g/sec, and the SLEV/Q ratio was greater than 1.
Guideline Values
[d] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).
[e] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term (8-hour) impacts of the toxic air pollutants.
NA = Not applicable

TABLE G.—*VOC/HAP Emissions from Open Burning of Scrap HE at TA–16*

NO.	CONSTITUENTS[d]	AMOUNT OF SCRAP HE BURNED PER YEAR[c]	AMOUNT OF EXPLOSIVE COMPONENTS IN A BURN PRODUCING VOC/HAP[d,e]		EMISSION FACTORS[b]	VOC/HAP POLLUTANTS	
						ANNUAL EMISSION RATE[a]	HOURLY EMISSION RATE[a,f]
		kg/year	lb/year	tons/year	lb/ton	lb/year	lb/hr
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Hydrogen Chloride	48,320	1,065	0.5	22.9	12.2	0.24
2	Hydrogen Fluoride	48,320	1,065	0.5	30.0	16.0	0.32
3	Ammonia	48,320	1,065	0.5	23.9	12.7	0.25
4	Ethanol	48,320	1,065	0.5	160.0	85.2	1.70
5	Methyl Alcohol	48,320	1,065	0.5	99.0	52.7	1.05
6	Acetylene	48,320	1,065	0.5	146.0	77.8	1.56
	Total					257	

Emission Source:
Open burning of scrap HE was considered at the pit located at TA–16–388.
Notes:
Annual and Hourly Emission Rates:
[a] Annual and hourly emission rates of each compound from burning scrap were estimated using applicable emission factors, scrap constituents, and their amount in scrap.
[b] Emission factors in lb/ton for the VOC/HAP constituents were obtained from Table 3–5 entitled, "Air Emissions From Burning of Explosives" (Carter 1978).
[c] The maximum total amount of scrap HE burned per year (48,320 kilograms) and the total estimated amount of VOC/HAP emissions per year (257 pounds) was obtained from Table G of Tewerson 1985.
Major Assumptions:
[d] Constituents of VOC/HAP emissions were selected based on Carter 1978. Due to uncertainty in identifying of typical composition of explosives and their amount in the scrap HE, chemicals of different toxicity were selected to represent the range of toxic emissions that may be emitted.
[e] The content of explosive components in scrap is 1% by weight.
[f] 50 hours of burn operations a year (50 burns per year at 1 hour length of burn).
VOC/HAP = volatile organic compound/hazardous air pollutant

TABLE H.—*8-Hour SLEV/Q Ratios of the Toxic Air Pollutants from Open Burning of Scrap HE at TA–16*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	OEL[d]	1/100 OF THE OEL[e]	8-HOUR SLEV[b,c]		ESTIMATED HOURLY EMISSION RATE[a] (Q^h)	SLEV/Q^h RATIO
			μg/m³	μg/m³	g/sec	lb/hr	lb/hr	
1	2	3	4	5	6	7	8	9
1	Hydrogen Chloride	7647-01-0	7,000	70	1.44E+00	1.14E+01	0.24	4.75E+01
2	Hydrogen Fluoride	7664-39-3	2,490	25	5.11E-01	4.05E+00	0.32	1.27E+01
3	Ammonia	7664-41-7	18,000	180	3.69E+00	2.93E+01	0.25	1.17E+02
4	Acetylene	74-86-2	2,662,000	26,620	5.46E+02	4.33E+03	1.56	2.78E+03
5	Ethanol	64-17-5	1,880,000	18,800	3.86E+02	3.06E+03	1.70	1.80E+03
6	Methyl Alcohol	67-56-1	262,000	2,620	5.38E+01	4.27E+02	1.05	4.06E+02

Emission Source:
Open burning of scrap HE was considered at the pit located at TA–16–388.
Notes:
Major Assumptions:
[a] Emission rates are presented in Table G. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3) Dispersion Model, Volume 1 (EPA 1992b)
Dispersion Analysis Results:
[b] In this analysis, receptor locations where the public could have access to were considered. These are locations along the south border of TA–16 near State Road 4, bordering Bandelier National Monument.
[c] The highest ISC–3 estimated concentration at fence line receptors was found to be 48.7 μg/m³ when emission rate is 1 g/sec.
Guideline Values
[d] OEL = occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH 1997).
[e] 1/100 of the OEL is 8-hour guideline value used in the analysis to estimate short-term (8-hour) impacts of the toxic air pollutants.

TABLE I.—*Annual SLEV/Q Ratios of the Toxic Air Pollutants from Open Burning of Scrap HE at TA–16*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	RfC[c]	ANNUAL SLEVs[b]		ESTIMATED ANNUAL EMISSION RATE[a] (Q[a])	SLEV/Q[a] RATIO
			μg/m³	g/sec	lb/year	lb/year	
1	2	3	4	5	6	7	8
1	Ammonia	7664-41-7	100	1.30E+02	5.14E+04	12.7	4.05E+03
2	Hydrogen Chloride	7647-01-0	20	2.59E+01	1.03E+04	12.2	8.43E+02

Emission Source:
Open burning of scrap HE was considered at the pit located at TA–16–388.
Notes:
Major Assumptions:
[a] Emission rates are presented in Table G. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with an initial dispersion parameters estimated based on an approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3) Dispersion Model, Volume 1 (EPA 1992b).
Dispersion Analysis Results:
[b] The ISC–3 estimated annual concentration used to compute annual SLEV was found to be 0.77 μg/m^3 at sensitive receptors when emission rate is 1 g/sec.
Guideline Value(s):
[c] RfC = Inhalation reference concentrations that represent the annual guideline value(s) used in the analysis to estimate annual impacts of the toxic air pollutants.

TABLE J.—*Annual SLEV/Q Ratios of the Toxic Air Pollutants from Open Burning of Scrap HE at TA–16*

NO.	TOXIC AIR POLLUTANTS	CAS NUMBER	RfC[c]	ANNUAL SLEVs[b]		ESTIMATED ANNUAL EMISSION RATE[a] (Q[a])	SLEV/Q[a] RATIO
			μg/m^3	g/sec	lb/year	lb/year	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Ammonia	7664-41-7	100	1.30E+02	5.14E+04	12.7	4.05E+03
2	Hydrogen Chloride	7647-01-0	20	2.59E+01	1.03E+04	12.2	8.43E+02

Emission Source:
Open burning of scrap HE was considered at the pit located at TA–16–388.
Notes:
Major Assumptions:
[a] Emission rates are presented in Table G. Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with an initial dispersion parameters estimated based on an approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3) Dispersion Model, Volume 1 (EPA 1992b).
Dispersion Analysis Results:
[b] The ISC–3 estimated annual concentration used to compute annual SLEV was found to be 0.77 μg/m^3 at sensitive receptors when emission rate is 1 g/sec.
Guideline Value(s):
[c] RfC = Inhalation reference concentrations that represent the annual guideline value(s) used in the analysis to estimate annual impacts of the toxic air pollutants.

TABLE K.—*Annual Impact Analysis of the Criteria Pollutants from Open Burning of Scrap HE at TA–16–388*

NO.	CRITERIA AIR POLLUTANTS	AVERAGING TIME PERIOD	ANNUAL EMISSION RATE[a,c]	ICS–3 ESTIMATED ANNUAL POLLUTANT CONCENTRATION (C^{an})[b,d]	NATIONAL (NAAQS)	(NAAQS)/(C^{an}) RATIO
			g/sec	μg/m³	μg/m³	
1	2	3	4	5	6	7
1	Particulate Matter (PM_{10})	Annual	9.66E-02	7.49E-02	50	6.68E+02
2	Nitrogen Oxide	Annual	9.68E-02	7.50E-02	100	1.33E+03
3	Carbon Monoxide	Annual	3.73E-02	2.89E-02	80	2.77E+03

Emission Source:
Open burning of scrap HE was considered at the pit located at TA–16–388.
Notes:
Major Assumptions:
[a] Annual emission rates were estimated based on information provided in Table G of Tewerson 1985.
[b] Emissions were modeled as surface-based volume source using EPA's ISC–3 Model with initial dispersion parameters estimated based on approximate tray dimensions. Initial lateral and vertical dimensions of the volume source was estimated based on the EPA Guideline, "Volume Source Inputs," EPA's User's Guide for the Industrial Source Complex (ISC–3) Dispersion Model, Volume 1 (EPA 1992b).
[c] Emissions would be released over 8,760 hours of operations per year.
Dispersion Analysis Results:
[d] 5 years of meteorological data (1991 to 1995) were used in the dispersion modeling analysis. The highest ISC–3 estimated annual concentration (C^{an}) was found to occur during 1991.

ATTACHMENT 13
AIR QUALITY IMPACT ASSESSMENT OF EMISSIONS FROM FIRING SITES

Technical Area(s): TA–14, TA–15, TA–36, TA–39, and TA–40 of the High Explosives Firing Sites (HEFSs)

Emission Sources Detonation of High Explosives at HEFSs Testing Sites

Hydrodynamic experiments involving the detonation of high explosives are conducted at several areas within TA–14, TA–15, TA–36, TA–39, and TA–40. These experiments are used to gain information on the physical properties and dynamic behavior of materials used in nuclear weapons and to evaluate the effects of aging on the nuclear weapons remaining in stockpile. HEFSs combine the capability of testing explosives with the ability to evaluate explosion dynamics.

<u>Screening Analysis</u>

Pollutant(s) Considered

There are up to eight metals that may be emitted into the atmosphere in respirable form during HEFSs testing operations. These include depleted uranium, beryllium, lead, aluminum, copper, tantalum, tungsten, and iron. Two of these TAs (TA–15 and TA–36) have the potential to emit all of these metals; TA–39 may emit all of these metals with the exception of depleted uranium; TA–40 may emit aluminum, copper, tantalum, tungsten, and iron; and TA–14 may emit depleted uranium and lead.

Three of the metals that may be emitted from HEFSs operations, beryllium, lead, and depleted uranium, are highly toxic. The 8-hour Guideline Values (GVs) developed for these pollutants are 0.02 microgram per cubic meter, 0.5 microgram per cubic meter, and 2 micrograms per cubic meter, respectively. The toxicity of depleted uranium is assumed to be the same as for a natural uranium. The other pollutants, copper, tungsten, tantalum, and iron, are moderately toxic, with 8-hour GVs between 10 micrograms per cubic meter and 50 micrograms per cubic meter.

These pollutants were all considered in the air quality impacts analysis. Lithium hydride, another toxic pollutant released from HEFSs operations, was not considered because it is highly reactive and undergoes rapid chemical transformation to lithium hydroxide, which has a very low vapor pressure and no OEL.

Emission Rates of Pollutants Considered

Total amounts of material that are expected to be used for HEFSs activities at each TA, together with the maximum annual and 8-hour respirable release rates were estimated from site operations data. Annual release rates were estimated using the assumption that the release fractions are 10 percent of the total material exploded. The 8-hour release rates of respirable particles were estimated using a scale factor of 0.085. That is, the 8-hour release was estimated by multiplying annual respirable emission rate by a factor of 0.085. This factor was derived from a consideration of the number of tests per year and the range in amount of material per shot, in order to best represent a release of this duration. The 8-hour emission rate is needed for a comparison with the appropriate SLEV.

Estimated emission rates of pollutants used in the dispersion modeling analysis for each TA are presented in Table A.

Dispersion Modeling Analysis

EPA's Puff Model

Total amount of materials released at each TA during HEFSs operations were modeled using the EPA's Puff Model.

Included in the EPA's TSCREEN Model, the Puff Model is designed to assess the impacts of toxic air pollutants from instantaneous releases. The model is applicable if the travel time to the receptor from the source exceeds the release duration and if the release duration is less than the averaging time of interest to the user.

It is assumed that a HEFSs explosion in the atmosphere reasonably simulates an instantaneous release, where all mass is released in less that 1 to 5 minutes.

The Puff Model conservatively uses worst-case meteorological conditions to determine the maximum concentrations at receptors located directly downwind under the plume centerline. The meteorological conditions that result in a maximum concentration at each of the downwind distances are usually a wind speed of 9.1×10^{-4} feet per second (1 meter per second), a low mixing height (984.24 to 1,640.40 feet [300 to 500 meters]), and stable atmospheric conditions.

The Puff Model assumes that all materials (emissions) are released during a very short period of time (i.e., 1 to 5 minutes), with zero emissions the rest of the averaging time. If the release duration is less than the selected averaging time, the model calculates a concentration reduction based on ratio of the duration time to the averaging time. That is, the estimated maximum instantaneous concentration is converted internally by the model to average 1-minute, 5-minute, 15-minute, and 60-minute concentrations. For this analysis, 60-minute concentrations were estimated and these values were then converted to 8-hour values using a factor 0.125.

Model Inputs Used in the Dispersion Analysis

- The total amount of material released projected from the index for this operation
- The initial dispersion parameters were Y = 76.11 feet (23.2 meters) for lateral dispersion and Z = 30.18 feet (9.2 meters) for vertical dispersion
- The downwind distances to the receptor locations were as follows:
  - TA–14: 7,496.63 feet (2,285 meters)
  - TA–15: 4,494.70 feet (1,370 meters)
  - TA–36: 1,640.40 feet (500 meters)

— TA–39: 3,001.93 feet (915 meters)
— TA–40: 4,215.83 feet (1,285 meters)

- Ground level release

Estimated emission rates of the pollutants are summarized in Table A.

Results

Estimated 8-hour pollutant concentrations ($C^{8\text{-hr}}$) were compared with the project's 8-hour GVs, 1/100 of the OEL, for each pollutant. Results of the analysis are presented in Table B.

The $GV/C^{8\text{-hr}}$ ratios are less than one (i.e., the estimated concentration of a pollutants is greater than its GV) for the following releases:

- Depleted uranium, beryllium, lead, aluminum, copper, tantalum, tungsten, and iron from TA–15
- Depleted uranium, beryllium, lead, copper, and iron from TA–36
- Beryllium, lead, aluminum, and copper from TA–39
- Depleted uranium and lead from TA–14
- Copper from TA–40

Based on the ratios, depleted uranium, beryllium, and lead are of particular concern. Additional information for a health risk analysis was therefore provided in a further analysis. Due to the fact that all releases from firing operations are short-term, the releases of these pollutants were not considered in the additive impact analysis, which is associated with long-term exposure.

<u>Detailed Analysis</u>

Detailed dispersion modeling was done for HEFSs for the pollutants that exceeded the short-term GVs using the screening analysis. This modeling was conducted using a combination of HOTSPOT 8.0 model and the ISCST3 model. HOTSPOT was used to calculate the effective release height and lateral and vertical dimensions of the volume. These calculated values were used in the ISCST3 modeling, which was run as a volume source model.

Modeling Assumptions

- Amount considered for each test = 154 pounds (70 kilograms)
- Using HOTSPOT, cloud top was calculated
- Cloud top = 76 $(w)^{0.25}$, where w is in pounds, and cloud top height is in meters
- Cloud top for 154-pound (70-kilogram) HE detonation = 76 $(154 \text{ pounds})^{0.25}$ = 878.3 feet (267.7 meters)
- Cloud radius = 0.2 x cloud top height
- Cloud radius = 0.2 x 267.7 meters
  = 175.7 feet (53.54 meters)
- Effective release height = 0.6 (76) $(w)^{0.25}$

- Effective release height = 0.6 (76) $(w)^{0.25}$
  = 0.6 x 267.7 meters
  = 524.9 feet (160 meters)
- Lateral dimension of the volume in meters, σ_y = 0.5 x cloud radius
- Vertical dimension of the volume in meters, σ_z= 0.2 x cloud top
- Lateral dimension of the volume in meters, σ_y = 0.5 x 53.54
  = 87.8 feet (26.77 meters)
- Vertical dimension of the volume in meters, σ_z= 0.2 x cloud top
  = 0.2 x 267.7
  = 175.7 feet (53.54 meters)

Emission Sources Modeled

TA	BERYLLIUM (Be)	DEPLETED URANIUM (DU)	LEAD (Pb)
TA–14	—	X	X
TA–15	X	X	X
TA–36	X	X	X
TA–39	X	—	X

Both the Expanded Operations and the No Action Alternatives were modeled.

Modeled Emission Rates—Expanded Operations Alternative

SOURCE NUMBER	POLLUTANT	ANNUAL RESPIRABLE EMISSION RATE (kg/yr)	HOURLY MODELED EMISSION RATE (g/sec)
TA–14	Depleted Uranium	3.1	0.0001
	Lead	3.1	0.0001
TA–15	Beryllium	3.0	0.0001
	Depleted Uranium	270.0	0.0086
	Lead	15.0	0.0005
TA–36	Beryllium	3.0	0.0001
	Depleted Uranium	120.0	0.0038
	Lead	3.0	0.0001
TA–39	Beryllium	3.0	0.0001
	Lead	3.0	0.0001

The No Action Alternative emission rates are one-third of the Expanded Operations Alternative emission rates. Therefore, modeling for the No Action Alternative was done using one-third of the emission rates stated in the above table.

Location of Sources and Receptors Modeled

SOURCES AND RECEPTORS	STATE PLANE COORDINATES, EAST (ft)	STATE PLANE COORDINATES, NORTH (ft)
TA–14	1,620,310	1,763,740
Receptor for TA–14	1,620,310	1,756,250
TA–15	1,624,875	1,758,375
Receptor for TA–15	1,622,500	1,754,000
TA–36	1,641,250	1,755,875
Receptor for TA–36	1,642,000	1,757,200
TA–39	1,637,875	1,745,500
Receptor for TA–39	1,636,500	1,742,500

Annual Average Modeled Concentrations

SOURCE NUMBER	POLLUTANT	NO ACTION ALTERNATIVE CONCENTRATION (μg/m^3)	EXPANDED OPERATIONS ALTERNATIVE CONCENTRATION (μg/m^3)
TA–14	Depleted Uranium	0.0	0.0
	Lead	0.0	0.0
TA–15	Beryllium	0.0	0.00001
	Depleted Uranium	0.00015	0.00043
	Lead	0.00001	0.00003
TA–36	Beryllium	0.0	0.00001
	Depleted Uranium	0.00013	0.00039
	Lead	0.0	0.00001
TA–39	Beryllium	0.0	0.00001
	Lead	0.0	0.00001

TABLE A.—*Estimated Emission Rates of the Pollutants That Have the Potential to be Released from High Explosives Firing Sites (HEFSs)*

NO.	TAS WITH HEFSs TESTING OPERATIONS[a]	POLLUTANTS THAT HAVE THE POTENTIAL TO BE RELEASED DURING TESTING OPERATIONS	ESTIMATED MAXIMUM AMOUNT OF MATERIAL THAT WILL BE USED DURING TESTING OPERATIONS[b]	ESTIMATED RESPIRABLE FRACTION RELEASE RATE		
				ANNUAL RATE[b]	8-HOUR RESPIRABLE RELEASE RATE[c]	
			kg/year	kg/year	kilograms	grams[d]
1	2	3	4	5	6	7
1	TA–14	Depleted Uranium	31.4	3.1	2.67E-01	2.67E+02
2		Lead	31.4	3.1	2.67E-01	2.67E+02
1	TA–15	Depleted Uranium	2,700	270.0	2.30E+01	2.30E+04
2		Beryllium	30	3.0	2.56E-01	2.56E+02
3		Lead	150	15.0	1.28E+00	1.28E+03
4		Aluminum	450	45.0	3.83E+00	3.83E+03
5		Copper	300	30.0	2.56E+00	2.56E+03
6		Tantalum	300	30.0	2.56E+00	2.56E+03
7		Tungsten	300	30.0	2.56E+00	2.56E+03
8		Iron	150	15.0	1.28E+00	1.28E+03
1	TA–36	Depleted Uranium	1,200	120.0	1.02E+01	1.02E+04
2		Beryllium	30	3.0	2.56E-01	2.56E+02
3		Lead	30	3.0	2.56E-01	2.56E+02
4		Aluminum	30	3.0	2.56E-01	2.56E+02
5		Copper	30	3.0	2.56E-01	2.56E+02
6		Tantalum	30	3.0	2.56E-01	2.56E+02
7		Tungsten	30	3.0	2.56E-01	2.56E+02
8		Iron	150	15.0	1.28E+00	1.28E+03

TABLE A.—*Estimated Emission Rates of the Pollutants That Have the Potential to be Released from High Explosives Firing Sites (HEFSs)*-Continued

NO.	TAS WITH HEFSs TESTING OPERATIONS[a]	POLLUTANTS THAT HAVE THE POTENTIAL TO BE RELEASED DURING TESTING OPERATIONS	ESTIMATED MAXIMUM AMOUNT OF MATERIAL THAT WILL BE USED DURING TESTING OPERATIONS[b]	ESTIMATED RESPIRABLE FRACTION RELEASE RATE		
				ANNUAL RATE[b]	8-HOUR RESPIRABLE RELEASE RATE[c]	
			kg/year	kg/year	kilograms	grams[d]
1	2	3	4	5	6	7
1	TA–39	Beryllium	30	3.0	2.56E-01	2.56E+02
2		Lead	30	3.0	2.56E-01	2.56E+02
3		Aluminum[e]	45,000	4,500.0	3.83E+02	3.83E+05
4		Copper[e]	45,000	4,500.0	3.83E+02	3.83E+05
5		Tantalum	30	3.0	2.56E-01	2.56E+02
6		Tungsten	30	3.0	2.56E-01	2.56E+02
7		Iron[e]	30,000	3,000.0	2.56E+02	2.56E+05
1	TA–40	Aluminum	240	24.0	2.04E+00	2.04E+03
2		Copper	300	30.0	2.56E+00	2.56E+03
3		Tantalum	90	9.0	7.67E-01	7.67E+02
4		Tungsten	30	3.0	2.56E-01	2.56E+02
5		Iron	60	6.0	5.11E-01	5.11E+02

Notes:
Emission Sources:
[a] Firing operations involve detonations of explosives at TA–14, TA–15, TA–36, TA–39, and TA–40. Particulate emissions released into the atmosphere due to detonation of high explosives contain bonded metal emissions in respirable form.
Emission Rates of Pollutants Considered:
[b] The maximum amount of material that will be used during testing operations and the estimated maximum annual respirable release rates (in kilograms per year per TA) were obtained from Table B for TA–14, Table D for TA–15, Table E for TA–36, Table H for TA–39, and Table J for TA–40 of EPA 1992c. Respirable release rates were estimated based on the assumption that this fraction is 10% of total amount of material exploded.
[c] The total 8-hour respirable release rates (in kilograms), as a results of these operations, were estimated using the scale factor of 0.085.
Major Assumptions:
Lithium hydride was not considered because it is highly reactive and undergoes chemical transformations to lithium hydroxide that has very low vapor pressure and no OEL.
Dispersion Analysis:
[d] The total amount of material released, in grams, was used in dispersion analysis to estimate maximum 1-hour average concentration at specified receptor locations. Each release was modeled using the EPA's Puff Model as an instantaneous release.
[e] These quantities are dominated by the support structures constructed for tests. These structures, in actuality, are not expended in explosive tests and do not contribute to test air emissions.

TABLE B.—*Air Quality Impact Analysis of the Pollutants That Have the Potential to be Released from High Explosives Firing Sites (HEFSs)*

NO.	TAs WITH HEFSs TESTING OPERATIONS[a]	POLLUTANTS THAT HAVE THE POTENTIAL TO BE RELEASED DURING TESTING OPERATIONS	8-HR RELEASE RATE OF RESPIRABLE FRACTION OF METALS	ESTIMATED CONCENTRATION AT THE SPECIFIED DISTANCES[b,c]		GUIDELINE VALUE (GV) (1/100 OF THE OEL)	$GV/C^{8\text{-hr}}$ RATIO
				1-HOUR CONC.[c,e,f] ($C^{1\text{-hr}}$)	8-HOUR CONC.[c] ($C^{8\text{-hr}}$)		
			grams	µg/m³	µg/m³	µg/m³	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	TA–14	Depleted Uranium	2.67E+02	7.17E+01	8.96E+00	2	2.23E-01
2		Lead	2.67E+02	7.17E+01	8.96E+00	0.5	5.58E-02
1	TA–15	Depleted Uranium	2.30E+04	7.61E+03	9.51E+02	2	2.10E-03
2		Beryllium	2.56E+02	8.47E+01	1.06E+01	0.02	1.89E-03
3		Lead	1.28E+03	4.24E+02	5.29E+01	0.5	9.44E-03
4		Aluminum	3.83E+03	1.27E+03	1.58E+02	100	6.31E-01
5		Copper	2.56E+03	8.47E+02	1.06E+02	10	9.44E-02
6		Tantalum	2.56E+03	8.47E+02	1.06E+02	50	4.72E-01
7		Tungsten	2.56E+03	8.47E+02	1.06E+02	50	4.72E-01
8		Iron	1.28E+03	4.24E+02	5.29E+01	50	9.44E-01
1	TA–36	Depleted Uranium	1.02E+04	3.97E+03	4.97E+02	2	4.03E-03
2		Beryllium	2.56E+02	9.97E+01	1.25E+01	0.02	1.60E-03
3		Lead	2.56E+02	9.97E+01	1.25E+01	0.5	4.01E-02
4		Aluminum	2.56E+02	9.97E+01	1.25E+01	100	8.02E+00
5		Copper	2.56E+02	9.97E+01	1.25E+01	10	8.02E-01
6		Tantalum	2.56E+02	9.97E+01	1.25E+01	50	4.01E+00
7		Tungsten	2.56E+02	9.97E+01	1.25E+01	50	4.01E+00
8		Iron	1.28E+03	4.99E+02	6.23E+01	50	8.02E-01

TABLE B.—*Air Quality Impact Analysis of the Pollutants That Have the Potential to be Released from High Explosives Firing Sites (HEFSs)*-Continued

NO.	TAs WITH HEFSs TESTING OPERATIONS[a]	POLLUTANTS THAT HAVE THE POTENTIAL TO BE RELEASED DURING TESTING OPERATIONS	8-HR RELEASE RATE OF RESPIRABLE FRACTION OF METALS	ESTIMATED CONCENTRATION AT THE SPECIFIED DISTANCES[b,c]		GUIDELINE VALUE (GV) (1/100 OF THE OEL)	$GV/C^{8\text{-hr}}$ RATIO
				1-HOUR CONC.[c,e,f] ($C^{1\text{-hr}}$)	8-HOUR CONC.[c] ($C^{8\text{-hr}}$)		
			grams	μg/m³	μg/m³	μg/m³	
1	2	3	4	5	6	7	8
1	TA–39	Beryllium	2.56E+02	9.30E+01	1.16E+01	0.02	1.72E-03
2		Lead	2.56E+02	9.30E+01	1.16E+01	0.5	4.30E-02
3		Aluminum	3.83E+05	1.39E+05	1.74E+04	100	5.75E-03
4		Copper	3.83E+05	1.39E+05	1.74E+04	10	5.75E-04
5		Tantalum	2.56E+02	9.30E+01	1.16E+01	50	4.30E+00
6		Tungsten	2.56E+02	9.30E+01	1.16E+01	50	4.30E+00
7		Iron	2.56E+02	9.30E+01	1.16E+01	50	4.30E+00
1	TA–40	Aluminum	2.04E+03	6.87E+02	8.59E+01	100	1.16E+00
2		Copper	2.56E+03	8.63E+02	1.08E+02	10	9.27E-02
3		Tantalum	7.67E+02	2.58E+02	3.23E+01	50	1.55E+00
4		Tungsten	2.56E+02	8.63E+01	1.08E+01	50	4.64E+00
5		Iron	5.11E+02	1.72E+02	2.15E+01	50	2.32E+00

Notes:
Emission Sources:
[a] Firing operations involve detonations of explosives at TA–14, TA–15, TA–36, TA–39, and TA–40. Particulate emissions released into the atmosphere due to detonation of high explosives contain bounded metal emissions in respirable form.
Emission Rates of Pollutants Considered:
[b] Emission rates of pollutants are from Table A.
Major Assumptions:
[c] Estimated 1-hour average concentrations was converted to 8-hour concentrations using a conversion factor of 0.125.
Dispersion Analysis:
[d] Total amounts of material released at each TA over 8-hour period were modeled using the EPA's PUFF Model as an instantaneous release scenario with assumed initial dispersion parameters. The lateral dispersion parameter (sigma Y) was assumed to be 23.2 meters; the vertical dispersion parameter (sigma Z) was assumed to be 9.2 meters.
[e] The conditions that produced the maximum concentrations at each of the downwind distances were: wind speed of 1 m/sec; mixing height of 320 meters; and stable atmospheric conditions.
[f] The downwind distances at which off-site concentrations were estimated were selected on TA by TA basis. These distances are as follows: TA–14, 2,285 meters; TA–15, 1,370 meters; TA–36, 500 meters; TA–39, 915 meters; and TA–40, 1,285 meters.

ATTACHMENT 14
AIR QUALITY IMPACT ASSESSMENT OF THE HEALTH RESEARCH LABORATORY (TA–43) EMISSIONS

Technical Area: TA–43

Emission Source(s)

There are four emission exhaust ducts located on the roof of the Health Research Laboratory (HRL) that emit carcinogenic pollutants from HRL operations. The pollutants of concern for this analysis are chloroform, trichloroethylene, methylene chloride, formaldehyde, and acrylamide.

The releases of pollutants may potentially impact nearby sensitive receptors (such as air intake shafts and/or operable windows) at the LANL Medical Center located in close proximity to HRL. Numerous receptor locations along the face and roof of the hospital were considered. Closest to HRL exhaust duct is an air intake shaft (#1) located within distance of 328 feet (100 meters) of stack B247 on the roof of the HRL.

Source Term Parameters

Annual pollutant emission rates were estimated were those projected for the Expanded Operations Alternative. Associated stack parameters and locations are presented in Table A. It was assumed that annual emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA's ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings, including the Medical Center and HRL Building 1, within the zone of the stack plume influence were considered in the downwash analysis.

The highest annual average concentrations of these pollutants were found at the elevated receptors of the Medical Center. These values were then used to estimate the incremental cancer risk of these releases using appropriate unit risk factors.

Results

Results of the analysis are presented in Tables B and C. As shown in Table C, four of the five pollutants considered (chloroform, trichloroethylene, formaldehyde, and acrylamide) have the estimated maximum cancer risk values greater than Guideline Value of 1.0×10^{-8}.

The maximum annual concentration of 3.04×10^{-2} micrograms per cubic meter was estimated for chloroform, the most critical of these carcinogens, at one of the air intake shaft of the Medical Center located at a height of 40 feet (12.2 meters) above the ground level (Refer to the Receptor #175 of the LANL sensitive receptors). The maximum cancer risk of chloroform is estimated to be 6.99×10^{-7} at this location, and sum of the cancer risks of all of these carcinogens combined is estimated to be 7.79×10^{-7}. These pollutants were further evaluated as a part of the additive impact analysis.

TABLE A.—*Stack Parameters and Estimated Annual Emission Rates of the Carcinogenic Pollutants That Have the Potential to be Released from the Health Research Laboratory of the TA–43 Facilities*

NO.	POLLUTANTS	STACK ID	STACK PARAMETERS				ANNUAL AVERAGE EMISSION RATES	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/year	g/sec
1	Acrylamide	Bldg. 247	380883; 3971376	12.80	13.41	0.18	5.86E-03	8.44E-08
		Bldg. 124/126	380838; 3971363	14.02	13.41	0.18	5.86E-03	8.44E-08
		N. Side FH	380848; 3971377	16.61	13.41	0.18	5.86E-03	8.44E-08
		S. Side FH	380854; 3971340	12.80	13.41	0.18	5.86E-03	8.44E-08
2	Chloroform	Bldg. 247	380883; 3971376	12.80	13.41	0.18	2.20E+00	3.17E-05
		Bldg. 124/126	380838; 3971363	14.02	13.41	0.18	2.13E+01	3.07E-04
		N. Side FH	380848; 3971377	16.61	13.41	0.18	2.13E+01	3.07E-04
		S. Side FH	380854; 3971340	12.80	13.41	0.18	2.13E+01	3.07E-04
3	Formaldehyde	Bldg. 247	380883; 3971376	12.80	13.41	0.18	1.73E-01	2.50E-06
		Bldg. 124/126	380838; 3971363	14.02	13.41	0.18	1.68E+00	2.41E-05
		N. Side FH	380848; 3971377	16.61	13.41	0.18	1.68E+00	2.41E-05
		S. Side FH	380854; 3971340	12.80	13.41	0.18	1.68E+00	2.41E-05
4	Methylene Chloride	N. Side FH	380848; 3971377	16.61	13.41	0.18	9.46E-01	1.36E-05
		S. Side FH	380854; 3971340	12.80	13.41	0.18	9.46E-01	1.36E-05
5	Trichloethylene	N. Side FH	380848; 3971377	16.61	13.41	0.18	1.02E+01	1.47E-04

TABLE B.—*ISC–3 Estimated Annual Concentrations of the Carcinogenic Pollutants That Have the Potential to be Released from the Health Research Laboratory of the TA–43 Facilities Using 1991 to 1995 Meteorological Data*

NO.	POLLUTANTS	ANNUAL ISC–3 ESTIMATED CONCENTRATIONS ($\mu g/m^3$)				
		METEOROLOGICAL DATA				
		1991	1992	1993	1994	1995
1	Acrylamide	1.11E-05	1.04E-05	1.15E-05	1.13E-05	1.15E-05
2	Chloroform	2.89E-02	2.60E-02	2.99E-02	2.95E-02	3.04E-02
3	Formaldehyde	2.28E-03	2.04E-03	2.36E-03	2.32E-03	2.40E-03
4	Methylene Chloride	7.20E-04	6.40E-04	7.80E-04	7.60E-04	7.60E-04
5	Trichloroethylene	3.18E-03	2.82E-03	3.22E-03	3.30E-03	3.34E-03

TABLE C.—*Results of the Dispersion Modeling Analysis of the Carcinogenic Pollutants from the Health Research Laboratory at TA–43*

NO.	CARCINOGENIC POLLUTANTS	CAS NUMBER	CAR CLASS	UNIT RISK FACTORS (URF)	ISC–3 ESTIMATED ANNUAL CONCENTRATION1 (C_{an})	MAXIMUM CANCER RISK (C_{an} x URF)	GUIDELINE VALUE
				$(\mu g/m^3)^{-1}$	$\mu g/m^3$		
1	**2**	**3**	**4**	**5**	**6**	**7**	**6**
1	Acrylamide	79-06-1	B2	1.30E-03	1.15E-05	1.50E-08	
2	Chloroform	67-66-3	B2	2.30E-05	3.04E-02	6.99E-07	
3	Formaldehyde	50-00-0	B1	1.30E-05	2.40E-03	3.12E-08	
4	Methylene Chloride	75-09-2	B2	4.70E-07	7.80E-04	3.67E-10	
5	Trichloroethylene	79-01-6	B2	1.00E-05	3.34E-03	3.34E-08	
Total Combined Maximum Cancer Risk						7.79E-07	1.00E-08

ATTACHMENT 15
AIR QUALITY IMPACT ASSESSMENT OF THE TA–53 CHLOROFORM EMISSIONS

Technical Area: TA–53, Building MPF–15

Emission Source(s)

Chloroform is used for cleaning in preparation for surface chemistry studies using the LANSCE neutron beam. All of the chloroform used evaporates during this process.

There are two emission sources of the chloroform emissions at TA–53; both are located on Building MPF–15. One emission source is an exhaust duct from the clean room and the other is an exhaust duct from chemistry laboratory.

Source Term Parameters

Stack parameters and their locations are provided in Table A.

Emission Rates of Pollutants Considered

Estimated annual emission rates of chloroform from the two emission sources are shown in Table A. All chloroform used is assumed released into the atmosphere. It was assumed that emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA's ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings within the zone of stack plume influence were considered in the downwash analysis. The highest annual concentration estimated by the ISC–3 Model (Table B) was used to estimate the maximum cancer risk of chloroform releases using its unit risk factor.

Results

Results of the analysis are presented in Tables B and C. As shown in Table C, the maximum combined cancer risk associated with releases of chloroform from two emission sources on building MPF–15 of the TA–53 facility is 1.29×10^{-8}, which is above the Guideline Value of 1.0×10^{-8}. This pollutant was, therefore, further evaluated as part of the additive impact analysis.

TABLE A.—*Stack Parameters and Emission Rate of the Chloroform Associated with TA–53 Building MPF–15*

NO.	EMISSIONS SOURCE	STACK ID	STACK PARAMETERS				ESTIMATED ANNUAL EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/year	g/sec
1	TA–53 MPF–15 Clean Room	Bldg. 15	386592; 3969778	10.97	15.52	0.15	1.20E+01	1.73E-04
2	TA–53 MPF–15 Chemistry Lab.	Bldg. 15	386589; 3969789	9.30	5.41	0.36	4.00E+00	5.76E-05

TABLE B.—*ISC–3-Estimated Annual Concentration of the Chloroform Associated with Emission Source of the TA–53 MPF–15 Using 1991 to 1995 Meteorological Data*

EMISSION SOURCE	ISC–3 ESTIMATED ANNUAL AVERAGE CONCENTRATIONS (μg/m^3)				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–53 MPF–15 Chemistry Lab. & Clean Room	4.30E-04	5.60E-04	5.20E-04	5.20E-04	5.30E-04

TABLE C.—*Results of the Dispersion Modeling Analysis of the Chloroform Emissions from TA–53 Building MPF–15*

NO.	EMISSION SOURCE	CHLOROFORM UNIT RISK FACTOR (URF)	ISC–3 ESTIMATED ANNUAL CONCENTRATION (C_{an})	MAXIMUM CANCER RISK (C_{an} x URF)	GUIDELINE VALUE
		(μg/m^3)$^{-1}$	μg/m^3		
1	**2**	**3**	**4**	**5**	**6**
1	TA–53 MPF–15 Chemistry Lab. & Clean Room	2.30E-05	5.60E-04	1.29E-08	1.00E-08

ATTACHMENT 16
AIR QUALITY IMPACT ASSESSMENT OF THE TA–55 BERYLLIUM EMISSIONS

Technical Area: TA–55, Building PF–4

Emission Source(s)

There are two beryllium emission sources at TA–55, located on Building PF–4, TA–55 FE–15 and TA–55 FE–16.

Source Term Parameters

Stack parameters and their locations are shown in Table A.

Emission Rates of Pollutants Considered

Annual emission rates of the beryllium were estimated based on the existing permit application for TA–55. Emissions from these sources are released to the atmosphere through a HEPA filtration system, with a removal efficiency of 99.95 percent. Controlled emission rates are estimated to be 3.0×10^{-3} pounds per year for TA–55 FE–15 and 4.2×10^{-3} pounds per year for TA–55 FE–16.

Estimated annual emission rates of the beryllium that were used in the analysis are shown in Table A. It was assumed that emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA's ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings within the zone of stack plume influence were considered in the downwash analysis. The highest annual concentration estimated by the ISC–3 Model (Table B) was used to compute the maximum combined cancer risk of beryllium releases using its unit risk factor.

Results

Results of the analysis are presented in Tables B and C. As shown in Table C, the combined cancer risk associated with releases of beryllium from emission sources on Building PF–4, TA–55 FE–15 and TA–55 FE–16, is 2.35×10^{-10}, which is below the Guideline Value of 1.0×10^{-8}.

TABLE A.—*Stack Parameters and Annual Beryllium Emission Rates Associated with TA–55 Building PF–4 Emission Sources FE–15 and FE–16*

NO.	EMISSION SOURCES	STACK ID	STACK PARAMETERS				PERMITTED ANNUAL EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/year	g/sec
1	TA–55 FE–15	FE–15	382458; 3969439	15.24	19.20	0.91	3.00E-03	4.32E-08
2	TA–55 FE–16	FE–16	382416; 3969359	9.45	12.80	0.91	4.20E-03	6.05E-08

TABLE B.—*TA–55 ISC–3 Estimated Annual Concentrations of the Beryllium Using 1991 to 1995 Meteorological Data*

EMISSION SOURCE	ISC–3 ESTIMATED ANNUAL AVERAGE CONCENTRATION (μg/m^3)				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–55 Building PF–4 FE–15 & FE–16	9.00E-08	6.40E-08	9.90E-08	8.70E-08	9.60E-08

TABLE C.—*Results of the Dispersion Modeling Analysis of the Beryllium Emissions from TA–55 Sources FE–15 and FE–16*

NO.	EMISSION SOURCE	BERYLLIUM UNIT RISK FACTOR (URF)	ISC–3 ESTIMATED ANNUAL CONC (C_{an})	COMBINED MAXIMUM CANCER RISK (C_{an} X URF)	GUIDELINE VALUE
		(μg/m^3)$^{-1}$	μg/m^3		
1	**2**	**3**	**4**	**5**	**6**
1	TA–55 Building PF–4 FE–15 & FE–16	2.40E-03	9.90E-08	2.38E-10	1.00E-08

ATTACHMENT 17
AIR QUALITY IMPACT ASSESSMENT OF THE TA–55 HYDROCHLORIC AND NITRIC ACID EMISSIONS

Technical Area: TA–55, Building PF–4, Stacks FE–15 and FE–16

Emission Source(s)

The chemistry group at TA–59 uses nitric and hydrochloric acids for the recovery of plutonium. There are few emission sources of hydrochloric and nitric acid at TA–55. The two sources that were considered in the analysis include stacks FE–15 and FE–16, located on Building PF–4.

Source Term Parameters

Stack parameters and their locations are provided in Table A.

Emission Rates of Pollutants Considered

Estimated maximum hourly emission rates of nitric acid and hydrochloric acids associated with stacks FE–15 and FE–16 that were used in the analysis are shown in Table A. It was assumed that emissions would be released over 8,760 hours of operation per year.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA's ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings within the zone of stack plume influence were considered in the downwash analysis.

The ISC–3-estimated 8-hour concentrations of nitric and hydrochloric acids are shown in Table B. Using these values and appropriate 8-hour Guideline Values (GVs), 8-hour SLEVs were estimated and compared to hourly emission rates of these pollutants.

Results

Results of the analysis are presented in Table C. As shown in Table C, the 8-hour concentrations of both hydrochloric acid and nitric acid are below the 8-hour GVs. Accordingly, 8-hour SLEV/Q ratios are all greater than one. That is, the estimated nitric acid and hydrochloric acid levels are below the applicable GVs.

TABLE A.—*Stack Parameters and Emission Rate of Hydrochloric and Nitric Acid Associated with TA–55 Building PF–4*

NO.	EMISSION SOURCE/ POLLUTANT	STACK ID	STACK PARAMETERS				MAXIMUM HOURLY EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	lb/hour	g/sec
	TA–55 Building PF–4	FE–15	382458; 3969439	15.24	19.20	0.91		
1	Hydrochloric Acid						0.533	0.0672
2	Nitric Acid						0.360	0.0454
	TA–55 Building PF–4	FE–16	382416; 3969359	9.45	12.80	0.91		
1	Nitric Acid						2.42	0.305

TABLE B.—*ISC–3 Estimated 8-Hour Concentration of the Hydrochloric and Nitric Acid Associated with TA–55 Building PF–4 Using 1991 to 1995 Meteorological Data*

NO.	EMISSION SOURCE/POLLUTANT	ISC–3 ESTIMATED 8-HOUR CONCENTRATION (μg/m^3)				
		METEOROLOGICAL DATA				
		1991	1992	1993	1994	1995
1	TA–55 Building PF–4, Stack FE–15, Hydrochloric Acid	2.36	2.81	1.87	3.10	1.94
2	TA–55 Building PF–4, Stack FE–15/FE–16, Nitric Acid	39.8	35.9	41.5	41.8	33.0

TABLE C.—***Results of the Dispersion Modeling Analysis of the Hydrochloric and Nitric Acid Emission from TA–55 Building PF–4 Stack FE–15 and FE–16***

NO.	SOURCE	POLLUTANT	ISC–3 ESTIMATED 8-HOUR CONCENTRATION	GUIDELINE VALUE (1/100 OF THE OELS)	8-HOUR SLEVS	HOURLY EMISSION RATE (Q^h)	SLEVS/Q^h RATIO
			μg/m^3	μg/m^3	lb/hr	lb/hr	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	TA–55 Building PF–4, Stack FE–15	Hydrochloric Acid	3.10	70.0	12.0	0.533	22.5
2	TA–55 Building PF–4, Stack FE–15/FE–16	Nitric Acid	41.8	52.0	3.46	2.78	1.25

ATTACHMENT 18
AIR QUALITY IMPACT ASSESSMENT OF THE TA–59 HYDROCHLORIC AND NITRIC ACIDS EMISSIONS

Technical Area: TA–59, Building 1

Emission Source(s)

The radio chemistry group at TA–59 uses large quantities of nitric and hydrochloric acid for the digestion and separation processes. One percent of each chemical is estimated to be released to the atmosphere due to container transfer.

There are two groups of emission sources of the hydrochloric and nitric acid at TA–59. They are both located on Building 1 and include exhaust fume hoods from laboratory rooms. One group of emission sources is associated with Hoods #102 through 106, and the other with Hoods #184 through 186. One representative stack with equivalent source parameters was used in the dispersion analysis for each group of these emissions sources.

Source Term Parameters

Stack parameters and their locations are provided in Table A.

Emission Rates of Pollutants Considered

Estimated maximum hourly emission rates of nitric acid and hydrochloric acids associated with two groups of emission sources that were used in the analysis are shown in Table A.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA's ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings within the zone of stack plume influence were considered in the downwash analysis.

Due to the fact that laboratory operating schedules are related to the daytime, the 8-hour concentration was computed for this time period. The highest daytime 8-hour concentration of hydrochloric and nitric acid was found to occur between 8:00 a.m. and 4:00 p.m. in 1991, at the receptor site located near boundary of TA–59 on Pajarito Road (Table B). These concentrations were compared to the appropriate 8-hour Guideline Values (GVs).

Results

Results of the analysis are presented in Table C. As shown in Table C, the 8-hour concentration of the nitric acid is above the 8-hour GV, and the 8-hour concentration of the hydrochloric acid is below the 8-hour GV. The results of the nitric acid analysis, therefore, were referred to the human health and ecological risk assessment process.

TABLE A.—*Stack Parameters and Emission Rate of the Hydrochloric and Nitric Acid Associated with Emission Sources of the TA–59 Building 1*

NO.	EMISSION SOURCE/ POLLUTANT[a]	STACK PARAMETERS					ESTIMATED MAXIMUM HOURLY EMISSION RATE	
		UTM COORD. (X; Y)	HEIGHT	AIRFLOW[b,c]	VELOCITY	DIAMETER		
		m	m	m^3/sec	m/sec	m	lb/hr	g/sec
1	TA–59 Rooms 102-106, Nitric Acid	381228; 3969886	18.29	8.73	14.06	0.89	5.00E+00	6.30E-01
2	TA–59 Rooms 184-186, Nitric Acid	381218; 3969911	12.27	0.54	5.80	0.34	2.50E+00	3.15E-01
3	TA–59 Rooms 102-106, Hydrogen Chloride	381228; 3969886	18.29	8.73	14.06	0.89	1.48E+00	1.86E-01
4	TA–59 Rooms 184-186, Hydrogen Chloride	381218; 3969911	12.27	0.54	5.80	0.34	7.20E-01	9.07E-02

Notes:
[a] All emission sources associated with a fume hoods on Building 1 were divided into the two categories: emission sources from Room 102-106 and emission sources from Room 184-186. A representative stack from each group of emissions sources was used in the dispersion modeling analysis.
[b] Due to the fact that fume hoods in Rooms 102, 103, 104, and 106 are connected to the central exhaust system, the total airflow rate of 18,500 cubic feet per minute going through the central system was used to estimate the average flow rate associated with a first group of emission sources.
[c] The average airflow rate associated with fume hoods of the second group of emission sources was estimated using the actual flow rate of each hood.

TABLE B.—*ISC–3 Estimated 8-Hour Concentration of the Hydrochloric and Nitric Acid Associated with Emission Source of the TA–59 Building 1 Using 1991 to 1995 Meteorological Data*[a]

EMISSION SOURCE/POLLUTANT	8-HOUR ESTIMATED CONCENTRATIONS (μg/m^3) METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–59 Building 1, Nitric Acid	83.8	87.4	120.0	91.8	83.2
TA–59 Building 1, Hydrogen Chloride	24.2	25.2	34.7	26.5	24.0

[a] The highest ISC–3 estimated 8-hour concentration of nitric and hydrochloric acid during daytime (between 8 a.m. and 4 p.m.) was found to occur in 1993.

TABLE C.—*Results of the Dispersion Modeling Analysis of the Hydrochloric and Nitric Acid Emissions from TA–59 Building 1*

NO.	POLLUTANT	ISC–3 ESTIMATED 8-HOUR CONCENTRATION μg/m^3	8-HOUR GUIDELINE VALUE (1/100 OF THE OELs) μg/m^3	GV/8-HOUR CONCENTRATION RATIO
1	2	3	4	5
1	Nitric Acid	120.0	52.0	0.433
2	Hydrogen Chloride	34.7	70.0	2.02

ATTACHMENT 19
AIR QUALITY IMPACT ASSESSMENT OF THE TA–53 OZONE EMISSIONS

Technical Area: TA–53, Building MPF–14

Emission Source(s)

Ozone is generated as a by-product from operation of the advanced free electron laser at TA–53. The source of ozone emissions is located at TA–53 Building MPF–14.

Source Term Parameters

Stack parameters, locations of emission sources, and the estimated maximum hourly emission rates of ozone are shown in Table A.

Dispersion Modeling Analysis

An air quality impacts analysis was conducted using EPA's ISC–3 Model and 5 years of on-site meteorological data. All nearby buildings within the zone of stack plume influence were considered in the downwash analysis.

The ISC–3-estimated 1-hour and 8-hour ozone concentrations are provided in Tables B and C, respectively. These values were compared with corresponding 1-hour National Ambient Air Quality Standards (NAAQS) ozone standard, and appropriate 8-hour Guideline Values (GVs).

Results

Results of the analysis are presented in Table D. As shown in Table D, the 1-hour and 8-hour ozone concentrations are below the applicable standards and GVs.

TABLE A.—*Stack Parameters and Emission Rate Associated with Ozone Emissions from TA–53 Building MPF–14*

NO.	EMISSION SOURCE	STACK ID	STACK PARAMETERS				MAXIMUM HOURLY EMISSION RATE	
			UTM COORD. (X; Y)	HEIGHT	VELOCITY	DIAMETER		
			m	m	m/sec	m	g/hr	g/sec
1	TA–53 MPF–14	B14	386180; 3969696	1.8	5.0	0.35	8.58E-01	2.38E-04

TABLE B.—*ISC–3 Estimated 1-Hour Concentration of the Ozone Associated with Emission Source of the TA–53 MPF–14 Using 1991 to 1995 Meteorological Data*

EMISSION SOURCE	ISC–3 ESTIMATED 1-HOUR CONCENTRATION (µg/m^3)[a]				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–53 Building MPF–14	0.858	0.332	0.608	0.503	0.343

Note:
[a] 5 years of meteorological conditions were used in the dispersion analysis. The ISC–3 estimated 1-hour ozone concentration was found to occur in 1991.

TABLE C.—*ISC–3 Estimated 8-Hour Ozone Concentration Associated with Emission Source of the TA–53 MPF–14 Using 1991 to 1995 Meteorological Data*

EMISSION SOURCE	ISC–3 ESTIMATED 8-HOUR CONCENTRATION (μg/m³)				
	METEOROLOGICAL DATA				
	1991	1992	1993	1994	1995
TA–53 Building MPF–14	1.07E-01	5.85E-02	7.59E-02	6.41E-02	4.84E-02

TABLE D.—*Results of the Dispersion Modeling Analysis of the Ozone Emissions from TA–53 Building MPF–14*

EMISSION SOURCE	ISC–3 ESTIMATED CONCENTRATION		NAAQS[a] 1-HOUR CONCENTRATION	8-HOUR GUIDELINE VALUE (1/100 OF THE OELS)
	1-HOUR CONCENTRATION	8-HOUR CONCENTRATION		
	μg/m³	μg/m³	μg/m³	μg/m³
1	2	3	4	5
TA–53, Building MPF–14	0.858	0.107	235	2

[a] NAAQS = National Ambient Air Quality Standards

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REFERENCES

ACGIH 1997 — *Guide to Occupational Exposure Values*. American Conference of Governmental Industrial Hygienists. 1997

Auer 1978 — "Correlation of Land Use and Cover with Meteorological Anomalies." A. H. Auer. *Journal of Applied Meteorology.* Vol. 17. 1978

BBER 1995 — *Projected Population Data for New Mexico Counties.* Bureau of Business and Economic Research. Santa Fe, New Mexico. 1995.

Bowen 1990 — *Los Alamos Climatology*. Brent Bowen. LA-11735-MS. UC-902. University of California, Berkeley, and Los Alamos National Laboratory. Los Alamos, New Mexico. 1990.

Carter 1978 — *Emissions from Open Burning or Detonation of Explosives*. Roy V. Carter. Paper presented at the 71st meeting of the Air Pollution Control Association. Houston, Texas. June 25–30, 1978.

DOC 1991 — *1990 Census of Population and Housing: Summary Population and Housing Characteristics, New Mexico*. U.S. Department of Commerce, Bureau of the Census. 1990 CPH-1-33. Washington, D.C. August 1991.

EPA 1988 — *A Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division. EPA-450/4-88-009. Research Triangle Park, North Carolina. 1988.

EPA 1992a — *User Guide for CAP–88-PC*. U.S. Environmental Protection Agency. Washington, D.C. March 1992.

EPA 1992b — *Industrial Source Complex (ISC) Dispersion Model User Guide*, Volume 1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division. EPA-450/4-92-008a. Research Triangle Park, North Carolina. 1992.

EPA 1992c — *Guideline on Air Quality Models* (Revised). U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. EPA-450/2-78-027R. Research Triangle Park, North Carolina. 1992.

EPA 1992d — *Tutorial Package For the TSCREEN Model, Puff Model.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division. EPA-450/4-90-013. Research Triangle Park, North Carolina. 1992.

EPA 1992e *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources*, Revised. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. EPA-454/R-92-019. Research Triangle Park, North Carolina. 1992.

EPA 1992f *A Tiered Modeling Approach For Assessing The Risks Due To Sources Of Hazardous Air Pollutants.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division. EPA-450/4-92-001. Research Triangle Park, North Carolina. 1992.

EPA 1993a *User's Guide to the Building Profile Input Program (BPIP).* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Technical Support Division. Research Triangle Park, North Carolina. 1993.

EPA 1993b *Integrated Risk Information System (IRIS) Data Base,* Version 1.0. U.S. Environmental Protection Agency, Office of Research and Development. 1993.

EPA 1995 "Compilation of Air Pollutant Emission Factors," Vol. 1. *Stationary Point and Area Sources*. U.S. Environmental Protection Agency. AP-42. January 1995

LANL 1990 *Nonradioactive Air Emissions Inventory* (Regulated Air Pollutants Reports). Los Alamos National Laboratory, Air Quality and Meteorology Section, Environmental Protection (EM–8), Environmental Management. Los Alamos, New Mexico. 1990.

LANL 1995a *Automatic Chemical Inventory System.* Los Alamos National Laboratory. Los Alamos, New Mexico. January 1996.

LANL 1995b *20 NMAC 2.70 Operating Permit Application for Los Alamos National Laboratory* (Title V Permit Application). Los Alamos National Laboratory. LA-UR-95-4192. Los Alamos, New Mexico. December 1995.

ORNL-LLNL 1996 *HOTSPOT 8.0,* CCC-644. Radiation Shielding Information Center. Oak Ridge National Laboratory and Lawrence Livermore Laboratory. January 1996.

TCI 1996 *Breeze Air™ ISC–3, Version 2.0, User's Guide for Windows.* Trinity Consultants Incorporated. 1996.

Tewerson 1985 *Prediction of Fire Properties of Materials,* Part 1. A. Tewerson. Factory Mutual Research Corporation. December 1985.

APPENDIX C
CONTAMINANT DATA SETS SUPPORTING ECOLOGICAL AND HUMAN HEALTH CONSEQUENCE ANALYSIS

Appendix C consists of nine statistical data tables constructed from databases maintained as part of LANL's Environmental Surveillance Program and Environmental Restoration (ER) Project. The tables include columns for: (1) the number of times for which the analyte was detected; (2) the number of times the analyte was sampled; (3) units; (4) the minimum, maximum, and arithmetic mean values; and (5) the 95 percent confidence limit (mean, plus two standard deviations). Only analytes that were detected at least once during the sampling period (1990 to 1996) are shown. Mean values and values for the 95 percent confidence interval are reported in exponential notation and rounded to two significant figures.

The NPDES table, Table C–1, consists of 1994 to 1996 data tabulated by the Water Quality and Hydrology Group (ESH–18) from laboratory inorganic trace analysis (CST–9) reports. The data are arranged by watershed.

Surface water and sediment tables, Tables C–2 through C–5, consist of environmental surveillance and compliance program data from the years 1991 through 1996, found in the LANL Environmental Surveillance Reports (e.g., *Environmental Surveillance at Los Alamos During 1995*, LANL 1996b). The data are arranged by location (on site, perimeter, and regional) and by watershed.

Groundwater tables, Tables C–6 and C–7, also consist of LANL environmental surveillance compliance program data from 1991 through 1996, found in the LANL Environmental Surveillance and Reports. The data are arranged by groundwater regime (alluvial, intermediate, and main) and by watershed (for alluvial and intermediate only).

Soils tables, Tables C–8 and C–9, consist of ER Project data. The data are arranged by both analyte and by watershed. Tables C–8 and C–9 in the Draft SWEIS contained incorrect data and these two tables have been completely reconstructed to eliminate these errors. These errors were a result of including data collected in the early phases of the ER Project that had not undergone quality assurance screening. These data contained known laboratory analytical errors, contained errors in unit conversions, and contained errors from samples contaminated either during sample collection or in the chemical laboratory during analysis. The problem occurred during data extraction because these samples with known problems were not screened. The corrected tables only use those data from the ER Project that have undergone quality assurance screening and are known to be error free.

Tables were constructed by first summing the total number of analyses for each analyte and reporting the number in the "Analyzed" column of each table. For radioactivity measurements, all zero and negative results were removed from the data set, and the remaining results were summed for each analyte and reported in the "Detected" column. Thus, for radionuclides, many results below the detection limit determined by the analytical laboratory are represented in the table as "Detects." For constituents other than radioactivity measurements, all non-detect results were removed from the data set, and the remaining results were summed for each analyte and reported in the "Detected" column. These detected results were used to calculate the minimum, mean, maximum, and 95 percent confidence limit. The detected results were not compared to either the detection limit for the analytical laboratory or the associated counting uncertainty for radionuclides. Thus, for radiochemical analyses of groundwater, surface water, and sediment, the detected results do not agree with LANL's Environmental Surveillance Program's definition of "detects" as results that are (1) greater than the detection limit and (2) equal to or greater than 4.66 times the counting uncertainty.

Because only positive "detects" were averaged, not the total number of samples analyzed, the number of "detects" is thus higher than reported in the LANL Environmental Surveillance Reports, and the mean and 95 percent upper confidence limits appearing in the Appendix C tables are artificially high. When used elsewhere in the SWEIS, such as in the analyses of human health impacts, these values thus (intentionally) result in conservative estimates of the consequences of LANL operations.

Data from Tables C–1 through C–7 were used in the study of the ingestion pathway in the human health analysis (section D.3.3 of appendix D). Data from Tables C–8 and C–9 are not used in the SWEIS but provided for additional information.

TABLE C–1.—*NPDES Detection Statistics by Watershed (NPDES Data 1994 to 1996)*

WATERSHED	ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Ancho	Boron (T)	mg/l	3	3	0.02	2.3E-02	0.03	3.5E-02
	Cadmium (T)	mg/l	2	3	0.0001	2.0E-04	0.0003	4.8E-04
	Chromium (T)	mg/l	2	3	0.005	5.5E-03	0.006	6.9E-03
	Copper (T)	mg/l	2	3	0.012	2.1E-02	0.029	4.5E-02
	Lead (T)	mg/l	2	3	0.003	3.0E-03	0.003	3.0E-03
	Radium-226, Radium-228	pCi/l	3	3	0.386	6.5E+00	18.503	2.7E+01
	Tritium	pCi/l	1	3	400	4.0E+02	400	
	Vanadium (T)	mg/l	3	3	0.009	1.0E-02	0.012	1.3E-02
	Zinc (T)	mg/l	2	3	0.04	6.0E-02	0.08	1.2E-01
Cañada del Buey	Aluminum (T)	mg/l	2	2	0.097	9.9E-02	0.1	1.0E-01
	Arsenic (T)	mg/l	1	1	0.0034	3.4E-03	0.0034	
	Boron (T)	mg/l	2	2	0.06	6.1E-02	0.061	6.2E-02
	Cadmium (T)	mg/l	1	2	0.0001	1.0E-04	0.0001	
	Chromium (T)	mg/l	2	2	0.015	2.1E-02	0.027	3.8E-02
	Radium-226, Radium-228	pCi/l	2	2	0.269	1.5E+00	2.695	4.9E+00
	Selenium (T)	mg/l	1	2	0.0022	2.2E-03	0.0022	
	Tritium	pCi/l	1	2	1000	1.0E+03	1000	
	Vanadium (T)	mg/l	2	2	0.009	1.5E-02	0.021	3.2E-02
	Zinc (T)	mg/l	1	2	0.026	2.6E-02	0.026	

TABLE C–1.—*NPDES Detection Statistics by Watershed (NPDES Data 1994 to 1996)*-Continued

WATERSHED	ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Guaje	Aluminum (T)	mg/l	4	6	0.1	2.4E-01	0.4	5.1E-01
	Arsenic (T)	mg/l	4	6	0.003	1.1E-02	0.027	3.3E-02
	Boron (T)	mg/l	6	6	0.02	4.8E-02	0.065	8.1E-02
	Cadmium (T)	mg/l	1	6	0.002	2.0E-03	0.002	
	Chromium (T)	mg/l	1	6	0.016	1.6E-02	0.016	
	Cobalt (T)	mg/l	2	6	0.005	6.5E-03	0.008	1.1E-02
	Copper (T)	mg/l	3	6	0.032	1.0E-01	0.23	3.2E-01
	Lead (T)	mg/l	1	6	0.045	4.5E-02	0.045	
	Radium-226, Radium-228	pCi/l	6	6	0.386	2.0E+00	5.469	6.3E+00
	Tritium	pCi/l	3	6	6	3.0E+02	700	1.0E+03
	Vanadium (T)	mg/l	6	6	0.014	2.7E-02	0.058	6.1E-02
	Zinc (T)	mg/l	6	6	0.02	1.6E-01	0.52	5.7E-01
Los Alamos	Aluminum (T)	mg/l	5	21	0.1	1.0E-01	0.1	1.0E-01
	Arsenic (T)	mg/l	11	13	0.002	1.3E-02	0.072	5.3E-02
	Boron (T)	mg/l	21	21	0.01	6.7E-02	0.15	1.4E-01
	Cadmium (T)	mg/l	2	21	0.0001	1.0E-04	0.0001	1.0E-04
	Chromium (T)	mg/l	17	20	0.004	9.5E-03	0.022	2.0E-02
	Cobalt (T)	mg/l	2	21	0.003	4.0E-03	0.005	6.8E-03
	Copper (T)	mg/l	15	20	0.004	5.8E-02	0.59	3.5E-01
	Lead (T)	mg/l	3	21	0.003	1.5E-02	0.04	5.8E-02
	Radium-226, Radium-228	pCi/l	21	21	0.02	1.1E+00	7.968	4.6E+00
	Selenium (T)	mg/l	7	21	0.001	1.9E-03	0.002	2.6E-03
	Tritium	pCi/l	11	21	100	3.2E+02	700	7.1E+02
	Vanadium (T)	mg/l	21	21	0.01	2.6E-02	0.06	5.0E-02
	Zinc (T)	mg/l	19	21	0.02	8.6E-02	0.3	2.2E-01

TABLE C–1.—*NPDES Detection Statistics by Watershed (NPDES Data 1994 to 1996)*-Continued

WATERSHED	ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad	Aluminum (T)	mg/l	8	19	0.06	1.6E-01	0.3	3.4E-01
	Arsenic (T)	mg/l	10	14	0.002	3.5E-03	0.0052	5.9E-03
	Boron (T)	mg/l	19	19	0.02	6.9E-02	0.23	1.8E-01
	Cadmium (T)	mg/l	5	18	0.0002	4.9E-03	0.023	2.5E-02
	Chromium (T)	mg/l	15	18	0.005	1.4E-02	0.063	4.5E-02
	Cobalt (T)	mg/l	2	19	0.006	1.7E-02	0.028	4.8E-02
	Copper (T)	mg/l	12	18	0.004	7.6E-02	0.54	3.8E-01
	Lead (T)	mg/l	3	18	0.002	6.3E-03	0.011	1.5E-02
	Mercury (T)	mg/l	1	18	0.0006	6.0E-04	0.0006	
	Radium-226, Radium-228	pCi/l	18	18	0.02	3.2E+00	11.9	1.1E+01
	Selenium (T)	mg/l	2	19	0.0028	4.6E-03	0.0063	9.5E-03
	Tritium	pCi/l	14	19	82	1.2E+04	134143	8.4E+04
	Vanadium (T)	mg/l	16	19	0.003	1.6E-02	0.037	3.6E-02
	Zinc (T)	mg/l	15	18	0.02	1.5E-01	1.2	7.5E-01
Pajarito	Aluminum (T)	mg/l	8	22	0.1	3.5E-01	1	1.0E+00
	Arsenic (T)	mg/l	10	22	0.0016	3.0E-03	0.009	7.6E-03
	Boron (T)	mg/l	23	23	0.02	1.5E-01	2.5	1.2E+00
	Cadmium (T)	mg/l	9	23	0.0001	1.0E-03	0.003	3.3E-03
	Chromium (T)	mg/l	16	23	0.004	1.2E-02	0.07	4.4E-02
	Cobalt (T)	mg/l	6	23	0.0005	3.8E-03	0.005	7.3E-03
	Copper (T)	mg/l	13	23	0.004	2.5E-02	0.15	1.0E-01
	Lead (T)	mg/l	6	23	0.002	6.5E-03	0.014	1.5E-02
	Mercury (T)	mg/l	3	23	0.00035	3.8E-04	0.0004	4.4E-04

TABLE C–1.—*NPDES Detection Statistics by Watershed (NPDES Data 1994 to 1996)*-Continued

WATERSHED	ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pajarito (cont.)	Radium-226, Radium-228	pCi/l	23	23	0.026	1.7E+00	8.198	7.2E+00
	Selenium (T)	mg/l	3	23	0.001	1.3E-03	0.002	2.5E-03
	Tritium	pCi/l	11	23	162	6.0E+02	2900	2.2E+03
	Vanadium (T)	mg/l	23	23	0.005	1.2E-02	0.037	2.7E-02
	Zinc (T)	mg/l	21	23	0.02	6.2E-02	0.19	1.6E-01
Sandia	Aluminum (T)	mg/l	6	17	0.1	3.0E-01	0.8	8.4E-01
	Arsenic (T)	mg/l	10	14	0.003	6.2E-03	0.026	2.0E-02
	Boron (T)	mg/l	17	17	0.03	6.9E-02	0.18	1.4E-01
	Cadmium (T)	mg/l	3	17	0.0001	1.7E-04	0.0003	4.0E-04
	Chromium (T)	mg/l	12	17	0.004	1.9E-02	0.06	5.5E-02
	Cobalt (T)	mg/l	6	17	0.003	6.5E-03	0.01	1.2E-02
	Copper (T)	mg/l	11	17	0.004	1.3E-02	0.034	3.3E-02
	Lead (T)	mg/l	3	17	0.004	1.0E-02	0.023	3.2E-02
	Mercury (T)	mg/l	1	17	0.0017	1.7E-03	0.0017	
	Radium-226, Radium-228	pCi/l	17	17	0.202	1.4E+00	6.457	4.5E+00
	Selenium (T)	mg/l	3	17	0.00145	2.3E-03	0.0034	4.3E-03
	Tritium	pCi/l	9	17	100	2.8E+02	700	6.9E+02
	Vanadium (T)	mg/l	16	16	0.007	1.7E-02	0.036	3.6E-02
	Zinc (T)	mg/l	17	17	0.016	5.9E-02	0.16	1.5E-01
Water	Aluminum (T)	mg/l	7	27	0.1	2.9E-01	1.2	1.1E+00
	Arsenic (T)	mg/l	14	26	0.002	4.0E-03	0.018	1.2E-02
	Boron (T)	mg/l	27	27	0.018	6.8E-02	0.45	2.4E-01
	Cadmium (T)	mg/l	4	27	0.0002	1.1E-03	0.002	3.2E-03
	Chromium (T)	mg/l	14	26	0.004	6.6E-03	0.017	1.4E-02
	Cobalt (T)	mg/l	5	27	0.004	5.0E-03	0.008	8.5E-03
	Copper (T)	mg/l	13	26	0.004	3.2E-02	0.31	2.0E-01

TABLE C–1.—*NPDES Detection Statistics by Watershed (NPDES Data 1994 to 1996)*-Continued

WATERSHED	ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Water (cont.)	Lead (T)	mg/l	6	27	0.0002	2.5E-03	0.004	5.1E-03
	Mercury (T)	mg/l	1	27	0.0003	3.0E-04	0.0003	
	Radium-226, Radium-228	pCi/l	27	27	0.0598	7.9E-01	3.414	2.8E+00
	Selenium (T)	mg/l	2	27	0.001	1.5E-03	0.002	2.9E-03
	Tritium	pCi/l	15	27	100	3.9E+02	1900	1.4E+03
	Vanadium (T)	mg/l	24	27	0.004	1.8E-02	0.12	6.4E-02
	Zinc (T)	mg/l	25	27	0.02	5.5E-02	0.15	1.3E-01

[a] (T) signifies that the total amount of the analyte in the sample was measured, that is, both the dissolved amount and the amount adsorbed to suspended particles.
[b] mg/l is milligrams of analyte per liter of sample; pCi/l is picocuries of radioactive analyte per liter of sample.
[c] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
On Site	Acetone	µg/l	4	15	1.5E+01	3.2E+01	4.9E+01	6.1E+01
	Aluminum	µg/l	58	63	5.0E+01	4.2E+03	6.4E+04	2.4E+04
	Americium-241	pCi/l	46	52	6.0E-04	2.5E-01	2.2E+00	1.2E+00
	Antimony	µg/l	14	62	3.0E-01	8.9E-01	3.0E+00	2.5E+00
	Arsenic	µg/l	39	60	2.0E+00	5.0E+00	1.3E+01	1.0E+01
	Barium	µg/l	54	54	7.3E+00	1.1E+02	8.1E+02	4.7E+02
	Benzoic acid	µg/l	1	11	1.1E+01	1.1E+01	1.1E+01	
	Beryllium	µg/l	11	63	5.0E-01	1.3E+01	1.2E+02	8.4E+01
	Bicarbonate	mg/l	58	60	1.2E+01	9.6E+01	2.3E+02	1.8E+02
	Bis(2-ethylhexyl) phthalate	µg/l	2	11	8.0E+00	1.1E+01	1.4E+01	1.9E+01
	Boron	µg/l	60	63	1.1E+01	8.0E+01	4.0E+02	2.5E+02
	Bromine	µg/l	1	3	1.1E+02	1.1E+02	1.1E+02	
	Cadmium	µg/l	8	60	3.0E-01	2.1E+01	1.5E+02	1.3E+02
	Calcium	mg/l	63	63	7.3E+00	2.4E+01	1.9E+02	7.0E+01
	Carbonate	mg/l	12	60	2.0E+00	1.2E+01	2.8E+01	2.9E+01
	Cesium-137	pCi/l	64	93	1.1E-01	2.2E+01	3.3E+02	1.4E+02
	Chlorine	mg/l	60	60	2.0E+00	3.3E+01	1.1E+02	8.5E+01
	Chromium	µg/l	38	63	1.0E+00	3.3E+01	7.6E+02	2.8E+02
	Cobalt	µg/l	14	57	4.0E+00	2.8E+01	1.6E+02	1.1E+02
	Copper	µg/l	37	63	4.0E+00	3.7E+01	7.5E+02	2.8E+02
	Cyanide	mg/l	13	48	1.0E-02	2.6E-02	1.1E-01	7.9E-02
	Di-n-butyl phthalate	µg/l	4	11	2.0E+00	6.3E+00	1.4E+01	1.8E+01
	Di-n-octyl phthalate	µg/l	1	11	8.0E+00	8.0E+00	8.0E+00	

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
On Site (cont.)	Fluorine	mg/l	58	60	1.0E-01	7.0E-01	2.5E+00	1.8E+00
	Gross Alpha	pCi/l	60	88	2.0E-01	7.6E+00	2.1E+02	6.4E+01
	Gross Beta	pCi/l	88	88	1.0E+00	2.7E+01	3.5E+02	1.3E+02
	Gross Gamma	pCi/l	52	86	1.0E+01	1.3E+02	6.0E+02	4.1E+02
	Hardness	mg/l	63	63	2.2E+01	7.8E+01	6.1E+02	2.3E+02
	HMX (Octogen)	µg/l	1	5	4.9E+00	4.9E+00	4.9E+00	
	Iron	µg/l	62	63	2.0E+01	3.1E+03	6.0E+04	2.0E+04
	Lead	µg/l	42	68	2.0E-01	7.4E+00	4.5E+01	2.8E+01
	Lithium	mg/l	11	13	4.0E-03	2.6E-02	5.9E-02	6.4E-02
	Magnesium	mg/l	63	63	1.3E+00	4.6E+00	3.3E+01	1.3E+01
	Manganese	µg/l	57	63	1.0E+00	1.6E+02	2.1E+03	8.2E+02
	Mercury	µg/l	16	62	1.0E-01	2.8E-01	1.0E+00	7.4E-01
	Molybdenum	µg/l	41	62	1.0E+00	2.5E+02	1.2E+03	8.6E+02
	Nickel	µg/l	12	63	2.0E+00	1.4E+02	7.9E+02	6.8E+02
	Nitrate, as Nitrogen	mg/l	50	63	3.0E-02	3.7E+00	2.0E+01	1.4E+01
	Nitrite, as Nitrogen	mg/l	1	3	4.6E-01	4.6E-01	4.6E-01	
	pH		60	60	3.6E+00		9.3E+00	
	Phosphate	mg/l	1	3	1.7E+00	1.7E+00	1.7E+00	
	Phosphate, as Phosphorous	mg/l	46	57	3.0E-02	1.8E+00	1.6E+01	7.4E+00
	Plutonium-238	pCi/l	116	176	1.0E-03	1.0E-01	4.7E+00	1.1E+00
	Plutonium-239, Plutonium-240	pCi/l	149	178	1.0E-03	7.3E-01	5.2E+01	1.0E+01
	Potassium	mg/l	58	58	1.2E+00	7.4E+00	4.3E+01	2.0E+01
	RDX (Cyclonite)	µg/l	1	6	7.6E-01	7.6E-01	7.6E-01	

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
On Site (cont.)	Selenium	µg/l	12	63	1.0E+00	6.3E+01	6.7E+02	4.5E+02
	Silica	mg/l	66	67	1.5E+01	6.1E+01	1.7E+02	1.2E+02
	Silver	µg/l	20	63	5.0E-01	4.8E+01	6.9E+02	3.5E+02
	Sodium	mg/l	63	63	5.0E+00	4.8E+01	1.8E+02	1.2E+02
	Strontium	µg/l	63	63	4.7E+01	1.2E+02	9.1E+02	3.9E+02
	Strontium-90	pCi/l	44	51	6.0E-02	2.7E+01	7.0E+02	2.4E+02
	Sulfate	mg/l	60	60	2.0E+00	2.9E+01	1.1E+02	9.3E+01
	Thallium	µg/l	11	63	1.7E-01	8.4E-01	6.0E+00	4.3E+00
	Tin	µg/l	14	58	1.0E+01	5.6E+01	2.4E+02	1.9E+02
	Total Dissolved Solids	mg/l	60	60	9.0E+01	3.5E+02	1.8E+03	8.4E+02
	Total Suspended Solids	mg/l	50	54	1.2E+00	7.3E+02	1.5E+04	5.3E+03
	Tritium	nCi/l	71	96	1.0E-04	1.2E+00	1.8E+01	7.7E+00
	Uranium	µg/l	63	79	6.0E-02	8.0E-01	9.5E+00	3.4E+00
	Vanadium	µg/l	44	63	1.0E+00	2.1E+01	9.0E+01	6.0E+01
	Zinc	µg/l	50	62	5.0E+00	7.3E+01	4.2E+02	2.2E+02
Perimeter	Acetone	µg/l	4	12	2.3E+01	2.6E+01	3.2E+01	3.4E+01
	Aluminum	µg/l	38	47	1.0E+01	9.5E+02	3.3E+03	2.8E+03
	Americium-241	pCi/l	24	32	7.0E-03	5.4E-02	1.7E-01	1.5E-01
	Antimony	µg/l	6	47	2.0E-01	4.8E-01	1.2E+00	1.2E+00
	Arsenic	µg/l	22	46	2.0E+00	3.5E+00	7.8E+00	6.8E+00
	Barium	µg/l	39	40	6.8E+00	1.8E+02	5.2E+03	1.8E+03
	Beryllium	µg/l	9	47	5.0E-01	1.4E+02	1.2E+03	9.4E+02
	Bicarbonate	mg/l	47	48	2.4E+01	6.3E+01	1.5E+02	1.2E+02

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Perimeter (cont.)	Bis(2-ethylhexyl) phthalate	µg/l	1	8	2.0E+00	2.0E+00	2.0E+00	
	Boron	µg/l	29	47	1.0E+01	2.5E+02	4.2E+03	1.8E+03
	Cadmium	µg/l	10	47	2.0E-01	1.2E+02	1.0E+03	7.4E+02
	Calcium	mg/l	46	48	6.0E+00	3.2E+01	8.1E+02	2.7E+02
	Carbonate	mg/l	3	48	4.0E+00	8.3E+00	1.2E+01	1.6E+01
	Cesium-137	pCi/l	39	57	2.0E-02	3.0E+01	3.2E+02	1.6E+02
	Chlorine	mg/l	47	48	9.2E-01	2.7E+01	2.1E+02	1.1E+02
	Chromium	µg/l	21	47	2.0E+00	2.7E+02	5.0E+03	2.4E+03
	Cobalt	µg/l	5	42	3.0E+00	2.1E+02	8.5E+02	9.4E+02
	Copper	µg/l	22	48	2.0E+00	1.1E+03	1.7E+04	8.7E+03
	Cyanide	mg/l	6	36	1.0E-02	1.3E-02	2.0E-02	2.4E-02
	Di-n-butyl phthalate	µg/l	1	8	4.0E+00	4.0E+00	4.0E+00	
	Dinitrotoluene [2,4-]	µg/l	1	10	3.4E+00	3.4E+00	3.4E+00	
	Fluorine	mg/l	44	48	6.0E-02	3.4E-01	1.1E+00	8.5E-01
	Gross Alpha	pCi/l	35	51	5.0E-02	1.9E+00	2.5E+01	1.0E+01
	Gross Beta	pCi/l	49	51	1.0E+00	9.3E+00	1.4E+02	4.9E+01
	Gross Gamma	pCi/l	36	54	1.0E+01	1.6E+02	9.0E+02	5.6E+02
	Hardness	mg/l	47	49	1.0E+01	5.0E+01	1.1E+02	1.0E+02
	Iron	µg/l	43	47	2.0E+01	6.1E+02	2.2E+03	1.8E+03
	Lead	µg/l	21	48	5.0E-01	4.6E+00	5.5E+01	2.8E+01
	Lithium	mg/l	8	9	1.0E-02	2.0E-02	3.0E-02	3.7E-02
	Magnesium	mg/l	46	48	1.2E+00	3.6E+00	8.8E+00	7.1E+00
	Manganese	µg/l	40	47	2.0E+00	1.7E+02	5.4E+03	1.9E+03

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Perimeter (cont.)	Mercury	µg/l	5	46	1.0E-01	2.2E-01	4.0E-01	5.5E-01
	Methylene chloride	µg/l	1	12	2.0E+01	2.0E+01	2.0E+01	
	Molybdenum	µg/l	12	45	1.0E+00	1.0E+02	1.0E+03	6.7E+02
	Nickel	µg/l	6	47	1.0E+01	9.9E+02	5.5E+03	5.4E+03
	Nitrate, as Nitrogen	mg/l	37	52	4.5E-03	1.9E+00	1.7E+01	8.6E+00
	pH		48	48	1.7E+00		8.6E+00	
	Phosphate	mg/l	1	3	1.1E-01	1.1E-01	1.1E-01	
	Phosphate, as Phosphorous	mg/l	31	45	2.0E-02	1.4E+00	9.0E+00	6.5E+00
	Plutonium-238	pCi/l	64	103	1.0E-03	2.3E-02	2.3E-01	9.8E-02
	Plutonium-239, Plutonium-240	pCi/l	87	103	3.0E-03	5.8E-01	1.2E+01	4.6E+00
	Potassium	mg/l	41	46	5.7E-01	5.0E+00	1.7E+01	1.5E+01
	Selenium	µg/l	6	46	2.0E+00	4.7E+00	7.0E+00	9.2E+00
	Silica	mg/l	51	51	1.7E+01	5.3E+01	9.9E+01	9.7E+01
	Silver	µg/l	9	47	4.0E-01	5.9E+01	3.7E+02	3.0E+02
	Sodium	mg/l	46	48	3.0E+00	2.9E+01	8.5E+01	8.5E+01
	Strontium	µg/l	46	47	3.8E+01	2.0E+02	5.3E+03	1.7E+03
	Strontium-90	pCi/l	21	32	1.0E-01	5.4E+01	5.0E+02	3.5E+02
	Sulfate	mg/l	48	48	2.5E+00	1.1E+01	3.5E+01	3.1E+01
	Thallium	µg/l	2	47	1.0E-01	2.0E-01	3.0E-01	4.8E-01
	Tin	µg/l	5	33	3.0E+01	2.2E+02	9.2E+02	1.0E+03
	Total Dissolved Solids	mg/l	48	48	6.6E+01	2.6E+02	1.1E+03	6.8E+02
	Total Suspended Solids	mg/l	26	32	2.0E+00	1.9E+03	1.4E+04	9.4E+03

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Perimeter (cont.)	Trinitrotoluene [2,4,6-]	µg/l	1	2	1.4E+00	1.4E+00	1.4E+00	
	Tritium	nCi/l	44	59	1.0E-04	4.2E-01	1.7E+00	1.2E+00
	Uranium	µg/l	39	56	6.0E-02	5.6E-01	2.7E+00	1.7E+00
	Vanadium	µg/l	26	47	3.0E+00	5.1E+01	1.0E+03	4.4E+02
	Zinc	µg/l	28	47	4.0E+00	9.2E+01	1.3E+03	5.8E+02
Regional	Aluminum	µg/l	36	36	2.0E+02	2.9E+03	1.4E+04	8.9E+03
	Americium-241	pCi/l	21	29	4.0E-03	3.2E-02	6.8E-02	6.7E-02
	Antimony	µg/l	4	36	1.0E-01	3.1E+00	9.0E+00	1.1E+01
	Arsenic	µg/l	24	35	2.0E+00	1.1E+01	6.3E+01	4.2E+01
	Barium	µg/l	30	30	4.5E+01	1.3E+02	1.0E+03	4.8E+02
	Beryllium	µg/l	5	36	3.0E+00	1.3E+01	5.0E+01	5.4E+01
	Bicarbonate	mg/l	42	42	5.9E+01	9.0E+01	1.7E+02	1.4E+02
	Boron	µg/l	34	36	1.0E+01	7.4E+01	5.7E+02	3.1E+02
	Cadmium	µg/l	2	36	3.0E+00	2.7E+01	5.1E+01	9.5E+01
	Calcium	mg/l	42	42	2.0E+01	4.0E+01	2.1E+02	9.6E+01
	Carbonate	mg/l	1	42	1.6E+01	1.6E+01	1.6E+01	
	Cesium-137	pCi/l	30	41	2.1E-01	4.9E+01	2.3E+02	1.9E+02
	Chlorine	mg/l	42	42	2.1E+00	9.5E+00	7.5E+01	3.6E+01
	Chromium	µg/l	19	36	2.0E+00	2.4E+01	2.5E+02	1.4E+02
	Cobalt	µg/l	5	30	4.0E+00	2.0E+01	5.0E+01	5.9E+01
	Copper	µg/l	10	36	2.0E+00	4.2E+01	2.4E+02	1.9E+02
	Cyanide	mg/l	3	30	1.0E-02	1.0E-02	1.0E-02	1.0E-02
	Fluorine	mg/l	42	42	1.0E-01	3.4E-01	1.0E+00	7.1E-01
	Gross Alpha	pCi/l	33	36	4.0E-01	3.2E+00	1.5E+01	9.6E+00
	Gross Beta	pCi/l	36	36	1.0E+00	1.0E+01	1.2E+02	5.2E+01

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Regional (cont.)	Gross Gamma	pCi/l	27	42	1.0E+01	1.5E+02	5.5E+02	4.9E+02
	Hardness	mg/l	42	42	5.0E+01	1.2E+02	1.7E+02	1.7E+02
	Iron	µg/l	36	36	1.4E+02	2.2E+03	1.3E+04	6.8E+03
	Lead	µg/l	22	36	1.0E+00	4.9E+00	1.9E+01	1.4E+01
	Lithium	mg/l	6	10	1.5E-02	3.9E-02	1.4E-01	1.4E-01
	Magnesium	mg/l	42	42	2.6E+00	7.0E+00	1.6E+01	1.2E+01
	Manganese	µg/l	36	36	2.0E+00	1.5E+02	1.6E+03	6.8E+02
	Mercury	µg/l	5	36	1.0E-01	1.2E-01	2.0E-01	2.1E-01
	Molybdenum	µg/l	14	36	2.0E+00	2.7E+02	2.4E+03	1.6E+03
	Nickel	µg/l	11	36	2.0E+00	6.4E+01	3.0E+02	2.8E+02
	Nitrate, as Nitrogen	mg/l	40	48	1.4E-02	1.2E+00	9.7E+00	6.5E+00
	pH		42	42	7.0E+00		8.8E+00	
	Phosphate	mg/l	1	6	2.6E-01	2.6E-01	2.6E-01	
	Phosphate, as Phosphorous	mg/l	23	42	3.0E-02	1.1E-01	2.0E-01	2.3E-01
	Plutonium-238	pCi/l	29	48	3.0E-03	1.8E-02	1.1E-01	5.9E-02
	Plutonium-239, Plutonium-240	pCi/l	33	48	2.0E-04	1.7E-02	9.2E-02	5.8E-02
	Potassium	mg/l	42	42	2.0E+00	3.1E+00	1.1E+01	6.4E+00
	Selenium	µg/l	12	36	2.0E+00	3.7E+00	8.0E+00	7.9E+00
	Silica	mg/l	48	48	1.4E+01	2.3E+01	4.4E+01	3.9E+01
	Silver	µg/l	2	36	1.0E+00	4.5E+01	8.8E+01	1.7E+02
	Sodium	mg/l	42	42	9.4E+00	1.9E+01	6.0E+01	3.6E+01
	Strontium	µg/l	36	36	8.3E+01	2.9E+02	1.0E+03	5.9E+02
	Strontium-90	pCi/l	24	29	1.0E-01	7.0E-01	3.3E+00	2.0E+00
	Sulfate	mg/l	42	42	6.0E+00	4.4E+01	1.1E+02	8.8E+01

TABLE C–2.—*Surface Water Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Regional (cont.)	Thallium	µg/l	1	36	2.0E-01	2.0E-01	2.0E-01	
	Tin	µg/l	1	30	3.3E+01	3.3E+01	3.3E+01	
	Total Dissolved Solids	mg/l	42	42	8.6E+01	2.5E+02	7.2E+02	4.6E+02
	Total Suspended Solids	mg/l	14	18	1.2E+01	1.7E+02	1.3E+03	8.4E+02
	Tritium	nCi/l	28	42	1.0E-04	2.4E-01	6.0E-01	6.3E-01
	Uranium	µg/l	41	43	2.0E-01	1.7E+00	3.9E+00	3.5E+00
	Vanadium	µg/l	30	36	2.0E+00	1.6E+01	1.3E+02	6.1E+01
	Zinc	µg/l	26	36	6.0E+00	4.1E+01	2.1E+02	1.3E+02

[a] On-site, perimeter, and regional locations are in accordance with the Environmental Surveillance Program.
[b] pCi/l is picocuries of radioactive analyte per liter of sample, nCi/l is nanocuries of radioactive analyte per liter of sample, µg/l is micrograms of analyte per liter of sample, mg/l is milligrams of analyte per liter of sample.
[c] Upper confidence limit (UCL) not calculated when the number of detected analyses equals 1.

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Ancho	Acetone	µg/l	2	2	2.5E+01	3.2E+01	3.8E+01	5.0E+01
	Aluminum	µg/l	5	7	5.0E+01	1.7E+03	7.0E+03	7.7E+03
	Americium-241	pCi/l	4	6	3.0E-03	3.0E-02	4.3E-02	6.6E-02
	Arsenic	µg/l	4	7	2.0E+00	3.0E+00	4.0E+00	4.6E+00
	Barium	µg/l	6	6	2.7E+01	1.6E+02	8.1E+02	8.0E+02
	Bicarbonate	mg/l	6	7	5.5E+01	6.5E+01	7.5E+01	7.8E+01
	Boron	µg/l	7	7	1.1E+01	5.2E+01	2.3E+02	2.1E+02
	Calcium	mg/l	7	7	7.3E+00	1.3E+01	1.6E+01	1.9E+01
	Carbonate	mg/l	4	7	1.4E+01	1.7E+01	2.3E+01	2.5E+01
	Cesium-137	pCi/l	5	9	1.1E-01	1.4E+00	3.3E+00	3.8E+00
	Chlorine	mg/l	7	7	2.0E+00	4.5E+00	8.3E+00	8.9E+00
	Chromium	µg/l	4	7	1.0E+00	4.8E+00	7.7E+00	1.1E+01
	Copper	µg/l	2	7	6.0E+00	6.5E+00	7.0E+00	7.9E+00
	Di-n-butyl phthalate	µg/l	1	2	1.4E+01	1.4E+01	1.4E+01	
	Fluorine	mg/l	7	7	2.5E-01	3.8E-01	4.0E-01	4.9E-01
	Gross Alpha	pCi/l	5	8	1.0E+00	5.7E+00	2.3E+01	2.5E+01
	Gross Beta	pCi/l	8	8	2.0E+00	1.4E+01	7.3E+01	6.3E+01
	Gross Gamma	pCi/l	4	8	8.0E+01	2.0E+02	4.6E+02	5.5E+02
	Hardness	mg/l	7	7	2.7E+01	4.7E+01	5.6E+01	6.6E+01
	Iron	µg/l	6	7	5.0E+01	8.3E+02	3.6E+03	3.6E+03
	Lead	µg/l	3	7	2.0E-01	2.7E+00	6.0E+00	8.7E+00
	Lithium	mg/l	1	1	2.2E-02	2.2E-02	2.2E-02	
	Magnesium	mg/l	7	7	2.2E+00	3.3E+00	4.0E+00	4.5E+00
	Manganese	µg/l	6	7	1.0E+00	3.4E+01	1.4E+02	1.4E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Ancho (cont.)	Molybdenum	µg/l	1	6	1.0E+01	1.0E+01	1.0E+01	
	Nitrate, as Nitrogen	mg/l	2	6	4.0E-02	4.8E-01	9.1E-01	1.7E+00
	pH		7	7	6.9E+00		9.3E+00	
	Phosphate, as Phosphorous	mg/l	2	6	3.0E-02	1.7E-01	3.0E-01	5.5E-01
	Plutonium-238	pCi/l	10	13	2.0E-03	6.7E-03	2.0E-02	1.8E-02
	Plutonium-239, Plutonium-240	pCi/l	10	13	2.0E-03	1.2E-02	3.9E-02	3.6E-02
	Potassium	mg/l	7	7	1.2E+00	2.5E+00	4.8E+00	4.8E+00
	Selenium	µg/l	2	7	1.0E+00	2.0E+00	3.0E+00	4.8E+00
	Silica	mg/l	7	7	1.5E+01	6.7E+01	8.1E+01	1.1E+02
	Sodium	mg/l	7	7	5.0E+00	1.0E+01	1.2E+01	1.5E+01
	Strontium	µg/l	7	7	4.7E+01	6.6E+01	7.6E+01	8.7E+01
	Strontium-90	pCi/l	6	7	9.0E-01	1.3E+02	7.0E+02	6.9E+02
	Sulfate	mg/l	7	7	2.0E+00	4.6E+00	8.7E+00	8.8E+00
	Tin	µg/l	2	5	3.6E+01	3.7E+01	3.8E+01	4.0E+01
	Total Dissolved Solids	mg/l	7	7	9.0E+01	3.8E+02	1.8E+03	1.6E+03
	Total Suspended Solids	mg/l	3	4	1.2E+00	1.6E+03	4.6E+03	6.8E+03
	Tritium	nCi/l	5	9	1.0E-01	3.4E-01	6.0E-01	7.0E-01
	Uranium	µg/l	8	9	2.2E-01	1.7E+00	9.5E+00	8.0E+00
	Vanadium	µg/l	7	7	6.0E+00	9.2E+00	1.1E+01	1.3E+01
	Zinc	µg/l	3	7	2.4E+01	1.1E+02	2.3E+02	3.2E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Cañada del Buey	Aluminum	µg/l	6	6	3.0E+02	1.2E+04	3.5E+04	3.9E+04
	Americium-241	pCi/l	2	3	2.3E-02	3.9E-02	5.5E-02	8.4E-02
	Antimony	µg/l	1	6	3.0E-01	3.0E-01	3.0E-01	
	Arsenic	µg/l	4	5	3.2E+00	4.5E+00	5.8E+00	6.8E+00
	Barium	µg/l	5	5	1.2E+02	2.1E+02	4.8E+02	5.1E+02
	Beryllium	µg/l	2	6	1.0E+00	2.0E+00	2.9E+00	4.6E+00
	Bicarbonate	mg/l	5	6	1.2E+01	4.9E+01	7.7E+01	9.7E+01
	Boron	µg/l	6	6	5.0E+01	6.3E+01	7.5E+01	8.3E+01
	Calcium	mg/l	6	6	1.0E+01	1.2E+01	1.6E+01	1.6E+01
	Cesium-137	pCi/l	3	5	1.1E+00	4.6E+00	1.0E+01	1.4E+01
	Chlorine	mg/l	5	6	7.0E+00	2.1E+01	5.7E+01	6.2E+01
	Chromium	µg/l	5	6	7.2E+00	1.7E+01	2.7E+01	3.1E+01
	Cobalt	µg/l	2	5	6.0E+00	8.0E+00	1.0E+01	1.4E+01
	Copper	µg/l	6	7	6.0E+00	2.9E+03	1.7E+04	1.7E+04
	Cyanide	mg/l	2	5	2.0E-02	2.0E-02	2.0E-02	2.0E-02
	Fluorine	mg/l	5	6	4.7E-01	5.1E-01	6.0E-01	6.1E-01
	Gross Alpha	pCi/l	5	5	3.2E-01	1.8E+00	3.0E+00	4.2E+00
	Gross Beta	pCi/l	5	5	5.0E+00	6.5E+00	1.0E+01	1.1E+01
	Gross Gamma	pCi/l	3	6	6.0E+01	1.8E+02	2.9E+02	4.0E+02
	Hardness	mg/l	6	7	2.2E+01	4.1E+01	5.5E+01	6.7E+01
	Iron	µg/l	6	6	7.2E+02	7.2E+03	1.8E+04	2.1E+04
	Lead	µg/l	5	6	2.0E+00	9.5E+00	1.3E+01	1.8E+01
	Lithium	mg/l	1	1	4.1E-02	4.1E-02	4.1E-02	
	Magnesium	mg/l	6	6	1.2E+00	3.5E+00	5.5E+00	6.6E+00
	Manganese	µg/l	6	6	1.2E+01	2.5E+02	5.2E+02	6.6E+02
	Mercury	µg/l	3	5	3.0E-01	3.7E-01	4.0E-01	4.8E-01

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Cañada del Buey (cont.)	Molybdenum	µg/l	5	6	1.0E+02	2.0E+02	5.0E+02	5.4E+02
	Nickel	µg/l	1	6	1.0E+01	1.0E+01	1.0E+01	
	Nitrate, as Nitrogen	mg/l	6	7	8.0E-02	1.8E+00	6.0E+00	6.2E+00
	pH		6	6	3.6E+00		8.4E+00	
	Phosphate, as Phosphorous	mg/l	5	6	8.0E-02	3.4E-01	7.0E-01	9.4E-01
	Plutonium-238	pCi/l	2	6	6.0E-03	6.5E-03	7.0E-03	7.9E-03
	Plutonium-239, Plutonium-240	pCi/l	6	6	8.0E-03	1.6E-02	4.4E-02	4.4E-02
	Potassium	mg/l	4	5	3.0E+00	4.7E+00	7.3E+00	8.6E+00
	Silica	mg/l	7	7	1.8E+01	5.1E+01	1.7E+02	1.6E+02
	Silver	µg/l	4	6	1.2E+00	9.1E+00	2.0E+01	2.7E+01
	Sodium	mg/l	6	6	3.0E+00	2.0E+01	3.4E+01	4.0E+01
	Strontium	µg/l	6	6	4.9E+01	7.2E+01	9.0E+01	9.9E+01
	Strontium-90	pCi/l	2	3	1.1E+00	1.1E+00	1.1E+00	1.1E+00
	Sulfate	mg/l	6	6	2.5E+00	1.9E+01	6.2E+01	6.5E+01
	Thallium	µg/l	1	6	2.0E-01	2.0E-01	2.0E-01	
	Tin	µg/l	1	6	4.0E+01	4.0E+01	4.0E+01	
	Total Dissolved Solids	mg/l	6	6	1.8E+02	3.1E+02	4.5E+02	5.3E+02
	Total Suspended Solids	mg/l	2	2	3.5E+01	4.6E+03	9.1E+03	1.7E+04
	Tritium	nCi/l	4	6	5.0E-04	4.0E-01	7.0E-01	1.0E+00
	Uranium	µg/l	5	6	2.2E-01	6.1E-01	1.3E+00	1.6E+00
	Vanadium	µg/l	5	6	3.0E+00	2.0E+01	3.7E+01	4.8E+01
	Zinc	µg/l	6	6	3.0E+01	8.4E+01	1.2E+02	1.6E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Chaquehui	Aluminum	µg/l	1	1	6.4E+04	6.4E+04	6.4E+04	
	Americium-241	pCi/l	1	1	6.0E-02	6.0E-02	6.0E-02	
	Barium	µg/l	1	1	6.2E+02	6.2E+02	6.2E+02	
	Beryllium	µg/l	1	1	5.0E+00	5.0E+00	5.0E+00	
	Bicarbonate	mg/l	1	1	6.0E+01	6.0E+01	6.0E+01	
	Calcium	mg/l	1	1	2.7E+01	2.7E+01	2.7E+01	
	Chlorine	mg/l	1	1	3.0E+00	3.0E+00	3.0E+00	
	Chromium	µg/l	1	1	3.6E+01	3.6E+01	3.6E+01	
	Cobalt	µg/l	1	1	1.4E+01	1.4E+01	1.4E+01	
	Copper	µg/l	1	1	3.3E+01	3.3E+01	3.3E+01	
	Fluorine	mg/l	1	1	5.0E-01	5.0E-01	5.0E-01	
	Gross Alpha	pCi/l	1	1	2.0E+00	2.0E+00	2.0E+00	
	Gross Beta	pCi/l	1	1	2.0E+00	2.0E+00	2.0E+00	
	Hardness	mg/l	1	1	4.1E+01	4.1E+01	4.1E+01	
	Iron	µg/l	1	1	6.0E+04	6.0E+04	6.0E+04	
	Lead	µg/l	1	1	3.0E+00	3.0E+00	3.0E+00	
	Magnesium	mg/l	1	1	1.2E+01	1.2E+01	1.2E+01	
	Manganese	µg/l	1	1	8.7E+02	8.7E+02	8.7E+02	
	Nickel	µg/l	1	1	2.4E+01	2.4E+01	2.4E+01	
	pH		1	1	7.9E+00		7.9E+00	
	Plutonium-238	pCi/l	1	1	2.0E-02	2.0E-02	2.0E-02	
	Plutonium-239, Plutonium-240	pCi/l	1	1	2.9E-02	2.9E-02	2.9E-02	
	Potassium	mg/l	1	1	1.0E+01	1.0E+01	1.0E+01	
	Silica	mg/l	1	1	8.0E+01	8.0E+01	8.0E+01	
	Sodium	mg/l	1	1	7.0E+00	7.0E+00	7.0E+00	

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Chaquehui (cont.)	Strontium	µg/l	1	1	6.0E+01	6.0E+01	6.0E+01	
	Strontium-90	pCi/l	1	1	1.9E+00	1.9E+00	1.9E+00	
	Sulfate	mg/l	1	1	3.0E+00	3.0E+00	3.0E+00	
	Total Dissolved Solids	mg/l	1	1	1.4E+02	1.4E+02	1.4E+02	
	Tritium	nCi/l	1	1	3.0E-01	3.0E-01	3.0E-01	
	Uranium	µg/l	1	1	1.4E+00	1.4E+00	1.4E+00	
	Vanadium	µg/l	1	1	6.0E+01	6.0E+01	6.0E+01	
	Zinc	µg/l	1	1	2.3E+02	2.3E+02	2.3E+02	
Frijoles	Acetone	µg/l	2	4	2.3E+01	2.4E+01	2.5E+01	2.7E+01
	Aluminum	µg/l	10	13	1.2E+02	5.2E+02	1.8E+03	1.7E+03
	Americium-241	pCi/l	8	8	7.0E-03	4.7E-02	1.7E-01	1.5E-01
	Antimony	µg/l	1	13	4.0E-01	4.0E-01	4.0E-01	
	Arsenic	µg/l	3	13	2.0E+00	2.3E+00	3.0E+00	3.5E+00
	Barium	µg/l	10	11	1.6E+01	2.0E+01	2.8E+01	2.8E+01
	Beryllium	µg/l	1	13	5.0E-01	5.0E-01	5.0E-01	
	Bicarbonate	mg/l	13	13	3.3E+01	5.1E+01	7.6E+01	7.3E+01
	Boron	µg/l	6	13	1.0E+01	1.5E+01	2.0E+01	2.3E+01
	Cadmium	µg/l	2	13	2.0E-01	1.6E+00	3.0E+00	5.6E+00
	Calcium	mg/l	12	13	8.0E+00	7.6E+01	8.1E+02	5.4E+02
	Carbonate	mg/l	1	13	4.0E+00	4.0E+00	4.0E+00	
	Cesium-137	pCi/l	7	14	4.0E-01	2.8E+01	9.5E+01	1.2E+02
	Chlorine	mg/l	13	13	3.0E+00	6.6E+00	3.2E+01	2.2E+01
	Chromium	µg/l	4	13	2.0E+00	3.5E+00	6.0E+00	7.3E+00
	Cobalt	µg/l	1	11	3.0E+00	3.0E+00	3.0E+00	
	Copper	µg/l	3	13	2.0E+00	5.7E+00	1.3E+01	1.8E+01

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Frijoles (cont.)	Cyanide	mg/l	1	11	1.0E-02	1.0E-02	1.0E-02	
	Dinitrotoluene [2,4-]	µg/l	1	4	3.4E+00	3.4E+00	3.4E+00	
	Fluorine	mg/l	12	13	9.0E-02	1.9E-01	3.0E-01	3.2E-01
	Gross Alpha	pCi/l	7	12	7.0E-01	4.7E+00	2.5E+01	2.3E+01
	Gross Beta	pCi/l	10	12	1.7E+00	3.2E+00	8.0E+00	7.1E+00
	Gross Gamma	pCi/l	6	11	4.0E+01	2.5E+02	7.0E+02	7.4E+02
	Hardness	mg/l	12	13	2.2E+01	3.7E+01	4.7E+01	4.9E+01
	Iron	µg/l	11	13	1.2E+02	3.4E+02	9.6E+02	8.8E+02
	Lead	µg/l	5	14	1.0E+00	1.2E+01	5.5E+01	6.0E+01
	Lithium	mg/l	3	3	1.0E-02	1.6E-02	2.3E-02	2.9E-02
	Magnesium	mg/l	12	13	2.7E+00	3.2E+00	3.5E+00	3.6E+00
	Manganese	µg/l	10	13	2.0E+00	1.6E+01	3.6E+01	4.2E+01
	Methylene chloride	µg/l	1	4	2.0E+01	2.0E+01	2.0E+01	
	Molybdenum	µg/l	2	12	1.0E+00	7.0E+00	1.3E+01	2.4E+01
	Nickel	µg/l	2	13	2.3E+01	3.9E+01	5.4E+01	8.2E+01
	Nitrate, as Nitrogen	mg/l	7	14	9.0E-03	4.3E-01	2.0E+00	1.9E+00
	pH		13	13	7.3E+00		8.4E+00	
	Phosphate, as Phosphorous	mg/l	7	13	5.0E-02	1.5E-01	3.0E-01	3.6E-01
	Plutonium-238	pCi/l	11	15	3.0E-03	1.2E-02	3.1E-02	3.0E-02
	Plutonium-239, Plutonium-240	pCi/l	9	15	3.0E-03	8.4E-03	1.6E-02	1.6E-02
	Potassium	mg/l	11	13	5.7E-01	2.0E+00	3.0E+00	3.3E+00
	Selenium	µg/l	2	13	2.0E+00	2.5E+00	3.0E+00	3.9E+00

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Frijoles (cont.)	Silica	mg/l	14	14	4.8E+01	6.0E+01	9.0E+01	8.1E+01
	Sodium	mg/l	12	13	7.9E+00	1.0E+01	1.2E+01	1.3E+01
	Strontium	µg/l	12	13	5.0E+01	5.8E+01	6.6E+01	6.7E+01
	Strontium-90	pCi/l	6	8	1.0E-01	8.4E+01	5.0E+02	4.9E+02
	Sulfate	mg/l	13	13	3.0E+00	6.1E+00	3.2E+01	2.2E+01
	Tin	µg/l	1	9	3.5E+01	3.5E+01	3.5E+01	
	Total Dissolved Solids	mg/l	13	13	9.0E+01	2.2E+02	9.9E+02	6.9E+02
	Total Suspended Solids	mg/l	4	5	2.0E+00	7.4E+00	1.9E+01	2.3E+01
	Trinitrotoluene [2,4,6-]	µg/l	1	1	1.4E+00	1.4E+00	1.4E+00	
	Tritium	nCi/l	10	14	1.0E-04	2.9E-01	8.0E-01	7.9E-01
	Uranium	µg/l	9	13	8.0E-02	4.5E-01	1.3E+00	1.3E+00
	Vanadium	µg/l	7	13	4.0E+00	8.3E+00	1.3E+01	1.5E+01
	Zinc	µg/l	6	13	9.0E+00	2.9E+01	6.4E+01	7.0E+01
Guaje	Aluminum	µg/l	4	5	1.1E+02	9.5E+02	2.3E+03	3.0E+03
	Americium-241	pCi/l	1	2	4.3E-02	4.3E-02	4.3E-02	
	Arsenic	µg/l	1	5	2.0E+00	2.0E+00	2.0E+00	
	Barium	µg/l	4	4	1.8E+01	2.3E+01	3.0E+01	3.3E+01
	Bicarbonate	mg/l	5	5	3.0E+01	3.7E+01	4.3E+01	4.6E+01
	Boron	µg/l	1	5	1.0E+01	1.0E+01	1.0E+01	
	Calcium	mg/l	5	5	7.0E+00	7.9E+00	1.0E+01	1.0E+01
	Cesium-137	pCi/l	3	5	4.0E-01	3.5E+01	1.0E+02	1.5E+02
	Chlorine	mg/l	5	5	9.2E-01	2.5E+00	6.7E+00	7.3E+00
	Chromium	µg/l	1	5	2.0E+00	2.0E+00	2.0E+00	
	Copper	µg/l	1	5	4.0E+00	4.0E+00	4.0E+00	

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Guaje (cont.)	Cyanide	mg/l	2	4	1.0E-02	1.0E-02	1.0E-02	1.0E-02
	Fluorine	mg/l	5	5	7.0E-02	1.5E-01	3.0E-01	3.4E-01
	Gross Alpha	pCi/l	5	5	2.0E-01	8.4E-01	1.0E+00	1.6E+00
	Gross Beta	pCi/l	5	5	2.0E+00	3.3E+00	4.0E+00	4.9E+00
	Gross Gamma	pCi/l	3	6	4.8E+01	1.4E+02	3.0E+02	4.2E+02
	Hardness	mg/l	5	5	1.0E+01	2.8E+01	3.5E+01	4.8E+01
	Iron	µg/l	5	5	1.1E+02	4.8E+02	1.2E+03	1.4E+03
	Lead	µg/l	1	5	1.0E+00	1.0E+00	1.0E+00	
	Lithium	mg/l	1	1	3.0E-02	3.0E-02	3.0E-02	
	Magnesium	mg/l	5	5	2.4E+00	2.7E+00	3.3E+00	3.4E+00
	Manganese	µg/l	4	5	7.0E+00	2.0E+01	3.5E+01	4.3E+01
	Nitrate, as Nitrogen	mg/l	4	6	4.5E-03	1.4E-01	4.8E-01	6.0E-01
	pH		5	5	7.4E+00		7.8E+00	
	Phosphate	mg/l	1	1	1.1E-01	1.1E-01	1.1E-01	
	Phosphate, as Phosphorous	mg/l	4	5	3.6E-02	1.2E-01	3.0E-01	3.7E-01
	Plutonium-238	pCi/l	5	8	1.9E-03	8.4E-03	2.0E-02	2.4E-02
	Plutonium-239, Plutonium-240	pCi/l	7	8	8.0E-03	2.4E-02	3.9E-02	4.9E-02
	Potassium	mg/l	5	5	1.8E+00	2.5E+00	3.0E+00	3.6E+00
	Selenium	µg/l	1	5	6.0E+00	6.0E+00	6.0E+00	
	Silica	mg/l	6	6	3.8E+01	5.0E+01	5.6E+01	6.3E+01
	Silver	µg/l	1	5	1.0E+00	1.0E+00	1.0E+00	
	Sodium	mg/l	5	5	5.0E+00	7.1E+00	1.0E+01	1.1E+01
	Strontium	µg/l	5	5	3.8E+01	5.0E+01	7.0E+01	7.8E+01
	Sulfate	mg/l	5	5	4.9E+00	5.4E+00	7.0E+00	7.2E+00

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Guaje (cont.)	Thallium	mg/l	2	3	2.4E+01	2.6E+01	2.8E+01	3.1E+01
	Tin	μg/l	1	3	3.0E+01	3.0E+01	3.0E+01	
	Total Dissolved Solids	mg/l	5	5	8.8E+01	1.4E+02	1.8E+02	2.1E+02
	Tritium	nCi/l	5	6	3.0E-04	3.6E-01	7.0E-01	9.7E-01
	Uranium	μg/l	3	5	7.0E-02	1.8E-01	3.6E-01	5.0E-01
	Vanadium	μg/l	1	5	3.0E+00	3.0E+00	3.0E+00	
	Zinc	μg/l	2	5	8.0E+00	3.5E+01	6.2E+01	1.1E+02
Los Alamos	Acetone	μg/l	1	5	1.5E+01	1.5E+01	1.5E+01	
	Aluminum	μg/l	19	20	1.0E+02	2.6E+03	1.4E+04	9.7E+03
	Americium-241	pCi/l	19	20	1.4E-02	2.3E-01	1.3E+00	9.6E-01
	Antimony	μg/l	2	20	1.2E+00	1.6E+00	2.0E+00	2.7E+00
	Arsenic	μg/l	6	20	3.0E+00	3.9E+00	5.2E+00	5.7E+00
	Barium	μg/l	19	19	1.6E+01	6.6E+01	1.4E+02	1.4E+02
	Benzoic acid	μg/l	1	4	1.1E+01	1.1E+01	1.1E+01	
	Beryllium	μg/l	2	20	1.0E+00	1.0E+00	1.0E+00	1.0E+00
	Bicarbonate	mg/l	17	17	2.4E+01	6.2E+01	1.4E+02	1.4E+02
	Bis(2-ethylhexyl) phthalate	μg/l	2	4	2.0E+00	8.0E+00	1.4E+01	2.5E+01
	Boron	μg/l	13	20	1.0E+01	4.8E+01	1.6E+02	1.2E+02
	Bromine	μg/l	1	4	1.1E+02	1.1E+02	1.1E+02	
	Cadmium	mg/l	17	17	4.0E+00	2.6E+01	1.1E+02	8.1E+01
	Calcium	mg/l	20	20	6.0E+00	1.6E+01	3.6E+01	3.6E+01
	Carbonate	mg/l	2	17	9.0E+00	1.9E+01	2.8E+01	4.6E+01
	Cesium-137	pCi/l	31	42	2.0E-02	1.2E+01	1.6E+02	7.5E+01
	Chromium	μg/l	5	20	4.0E+00	9.8E+00	1.7E+01	1.9E+01

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Los Alamos (cont.)	Cobalt	µg/l	4	19	4.0E+00	7.0E+00	1.0E+01	1.3E+01
	Copper	µg/l	5	20	7.0E+00	1.3E+01	2.1E+01	2.4E+01
	Cyanide	mg/l	1	14	1.0E-02	1.0E-02	1.0E-02	
	Di-n-butyl phthalate	µg/l	2	4	4.0E+00	5.5E+00	7.0E+00	9.7E+00
	Di-n-octyl phthalate	µg/l	1	4	8.0E+00	8.0E+00	8.0E+00	
	Fluorine	mg/l	15	17	6.0E-02	4.2E-01	1.1E+00	1.0E+00
	Gross Alpha	pCi/l	28	41	3.0E-01	3.4E+00	3.2E+01	1.8E+01
	Gross Beta	pCi/l	41	41	1.0E+00	2.8E+01	2.1E+02	1.2E+02
	Gross Gamma	pCi/l	25	37	1.0E+01	7.9E+01	4.0E+02	2.5E+02
	Hardness	mg/l	20	20	1.5E+01	5.3E+01	1.5E+02	1.2E+02
	Iron	µg/l	20	20	2.0E+01	1.5E+03	7.9E+03	5.6E+03
	Lead	µg/l	11	22	1.0E+00	1.2E+01	4.5E+01	4.1E+01
	Lithium	mg/l	3	6	6.0E-03	1.3E-02	2.0E-02	2.7E-02
	Magnesium	mg/l	20	20	1.3E+00	2.6E+00	5.2E+00	4.6E+00
	Manganese	µg/l	15	20	4.0E+00	1.3E+02	5.2E+02	4.6E+02
	Mercury	µg/l	5	20	1.0E-01	2.8E-01	1.0E+00	1.1E+00
	Molybdenum	µg/l	6	20	6.0E+00	2.4E+01	5.1E+01	5.7E+01
	Nickel	µg/l	3	20	2.0E+00	1.5E+01	2.2E+01	3.8E+01
	Nitrate, as Nitrogen	mg/l	13	22	7.0E-02	1.1E+00	3.9E+00	3.1E+00
	Nitrite, as Nitrogen	mg/l	1	4	4.6E-01	4.6E-01	4.6E-01	
	pH		17	17	7.1E+00		9.2E+00	
	Phosphate	mg/l	1	4	1.7E+00	1.7E+00	1.7E+00	

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Los Alamos (cont.)	Phosphate, as Phosphorous	mg/l	11	17	4.0E-02	2.1E-01	8.0E-01	7.0E-01
	Plutonium-238	pCi/l	78	108	1.0E-03	2.8E-02	2.5E-01	1.2E-01
	Plutonium-239, Plutonium-240	pCi/l	104	110	2.0E-03	4.9E-01	1.2E+01	4.2E+00
	Potassium	mg/l	19	20	1.7E+00	4.5E+00	7.2E+00	8.4E+00
	Selenium	µg/l	2	20	1.3E+00	4.2E+00	7.0E+00	1.2E+01
	Silica	mg/l	20	21	1.5E+01	3.3E+01	5.1E+01	5.3E+01
	Silver	µg/l	1	20	1.0E+00	1.0E+00	1.0E+00	
	Sodium	mg/l	20	20	5.0E+00	2.5E+01	8.7E+01	7.1E+01
	Strontium	µg/l	20	20	4.5E+01	9.2E+01	2.3E+02	1.9E+02
	Strontium-90	pCi/l	14	18	1.0E-01	1.4E+01	8.5E+01	6.1E+01
	Sulfate	mg/l	17	17	4.0E+00	7.6E+00	2.2E+01	1.7E+01
	Thallium	µg/l	3	20	4.3E-01	6.1E-01	8.0E-01	9.8E-01
	Total Dissolved Solids	mg/l	17	17	6.6E+01	2.1E+02	5.4E+02	4.8E+02
	Total Suspended Solids	mg/l	32	35	1.8E+00	1.3E+03	1.4E+04	7.6E+03
	Tritium	nCi/l	32	42	2.0E-04	5.7E-01	2.2E+00	1.6E+00
	Uranium	µg/l	23	33	6.0E-02	4.5E-01	2.2E+00	1.4E+00
	Vanadium	µg/l	6	20	4.0E+00	1.2E+01	2.2E+01	2.7E+01
	Zinc	µg/l	13	20	6.0E+00	4.6E+01	1.2E+02	1.2E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad	Aluminum	µg/l	10	11	9.0E+01	2.7E+03	1.4E+04	1.1E+04
	Americium-241	pCi/l	6	8	2.2E-02	1.1E+00	2.2E+00	2.7E+00
	Antimony	µg/l	3	11	6.0E-01	1.6E+00	3.0E+00	4.1E+00
	Arsenic	µg/l	9	11	2.0E+00	3.3E+00	5.0E+00	5.3E+00
	Barium	µg/l	9	9	3.0E+01	5.4E+01	9.3E+01	9.8E+01
	Beryllium	µg/l	2	11	5.0E-01	1.3E+00	2.0E+00	3.4E+00
	Bicarbonate	mg/l	11	11	7.0E+01	1.3E+02	2.1E+02	2.0E+02
	Boron	µg/l	11	11	1.9E+01	2.1E+02	4.1E+02	5.4E+02
	Cadmium	µg/l	1	11	4.0E-01	4.0E-01	4.0E-01	
	Calcium	mg/l	11	11	2.5E+01	4.6E+01	1.9E+02	1.4E+02
	Carbonate	mg/l	2	11	2.0E+00	7.0E+00	1.2E+01	2.1E+01
	Cesium-137	pCi/l	7	8	2.4E-01	2.6E+01	9.0E+01	9.3E+01
	Chlorine	mg/l	11	11	6.0E+00	2.9E+01	7.4E+01	7.7E+01
	Chromium	µg/l	5	11	3.0E+00	4.5E+00	6.3E+00	7.0E+00
	Cobalt	µg/l	2	10	4.0E+00	3.2E+01	6.0E+01	1.1E+02
	Copper	µg/l	10	11	6.0E+00	2.1E+01	4.0E+01	4.1E+01
	Cyanide	mg/l	3	9	1.0E-02	1.5E-02	2.0E-02	2.5E-02
	Fluorine	mg/l	11	11	3.0E-01	7.3E-01	1.1E+00	1.3E+00
	Gross Alpha	pCi/l	7	9	4.4E-01	1.3E+01	4.9E+01	5.0E+01
	Gross Beta	pCi/l	9	9	6.4E+00	8.1E+01	3.5E+02	3.0E+02
	Gross Gamma	pCi/l	7	9	2.0E+01	1.2E+02	6.0E+02	5.5E+02
	Hardness	mg/l	11	11	7.3E+01	1.5E+02	6.1E+02	4.6E+02
	Iron	µg/l	11	11	7.0E+01	1.8E+03	1.1E+04	8.1E+03
	Lead	µg/l	6	12	5.0E-01	9.1E+00	4.3E+01	4.2E+01
	Lithium	mg/l	2	2	2.9E-02	3.2E-02	3.4E-02	3.9E-02
	Magnesium	mg/l	11	11	2.2E+00	7.9E+00	3.3E+01	2.5E+01

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Manganese	µg/l	10	11	5.0E+00	3.7E+01	8.3E+01	8.2E+01
	Mercury	µg/l	2	11	3.0E-01	3.5E-01	4.0E-01	4.9E-01
	Molybdenum	µg/l	8	10	1.1E+01	2.8E+02	1.2E+03	1.1E+03
	Nickel	µg/l	2	11	1.0E+01	2.5E+01	4.0E+01	6.7E+01
	Nitrite, as Nitrogen	mg/l	11	11	5.1E-01	6.8E+00	1.8E+01	1.7E+01
	pH		11	11	7.5E+00		8.6E+00	
	Phosphate, as Phosphorous	mg/l	10	10	8.0E-02	3.6E+00	9.0E+00	1.1E+01
	Plutonium-238	pCi/l	9	10	3.9E-03	9.8E-01	4.7E+00	4.2E+00
	Plutonium-239, Plutonium-240	pCi/l	8	10	7.0E-03	4.3E-01	1.5E+00	1.5E+00
	Potassium	mg/l	11	11	3.0E+00	1.3E+01	4.3E+01	3.5E+01
	Selenium	µg/l	4	11	1.0E+00	1.7E+02	6.7E+02	8.4E+02
	Silica	mg/l	11	11	3.9E+01	6.8E+01	9.9E+01	1.1E+02
	Sodium	mg/l	11	11	2.1E+01	7.3E+01	1.8E+02	1.6E+02
	Strontium	µg/l	11	11	6.0E+01	1.0E+02	1.6E+02	1.6E+02
	Strontium-90	pCi/l	8	9	5.0E-01	9.0E+01	5.0E+02	4.3E+02
	Sulfate	mg/l	11	11	5.0E+00	2.1E+01	4.1E+01	4.8E+01
	Thallium	µg/l	2	11	1.7E-01	3.1E+00	6.0E+00	1.1E+01
	Tin	µg/l	2	8	4.5E+01	8.8E+01	1.3E+02	2.1E+02
	Total Dissolved Solids	mg/l	11	11	2.1E+02	4.1E+02	1.1E+03	9.1E+02
	Total Suspended Solids	mg/l	3	4	2.0E+00	1.3E+01	2.4E+01	3.5E+01
	Tritium	nCi/l	9	10	4.0E-04	6.7E+00	1.8E+01	2.1E+01
	Uranium	µg/l	11	11	4.0E-01	1.2E+00	2.7E+00	2.7E+00

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Vanadium	µg/l	7	11	9.0E+00	1.0E+01	1.1E+01	1.2E+01
	Zinc	µg/l	9	11	1.0E+01	2.5E+01	3.9E+01	4.2E+01
Pajarito	Acetone	µg/l	1	4	2.4E+01	2.4E+01	2.4E+01	
	Aluminum	µg/l	8	10	1.0E+01	9.5E+02	3.8E+03	3.6E+03
	Americium-241	pCi/l	7	8	8.0E-03	2.5E-02	3.7E-02	4.9E-02
	Antimony	µg/l	2	10	3.0E-01	4.5E-01	6.0E-01	8.7E-01
	Arsenic	µg/l	4	10	2.0E+00	4.0E+00	9.0E+00	1.1E+01
	Barium	µg/l	9	9	3.8E+01	8.9E+01	1.8E+02	2.0E+02
	Beryllium	µg/l	3	10	5.0E-01	2.4E+01	6.8E+01	1.0E+02
	Bicarbonate	mg/l	11	11	5.7E+01	7.8E+01	9.5E+01	1.0E+02
	Boron	µg/l	10	10	2.0E+01	4.9E+01	2.1E+02	1.6E+02
	Cadmium	µg/l	3	10	3.0E-01	5.1E+01	1.5E+02	2.2E+02
	Calcium	mg/l	10	11	1.5E+01	2.2E+01	3.0E+01	3.1E+01
	Cesium-137	pCi/l	11	17	2.1E-01	4.1E+01	3.3E+02	2.4E+02
	Chlorine	mg/l	11	11	5.0E+00	2.4E+01	6.2E+01	6.8E+01
	Chromium	µg/l	7	10	2.2E+00	7.8E+01	5.1E+02	4.6E+02
	Cobalt	µg/l	3	9	1.4E+01	8.3E+01	1.7E+02	2.4E+02
	Copper	µg/l	4	10	4.0E+00	1.4E+02	5.2E+02	6.5E+02
	Di-n-butyl phthalate	µg/l	1	4	2.0E+00	2.0E+00	2.0E+00	
	Fluorine	mg/l	10	11	1.0E-01	3.4E-01	5.0E-01	6.6E-01
	Gross Alpha	pCi/l	13	15	5.0E-02	1.1E+00	3.0E+00	2.6E+00
	Gross Beta	pCi/l	15	15	1.0E+00	4.6E+00	9.0E+00	9.2E+00
	Gross Gamma	pCi/l	10	14	1.0E+01	1.6E+02	9.0E+02	7.0E+02
	Hardness	mg/l	11	11	5.6E+01	7.7E+01	1.1E+02	1.1E+02
	Iron	µg/l	9	10	2.0E+01	2.7E+03	1.8E+04	1.4E+04

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pajarito (cont.)	Lead	µg/l	3	10	5.0E-01	1.5E+00	2.0E+00	3.1E+00
	Lithium	mg/l	2	2	4.0E-03	1.6E-02	2.7E-02	4.8E-02
	Magnesium	mg/l	10	11	4.3E+00	5.5E+00	7.3E+00	7.8E+00
	Manganese	µg/l	9	10	2.0E+00	3.1E+02	2.1E+03	1.7E+03
	Mercury	µg/l	1	10	2.0E-01	2.0E-01	2.0E-01	
	Molybdenum	µg/l	5	10	1.0E+00	9.9E+01	3.4E+02	4.0E+02
	Nickel	µg/l	1	10	2.4E+02	2.4E+02	2.4E+02	
	Nitrate, as Nitrogen	mg/l	10	11	4.0E-02	6.4E-01	1.5E+00	1.5E+00
	pH		11	11	6.8E+00		8.5E+00	
	Phosphate, as Phosphorous	mg/l	5	11	2.0E-02	1.5E-01	3.0E-01	3.9E-01
	Plutonium-238	pCi/l	18	31	1.0E-03	9.4E-03	2.2E-02	2.3E-02
	Plutonium-239 Plutonium-240	pCi/l	20	31	1.0E-03	1.2E-02	4.5E-02	3.3E-02
	Potassium	mg/l	10	11	1.5E+00	3.3E+00	5.0E+00	5.5E+00
	Selenium	µg/l	1	10	3.0E+00	3.0E+00	3.0E+00	
	Silica	mg/l	11	11	2.9E+01	5.3E+01	7.3E+01	9.0E+01
	Silver	µg/l	3	10	1.0E+00	3.4E+01	9.6E+01	1.4E+02
	Sodium	mg/l	10	11	1.2E+01	1.9E+01	3.1E+01	3.4E+01
	Strontium	µg/l	10	10	1.1E+02	1.8E+02	5.1E+02	4.1E+02
	Strontium-90	pCi/l	7	9	3.0E-01	1.5E+01	1.0E+02	9.0E+01
	Sulfate	mg/l	11	11	4.0E+00	1.1E+01	3.2E+01	2.7E+01
	Thallium	µg/l	1	10	2.0E-01	2.0E-01	2.0E-01	
	Tin	µg/l	3	9	1.0E+01	3.0E+01	6.3E+01	8.8E+01
	Total Dissolved Solids	mg/l	11	11	1.4E+02	2.4E+02	7.5E+02	5.8E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pajarito (cont.)	Total Suspended Solids	mg/l	6	8	2.0E+00	1.6E+01	4.1E+01	5.5E+01
	Tritium	nCi/l	11	17	1.0E-04	3.7E-01	6.0E-01	7.9E-01
	Uranium	µg/l	11	14	1.0E-01	6.7E-01	1.2E+00	1.6E+00
	Vanadium	µg/l	7	10	1.0E+00	2.8E+01	1.0E+02	9.6E+01
	Zinc	µg/l	6	10	5.0E+00	8.0E+01	2.5E+02	2.6E+02
Pueblo	Acetone	µg/l	1	5	3.2E+01	3.2E+01	3.2E+01	
	Aluminum	µg/l	13	16	1.6E+02	1.2E+03	3.2E+03	3.2E+03
	Americium-241	pCi/l	10	13	6.0E-04	7.2E-02	1.7E-01	1.9E-01
	Antimony	µg/l	4	15	2.0E-01	2.8E-01	4.0E-01	4.7E-01
	Arsenic	µg/l	15	16	2.0E+00	5.6E+00	1.3E+01	1.3E+01
	Barium	µg/l	13	13	6.8E+00	4.2E+02	5.2E+03	3.3E+03
	Beryllium	µg/l	5	16	1.0E+00	2.4E+02	1.2E+03	1.3E+03
	Bicarbonate	mg/l	15	16	3.5E+01	9.0E+01	2.3E+02	1.9E+02
	Bis(2-ethylhexyl) phthalate	µg/l	1	2	8.0E+00	8.0E+00	8.0E+00	
	Boron	µg/l	14	16	2.5E+01	4.3E+02	4.2E+03	2.6E+03
	Cadmium	µg/l	5	16	3.0E-01	2.0E+02	1.0E+03	1.1E+03
	Calcium	mg/l	16	16	9.7E+00	1.7E+01	3.1E+01	2.9E+01
	Cesium-137	pCi/l	23	24	4.9E-01	2.9E+01	3.2E+02	1.8E+02
	Chlorine	mg/l	16	16	2.8E+01	6.0E+01	2.1E+02	1.6E+02
	Chromium	µg/l	12	16	3.2E+00	4.3E+02	5.0E+03	3.3E+03
	Cobalt	µg/l	4	16	5.0E+00	2.2E+02	8.5E+02	1.1E+03
	Copper	µg/l	12	16	2.0E+00	4.6E+02	5.3E+03	3.5E+03
	Cyanide	mg/l	2	8	2.0E-02	3.0E-02	4.0E-02	5.8E-02
	Fluorine	mg/l	16	16	2.0E-01	4.4E-01	9.0E-01	8.3E-01

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Gross Alpha	pCi/l	13	21	2.0E-01	1.4E+00	3.0E+00	3.1E+00
	Gross Beta	pCi/l	21	21	2.0E+00	2.1E+01	1.4E+02	7.8E+01
	Gross Gamma	pCi/l	19	24	1.0E+01	1.4E+02	5.0E+02	4.5E+02
	Hardness	mg/l	16	16	3.0E+01	5.5E+01	9.9E+01	1.0E+02
	Iron	µg/l	15	16	2.0E+02	7.9E+02	1.9E+03	1.9E+03
	Lead	µg/l	12	15	1.0E+00	2.6E+00	5.6E+00	5.8E+00
	Lithium	mg/l	2	2	1.0E-02	1.1E-02	1.1E-02	1.2E-02
	Magnesium	mg/l	16	16	1.2E+00	3.1E+00	6.4E+00	6.0E+00
	Manganese	µg/l	16	16	2.0E+00	3.8E+02	5.4E+03	3.1E+03
	Mercury	µg/l	5	16	1.0E-01	2.8E-01	4.0E-01	6.1E-01
	Molybdenum	µg/l	8	16	2.0E+00	1.3E+02	1.0E+03	8.3E+02
	Nickel	µg/l	3	16	3.0E+01	1.9E+03	5.5E+03	8.2E+03
	Nitrate, as Nitrogen	mg/l	13	16	2.5E-01	4.7E+00	1.7E+01	1.6E+01
	pH		16	16	1.7E+00		8.7E+00	
	Phosphate, as Phosphorous	mg/l	12	12	3.0E-01	2.1E+00	8.9E+00	7.6E+00
	Plutonium-238	pCi/l	28	57	1.0E-03	5.1E-02	4.6E-01	2.4E-01
	Plutonium-239, Plutonium-240	pCi/l	49	57	4.0E-03	2.1E+00	5.2E+01	1.9E+01
	Potassium	mg/l	13	13	4.0E+00	9.6E+00	1.5E+01	1.9E+01
	Selenium	µg/l	1	16	1.8E+01	1.8E+01	1.8E+01	
	Silica	mg/l	16	16	1.7E+01	5.0E+01	9.1E+01	1.1E+02
	Silver	µg/l	9	16	4.0E-01	1.3E+02	6.9E+02	6.1E+02
	Sodium	mg/l	16	16	3.6E+01	5.9E+01	8.1E+01	8.7E+01
	Strontium	µg/l	16	16	5.1E+01	4.1E+02	5.3E+03	3.0E+03
	Strontium-90	pCi/l	9	11	5.0E-01	3.3E+00	8.3E+00	9.2E+00

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Sulfate	mg/l	16	16	6.0E+00	1.8E+01	3.8E+01	3.8E+01
	Thallium	µg/l	3	16	1.0E-01	2.0E-01	3.0E-01	4.0E-01
	Tin	µg/l	1	12	9.2E+02	9.2E+02	9.2E+02	
	Total Dissolved Solids	mg/l	16	16	1.9E+02	3.4E+02	4.7E+02	5.2E+02
	Total Suspended Solids	mg/l	15	16	2.0E+00	1.9E+03	1.5E+04	9.5E+03
	Tritium	nCi/l	19	24	4.0E-04	3.7E-01	1.5E+00	1.0E+00
	Uranium	µg/l	12	20	6.0E-02	3.9E-01	8.0E-01	9.3E-01
	Vanadium	µg/l	10	16	4.0E+00	1.2E+02	1.0E+03	7.4E+02
	Zinc	µg/l	13	16	4.0E+00	1.7E+02	1.3E+03	8.9E+02
Sandia	Aluminum	µg/l	17	18	1.0E+02	6.9E+02	3.3E+03	2.3E+03
	Americium-241	pCi/l	11	13	2.0E-03	3.6E-02	6.6E-02	8.2E-02
	Antimony	µg/l	6	18	3.0E-01	7.3E-01	1.7E+00	1.7E+00
	Arsenic	µg/l	13	15	4.0E+00	5.5E+00	9.0E+00	8.1E+00
	Barium	µg/l	15	15	2.4E+01	8.3E+01	7.7E+02	4.6E+02
	Beryllium	µg/l	3	18	5.0E-01	4.1E+01	1.2E+02	1.8E+02
	Bicarbonate	mg/l	18	18	8.8E+01	1.2E+02	1.5E+02	1.6E+02
	Boron	µg/l	18	18	4.2E+01	8.7E+01	4.0E+02	2.5E+02
	Cadmium	µg/l	5	15	6.0E-01	3.3E+01	1.5E+02	1.6E+02
	Calcium	mg/l	18	18	1.5E+01	2.5E+01	4.0E+01	3.8E+01
	Carbonate	mg/l	6	18	2.0E+00	7.3E+00	1.5E+01	1.9E+01
	Cesium-137	pCi/l	9	20	5.2E-01	4.1E+01	2.7E+02	2.2E+02
	Chlorine	mg/l	18	18	2.7E+01	5.5E+01	1.1E+02	9.4E+01
	Chromium	µg/l	15	18	1.1E+01	6.6E+01	7.6E+02	4.5E+02
	Cobalt	µg/l	2	15	2.6E+01	9.3E+01	1.6E+02	2.8E+02
	Copper	µg/l	15	18	5.0E+00	6.1E+01	7.5E+02	4.4E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Sandia (cont.)	Cyanide	mg/l	8	15	1.0E-02	2.9E-02	1.1E-01	9.5E-02
	Di-n-butyl phthalate	µg/l	1	2	2.0E+00	2.0E+00	2.0E+00	
	Fluorine	mg/l	18	18	4.0E-01	1.2E+00	2.5E+00	2.5E+00
	Gross Alpha	pCi/l	8	18	1.0E+00	2.8E+01	2.1E+02	1.8E+02
	Gross Beta	pCi/l	18	18	1.0E+00	1.2E+01	3.1E+01	2.6E+01
	Gross Gamma	pCi/l	8	19	2.0E+01	1.9E+02	4.8E+02	5.7E+02
	Hardness	mg/l	18	18	5.5E+01	8.4E+01	1.4E+02	1.3E+02
	Iron	µg/l	18	18	9.0E+01	6.5E+02	2.6E+03	1.8E+03
	Lead	µg/l	13	21	2.0E+00	4.7E+00	1.9E+01	1.5E+01
	Lithium	mg/l	3	3	4.3E-02	4.9E-02	5.9E-02	6.7E-02
	Magnesium	mg/l	18	18	4.0E+00	5.0E+00	7.3E+00	6.5E+00
	Manganese	µg/l	17	18	7.0E+00	1.1E+02	8.0E+02	5.8E+02
	Mercury	µg/l	5	17	1.0E-01	1.4E-01	3.0E-01	3.2E-01
	Molybdenum	µg/l	18	18	6.0E+01	3.7E+02	1.2E+03	1.0E+03
	Nickel	µg/l	4	18	1.0E+01	3.7E+02	7.9E+02	1.2E+03
	Nitrate, as Nitrogen	mg/l	18	18	4.0E-02	4.1E+00	2.0E+01	1.5E+01
	pH		18	18	7.7E+00		8.9E+00	
	Phosphate, as Phosphorous	mg/l	18	18	2.6E-01	3.1E+00	1.6E+01	9.8E+00
	Plutonium-238	pCi/l	11	21	2.0E-03	7.6E-03	2.1E-02	2.0E-02
	Plutonium-239, Plutonium-240	pCi/l	18	21	1.0E-03	1.1E-02	4.4E-02	3.4E-02
	Potassium	mg/l	15	15	3.0E+00	1.1E+01	1.4E+01	1.6E+01
	Selenium	µg/l	4	18	2.0E+00	2.5E+00	3.1E+00	3.7E+00
	Silica	mg/l	21	21	2.4E+01	8.4E+01	1.0E+02	1.2E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Sandia (cont.)	Silver	µg/l	11	18	5.0E-01	1.9E+01	6.7E+01	7.9E+01
	Sodium	mg/l	18	18	4.8E+01	8.4E+01	1.1E+02	1.2E+02
	Strontium	µg/l	18	18	7.1E+01	1.8E+02	9.1E+02	6.5E+02
	Strontium-90	pCi/l	11	13	6.0E-02	4.4E-01	1.1E+00	1.2E+00
	Sulfate	mg/l	18	18	1.3E+01	6.8E+01	1.1E+02	1.3E+02
	Thallium	µg/l	3	18	2.0E-01	2.0E-01	2.0E-01	2.0E-01
	Tin	µg/l	6	18	2.0E+01	7.6E+01	2.4E+02	2.6E+02
	Total Dissolved Solids	mg/l	18	18	2.2E+02	4.7E+02	7.6E+02	7.2E+02
	Total Suspended Solids	mg/l	6	6	4.0E+00	9.8E+00	2.2E+01	2.4E+01
	Tritium	nCi/l	15	21	2.0E-04	3.9E-01	1.1E+00	1.1E+00
	Uranium	µg/l	15	19	3.0E-01	8.7E-01	4.7E+00	3.1E+00
	Vanadium	µg/l	18	18	8.1E+00	2.7E+01	9.0E+01	7.7E+01
	Zinc	µg/l	18	18	1.0E+01	7.4E+01	2.1E+02	1.8E+02
Water	Acetone	µg/l	1	2	4.9E+01	4.9E+01	4.9E+01	
	Aluminum	µg/l	3	3	6.0E+02	5.0E+03	1.2E+04	1.7E+04
	Americium-241	pCi/l	1	2	1.3E-02	1.3E-02	1.3E-02	
	Antimony	µg/l	1	3	3.0E-01	3.0E-01	3.0E-01	
	Arsenic	µg/l	2	3	2.0E+00	3.0E+00	4.0E+00	5.8E+00
	Barium	µg/l	2	2	4.0E+02	4.6E+02	5.2E+02	6.3E+02
	Beryllium	µg/l	1	3	1.0E+00	1.0E+00	1.0E+00	
	Bicarbonate	mg/l	3	3	4.8E+01	5.8E+01	6.6E+01	7.7E+01
	Boron	µg/l	3	3	3.0E+01	5.6E+01	9.0E+01	1.2E+02
	Cadmium	µg/l	2	3	2.1E+00	2.6E+00	3.0E+00	3.8E+00
	Calcium	mg/l	3	3	1.2E+01	1.4E+01	1.6E+01	1.9E+01
	Cesium-137	pCi/l	4	5	7.1E-01	5.7E+01	1.7E+02	2.2E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Water (cont.)	Chlorine	mg/l	3	3	9.0E+00	1.8E+01	2.9E+01	3.8E+01
	Fluorine	mg/l	2	3	1.7E-01	1.7E-01	1.7E-01	1.7E-01
	Gross Alpha	pCi/l	3	4	1.0E+00	2.8E+00	5.5E+00	7.6E+00
	Gross Beta	pCi/l	4	4	4.0E+00	6.9E+00	9.0E+00	1.1E+01
	Gross Gamma	pCi/l	3	5	2.4E+01	9.5E+01	1.9E+02	2.6E+02
	Hardness	mg/l	3	3	4.8E+01	5.5E+01	5.9E+01	6.7E+01
	HMX (Octogen)	µg/l	1	1	4.9E+00	4.9E+00	4.9E+00	
	Iron	µg/l	3	3	4.0E+02	2.4E+03	5.6E+03	8.1E+03
	Lead	µg/l	3	3	2.0E+00	2.3E+00	3.0E+00	3.5E+00
	Lithium	mg/l	1	1	5.0E-03	5.0E-03	5.0E-03	
	Magnesium	mg/l	3	3	4.5E+00	4.8E+00	5.0E+00	5.3E+00
	Manganese	µg/l	3	3	1.4E+01	2.3E+01	2.9E+01	4.0E+01
	Nickel	µg/l	1	3	1.0E+01	1.0E+01	1.0E+01	
	Nitrate, as Nitrogen	mg/l	3	3	3.0E-02	4.1E+00	9.6E+00	1.4E+01
	pH		3	3	6.8E+00		7.5E+00	
	Phosphate, as Phosphorous	mg/l	3	3	6.0E-02	1.6E-01	2.2E-01	3.3E-01
	Plutonium-238	pCi/l	7	9	2.4E-03	1.5E-02	2.3E-02	3.0E-02
	Plutonium-239, Plutonium-240	pCi/l	4	9	1.0E-03	4.3E-03	7.3E-03	9.5E-03
	Potassium	mg/l	3	3	3.9E+00	4.4E+00	5.2E+00	5.8E+00
	RDX (Cyclonite)	µg/l	1	1	7.6E-01	7.6E-01	7.6E-01	
	Selenium	µg/l	1	3	4.8E+01	4.8E+01	4.8E+01	
	Silica	mg/l	3	3	3.0E+01	3.4E+01	3.8E+01	4.2E+01
	Sodium	mg/l	3	3	1.7E+01	1.8E+01	1.9E+01	2.1E+01
	Strontium	µg/l	3	3	8.8E+01	9.9E+01	1.2E+02	1.4E+02

TABLE C–3.—*Surface Water Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Water (cont.)	Strontium-90	pCi/l	1	2	1.1E+00	1.1E+00	1.1E+00	
	Sulfate	mg/l	3	3	6.0E+00	6.6E+00	7.0E+00	7.8E+00
	Tin	µg/l	2	3	2.6E+01	2.8E+01	3.0E+01	3.4E+01
	Total Dissolved Solids	mg/l	3	3	1.7E+02	1.8E+02	1.9E+02	2.0E+02
	Total Suspended Solids	mg/l	3	3	3.0E+00	1.4E+01	3.6E+01	5.2E+01
	Tritium	nCi/l	4	5	3.0E-04	3.4E-01	8.0E-01	1.0E+00
	Uranium	µg/l	4	4	1.0E-01	4.0E-01	6.2E-01	8.9E-01
	Vanadium	µg/l	1	3	8.0E+00	8.0E+00	8.0E+00	
	Zinc	µg/l	1	2	2.0E+01	2.0E+01	2.0E+01	

[a] Watershed includes both on-site and perimeter analyses as designated by the Environmental Surveillance Program.
[b] pCi/l is picocuries of radioactive analyte per liter of sample, nCi/l is nanocuries of radioactive analyte per liter of sample, µg/l is micrograms of analyte per liter of sample, mg/l is milligrams of analyte per liter of sample.
[c] Upper confidence limit (UCL) not calculated when the number of detected analyses equals 1.

TABLE C–4.—*Sediment Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
On Site	Aluminum	mg/kg	210	210	6.1E+02	5.5E+03	3.2E+04	1.5E+04
	Americium-241	pCi/g	207	224	1.0E-03	4.6E-01	1.2E+01	3.8E+00
	Antimony	mg/kg	6	211	2.5E-01	3.6E+00	8.0E+00	9.8E+00
	Arsenic	mg/kg	204	214	2.8E-01	1.4E+00	5.5E+00	3.4E+00
	Barium	mg/kg	213	213	6.2E+00	8.0E+01	5.5E+02	2.9E+02
	Beryllium	mg/kg	164	211	2.0E-02	5.8E-01	2.9E+00	1.7E+00
	Bis(2-ethylhexyl) phthalate	µg/kg	2	30	3.5E+02	3.5E+02	3.5E+02	3.5E+02
	Boron	mg/kg	95	210	1.1E+00	8.9E+00	1.2E+02	3.9E+01
	Cadmium	mg/kg	33	214	1.8E-01	6.0E-01	2.3E+00	1.5E+00
	Calcium	mg/kg	21	21	1.8E+02	1.2E+03	4.6E+03	3.9E+03
	Cesium-137	pCi/g	252	294	1.0E-02	1.9E+00	1.1E+02	1.8E+01
	Chromium	mg/kg	210	214	1.1E+00	1.2E+01	1.2E+03	1.8E+02
	Cobalt	mg/kg	201	210	5.2E-01	3.5E+00	1.2E+01	8.4E+00
	Copper	mg/kg	159	211	6.7E-01	4.5E+00	3.3E+01	1.2E+01
	Di-n-butyl phthalate	µg/kg	21	30	3.8E+02	6.0E+02	1.0E+03	9.9E+02
	Gross Alpha	pCi/g	292	292	8.0E-01	5.6E+00	5.4E+01	1.9E+01
	Gross Beta	pCi/g	290	292	5.0E-01	4.8E+00	8.9E+01	1.9E+01
	Gross Gamma	pCi/g	262	296	1.0E+00	5.3E+00	1.1E+02	2.2E+01
	Iron	mg/kg	211	211	2.4E+01	6.2E+03	2.7E+04	1.5E+04
	Lead	mg/kg	167	213	1.0E+00	1.3E+01	1.4E+02	3.8E+01
	Lithium	mg/kg	21	21	1.2E+00	8.0E+00	5.1E+01	2.9E+01
	Magnesium	mg/kg	21	21	1.2E+02	7.2E+02	2.5E+03	2.2E+03
	Manganese	mg/kg	211	211	4.7E+01	2.4E+02	6.6E+02	5.0E+02
	Mercury	mg/kg	50	196	1.0E-02	2.9E-02	2.0E-01	8.7E-02

TABLE C–4.—*Sediment Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
On Site (cont.)	Molybdenum	mg/kg	41	211	3.0E-01	1.9E+00	1.4E+01	6.4E+00
	Nickel	mg/kg	116	210	1.1E+00	6.3E+00	1.6E+01	1.3E+01
	Plutonium-238	pCi/g	265	295	2.0E-04	1.8E-01	6.8E+00	1.7E+00
	Plutonium-239, Plutonium-240	pCi/g	294	295	1.0E-03	4.4E-01	1.7E+01	3.7E+00
	Potassium	mg/kg	20	21	1.3E+02	7.2E+02	2.7E+03	2.3E+03
	Selenium	mg/kg	72	214	1.2E-01	3.7E-01	7.0E-01	6.0E-01
	Silver	mg/kg	16	214	3.5E-01	3.5E+00	1.3E+01	1.0E+01
	Sodium	mg/kg	21	21	3.1E+01	1.3E+02	3.1E+02	3.1E+02
	Strontium	mg/kg	210	210	1.6E+00	2.3E+01	1.0E+03	1.8E+02
	Strontium-90	pCi/g	216	251	1.0E-01	4.2E-01	5.0E+00	1.6E+00
	Thallium	mg/kg	20	211	4.0E-02	1.8E+00	1.8E+01	1.0E+01
	Tin	mg/kg	45	210	2.4E+00	2.2E+01	8.6E+01	7.3E+01
	Tritium	nCi/l[d]	172	244	1.3E-02	3.6E+00	9.4E+01	2.8E+01
	Uranium	mg/kg	283	283	4.0E-01	2.0E+00	4.8E+00	3.8E+00
	Vanadium	mg/kg	208	210	1.5E+00	1.2E+01	1.1E+02	3.9E+01
	Zinc	mg/kg	211	211	6.0E+00	4.4E+01	6.5E+02	1.6E+02
Perimeter	Aluminum	mg/kg	123	123	3.8E+02	4.8E+03	1.9E+04	1.2E+04
	Americium-241	pCi/g	115	124	1.0E-03	3.4E-02	5.3E-01	2.2E-01
	Antimony	mg/kg	4	122	3.0E-02	2.2E-01	7.8E-01	9.7E-01
	Arsenic	mg/kg	111	128	2.1E-01	2.1E+00	6.5E+01	1.5E+01
	Barium	mg/kg	128	128	4.9E+00	6.6E+01	6.0E+02	2.4E+02
	Beryllium	mg/kg	101	123	8.0E-02	4.9E-01	1.8E+00	1.1E+00
	Boron	mg/kg	56	123	5.0E-01	4.5E+00	3.3E+01	1.6E+01
	Cadmium	mg/kg	24	128	2.2E-01	7.6E-01	1.8E+00	1.6E+00
	Calcium	mg/kg	8	8	3.1E+02	4.8E+03	1.3E+04	1.5E+04
	Cesium-137	pCi/g	111	149	2.0E-02	2.8E-01	2.1E+00	9.9E-01

TABLE C–4.—*Sediment Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Perimeter (cont.)	Chromium	mg/kg	127	127	5.8E-01	4.7E+00	1.5E+01	1.0E+01
	Cobalt	mg/kg	119	123	6.0E-01	3.3E+00	1.8E+01	8.0E+00
	Copper	mg/kg	110	123	5.0E-01	4.5E+00	4.4E+01	1.6E+01
	Cyanide	mg/kg	2	5	7.5E-02	1.5E-01	2.3E-01	3.7E-01
	Gross Alpha	pCi/g	146	146	4.1E-01	3.7E+00	1.4E+01	8.6E+00
	Gross Beta	pCi/g	145	145	3.0E-01	2.9E+00	2.8E+01	8.5E+00
	Gross Gamma	pCi/g	138	149	1.0E+00	4.5E+00	1.5E+01	1.1E+01
	Iron	mg/kg	123	123	5.3E+02	6.8E+03	2.2E+04	1.5E+04
	Lead	mg/kg	109	128	1.0E+00	9.9E+00	3.3E+01	2.3E+01
	Lithium	mg/kg	13	13	2.9E+00	1.1E+01	3.1E+01	2.7E+01
	Magnesium	mg/kg	13	13	2.4E+02	1.3E+03	4.1E+03	3.7E+03
	Manganese	mg/kg	123	123	3.7E+01	2.4E+02	6.4E+02	5.0E+02
	Mercury	mg/kg	32	122	1.0E-02	3.0E-02	1.2E-01	6.7E-02
	Molybdenum	mg/kg	21	123	4.0E-01	1.3E+00	2.5E+00	2.5E+00
	Nickel	mg/kg	82	123	1.5E+00	5.2E+00	1.5E+01	1.1E+01
	Plutonium-238	pCi/g	134	150	3.0E-04	6.7E-03	6.1E-02	2.7E-02
	Plutonium-239, Plutonium-240	pCi/g	149	150	1.0E-03	4.0E-01	1.2E+01	3.7E+00
	Potassium	mg/kg	13	13	2.3E+02	9.7E+02	2.6E+03	2.5E+03
	Selenium	mg/kg	39	127	1.0E-01	2.2E+00	6.8E+01	2.4E+01
	Silver	mg/kg	13	128	1.2E+00	6.6E+00	2.7E+01	2.1E+01
	Sodium	mg/kg	8	8	7.3E+01	1.7E+02	3.6E+02	3.9E+02
	Strontium	mg/kg	121	122	1.4E+00	1.2E+01	9.7E+01	3.7E+01
	Strontium-90	pCi/g	110	140	1.0E-01	2.8E-01	2.9E+00	9.3E-01
	Thallium	mg/kg	23	122	5.0E-02	8.8E-01	6.4E+00	4.3E+00
	Tin	mg/kg	43	122	3.4E+00	1.1E+01	3.5E+01	2.3E+01
	Tritium	nCi/l[d]	95	131	4.7E-02	6.8E-01	3.6E+00	1.9E+00

TABLE C–4.—*Sediment Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Perimeter (cont.)	Uranium	mg/kg	132	132	3.2E-01	2.1E+00	5.9E+00	4.2E+00
	Vanadium	mg/kg	121	122	2.0E+00	1.0E+01	4.3E+01	2.4E+01
	Zinc	mg/kg	122	122	5.5E+00	3.8E+01	3.3E+02	1.1E+02
Regional	Acetone	µg/kg	1	1	2.6E+01	2.6E+01	2.6E+01	
	Aluminum	mg/kg	45	46	6.8E+02	4.9E+03	1.3E+04	1.1E+04
	Americium-241	pCi/g	43	44	1.0E-03	1.6E-02	1.6E-01	9.3E-02
	Arsenic	mg/kg	49	52	4.1E-01	2.2E+00	5.3E+00	4.5E+00
	Barium	mg/kg	51	52	1.1E+01	1.8E+02	6.4E+02	5.3E+02
	Beryllium	mg/kg	35	46	1.0E-01	4.4E-01	7.7E-01	8.1E-01
	Boron	mg/kg	22	46	1.0E+00	1.0E+01	1.0E+02	5.4E+01
	Butyl benzyl phthalate	µg/kg	1	3	1.7E+03	1.7E+03	1.7E+03	
	Cadmium	mg/kg	16	52	2.9E-01	8.4E-01	1.7E+00	1.7E+00
	Calcium	mg/kg	8	9	1.6E+03	6.8E+03	1.6E+04	1.8E+04
	Cesium-137	pCi/g	51	63	1.0E-02	2.5E-01	7.7E+00	2.4E+00
	Chromium	mg/kg	51	52	5.5E-01	7.1E+00	2.6E+01	1.6E+01
	Cobalt	mg/kg	44	46	6.2E-01	4.2E+00	1.3E+01	8.9E+00
	Copper	mg/kg	37	46	1.2E+00	5.1E+00	1.2E+01	1.0E+01
	Gross Alpha	pCi/g	61	61	8.0E-01	3.6E+00	1.5E+01	8.6E+00
	Gross Beta	pCi/g	61	61	3.0E-01	2.7E+00	6.0E+00	5.0E+00
	Gross Gamma	pCi/g	55	63	1.3E+00	3.2E+00	1.1E+01	7.0E+00
	Iron	mg/kg	44	46	3.8E+02	7.2E+03	1.9E+04	1.6E+04
	Lead	mg/kg	29	52	1.0E-01	6.4E+00	3.2E+01	1.8E+01
	Lithium	mg/kg	4	4	1.2E+00	4.4E+00	1.1E+01	1.3E+01
	Magnesium	mg/kg	4	4	3.3E+02	9.4E+02	2.5E+03	3.0E+03
	Manganese	mg/kg	46	46	2.6E-01	1.8E+02	3.9E+02	3.7E+02
	Mercury	mg/kg	20	52	2.0E-02	3.2E-02	9.7E-02	6.8E-02

TABLE C–4.—*Sediment Detection Statistics by Location and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Regional (cont.)	Molybdenum	mg/kg	6	46	1.3E+00	2.4E+00	3.9E+00	4.5E+00
	Nickel	mg/kg	31	46	2.0E+00	7.4E+00	2.2E+01	1.5E+01
	Plutonium-238	pCi/g	53	59	2.0E-04	3.8E-03	1.3E-02	1.0E-02
	Plutonium-239, Plutonium-240	pCi/g	59	59	1.0E-03	4.2E-03	2.4E-02	1.1E-02
	Potassium	mg/kg	4	4	1.3E+02	4.0E+02	1.1E+03	1.3E+03
	Selenium	mg/kg	18	52	1.0E-01	5.3E-01	2.7E+00	1.9E+00
	Silver	mg/kg	6	52	1.0E+00	3.0E+00	5.0E+00	5.5E+00
	Sodium	mg/kg	4	4	3.8E+01	8.5E+01	1.8E+02	2.1E+02
	Strontium	mg/kg	45	46	3.4E+00	5.1E+01	2.2E+02	1.3E+02
	Strontium-90	pCi/g	37	55	1.0E-01	6.4E-01	1.1E+01	4.2E+00
	Thallium	mg/kg	6	46	5.0E-02	7.8E-02	1.0E-01	1.1E-01
	Tin	mg/kg	12	46	8.0E+00	1.3E+01	2.1E+01	2.1E+01
	Tritium	nCi/l[d]	30	58	2.1E-02	2.1E-01	6.0E-01	4.5E-01
	Uranium	mg/kg	61	61	6.1E-01	2.2E+00	1.4E+01	5.7E+00
	Vanadium	mg/kg	45	46	1.5E+00	1.6E+01	4.8E+01	3.5E+01
	Zinc	mg/kg	44	45	6.1E+00	2.2E+01	5.3E+01	4.3E+01

[a] On-site, perimeter, and regional locations are in accordance with the Environmental Surveillance Program.
[b] pCi/g is picocuries of radioactive analyte per gram of sample, nCi/l is nanocuries of radioactive analyte per liter of sample, µg/kg is micrograms of analyte per kilogram of sample, mg/kg is milligrams of analyte per kilogram of sample.
[c] Upper confidence limit (UCL) not calculated when the number of detected analyses equals 1.
[d] Tritium is reported as nanocuries of tritium per liter of water because tritium in sediments exists as tritiated water. The water is distilled, and the tritium content of the water is measured.

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Ancho	Aluminum	mg/kg	60	60	8.4E+02	9.0E+03	3.2E+04	2.2E+04
	Americium-241	pCi/g	49	61	1.0E-03	3.4E-02	4.2E-01	2.2E-01
	Antimony	mg/kg	3	60	3.0E+00	5.0E+00	8.0E+00	1.0E+01
	Arsenic	mg/kg	59	61	2.8E-01	2.3E+00	5.5E+00	4.7E+00
	Barium	mg/kg	61	61	6.2E+00	1.7E+02	5.5E+02	4.7E+02
	Beryllium	mg/kg	37	60	1.1E-01	1.3E+00	2.9E+00	3.0E+00
	Boron	mg/kg	31	60	1.5E+00	1.1E+01	6.3E+01	3.8E+01
	Cadmium	mg/kg	8	61	3.6E-01	8.2E-01	2.3E+00	2.3E+00
	Calcium	mg/kg	1	1	3.4E+03	3.4E+03	3.4E+03	
	Cesium-137	pCi/g	80	87	4.0E-02	2.7E-01	1.0E+00	6.5E-01
	Chromium	mg/kg	59	61	1.3E+00	3.1E+01	1.2E+03	3.4E+02
	Cobalt	mg/kg	55	60	1.3E+00	5.6E+00	1.2E+01	1.1E+01
	Copper	mg/kg	45	60	1.5E+00	5.4E+00	1.2E+01	1.0E+01
	Di-n-butyl phthalate	µg/kg	1	1	6.5E+02	6.5E+02	6.5E+02	
	Gross Alpha	pCi/g	86	86	1.0E+00	5.4E+00	1.7E+01	1.1E+01
	Gross Beta	pCi/g	86	86	1.0E+00	4.7E+00	1.0E+01	8.7E+00
	Gross Gamma	pCi/g	72	88	1.0E+00	3.2E+00	1.0E+01	7.1E+00
	Iron	mg/kg	60	60	6.0E+02	8.3E+03	2.7E+04	1.9E+04
	Lead	mg/kg	47	61	1.0E+00	1.5E+01	3.4E+01	3.1E+01
	Lithium	mg/kg	1	1	1.2E+01	1.2E+01	1.2E+01	
	Magnesium	mg/kg	1	1	2.2E+03	2.2E+03	2.2E+03	
	Manganese	mg/kg	60	60	4.7E+01	3.3E+02	6.6E+02	6.2E+02
	Mercury	mg/kg	20	61	1.0E-02	2.1E-02	5.0E-02	4.1E-02
	Molybdenum	mg/kg	4	60	6.0E-01	1.9E+00	2.8E+00	3.8E+00
	Nickel	mg/kg	49	60	3.2E+00	8.1E+00	1.6E+01	1.4E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Ancho (cont.)	Plutonium-238	pCi/g	67	88	6.0E-04	6.8E-03	4.8E-02	2.5E-02
	Plutonium-239, Plutonium-240	pCi/g	88	88	1.0E-03	7.4E-02	1.7E+00	6.3E-01
	Potassium	mg/kg	1	1	2.0E+03	2.0E+03	2.0E+03	
	Selenium	mg/kg	32	61	1.2E-01	3.5E-01	5.5E-01	6.0E-01
	Silver	mg/kg	2	61	1.7E+00	2.6E+00	3.5E+00	5.2E+00
	Sodium	mg/kg	1	1	2.5E+02	2.5E+02	2.5E+02	
	Strontium	mg/kg	60	60	3.1E+00	5.7E+01	1.0E+03	3.3E+02
	Strontium-90	pCi/g	57	63	1.0E-01	4.1E-01	2.5E+00	1.2E+00
	Thallium	mg/kg	4	60	2.0E-01	1.4E+00	5.0E+00	6.2E+00
	Tin	mg/kg	14	60	7.0E+00	5.2E+01	8.6E+01	1.1E+02
	Tritium	nCi/l[d]	54	83	1.5E-02	5.9E-01	4.5E+00	2.3E+00
	Uranium	mg/kg	76	76	4.5E-01	2.2E+00	4.8E+00	4.2E+00
	Vanadium	mg/kg	60	60	2.6E+00	2.4E+01	1.1E+02	6.4E+01
	Zinc	mg/kg	60	60	6.0E+00	6.2E+01	6.5E+02	2.5E+02
Bayo	Aluminum	mg/kg	4	4	1.5E+03	2.8E+03	5.9E+03	7.0E+03
	Americium-241	pCi/g	5	5	2.0E-03	2.3E-02	1.1E-01	1.2E-01
	Arsenic	mg/kg	3	4	4.0E-01	5.1E-01	7.3E-01	8.9E-01
	Barium	mg/kg	4	4	2.2E+01	4.5E+01	8.7E+01	1.0E+02
	Beryllium	mg/kg	2	4	1.6E-01	2.7E-01	3.8E-01	5.8E-01
	Boron	mg/kg	1	4	2.9E+00	2.9E+00	2.9E+00	
	Cadmium	mg/kg	1	4	3.9E-01	3.9E-01	3.9E-01	
	Cesium-137	pCi/g	1	6	7.0E-02	7.0E-02	7.0E-02	
	Chromium	mg/kg	4	4	2.8E+00	4.2E+00	6.6E+00	7.5E+00
	Cobalt	mg/kg	4	4	1.1E+00	2.4E+00	4.3E+00	5.1E+00
	Copper	mg/kg	4	4	1.8E+00	3.5E+00	5.5E+00	6.6E+00

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Bayo (cont.)	Gross Alpha	pCi/g	6	6	1.0E+00	1.7E+00	2.0E+00	2.7E+00
	Gross Beta	pCi/g	6	6	9.0E-01	1.5E+00	2.0E+00	2.6E+00
	Gross Gamma	pCi/g	6	6	1.0E+00	3.0E+00	7.0E+00	7.1E+00
	Iron	mg/kg	4	4	1.4E+03	3.4E+03	5.5E+03	6.7E+03
	Lead	mg/kg	1	4	8.0E+00	8.0E+00	8.0E+00	
	Manganese	mg/kg	4	4	9.8E+01	1.2E+02	1.7E+02	1.9E+02
	Molybdenum	mg/kg	1	4	1.4E+00	1.4E+00	1.4E+00	
	Nickel	mg/kg	3	4	2.0E+00	5.2E+00	9.8E+00	1.3E+01
	Plutonium-238	pCi/g	5	6	2.0E-03	7.0E-03	1.1E-02	1.5E-02
	Plutonium-239, Plutonium-240	pCi/g	6	6	2.0E-03	4.2E-03	7.0E-03	8.0E-03
	Strontium	mg/kg	4	4	4.9E+00	1.4E+01	3.9E+01	4.7E+01
	Strontium-90	pCi/g	5	6	1.0E-01	2.4E-01	5.0E-01	5.7E-01
	Tin	mg/kg	1	4	1.3E+01	1.3E+01	1.3E+01	
	Tritium	nCi/l[d]	3	3	3.0E-01	4.6E-01	7.0E-01	8.8E-01
	Uranium	mg/kg	6	6	9.3E-01	2.0E+00	2.8E+00	3.5E+00
	Vanadium	mg/kg	4	4	5.6E+00	9.6E+00	1.5E+01	1.9E+01
	Zinc	mg/kg	4	4	1.1E+01	1.4E+01	2.2E+01	2.5E+01
Cañada del Buey	Aluminum	mg/kg	13	13	1.8E+03	5.0E+03	2.1E+04	1.5E+04
	Americium-241	pCi/g	15	16	2.0E-03	2.6E-02	1.5E-01	9.8E-02
	Arsenic	mg/kg	13	13	3.0E-01	9.5E-01	3.0E+00	2.3E+00
	Barium	mg/kg	13	13	1.7E+01	4.0E+01	8.3E+01	8.0E+01
	Beryllium	mg/kg	9	13	1.1E-01	5.5E-01	1.4E+00	1.4E+00
	Bis(2-ethylhexyl) phthalate	µg/kg	2	9	3.5E+02	3.5E+02	3.5E+02	3.5E+02
	Boron	mg/kg	8	13	1.3E+00	2.5E+00	5.4E+00	5.1E+00

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Cañada del Buey (cont.)	Cadmium	mg/kg	4	13	2.0E-01	4.8E-01	1.1E+00	1.3E+00
	Cesium-137	pCi/g	20	24	4.0E-02	2.1E-01	6.0E-01	5.0E-01
	Chromium	mg/kg	13	13	1.4E+00	4.0E+00	1.3E+01	1.0E+01
	Cobalt	mg/kg	13	13	5.2E-01	2.7E+00	4.9E+00	5.6E+00
	Copper	mg/kg	8	13	6.7E-01	2.4E+00	5.2E+00	5.5E+00
	Di-n-butyl phthalate	µg/kg	6	9	4.6E+02	7.1E+02	1.0E+03	1.2E+03
	Gross Alpha	pCi/g	24	24	1.9E+00	4.2E+00	1.0E+01	7.9E+00
	Gross Beta	pCi/g	23	24	1.4E+00	2.8E+00	7.0E+00	5.4E+00
	Gross Gamma	pCi/g	21	24	1.0E+00	5.7E+00	2.1E+01	1.6E+01
	Iron	mg/kg	13	13	2.4E+01	5.2E+03	1.5E+04	1.3E+04
	Lead	mg/kg	11	13	3.4E+00	6.9E+00	9.2E+00	1.0E+01
	Manganese	mg/kg	13	13	8.0E+01	1.9E+02	3.1E+02	3.4E+02
	Mercury	mg/kg	1	13	2.0E-02	2.0E-02	2.0E-02	
	Nickel	mg/kg	8	13	1.1E+00	4.7E+00	1.0E+01	1.0E+01
	Plutonium-238	pCi/g	24	24	1.0E-03	5.7E-02	2.4E-01	2.0E-01
	Plutonium-239, Plutonium-240	pCi/g	24	24	2.0E-03	6.7E-02	2.3E-01	2.1E-01
	Selenium	mg/kg	3	13	3.0E-01	4.0E-01	5.0E-01	6.0E-01
	Strontium	mg/kg	13	13	3.2E+00	7.7E+00	2.0E+01	1.8E+01
	Strontium-90	pCi/g	12	18	1.0E-01	2.2E-01	4.0E-01	4.6E-01
	Thallium	mg/kg	1	13	2.0E-01	2.0E-01	2.0E-01	
	Tin	mg/kg	1	13	8.0E+00	8.0E+00	8.0E+00	
	Tritium	nCi/l[d]	17	19	2.0E-01	1.4E+00	3.7E+00	3.9E+00

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Cañada del Buey (cont.)	Uranium	mg/kg	24	24	4.0E-01	2.0E+00	4.4E+00	4.1E+00
	Vanadium	mg/kg	13	13	1.8E+00	8.2E+00	2.4E+01	2.0E+01
	Zinc	mg/kg	13	13	1.1E+01	2.8E+01	6.0E+01	5.5E+01
Chaquehui	Aluminum	mg/kg	4	4	3.1E+03	6.3E+03	1.2E+04	1.4E+04
	Americium-241	pCi/g	3	3	3.0E-03	5.3E-03	1.0E-02	1.3E-02
	Arsenic	mg/kg	4	5	7.0E-01	1.6E+00	3.0E+00	3.9E+00
	Barium	mg/kg	5	5	5.5E+01	1.5E+02	3.2E+02	3.6E+02
	Beryllium	mg/kg	4	4	3.1E-01	5.3E-01	8.9E-01	1.0E+00
	Boron	mg/kg	2	4	3.0E+00	3.7E+00	4.4E+00	5.7E+00
	Cadmium	mg/kg	1	5	1.3E+00	1.3E+00	1.3E+00	
	Calcium	mg/kg	1	1	4.6E+03	4.6E+03	4.6E+03	
	Cesium-137	pCi/g	5	5	1.0E-01	2.8E-01	6.1E-01	7.2E-01
	Chromium	mg/kg	5	5	3.1E+00	5.8E+00	9.1E+00	1.1E+01
	Cobalt	mg/kg	4	4	2.6E+00	4.0E+00	5.1E+00	6.1E+00
	Copper	mg/kg	4	4	4.9E+00	7.7E+00	1.3E+01	1.5E+01
	Gross Alpha	pCi/g	5	5	3.0E+00	4.2E+00	9.0E+00	9.6E+00
	Gross Beta	pCi/g	5	5	2.0E+00	3.4E+00	6.0E+00	6.7E+00
	Gross Gamma	pCi/g	5	5	2.6E+00	3.2E+00	4.3E+00	4.5E+00
	Iron	mg/kg	4	4	6.0E+03	1.0E+04	1.4E+04	1.7E+04
	Lead	mg/kg	4	5	3.8E+00	7.7E+00	1.4E+01	1.7E+01
	Lithium	mg/kg	1	1	1.4E+01	1.4E+01	1.4E+01	
	Magnesium	mg/kg	1	1	2.4E+03	2.4E+03	2.4E+03	
	Manganese	mg/kg	4	4	1.3E+02	2.6E+02	3.5E+02	4.6E+02
	Mercury	mg/kg	2	5	3.0E-02	4.0E-02	5.0E-02	6.8E-02
	Molybdenum	mg/kg	2	4	1.8E+00	2.9E+00	4.0E+00	6.0E+00

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Chaquehui (cont.)	Nickel	mg/kg	4	4	3.8E+00	7.0E+00	1.1E+01	1.3E+01
	Plutonium-238	pCi/g	4	5	1.0E-03	7.0E-03	1.8E-02	2.2E-02
	Plutonium-239, Plutonium-240	pCi/g	5	5	4.0E-03	1.1E-02	2.8E-02	3.1E-02
	Potassium	mg/kg	1	1	2.7E+03	2.7E+03	2.7E+03	
	Selenium	mg/kg	2	5	3.8E-01	4.9E-01	6.0E-01	8.0E-01
	Silver	mg/kg	1	5	1.8E+00	1.8E+00	1.8E+00	
	Sodium	mg/kg	1	1	2.6E+02	2.6E+02	2.6E+02	
	Strontium	mg/kg	4	4	1.0E+01	3.1E+01	6.5E+01	8.1E+01
	Strontium-90	pCi/g	4	4	1.0E-01	3.8E-01	1.0E+00	1.2E+00
	Thallium	mg/kg	2	4	7.0E-02	1.6E-01	2.5E-01	4.1E-01
	Tin	mg/kg	1	4	9.6E+00	9.6E+00	9.6E+00	
	Tritium	nCi/l[d]	3	5	3.0E-01	1.1E+01	2.8E+01	4.1E+01
	Uranium	mg/kg	5	5	1.4E+00	2.2E+00	2.9E+00	3.4E+00
	Vanadium	mg/kg	4	4	6.5E+00	1.4E+01	2.0E+01	2.5E+01
	Zinc	mg/kg	4	4	1.9E+01	3.4E+01	4.7E+01	6.2E+01
Frijoles	Aluminum	mg/kg	9	9	3.8E+02	5.8E+03	1.5E+04	1.6E+04
	Americium-241	pCi/g	7	9	3.0E-03	2.4E-02	1.4E-01	1.2E-01
	Arsenic	mg/kg	7	10	2.1E-01	1.5E+00	4.0E+00	4.5E+00
	Barium	mg/kg	10	10	4.9E+00	7.0E+01	2.1E+02	2.2E+02
	Beryllium	mg/kg	8	9	1.0E-01	4.9E-01	1.2E+00	1.3E+00
	Boron	mg/kg	3	9	8.6E-01	1.5E+00	1.9E+00	2.6E+00
	Cadmium	mg/kg	2	10	2.2E-01	3.8E-01	5.4E-01	8.3E-01
	Calcium	mg/kg	1	1	1.3E+04	1.3E+04	1.3E+04	
	Cesium-137	pCi/g	10	12	7.0E-02	2.0E-01	5.0E-01	4.8E-01
	Chromium	mg/kg	10	10	5.8E-01	4.7E+00	1.3E+01	1.3E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Frijoles (cont.)	Cobalt	mg/kg	9	9	7.3E-01	3.0E+00	6.7E+00	7.1E+00
	Copper	mg/kg	7	9	1.0E+00	5.9E+00	1.4E+01	1.5E+01
	Gross Alpha	pCi/g	11	11	4.1E-01	2.2E+00	4.0E+00	4.4E+00
	Gross Beta	pCi/g	11	11	1.0E+00	1.8E+00	5.0E+00	4.1E+00
	Gross Gamma	pCi/g	12	12	2.0E+00	3.5E+00	7.0E+00	6.6E+00
	Iron	mg/kg	9	9	8.2E+02	6.7E+03	1.6E+04	1.7E+04
	Lead	mg/kg	8	10	3.0E+00	9.5E+00	2.0E+01	2.3E+01
	Lithium	mg/kg	1	1	2.0E+01	2.0E+01	2.0E+01	
	Magnesium	mg/kg	1	1	4.1E+03	4.1E+03	4.1E+03	
	Manganese	mg/kg	9	9	3.7E+01	2.7E+02	6.4E+02	6.9E+02
	Mercury	mg/kg	3	10	2.0E-02	3.0E-02	4.0E-02	5.0E-02
	Nickel	mg/kg	5	9	1.5E+00	5.4E+00	1.1E+01	1.3E+01
	Plutonium-238	pCi/g	9	12	4.0E-04	5.0E-03	1.6E-02	1.6E-02
	Plutonium-239, Plutonium-240	pCi/g	12	12	2.0E-03	6.0E-03	2.0E-02	1.5E-02
	Potassium	mg/kg	1	1	2.6E+03	2.6E+03	2.6E+03	
	Selenium	mg/kg	4	10	6.0E-01	7.8E-01	1.1E+00	1.2E+00
	Silver	mg/kg	2	10	2.4E+00	1.5E+01	2.7E+01	4.9E+01
	Sodium	mg/kg	1	1	3.6E+02	3.6E+02	3.6E+02	
	Strontium	mg/kg	9	9	1.4E+00	1.9E+01	6.3E+01	6.1E+01
	Strontium-90	pCi/g	8	10	1.0E-01	3.0E-01	1.3E+00	1.1E+00
	Thallium	mg/kg	1	9	3.0E-01	3.0E-01	3.0E-01	
	Tin	mg/kg	3	9	3.6E+00	5.6E+00	7.1E+00	9.1E+00
	Tritium	nCi/l[d]	5	11	1.0E-01	3.6E-01	9.6E-01	1.0E+00
	Uranium	mg/kg	12	12	1.2E+00	2.3E+00	4.6E+00	4.1E+00

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Guaje	Vanadium	mg/kg	8	9	2.0E+00	1.1E+01	2.3E+01	2.7E+01
	Zinc	mg/kg	9	9	5.5E+00	3.5E+01	8.1E+01	8.5E+01
	Aluminum	mg/kg	4	4	1.7E+03	2.9E+03	5.5E+03	6.4E+03
	Americium-241	pCi/g	3	5	1.0E-03	1.7E-03	2.0E-03	2.8E-03
	Arsenic	mg/kg	4	4	4.0E-01	4.9E-01	6.0E-01	6.6E-01
	Barium	mg/kg	4	4	2.1E+01	3.5E+01	5.3E+01	6.8E+01
	Beryllium	mg/kg	2	4	1.7E-01	2.6E-01	3.4E-01	5.0E-01
	Cadmium	mg/kg	1	4	3.2E-01	3.2E-01	3.2E-01	
	Cesium-137	pCi/g	4	6	4.0E-02	7.5E-02	1.0E-01	1.4E-01
	Chromium	mg/kg	4	4	2.7E+00	6.1E+00	1.2E+01	1.4E+01
	Cobalt	mg/kg	4	4	2.2E+00	2.5E+00	3.0E+00	3.2E+00
	Copper	mg/kg	3	4	2.4E+00	4.3E+00	7.3E+00	9.6E+00
	Gross Alpha	pCi/g	6	6	1.7E+00	2.3E+00	3.0E+00	3.4E+00
	Gross Beta	pCi/g	6	6	1.0E+00	1.7E+00	3.0E+00	3.2E+00
	Gross Gamma	pCi/g	6	6	1.0E+00	3.2E+00	9.0E+00	9.1E+00
	Iron	mg/kg	4	4	6.2E+02	7.4E+03	1.7E+04	2.1E+04
	Lead	mg/kg	2	4	6.0E+00	7.2E+00	8.3E+00	1.0E+01
	Manganese	mg/kg	4	4	8.8E+01	1.7E+02	3.2E+02	3.8E+02
	Molybdenum	mg/kg	1	4	1.4E+00	1.4E+00	1.4E+00	
	Nickel	mg/kg	3	4	3.1E+00	5.9E+00	9.1E+00	1.2E+01
	Plutonium-238	pCi/g	6	6	1.0E-03	6.3E-03	1.5E-02	1.8E-02
	Plutonium-239, Plutonium-240	pCi/g	6	6	1.0E-03	3.5E-02	1.9E-01	1.9E-01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Guaje (cont.)	Selenium	mg/kg	1	4	5.0E-01	5.0E-01	5.0E-01	
	Silver	mg/kg	1	4	2.9E+00	2.9E+00	2.9E+00	
	Strontium	mg/kg	4	4	5.7E+00	1.2E+01	2.5E+01	3.0E+01
	Strontium-90	pCi/g	6	6	1.0E-01	6.3E-01	2.9E+00	2.9E+00
	Tin	mg/kg	1	4	8.2E+00	8.2E+00	8.2E+00	
	Tritium	nCi/l[d]	3	3	1.0E-01	4.3E-01	1.0E+00	1.4E+00
	Uranium	mg/kg	6	6	1.5E+00	2.0E+00	2.4E+00	2.6E+00
	Vanadium	mg/kg	4	4	5.5E+00	1.6E+01	3.3E+01	4.0E+01
	Zinc	mg/kg	4	4	1.2E+01	3.2E+01	7.5E+01	9.0E+01
Los Alamos	Aluminum	mg/kg	59	59	6.1E+02	2.9E+03	7.1E+03	6.5E+03
	Americium-241	pCi/g	61	62	1.0E-03	1.1E-01	4.9E-01	3.6E-01
	Arsenic	mg/kg	53	59	3.2E-01	2.1E+00	6.5E+01	2.0E+01
	Barium	mg/kg	59	59	7.2E+00	3.3E+01	2.6E+02	1.0E+02
	Beryllium	mg/kg	47	59	1.1E-01	2.9E-01	5.7E-01	5.5E-01
	Boron	mg/kg	19	59	5.0E-01	8.3E+00	3.7E+01	3.2E+01
	Cadmium	mg/kg	3	59	4.6E-01	6.0E-01	8.0E-01	9.6E-01
	Calcium	mg/kg	8	8	1.8E+02	5.3E+02	1.0E+03	1.1E+03
	Cesium-137	pCi/g	58	72	2.0E-02	9.2E-01	4.0E+00	2.8E+00
	Chromium	mg/kg	57	58	1.1E+00	3.4E+00	1.5E+01	8.1E+00
	Cobalt	mg/kg	56	59	7.7E-01	2.7E+00	1.3E+01	6.8E+00
	Copper	mg/kg	46	59	1.0E+00	3.6E+00	1.1E+01	8.0E+00
	Gross Alpha	pCi/g	73	73	8.0E-01	2.5E+00	6.1E+00	4.9E+00
	Gross Beta	pCi/g	71	72	5.0E-01	2.2E+00	6.0E+00	5.0E+00
	Gross Gamma	pCi/g	63	73	1.0E+00	4.1E+00	1.4E+01	1.1E+01
	Iron	mg/kg	59	59	5.3E+02	4.2E+03	2.2E+04	1.1E+04
	Lead	mg/kg	48	59	2.0E+00	1.1E+01	2.8E+01	2.2E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Los Alamos (cont.)	Lithium	mg/kg	8	8	1.2E+00	3.5E+00	5.4E+00	6.2E+00
	Magnesium	mg/kg	8	8	1.2E+02	4.0E+02	7.2E+02	8.2E+02
	Manganese	mg/kg	59	59	5.4E+01	1.5E+02	4.0E+02	2.9E+02
	Mercury	mg/kg	14	51	1.0E-02	3.5E-02	1.2E-01	1.0E-01
	Molybdenum	mg/kg	13	59	3.3E-01	8.4E-01	1.8E+00	1.9E+00
	Nickel	mg/kg	27	59	2.1E+00	4.5E+00	1.5E+01	1.1E+01
	Plutonium-238	pCi/g	69	72	3.0E-04	1.6E-02	6.4E-02	4.7E-02
	Plutonium-239, Plutonium-240	pCi/g	71	72	1.0E-03	1.5E-01	1.3E+00	4.9E-01
	Potassium	mg/kg	7	8	1.3E+02	3.3E+02	5.5E+02	6.1E+02
	Selenium	mg/kg	18	59	1.9E-01	4.2E+00	6.8E+01	3.6E+01
	Silver	mg/kg	8	59	3.5E-01	7.5E+00	1.5E+01	1.7E+01
	Sodium	mg/kg	8	8	3.1E+01	8.1E+01	1.3E+02	1.7E+02
	Strontium	mg/kg	59	59	1.8E+00	7.8E+00	4.1E+01	2.1E+01
	Strontium-90	pCi/g	64	73	1.0E-01	3.3E-01	4.0E+00	1.3E+00
	Thallium	mg/kg	2	59	1.0E-01	3.5E-01	6.0E-01	1.1E+00
	Tin	mg/kg	13	59	3.4E+00	8.3E+00	1.3E+01	1.4E+01
	Tritium	nCi/l[d]	32	51	1.0E-01	7.9E-01	5.4E+00	2.7E+00
	Uranium	mg/kg	71	71	7.7E-01	1.8E+00	4.4E+00	3.4E+00
	Vanadium	mg/kg	58	59	1.6E+00	6.6E+00	4.2E+01	1.8E+01
	Zinc	mg/kg	59	59	8.0E+00	2.8E+01	9.3E+01	5.7E+01
Mortandad	Aluminum	mg/kg	87	87	8.5E+02	5.5E+03	1.9E+04	1.3E+04
	Americium-241	pCi/g	83	86	1.0E-03	1.0E+00	1.2E+01	6.1E+00
	Antimony	mg/kg	5	86	3.0E-02	1.3E-01	3.0E-01	4.0E-01
	Arsenic	mg/kg	81	88	3.0E-01	1.5E+00	4.6E+00	3.2E+00
	Barium	mg/kg	88	88	9.8E+00	6.0E+01	5.2E+02	1.8E+02
	Beryllium	mg/kg	80	87	1.1E-01	5.3E-01	1.8E+00	1.2E+00
	Boron	mg/kg	47	87	1.0E+00	7.3E+00	1.2E+02	4.2E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Cadmium	mg/kg	15	88	1.8E-01	7.4E-01	1.7E+00	1.5E+00
	Calcium	mg/kg	8	8	2.9E+02	1.5E+03	5.7E+03	5.3E+03
	Cesium-137	pCi/g	85	101	3.0E-02	4.7E+00	1.1E+02	3.2E+01
	Chromium	mg/kg	88	88\	8.1E-01	4.2E+00	1.1E+01	8.9E+00
	Cobalt	mg/kg	86	87	5.9E-01	3.2E+00	1.8E+01	8.1E+00
	Copper	mg/kg	72	87	5.0E-01	5.4E+00	4.4E+01	1.9E+01
	Cyanide	mg/kg	2	5	7.5E-02	1.5E-01	2.3E-01	3.7E-01
	Gross Alpha	pCi/g	98	98	1.0E+00	8.6E+00	5.4E+01	2.9E+01
	Gross Beta	pCi/g	98	98	1.0E+00	8.0E+00	8.9E+01	3.1E+01
	Gross Gamma	pCi/g	95	101	1.0E+00	9.2E+00	1.1E+02	3.5E+01
	Iron	mg/kg	87	87	5.0E+02	6.6E+03	1.8E+04	1.4E+04
	Lead	mg/kg	69	88	1.0E+00	1.1E+01	2.6E+01	2.0E+01
	Lithium	mg/kg	13	13	2.6E+00	7.8E+00	1.3E+01	1.6E+01
	Magnesium	mg/kg	13	13	1.8E+02	7.2E+02	2.9E+03	2.2E+03
	Manganese	mg/kg	87	87	7.9E+01	2.7E+02	6.4E+02	5.2E+02
	Mercury	mg/kg	19	81	1.0E-02	2.9E-02	5.0E-02	4.9E-02
	Molybdenum	mg/kg	23	87	4.5E-01	1.4E+00	2.6E+00	2.8E+00
	Nickel	mg/kg	50	87	1.6E+00	5.4E+00	1.3E+01	9.8E+00
	Plutonium-238	pCi/g	96	102	3.0E-04	4.6E-01	6.8E+00	2.9E+00
	Plutonium-239, Plutonium-240	pCi/g	101	102	1.0E-03	1.0E+00	1.7E+01	6.4E+00
	Potassium	mg/kg	13	13	1.5E+02	6.9E+02	2.2E+03	1.8E+03
	Selenium	mg/kg	25	87	2.0E-01	3.9E-01	7.3E-01	6.6E-01
	Silver	mg/kg	3	88	5.3E-01	1.1E+00	1.9E+00	2.5E+00
	Sodium	mg/kg	8	8	4.2E+01	9.0E+01	2.6E+02	2.4E+02
	Strontium	mg/kg	85	86	1.6E+00	1.1E+01	3.6E+01	2.6E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Strontium-90	pCi/g	87	99	1.0E-01	4.5E-01	3.9E+00	1.7E+00
	Thallium	mg/kg	21	86	5.0E-02	4.9E-01	5.0E+00	2.8E+00
	Tin	mg/kg	32	86	4.0E+00	1.2E+01	3.5E+01	2.5E+01
	Tritium	nCi/l[d]	68	90	1.0E-01	6.4E+00	9.4E+01	4.3E+01
	Uranium	mg/kg	88	88	3.2E-01	2.2E+00	5.4E+00	4.4E+00
	Vanadium	mg/kg	85	86	1.5E+00	8.8E+00	2.4E+01	1.9E+01
	Zinc	mg/kg	86	86	9.3E+00	4.3E+01	3.3E+02	1.2E+02
Pajarito	Aluminum	mg/kg	30	30	1.0E+03	5.0E+03	1.5E+04	1.1E+04
	Americium-241	pCi/g	36	37	1.0E-03	9.5E-03	4.9E-02	3.2E-02
	Arsenic	mg/kg	29	31	3.2E-01	1.2E+00	3.0E+00	2.3E+00
	Barium	mg/kg	31	31	1.1E+01	6.3E+01	5.3E+02	2.5E+02
	Beryllium	mg/kg	26	30	1.1E-01	3.6E-01	7.4E-01	7.4E-01
	Boron	mg/kg	19	30	1.4E+00	4.0E+00	2.2E+01	1.3E+01
	Cadmium	mg/kg	7	31	2.0E-01	5.8E-01	1.8E+00	1.7E+00
	Calcium	mg/kg	1	1	5.6E+02	5.6E+02	5.6E+02	
	Cesium-137	pCi/g	44	52	3.0E-02	2.2E-01	1.2E+00	6.1E-01
	Chromium	mg/kg	30	31	1.6E+00	5.1E+00	1.4E+01	1.0E+01
	Cobalt	mg/kg	29	30	6.5E-01	3.1E+00	1.1E+01	7.5E+00
	Copper	mg/kg	25	30	9.5E-01	3.0E+00	1.2E+01	7.7E+00
	Di-n-butyl phthalate	µg/kg	12	18	3.9E+02	5.7E+02	8.7E+02	9.1E+02
	Gross Alpha	pCi/g	52	52	1.0E+00	4.5E+00	1.3E+01	8.9E+00
	Gross Beta	pCi/g	52	52	7.0E-01	3.0E+00	7.0E+00	5.9E+00
	Gross Gamma	pCi/g	49	52	1.0E+00	3.7E+00	1.3E+01	8.6E+00
	Iron	mg/kg	30	30	2.0E+03	7.3E+03	1.6E+04	1.4E+04
	Lead	mg/kg	25	31	1.2E+00	1.7E+01	1.4E+02	7.1E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pajarito (cont.)	Lithium	mg/kg	1	1	3.0E+00	3.0E+00	3.0E+00	
	Magnesium	mg/kg	1	1	3.9E+02	3.9E+02	3.9E+02	
	Manganese	mg/kg	30	30	4.6E+01	2.3E+02	6.2E+02	4.7E+02
	Mercury	mg/kg	6	31	1.0E-02	2.3E-02	4.0E-02	4.4E-02
	Molybdenum	mg/kg	5	30	5.0E-01	2.4E+00	5.5E+00	6.1E+00
	Nickel	mg/kg	15	30	3.0E+00	4.8E+00	9.9E+00	8.7E+00
	Plutonium-238	pCi/g	50	52	1.0E-03	7.6E-03	3.6E-02	2.2E-02
	Plutonium-239, Plutonium-240	pCi/g	52	52	1.0E-03	2.9E-02	2.3E-01	1.2E-01
	Potassium	mg/kg	1	1	2.7E+02	2.7E+02	2.7E+02	
	Selenium	mg/kg	9	31	1.0E-01	3.2E-01	5.0E-01	6.3E-01
	Sodium	mg/kg	1	1	8.0E+01	8.0E+01	8.0E+01	
	Strontium	mg/kg	30	30	2.2E+00	9.4E+00	3.1E+01	2.1E+01
	Strontium-90	pCi/g	30	39	1.0E-01	2.2E-01	9.0E-01	5.4E-01
	Thallium	mg/kg	3	30	2.0E-01	3.7E-01	6.5E-01	8.6E-01
	Tin	mg/kg	2	30	6.0E+00	9.0E+00	1.2E+01	1.7E+01
	Tritium	nCi/l[d]	42	49	7.5E-02	1.9E+00	6.6E+00	6.0E+00
	Uranium	mg/kg	52	52	6.0E-01	1.9E+00	4.5E+00	3.8E+00
	Vanadium	mg/kg	30	30	1.8E+00	9.9E+00	2.5E+01	2.0E+01
	Zinc	mg/kg	30	30	9.2E+00	5.2E+01	3.9E+02	1.9E+02
Potrillo	Aluminum	mg/kg	2	2	5.0E+03	6.1E+03	7.3E+03	9.3E+03
	Americium-241	pCi/g	3	3	2.0E-03	4.3E-03	7.0E-03	9.4E-03
	Arsenic	mg/kg	2	2	1.6E+00	1.7E+00	1.7E+00	1.8E+00
	Barium	mg/kg	2	2	6.7E+01	7.0E+01	7.3E+01	7.7E+01
	Beryllium	mg/kg	2	2	2.7E-01	5.2E-01	7.6E-01	1.2E+00
	Boron	mg/kg	1	2	2.8E+00	2.8E+00	2.8E+00	

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Potrillo (cont.)	Cadmium	mg/kg	1	2	5.4E-01	5.4E-01	5.4E-01	
	Cesium-137	pCi/g	3	3	1.0E-01	2.1E-01	4.0E-01	5.4E-01
	Chromium	mg/kg	2	2	3.1E+00	4.7E+00	6.3E+00	9.2E+00
	Cobalt	mg/kg	2	2	2.0E+00	2.5E+00	2.9E+00	3.7E+00
	Copper	mg/kg	2	2	3.2E+00	4.2E+00	5.2E+00	7.0E+00
	Gross Alpha	pCi/g	3	3	4.0E+00	4.4E+00	4.8E+00	5.2E+00
	Gross Beta	pCi/g	3	3	3.5E+00	3.8E+00	4.0E+00	4.3E+00
	Gross Gamma	pCi/g	3	3	3.0E+00	4.6E+00	6.0E+00	7.6E+00
	Iron	mg/kg	2	2	5.9E+03	6.7E+03	7.6E+03	9.1E+03
	Lead	mg/kg	2	2	5.7E+00	7.6E+00	9.4E+00	1.3E+01
	Manganese	mg/kg	2	2	2.0E+02	2.1E+02	2.3E+02	2.5E+02
	Mercury	mg/kg	1	2	2.0E-02	2.0E-02	2.0E-02	
	Molybdenum	mg/kg	1	2	1.1E+00	1.1E+00	1.1E+00	
	Nickel	mg/kg	2	2	4.0E+00	5.3E+00	6.5E+00	8.8E+00
	Plutonium-238	pCi/g	3	3	1.0E-03	1.2E-02	2.9E-02	4.2E-02
	Plutonium-239, Plutonium-240	pCi/g	3	3	5.0E-03	8.7E-03	1.1E-02	1.5E-02
	Selenium	mg/kg	1	2	7.0E-01	7.0E-01	7.0E-01	
	Strontium	mg/kg	2	2	1.0E+01	1.1E+01	1.2E+01	1.4E+01
	Strontium-90	pCi/g	3	3	2.0E-01	3.0E-01	4.0E-01	5.0E-01
	Thallium	mg/kg	2	2	3.0E-01	4.5E-01	6.0E-01	8.7E-01
	Tin	mg/kg	1	2	2.4E+00	2.4E+00	2.4E+00	
	Tritium	nCi/l[d]	2	3	1.3E-02	6.6E-01	1.3E+00	2.5E+00
	Uranium	mg/kg	3	3	1.8E+00	2.5E+00	3.2E+00	3.8E+00
	Vanadium	mg/kg	2	2	6.3E+00	8.2E+00	1.0E+01	1.4E+01
	Zinc	mg/kg	2	2	2.4E+01	2.9E+01	3.5E+01	4.4E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo	Aluminum	mg/kg	30	30	1.1E+03	3.0E+03	6.3E+03	6.7E+03
	Americium-241	pCi/g	29	31	2.0E-03	1.0E-01	5.3E-01	4.2E-01
	Antimony	mg/kg	1	31	6.0E+00	6.0E+00	6.0E+00	
	Arsenic	mg/kg	29	31	3.5E-01	7.7E-01	1.6E+00	1.4E+00
	Barium	mg/kg	30	30	1.2E+01	2.9E+01	9.2E+01	6.0E+01
	Beryllium	mg/kg	22	31	2.0E-02	3.5E-01	7.0E-01	7.2E-01
	Boron	mg/kg	7	30	3.6E+00	1.0E+01	2.3E+01	2.7E+01
	Cadmium	mg/kg	6	31	5.0E-01	6.7E-01	8.0E-01	9.0E-01
	Calcium	mg/kg	6	6	3.1E+02	8.8E+02	2.7E+03	2.7E+03
	Cesium-137	pCi/g	29	37	1.0E-02	2.5E-01	3.1E+00	1.4E+00
	Chromium	mg/kg	31	31	1.4E+00	3.3E+00	1.3E+01	8.1E+00
	Cobalt	mg/kg	28	30	9.4E-01	2.8E+00	7.1E+00	6.3E+00
	Copper	mg/kg	27	31	1.1E+00	4.0E+00	3.3E+01	1.6E+01
	Gross Alpha	pCi/g	37	37	2.0E+00	4.3E+00	1.4E+01	1.0E+01
	Gross Beta	pCi/g	37	37	3.0E-01	1.8E+00	4.0E+00	3.5E+00
	Gross Gamma	pCi/g	33	37	1.0E+00	4.2E+00	1.5E+01	1.1E+01
	Iron	mg/kg	31	31	7.5E+02	6.3E+03	2.5E+04	1.8E+04
	Lead	mg/kg	29	30	4.1E+00	1.5E+01	6.0E+01	3.9E+01
	Lithium	mg/kg	6	6	2.9E+00	1.4E+01	5.1E+01	5.1E+01
	Magnesium	mg/kg	6	6	2.4E+02	4.9E+02	1.2E+03	1.2E+03
	Manganese	mg/kg	31	31	4.7E+01	2.4E+02	6.5E+02	5.1E+02
	Mercury	mg/kg	7	25	1.0E-02	4.9E-02	2.0E-01	1.8E-01
	Molybdenum	mg/kg	7	31	3.0E-01	3.3E+00	1.4E+01	1.3E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Nickel	mg/kg	9	30	1.5E+00	4.3E+00	9.4E+00	1.1E+01
	Plutonium-238	pCi/g	35	37	2.0E-04	1.4E-02	6.1E-02	4.6E-02
	Plutonium-239, Plutonium-240	pCi/g	37	37	2.7E-03	1.7E+00	1.2E+01	7.7E+00
	Potassium	mg/kg	6	6	2.3E+02	5.1E+02	1.0E+03	1.1E+03
	Selenium	mg/kg	8	31	2.0E-01	3.8E-01	5.0E-01	6.1E-01
	Silver	mg/kg	5	31	6.0E-01	2.6E+00	4.0E+00	5.3E+00
	Sodium	mg/kg	6	6	8.7E+01	1.8E+02	3.1E+02	3.6E+02
	Strontium	mg/kg	30	30	2.3E+00	7.3E+00	3.8E+01	2.1E+01
	Strontium-90	pCi/g	29	37	1.0E-01	4.7E-01	5.0E+00	2.3E+00
	Thallium	mg/kg	1	31	1.8E+01	1.8E+01	1.8E+01	
	Tin	mg/kg	9	30	3.1E+00	9.1E+00	1.5E+01	1.6E+01
	Tritium	nCi/l[d]	17	27	1.0E-01	6.8E-01	3.6E+00	2.3E+00
	Uranium	mg/kg	36	36	7.7E-01	2.2E+00	5.9E+00	4.3E+00
	Vanadium	mg/kg	30	30	2.5E+00	6.7E+00	1.7E+01	1.4E+01
	Zinc	mg/kg	31	31	1.3E+01	4.6E+01	1.4E+02	1.1E+02
Sandia	Aluminum	mg/kg	17	17	1.6E+03	3.2E+03	7.1E+03	6.2E+03
	Americium-241	pCi/g	17	17	1.0E-03	1.6E-02	2.4E-01	1.3E-01
	Antimony	mg/kg	1	17	7.8E-01	7.8E-01	7.8E-01	
	Arsenic	mg/kg	17	18	4.0E-01	1.4E+00	1.0E+01	5.8E+00
	Barium	mg/kg	18	18	1.6E+01	4.8E+01	3.0E+02	1.8E+02
	Beryllium	mg/kg	15	17	8.0E-02	3.4E-01	6.0E-01	6.5E-01
	Boron	mg/kg	7	17	1.0E+00	2.7E+00	3.7E+00	4.6E+00
	Cadmium	mg/kg	3	18	3.0E-01	7.7E-01	1.2E+00	1.7E+00
	Calcium	mg/kg	1	1	7.0E+03	7.0E+03	7.0E+03	
	Cesium-137	pCi/g	9	20	4.0E-02	1.2E-01	3.0E-01	2.8E-01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Sandia (cont.)	Chromium	mg/kg	18	18	2.5E+00	6.4E+00	1.2E+01	1.2E+01
	Cobalt	mg/kg	17	17	8.0E-01	2.5E+00	6.0E+00	5.2E+00
	Copper	mg/kg	15	17	1.6E+00	2.9E+00	5.6E+00	5.4E+00
	Di-n-butyl phthalate	µg/kg	1	1	4.4E+02	4.4E+02	4.4E+02	
	Gross Alpha	pCi/g	19	19	2.0E+00	2.7E+00	5.0E+00	4.3E+00
	Gross Beta	pCi/g	19	19	1.0E+00	1.7E+00	3.0E+00	3.0E+00
	Gross Gamma	pCi/g	20	20	1.0E+00	2.7E+00	1.0E+01	6.8E+00
	Iron	mg/kg	17	17	1.8E+03	5.7E+03	1.8E+04	1.5E+04
	Lead	mg/kg	17	18	3.0E+00	7.5E+00	1.3E+01	1.5E+01
	Lithium	mg/kg	1	1	3.1E+01	3.1E+01	3.1E+01	
	Magnesium	mg/kg	1	1	2.6E+03	2.6E+03	2.6E+03	
	Manganese	mg/kg	17	17	9.7E+01	2.0E+02	3.5E+02	3.9E+02
	Mercury	mg/kg	2	15	2.0E-02	2.0E-02	2.0E-02	2.0E-02
	Molybdenum	mg/kg	4	17	6.0E-01	1.3E+00	1.8E+00	2.2E+00
	Nickel	mg/kg	12	17	2.0E+00	4.4E+00	1.1E+01	1.1E+01
	Plutonium-238	pCi/g	17	20	1.0E-03	3.6E-03	1.3E-02	1.0E-02
	Plutonium-239, Plutonium-240	pCi/g	20	20	1.0E-03	2.6E-03	5.0E-03	5.3E-03
	Potassium	mg/kg	1	1	1.7E+03	1.7E+03	1.7E+03	
	Selenium	mg/kg	4	18	3.0E-01	4.3E-01	6.0E-01	7.3E-01
	Silver	mg/kg	5	18	2.0E+00	4.6E+00	8.0E+00	9.3E+00
	Sodium	mg/kg	1	1	2.6E+02	2.6E+02	2.6E+02	
	Strontium	mg/kg	17	17	2.6E+00	8.2E+00	2.9E+01	2.2E+01
	Strontium-90	pCi/g	10	18	1.0E-01	2.5E-01	8.0E-01	6.6E-01
	Thallium	mg/kg	5	17	6.0E-02	3.6E+00	8.2E+00	1.1E+01
	Tin	mg/kg	7	17	4.0E+00	9.4E+00	1.8E+01	1.9E+01

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Sandia (cont.)	Tritium	nCi/l[d]	12	17	1.0E-01	1.1E+00	2.7E+00	2.9E+00
	Uranium	mg/kg	18	18	7.0E-01	1.7E+00	3.4E+00	3.0E+00
	Vanadium	mg/kg	17	17	2.7E+00	9.3E+00	4.3E+01	3.0E+01
	Zinc	mg/kg	17	17	1.8E+01	3.2E+01	7.7E+01	6.9E+01
Water	Aluminum	mg/kg	10	10	6.6E+02	6.3E+03	2.1E+04	1.9E+04
	Americium-241	pCi/g	10	10	1.0E-03	1.4E-02	1.1E-01	7.9E-02
	Arsenic	mg/kg	10	11	4.0E-01	1.2E+00	2.4E+00	2.8E+00
	Barium	mg/kg	11	11	1.4E+01	9.6E+01	2.5E+02	2.8E+02
	Beryllium	mg/kg	8	10	1.7E-01	5.6E-01	1.3E+00	1.3E+00
	Boron	mg/kg	5	10	2.5E+00	8.1E+00	2.5E+01	2.7E+01
	Cadmium	mg/kg	3	11	3.6E-01	5.4E-01	7.0E-01	8.9E-01
	Calcium	mg/kg	1	1	3.7E+03	3.7E+03	3.7E+03	
	Cesium-137	pCi/g	11	13	8.0E-02	2.4E-01	7.0E-01	6.3E-01
	Chromium	mg/kg	11	11	2.0E+00	4.5E+00	1.2E+01	1.2E+01
	Cobalt	mg/kg	9	10	1.5E+00	3.2E+00	6.5E+00	7.5E+00
	Copper	mg/kg	8	10	9.7E-01	4.8E+00	1.2E+01	1.3E+01
	Di-n-butyl phthalate	µg/kg	1	1	3.8E+02	3.8E+02	3.8E+02	
	Gross Alpha	pCi/g	13	13	2.0E+00	3.7E+00	8.7E+00	8.4E+00
	Gross Beta	pCi/g	13	13	1.0E+00	2.9E+00	7.0E+00	7.1E+00
	Gross Gamma	pCi/g	12	13	1.5E+00	3.7E+00	9.0E+00	7.7E+00
	Iron	mg/kg	10	10	1.5E+03	6.7E+03	1.6E+04	1.6E+04
	Lead	mg/kg	10	11	1.5E+00	9.3E+00	1.7E+01	1.9E+01
	Lithium	mg/kg	1	1	1.3E+01	1.3E+01	1.3E+01	
	Magnesium	mg/kg	1	1	2.5E+03	2.5E+03	2.5E+03	
	Manganese	mg/kg	10	10	4.3E+01	2.0E+02	3.9E+02	4.3E+02

TABLE C–5.—*Sediment Detection Statistics by Watershed and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

WATERSHED[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Water (cont.)	Mercury	mg/kg	5	11	1.0E-02	2.4E-02	4.0E-02	4.7E-02
	Molybdenum	mg/kg	1	10	1.8E+00	1.8E+00	1.8E+00	
	Nickel	mg/kg	7	10	1.9E+00	5.8E+00	1.1E+01	1.2E+01
	Plutonium-238	pCi/g	10	13	1.0E-03	2.1E-03	7.0E-03	6.1E-03
	Plutonium-239, Plutonium-240	pCi/g	13	13	2.0E-03	6.4E-03	1.4E-02	1.4E-02
	Potassium	mg/kg	1	1	2.5E+03	2.5E+03	2.5E+03	
	Selenium	mg/kg	2	11	4.0E-01	4.5E-01	5.0E-01	5.9E-01
	Silver	mg/kg	1	11	1.7E+00	1.7E+00	1.7E+00	
	Sodium	mg/kg	1	1	2.9E+02	2.9E+02	2.9E+02	
	Strontium	mg/kg	10	10	2.9E+00	2.2E+01	9.5E+01	7.8E+01
	Strontium-90	pCi/g	10	12	1.0E-01	1.7E-01	4.0E-01	3.8E-01
	Thallium	mg/kg	1	10	4.0E-02	4.0E-02	4.0E-02	
	Tin	mg/kg	2	10	6.0E+00	8.0E+00	1.0E+01	1.4E+01
	Tritium	nCi/l[d]	6	9	4.7E-02	2.6E+00	1.5E+01	1.4E+01
	Uranium	mg/kg	13	13	6.5E-01	1.7E+00	2.9E+00	2.9E+00
	Vanadium	mg/kg	10	10	3.2E+00	8.3E+00	2.4E+01	2.2E+01
	Zinc	mg/kg	10	10	1.4E+01	2.9E+01	4.7E+01	5.4E+01

[a] Watershed includes both on-site and perimeter analyses as designated by the Environmental Surveillance Program.
[b] pCi/g is picocuries of radioactive analyte per gram of sample, nCi/l is nanocuries of radioactive analyte per liter of sample, µg/kg is micrograms of analyte per kilogram of sample, mg/kg is milligrams of analyte per kilogram of sample.
[c] Upper confidence limit (UCL) not calculated when the number of detected analyses equals 1.
[d] Tritium is reported as nanocuries of tritium per liter (nCi/l) of water because tritium in sediments exists as tritiated water. The water is distilled, and the tritium content of the water is measured.

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Wells	Acetone	µg/l	5	40	2.0E+00	7.4E+00	2.1E+01	2.3E+01
	Actinium-228	pCi/l	3	6	1.2E+00	6.2E+00	9.8E+00	1.5E+01
	Aluminum	µg/l	161	174	2.5E+01	9.8E+03	2.4E+05	6.7E+04
	Americium-241	pCi/l	166	201	9.0E-04	2.9E+00	9.4E+01	2.6E+01
	Ammonia, as Nitrogen	mg/l	4	11	3.0E-02	1.0E-01	2.4E-01	2.9E-01
	Antimony	µg/l	22	171	2.0E-01	1.4E+00	3.0E+00	2.9E+00
	Arsenic	µg/l	77	172	1.0E+00	9.2E+00	8.3E+01	3.9E+01
	Barium	µg/l	139	159	3.0E-02	2.6E+02	3.1E+03	1.3E+03
	Barium-140	pCi/l	17	23	6.7E-01	7.0E+00	1.9E+01	1.6E+01
	Benzidine [m-]	µg/l	1	27	2.0E+01	2.0E+01	2.0E+01	
	Beryllium	µg/l	36	171	3.0E-01	6.0E+00	3.0E+01	2.0E+01
	Bicarbonate	mg/l	145	146	2.6E+01	1.1E+02	3.2E+02	2.2E+02
	Bis(2-ethylhexyl) phthalate	µg/l	2	38	4.0E+00	6.0E+00	8.0E+00	1.2E+01
	Bismuth-211	pCi/l	2	6	3.3E+01	4.1E+01	4.8E+01	6.1E+01
	Bismuth-212	pCi/l	5	6	2.2E+01	3.8E+01	7.6E+01	8.5E+01
	Bismuth-214	pCi/l	1	6	8.3E+00	8.3E+00	8.3E+00	
	Boron	µg/l	134	181	1.3E+01	8.0E+01	5.0E+02	2.3E+02
	Cadmium	µg/l	23	173	2.0E-01	4.7E+00	3.6E+01	2.1E+01
	Cadmium-109	pCi/l	5	6	2.5E+01	4.0E+01	5.7E+01	6.9E+01
	Calcium	mg/l	174	174	6.0E+00	2.7E+01	3.2E+02	8.8E+01
	Carbonate	mg/l	2	147	1.0E+00	2.0E+00	3.0E+00	4.8E+00
	Cerium-139	pCi/l	2	6	5.5E-02	2.8E-01	5.0E-01	9.1E-01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Wells (cont.)	Cerium-144	pCi/l	33	51	2.8E-01	3.3E+01	1.6E+02	1.2E+02
	Cesium-134	pCi/l	1	6	2.4E-01	2.4E-01	2.4E-01	
	Cesium-137	pCi/l	103	165	1.3E-02	1.4E+01	2.6E+02	1.0E+02
	Chlorine	mg/l	150	150	6.0E+00	3.6E+01	4.5E+02	1.2E+02
	Chloro-3-methylphenol [4-]	µg/l	1	38	2.0E+01	2.0E+01	2.0E+01	
	Chloromethane	µg/l	1	40	1.1E+01	1.1E+01	1.1E+01	
	Chlorophenol [o-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Chromium	µg/l	67	171	1.1E+00	4.4E+02	7.7E+03	3.5E+03
	Cobalt	µg/l	29	174	3.1E+00	1.6E+01	7.1E+01	5.0E+01
	Cobalt-57	pCi/l	23	34	1.4E-01	4.7E+00	1.8E+01	1.5E+01
	Cobalt-60	pCi/l	45	51	1.4E-01	1.1E+01	4.6E+01	3.6E+01
	Copper	µg/l	63	174	1.3E+00	3.8E+01	8.7E+02	2.6E+02
	Cyanide	mg/l	15	138	1.0E-02	2.6E-02	6.0E-02	5.6E-02
	Dichlorophenol [2,4-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Dimethylphenol [2,4-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Di-n-butyl phthalate	µg/l	2	38	1.1E+01	1.2E+01	1.2E+01	1.3E+01
	Dinitrophenol [2,4-]	µg/l	1	38	5.0E+01	5.0E+01	5.0E+01	
	Europium-152	pCi/l	40	51	9.8E-01	2.9E+01	1.2E+02	1.0E+02
	Fluorine	mg/l	161	169	1.0E-01	9.3E-01	2.2E+00	2.1E+00
	Gross Alpha	pCi/l	134	166	2.0E-01	1.2E+01	1.4E+02	6.0E+01
	Gross Beta	pCi/l	164	166	2.0E+00	7.3E+01	6.3E+02	3.0E+02
	Gross Gamma	pCi/l	135	160	2.0E+00	1.2E+02	9.0E+02	3.8E+02

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Wells (cont.)	Hardness	mg/l	125	125	2.0E+01	1.0E+02	1.1E+03	3.7E+02
	Iodine-129	pCi/l	2	7	7.7E-01	1.9E+00	3.1E+00	5.3E+00
	Iron	µg/l	161	174	4.0E+01	7.5E+03	1.9E+05	5.4E+04
	Lanthanum-140	pCi/l	1	6	3.8E+02	3.8E+02	3.8E+02	
	Lead	µg/l	68	176	6.0E-01	3.2E+01	4.1E+02	1.6E+02
	Lead-210	pCi/l	4	6	1.5E+02	1.0E+03	1.7E+03	2.3E+03
	Lead-211	pCi/l	3	6	1.8E+00	1.2E+01	2.6E+01	3.7E+01
	Lead-212	pCi/l	3	6	1.2E-01	3.8E+00	6.2E+00	1.0E+01
	Lead-214	pCi/l	2	6	5.0E+00	7.9E+00	1.1E+01	1.6E+01
	Lithium	mg/l	63	94	1.0E-03	3.1E-02	1.3E-01	8.2E-02
	Magnesium	mg/l	154	174	1.4E+00	6.1E+00	7.7E+01	2.1E+01
	Manganese	µg/l	127	174	7.0E-01	8.4E+02	1.4E+04	5.5E+03
	Manganese-54	pCi/l	2	6	5.2E-01	5.2E-01	5.3E-01	5.3E-01
	Mercury	µg/l	41	173	3.0E-02	9.5E-01	1.4E+01	6.0E+00
	Mercury-203	pCi/l	6	6	9.9E-02	1.7E+00	3.2E+00	4.1E+00
	Methyl-4,6-dinitrophenol [2-]	µg/l	1	38	5.0E+01	5.0E+01	5.0E+01	
	Methylphenol [2-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Methylphenol [4-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Molybdenum	µg/l	114	175	2.0E-01	1.9E+02	1.0E+03	6.6E+02
	Neptunium-237	pCi/l	32	51	4.9E-02	2.5E+01	1.1E+02	9.1E+01
	Nickel	µg/l	39	174	1.1E+00	3.1E+01	1.7E+02	1.0E+02
	Nitrate, as Nitrogen	mg/l	156	184	4.0E-02	1.2E+01	6.6E+01	4.5E+01
	Nitrite, as Nitrogen	mg/l	4	11	2.0E-02	4.5E-02	9.0E-02	1.1E-01
	Nitrophenol [2-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Wells (cont.)	Nitrophenol [4-]	µg/l	1	38	5.0E+01	5.0E+01	5.0E+01	
	Pentachlorophenol	µg/l	2	38	1.1E+01	3.1E+01	5.0E+01	8.6E+01
	pH		150	150	1.0E-01		9.0E+00	
	Phenol	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Phosphate, as Phosphorous	mg/l	122	129	2.0E-02	7.4E-01	2.9E+01	6.2E+00
	Phosphorous	mg/l	17	29	4.3E-02	6.7E-01	4.8E+00	3.8E+00
	Plutonium-238	pCi/l	117	167	1.0E-03	7.5E-02	2.4E+00	6.3E-01
	Plutonium-239, Plutonium-240	pCi/l	149	167	1.0E-03	1.7E-01	7.6E+00	1.8E+00
	Potassium	mg/l	165	171	1.0E+00	1.2E+01	3.6E+01	2.8E+01
	Potassium-40	pCi/l	24	34	2.2E+00	2.9E+02	1.3E+03	9.3E+02
	Protactinium-231	pCi/l	4	6	6.5E+00	1.0E+01	1.5E+01	1.8E+01
	Protactinium-233	pCi/l	3	6	1.5E-01	6.6E-01	1.3E+00	1.8E+00
	Protactinium-234M	pCi/l	5	6	2.9E+01	2.5E+02	5.0E+02	6.2E+02
	Pyridine	µg/l	2	5	1.0E+01	1.0E+01	1.0E+01	1.0E+01
	Radium-223	pCi/l	2	6	2.8E+00	5.5E+00	8.3E+00	1.3E+01
	Radium-224	pCi/l	1	6	3.2E+01	3.2E+01	3.2E+01	
	Radium-226	pCi/l	5	6	2.5E+01	9.4E+01	1.8E+02	2.2E+02
	Radon-219	pCi/l	2	6	5.9E-01	5.8E+00	1.1E+01	2.1E+01
	Ruthenium-106	pCi/l	23	51	2.1E+00	3.2E+01	1.5E+02	1.0E+02
	Selenium	µg/l	30	172	1.0E+00	1.8E+01	9.0E+01	7.6E+01
	Selenium-75	pCi/l	3	6	3.3E-01	9.6E-01	1.8E+00	2.5E+00
	Silica	mg/l	148	148	2.0E+01	4.2E+01	1.6E+02	7.4E+01
	Silver	µg/l	19	173	3.0E-01	1.6E+01	1.7E+02	9.2E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Wells (cont.)	Sodium	mg/l	174	174	4.0E+00	5.6E+01	1.6E+02	1.2E+02
	Sodium-22	pCi/l	38	51	2.9E-02	7.5E+00	3.3E+01	2.3E+01
	Strontium	µg/l	175	175	4.8E+01	1.6E+02	1.5E+03	4.4E+02
	Strontium-85	pCi/l	2	6	3.5E+00	3.5E+00	3.5E+00	3.6E+00
	Strontium-90	pCi/l	141	151	1.0E-01	2.2E+01	3.7E+02	1.0E+02
	Sulfate	mg/l	172	172	2.0E+00	1.5E+01	1.5E+02	4.5E+01
	Thallium	µg/l	27	170	4.0E-02	1.3E+00	6.0E+00	4.0E+00
	Thallium-208	pCi/l	3	6	9.4E-02	3.3E+00	6.8E+00	1.0E+01
	Thorium-227	pCi/l	3	6	5.8E+00	8.7E+00	1.3E+01	1.7E+01
	Thorium-234	pCi/l	2	6	6.0E+00	1.6E+02	3.1E+02	5.8E+02
	Tin	µg/l	10	160	1.0E+01	3.3E+01	7.0E+01	7.0E+01
	Tin-113	pCi/l	3	6	6.7E-01	1.1E+00	1.6E+00	2.0E+00
	Total Dissolved Solids	mg/l	152	152	1.1E+01	3.1E+02	1.4E+03	6.7E+02
	Total Kjeldahl Nitrogen	mg/l	9	11	4.0E-02	6.8E-01	2.5E+00	2.2E+00
	Total Suspended Solids	mg/l	32	59	1.0E+00	8.6E+01	8.6E+02	4.5E+02
	Trichlorobenzene [1,2,4-]	µg/l	1	44	5.0E+00	5.0E+00	5.0E+00	
	Trichlorophenol [2,4,5-]	µg/l	1	38	5.0E+01	5.0E+01	5.0E+01	
	Trichlorophenol [2,4,6-]	µg/l	1	38	1.0E+01	1.0E+01	1.0E+01	
	Tritium	nCi/l	145	167	2.9E-02	1.2E+01	1.1E+02	4.9E+01
	Turbidity	NTU	27	27	3.5E-01	6.2E+00	8.0E+01	3.7E+01
	Uranium	µg/l	150	167	2.0E-02	2.0E+00	5.0E+01	1.1E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Wells (cont.)	Vanadium	µg/l	64	171	1.7E+00	3.1E+01	3.5E+02	1.3E+02
	Yttrium-88	pCi/l	3	6	1.0E+00	1.7E+00	2.3E+00	3.0E+00
	Zinc	µg/l	96	174	9.0E-02	9.2E+01	1.6E+03	4.7E+02
	Zinc-65	pCi/l	5	6	7.8E-01	1.2E+00	1.6E+00	2.0E+00
Springs (Threemile Spring)	Bicarbonate	mg/l	1	1	5.7E+01	5.7E+01	5.7E+01	
	Calcium	mg/l	1	1	1.1E+01	1.1E+01	1.1E+01	
	Chlorine	mg/l	1	1	6.3E+00	6.3E+00	6.3E+00	
	Fluorine	mg/l	1	1	1.5E-01	1.5E-01	1.5E-01	
	Hardness	mg/l	1	1	4.3E+01	4.3E+01	4.3E+01	
	Magnesium	mg/l	1	1	3.9E+00	3.9E+00	3.9E+00	
	pH		1	1	6.6E+00		6.6E+00	
	Phosphate, as Phosphorous	mg/l	1	1	4.0E-02	4.0E-02	4.0E-02	
	Potassium	mg/l	1	1	3.2E+00	3.2E+00	3.2E+00	
	Silica	mg/l	1	1	3.5E+01	3.5E+01	3.5E+01	
	Sodium	mg/l	1	1	1.0E+01	1.0E+01	1.0E+01	
	Sulfate	mg/l	1	1	5.1E+00	5.1E+00	5.1E+00	
	Total Dissolved Solids	mg/l	1	1	1.5E+02	1.5E+02	1.5E+02	
Intermediate Perched Groundwater Wells	Aluminum	µg/l	4	13	4.0E+01	3.9E+03	1.5E+04	1.9E+04
	Americium-241	pCi/l	6	8	1.1E-02	4.8E-02	1.1E-01	1.3E-01
	Antimony	µg/l	3	13	1.0E-01	4.5E+01	1.3E+02	2.0E+02
	Arsenic	µg/l	5	13	2.0E+00	4.7E+00	7.0E+00	9.0E+00
	Barium	µg/l	9	11	3.0E+01	6.1E+01	1.7E+02	1.5E+02
	Beryllium	µg/l	1	13	3.0E+00	3.0E+00	3.0E+00	
	Bicarbonate	mg/l	13	13	5.3E+01	9.7E+01	1.6E+02	1.6E+02

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Intermediate Perched Groundwater Wells (cont.)	Boron	µg/l	12	13	3.0E+01	1.4E+02	2.3E+02	2.8E+02
	Cadmium	µg/l	4	13	4.0E-01	5.7E+00	1.0E+01	1.4E+01
	Calcium	mg/l	13	13	1.0E+01	2.8E+01	3.8E+01	4.6E+01
	Cesium-137	pCi/l	8	13	3.2E-01	1.0E+01	5.6E+01	4.9E+01
	Chlorine	mg/l	13	13	4.6E+00	3.9E+01	6.1E+01	7.2E+01
	Chromium	µg/l	2	13	1.6E+00	4.0E+00	6.4E+00	1.1E+01
	Cobalt	µg/l	1	13	9.0E+00	9.0E+00	9.0E+00	
	Copper	µg/l	5	13	8.0E+00	3.2E+01	5.5E+01	7.0E+01
	Fluorine	mg/l	13	13	2.0E-01	4.7E-01	9.0E-01	1.0E+00
	Gross Alpha	pCi/l	5	13	1.0E+00	1.8E+00	3.0E+00	3.5E+00
	Gross Beta	pCi/l	13	13	1.2E+00	8.8E+00	5.2E+01	3.5E+01
	Gross Gamma	pCi/l	10	13	1.0E+01	9.5E+01	2.4E+02	2.3E+02
	Hardness	mg/l	13	13	3.3E+01	9.5E+01	1.2E+02	1.6E+02
	Iron	µg/l	13	13	4.5E+02	8.1E+03	5.7E+04	3.9E+04
	Lead	µg/l	11	15	4.6E+00	3.5E+01	9.1E+01	1.1E+02
	Lithium	mg/l	2	2	1.3E-02	2.4E-02	3.5E-02	5.5E-02
	Magnesium	mg/l	13	13	1.8E+00	6.6E+00	8.6E+00	1.0E+01
	Manganese	µg/l	13	13	5.6E+01	1.6E+02	6.8E+02	4.8E+02
	Mercury	µg/l	3	13	2.0E-01	3.7E-01	7.0E-01	9.4E-01
	Molybdenum	µg/l	6	13	5.0E+00	1.8E+01	6.2E+01	6.2E+01
	Nickel	µg/l	2	13	2.0E+01	3.1E+01	4.1E+01	6.0E+01
	Nitrate, as Nitrogen	mg/l	11	13	9.0E-02	5.5E+00	1.9E+01	1.8E+01
	pH		9	9	6.9E+00		8.6E+00	
	Phosphate, as Phosphorous	mg/l	10	11	1.0E-01	1.1E+00	4.1E+00	3.9E+00

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Intermediate Perched Groundwater Wells (cont.)	Plutonium-238	pCi/l	6	16	3.0E-03	1.2E-02	3.0E-02	3.3E-02
	Plutonium-239, Plutonium-240	pCi/l	10	16	7.0E-03	1.5E-01	1.3E+00	9.5E-01
	Potassium	mg/l	12	13	1.6E+00	5.1E+00	9.6E+00	9.8E+00
	Selenium	µg/l	1	13	2.0E+00	2.0E+00	2.0E+00	
	Silica	mg/l	12	13	7.0E+00	4.2E+01	6.8E+01	8.1E+01
	Sodium	mg/l	13	13	1.8E+01	4.3E+01	8.8E+01	8.4E+01
	Strontium	µg/l	12	13	3.3E+01	1.5E+02	2.1E+02	2.6E+02
	Strontium-90	pCi/l	6	9	1.0E-01	3.9E+00	2.1E+01	2.0E+01
	Sulfate	mg/l	12	13	7.3E+00	2.1E+01	3.1E+01	3.7E+01
	Thallium	µg/l	2	13	1.0E-01	6.0E-01	1.1E+00	2.0E+00
	Tin	µg/l	1	11	7.0E+01	7.0E+01	7.0E+01	
	Total Dissolved Solids	mg/l	11	13	1.8E+02	2.6E+02	3.3E+02	3.6E+02
	Total Suspended Solids	mg/l	2	4	7.6E+00	9.3E+00	1.1E+01	1.4E+01
	Tritium	nCi/l	13	13	1.8E-01	1.3E+00	3.1E+00	3.7E+00
	Uranium	µg/l	11	13	8.0E-02	6.4E-01	3.3E+00	2.5E+00
	Vanadium	µg/l	4	13	2.0E+00	1.2E+01	3.0E+01	3.7E+01
	Zinc	µg/l	12	13	8.2E+01	2.7E+03	9.5E+03	9.0E+03
Spring from Basalt (Basalt Spring)	Aluminum	µg/l	5	6	6.0E+01	6.5E+02	2.3E+03	2.5E+03
	Americium-241	pCi/l	2	5	3.0E-02	3.4E-02	3.8E-02	4.5E-02
	Antimony	µg/l	4	6	4.0E-01	7.5E-01	1.0E+00	1.4E+00
	Arsenic	µg/l	5	6	3.0E+00	6.0E+00	1.3E+01	1.4E+01
	Barium	µg/l	5	5	4.8E+01	7.3E+01	1.1E+02	1.2E+02
	Bicarbonate	mg/l	6	6	5.3E+01	9.7E+01	1.2E+02	1.5E+02

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Spring from Basalt (Basalt Spring) (cont.)	Boron	µg/l	6	6	8.0E+01	1.7E+02	2.7E+02	3.5E+02
	Bromine	µg/l	1	1	8.0E+01	8.0E+01	8.0E+01	
	Calcium	mg/l	6	6	1.2E+01	2.6E+01	3.7E+01	4.4E+01
	Cesium-137	pCi/l	4	6	1.2E+00	4.9E+00	1.3E+01	1.6E+01
	Chlorine	mg/l	6	6	2.1E+01	3.2E+01	4.5E+01	5.0E+01
	Chloroethane	µg/l	1	2	2.1E+01	2.1E+01	2.1E+01	
	Chromium	µg/l	3	6	1.5E+00	3.2E+00	5.0E+00	6.7E+00
	Cobalt	µg/l	1	6	1.5E+01	1.5E+01	1.5E+01	
	Copper	µg/l	4	6	3.0E+00	9.3E+00	1.7E+01	2.3E+01
	Cyanide	mg/l	1	4	2.3E-02	2.3E-02	2.3E-02	
	Fluorine	mg/l	6	6	3.0E-01	4.7E-01	8.0E-01	8.2E-01
	Gross Alpha	pCi/l	4	6	1.0E+00	2.4E+00	4.0E+00	5.6E+00
	Gross Beta	pCi/l	6	6	5.0E+00	8.2E+00	1.3E+01	1.4E+01
	Gross Gamma	pCi/l	5	6	2.0E+01	6.4E+01	1.9E+02	2.1E+02
	Hardness	mg/l	6	6	4.3E+01	8.7E+01	1.3E+02	1.5E+02
	Iron	µg/l	6	6	3.0E+01	3.9E+02	1.5E+03	1.5E+03
	Lead	µg/l	4	7	1.0E+00	2.3E+00	5.2E+00	6.3E+00
	Magnesium	mg/l	6	6	3.1E+00	6.2E+00	9.4E+00	1.1E+01
	Manganese	µg/l	5	6	1.7E+01	1.8E+02	6.4E+02	7.0E+02
	Mercury	µg/l	3	6	1.0E-01	4.3E-01	8.0E-01	1.1E+00
	Molybdenum	µg/l	4	6	3.0E+00	2.2E+01	6.9E+01	8.5E+01
	Nickel	µg/l	1	6	3.4E+01	3.4E+01	3.4E+01	
	Nitrate, as Nitrogen	mg/l	7	7	1.3E+00	5.3E+00	1.5E+01	1.6E+01
	Nitrite, as Nitrogen	mg/l	1	1	9.2E-01	9.2E-01	9.2E-01	
	pH		6	6	6.7E+00		8.3E+00	

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Spring from Basalt	Phosphate	mg/l	1	1	5.7E+00	5.7E+00	5.7E+00	
(Basalt Spring) (cont.)	Phosphate, as Phosphorous	mg/l	5	5	2.0E-01	3.0E+00	6.9E+00	8.3E+00
	Plutonium-238	pCi/l	3	6	1.2E-02	1.3E-02	1.4E-02	1.5E-02
	Plutonium-239, Plutonium-240	pCi/l	5	6	1.4E-02	5.5E-02	1.4E-01	1.6E-01
	Potassium	mg/l	5	5	4.0E+00	8.1E+00	1.2E+01	1.5E+01
	Silica	mg/l	7	7	5.0E+01	6.1E+01	8.1E+01	8.5E+01
	Silver	µg/l	1	6	1.0E+00	1.0E+00	1.0E+00	
	Sodium	mg/l	6	6	2.7E+01	4.2E+01	6.7E+01	7.4E+01
	Strontium	µg/l	6	6	6.0E+01	1.4E+02	2.0E+02	2.5E+02
	Strontium-90	pCi/l	4	5	4.0E-01	5.0E-01	7.0E-01	7.8E-01
	Sulfate	mg/l	6	6	8.7E+00	2.1E+01	3.4E+01	3.7E+01
	Thallium	µg/l	2	6	4.0E-02	2.2E-01	4.0E-01	7.3E-01
	Total Dissolved Solids	mg/l	6	6	2.5E+02	3.2E+02	3.8E+02	4.1E+02
	Total Suspended Solids	mg/l	2	2	3.7E+00	1.7E+01	3.0E+01	5.4E+01
	Tritium	nCi/l	5	6	2.0E-01	4.2E-01	8.0E-01	9.6E-01
	Uranium	µg/l	6	6	5.9E-01	1.0E+00	2.1E+00	2.2E+00
	Vanadium	µg/l	6	6	7.0E+00	1.2E+01	1.9E+01	2.2E+01
	Zinc	µg/l	3	6	1.0E+01	2.1E+01	3.0E+01	4.1E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Main Aquifer Supply Wells	Acetone	µg/l	1	2	4.1E+01	4.1E+01	4.1E+01	
	Aluminum	µg/l	12	79	3.0E+01	3.5E+02	1.9E+03	1.4E+03
	Americium-241	pCi/l	40	53	2.0E-03	3.5E-02	1.1E-01	8.4E-02
	Antimony	µg/l	14	79	3.0E-01	1.4E+00	4.0E+00	3.3E+00
	Arsenic	µg/l	48	79	2.0E+00	1.3E+01	4.8E+01	4.1E+01
	Barium	µg/l	57	64	3.0E+00	4.9E+01	2.9E+02	1.5E+02
	Beryllium	µg/l	6	79	1.0E+00	1.3E+00	2.0E+00	2.4E+00
	Bicarbonate	mg/l	78	78	4.7E+01	1.1E+02	3.0E+02	2.2E+02
	Boron	µg/l	57	79	8.0E+00	8.1E+01	5.0E+02	2.9E+02
	Bromine	µg/l	2	2	1.0E+02	1.1E+02	1.1E+02	1.2E+02
	Cadmium	µg/l	4	79	1.8E+00	3.6E+00	5.0E+00	6.3E+00
	Calcium	mg/l	79	79	2.0E+00	1.5E+01	3.2E+01	2.9E+01
	Carbonate	mg/l	12	78	2.0E+00	1.2E+01	3.5E+01	3.1E+01
	Cesium-137	pCi/l	38	71	2.0E-02	5.9E+01	4.3E+02	2.7E+02
	Chlorine	mg/l	74	75	2.0E+00	5.7E+00	2.1E+01	1.5E+01
	Chloroethane	µg/l	1	2	1.3E+01	1.3E+01	1.3E+01	
	Chromium	µg/l	47	79	2.0E+00	1.2E+01	3.9E+01	2.9E+01
	Cobalt	µg/l	2	77	3.0E+00	6.7E+01	1.3E+02	2.5E+02
	Copper	µg/l	36	79	1.0E+00	1.7E+01	8.3E+01	5.3E+01
	Cyanide	mg/l	2	63	1.0E-02	1.0E-02	1.0E-02	1.0E-02
	Fluorine	mg/l	78	78	2.0E-01	1.6E+00	4.9E+01	1.4E+01
	Gross Alpha	pCi/l	49	74	2.0E-01	2.8E+00	3.0E+01	1.2E+01
	Gross Beta	pCi/l	74	74	7.0E-01	3.7E+00	9.0E+00	7.4E+00
	Gross Gamma	pCi/l	43	69	1.0E+01	1.3E+02	5.5E+02	3.7E+02
	Hardness	mg/l	79	79	5.0E+00	4.7E+01	1.2E+02	9.9E+01
	Iron	µg/l	28	79	1.0E+01	2.6E+03	2.9E+04	1.7E+04

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Main Aquifer Supply Wells (cont.)	Lead	µg/l	25	84	1.0E+00	1.2E+01	9.5E+01	5.3E+01
	Lithium	mg/l	11	11	2.4E-02	4.4E-02	1.1E-01	9.7E-02
	Magnesium	mg/l	68	79	4.2E-02	2.9E+00	9.4E+00	8.2E+00
	Manganese	µg/l	28	79	1.0E+00	4.2E+01	2.7E+02	1.8E+02
	Mercury	µg/l	8	68	1.0E-01	1.5E-01	2.0E-01	2.6E-01
	Molybdenum	µg/l	27	79	1.0E+00	7.0E+00	3.0E+01	2.3E+01
	Nickel	µg/l	5	79	5.0E+00	1.5E+01	2.3E+01	3.0E+01
	Nitrate, as Nitrogen	mg/l	81	85	4.5E-03	8.0E-01	9.9E+00	3.4E+00
	pH		78	78	7.2E+00		9.4E+00	
	Phosphate, as Phosphorous	mg/l	30	79	2.0E-02	1.3E-01	3.0E-01	3.4E-01
	Plutonium-238	pCi/l	44	82	1.0E-04	1.2E-02	4.7E-02	3.1E-02
	Plutonium-239, Plutonium-240	pCi/l	59	82	1.0E-04	3.2E-02	6.7E-01	2.1E-01
	Potassium	mg/l	65	79	4.6E-01	2.5E+00	4.4E+00	4.0E+00
	Selenium	µg/l	14	79	1.7E+00	4.3E+00	1.2E+01	1.1E+01
	Silica	mg/l	78	80	9.3E+00	6.3E+01	1.2E+02	1.2E+02
	Silver	µg/l	11	78	2.0E+00	3.6E+01	5.8E+01	7.9E+01
	Sodium	mg/l	79	79	1.0E+01	3.5E+01	1.9E+02	1.1E+02
	Strontium	µg/l	75	79	1.0E+01	1.2E+02	8.3E+02	3.8E+02
	Strontium-90	pCi/l	22	41	1.0E-01	8.5E-01	4.6E+00	3.2E+00
	Sulfate	mg/l	74	75	2.0E+00	7.6E+00	4.1E+01	2.4E+01
	Thallium	µg/l	5	78	4.0E-02	7.9E+00	1.9E+01	2.5E+01
	Tin	µg/l	7	67	1.0E+01	1.6E+01	3.4E+01	3.5E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Main Aquifer Supply Wells (cont.)	Total Dissolved Solids	mg/l	75	82	9.0E+01	2.1E+02	5.3E+02	3.9E+02
	Tritium	nCi/l	40	76	3.0E-03	3.4E-01	1.1E+00	7.8E-01
	Uranium	µg/l	52	77	6.0E-02	2.1E+00	1.7E+01	8.6E+00
	Vanadium	µg/l	67	79	5.0E+00	2.9E+01	2.6E+02	1.0E+02
	Zinc	µg/l	46	79	3.9E+00	6.8E+01	1.3E+03	4.5E+02
Test Wells	Acetone	µg/l	4	5	3.2E+01	4.0E+01	5.9E+01	6.6E+01
	Aluminum	µg/l	18	55	3.0E+01	1.7E+02	1.0E+03	6.7E+02
	Americium-241	pCi/l	32	49	6.0E-03	2.7E-02	6.2E-02	5.7E-02
	Antimony	µg/l	14	54	6.0E-01	2.7E+01	2.8E+02	1.7E+02
	Arsenic	µg/l	23	56	1.0E+00	3.4E+00	1.2E+01	7.5E+00
	Barium	µg/l	43	48	3.0E+00	3.0E+01	9.1E+01	7.8E+01
	Beryllium	µg/l	3	55	1.0E+00	1.5E+00	2.0E+00	2.5E+00
	Bicarbonate	mg/l	56	56	3.2E+01	6.6E+01	1.1E+02	1.0E+02
	Boron	µg/l	40	55	1.0E+01	4.9E+01	3.0E+02	1.6E+02
	Bromine	µg/l	1	1	4.0E+01	4.0E+01	4.0E+01	
	Cadmium	µg/l	10	55	1.0E-01	4.3E+00	1.3E+01	1.3E+01
	Calcium	mg/l	55	55	2.1E+00	1.5E+01	5.2E+01	4.0E+01
	Carbonate	mg/l	4	56	1.0E+00	2.5E+00	3.0E+00	4.5E+00
	Cesium-137	pCi/l	29	55	2.0E-02	1.2E+01	1.6E+02	8.8E+01
	Chlorine	mg/l	81	81	1.0E+00	7.0E+00	5.6E+01	3.0E+01
	Chromium	µg/l	19	55	1.0E+00	1.1E+01	6.3E+01	4.0E+01
	Cobalt	µg/l	5	55	3.0E+00	7.9E+00	2.2E+01	2.3E+01
	Copper	µg/l	25	55	3.0E+00	1.2E+02	8.0E+02	4.8E+02
	Cyanide	mg/l	4	44	1.0E-02	1.0E-02	1.0E-02	1.0E-02

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Test Wells (cont.)	Di-n-butyl phthalate	µg/l	2	7	1.5E+01	1.5E+01	1.5E+01	1.5E+01
	Fluorine	mg/l	55	55	1.0E-01	3.1E-01	6.0E-01	5.6E-01
	Gross Alpha	pCi/l	33	57	1.8E-01	1.4E+00	9.0E+00	4.4E+00
	Gross Beta	pCi/l	57	57	1.0E+00	3.2E+00	1.2E+01	7.1E+00
	Gross Gamma	pCi/l	30	58	2.0E+00	8.0E+01	3.2E+02	2.4E+02
	Hardness	mg/l	53	54	5.7E+00	5.7E+01	1.8E+02	1.4E+02
	Iron	µg/l	48	55	4.5E+01	2.3E+03	2.0E+04	1.0E+04
	Lead	µg/l	45	56	1.0E+00	2.6E+02	9.0E+03	2.9E+03
	Lithium	mg/l	10	10	1.0E-02	2.1E-02	2.8E-02	3.1E-02
	Magnesium	mg/l	54	55	1.2E-01	4.3E+00	1.1E+01	8.9E+00
	Manganese	µg/l	44	55	1.0E+00	5.6E+01	4.8E+02	2.2E+02
	Mercury	µg/l	7	56	7.8E-02	2.1E-01	7.0E-01	6.5E-01
	Molybdenum	µg/l	7	55	3.0E+00	1.3E+02	7.2E+02	6.7E+02
	Nickel	µg/l	9	55	4.0E-01	2.9E+01	9.0E+01	8.0E+01
	Nitrate, as Nitrogen	mg/l	66	81	4.0E-02	1.4E+00	2.3E+01	8.3E+00
	pH		56	56	6.7E+00		8.6E+00	
	Phosphate	mg/l	1	1	5.0E-02	5.0E-02	5.0E-02	
	Phosphate, as Phosphorous	mg/l	22	50	1.6E-02	1.2E-01	4.0E-01	3.4E-01
	Plutonium-238	pCi/l	36	67	1.0E-03	1.3E-02	4.3E-02	4.0E-02
	Plutonium-239, Plutonium-240	pCi/l	48	67	1.0E-03	2.7E-02	2.3E-01	1.2E-01
	Potassium	mg/l	43	55	8.4E-01	2.0E+00	4.7E+00	3.9E+00
	Selenium	µg/l	12	56	1.0E+00	8.3E+00	4.0E+01	3.8E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Test Wells (cont.)	Silica	mg/l	54	57	5.0E+00	5.5E+01	8.4E+01	1.0E+02
	Silver	µg/l	3	55	1.3E+01	1.7E+01	2.0E+01	2.5E+01
	Sodium	mg/l	55	55	5.0E+00	1.4E+01	1.4E+02	4.8E+01
	Strontium	µg/l	54	55	3.5E+01	9.3E+01	8.0E+02	3.3E+02
	Strontium-90	pCi/l	53	75	1.0E-01	1.4E+00	3.5E+01	1.1E+01
	Sulfate	mg/l	53	56	1.0E+00	6.2E+00	2.5E+01	2.0E+01
	Thallium	µg/l	1	54	2.3E-01	2.3E-01	2.3E-01	
	Tin	µg/l	6	52	1.0E+01	4.4E+01	9.0E+01	1.0E+02
	Toluene	µg/l	2	5	9.0E+00	1.2E+01	1.4E+01	1.9E+01
	Total Dissolved Solids	mg/l	54	56	8.0E+00	1.7E+02	1.9E+03	6.6E+02
	Total Suspended Solids	mg/l	10	28	1.0E+00	6.2E+00	2.6E+01	2.1E+01
	Tritium	nCi/l	33	59	2.0E-02	4.4E-01	2.1E+00	1.4E+00
	Uranium	µg/l	43	57	4.0E-02	6.3E-01	2.7E+00	2.0E+00
	Vanadium	µg/l	22	55	1.0E+00	7.5E+00	1.5E+01	1.7E+01
	Zinc	µg/l	53	55	1.9E+01	1.2E+03	7.0E+03	4.2E+03
Springs	Acetone	µg/l	13	18	2.0E+01	2.9E+01	4.4E+01	4.5E+01
	Aluminum	µg/l	91	124	1.0E+01	2.5E+03	4.1E+04	1.6E+04
	Americium-241	pCi/l	64	80	2.4E-03	3.6E-02	7.9E-02	7.7E-02
	Ammonia, as Nitrogen	µg/l	21	124	6.0E+00	5.3E+01	8.3E+02	4.1E+02
	Antimony	µg/l	15	124	2.0E-01	1.0E+00	7.0E+00	4.5E+00
	Arsenic	µg/l	84	124	1.0E+00	6.1E+00	7.0E+01	2.6E+01
	Barium	µg/l	99	101	7.0E+00	8.7E+01	8.3E+02	3.6E+02
	Beryllium	µg/l	20	124	5.0E-01	1.7E+00	1.3E+01	7.3E+00

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Springs (cont.)	Bicarbonate	mg/l	123	123	4.2E+01	9.4E+01	5.0E+02	2.1E+02
	Boron	µg/l	107	124	2.0E+00	3.5E+01	2.0E+02	9.8E+01
	Bromine	µg/l	3	4	2.0E+01	4.7E+01	6.0E+01	9.3E+01
	Butanone [2-]	µg/l	2	18	2.3E+01	2.5E+01	2.6E+01	2.9E+01
	Cadmium	µg/l	34	124	2.0E-01	3.5E+00	1.7E+01	1.1E+01
	Calcium	mg/l	121	123	4.2E-01	2.3E+01	1.1E+02	5.7E+01
	Carbonate	mg/l	3	123	2.0E+00	7.0E+00	1.7E+01	2.4E+01
	Cesium-137	pCi/l	58	118	1.0E-02	2.5E+01	1.4E+02	1.1E+02
	Chlorine	mg/l	123	123	1.0E+00	5.4E+00	3.3E+01	1.5E+01
	Chloroethane	µg/l	3	18	1.1E+01	1.2E+01	1.4E+01	1.5E+01
	Chromium	µg/l	85	124	1.0E+00	9.3E+00	1.2E+02	3.7E+01
	Cobalt	µg/l	11	101	3.0E+00	9.7E+00	3.3E+01	2.9E+01
	Copper	µg/l	38	124	1.0E+00	1.5E+01	2.5E+02	9.5E+01
	Cyanide	mg/l	4	101	1.0E-02	5.8E-02	1.2E-01	1.5E-01
	Di-n-butyl phthalate	µg/l	4	20	1.4E+01	2.0E+01	3.7E+01	4.3E+01
	Dinitrotoluene [2,4-]	µg/l	1	38	1.8E-01	1.8E-01	1.8E-01	
	Fluorine	mg/l	123	123	2.9E-01	4.9E-01	1.4E+00	8.3E-01
	Gross Alpha	pCi/l	93	124	1.0E-01	3.4E+00	3.6E+01	1.4E+01
	Gross Beta	pCi/l	124	124	1.5E+00	5.2E+00	6.2E+01	1.8E+01
	Gross Gamma	pCi/l	77	124	1.0E+01	1.2E+02	1.0E+03	4.3E+02
	Hardness	mg/l	119	123	1.3E+01	7.7E+01	5.8E+02	2.1E+02
	HMX (Octogen)	µg/l	1	17	4.9E+00	4.9E+00	4.9E+00	
	Iron	µg/l	94	124	1.0E+01	2.3E+03	2.9E+04	1.4E+04
	Lead	µg/l	66	127	2.0E-01	8.9E+00	2.0E+02	6.6E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Springs (cont.)	Lithium	mg/l	16	16	2.0E-02	2.8E-02	5.8E-02	5.0E-02
	Magnesium	mg/l	120	123	4.0E-01	3.7E+00	1.8E+01	8.7E+00
	Manganese	µg/l	85	124	1.0E+00	2.0E+02	7.0E+03	1.8E+03
	Mercury	µg/l	3	124	1.0E-01	2.7E-01	6.0E-01	8.4E-01
	Methylene chloride	µg/l	3	18	5.0E+00	5.0E+00	5.0E+00	5.0E+00
	Molybdenum	µg/l	25	103	1.0E+00	4.0E+00	1.6E+01	1.3E+01
	Nitrate, as Nitrogen	mg/l	96	126	2.0E-02	1.0E+00	2.8E+01	6.8E+00
	pH		123	123	6.8E+00		8.9E+00	
	Phosphate, as Phosphorous	mg/l	58	123	2.0E-02	4.5E-01	5.1E+00	2.3E+00
	Plutonium-238	pCi/l	80	125	3.0E-04	1.7E-02	1.4E-01	5.7E-02
	Plutonium-239, Plutonium-240	pCi/l	87	125	1.0E-03	1.8E-02	6.2E-02	4.6E-02
	Potassium	mg/l	120	123	2.0E-01	2.9E+00	9.4E+00	6.1E+00
	RDX (Cyclonite)	µg/l	1	18	2.3E+01	2.3E+01	2.3E+01	
	Selenium	µg/l	26	124	1.0E+00	6.5E+00	7.0E+01	3.5E+01
	Silica	mg/l	127	127	2.2E+01	6.1E+01	8.8E+01	9.5E+01
	Silver	µg/l	8	124	1.0E+00	3.0E+01	1.3E+02	1.2E+02
	Sodium	mg/l	120	123	5.0E+00	2.1E+01	1.4E+02	6.7E+01
	Strontium	µg/l	124	124	1.0E+00	1.9E+02	1.4E+03	5.4E+02
	Strontium-90	pCi/l	68	101	1.0E-01	9.5E-01	2.0E+01	5.8E+00
	Sulfate	mg/l	123	123	1.0E+00	6.7E+00	3.3E+01	1.6E+01
	Tetryl(methyl-2,4,6-trinitrophenylnitramine)	µg/l	1	18	6.1E-01	6.1E-01	6.1E-01	

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Springs (cont.)	Thallium	µg/l	9	124	4.0E-02	2.8E+00	1.6E+01	1.3E+01
	Tin	µg/l	13	78	8.0E+00	3.5E+01	5.9E+01	6.4E+01
	Total Dissolved Solids	mg/l	123	123	6.0E+00	2.0E+02	2.1E+03	6.0E+02
	Total Suspended Solids	mg/l	10	32	1.2E+00	1.4E+01	8.4E+01	6.5E+01
	Trinitrotoluene [2,4,6-]	µg/l	2	18	2.0E-01	2.5E+00	4.8E+00	9.0E+00
	Tritium	nCi/l	83	124	1.5E-02	3.5E-01	3.8E+00	1.2E+00
	Uranium	µg/l	133	143	1.0E-01	2.7E+00	3.9E+01	1.3E+01
	Vanadium	µg/l	111	124	1.0E+00	2.0E+01	1.6E+02	7.5E+01
	Zinc	µg/l	60	124	1.0E+00	1.6E+02	6.5E+03	1.8E+03
Springs from Volcanics (Water Canyon Gallery)	Aluminum	µg/l	5	6	9.0E+01	6.1E+02	1.2E+03	1.6E+03
	Americium-241	pCi/l	3	4	3.0E-03	1.8E-02	3.0E-02	4.6E-02
	Arsenic	µg/l	1	6	1.5E+00	1.5E+00	1.5E+00	
	Barium	µg/l	4	5	1.2E+01	6.9E+01	2.3E+02	2.9E+02
	Bicarbonate	mg/l	6	6	2.8E+01	4.3E+01	6.7E+01	7.0E+01
	Boron	µg/l	1	6	2.4E+01	2.4E+01	2.4E+01	
	Calcium	mg/l	6	6	6.0E+00	7.5E+00	1.1E+01	1.1E+01
	\Cesium-137	pCi/l	3	6	2.2E-01	5.1E+01	1.5E+02	2.2E+02
	Chlorine	mg/l	6	6	1.0E+00	3.2E+00	1.2E+01	1.2E+01
	Chromium	µg/l	2	6	5.3E+00	6.2E+00	7.0E+00	8.6E+00
	Copper	µg/l	2	6	3.0E+00	5.5E+00	8.0E+00	1.3E+01
	Fluorine	mg/l	2	6	6.0E-02	1.3E-01	2.0E-01	3.3E-01
	Gross Alpha	pCi/l	5	6	4.4E-01	8.9E-01	1.0E+00	1.4E+00
	Gross Beta	pCi/l	6	6	2.0E+00	3.4E+00	5.0E+00	6.0E+00

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Springs from Volcanics (Water Canyon Gallery) (cont.)	Gross Gamma	pCi/l	3	5	3.0E+01	2.9E+02	8.2E+02	1.2E+03
	Hardness	mg/l	6	6	2.5E+01	3.1E+01	3.9E+01	4.0E+01
	Iron	µg/l	4	6	4.0E+01	3.5E+02	5.6E+02	8.2E+02
	Lead	µg/l	1	6	1.7E+00	1.7E+00	1.7E+00	
	Lithium	mg/l	1	1	9.0E-03	9.0E-03	9.0E-03	
	Magnesium	mg/l	5	6	3.0E+00	3.3E+00	3.8E+00	3.9E+00
	Manganese	µg/l	2	6	2.0E+00	2.5E+00	3.0E+00	3.9E+00
	Molybdenum	µg/l	1	6	2.0E+00	2.0E+00	2.0E+00	
	Nickel	µg/l	1	6	2.0E+01	2.0E+01	2.0E+01	
	Nitrate, as Nitrogen	mg/l	6	6	1.5E-01	3.7E-01	9.7E-01	9.7E-01
	pH		6	6	6.9E+00		8.0E+00	
	Phosphate, as Phosphorous	mg/l	3	6	4.0E-02	1.5E-01	2.0E-01	3.3E-01
	Plutonium-238	pCi/l	5	6	3.0E-03	5.8E-03	9.0E-03	1.1E-02
	Plutonium-239, Plutonium-240	pCi/l	5	6	4.0E-03	1.3E-02	2.2E-02	2.7E-02
	Potassium	mg/l	5	6	1.5E+00	2.1E+00	3.0E+00	3.3E+00
	Selenium	µg/l	1	6	4.0E+00	4.0E+00	4.0E+00	
	Silica	mg/l	6	6	1.6E+01	4.0E+01	4.8E+01	6.4E+01
	Sodium	mg/l	5	6	5.1E+00	7.2E+00	1.2E+01	1.3E+01
	Strontium	µg/l	5	6	4.2E+01	5.6E+01	8.1E+01	8.5E+01
	Strontium-90	pCi/l	1	3	1.0E-01	1.0E-01	1.0E-01	
	Sulfate	mg/l	6	6	2.0E+00	3.1E+00	6.0E+00	6.2E+00
	Thallium	µg/l	1	6	1.2E+00	1.2E+00	1.2E+00	

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Springs from Volcanics	Total Dissolved Solids	mg/l	5	6	6.8E+01	9.5E+01	1.4E+02	1.5E+02
(Water Canyon Gallery) (cont.)	Total Suspended Solids	mg/l	2	2	2.0E+00	2.0E+00	2.0E+00	2.0E+00
	Tritium	nCi/l	3	6	1.0E-01	4.3E-01	1.0E+00	1.4E+00
	Uranium	µg/l	3	6	1.0E-01	2.5E-01	4.0E-01	5.5E-01
	Vanadium	µg/l	3	6	4.0E+00	8.3E+00	1.1E+01	1.6E+01
	Zinc	µg/l	1	6	3.0E+01	3.0E+01	3.0E+01	
San Ildefonso Wells	Acetone	µg/l	1	12	3.10E+01	3.10E+01	3.10E+01	
	Aluminum	µg/l	12	47	3.00E+01	1.04E+02	1.60E+02	1.93E+02
	Americium-241	pCi/l	36	46	2.00E-03	2.64E-02	7.50E-02	6.02E-02
	Antimony	µg/l	17	47	3.00E-01	1.98E+00	8.00E+00	6.70E+00
	Arsenic	µg/l	47	52	2.00E+00	8.66E+00	4.10E+01	2.14E+01
	Barium	µg/l	48	51	1.00E+00	9.68E+01	3.30E+02	3.33E+01
	Beryllium	µg/l	6	52	1.00E+00	7.00E+00	1.70E+01	2.04E+01
	Bicarbonate	mg/l	52	52	6.80E+01	2.11E+02	5.71E+02	4.73E+02
	Bis(2-ethylhexyl) phthalate	µg/l	10	19	1.10E+01	1.48E+01	1.90E+01	2.15E+01
	Boron	µg/l	45	47	8.00E+00	4.02E+02	2.20E+03	1.65E+03
	Bromine	µg/l	8	8	7.00E+01	4.83E+02	1.78E+03	1.71E+03
	Cadmium	µg/l	5	52	2.00E-01	1.34E+00	5.00E+00	5.49E+00
	Calcium	mg/l	52	52	2.80E+00	2.88E+01	8.50E+01	7.61E+01
	Carbonate	mg/l	22	52	1.00E+00	1.01E+01	3.40E+01	2.70E+01
	Cesium-137	pCi/l	35	52	1.50E-01	1.19E+01	9.00E+01	5.87E+01
	Chlorine	mg/l	52	52	3.00E+00	6.57E+01	4.46E+02	2.83E+02
	Chloroethane	µg/l	6	12	1.30E+01	1.52E+01	1.80E+01	1.86E+01

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
San Ildefonso Wells (cont.)	Chromium	µg/l	23	52	2.00E-01	1.28E+01	5.50E+01	3.53E+01
	Cobalt	µg/l	6	47	4.00E+00	1.58E+01	5.50E+01	5.61E+01
	Copper	µg/l	28	52	2.00E+00	1.58E+01	1.20E+02	5.98E+01
	Cyanide	mg/l	1	30	3.00E-02	3.00E-02	3.00E-02	
	Di-n-butyl phthalate	µg/l	1	19	1.10E+01	1.10E+01	1.10E+01	
	Fluorine	mg/l	52	52	1.30E-01	2.04E+00	4.90E+01	1.56E+01
	Gross Alpha	pCi/l	35	52	2.10E-01	9.04E+00	4.00E+01	2.74E+01
	Gross Beta	pCi/l	50	52	8.00E-01	5.11E+00	1.70E+01	1.25E+01
	Gross Gamma	pCi/l	33	47	1.00E+01	1.31E+02	5.00E+02	3.86E+02
	Hardness	mg/l	52	52	8.00E+00	8.04E+01	2.35E+02	2.16E+02
	Iron	µg/l	33	52	2.00E+01	6.67E+02	9.60E+03	4.21E+03
	Lead	µg/l	14	62	5.00E-01	2.43E+00	6.00E+00	5.78E+00
	Lithium	mg/l	8	8	3.00E-02	1.05E-01	2.90E-01	2.80E-01
	Magnesium	mg/l	47	52	4.00E-02	2.33E+00	7.80E+00	6.66E+00
	Manganese	µg/l	29	52	1.00E+00	7.59E+00	3.60E+01	2.20E+01
	Mercury	µg/l	6	51	1.00E-01	4.17E-01	1.00E+00	1.26E+00
	Molybdenum	µg/l	21	47	1.70E+00	1.31E+01	5.70E+01	4.41E+01
	Nickel	µg/l	3	47	1.00E+01	2.27E+01	3.00E+01	4.47E+01
	Nitrate, as Nitrogen	mg/l	55	60	2.49E-02	2.75E+00	1.90E+01	1.11E+01
	Phosphate	mg/l	2	8	1.00E-01	1.25E-01	1.50E-01	1.96E-01
	Phosphate, as Phosphorous	mg/l	11	45	3.27E-02	1.21E-01	4.00E-01	3.15E-01
	Plutonium-238	pCi/l	29	52	3.00E-03	2.61E-02	1.10E-01	8.51E-02

TABLE C–6.—*Groundwater Detection Statistics by Regime and Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
San Ildefonso Wells (cont.)	Plutonium-239, Plutonium-240	pCi/l	37	52	9.00E-04	2.83E-02	3.37E-01	1.42E-01
	Potassium	mg/l	46	52	5.30E-01	2.37E+00	6.00E+00	5.04E+00
	Selenium	µg/l	14	52	2.00E+00	3.37E+00	6.50E+00	6.37E+00
	Silica	mg/l	57	60	2.10E+01	3.59E+01	6.30E+01	5.72E+01
	Silver	µg/l	5	52	1.00E+00	2.64E+01	4.40E+01	6.76E+01
	Sodium	mg/l	52	52	1.40E+01	1.23E+02	5.20E+02	3.80E+02
	Strontium	µg/l	47	47	2.68E+01	4.31E+02	1.50E+03	1.18E+03
	Strontium-90	pCi/l	33	46	1.00E-01	7.21E-01	8.40E+00	3.67E+00
	Sulfate	mg/l	52	52	4.00E+00	3.08E+01	8.20E+01	7.36E+01
	Thallium	µg/l	12	47	3.00E-02	1.93E-01	9.00E-01	7.35E-01
	Tin	µg/l	1	40	1.00E+01	1.00E+01	1.00E+01	
	Total Dissolved Solids	mg/l	52	52	1.10E+02	4.56E+02	1.45E+03	1.17E+03
	Total Suspended Solids	mg/l	2	18	2.00E+00	2.40E+00	2.80E+00	3.53E+00
	Trichloroethane [1,1,1-]	µg/l	1	12	2.30E+01	2.30E+01	2.30E+01	
	Tritium	nCi/l	34	52	9.80E-02	3.94E-01	2.10E+00	1.10E+00
	Uranium	µg/l	50	52	2.00E-01	1.11E+01	3.52E+01	2.97E+01
	Vanadium	µg/l	44	47	5.00E+00	1.87E+01	6.00E+01	3.90E+01
	Zinc	µg/l	36	52	3.90E+00	1.11E+02	1.30E+03	5.61E+02

[a] Groundwater regime designations are in accordance with the Environmental Surveillance Program.

[b] pCi/l is picocuries of radioactive analyte per liter of sample, nCi/l is nanocuries of radioactive analyte per liter, µg/l is micrograms of analyte per liter of sample, mg/l is milligrams of analyte per liter of sample, NTU is nephelometric turbidity units.

c Upper confidence limit (UCL) not calculated when the number of detected analyses equals 1.

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAX
Alluvial Groundwater Cañada del Buey	Aluminum	µg/l	8	8	4.7E+03	5.9E+04	1.6
	Americium-241	pCi/l	6	6	1.8E-02	2.7E-02	4.1
	Ammonia, as Nitrogen	mg/l	4	11	3.0E-02	1.0E-01	2.4
	Antimony	µg/l	1	6	1.0E+00	1.0E+00	1.0
	Arsenic	µg/l	8	8	5.0E+00	2.3E+01	7.2
	Barium	µg/l	8	8	8.3E+01	6.9E+02	1.6
	Beryllium	µg/l	5	8	3.0E+00	8.6E+00	2.0
	Bicarbonate	mg/l	8	8	6.6E+01	7.6E+01	9.8
	Boron	µg/l	8	8	3.7E+01	5.5E+01	9.0
	Cadmium	µg/l	3	8	1.0E+00	3.0E+00	5.0
	Calcium	mg/l	8	8	1.3E+01	2.5E+01	4.2
	Cesium-137	pCi/l	1	8	2.1E+00	2.1E+00	2.1
	Chlorine	mg/l	8	8	7.0E+00	1.1E+01	1.3
	Chromium	µg/l	6	8	1.2E+01	4.0E+01	1.0
	Cobalt	µg/l	5	8	4.0E+00	1.2E+01	2.8
	Copper	µg/l	6	8	5.0E+00	2.8E+01	7.1
	Cyanide	mg/l	2	7	5.0E-02	5.5E-02	6.0
	Fluorine	mg/l	8	8	1.0E-01	1.9E-01	3.0
	Gross Alpha	pCi/l	8	8	3.0E+00	1.3E+01	2.6
	Gross Beta	pCi/l	8	8	7.0E+00	1.8E+01	2.9
	Gross Gamma	pCi/l	6	8	4.0E+01	1.2E+02	4.0
	Hardness	mg/l	8	8	5.3E+01	1.0E+02	1.9
	Iron	µg/l	8	8	2.2E+03	3.6E+04	1.3
	Lead	µg/l	5	6	3.0E+00	8.3E+01	2.4
	Lithium	mg/l	2	2	3.4E-02	6.5E-02	9.5

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater Cañada del Buey (cont.)	Magnesium	mg/l	8	8	3.8E+00	9.7E+00	2.1E+01	2.0E+01
	Manganese	µg/l	8	8	4.0E+00	8.6E+02	2.4E+03	2.6E+03
	Mercury	µg/l	3	8	2.0E-01	3.3E-01	6.0E-01	8.0E-01
	Molybdenum	µg/l	1	8	2.0E+00	2.0E+00	2.0E+00	
	Nickel	µg/l	6	8	1.0E+01	3.3E+01	8.0E+01	8.2E+01
	Nitrate, as Nitrogen	mg/l	15	18	4.0E-02	1.4E+00	1.7E+01	1.0E+01
	Nitrite, as Nitrogen	mg/l	4	11	2.0E-02	4.5E-02	9.0E-02	1.1E-01
	pH		8	8	6.8E+00		9.0E+00	
	Phosphate, as Phosphorous	mg/l	7	7	1.0E-01	3.9E-01	6.0E-01	7.2E-01
	Plutonium-238	pCi/l	4	8	2.0E-03	1.9E-02	3.4E-02	5.0E-02
	Plutonium-239, Plutonium-240	pCi/l	5	8	3.0E-03	1.6E-02	3.9E-02	4.3E-02
	Potassium	mg/l	8	8	2.1E+00	1.1E+01	2.2E+01	2.6E+01
	Selenium	µg/l	6	8	1.0E+00	5.4E+00	1.6E+01	1.6E+01
	Silica	mg/l	8	8	5.3E+01	6.0E+01	6.7E+01	6.9E+01
	Sodium	mg/l	8	8	2.0E+01	2.4E+01	3.0E+01	3.1E+01
	Strontium	µg/l	8	8	1.0E+02	1.8E+02	3.3E+02	3.4E+02
	Strontium-90	pCi/l	5	5	2.0E-01	5.6E-01	1.1E+00	1.4E+00
	Sulfate	mg/l	8	8	2.0E+00	7.0E+00	9.0E+00	1.2E+01
	Thallium	µg/l	2	6	2.0E+00	4.0E+00	6.0E+00	9.7E+00
	Tin	µg/l	3	8	3.0E+01	4.1E+01	5.0E+01	6.2E+01
	Total Dissolved Solids	mg/l	8	8	9.6E+01	1.8E+02	2.1E+02	2.5E+02
	Total Kjeldahl Nitrogen	mg/l	9	11	4.0E-02	6.8E-01	2.5E+00	2.2E+00

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Alluvial Groundwater	Total Suspended Solids	mg/l	3	3	3.0E+00	1.8E+01	4.6E+01	6.7E+01
Cañada del Buey (cont.)	Tritium	nCi/l	8	8	2.9E-02	4.0E-01	9.0E-01	9.1E-01
	Uranium	µg/l	7	8	2.8E-01	2.6E+00	5.8E+00	6.1E+00
	Vanadium	µg/l	7	8	1.4E+01	5.8E+01	1.5E+02	1.5E+02
	Zinc	µg/l	7	8	8.6E+01	2.4E+02	7.2E+02	6.8E+02
Los Alamos	Acetone	µg/l	2	16	2.0E+00	3.0E+00	4.0E+00	5.8E+00
	Aluminum	µg/l	69	75	1.0E+02	7.7E+03	2.4E+05	7.1E+04
	Americium-241	pCi/l	75	95	9.0E-04	3.5E+00	9.4E+01	3.2E+01
	Antimony	µg/l	3	74	7.0E-01	1.2E+00	2.0E+00	2.6E+00
	Arsenic	µg/l	24	74	1.0E+00	8.0E+00	8.3E+01	4.2E+01
	Barium	µg/l	57	69	3.0E-02	2.2E+02	3.1E+03	1.5E+03
	Barium-140	pCi/l	7	11	2.5E+00	7.0E+00	1.1E+01	1.3E+01
	Beryllium	µg/l	16	75	3.0E-01	5.9E+00	3.0E+01	2.4E+01
	Bicarbonate	mg/l	59	59	2.6E+01	6.3E+01	1.0E+02	1.0E+02
	Boron	µg/l	44	81	1.3E+01	5.7E+01	2.7E+02	1.6E+02
	Cadmium	µg/l	9	74	1.2E+00	9.3E+00	3.6E+01	3.3E+01
	Calcium	mg/l	75	75	7.5E+00	2.1E+01	3.2E+02	9.2E+01
	Cerium-144	pCi/l	18	27	1.0E+00	3.1E+01	1.1E+02	1.1E+02
	Cesium-137	pCi/l	52	73	1.3E-02	1.6E+01	2.6E+02	1.1E+02
	Chlorine	mg/l	63	63	6.0E+00	4.3E+01	1.1E+02	8.7E+01
	Chloro-3-methylphenol[4-]	µg/l	1	16	2.0E+01	2.0E+01	2.0E+01	
	Chlorophenol[o-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Chromium	µg/l	28	75	1.8E+00	5.1E+02	7.0E+03	3.7E+03
	Cobalt	µg/l	7	75	4.0E+00	2.5E+01	7.1E+01	7.1E+01

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Los Alamos (cont.)	Cobalt-57	pCi/l	10	16	1.4E-01	5.6E+00	1.8E+01	1.7E+01
	Cobalt-60	pCi/l	24	27	1.4E-01	9.7E+00	3.7E+01	3.4E+01
	Copper	µg/l	19	75	1.3E+00	6.0E+01	8.7E+02	4.5E+02
	Cyanide	mg/l	1	57	4.0E-02	4.0E-02	4.0E-02	
	Dichlorophenol [2,4-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Dimethylphenol [2,4-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Di-n-butyl phthalate	µg/l	1	16	1.1E+01	1.1E+01	1.1E+01	
	Dinitrophenol [2,4-]	µg/l	1	16	5.0E+01	5.0E+01	5.0E+01	
	Europium-152	pCi/l	20	27	1.4E+00	3.3E+01	1.2E+02	1.1E+02
	Fluorine	mg/l	69	73	1.2E-01	6.6E-01	1.0E+00	1.2E+00
	Gross Alpha	pCi/l	56	73	2.0E-01	5.1E+00	7.4E+01	3.2E+01
	Gross Beta	pCi/l	72	73	2.0E+00	3.9E+01	1.5E+02	1.2E+02
	Gross Gamma	pCi/l	61	69	2.0E+00	1.3E+02	9.0E+02	4.6E+02
	Hardness	mg/l	48	48	2.5E+01	8.0E+01	1.1E+03	3.8E+02
	Iodine-129	pCi/l	1	2	3.1E+00	3.1E+00	3.1E+00	
	Iron	µg/l	71	75	5.0E+01	5.4E+03	1.9E+05	5.3E+04
	Lead	µg/l	24	74	6.0E-01	3.4E+01	4.1E+02	2.0E+02
	Lithium	mg/l	24	44	3.0E-03	3.5E-02	1.3E-01	9.8E-02
	Magnesium	mg/l	63	75	2.2E+00	5.3E+00	7.7E+01	2.4E+01
	Manganese	µg/l	50	75	7.0E-01	9.2E+02	1.4E+04	6.8E+03
	Mercury	µg/l	13	74	1.0E-01	2.2E+00	1.4E+01	1.1E+01
	Methyl-4,6-dinitrophenol[2-]	µg/l	1	16	5.0E+01	5.0E+01	5.0E+01	

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Los Alamos (cont.)	Methylphenol[2-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Methylphenol[4-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Molybdenum	µg/l	45	76	2.0E+00	2.9E+02	1.0E+03	9.1E+02
	Neptunium-237	pCi/l	18	27	4.9E-02	2.8E+01	1.0E+02	9.6E+01
	Nickel	µg/l	9	75	1.1E+00	4.9E+01	1.7E+02	1.6E+02
	Nitrate, as Nitrogen	mg/l	54	75	4.0E-02	5.9E-01	7.3E+00	2.9E+00
	Nitrophenol[2-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Nitrophenol[4-]	µg/l	1	16	5.0E+01	5.0E+01	5.0E+01	
	Pentachlorophenol	µg/l	1	16	5.0E+01	5.0E+01	5.0E+01	
	pH		63	63	1.0E-01		8.0E+00	
	Phenol	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Phosphate, as Phosphorous	mg/l	49	55	2.0E-02	8.9E-01	2.9E+01	9.2E+00
	Phosphorous	mg/l	8	15	4.3E-02	1.3E-01	2.3E-01	2.5E-01
	Plutonium-238	pCi/l	44	74	1.0E-03	2.6E-02	3.6E-01	1.4E-01
	Plutonium-239, Plutonium-240	pCi/l	65	74	1.0E-03	7.8E-02	1.6E+00	5.3E-01
	Potassium	mg/l	69	75	1.7E+00	6.3E+00	3.0E+01	1.4E+01
	Potassium-40	pCi/l	13	16	2.2E+00	2.4E+02	5.0E+02	5.7E+02
	Ruthenium-106	pCi/l	12	27	2.2E+00	3.8E+01	1.5E+02	1.3E+02
	Selenium	µg/l	4	74	3.0E+00	5.3E+00	1.0E+01	1.2E+01
	Silica	mg/l	61	61	2.2E+01	4.0E+01	6.7E+01	5.7E+01
	Silver	µg/l	4	75	4.0E-01	1.4E+01	2.6E+01	3.5E+01
	Sodium	mg/l	75	75	4.0E+00	3.2E+01	5.9E+01	5.1E+01
	Sodium-22	pCi/l	16	27	2.9E-02	3.1E+00	1.1E+01	9.9E+00

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Los Alamos (cont.)	Strontium	µg/l	76	76	4.8E+01	1.2E+02	9.3E+02	3.5E+02
	Strontium-90	pCi/l	65	68	3.0E-01	2.2E+01	3.7E+02	1.2E+02
	Sulfate	mg/l	75	75	4.0E+00	8.9E+00	3.1E+01	1.7E+01
	Thallium	µg/l	9	74	3.0E-01	1.2E+00	3.0E+00	3.3E+00
	Tin	µg/l	2	71	3.0E+01	5.0E+01	7.0E+01	1.1E+02
	Total Dissolved Solids	mg/l	63	63	7.4E+01	2.2E+02	8.0E+02	4.5E+02
	Total Suspended Solids	mg/l	14	26	2.0E+00	8.1E+01	4.2E+02	3.4E+02
	Trichlorophenol [2,4,5-]	µg/l	1	16	5.0E+01	5.0E+01	5.0E+01	
	Trichlorophenol [2,4,6-]	µg/l	1	16	1.0E+01	1.0E+01	1.0E+01	
	Tritium	nCi/l	60	74	4.6E-02	8.2E-01	9.3E+00	3.8E+00
	Turbidity	NTU	15	15	6.0E-01	8.3E+00	8.0E+01	4.8E+01
	Uranium	µg/l	61	73	2.0E-02	1.8E+00	5.0E+01	1.5E+01
	Vanadium	µg/l	22	75	1.7E+00	2.8E+01	3.5E+02	1.8E+02
	Zinc	µg/l	34	75	9.0E-02	1.1E+02	1.6E+03	6.5E+02
Mortandad	Acetone	µg/l	1	17	2.1E+01	2.1E+01	2.1E+01	
	Actinium-228	pCi/l	3	6	1.2E+00	6.2E+00	9.8E+00	1.5E+01
	Aluminum	µg/l	59	63	2.5E+01	5.4E+03	4.4E+04	2.5E+04
	Americium-241	pCi/l	64	75	1.2E-01	2.9E+00	6.6E+01	2.3E+01
	Antimony	µg/l	10	63	2.0E-01	1.6E+00	3.0E+00	3.4E+00
	Arsenic	µg/l	27	63	2.0E+00	4.6E+00	1.2E+01	9.7E+00
	Barium	µg/l	51	57	4.0E+01	2.1E+02	9.1E+02	5.5E+02
	Barium-140	pCi/l	8	10	6.7E-01	7.1E+00	1.9E+01	2.0E+01

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Benzidine[m-]	µg/l	1	15	2.0E+01	2.0E+01	2.0E+01	
	Beryllium	µg/l	11	63	1.2E+00	3.2E+00	1.2E+01	9.5E+00
	Bicarbonate	mg/l	52	53	5.9E+01	1.6E+02	2.5E+02	2.4E+02
	Bis(2-ethylhexyl) phthalate	µg/l	1	16	4.0E+00	4.0E+00	4.0E+00	
	Bismuth-211	pCi/l	2	6	3.3E+01	4.1E+01	4.8E+01	6.1E+01
	Bismuth-212	pCi/l	5	6	2.2E+01	3.8E+01	7.6E+01	8.5E+01
	Bismuth-214	pCi/l	1	6	8.3E+00	8.3E+00	8.3E+00	
	Boron	µg/l	59	65	3.0E+01	7.5E+01	1.1E+02	1.1E+02
	Cadmium	µg/l	2	63	6.0E-01	8.0E-01	1.0E+00	1.4E+00
	Cadmium-109	pCi/l	5	6	2.5E+01	4.0E+01	5.7E+01	6.9E+01
	Calcium	mg/l	63	63	1.4E+01	3.2E+01	7.3E+01	6.4E+01
	Carbonate	mg/l	2	53	1.0E+00	2.0E+00	3.0E+00	4.8E+00
	Cerium-139	pCi/l	2	6	5.5E-02	2.8E-01	5.0E-01	9.1E-01
	Cerium-144	pCi/l	13	18	1.6E+00	4.1E+01	1.6E+02	1.4E+02
	Cesium-134	pCi/l	1	6	2.4E-01	2.4E-01	2.4E-01	
	Cesium-137	pCi/l	33	57	3.6E-01	4.1E+00	3.2E+01	1.7E+01
	Chlorine	mg/l	53	53	7.0E+00	1.8E+01	3.1E+01	2.9E+01
	Chloromethane	µg/l	1	17	1.1E+01	1.1E+01	1.1E+01	
	Chromium	µg/l	23	63	1.1E+00	1.4E+01	2.8E+01	2.9E+01
	Cobalt	µg/l	8	63	5.0E+00	7.5E+00	1.2E+01	1.2E+01
	Cobalt-57	pCi/l	10	14	1.7E-01	5.0E+00	1.5E+01	1.5E+01
	Cobalt-60	pCi/l	16	18	3.0E-01	1.3E+01	4.6E+01	4.3E+01
	Copper	µg/l	24	63	5.6E+00	3.1E+01	1.0E+02	7.6E+01
	Cyanide	mg/l	12	53	1.0E-02	2.0E-02	3.4E-02	3.7E-02

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Di-n-butyl phthalate	µg/l	1	16	1.2E+01	1.2E+01	1.2E+01	
	Europium-152	pCi/l	15	18	9.8E-01	2.5E+01	1.2E+02	9.2E+01
	Fluorine	mg/l	60	60	3.0E-01	1.6E+00	2.2E+00	2.4E+00
	Gross Alpha	pCi/l	52	57	6.0E-01	2.2E+01	1.4E+02	8.8E+01
	Gross Beta	pCi/l	56	57	2.0E+01	1.6E+02	6.3E+02	4.7E+02
	Gross Gamma	pCi/l	43	57	1.0E+01	1.2E+02	4.0E+02	2.9E+02
	Hardness	mg/l	47	47	4.9E+01	1.1E+02	2.4E+02	2.1E+02
	Iron	µg/l	56	63	4.0E+01	3.8E+03	3.1E+04	1.8E+04
	Lanthanum-140	pCi/l	1	6	3.8E+02	3.8E+02	3.8E+02	
	Lead	µg/l	23	67	2.0E+00	2.2E+01	5.8E+01	5.1E+01
	Lead-210	pCi/l	4	6	1.5E+02	1.0E+03	1.7E+03	2.3E+03
	Lead-211	pCi/l	3	6	1.8E+00	1.2E+01	2.6E+01	3.7E+01
	Lead-212	pCi/l	3	6	1.2E-01	3.8E+00	6.2E+00	1.0E+01
	Lead-214	pCi/l	2	6	5.0E+00	7.9E+00	1.1E+01	1.6E+01
	Lithium	mg/l	30	37	2.0E-03	2.9E-02	8.0E-02	6.6E-02
	Magnesium	mg/l	57	63	2.1E+00	5.5E+00	2.0E+01	1.2E+01
	Manganese	µg/l	41	63	2.0E+00	2.0E+02	8.6E+02	7.0E+02
	Manganese-54	pCi/l	2	6	5.2E-01	5.2E-01	5.3E-01	5.3E-01
	Mercury	µg/l	17	63	3.0E-02	4.3E-01	1.9E+00	1.4E+00
	Mercury-203	pCi/l	6	6	9.9E-02	1.7E+00	3.2E+00	4.1E+00
	Molybdenum	µg/l	59	63	2.0E-01	1.5E+02	9.4E+02	4.0E+02
	Neptunium-237	pCi/l	12	18	1.3E+00	1.7E+01	6.4E+01	6.1E+01
	Nickel	µg/l	18	63	4.8E+00	2.1E+01	1.1E+02	6.9E+01
	Nitrate, as Nitrogen	mg/l	63	63	4.8E+00	2.7E+01	6.6E+01	6.0E+01

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Pentachlorophenol	µg/l	1	16	1.1E+01	1.1E+01	1.1E+01	
	pH		53	53	2.2E+00		8.6E+00	
	Phosphate, as Phosphorous	mg/l	47	47	6.0E-02	3.3E-01	9.0E-01	7.9E-01
	Phosphorous	mg/l	5	10	7.0E-02	1.0E-01	1.5E-01	1.6E-01
	Plutonium-238	pCi/l	55	57	3.0E-03	1.3E-01	2.4E+00	9.2E-01
	Plutonium-239, Plutonium-240	pCi/l	53	57	1.0E-02	3.5E-01	7.6E+00	2.9E+00
	Potassium	mg/l	63	63	3.8E+00	1.9E+01	3.6E+01	3.4E+01
	Potassium-40	pCi/l	8	14	2.8E+01	1.9E+02	3.9E+02	4.3E+02
	Protactinium-231	pCi/l	4	6	6.5E+00	1.0E+01	1.5E+01	1.8E+01
	Protactinium-233	pCi/l	3	6	1.5E-01	6.6E-01	1.3E+00	1.8E+00
	Protactinium-234M	pCi/l	5	6	2.9E+01	2.5E+02	5.0E+02	6.2E+02
	Pyridine	µg/l	2	5	1.0E+01	1.0E+01	1.0E+01	1.0E+01
	Radium-223	pCi/l	2	6	2.8E+00	5.5E+00	8.3E+00	1.3E+01
	Radium-224	pCi/l	1	6	3.2E+01	3.2E+01	3.2E+01	
	Radium-226	pCi/l	5	6	2.5E+01	9.4E+01	1.8E+02	2.2E+02
	Radon-219	pCi/l	2	6	5.9E-01	5.8E+00	1.1E+01	2.1E+01
	Ruthenium-106	pCi/l	8	18	2.1E+00	3.2E+01	6.1E+01	7.8E+01
	Selenium	µg/l	17	63	1.0E+00	2.7E+01	9.0E+01	9.9E+01
	Selenium-75	pCi/l	3	6	3.3E-01	9.6E-01	1.8E+00	2.5E+00
	Silica	mg/l	53	53	2.0E+01	4.2E+01	1.6E+02	8.5E+01
	Silver	µg/l	9	62	1.0E+00	2.7E+01	1.7E+02	1.3E+02
	Sodium	mg/l	63	63	1.8E+01	9.2E+01	1.5E+02	1.4E+02
	Sodium-22	pCi/l	18	18	3.6E+00	1.2E+01	3.3E+01	2.8E+01

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Mortandad (cont.)	Strontium	µg/l	63	63	7.5E+01	1.6E+02	3.9E+02	2.9E+02
	Strontium-85	pCi/l	2	6	3.5E+00	3.5E+00	3.5E+00	3.6E+00
	Strontium-90	pCi/l	52	57	1.0E-01	3.1E+01	1.3E+02	1.0E+02
	Sulfate	mg/l	62	62	5.0E+00	2.1E+01	8.1E+01	4.6E+01
	Thallium	µg/l	10	63	4.0E-02	1.1E+00	2.2E+00	3.1E+00
	Thallium-208	pCi/l	3	6	9.4E-02	3.3E+00	6.8E+00	1.0E+01
	Thorium-227	pCi/l	3	6	5.8E+00	8.7E+00	1.3E+01	1.7E+01
	Thorium-234	pCi/l	2	6	6.0E+00	1.6E+02	3.1E+02	5.8E+02
	Tin	µg/l	1	57	1.6E+01	1.6E+01	1.6E+01	
	Tin-113	pCi/l	3	6	6.7E-01	1.1E+00	1.6E+00	2.0E+00
	Total Dissolved Solids	mg/l	55	55	2.0E+02	4.3E+02	7.9E+02	7.2E+02
	Total Suspended Solids	mg/l	13	21	1.0E+00	1.2E+02	8.6E+02	6.2E+02
	Trichlorobenzene [1,2,4-]	µg/l	1	22	5.0E+00	5.0E+00	5.0E+00	
	Tritium	nCi/l	57	57	1.4E+01	2.9E+01	1.1E+02	6.9E+01
	Turbidity	NTU	8	8	3.5E-01	3.9E+00	1.7E+01	1.6E+01
	Uranium	µg/l	58	58	4.0E-01	2.3E+00	6.5E+00	5.1E+00
	Vanadium	µg/l	21	63	3.0E+00	2.3E+01	7.0E+01	5.5E+01
	Yttrium-88	pCi/l	3	6	1.0E+00	1.7E+00	2.3E+00	3.0E+00
	Zinc	µg/l	34	63	6.0E+00	5.6E+01	1.7E+02	1.3E+02
	Zinc-65	pCi/l	5	6	7.8E-01	1.2E+00	1.6E+00	2.0E+00
Pajarito	Aluminum	µg/l	16	16	5.0E+01	1.5E+04	1.0E+05	8.2E+04
	Americium-241	pCi/l	8	8	1.0E-02	3.8E-02	6.3E-02	7.7E-02
	Antimony	µg/l	6	16	5.0E-01	1.2E+00	2.0E+00	2.5E+00

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pajarito (cont.)	Arsenic	µg/l	8	15	3.0E+00	1.6E+01	6.8E+01	6.3E+01
	Barium	µg/l	13	13	2.9E+01	5.2E+02	2.8E+03	2.5E+03
	Beryllium	µg/l	3	13	3.0E+00	1.1E+01	1.9E+01	2.7E+01
	Bicarbonate	mg/l	17	17	2.8E+01	8.9E+01	3.2E+02	2.4E+02
	Boron	µg/l	12	16	2.0E+01	3.3E+01	5.8E+01	5.6E+01
	Cadmium	µg/l	7	16	3.0E-01	1.8E+00	7.0E+00	6.6E+00
	Calcium	mg/l	17	17	6.0E+00	4.1E+01	2.1E+02	1.4E+02
	Cesium-137	pCi/l	10	16	1.8E+00	4.2E+01	2.4E+02	2.0E+02
	Chlorine	mg/l	17	17	6.0E+00	6.9E+01	4.5E+02	2.9E+02
	Chromium	µg/l	6	13	2.0E+00	2.1E+02	7.4E+02	8.1E+02
	Cobalt	µg/l	4	16	4.0E+00	3.0E+01	5.9E+01	8.6E+01
	Copper	µg/l	9	16	2.0E+00	2.8E+01	1.3E+02	1.1E+02
	Fluorine	mg/l	13	17	1.0E-01	1.9E-01	4.4E-01	3.6E-01
	Gross Alpha	pCi/l	12	16	7.9E-01	7.7E+00	5.0E+01	3.5E+01
	Gross Beta	pCi/l	16	16	2.0E+00	9.1E+00	5.4E+01	3.4E+01
	Gross Gamma	pCi/l	15	16	2.2E+01	9.1E+01	3.4E+02	2.5E+02
	Hardness	mg/l	17	17	2.0E+01	1.7E+02	7.8E+02	6.1E+02
	Iron	µg/l	16	16	2.6E+02	1.9E+04	1.2E+05	9.5E+04
	Lead	µg/l	11	17	1.4E+00	4.0E+01	2.1E+02	1.8E+02
	Lithium	mg/l	2	3	1.0E-03	1.0E-03	1.0E-03	1.0E-03
	Magnesium	mg/l	17	17	1.4E+00	9.9E+00	4.8E+01	3.3E+01
	Manganese	µg/l	16	16	3.0E+00	1.8E+03	1.3E+04	8.6E+03
	Mercury	µg/l	8	16	1.0E-01	3.4E-01	6.0E-01	6.6E-01
	Molybdenum	µg/l	7	16	1.0E+00	7.7E+00	2.0E+01	2.2E+01
	Nickel	µg/l	3	16	1.0E+01	5.8E+01	9.8E+01	1.5E+02

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pajarito (cont.)	Nitrate, as Nitrogen	mg/l	13	17	6.0E-02	2.9E+00	1.7E+01	1.3E+01
	pH		17	17	6.5E+00		7.5E+00	
	Phosphate, as Phosphorous	mg/l	13	14	2.0E-02	4.1E-01	3.1E+00	2.1E+00
	Plutonium-238	pCi/l	7	16	2.0E-03	2.0E-02	5.9E-02	5.9E-02
	Plutonium-239, Plutonium-240	pCi/l	14	16	4.0E-03	1.6E-02	3.6E-02	3.5E-02
	Potassium	mg/l	14	14	1.0E+00	4.1E+00	1.6E+01	1.1E+01
	Selenium	µg/l	2	15	1.0E+00	3.5E+00	6.0E+00	1.1E+01
	Silica	mg/l	17	17	2.7E+01	3.6E+01	4.7E+01	4.8E+01
	Silver	µg/l	5	16	3.0E-01	2.0E+00	5.0E+00	5.9E+00
	Sodium	mg/l	17	17	4.0E+00	3.3E+01	1.6E+02	1.1E+02
	Strontium	µg/l	16	16	5.0E+01	3.0E+02	1.5E+03	1.0E+03
	Strontium-90	pCi/l	10	10	2.0E-01	8.7E-01	1.7E+00	1.9E+00
	Sulfate	mg/l	17	17	3.3E+00	2.1E+01	1.5E+02	9.3E+01
	Thallium	µg/l	4	16	9.0E-02	1.1E+00	2.0E+00	3.2E+00
	Tin	µg/l	4	13	1.0E+01	2.4E+01	4.4E+01	5.2E+01
	Total Dissolved Solids	mg/l	17	17	1.1E+01	2.8E+02	1.4E+03	9.2E+02
	Total Suspended Solids	mg/l	1	4	1.0E+00	1.0E+00	1.0E+00	
	Tritium	nCi/l	13	16	1.0E-01	4.3E-01	8.0E-01	8.8E-01
	Uranium	µg/l	12	16	6.0E-02	2.5E+00	1.8E+01	1.3E+01
	Vanadium	µg/l	6	13	1.0E+01	5.8E+01	1.4E+02	1.9E+02
	Zinc	µg/l	12	16	3.0E+00	1.0E+02	6.4E+02	4.9E+02

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo	Acetone	µg/l	2	6	5.0E+00	5.0E+00	5.0E+00	5.0E+00
	Aluminum	µg/l	9	12	1.3E+02	2.3E+03	8.5E+03	8.6E+03
	Americium-241	pCi/l	13	17	1.8E-02	2.4E+00	1.4E+01	1.2E+01
	Antimony	µg/l	2	12	1.6E+00	1.8E+00	2.0E+00	2.4E+00
	Arsenic	µg/l	10	12	3.8E+00	8.1E+00	1.1E+01	1.3E+01
	Barium	µg/l	10	12	6.0E-02	8.9E+01	2.4E+02	2.6E+02
	Barium-140	pCi/l	2	2	6.0E+00	7.0E+00	8.0E+00	9.8E+00
	Beryllium	µg/l	1	12	8.0E+00	8.0E+00	8.0E+00	
	Bicarbonate	mg/l	10	10	1.1E+02	1.4E+02	1.7E+02	1.8E+02
	Bis(2-ethylhexyl) phthalate	µg/l	1	5	8.0E+00	8.0E+00	8.0E+00	
	Boron	µg/l	11	11	2.0E+02	2.7E+02	5.0E+02	4.5E+02
	Cadmium	µg/l	2	12	2.0E-01	6.0E-01	1.0E+00	1.7E+00
	Calcium	mg/l	12	12	1.7E+01	2.1E+01	2.7E+01	2.9E+01
	Cerium-144	pCi/l	2	6	2.8E-01	1.8E+00	3.4E+00	6.3E+00
	Cesium-137	pCi/l	7	11	7.8E-01	3.6E+00	1.3E+01	1.3E+01
	Chlorine	mg/l	10	10	3.5E+01	3.8E+01	4.7E+01	4.5E+01
	Chromium	µg/l	4	12	6.0E+00	3.3E+03	7.7E+03	1.1E+04
	Cobalt	µg/l	5	12	3.1E+00	8.3E+00	1.7E+01	1.9E+01
	Cobalt-57	pCi/l	3	4	3.3E-01	1.0E+00	1.8E+00	2.5E+00
	Cobalt-60	pCi/l	5	6	1.2E+00	8.1E+00	1.9E+01	2.6E+01
	Copper	µg/l	5	12	2.5E+00	1.5E+01	5.1E+01	5.6E+01
	Europium-152	pCi/l	5	6	3.0E+00	2.4E+01	7.1E+01	8.2E+01
	Fluorine	mg/l	12	12	4.0E-01	5.6E-01	7.0E-01	7.2E-01
	Gross Alpha	pCi/l	6	12	2.0E-01	3.6E+00	9.0E+00	1.0E+01

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Gross Beta	pCi/l	12	12	1.0E+01	1.4E+01	1.9E+01	2.0E+01
	Gross Gamma	pCi/l	10	10	3.6E+01	1.2E+02	2.8E+02	2.8E+02
	Hardness	mg/l	6	6	7.0E+01	8.2E+01	8.7E+01	9.5E+01
	Iodine-129	pCi/l	1	1	7.7E-01	7.7E-01	7.7E-01	
	Iron	µg/l	10	12	5.0E+01	1.4E+03	5.6E+03	5.7E+03
	Lead	µg/l	5	12	1.0E+00	6.0E+00	1.8E+01	2.0E+01
	Lithium	mg/l	5	8	2.0E-02	2.8E-02	4.7E-02	5.0E-02
	Magnesium	mg/l	10	12	3.5E+00	4.6E+00	5.8E+00	6.4E+00
	Manganese	µg/l	12	12	1.3E+02	1.5E+03	6.6E+03	5.0E+03
	Molybdenum	µg/l	2	12	1.2E+00	3.6E+00	6.0E+00	1.0E+01
	Neptunium-237	pCi/l	2	6	9.0E+00	5.8E+01	1.1E+02	1.9E+02
	Nickel	µg/l	3	12	4.7E+00	6.7E+00	1.0E+01	1.2E+01
	Nitrate, as Nitrogen	mg/l	11	12	3.4E-01	3.0E+00	1.4E+01	1.1E+01
	pH		10	10	6.9E+00		7.7E+00	
	Phosphate, as Phosphorous	mg/l	7	7	2.2E+00	3.4E+00	4.9E+00	5.5E+00
	Phosphorous	mg/l	4	4	8.2E-02	2.4E+00	4.8E+00	7.9E+00
	Plutonium-238	pCi/l	7	12	3.0E-03	2.1E-02	8.9E-02	8.3E-02
	Plutonium-239, Plutonium-240	pCi/l	12	12	2.4E-02	1.1E-01	4.0E-01	3.4E-01
	Potassium	mg/l	12	12	1.0E+01	1.4E+01	2.1E+01	2.0E+01
	Potassium-40	pCi/l	3	4	6.7E+00	8.2E+02	1.3E+03	2.2E+03
	Ruthenium-106	pCi/l	3	6	3.2E+00	7.9E+00	1.1E+01	1.6E+01
	Selenium	µg/l	1	12	3.0E+00	3.0E+00	3.0E+00	
	Silica	mg/l	10	10	3.5E+01	5.6E+01	7.8E+01	9.0E+01

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Silver	µg/l	1	12	2.0E+00	2.0E+00	2.0E+00	
	Sodium	mg/l	12	12	6.0E+01	6.5E+01	6.9E+01	7.0E+01
	Sodium-22	pCi/l	4	6	1.0E-01	3.6E+00	1.2E+01	1.5E+01
	Strontium	µg/l	12	12	8.7E+01	1.3E+02	3.0E+02	2.4E+02
	Strontium-90	pCi/l	9	11	2.0E-01	1.5E+00	4.2E+00	4.2E+00
	Sulfate	mg/l	11	11	6.8E+00	1.5E+01	2.7E+01	3.0E+01
	Thallium	µg/l	2	11	2.0E-01	4.0E-01	6.0E-01	9.7E-01
	Total Dissolved Solids	mg/l	10	10	2.4E+02	3.0E+02	4.0E+02	3.9E+02
	Total Suspended Solids	mg/l	1	5	2.4E+00	2.4E+00	2.4E+00	
	Tritium	nCi/l	7	12	1.0E-01	3.4E-01	1.1E+00	1.0E+00
	Turbidity	NTU	4	4	1.5E+00	2.5E+00	5.6E+00	6.6E+00
	Uranium	µg/l	12	12	4.0E-02	6.0E-01	1.8E+00	1.6E+00
	Vanadium	µg/l	8	12	3.4E+00	1.3E+01	3.0E+01	3.2E+01
	Zinc	µg/l	9	12	7.8E+00	5.0E+01	1.6E+02	1.4E+02
Intermediate Perched Groundwater Los Alamos	Aluminum	µg/l	6	7	6.0E+01	3.1E+03	1.5E+04	1.5E+04
	Americium-241	pCi/l	3	6	3.0E-02	6.0E-02	1.1E-01	1.5E-01
	Antimony	µg/l	4	7	4.0E-01	7.5E-01	1.0E+00	1.4E+00
	Arsenic	µg/l	6	7	3.0E+00	6.0E+00	1.3E+01	1.3E+01
	Barium	µg/l	6	6	4.8E+01	9.0E+01	1.7E+02	1.8E+02
	Beryllium	µg/l	1	7	3.0E+00	3.0E+00	3.0E+00	
	Bicarbonate	mg/l	7	7	5.3E+01	9.1E+01	1.2E+02	1.5E+02
	Boron	µg/l	7	7	6.3E+01	1.5E+02	2.7E+02	3.3E+02
	Bromine	µg/l	1	1	8.0E+01	8.0E+01	8.0E+01	
	Cadmium	µg/l	1	7	5.0E+00	5.0E+00	5.0E+00	

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Intermediate Perched Groundwater Los Alamos (cont.)	Calcium	mg/l	7	7	1.2E+01	2.6E+01	3.7E+01	4.2E+01
	Cesium-137	pCi/l	4	7	1.2E+00	4.9E+00	1.3E+01	1.6E+01
	Chlorine	mg/l	7	7	2.1E+01	3.6E+01	6.1E+01	6.4E+01
	Chloroethane	µg/l	1	2	2.1E+01	2.1E+01	2.1E+01	
	Chromium	µg/l	3	7	1.5E+00	3.2E+00	5.0E+00	6.7E+00
	Cobalt	µg/l	1	7	1.5E+01	1.5E+01	1.5E+01	
	Copper	µg/l	5	7	3.0E+00	1.3E+01	3.0E+01	3.5E+01
	Cyanide	mg/l	1	5	2.3E-02	2.3E-02	2.3E-02	
	Fluorine	mg/l	7	7	3.0E-01	4.5E-01	8.0E-01	7.9E-01
	Gross Alpha	pCi/l	5	7	1.0E+00	2.5E+00	4.0E+00	5.4E+00
	Gross Beta	pCi/l	7	7	5.0E+00	1.4E+01	5.2E+01	4.8E+01
	Gross Gamma	pCi/l	6	7	2.0E+01	6.2E+01	1.9E+02	1.9E+02
	Hardness	mg/l	7	7	4.3E+01	8.7E+01	1.3E+02	1.4E+02
	Iron	µg/l	7	7	3.0E+01	1.9E+03	1.1E+04	1.0E+04
	Lead	µg/l	5	8	1.0E+00	7.4E+00	2.8E+01	3.1E+01
	Magnesium	mg/l	7	7	3.1E+00	6.1E+00	9.4E+00	1.1E+01
	Manganese	µg/l	6	7	1.7E+01	2.6E+02	6.8E+02	8.9E+02
	Mercury	µg/l	3	7	1.0E-01	4.3E-01	8.0E-01	1.1E+00
	Molybdenum	µg/l	5	7	3.0E+00	3.0E+01	6.9E+01	9.6E+01
	Nickel	µg/l	1	7	3.4E+01	3.4E+01	3.4E+01	
	Nitrate, as Nitrogen	mg/l	8	8	5.0E-01	4.7E+00	1.5E+01	1.5E+01
	Nitrite, as Nitrogen	mg/l	1	1	9.2E-01	9.2E-01	9.2E-01	
	pH		7	7	6.7E+00		8.3E+00	
	Phoisphate	mg/l	6	6	2.0E-01	2.6E+00	6.9E+00	7.8E+00
	Phosphate	mg/l	1	1	5.7E+00	5.7E+00	5.7E+00	

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Intermediate Perched Groundwater Los Alamos (cont.)	Plutonium-238	pCi/l	4	7	1.2E-02	1.7E-02	3.0E-02	3.4E-02
	Plutonium-239, Plutonium-240	pCi/l	6	7	1.4E-02	5.6E-02	1.4E-01	1.5E-01
	Potassium	mg/l	6	6	4.0E+00	8.0E+00	1.2E+01	1.4E+01
	Silica	mg/l	8	8	3.9E+01	5.8E+01	8.1E+01	8.5E+01
	Silver	µg/l	1	7	1.0E+00	1.0E+00	1.0E+00	
	Sodium	mg/l	7	7	2.7E+01	4.2E+01	6.7E+01	7.1E+01
	Strontium	µg/l	7	7	6.0E+01	1.4E+02	2.0E+02	2.5E+02
	Strontium-90	pCi/l	5	6	4.0E-01	4.6E+00	2.1E+01	2.3E+01
	Sulfate	mg/l	7	7	8.0E+00	1.9E+01	3.4E+01	3.7E+01
	Thallium	µg/l	2	7	4.0E-02	2.2E-01	4.0E-01	7.3E-01
	Total Dissolved Solids	mg/l	7	7	2.4E+02	3.1E+02	3.8E+02	4.1E+02
	Total Suspended Solids	mg/l	2	2	3.7E+00	1.7E+01	3.0E+01	5.4E+01
	Tritium	nCi/l	6	7	2.0E-01	6.8E-01	2.0E+00	2.1E+00
	Uranium	µg/l	7	7	5.9E-01	1.3E+00	3.3E+00	3.4E+00
	Vanadium	µg/l	7	7	7.0E+00	1.5E+01	3.0E+01	3.1E+01
	Zinc	µg/l	4	7	1.0E+01	3.6E+01	8.2E+01	9.9E+01
Pueblo	Aluminum	µg/l	3	12	4.0E+01	1.0E+02	2.3E+02	3.2E+02
	Americium-241	pCi/l	5	7	1.1E-02	3.5E-02	6.5E-02	8.8E-02
	Antimony	µg/l	3	12	1.0E-01	4.5E+01	1.3E+02	2.0E+02
	Arsenic	µg/l	4	12	2.0E+00	4.4E+00	7.0E+00	9.0E+00
	Barium	µg/l	8	10	3.0E+01	4.7E+01	8.2E+01	8.6E+01
	Bicarbonate	mg/l	12	12	6.8E+01	1.0E+02	1.6E+02	1.6E+02
	Boron	µg/l	11	12	3.0E+01	1.5E+02	2.3E+02	2.8E+02

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Cadmium	µg/l	3	12	4.0E-01	5.9E+00	1.0E+01	1.6E+01
	Calcium	mg/l	12	12	1.0E+01	2.8E+01	3.8E+01	4.7E+01
	Cesium-137	pCi/l	8	12	3.2E-01	1.0E+01	5.6E+01	4.9E+01
	Chlorine	mg/l	12	12	4.6E+00	3.7E+01	6.0E+01	6.9E+01
	Chromium	µg/l	2	12	1.6E+00	4.0E+00	6.4E+00	1.1E+01
	Cobalt	µg/l	1	12	9.0E+00	9.0E+00	9.0E+00	
	Copper	µg/l	4	12	8.0E+00	3.3E+01	5.5E+01	7.7E+01
	Fluorine	mg/l	12	12	2.0E-01	4.9E-01	9.0E-01	1.0E+00
	Gross Alpha	pCi/l	4	12	1.0E+00	1.5E+00	2.0E+00	2.7E+00
	Gross Beta	pCi/l	12	12	1.2E+00	5.2E+00	9.0E+00	1.0E+01
	Gross Gamma	pCi/l	9	12	1.0E+01	1.0E+02	2.4E+02	2.4E+02
	Hardness	mg/l	12	12	3.3E+01	9.6E+01	1.2E+02	1.6E+02
	Iron	µg/l	12	12	4.5E+02	7.9E+03	5.7E+04	4.1E+04
	Lead	µg/l	10	14	4.6E+00	3.6E+01	9.1E+01	1.1E+02
	Lithium	mg/l	2	2	1.3E-02	2.4E-02	3.5E-02	5.5E-02
	Magnesium	mg/l	12	12	1.8E+00	6.7E+00	8.6E+00	1.0E+01
	Manganese	µg/l	12	12	5.6E+01	1.2E+02	2.0E+02	2.1E+02
	Mercury	µg/l	3	12	2.0E-01	3.7E-01	7.0E-01	9.4E-01
	Molybdenum	µg/l	5	12	5.0E+00	8.8E+00	1.5E+01	1.6E+01
	Nickel	µg/l	2	12	2.0E+01	3.1E+01	4.1E+01	6.0E+01
	Nitrate, as Nitrogen	mg/l	10	12	9.0E-02	6.0E+00	1.9E+01	1.8E+01
	pH		6	6	7.1E+00		8.6E+00	
	Phosphate, as Phosphorous	mg/l	9	10	1.0E-01	1.2E+00	4.1E+00	4.1E+00
	Plutonium-238	pCi/l	5	15	3.0E-03	8.2E-03	1.9E-02	2.1E-02

TABLE C–7.—*Groundwater Detection Statistics by Watershed and by Analyte (Environmental Surveillance Report Data 1991 to 1996)*-Continued

GROUNDWATER REGIME[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Pueblo (cont.)	Plutonium-239, Plutonium-240	pCi/l	9	15	7.0E-03	1.6E-01	1.3E+00	1.0E+00
	Potassium	mg/l	11	12	1.6E+00	4.9E+00	9.6E+00	9.7E+00
	Selenium	µg/l	1	12	2.0E+00	2.0E+00	2.0E+00	
	Silica	mg/l	11	12	7.0E+00	4.3E+01	6.8E+01	8.3E+01
	Sodium	mg/l	12	12	1.8E+01	4.3E+01	8.8E+01	8.6E+01
	Strontium	µg/l	11	12	3.3E+01	1.5E+02	2.1E+02	2.7E+02
	Strontium-90	pCi/l	5	8	1.0E-01	4.6E-01	7.0E-01	9.6E-01
	Sulfate	mg/l	11	12	7.3E+00	2.2E+01	3.1E+01	3.6E+01
	Thallium	µg/l	2	12	1.0E-01	6.0E-01	1.1E+00	2.0E+00
	Tin	µg/l	1	10	7.0E+01	7.0E+01	7.0E+01	
	Total Dissolved Solids	mg/l	10	12	1.8E+02	2.6E+02	3.3E+02	3.7E+02
	Total Suspended Solids	mg/l	2	4	7.6E+00	9.3E+00	1.1E+01	1.4E+01
	Tritium	nCi/l	12	12	1.8E-01	1.2E+00	3.1E+00	3.7E+00
	Uranium	µg/l	10	12	8.0E-02	3.7E-01	8.0E-01	8.0E-01
	Vanadium	µg/l	3	12	2.0E+00	6.0E+00	1.1E+01	1.5E+01
	Zinc	µg/l	11	12	1.4E+02	3.0E+03	9.5E+03	9.3E+03

[a] Groundwater regime designations are in accordance with the Environmental Surveillance Program.
[b] pCi/l is picocuries of radioactive analyte per liter of sample, nCi/l is nanocuries of radioactive analyte per liter, µg/l is micrograms of analyte per liter of sample, mg/l is milligrams of analyte per liter of sample, NTU is nephelometric turbidity units.
[c] Upper confidence limit (UCL) not calculated when the number of detected analyses equals 1.

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Acid Canyon (Part of Pueblo/ Acid Canyon)	Acenaphthene	mg/kg	1	26	1.8E+00	1.8E+00	1.8E+00	
	Acetone	mg/kg	2	3	3.4E-02	4.0E-02	4.5E-02	5.1E-02
	Anthracene	mg/kg	1	26	2.2E+00	2.2E+00	2.2E+00	
	Benzo(a)anthracene	mg/kg	1	26	2.5E+00	2.5E+00	2.5E+00	
	Benzo(a)pyrene	mg/kg	1	26	2.6E+00	2.6E+00	2.6E+00	
	Benzo(b)fluoranthene	mg/kg	2	26	3.6E-01	1.5E+00	2.7E+00	3.9E+00
	Benzo(g,h,i)perylene	mg/kg	1	26	1.3E+00	1.3E+00	1.3E+00	
	Benzo(k)fluoranthene	mg/kg	1	26	1.0E+00	1.0E+00	1.0E+00	
	Chlordane[alpha-]	mg/kg	1	2	5.0E-03	5.0E-03	5.0E-03	
	Chlordane[gamma-]	mg/kg	1	2	6.6E-03	6.6E-03	6.6E-03	
	Chrysene	mg/kg	1	26	2.3E+00	2.3E+00	2.3E+00	
	DDT[4,4’-]	mg/kg	1	2	2.2E-02	2.2E-02	2.2E-02	
	Dibenzofuran	mg/kg	1	26	1.6E+00	1.6E+00	1.6E+00	
	Dieldrin	mg/kg	1	2	4.7E-03	4.7E-03	4.7E-03	
	Fluoranthene	mg/kg	1	26	5.2E+00	5.2E+00	5.2E+00	
	Fluorene	mg/kg	1	26	2.7E+00	2.7E+00	2.7E+00	
	Indeno(1,2,3-cd) pyrene	mg/kg	1	26	1.2E+00	1.2E+00	1.2E+00	
	Methylene Chloride	mg/kg	1	3	7.0E-03	7.0E-03	7.0E-03	
	Methylnaphthalene[2-]	mg/kg	1	26	2.3E+00	2.3E+00	2.3E+00	
	Naphthalene	mg/kg	1	29	8.5E+00	8.5E+00	8.5E+00	
	Phenanthrene	mg/kg	1	26	7.6E+00	7.6E+00	7.6E+00	
	Pyrene	mg/kg	4	26	3.8E-01	1.5E+00	4.7E+00	3.7E+00
Ancho Canyon	Acenaphthene	mg/kg	12	279	3.3E-02	2.7E+00	1.0E+01	4.5E+00
	Amino-2,6-dinitrotoluene[4-]	mg/kg	3	242	9.7E-02	2.4E-01	4.5E-01	4.6E-01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ancho Canyon (Cont.)	Amino-4,6-dinitrotoluene[2-]	mg/kg	2	242	4.3E-01	4.9E-01	5.5E-01	6.2E-01
	Anthracene	mg/kg	16	279	6.6E-02	3.4E+00	1.6E+01	5.7E+00
	Aroclor-1016	mg/kg	4	96	1.8E-01	3.1E-01	7.0E-01	5.7E-01
	Aroclor-1221	mg/kg	4	96	3.5E-01	6.2E-01	1.4E+00	1.1E+00
	Aroclor-1232	mg/kg	4	96	1.8E-01	3.1E-01	7.0E-01	5.7E-01
	Aroclor-1242	mg/kg	14	144	1.8E-01	2.3E+02	3.1E+03	6.7E+02
	Aroclor-1248	mg/kg	13	96	3.6E-02	2.0E+00	2.1E+01	5.1E+00
	Aroclor-1254	mg/kg	32	144	3.7E-02	1.5E+00	2.2E+01	3.1E+00
	Aroclor-1260	mg/kg	14	144	3.6E-02	1.5E+00	7.4E+00	2.5E+00
	Aroclors (Mixed)	mg/kg	16	64	3.7E-02	2.0E+02	3.1E+03	5.9E+02
	Benzo(a)anthracene	mg/kg	19	279	2.3E-01	6.1E+00	3.2E+01	1.0E+01
	Benzo(a)pyrene	mg/kg	21	279	1.6E-01	5.8E+00	2.9E+01	9.2E+00
	Benzo(b)fluoranthene	mg/kg	23	279	2.0E-01	5.7E+00	3.5E+01	9.5E+00
	Benzo(g,h,i)perylene	mg/kg	22	279	1.3E-01	2.2E+00	9.6E+00	3.4E+00
	Benzo(k)fluoranthene	mg/kg	21	279	2.0E-01	2.7E+00	1.1E+01	3.9E+00
	Benzoic Acid	mg/kg	5	279	4.9E-02	5.7E-01	1.1E+00	9.3E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	21	279	3.8E-02	5.4E-01	1.7E+00	7.4E-01
	Butylbenzylphthalate	mg/kg	1	279	2.2E-01	2.2E-01	2.2E-01	
	Chrysene	mg/kg	23	279	1.8E-01	5.7E+00	3.3E+01	9.5E+00
	DDD[4,4'-]	mg/kg	1	42	1.1E-02	1.1E-02	1.1E-02	
	DDE[4,4'-]	mg/kg	1	42	7.9E-02	7.9E-02	7.9E-02	
	DDT[4,4'-]	mg/kg	2	42	5.5E-03	1.0E-02	1.5E-02	2.0E-02
	Di-n-butylphthalate	mg/kg	26	279	3.6E-02	2.4E+00	1.3E+01	3.9E+00
	Di-n-octylphthalate	mg/kg	1	279	4.5E+00	4.5E+00	4.5E+00	
	Dibenz(a,h)anthracene	mg/kg	7	279	3.3E-02	2.0E+00	4.0E+00	3.3E+00
	Dibenzofuran	mg/kg	8	279	4.1E-01	1.8E+00	5.6E+00	3.0E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ancho Canyon (Cont.)	Fluorene	mg/kg	12	279	3.6E-01	2.8E+00	1.0E+01	4.7E+00
	HMX	mg/kg	4	242	1.3E+00	1.2E+01	2.5E+01	2.3E+01
	Indeno(1,2,3-cd) pyrene	mg/kg	20	279	1.3E-01	3.9E+00	1.7E+01	6.4E+00
	Methylnaphthalene[2-]	mg/kg	5	279	4.0E-01	7.5E-01	1.1E+00	1.0E+00
	Naphthalene	mg/kg	10	279	1.7E-01	2.7E+00	8.4E+00	4.4E+00
	Nitrotoluene[2-]	mg/kg	3	242	7.9E-01	1.4E+00	1.9E+00	2.1E+00
	Nitrotoluene[3-]	mg/kg	3	242	6.0E-01	2.0E+00	4.8E+00	4.8E+00
	Nitrotoluene[4-]	mg/kg	2	242	3.2E+00	4.3E+00	5.4E+00	6.5E+00
	Phenanthrene	mg/kg	21	279	3.0E-01	1.4E+01	7.9E+01	2.4E+01
	Pyrene	mg/kg	23	279	4.3E-01	1.2E+01	7.3E+01	2.0E+01
	RDX	mg/kg	1	242	9.2E+00	9.2E+00	9.2E+00	9.2E+00
	Tetryl	mg/kg	3	242	3.5E-01	9.7E-01	2.0E+00	2.0E+00
	Trinitrobenzene[1,3,5-]	mg/kg	3	242	3.1E-01	3.1E+00	8.0E+00	8.0E+00
	Trinitrotoluene[2,4,6-]	mg/kg	1	242	1.0E+00	1.0E+00	1.0E+00	
Barrancas Canyon	Amino-2,6-dinitrotoluene[4-]	mg/kg	1	8	1.6E-01	1.6E-01	1.6E-01	
	Dinitrotoluene[2,6-]	mg/kg	1	8	7.9E-01	7.9E-01	7.9E-01	
	HMX	mg/kg	1	8	1.6E+00	1.6E+00	1.6E+00	
	Nitrobenzene	mg/kg	2	8	1.0E-01	1.3E-01	1.5E-01	1.8E-01
	Nitrotoluene[2-]	mg/kg	1	8	2.1E-01	2.1E-01	2.1E-01	
	Nitrotoluene[3-]	mg/kg	1	8	4.4E-01	4.4E-01	4.4E-01	
	Nitrotoluene[4-]	mg/kg	1	8	4.7E-01	4.7E-01	4.7E-01	
Bayo Canyon	Nitrobenzene	mg/kg	1	36	9.8E-02	9.8E-02	9.8E-02	
	Nitrotoluene[3-]	mg/kg	2	28	2.1E-01	2.1E-01	2.1E-01	2.1E-01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Cañada del Buey	Acenaphthene	mg/kg	10	172	4.5E-01	2.6E+00	7.8E+00	4.4E+00
	Acenaphthylene	mg/kg	3	172	6.3E-01	1.9E+00	2.8E+00	3.2E+00
	Acetone	mg/kg	2	80	4.1E-02	2.3E-01	4.2E-01	6.1E-01
	Aldrin	mg/kg	1	74	4.9E-02	4.9E-02	4.9E-02	
	Anthracene	mg/kg	16	172	4.1E-01	2.4E+00	1.3E+01	4.1E+00
	Aroclor-1254	mg/kg	10	159	7.0E-02	4.6E+00	2.2E+01	1.0E+01
	Aroclor-1260	mg/kg	4	159	4.3E-02	1.7E-01	3.7E-01	3.2E-01
	Aroclors (Mixed)	mg/kg	2	85	7.0E-02	1.1E+01	2.2E+01	3.2E+01
	BHC[alpha-]	mg/kg	1	74	4.0E-03	4.0E-03	4.0E-03	
	BHC[delta-]	mg/kg	1	74	1.6E-01	1.6E-01	1.6E-01	
	BHC[gamma-]	mg/kg	3	74	2.8E-03	3.1E-02	8.2E-02	8.2E-02
	Benzo(a)anthracene	mg/kg	36	172	3.6E-01	2.4E+00	1.7E+01	3.6E+00
	Benzo(a)pyrene	mg/kg	33	172	4.7E-01	2.3E+00	1.6E+01	3.3E+00
	Benzo(b)fluoranthene	mg/kg	38	172	4.1E-01	3.3E+00	2.1E+01	4.8E+00
	Benzo(g,h,i)perylene	mg/kg	16	172	4.3E-01	1.9E+00	1.1E+01	3.2E+00
	Benzo(k)fluoranthene	mg/kg	22	172	4.1E-01	2.9E+00	2.8E+01	5.4E+00
	Bis(2-ethylhexyl) phthalate	mg/kg	24	172	3.7E-01	1.4E+00	4.4E+00	1.8E+00
	Butylbenzylphthalate	mg/kg	4	172	4.3E-01	1.1E+00	2.9E+00	2.3E+00
	Chrysene	mg/kg	40	172	3.6E-01	2.8E+00	2.6E+01	4.5E+00
	DDD[4,4'-]	mg/kg	2	74	4.5E-03	1.3E-02	2.1E-02	2.9E-02
	DDE[4,4'-]	mg/kg	6	74	6.2E-03	2.4E-02	8.4E-02	4.9E-02
	DDT[4,4'-]	mg/kg	8	74	6.1E-03	1.5E-02	4.9E-02	2.5E-02
	Di-n-butylphthalate	mg/kg	6	172	4.4E-01	1.1E+00	1.8E+00	1.6E+00
	Di-n-octylphthalate	mg/kg	1	172	7.4E-01	7.4E-01	7.4E-01	
	Dibenz(a,h)anthracene	mg/kg	5	172	4.5E-01	1.9E+00	4.8E+00	3.6E+00
	Dibenzofuran	mg/kg	7	172	4.5E-01	3.2E+00	1.2E+01	6.4E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Cañada del Buey (Cont.)	Dieldrin	mg/kg	15	75	7.9E-04	1.2E-02	1.1E-01	2.6E-02
	Endosulfan II	mg/kg	9	74	2.5E-03	9.2E-03	2.1E-02	1.4E-02
	Endosulfan Sulfate	mg/kg	2	75	1.8E-03	1.9E-03	2.0E-03	2.1E-03
	Endrin	mg/kg	6	74	2.3E-03	1.1E-02	2.7E-02	1.8E-02
	Endrin Aldehyde	mg/kg	6	74	3.1E-03	3.9E-02	1.8E-01	9.5E-02
	Fluoranthene	mg/kg	52	172	3.7E-01	6.3E+00	7.4E+01	1.0E+01
	Fluorene	mg/kg	8	172	4.7E-01	3.5E+00	1.1E+01	6.4E+00
	Heptachlor	mg/kg	1	75	2.8E-02	2.8E-02	2.8E-02	
	Heptachlor Epoxide	mg/kg	6	75	3.0E-03	6.8E-03	1.5E-02	1.0E-02
	Indeno(1,2,3-cd)pyrene	mg/kg	20	172	3.6E-01	2.0E+00	1.1E+01	3.4E+00
	Isopropyltoluene[4-]	mg/kg	1	80	3.5E-02	3.5E-02	3.5E-02	
	Methoxychlor[4,4’-]	mg/kg	7	75	2.6E-02	4.0E+01	2.8E+02	1.2E+02
	Methylene Chloride	mg/kg	7	80	6.8E-03	1.4E-02	5.1E-02	2.7E-02
	Methylnaphthalene[2-]	mg/kg	4	172	4.3E-01	3.8E+00	9.8E+00	7.9E+00
	Methylphenol[4-]	mg/kg	2	172	5.4E-01	8.7E-01	1.2E+00	1.5E+00
	Naphthalene	mg/kg	8	179	4.7E-01	8.0E+00	3.9E+01	1.7E+01
	Phenanthrene	mg/kg	44	172	3.8E-01	6.8E+00	8.3E+01	1.2E+01
	Phenol	mg/kg	1	172	5.6E-01	5.6E-01	5.6E-01	
	Pyrene	mg/kg	49	172	3.8E-01	5.8E+00	6.2E+01	9.0E+00
	Trichloro-1,2,2-trifluoroethane[1,1,2-]	mg/kg	2	80	6.0E-03	1.5E+00	3.0E+00	4.5E+00
	Trichloroethane[1,1,1-]	mg/kg	2	80	7.0E-03	1.1E+01	2.1E+01	3.1E+01
	Trichloroethene	mg/kg	2	80	2.1E-02	6.6E-01	1.3E+00	1.9E+00
	Trichlorofluoromethane	mg/kg	1	80	6.0E-03	6.0E-03	6.0E-03	
Chaquehui Canyon	Acenaphthene	mg/kg	20	235	4.5E-02	1.2E+00	1.3E+01	2.5E+00
	Acenaphthylene	mg/kg	1	235	4.9E-01	4.9E-01	4.9E-01	
	Aldrin	mg/kg	2	34	2.9E-02	3.6E-02	4.2E-02	4.9E-02

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Chaquehui Canyon (Cont.)	Amino-2,6-dinitrotoluene[4-]	mg/kg	3	92	3.6E-01	2.1E+00	5.4E+00	5.4E+00
	Amino-4,6-dinitrotoluene[2-]	mg/kg	3	98	3.6E-01	2.1E+00	5.4E+00	5.4E+00
	Aniline	mg/kg	1	193	4.1E-01	4.1E-01	4.1E-01	
	Anthracene	mg/kg	24	235	1.8E-01	1.7E+00	1.9E+01	3.2E+00
	Aroclor-1016	mg/kg	4	41	3.4E-02	1.5E+00	3.6E+00	3.1E+00
	Aroclor-1221	mg/kg	4	41	6.7E-02	3.1E+00	7.2E+00	6.2E+00
	Aroclor-1232	mg/kg	4	41	3.4E-02	1.5E+00	3.6E+00	3.1E+00
	Aroclor-1242	mg/kg	4	45	3.4E-02	1.5E+00	3.6E+00	3.1E+00
	Aroclor-1248	mg/kg	4	41	3.4E-02	1.5E+00	3.6E+00	3.1E+00
	Aroclor-1254	mg/kg	21	48	3.4E-02	9.1E-01	3.6E+00	1.3E+00
	Aroclor-1260	mg/kg	12	48	7.0E-02	2.7E+00	1.1E+01	4.7E+00
	Aroclors (Mixed)	mg/kg	8	19	1.0E-01	8.2E-01	2.3E+00	1.4E+00
	Azobenzene	mg/kg	1	193	4.3E-01	4.3E-01	4.3E-01	
	BHC[alpha-]	mg/kg	2	34	2.7E-02	3.4E-02	4.1E-02	4.8E-02
	BHC[beta-]	mg/kg	2	34	2.3E-03	2.4E-03	2.4E-03	2.5E-03
	BHC[delta-]	mg/kg	2	34	2.6E-02	3.2E-02	3.7E-02	4.3E-02
	Benzo(a)anthracene	mg/kg	42	235	5.2E-02	2.0E+00	2.7E+01	3.3E+00
	Benzo(a)pyrene	mg/kg	37	235	7.4E-02	2.2E+00	2.9E+01	3.8E+00
	Benzo(b)fluoranthene	mg/kg	43	235	6.4E-02	2.4E+00	2.8E+01	3.8E+00
	Benzo(g,h,i)perylene	mg/kg	27	235	5.5E-02	1.3E+00	1.3E+01	2.3E+00
	Benzo(k)fluoranthene	mg/kg	30	230	6.3E-02	2.5E+00	2.1E+01	4.0E+00
	Benzoic Acid	mg/kg	2	235	2.0E-01	2.1E-01	2.2E-01	2.3E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	15	235	4.5E-02	9.9E-01	3.2E+00	1.4E+00
	Butylbenzylphthalate	mg/kg	4	235	4.4E-01	6.9E-01	9.8E-01	9.3E-01
	Carbazole	mg/kg	5	16	1.9E-01	1.0E+00	3.0E+00	2.0E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Chaquehui Canyon (Cont.)	Chrysene	mg/kg	46	235	6.4E-02	2.0E+00	2.9E+01	3.4E+00
	DDD[4,4'-]	mg/kg	2	34	7.5E-03	9.8E-03	1.2E-02	1.4E-02
	DDE[4,4'-]	mg/kg	6	34	1.4E-03	1.9E-03	2.4E-03	2.2E-03
	DDT[4,4'-]	mg/kg	6	34	4.4E-03	1.0E-02	2.3E-02	1.6E-02
	D[2,4-]	mg/kg	2	51	1.9E+00	2.1E+00	2.3E+00	2.5E+00
	Di-n-butylphthalate	mg/kg	21	235	3.4E-02	1.2E+00	4.8E+00	1.9E+00
	Dibenz(a,h)anthracene	mg/kg	8	235	8.3E-02	9.3E-01	4.7E+00	2.0E+00
	Dibenzofuran	mg/kg	9	235	4.6E-02	9.7E-01	5.6E+00	2.1E+00
	Dichlorobenzene[1,4-]	mg/kg	1	238	1.8E-01	1.8E-01	1.8E-01	
	Dieldrin	mg/kg	2	34	7.0E-04	7.7E-04	8.3E-04	9.0E-04
	Diethylphthalate	mg/kg	1	235	3.0E+01	3.0E+01	3.0E+01	
	Dimethylphenol[2,4-]	mg/kg	1	235	7.0E-01	7.0E-01	7.0E-01	
	Dinitrotoluene[2,4-]	mg/kg	1	364	2.0E+00	2.0E+00	2.0E+00	
	Dinoseb	mg/kg	1	51	6.9E-01	6.9E-01	6.9E-01	
	Endosulfan I	mg/kg	1	34	6.1E-03	6.1E-03	6.1E-03	
	Endosulfan II	mg/kg	6	34	2.0E-03	4.4E-03	1.1E-02	7.2E-03
	Endosulfan Sulfate	mg/kg	1	34	1.8E-02	1.8E-02	1.8E-02	
	Endrin	mg/kg	2	34	2.3E-03	2.5E-03	2.7E-03	2.9E-03
	Endrin Aldehyde	mg/kg	1	26	8.7E-03	8.7E-03	8.7E-03	
	Fluoranthene	mg/kg	63	235	4.2E-02	2.7E+00	5.4E+01	4.5E+00
	Fluorene	mg/kg	14	235	8.8E-02	1.6E+00	1.5E+01	3.7E+00
	Indeno(1,2,3-cd)pyrene	mg/kg	30	235	5.0E-02	1.4E+00	1.4E+01	2.4E+00
	Methylene Chloride	mg/kg	2	3	4.2E-03	4.6E-03	5.0E-03	5.4E-03
	Methylnaphthalene[2-]	mg/kg	4	235	4.9E-02	2.6E+00	9.3E+00	7.1E+00
	Methylphenol[2-]	mg/kg	1	235	3.7E-01	3.7E-01	3.7E-01	
	Methylphenol[4-]	mg/kg	1	235	9.8E-01	9.8E-01	9.8E-01	
	Naphthalene	mg/kg	14	237	6.0E-02	2.6E+00	2.7E+01	6.3E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Chaquehui Canyon (Cont.)	Nitrobenzene	mg/kg	2	364	2.5E-01	3.8E-01	5.1E-01	6.4E-01
	Nitrotoluene[2-]	mg/kg	1	123	1.6E-01	1.6E-01	1.6E-01	
	Nitrotoluene[3-]	mg/kg	1	123	5.1E-01	5.1E-01	5.1E-01	
	Nitrotoluene[4-]	mg/kg	1	123	5.1E-01	5.1E-01	5.1E-01	
	Phenanthrene	mg/kg	49	235	6.4E-02	3.5E+00	6.7E+01	6.3E+00
	Pyrene	mg/kg	68	235	1.1E-01	3.3E+00	5.1E+01	5.3E+00
	Pyridine	mg/kg	1	16	1.6E+00	1.6E+00	1.6E+00	
	RDX	mg/kg	2	129	5.0E-01	5.2E-01	5.4E-01	5.6E-01
	Tetryl	mg/kg	1	129	6.9E-01	6.9E-01	6.9E-01	
	Trinitrobenzene[1,3,5-]	mg/kg	1	129	1.7E-01	1.7E-01	1.7E-01	
	Trinitrotoluene[2,4,6-]	mg/kg	1	129	2.7E-01	2.7E-01	2.7E-01	
DP Canyon (Part of Los Alamos Canyon)	Acenaphthene	mg/kg	6	665	3.5E-01	2.5E+00	1.1E+01	5.9E+00
	Acenaphthylene	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Acetone	mg/kg	46	223	6.3E-03	3.2E-02	2.1E-01	4.1E-02
	Anthracene	mg/kg	7	665	3.4E-01	3.6E+00	2.1E+01	9.4E+00
	Aroclor-1254	mg/kg	1	36	1.1E+00	1.1E+00	1.1E+00	
	Aroclor-1260	mg/kg	19	36	7.0E-02	1.7E+00	1.7E+01	3.4E+00
	Aroclors (Mixed)	mg/kg	18	26	7.0E-02	1.8E+00	1.7E+01	3.6E+00
	Benzene	mg/kg	1	223	3.0E+00	3.0E+00	3.0E+00	
	Benzo(a)anthracene	mg/kg	21	665	4.4E-02	5.5E+00	9.8E+01	1.5E+01
	Benzo(a)pyrene	mg/kg	16	665	2.2E-01	5.6E+00	7.4E+01	1.5E+01
	Benzo(b)fluoranthene	mg/kg	35	665	9.2E-02	3.0E+00	7.6E+01	7.3E+00
	Benzo(g,h,i)perylene	mg/kg	9	664	1.4E-01	4.7E+00	3.7E+01	1.3E+01
	Benzo(k)fluoranthene	mg/kg	12	664	5.3E-02	6.3E+00	6.6E+01	1.7E+01
	Benzoic Acid	mg/kg	5	665	3.6E-01	2.1E+00	3.7E+00	3.2E+00
	Benzyl Alcohol	mg/kg	1	665	7.0E-01	7.0E-01	7.0E-01	
	Bis(2-chloroethoxy) methane	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Bis(2-chloroethyl)ether	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Bis(2-ethylhexyl) phthalate	mg/kg	29	665	6.4E-02	4.2E+00	6.2E+01	8.5E+00
	Bromophenyl-phenylether[4-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Butanone[2-]	mg/kg	1	223	6.3E-02	6.3E-02	6.3E-02	
	Butylbenzylphthalate	mg/kg	2	665	3.5E-01	4.3E-01	5.0E-01	5.8E-01
	Carbazole	mg/kg	1	6	3.5E-01	3.5E-01	3.5E-01	
	Carbon Disulfide	mg/kg	2	223	9.2E-03	1.1E-02	1.2E-02	1.3E-02
	Chloro-3-methylphenol [4-]	mg/kg	2	664	7.0E-01	1.8E+00	2.9E+00	4.0E+00
	Chloroaniline[4-]	mg/kg	1	665	7.0E-01	7.0E-01	7.0E-01	
	Chlorobenzene	mg/kg	1	223	2.5E+00	2.5E+00	2.5E+00	
	Chloronaphthalene[1-]	mg/kg	1	6	7.0E-01	7.0E-01	7.0E-01	
	Chloronaphthalene[2-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Chlorophenol[2-]	mg/kg	2	665	3.5E-01	1.4E+00	2.5E+00	3.6E+00
	Chlorophenyl-phenyl [4-] Ether	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Chrysene	mg/kg	24	664	9.3E-02	5.5E+00	1.1E+02	1.5E+01
	DDT[4,4’-]	mg/kg	1	2	2.0E-02	2.0E-02	2.0E-02	
	Di-n-butylphthalate	mg/kg	12	665	5.8E-02	1.0E+00	5.2E+00	1.9E+00
	Di-n-octylphthalate	mg/kg	2	665	3.5E-01	4.6E-01	5.6E-01	6.7E-01
	Dibenz(a,h)anthracene	mg/kg	3	665	3.5E-01	5.7E+00	1.6E+01	1.6E+01
	Dibenzofuran	mg/kg	2	665	3.5E-01	3.1E+00	5.8E+00	8.5E+00
	Dichlorobenzene[1,2-]	mg/kg	1	882	3.5E-01	3.5E-01	3.5E-01	
	Dichlorobenzene[1,3-]	mg/kg	1	881	3.5E-01	3.5E-01	3.5E-01	
	Dichlorobenzene[1,4-]	mg/kg	2	881	3.5E-01	8.8E-01	1.4E+00	1.9E+00
	Dichlorobenzidine [3,3’-]	mg/kg	1	665	7.0E-01	7.0E-01	7.0E-01	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Dichlorodifluoro methane	mg/kg	2	216	3.4E-02	3.6E-02	3.8E-02	4.0E-02
	Dichloroethene[1,1-]	mg/kg	1	222	2.9E+00	2.9E+00	2.9E+00	
	Dichlorophenol[2,4-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Diethylphthalate	mg/kg	4	665	3.5E-01	2.5E+01	9.0E+01	6.8E+01
	Dimethyl Phthalate	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Dimethylphenol[2,4-]	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	
	Dinitro-2-methylphenol [4,6-]	mg/kg	1	665	1.7E+00	1.7E+00	1.7E+00	
	Dinitrophenol[2,4-]	mg/kg	1	665	1.7E+00	1.7E+00	1.7E+00	
	Dinitrotoluene[2,4-]	mg/kg	2	664	3.5E-01	1.0E+00	1.7E+00	2.4E+00
	Dinitrotoluene[2,6-]	mg/kg	1	658	3.5E-01	3.5E-01	3.5E-01	
	Diphenylamine	mg/kg	1	6	1.1E+00	1.1E+00	1.1E+00	
	Diphenylhydrazine [1,2-]	mg/kg	1	6	1.7E+00	1.7E+00	1.7E+00	
	Fluoranthene	mg/kg	41	664	3.4E-01	9.1E+00	3.2E+02	2.5E+01
	Fluorene	mg/kg	4	665	3.5E-01	3.1E+00	1.1E+01	8.4E+00
	Hexachlorobenzene	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Hexachlorobutadiene	mg/kg	1	730	3.5E-01	3.5E-01	3.5E-01	
	Hexachlorocyclopenta diene	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	
	Hexachloroethane	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	
	Indeno(1,2,3-cd) pyrene”	mg/kg	11	665	1.1E-01	4.0E+00	3.8E+01	1.1E+01
	Isophorone	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	
	Isopropyltoluene[4-]	mg/kg	4	217	9.0E-03	1.4E-02	2.5E-02	2.1E-02
	Methylene Chloride	mg/kg	8	223	4.7E-03	1.6E-02	5.9E-02	2.8E-02
	Methylnaphthalene[2-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	3.5E-01
	Methylphenol[2-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Methylphenol[3-]	mg/kg	1	6	3.5E-01	3.5E-01	3.5E-01	
	Methylphenol[4-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Naphthalene	mg/kg	2	730	3.5E-01	4.0E-01	4.4E-01	4.9E-01
	Nitroaniline[2-]	mg/kg	1	665	1.7E+00	1.7E+00	1.7E+00	
	Nitroaniline[3-]	mg/kg	1	665	1.7E+00	1.7E+00	1.7E+00	
	Nitroaniline[4-]	mg/kg	1	665	1.7E+00	1.7E+00	1.7E+00	
	Nitrobenzene	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	
	Nitrophenol[2-]	mg/kg	1	664	3.5E-01	3.5E-01	3.5E-01	
	Nitrophenol[4-]	mg/kg	2	664	1.7E+00	2.4E+00	3.1E+00	3.8E+00
	Nitroso-di-n-propylamine[N-]	mg/kg	2	665	3.5E-01	9.3E-01	1.5E+00	2.1E+00
	Nitrosodimethylamine [N-]	mg/kg	1	567	3.5E-01	3.5E-01	3.5E-01	
	Nitrosodiphenylamine [N-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Oxybis(1-chloro propane)[2,2’-]	mg/kg	1	655	3.5E-01	3.5E-01	3.5E-01	
	Pentachlorophenol	mg/kg	2	664	1.7E+00	2.8E+00	3.9E+00	5.0E+00
	Phenanthrene	mg/kg	29	664	5.0E-02	6.7E+00	1.6E+02	1.8E+01
	Phenol	mg/kg	5	665	3.5E-01	1.2E+00	2.6E+00	1.9E+00
	Pyrene	mg/kg	45	665	7.4E-02	6.3E+00	2.3E+02	1.6E+01
	Tetrachloroethene	mg/kg	1	222	6.1E-02	6.1E-02	6.1E-02	
	Toluene	mg/kg	39	223	5.0E-03	8.9E-02	2.6E+00	2.2E-01
	Trichlorobenzene [1,2,4-]	mg/kg	2	730	3.5E-01	9.3E-01	1.5E+00	2.1E+00
	Trichloroethene	mg/kg	1	223	2.4E+00	2.4E+00	2.4E+00	
	Trichlorofluoromethane	mg/kg	4	216	1.1E-02	1.7E-02	2.6E-02	2.4E-02

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Trichlorophenol[2,4,5-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Trichlorophenol[2,4,6-]	mg/kg	1	665	3.5E-01	3.5E-01	3.5E-01	
	Xylene (Total)	mg/kg	5	222	6.0E-03	1.5E-02	2.1E-02	2.1E-02
Los Alamos Canyon	Acenaphthene	mg/kg	6	259	6.1E-01	1.9E+00	4.6E+00	3.4E+00
	Acetone	mg/kg	1	7	2.5E-02	2.5E-02	2.5E-02	
	Aniline	mg/kg	2	257	4.0E-01	6.6E-01	9.1E-01	1.2E+00
	Anthracene	mg/kg	8	259	6.1E-01	3.5E+00	1.2E+01	6.5E+00
	Aroclor-1254	mg/kg	5	37	1.6E-01	5.8E-01	1.3E+00	9.7E-01
	Aroclor-1260	mg/kg	10	37	7.6E-02	2.4E+00	1.7E+01	5.7E+00
	Aroclors (Mixed)	mg/kg	3	14	1.5E+00	7.5E+00	1.7E+01	1.7E+01
	Benzene	mg/kg	1	7	1.0E-02	1.0E-02	1.0E-02	
	Benzo(a)anthracene	mg/kg	15	259	7.7E-02	3.9E+00	2.3E+01	7.3E+00
	Benzo(a)pyrene	mg/kg	11	259	8.3E-02	3.5E+00	1.6E+01	6.7E+00
	Benzo(b)fluoranthene	mg/kg	27	259	9.6E-02	2.4E+00	1.7E+01	3.9E+00
	Benzo(g,h,i)perylene	mg/kg	7	259	4.4E-01	2.1E+00	6.0E+00	4.0E+00
	Benzo(k)fluoranthene	mg/kg	10	259	8.1E-02	2.7E+00	9.7E+00	4.6E+00
	Benzoic Acid	mg/kg	4	259	8.1E-01	1.7E+00	3.5E+00	3.0E+00
	Bis(2-ethylhexyl) phthalate	mg/kg	7	259	5.5E-02	1.2E+00	5.5E+00	2.7E+00
	Butylbenzylphthalate	mg/kg	3	259	8.2E-02	8.9E-01	1.5E+00	1.7E+00
	Chlordane[alpha-]	mg/kg	1	21	7.2E-03	7.2E-03	7.2E-03	
	Chlordane[gamma-]	mg/kg	1	21	6.8E-03	6.8E-03	6.8E-03	
	Chlorophenol[2-]	mg/kg	1	259	3.7E-01	3.7E-01	3.7E-01	
	Chrysene	mg/kg	19	259	9.6E-02	3.3E+00	1.8E+01	5.5E+00
	DDE[4,4'-]	mg/kg	3	21	8.5E-03	8.9E-03	9.7E-03	9.7E-03
	DDT[4,4'-]	mg/kg	7	21	5.9E-03	2.0E-02	4.8E-02	3.1E-02

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Los Alamos Canyon (Cont.)	Di-n-butylphthalate	mg/kg	17	259	4.2E-01	1.4E+00	3.5E+00	1.8E+00
	Dibenz(a,h)anthracene	mg/kg	2	259	1.6E+00	3.0E+00	4.3E+00	5.7E+00
	Dibenzofuran	mg/kg	3	259	5.2E-01	1.7E+00	2.5E+00	2.9E+00
	Dichlorobenzene[1,3-]	mg/kg	1	264	3.7E-01	3.7E-01	3.7E-01	
	Diethylphthalate	mg/kg	1	259	6.1E-01	6.1E-01	6.1E-01	
	Endosulfan II	mg/kg	1	21	4.2E-03	4.2E-03	4.2E-03	
	Fluoranthene	mg/kg	29	259	1.8E-01	4.3E+00	4.1E+01	7.7E+00
	Fluorene	mg/kg	5	259	6.1E-01	2.2E+00	4.7E+00	3.9E+00
	Indeno(1,2,3-cd) pyrene	mg/kg	7	259	4.2E-01	2.1E+00	5.7E+00	3.9E+00
	Methylnaphthalene[2-]	mg/kg	2	259	1.0E+00	1.1E+00	1.2E+00	1.3E+00
	Methylphenol[4-]	mg/kg	1	259	3.7E-01	3.7E-01	3.7E-01	
	Naphthalene	mg/kg	3	259	5.7E-01	1.9E+00	2.7E+00	3.2E+00
	Phenanthrene	mg/kg	19	259	8.5E-02	5.7E+00	3.9E+01	1.0E+01
	Pyrene	mg/kg	30	259	2.1E-01	4.6E+00	3.9E+01	7.8E+00
	Toluene	mg/kg	4	7	1.0E-02	1.6E-02	2.9E-02	2.5E-02
	Xylene (Total)	mg/kg	2	7	9.5E-03	1.1E-02	1.2E-02	1.3E-02
Mortandad Canyon	Acenaphthene	mg/kg	3	88	4.1E-01	1.4E+00	2.6E+00	2.7E+00
	Acetone	mg/kg	1	51	1.6E-02	1.6E-02	1.6E-02	
	Aniline	mg/kg	1	88	3.1E-01	3.1E-01	3.1E-01	
	Anthracene	mg/kg	3	88	8.4E-01	2.7E+00	5.1E+00	5.2E+00
	Aroclor-1254	mg/kg	1	30	1.5E-01	1.5E-01	1.5E-01	
	Aroclor-1260	mg/kg	4	30	2.0E-02	3.6E-02	5.3E-02	5.4E-02
	Aroclors (Mixed)	mg/kg	5	30	2.0E-02	5.9E-02	1.5E-01	1.1E-01
	Benzene	mg/kg	1	51	1.0E-03	1.0E-03	1.0E-03	
	Benzo(a)anthracene	mg/kg	10	88	1.7E-01	5.7E+00	2.3E+01	1.1E+01
	Benzo(a)pyrene	mg/kg	12	88	1.5E-01	4.8E+00	2.3E+01	9.1E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Mortandad Canyon	Benzo(b)fluoranthene	mg/kg	13	88	2.8E-01	5.2E+00	2.6E+01	1.0E+01
	Benzo(g,h,i)perylene	mg/kg	4	88	2.1E+00	6.2E+00	1.3E+01	1.1E+01
	Benzo(k)fluoranthene	mg/kg	4	84	2.0E+00	5.2E+00	1.1E+01	9.1E+00
	Benzoic Acid	mg/kg	3	88	1.1E-01	1.4E-01	1.8E-01	1.8E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	5	88	7.3E-02	1.1E+00	3.8E+00	2.4E+00
	Bromodichloromethane	mg/kg	1	51	4.0E-03	4.0E-03	4.0E-03	
	Butanone[2-]	mg/kg	1	51	8.0E-03	8.0E-03	8.0E-03	
	Carbon Disulfide	mg/kg	1	51	5.8E-03	5.8E-03	5.8E-03	
	Chrysene	mg/kg	12	88	1.8E-01	5.4E+00	2.6E+01	1.0E+01
	Dibenz(a,h)anthracene	mg/kg	3	88	6.3E-01	1.6E+00	2.7E+00	2.8E+00
	Dibenzofuran	mg/kg	1	88	9.4E-01	9.4E-01	9.4E-01	
	Dichlorobenzidine [3,3'-]	mg/kg	1	88	7.0E-01	7.0E-01	7.0E-01	
	Fluoranthene	mg/kg	13	88	1.1E-01	4.8E+00	2.7E+01	9.6E+00
	Fluorene	mg/kg	2	88	7.2E-01	1.4E+00	2.1E+00	2.8E+00
	Indeno(1,2,3-cd)pyrene	mg/kg	6	88	3.9E-01	4.7E+00	1.4E+01	8.8E+00
	Isopropyltoluene[4-]	mg/kg	1	51	4.4E-02	4.4E-02	4.4E-02	
	Methyl-2-pentanone [4-]	mg/kg	1	51	3.0E-03	3.0E-03	3.0E-03	
	Naphthalene	mg/kg	2	105	2.0E-03	3.1E-01	6.1E-01	9.1E-01
	Phenanthrene	mg/kg	10	88	8.7E-02	6.5E+00	2.6E+01	1.2E+01
	Pyrene	mg/kg	14	88	1.0E-01	8.0E+00	4.4E+01	1.5E+01
	Tetrachloroethene	mg/kg	9	51	1.0E-03	2.8E-03	5.0E-03	3.8E-03
	Toluene	mg/kg	10	51	2.0E-03	8.9E-03	1.6E-02	1.2E-02
	Trichlorobenzene [1,2,3-]	mg/kg	1	17	2.0E-03	2.0E-03	2.0E-03	
	Trichlorofluoromethane	mg/kg	1	51	1.9E-02	1.9E-02	1.9E-02	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Mortandad Canyon (Cont.)	Trimethylbenzene [1,24-]	mg/kg	4	51	3.0E-03	9.3E-03	2.6E-02	2.0E-02
	Trimethylbenzene [1,3,5-]	mg/kg	1	51	8.2E-03	8.2E-03	8.2E-03	
	Xylene[1,2-]	mg/kg	1	10	1.0E-03	1.0E-03	1.0E-03	
	Xylene[1,3-]	mg/kg	6	10	1.0E-03	2.2E-03	5.0E-03	3.7E-03
Pajarito Canyon	Acenaphthene	mg/kg	1	87	5.1E-01	5.1E-01	5.1E-01	
	Acetone	mg/kg	2	41	5.3E-02	6.5E-02	7.6E-02	8.8E-02
	Aldrin	mg/kg	1	38	2.4E-03	2.4E-03	2.4E-03	
	Amino-2,6-dinitrotoluene[4-]	mg/kg	1	88	1.0E+00	1.0E+00	1.0E+00	
	Amino-4,6-dinitrotoluene[2-]	mg/kg	2	88	4.1E-01	7.1E-01	1.0E+00	1.3E+00
	Anthracene	mg/kg	2	87	1.2E+00	1.7E+01	3.2E+01	4.7E+01
	Aroclor-1254	mg/kg	2	38	1.6E+00	2.1E+00	2.6E+00	3.1E+00
	BHC[gamma-]	mg/kg	1	38	4.1E-03	4.1E-03	4.1E-03	
	Benzo(a)anthracene	mg/kg	7	87	3.7E-01	2.4E+01	1.6E+02	6.9E+01
	Benzo(a)pyrene	mg/kg	8	87	4.4E-01	1.7E+01	1.3E+02	4.9E+01
	Benzo(b)fluoranthene	mg/kg	13	87	3.9E-01	1.6E+01	2.0E+02	4.7E+01
	Benzo(g,h,i)perylene	mg/kg	4	87	4.1E-01	1.6E+01	6.4E+01	4.8E+01
	Benzo(k)fluoranthene	mg/kg	2	87	1.5E+00	3.9E+01	7.7E+01	1.1E+02
	Benzoic Acid	mg/kg	2	85	1.4E-01	1.8E-01	2.1E-01	2.5E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	6	87	3.8E-01	1.2E+00	2.9E+00	1.9E+00
	Butylbenzylphthalate	mg/kg	2	87	4.6E-02	5.6E-02	6.6E-02	7.6E-02
	Carbon Disulfide	mg/kg	3	41	7.0E-03	9.6E-03	1.2E-02	1.2E-02
	Chlordane[alpha-]	mg/kg	1	38	1.6E-02	1.6E-02	1.6E-02	
	Chrysene	mg/kg	10	85	4.5E-01	2.0E+01	1.9E+02	5.8E+01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Pajarito Canyon (Cont.)	DDE[4,4'-]	mg/kg	4	38	4.5E-03	1.5E-02	3.9E-02	3.1E-02
	DDT[4,4'-]	mg/kg	11	38	3.8E-03	1.4E-02	5.1E-02	2.3E-02
	Di-n-butylphthalate	mg/kg	2	87	8.5E-01	4.6E+01	9.2E+01	1.4E+02
	Di-n-octylphthalate	mg/kg	1	87	4.0E-01	4.0E-01	4.0E-01	
	Dibenz(a,h)anthracene	mg/kg	3	87	5.8E-01	8.1E+00	2.3E+01	2.3E+01
	Dieldrin	mg/kg	1	38	4.8E-02	4.8E-02	4.8E-02	
	Diethylphthalate	mg/kg	1	87	4.6E-01	4.6E-01	4.6E-01	
	Dinitrotoluene[2,4-]	mg/kg	1	175	6.0E-01	6.0E-01	6.0E-01	
	Dinitrotoluene[2,6-]	mg/kg	1	176	6.0E-01	6.0E-01	6.0E-01	
	Endosulfan I	mg/kg	2	38	6.4E-03	1.2E-02	1.7E-02	2.2E-02
	Endosulfan II	mg/kg	1	38	2.4E-02	2.4E-02	2.4E-02	
	Endrin	mg/kg	2	38	8.2E-02	1.1E-01	1.3E-01	1.5E-01
	Fluoranthene	mg/kg	15	87	5.2E-02	2.5E+01	3.1E+02	6.6E+01
	Heptachlor	mg/kg	1	38	6.1E-03	6.1E-03	6.1E-03	
	Indeno(1,2,3-cd)pyrene	mg/kg	5	87	3.6E-01	1.7E+01	8.0E+01	4.8E+01
	Isopropylbenzene	mg/kg	1	17	5.7E-02	5.7E-02	5.7E-02	
	Isopropyltoluene[4-]	mg/kg	1	17	1.1E+00	1.1E+00	1.1E+00	
	Methoxychlor[4,4'-]	mg/kg	2	38	2.7E-02	4.0E-02	5.2E-02	6.5E-02
	Methylene Chloride	mg/kg	16	41	1.1E-02	2.2E-02	6.4E-02	2.9E-02
	Nitrobenzene	mg/kg	2	175	2.0E+00	4.5E+00	7.1E+00	9.6E+00
	Phenanthrene	mg/kg	10	87	4.9E-01	1.6E+01	1.5E+02	4.6E+01
	Pyrene	mg/kg	12	87	5.1E-01	2.4E+01	2.8E+02	7.1E+01
	Toluene	mg/kg	3	41	5.0E-03	7.0E-03	8.0E-03	9.0E-03
	Trichloro-1,2,2-trifluoroethane[1,1,2-]	mg/kg	1	17	1.7E-02	1.7E-02	1.7E-02	
	Trinitrobenzene[1,3,5-]	mg/kg	1	88	1.7E-01	1.7E-01	1.7E-01	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Pueblo Canyon (Part of Pueblo/ Acid Canyon	Aroclor-1260	mg/kg	1	4	4.6E-02	4.6E-02	4.6E-02	
Rio Grande	Acetone	mg/kg	2	5	7.0E-02	7.0E-02	7.0E-02	7.0E-02
Sandia Canyon	Acenaphthene	mg/kg	1	74	5.7E-01	5.7E-01	5.7E-01	
	Acetone	mg/kg	23	64	4.2E-03	5.4E-01	1.9E+00	7.9E-01
	Anthracene	mg/kg	2	92	4.7E-01	6.3E-01	7.8E-01	9.4E-01
	Aroclor-1248	mg/kg	6	110	4.7E-02	7.9E-01	2.1E+00	1.5E+00
	Aroclor-1254	mg/kg	26	113	2.1E-02	1.2E+00	3.8E+00	1.6E+00
	Aroclor-1260	mg/kg	46	113	2.2E-02	6.6E-01	3.7E+00	9.1E-01
	Aroclors (Mixed)	mg/kg	7	28	2.1E-02	6.0E-01	1.7E+00	1.1E+00
	BHC[alpha-]	mg/kg	2	82	5.1E-02	8.4E-02	1.2E-01	1.5E-01
	Benzo(a)anthracene	mg/kg	4	92	5.3E-01	2.5E+00	4.6E+00	4.2E+00
	Benzo(a)pyrene	mg/kg	7	92	5.0E-01	6.2E+00	2.2E+01	1.2E+01
	Benzo(b)fluoranthene	mg/kg	8	92	1.0E-01	6.8E+00	3.1E+01	1.4E+01
	Benzo(g,h,i)perylene	mg/kg	3	92	4.3E-01	1.1E+00	1.8E+00	1.9E+00
	Benzo(k)fluoranthene	mg/kg	5	92	1.3E-01	1.9E+00	3.6E+00	3.1E+00
	Bis(2-ethylhexyl) phthalate	mg/kg	18	92	3.6E-01	2.9E+01	9.5E+01	4.0E+01
	Butanone[2-]	mg/kg	8	63	3.0E-02	1.0E-01	3.1E-01	1.8E-01
	Butylbenzylphthalate	mg/kg	1	92	9.2E-01	9.2E-01	9.2E-01	
	Chlordane[alpha-]	mg/kg	7	36	4.7E-03	3.0E-02	1.3E-01	6.4E-02
	Chlordane[gamma-]	mg/kg	7	36	3.8E-03	3.4E-02	1.5E-01	7.3E-02
	Chrysene	mg/kg	7	92	1.6E-01	3.4E+00	9.6E+00	5.9E+00
	DDE[4,4'-]	mg/kg	7	82	8.4E-02	2.9E-01	6.1E-01	4.7E-01
	DDT[4,4'-]	mg/kg	5	82	5.9E-03	1.6E-01	2.5E-01	2.6E-01
	Di-n-butylphthalate	mg/kg	1	92	4.6E+01	4.6E+01	4.6E+01	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Sandia Canyon (Cont.)	Dibenz(a,h)anthracene	mg/kg	1	92	4.5E-01	4.5E-01	4.5E-01	
	Dieldrin	mg/kg	1	82	1.6E-02	1.6E-02	1.6E-02	
	Diethylphthalate	mg/kg	1	92	6.9E-01	6.9E-01	6.9E-01	
	Endosulfan I	mg/kg	4	82	8.3E-02	1.5E-01	2.3E-01	2.1E-01
	Endosulfan II	mg/kg	3	82	5.0E-03	8.2E-03	9.9E-03	1.1E-02
	Endrin	mg/kg	3	82	6.0E-01	6.0E-01	6.1E-01	6.1E-01
	Endrin Aldehyde	mg/kg	2	82	5.8E-03	5.9E-03	6.0E-03	6.1E-03
	Fluoranthene	mg/kg	9	92	3.2E-01	1.3E+01	6.0E+01	2.6E+01
	Fluorene	mg/kg	1	92	3.8E-01	3.8E-01	3.8E-01	
	Hexanone[2-]	mg/kg	2	64	2.0E-01	3.6E-01	5.1E-01	6.7E-01
	Indeno(1,2,3-cd)pyrene	mg/kg	4	92	6.6E-01	3.9E+00	1.2E+01	9.1E+00
	Isopropyltoluene[4-]	mg/kg	1	29	2.8E-01	2.8E-01	2.8E-01	
	Methyl-2-pentanone [4-]	mg/kg	3	63	6.7E-03	4.2E-02	7.9E-02	8.4E-02
	Methylene Chloride	mg/kg	6	63	2.7E-03	8.7E-03	2.5E-02	1.6E-02
	Phenanthrene	mg/kg	7	92	5.9E-01	1.3E+01	5.0E+01	2.7E+01
	Phenol	mg/kg	1	92	1.9E+00	1.9E+00	1.9E+00	
	Pyrene	mg/kg	9	92	2.2E-01	9.8E+00	4.3E+01	1.9E+01
	Tetrachloroethene	mg/kg	1	63	2.6E-03	2.6E-03	2.6E-03	
	Toluene	mg/kg	3	63	8.0E-03	1.2E-02	1.5E-02	1.6E-02
	Trichloroethane[1,1,1-]	mg/kg	1	64	1.6E-01	1.6E-01	1.6E-01	
	Xylene (Total)	mg/kg	1	63	3.5E-02	3.5E-02	3.5E-02	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Starmer's Gulch (Part of Pajarito Canyon)	Amino-2,6-dinitrotoluene[4-]	mg/kg	1	33	4.0E-01	4.0E-01	4.0E-01	
	Amino-4,6-dinitrotoluene[2-]	mg/kg	1	33	4.0E-01	4.0E-01	4.0E-01	
	Bis(2-ethylhexyl) phthalate	mg/kg	2	32	1.1E+00	1.9E+00	2.7E+00	3.5E+00
	HMX	mg/kg	1	53	1.7E+00	1.7E+00	1.7E+00	
	Trinitrotoluene[2,4,6-]	mg/kg	1	53	1.7E-01	1.7E-01	1.7E-01	
Ten-Site Canyon (Part of Mortandad Canyon)	Acenaphthene	mg/kg	26	315	3.5E-02	1.8E+00	9.2E+00	2.8E+00
	Acenaphthylene	mg/kg	1	315	4.1E-02	4.1E-02	4.1E-02	
	Acetone	mg/kg	23	92	7.0E-03	3.1E-02	1.2E-01	4.1E-02
	Aldrin	mg/kg	1	19	2.6E-03	2.6E-03	2.6E-03	
	Aniline	mg/kg	1	250	2.1E-01	2.1E-01	2.1E-01	
	Anthracene	mg/kg	27	315	6.9E-02	2.4E+00	1.3E+01	3.6E+00
	Aroclor-1254	mg/kg	21	337	5.0E-02	7.3E-01	6.0E+00	1.3E+00
	Aroclor-1260	mg/kg	58	341	3.0E-02	2.0E+01	3.4E+02	3.7E+01
	Aroclors (Mixed)	mg/kg	48	281	0.0E+00	4.2E-01	6.0E+00	6.9E-01
	Azobenzene	mg/kg	1	249	1.1E+01	1.1E+01	1.1E+01	
	Benzo(a)anthracene	mg/kg	43	315	2.6E-02	4.2E+00	3.7E+01	6.5E+00
	Benzo(a)pyrene	mg/kg	46	315	4.0E-02	5.1E+00	4.8E+01	8.1E+00
	Benzo(b)fluoranthene	mg/kg	44	315	3.6E-02	5.8E+00	5.2E+01	9.3E+00
	"Benzo(g,h,i)perylene"	mg/kg	36	315	5.7E-02	3.3E+00	3.3E+01	5.5E+00
	Benzo(k)fluoranthene	mg/kg	31	313	2.7E-02	4.3E+00	4.5E+01	7.6E+00
	Benzoic Acid	mg/kg	4	311	4.0E-02	2.0E-01	6.1E-01	4.8E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	55	311	4.6E-02	1.7E+00	1.4E+01	2.4E+00
	Butanone[2-]	mg/kg	1	92	3.0E-03	3.0E-03	3.0E-03	
	Butylbenzylphthalate	mg/kg	3	311	9.1E-02	1.5E-01	2.7E-01	2.7E-01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ten-Site Canyon (Part of Mortandad Canyon) (Cont.)	Carbon Disulfide	mg/kg	1	92	4.0E-03	4.0E-03	4.0E-03	
	Chloroaniline[4-]	mg/kg	1	311	1.4E-01	1.4E-01	1.4E-01	
	Chrysene	mg/kg	50	315	3.8E-02	4.7E+00	4.7E+01	7.4E+00
	Di-n-butylphthalate	mg/kg	35	311	3.5E-02	9.5E-01	5.2E+00	1.3E+00
	Di-n-octylphthalate	mg/kg	2	311	3.7E-02	5.2E-01	1.0E+00	1.5E+00
	Dibenz(a,h)anthracene	mg/kg	14	315	5.5E-02	1.3E+00	8.8E+00	2.5E+00
	Dibenzofuran	mg/kg	20	311	4.7E-02	8.1E-01	3.8E+00	1.3E+00
	Dichloroethene [cis-1,2-]	mg/kg	3	79	1.0E-03	2.3E-03	3.0E-03	3.7E-03
	Dieldrin	mg/kg	1	19	5.7E-03	5.7E-03	5.7E-03	
	Dimethyl Phthalate	mg/kg	1	311	6.0E-02	6.0E-02	6.0E-02	
	Endosulfan II	mg/kg	1	19	1.6E-02	1.6E-02	1.6E-02	
	Fluoranthene	mg/kg	63	315	3.5E-02	7.6E+00	7.0E+01	1.2E+01
	Fluorene	mg/kg	20	315	1.1E-01	1.4E+00	6.4E+00	2.1E+00
	Hexachlorobenzene	mg/kg	2	311	7.1E-02	1.8E-01	2.8E-01	3.8E-01
	Hexanone[2-]	mg/kg	2	92	6.0E-03	1.0E-02	1.4E-02	1.8E-02
	Hydrocarbons, Total Petroleum	mg/kg	8	10	4.5E+01	4.7E+03	8.6E+03	7.1E+03
	Indeno(1,2,3-cd)pyrene	mg/kg	34	315	5.1E-02	3.5E+00	2.8E+01	5.6E+00
	Methylene Chloride	mg/kg	4	90	7.3E-03	2.7E-02	6.0E-02	5.1E-02
	Methylnaphthalene[2-]	mg/kg	15	311	3.5E-02	4.3E-01	1.7E+00	6.9E-01
	Methylphenol[4-]	mg/kg	1	311	3.8E-02	3.8E-02	3.8E-02	
	Naphthalene	mg/kg	21	319	0.0E+00	1.1E+00	7.0E+00	1.8E+00
	Organics, Diesel Range	mg/kg	17	40	4.9E+00	1.5E+03	2.5E+04	4.5E+03
	Pentachlorophenol	mg/kg	2	311	2.3E-01	1.1E+00	1.9E+00	2.7E+00
	Phenanthrene	mg/kg	46	315	8.0E-02	8.4E+00	5.9E+01	1.3E+01
	Phenol	mg/kg	3	311	5.8E-02	1.0E-01	1.6E-01	1.6E-01
	Pyrene	mg/kg	64	315	3.4E-02	7.9E+00	1.1E+02	1.2E+01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ten-Site Canyon (Part of Mortandad Canyon) (Cont.)	Tetrachloroethene	mg/kg	2	92	2.0E-03	2.0E-03	2.0E-03	2.0E-03
	Toluene	mg/kg	7	92	2.0E-03	8.1E-03	2.2E-02	1.4E-02
	Trichlorobenzene [1,2,4-]	mg/kg	1	313	1.4E-01	1.4E-01	1.4E-01	
	Trichloroethene	mg/kg	6	92	9.0E-03	1.4E-02	2.1E-02	1.8E-02
	Trichlorofluoromethane	mg/kg	3	91	3.0E-03	8.7E-03	1.7E-02	1.7E-02
	Xylene (Total)	mg/kg	1	90	3.0E-03	3.0E-03	3.0E-03	
Three-Mile Canyon (Part of Pajarito Canyon)	Acenaphthene	mg/kg	4	37	8.3E-01	1.1E+01	3.2E+01	2.5E+01
	Anthracene	mg/kg	6	37	1.1E+00	1.6E+01	6.3E+01	3.5E+01
	Benzo(a)anthracene	mg/kg	8	37	6.4E-01	4.2E+01	2.4E+02	9.9E+01
	Benzo(a)pyrene	mg/kg	8	37	7.8E-01	4.2E+01	2.5E+02	1.0E+02
	Benzo(b)fluoranthene	mg/kg	8	37	6.3E-01	4.7E+01	2.9E+02	1.2E+02
	Benzo(g,h,i)perylene	mg/kg	8	37	4.5E-01	2.2E+01	1.3E+02	5.3E+01
	Benzo(k)fluoranthene	mg/kg	8	37	8.6E-01	2.4E+01	1.1E+02	5.1E+01
	Benzoic Acid	mg/kg	5	37	1.3E-01	2.1E-01	3.5E-01	3.0E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	3	37	6.3E-01	1.7E+00	3.3E+00	3.3E+00
	Butylbenzylphthalate	mg/kg	1	37	8.7E-01	8.7E-01	8.7E-01	
	Chrysene	mg/kg	8	37	8.0E-01	4.5E+01	2.6E+02	1.1E+02
	Di-n-butylphthalate	mg/kg	4	37	1.5E+00	8.1E+00	2.6E+01	2.0E+01
	Dibenz(a,h)anthracene	mg/kg	4	37	1.4E+00	4.2E+00	9.3E+00	7.9E+00
	Dibenzofuran	mg/kg	2	37	6.3E-01	1.5E+00	2.3E+00	3.1E+00
	Fluoranthene	mg/kg	10	37	8.0E-01	7.1E+01	5.2E+02	1.7E+02
	Fluorene	mg/kg	4	37	9.7E-01	1.1E+01	3.2E+01	2.5E+01
	HMX	mg/kg	15	102	1.3E-01	1.6E+02	2.2E+03	4.5E+02
	Indeno(1,2,3-cd)pyrene	mg/kg	8	37	5.2E-01	2.5E+01	1.4E+02	5.8E+01
	Naphthalene	mg/kg	1	37	2.6E+01	2.6E+01	2.6E+01	
	Phenanthrene	mg/kg	10	37	7.7E-01	4.2E+01	2.9E+02	9.9E+01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Three-Mile Canyon (Part of Pajarito Canyon)	Pyrene	mg/kg	8	37	1.2E+00	7.6E+01	4.4E+02	1.8E+02
	RDX	mg/kg	6	102	6.3E-01	3.2E+02	1.9E+03	9.5E+02
	Trinitrobenzene[1,3,5-]	mg/kg	1	102	3.7E-01	3.7E-01	3.7E-01	
Two-Mile Canyon (Part of Pajarito Canyon)	Acetone	mg/kg	14	61	5.0E-03	2.9E-02	7.4E-02	4.1E-02
	Amino-2,6-dinitrotoluene[4-]	mg/kg	2	300	9.1E-02	1.3E-01	1.6E-01	2.0E-01
	Aroclor-1254	mg/kg	2	13	4.7E-01	4.8E-01	4.8E-01	4.9E-01
	Aroclors (Mixed)	mg/kg	2	13	4.7E-01	4.8E-01	4.8E-01	4.9E-01
	Benzo(a)anthracene	mg/kg	3	154	5.5E-02	3.0E+00	8.0E+00	8.0E+00
	Benzo(a)pyrene	mg/kg	1	154	5.3E-02	5.3E-02	5.3E-02	
	Benzo(b)fluoranthene	mg/kg	2	154	4.5E-02	4.7E-01	9.0E-01	1.3E+00
	Benzo(g,h,i)perylene	mg/kg	1	154	1.8E-01	1.8E-01	1.8E-01	
	Benzo(k)fluoranthene	mg/kg	2	154	5.8E-02	6.9E-02	8.0E-02	9.1E-02
	Benzoic Acid	mg/kg	2	138	1.2E-01	1.5E-01	1.9E-01	2.2E-01
	Bis(2-ethylhexyl) phthalate	mg/kg	17	154	3.8E-02	4.7E+00	5.1E+01	1.1E+01
	Butanone[2-]	mg/kg	1	62	9.0E-03	9.0E-03	9.0E-03	
	Chloronaphthalene[2-]	mg/kg	1	154	2.7E-01	2.7E-01	2.7E-01	
	Chrysene	mg/kg	1	152	7.3E+00	7.3E+00	7.3E+00	
	Di-n-butylphthalate	mg/kg	25	154	4.6E-02	9.3E+00	1.5E+02	2.2E+01
	Di-n-octylphthalate	mg/kg	3	154	1.0E-01	7.4E-01	2.0E+00	2.0E+00
	Dichlorobenzene[1,2-]	mg/kg	1	216	3.2E-01	3.2E-01	3.2E-01	
	Dichlorobenzene[1,3-]	mg/kg	1	216	3.1E-01	3.1E-01	3.1E-01	
	Diethylphthalate	mg/kg	1	154	4.1E-02	4.1E-02	4.1E-02	
	Dinitrobenzene[1,3-]	mg/kg	1	300	5.4E-01	5.4E-01	5.4E-01	
	Dinitrotoluene[2,4-]	mg/kg	1	454	2.6E-01	2.6E-01	2.6E-01	
	Dinitrotoluene[2,6-]	mg/kg	1	454	2.6E-01	2.6E-01	2.6E-01	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Two-Mile Canyon (Part of Pajarito Canyon) (Cont.)	Fluoranthene	mg/kg	2	154	7.6E-01	1.0E+01	2.0E+01	3.0E+01
	HMX	mg/kg	11	300	8.5E-03	4.7E+00	3.8E+01	1.1E+01
	Hexachlorobenzene	mg/kg	1	154	2.7E-01	2.7E-01	2.7E-01	
	Naphthalene	mg/kg	1	170	2.3E+00	2.3E+00	2.3E+00	
	Nitrobenzene	mg/kg	1	454	1.8E-01	1.8E-01	1.8E-01	
	Nitrotoluene[3-]	mg/kg	1	300	1.6E-01	1.6E-01	1.6E-01	
	Phenanthrene	mg/kg	2	154	1.4E-01	7.6E+00	1.5E+01	2.2E+01
	Phenol	mg/kg	1	154	7.2E-02	7.2E-02	7.2E-02	
	Pyrene	mg/kg	4	154	1.9E-01	6.1E+00	2.3E+01	1.7E+01
	RDX	mg/kg	7	300	1.8E-01	1.0E+00	1.8E+00	1.4E+00
	Tetryl	mg/kg	3	300	4.3E-01	6.0E+00	9.5E+00	1.2E+01
	Toluene	mg/kg	1	62	3.0E-03	3.0E-03	3.0E-03	
	Trichloro-1,2,2-trifluoroethane[1,1,2-]	mg/kg	3	62	6.0E-03	9.3E-03	1.5E-02	1.5E-02
	Trichlorobenzene [1,2,4-]	mg/kg	1	169	3.7E-01	3.7E-01	3.7E-01	
	Trichloroethene	mg/kg	1	62	1.0E-03	1.0E-03	1.0E-03	
	Trinitrotoluene[2,4,6-]	mg/kg	3	300	1.2E-01	9.0E-01	2.3E+00	2.3E+00
Water Canyon	Acenaphthene	mg/kg	67	473	4.2E-02	3.5E+00	5.0E+01	
	Acenaphthylene	mg/kg	12	473	4.5E-02	2.7E-01	1.9E+00	5.7E-01
	Acetone	mg/kg	7	106	8.0E-03	1.8E-01	5.2E-01	3.1E-01
	Amino-2,6-dinitrotoluene[4-]	mg/kg	64	485	9.7E-02	6.5E+00	6.4E+01	9.9E+00
	Amino-4,6-dinitrotoluene[2-]	mg/kg	74	462	8.4E-02	1.0E+01	8.3E+01	1.4E+01
	Aniline	mg/kg	1	470	1.9E+00	1.9E+00	1.9E+00	
	Anthracene	mg/kg	93	473	3.7E-02	5.0E+00	1.2E+02	8.6E+00
	Aroclor-1260	mg/kg	6	32	3.8E-02	1.7E+00	3.1E+00	2.8E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Water Canyon (Cont.)	Aroclors (Mixed)	mg/kg	4	6	2.0E+00	2.6E+00	3.1E+00	3.2E+00
	Azobenzene	mg/kg	1	411	1.9E+00	1.9E+00	1.9E+00	
	Benzene	mg/kg	1	109	2.0E-03	2.0E-03	2.0E-03	
	Benzo(a)anthracene	mg/kg	111	473	3.6E-02	1.0E+01	4.2E+02	1.9E+01
	Benzo(a)pyrene	mg/kg	121	473	5.3E-02	8.9E+00	4.6E+02	1.7E+01
	Benzo(b)fluoranthene	mg/kg	137	474	4.3E-02	1.2E+01	5.8E+02	2.2E+01
	Benzo(g,h,i)perylene	mg/kg	97	473	3.8E-02	6.7E+00	3.5E+02	1.4E+01
	Benzo(k)fluoranthene	mg/kg	84	451	4.2E-02	6.3E+00	1.5E+02	1.1E+01
	Benzoic Acid	mg/kg	49	472	3.5E-02	5.2E-01	9.5E+00	9.1E-01
	Benzyl Alcohol	mg/kg	4	472	5.2E-02	1.0E+00	3.8E+00	2.9E+00
	Bis(2-chloroethoxy) methane	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Bis(2-chloroethyl)ether	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Bis(2-ethylhexyl) phthalate	mg/kg	119	472	3.8E-02	5.3E+00	1.5E+02	8.4E+00
	Bromophenyl-phenylether[4-]	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Butanone[2-]	mg/kg	6	106	9.0E-03	2.1E-02	3.2E-02	2.8E-02
	Butylbenzylphthalate	mg/kg	4	472	3.0E-01	3.9E+00	1.3E+01	1.0E+01
	Carbazole	mg/kg	1	51	1.8E+00	1.8E+00	1.8E+00	
	Chloro-3-methylphenol[4-]	mg/kg	2	472	3.8E+00	4.6E+00	5.3E+00	6.1E+00
	Chloroaniline[4-]	mg/kg	1	472	3.8E+00	3.8E+00	3.8E+00	
	Chloronaphthalene[2-]	mg/kg	2	471	3.6E-01	1.1E+00	1.9E+00	2.7E+00
	Chlorophenol[2-]	mg/kg	2	471	3.5E-01	1.1E+00	1.9E+00	2.7E+00
	Chlorophenyl-phenyl[4-] Ether	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Chrysene	mg/kg	130	473	3.8E-02	1.2E+01	6.1E+02	2.3E+01

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Water Canyon (Cont.)	Di-n-butylphthalate	mg/kg	33	472	3.7E-02	7.6E-01	1.4E+01	1.6E+00
	Di-n-octylphthalate	mg/kg	5	472	7.8E-02	1.4E+00	4.5E+00	3.1E+00
	Dibenz(a,h)anthracene	mg/kg	56	473	3.8E-02	2.5E+00	6.8E+01	5.0E+00
	Dibenzofuran	mg/kg	47	472	3.6E-02	2.7E+00	3.1E+01	4.5E+00
	Dichlorobenzene[1,2-]	mg/kg	1	581	1.9E+00	1.9E+00	1.9E+00	
	Dichlorobenzene[1,3-]	mg/kg	1	581	1.9E+00	1.9E+00	1.9E+00	
	Dichlorobenzene[1,4-]	mg/kg	2	581	5.0E-02	9.8E-01	1.9E+00	2.8E+00
	Dichlorobenzidine [3,3'-]	mg/kg	1	472	3.8E+00	3.8E+00	3.8E+00	
	Dichloroethene [cis-1,2-]	mg/kg	11	98	1.0E-03	7.4E-03	6.7E-02	1.9E-02
	Dichlorophenol[2,4-]	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Diethylphthalate	mg/kg	7	472	5.6E-02	3.3E-01	1.9E+00	8.6E-01
	Dimethyl Phthalate	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Dimethylphenol[2,4-]	mg/kg	2	472	1.3E-01	1.0E+00	1.9E+00	2.8E+00
	Dinitro-2-methylphenol [4,6-]	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Dinitrobenzene[1,3-]	mg/kg	7	496	7.2E-02	5.8E+00	2.9E+01	1.4E+01
	Dinitrophenol[2,4-]	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Dinitrotoluene[2,4-]	mg/kg	53	967	4.6E-02	6.4E-01	4.0E+00	8.5E-01
	Dinitrotoluene[2,6-]	mg/kg	11	968	5.3E-02	3.7E-01	1.9E+00	6.9E-01
	Fluoranthene	mg/kg	163	475	3.4E-02	1.7E+01	9.8E+02	3.2E+01
	Fluorene	mg/kg	64	473	4.0E-02	3.3E+00	5.4E+01	5.6E+00
	Hexachlorobenzene	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Hexachlorobutadiene	mg/kg	1	477	1.9E+00	1.9E+00	1.9E+00	
	Hexachlorocyclo pentadiene	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Hexachloroethane	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Water Canyon (Cont.)	Indeno(1,2,-cd)pyrene	mg/kg	99	473	3.9E-02	6.2E+00	2.7E+02	1.2E+01
	Isophorone	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Isopropyltoluene[4-]	mg/kg	15	109	1.0E-03	9.0E-03	3.0E-02	1.3E-02
	Methyl-2-pentanone [4-]	mg/kg	1	106	2.0E-02	2.0E-02	2.0E-02	
	Methylene Chloride	mg/kg	17	109	3.0E-03	2.0E-02	1.3E-01	3.5E-02
	Methylnaphthalene[2-]	mg/kg	30	472	4.3E-02	2.1E+00	1.6E+01	3.5E+00
	Methylphenol[2-]	mg/kg	5	472	6.4E-02	7.6E-01	1.9E+00	1.6E+00
	Methylphenol[4-]	mg/kg	17	427	4.2E-02	4.3E-01	1.9E+00	6.9E-01
	Naphthalene	mg/kg	52	478	2.6E-03	3.5E+00	4.1E+01	5.7E+00
	Nitroaniline[2-]	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Nitroaniline[3-]	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Nitroaniline[4-]	mg/kg	2	472	6.8E-01	2.2E+00	3.8E+00	5.4E+00
	Nitrobenzene	mg/kg	5	968	9.1E-02	7.8E-01	1.9E+00	1.5E+00
	Nitrophenol[2-]	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Nitrophenol[4-]	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Nitroso-di-n-propylamine[N-]	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Nitrosodimethylamine [N-]	mg/kg	1	471	1.9E+00	1.9E+00	1.9E+00	
	Nitrosodiphenylamine [N-]	mg/kg	3	472	5.7E-02	7.7E-01	1.9E+00	1.9E+00
	Nitrotoluene[2-]	mg/kg	1	494	1.6E+00	1.6E+00	1.6E+00	
	Nitrotoluene[3-]	mg/kg	1	494	2.1E+00	2.1E+00	2.1E+00	
	Nitrotoluene[4-]	mg/kg	3	494	7.9E-01	4.0E+00	6.7E+00	7.4E+00
	Pentachlorophenol	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Phenanthrene	mg/kg	142	474	4.0E-02	1.3E+01	6.1E+02	2.4E+01
	Phenol	mg/kg	3	472	4.3E-02	7.0E-01	1.9E+00	1.9E+00

TABLE C–8.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Organics)*-Continued

WATERSHED	ANALYTE NAME	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Water Canyon (Cont.)	Pyrene	mg/kg	167	474	3.6E-02	1.3E+01	7.2E+02	2.4E+01
	RDX	mg/kg	85	498	1.8E-01	2.3E+03	3.0E+04	3.6E+03
	TATB	mg/kg	1	15	3.3E+00	3.3E+00	3.3E+00	
	Tetrachloroethene	mg/kg	3	109	1.0E-03	3.3E-03	7.0E-03	7.0E-03
	Tetryl	mg/kg	21	496	9.1E-02	7.1E-01	3.0E+00	1.2E+00
	Toluene	mg/kg	26	109	2.0E-03	8.2E-03	2.8E-02	1.1E-02
	Trichlorobenzene [1,2,4-]	mg/kg	1	477	1.9E+00	1.9E+00	1.9E+00	
	Trichloroethane[1,1,1-]	mg/kg	2	109	2.0E-03	3.5E-03	5.0E-03	6.5E-03
	Trichloroethene	mg/kg	23	109	2.0E-03	1.3E-02	1.1E-01	2.2E-02
	Trichlorofluoromethane	mg/kg	21	109	1.0E-03	2.5E-03	5.0E-03	3.0E-03
	Trichlorophenol[2,4,5-]	mg/kg	1	472	9.5E+00	9.5E+00	9.5E+00	
	Trichlorophenol[2,4,6-]	mg/kg	1	472	1.9E+00	1.9E+00	1.9E+00	
	Trimethylbenzene [1,2,4-]	mg/kg	3	109	5.5E-02	8.2E-02	1.2E-01	1.2E-01
	Trinitrobenzene[1,3,5-]	mg/kg	13	496	9.0E-02	6.7E-01	3.4E+00	1.2E+00
	Trinitrotoluene[2,4,6-]	mg/kg	58	496	9.3E-02	1.7E+02	4.6E+03	3.4E+02
	Xylene (Total)	mg/kg	3	109	5.5E-02	8.6E-02	1.4E-01	1.4E-01

Note: Watersheds are defined in ER Project FIMAD map G105700, July 24, 1997.

Note: The analytical data provided in these tables were obtained from the Facility for Information Management, Analysis, and Display (FIMAD) in August, 1998. The data represent analytical results for surface soil samples collected by the ER Project with a begin depth equal to 0 inches and an end depth less than or equal to 12 inches. The data were obtained from ER Project-approved fixed-site analytical laboratories using standard analytical methods (EPA methods for organics and inorganics; LANL-approved methods for radionuclides). Field measurements, non-standard measurements (e.g. x-ray fluorescence), and measurements for non-chemical specific data (e.g. gross radioactivity) were excluded. Quality assurance/quality control data were also excluded. The ER Project may have removed contaminated soil in voluntary corrective actions subsequent to sampling; therefore, some analytical results may represent contaminants that have been removed since the samples were taken.

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Acid Canyon (Part of Pueblo/ Acid Canyon)	Aluminum	mg/kg	38	38	9.6E+02	4.6E+03	1.3E+04	5.5E+03
	Americium-241	pCi/g	1	3	1.7E+00	1.7E+00	1.7E+00	
	Antimony	mg/kg	7	50	9.0E-01	5.9E+01	1.2E+02	1.0E+02
	Arsenic	mg/kg	37	46	4.0E-01	1.5E+00	3.1E+00	1.7E+00
	Barium	mg/kg	43	46	1.1E+01	7.0E+01	3.1E+02	9.2E+01
	Beryllium	mg/kg	7	46	4.3E-01	1.8E+00	3.3E+00	2.7E+00
	Calcium	mg/kg	37	38	4.3E+02	2.1E+03	7.4E+03	2.6E+03
	Cesium-137	pCi/g	11	26	1.8E-01	5.2E-01	1.3E+00	7.5E-01
	Chromium, Total	mg/kg	38	46	2.7E+00	6.0E+00	1.2E+01	6.9E+00
	Cobalt	mg/kg	17	38	1.6E+00	3.0E+00	5.0E+00	3.5E+00
	Copper	mg/kg	10	13	1.2E+00	7.5E+00	1.7E+01	1.0E+01
	Cyanide, Total	mg/kg	1	7	5.0E-02	5.0E-02	5.0E-02	
	Iron	mg/kg	38	38	3.6E+03	7.6E+03	1.4E+04	8.4E+03
	Lead	mg/kg	44	46	4.4E+00	2.9E+01	1.6E+02	3.7E+01
	Magnesium	mg/kg	33	38	1.7E+02	9.3E+02	3.0E+03	1.2E+03
	Manganese	mg/kg	13	13	1.5E+02	2.4E+02	3.3E+02	2.7E+02
	Mercury	mg/kg	21	43	1.8E-02	3.3E-01	1.0E+00	4.5E-01
	Molybdenum	mg/kg	3	25	2.2E+00	2.5E+00	2.8E+00	2.8E+00
	Nickel	mg/kg	5	46	4.4E+00	6.0E+00	7.6E+00	7.1E+00
	Plutonium-238	pCi/g	4	39	2.6E-02	5.5E-02	9.8E-02	8.5E-02
	Plutonium-239	pCi/g	21	39	1.3E-02	8.3E+00	2.4E+01	1.1E+01
	Potassium	mg/kg	20	38	2.2E+02	7.9E+02	1.7E+03	9.7E+02
	Potassium-40	pCi/g	1	1	1.9E+01	1.9E+01	1.9E+01	
	Radium-226	pCi/g	1	1	8.6E-01	8.6E-01	8.6E-01	
	Selenium	mg/kg	1	46	5.5E-01	5.5E-01	5.5E-01	

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Acid Canyon (Part of Pueblo/ Acid Canyon) (Cont.)	Silver	mg/kg	4	46	3.3E+00	5.3E+00	9.0E+00	8.0E+00
	Sodium	mg/kg	25	38	7.2E+01	1.7E+02	4.1E+02	2.0E+02
	Strontium	mg/kg	21	25	2.4E+00	9.8E+00	2.2E+01	1.3E+01
	Strontium-90	pCi/g	2	25	9.7E-01	1.3E+00	1.7E+00	2.0E+00
	Thallium	mg/kg	4	46	5.0E-02	1.6E+01	6.4E+01	4.8E+01
	Tritium	pCi/g	46	46	2.3E-02	6.5E-02	2.3E-01	8.1E-02
	Uranium-234	pCi/g	24	25	5.3E-01	1.1E+00	2.2E+00	1.2E+00
	Uranium-238	pCi/g	22	25	5.3E-01	9.1E-01	1.7E+00	1.0E+00
	Vanadium	mg/kg	32	38	3.0E+00	1.0E+01	2.3E+01	1.2E+01
	Zinc	mg/kg	38	38	2.4E+01	4.6E+01	1.0E+02	5.2E+01
Ancho Canyon	Actinium-228	pCi/g	116	161	4.8E-01	1.5E+00	4.3E+00	1.6E+00
	Aluminum	mg/kg	356	356	6.6E+02	5.2E+03	2.1E+04	5.6E+03
	Americium-241	pCi/g	8	363	1.6E-01	2.3E+00	9.3E+00	4.5E+00
	Antimony	mg/kg	18	410	7.3E-02	1.3E+01	1.8E+02	3.3E+01
	Arsenic	mg/kg	169	410	3.7E-01	2.5E+00	1.5E+02	4.3E+00
	Barium	mg/kg	411	447	4.4E+00	8.2E+01	7.5E+02	8.8E+01
	Barium-140	pCi/g	3	184	2.1E-01	2.0E+00	5.5E+00	5.5E+00
	Beryllium	mg/kg	242	447	1.5E-01	2.2E+00	3.5E+02	5.1E+00
	Bismuth-211	pCi/g	60	145	3.7E-01	2.8E+00	7.8E+00	3.2E+00
	Bismuth-212	pCi/g	19	145	5.4E-01	2.0E+00	5.2E+00	2.6E+00
	Bismuth-214	pCi/g	112	167	3.2E-01	1.3E+00	3.5E+00	1.4E+00
	Cadmium	mg/kg	108	449	7.6E-03	1.9E+01	1.5E+03	4.8E+01
	Cadmium-109	pCi/g	17	47	1.3E+00	2.2E+00	3.8E+00	2.6E+00
	Calcium	mg/kg	326	358	2.9E+00	3.1E+03	5.8E+04	3.6E+03
	Cesium-134	pCi/g	1	126	4.0E-01	4.0E-01	4.0E-01	
	Cesium-137	pCi/g	268	468	2.5E-02	5.2E-01	1.7E+01	6.5E-01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ancho Canyon (Cont.)	Chromium, Total	mg/kg	371	449	1.0E+00	7.4E+00	1.3E+02	8.7E+00
	Cobalt	mg/kg	214	395	2.7E-01	7.0E+00	4.4E+02	1.2E+01
	Cobalt-57	pCi/g	1	162	2.2E-01	2.2E-01	2.2E-01	
	Cobalt-60	pCi/g	3	379	8.1E-02	9.6E+00	2.8E+01	2.8E+01
	Copper	mg/kg	327	393	8.4E-01	3.8E+02	7.8E+04	8.6E+02
	Cyanide, Total	mg/kg	13	218	2.0E-01	1.7E+00	7.7E+00	2.8E+00
	Europium-152	pCi/g	12	223	1.3E-01	2.6E-01	4.5E-01	3.1E-01
	Iron	mg/kg	355	356	1.1E+03	6.9E+03	3.2E+04	7.3E+03
	Lead	mg/kg	431	445	1.0E+00	5.3E+01	1.0E+04	1.0E+02
	Lead-210	pCi/g	30	161	1.7E+00	1.4E+01	1.6E+02	2.5E+01
	Lead-212	pCi/g	152	188	3.7E-01	1.3E+00	3.6E+00	1.4E+00
	Lead-214	pCi/g	147	183	2.9E-01	1.1E+00	3.1E+00	1.2E+00
	Magnesium	mg/kg	301	356	9.2E+01	1.2E+03	7.2E+03	1.3E+03
	Manganese	mg/kg	356	356	5.6E+01	2.3E+02	8.3E+02	2.4E+02
	Manganese-54	pCi/g	3	126	4.5E-02	1.1E-01	2.4E-01	2.4E-01
	Mercury	mg/kg	96	433	3.5E-03	1.6E+00	4.4E+01	2.8E+00
	Mercury-203	pCi/g	2	29	6.1E-02	1.9E-01	3.3E-01	4.6E-01
	Neptunium-237	pCi/g	11	243	4.6E-01	7.9E-01	1.5E+00	1.0E+00
	Nickel	mg/kg	241	447	1.1E+00	1.1E+01	4.3E+02	1.6E+01
	Plutonium-238	pCi/g	66	156	2.0E-03	4.0E-02	1.1E+00	7.4E-02
	Plutonium-239	pCi/g	66	78	5.0E-03	5.2E-01	1.4E+01	9.6E-01
	Potassium	mg/kg	261	355	1.8E+02	1.3E+03	8.4E+03	1.4E+03
	Potassium-40	pCi/g	227	264	1.5E+01	2.8E+01	4.4E+01	2.8E+01
	Protactinium-231	pCi/g	16	127	1.1E+00	2.1E+00	5.4E+00	2.6E+00
	Protactinium-234	pCi/g	9	112	9.4E-01	5.9E+00	1.3E+01	8.6E+00
	Protactinium-234M	pCi/g	29	126	6.5E+00	8.5E+02	1.0E+04	1.6E+03

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ancho Canyon (Cont.)	Radium-223	pCi/g	5	126	1.7E-01	4.5E-01	1.2E+00	8.4E-01
	Radium-224	pCi/g	47	151	8.4E-01	3.1E+00	7.4E+00	3.6E+00
	Radium-226	pCi/g	132	213	7.9E-01	2.5E+01	1.7E+03	5.5E+01
	Radon-219	pCi/g	2	135	2.2E-01	2.1E+00	4.0E+00	5.9E+00
	Ruthenium-106	pCi/g	1	321	3.6E+00	3.6E+00	3.6E+00	
	Selenium	mg/kg	15	409	6.7E-02	7.8E+00	1.0E+02	2.2E+01
	Silver	mg/kg	28	449	2.5E-01	1.1E+01	1.0E+02	2.1E+01
	Sodium	mg/kg	236	355	3.4E+01	1.8E+02	5.9E+03	2.3E+02
	Sodium-22	pCi/g	2	321	1.9E-01	2.9E-01	3.8E-01	4.8E-01
	Thallium	mg/kg	12	433	1.1E-01	2.0E+01	2.3E+02	5.9E+01
	Thallium-208	pCi/g	161	179	1.4E-01	4.8E-01	1.4E+00	5.1E-01
	Thorium	mg/kg	27	54	3.7E+00	9.4E+00	1.6E+01	1.1E+01
	Thorium-227	pCi/g	7	127	9.4E-01	2.7E+00	9.6E+00	5.1E+00
	Thorium-228	pCi/g	111	111	4.2E-01	1.5E+00	3.5E+00	1.7E+00
	Thorium-230	pCi/g	93	111	3.8E-01	1.5E+00	3.2E+00	1.6E+00
	Thorium-232	pCi/g	121	151	5.5E-01	1.7E+00	4.4E+00	1.9E+00
	Thorium-234	pCi/g	62	158	1.1E+00	1.8E+02	3.6E+03	3.1E+02
	Uranium	mg/kg	233	405	4.5E-01	4.4E+02	3.5E+04	8.1E+02
	Uranium-234	pCi/g	19	20	5.0E-01	5.1E+00	5.6E+01	1.1E+01
	Uranium-235	pCi/g	42	166	1.1E-01	6.2E+00	1.1E+02	1.2E+01
	Uranium-238	pCi/g	20	20	7.4E-01	4.5E+01	6.9E+02	1.1E+02
	Vanadium	mg/kg	255	356	7.2E-01	1.1E+01	1.3E+02	1.2E+01
	Yttrium-88	pCi/g	1	28	3.0E-01	3.0E-01	3.0E-01	
	Zinc	mg/kg	407	407	8.9E+00	6.5E+01	4.0E+03	8.7E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Barrancas Canyon	Aluminum	mg/kg	38	38	6.3E+02	2.5E+03	7.1E+03	3.1E+03
	Arsenic	mg/kg	6	38	2.1E+00	2.7E+00	3.4E+00	3.1E+00
	Barium	mg/kg	7	38	4.4E+01	7.3E+01	1.0E+02	8.8E+01
	Beryllium	mg/kg	1	38	1.0E+00	1.0E+00	1.0E+00	
	Calcium	mg/kg	12	38	1.1E+03	4.1E+03	1.4E+04	6.6E+03
	Cesium-137	pCi/g	3	3	2.9E-01	3.1E-01	3.4E-01	3.4E-01
	Chromium, Total	mg/kg	9	38	2.1E+00	3.2E+00	4.9E+00	3.9E+00
	Copper	mg/kg	9	38	6.2E+00	8.9E+00	1.8E+01	1.1E+01
	Iron	mg/kg	38	38	1.3E+03	4.6E+03	1.0E+04	5.3E+03
	Lead	mg/kg	38	38	1.4E+00	9.9E+00	2.8E+01	1.2E+01
	Magnesium	mg/kg	6	38	1.1E+03	1.4E+03	1.7E+03	1.5E+03
	Manganese	mg/kg	38	38	7.2E+01	2.1E+02	3.9E+02	2.4E+02
	Mercury	mg/kg	1	38	1.2E-01	1.2E-01	1.2E-01	
	Nickel	mg/kg	1	38	1.0E+02	1.0E+02	1.0E+02	
	Potassium	mg/kg	4	38	1.2E+03	1.3E+03	1.4E+03	1.4E+03
	Strontium-90	pCi/g	3	38	5.3E-01	9.1E-01	1.1E+00	1.3E+00
	Zinc	mg/kg	38	38	8.2E+00	4.7E+01	6.7E+02	8.1E+01
Bayo Canyon	Aluminum	mg/kg	90	90	1.1E+03	8.7E+03	6.9E+04	1.2E+04
	Arsenic	mg/kg	9	90	8.0E-01	1.7E+00	3.4E+00	2.4E+00
	Barium	mg/kg	43	90	4.4E+01	1.0E+02	5.2E+02	1.3E+02
	Beryllium	mg/kg	1	90	1.1E+00	1.1E+00	1.1E+00	
	Cadmium	mg/kg	1	90	1.1E+00	1.1E+00	1.1E+00	
	Calcium	mg/kg	52	90	1.1E+03	2.8E+03	3.4E+04	4.0E+03
	Cesium-137	pCi/g	7	7	3.2E-02	2.8E-01	6.2E-01	4.4E-01
	Chromium, Total	mg/kg	53	90	2.0E+00	4.5E+00	2.1E+01	5.4E+00
	Cobalt	mg/kg	4	90	4.0E+00	8.5E+00	1.8E+01	1.5E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Bayo Canyon (Cont.)	Copper	mg/kg	24	90	5.2E+00	1.1E+01	5.1E+01	1.5E+01
	Europium-152	pCi/g	2	7	1.5E-01	2.5E-01	3.5E-01	4.5E-01
	Iron	mg/kg	90	90	1.7E+03	6.3E+03	1.9E+04	7.0E+03
	Lead	mg/kg	90	90	3.3E+00	1.5E+01	1.6E+02	1.9E+01
	Lithium	mg/kg	7	7	2.1E+01	2.6E+01	2.9E+01	2.8E+01
	Magnesium	mg/kg	29	90	4.8E+02	1.3E+03	3.4E+03	1.6E+03
	Manganese	mg/kg	90	90	9.2E+01	2.6E+02	8.7E+02	2.9E+02
	Mercury	mg/kg	1	83	5.2E-01	5.2E-01	5.2E-01	
	Molybdenum	mg/kg	1	7	4.0E+00	4.0E+00	4.0E+00	
	Nickel	mg/kg	3	90	8.0E+00	9.5E+00	1.2E+01	1.2E+01
	Potassium	mg/kg	37	90	1.1E+03	7.4E+03	3.8E+04	1.2E+04
	Sodium	mg/kg	7	90	1.6E+04	2.6E+04	3.1E+04	3.1E+04
	Strontium	mg/kg	7	7	3.0E+01	5.9E+01	1.2E+02	8.9E+01
	Strontium-90	pCi/g	6	86	1.7E+00	8.7E+00	1.3E+01	1.3E+01
	Thallium	mg/kg	1	90	1.0E+01	1.0E+01	1.0E+01	
	Vanadium	mg/kg	19	90	4.0E+00	1.5E+01	4.5E+01	2.0E+01
	Zinc	mg/kg	90	90	1.1E+01	3.1E+01	8.8E+01	3.4E+01
Cañada del Buey	Aluminum	mg/kg	157	157	6.7E+02	4.7E+03	1.7E+04	5.1E+03
	Americium-241	pCi/g	23	88	5.0E-03	1.3E-01	1.0E+00	2.3E-01
	Antimony	mg/kg	4	194	8.0E-02	2.0E+01	7.6E+01	5.7E+01
	Arsenic	mg/kg	92	194	9.0E-01	5.1E+00	2.1E+02	9.6E+00
	Barium	mg/kg	147	194	1.1E+01	8.4E+01	4.1E+02	9.3E+01
	Beryllium	mg/kg	48	194	3.9E-01	8.4E-01	6.0E+00	1.1E+00
	Cadmium	mg/kg	30	194	6.2E-01	4.1E+00	4.7E+01	7.2E+00
	Calcium	mg/kg	132	157	3.6E+02	2.4E+03	2.3E+04	2.9E+03
	Cesium	mg/kg	13	27	3.0E-01	2.5E+00	9.1E+00	4.3E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Cañada del Buey (Cont.)	Cesium-137	pCi/g	61	170	3.6E-02	3.0E-01	1.2E+00	3.7E-01
	Chromium, Total	mg/kg	178	194	1.3E+00	1.6E+01	8.1E+02	2.6E+01
	Cobalt	mg/kg	22	157	8.0E-01	7.6E+00	6.0E+01	1.4E+01
	Copper	mg/kg	122	157	8.1E-01	2.2E+02	8.1E+03	3.9E+02
	Cyanide, Total	mg/kg	1	2	1.2E+00	1.2E+00	1.2E+00	
	Iron	mg/kg	157	157	1.7E+03	7.3E+03	3.3E+04	8.1E+03
	Lead	mg/kg	190	194	2.9E+00	2.8E+02	4.4E+04	7.4E+02
	Lithium	mg/kg	9	27	2.1E+00	6.0E+00	2.2E+01	1.0E+01
	Magnesium	mg/kg	72	157	1.9E+02	1.3E+03	4.3E+03	1.4E+03
	Manganese	mg/kg	157	157	4.5E+01	2.2E+02	7.1E+02	2.4E+02
	Mercury	mg/kg	97	171	2.0E-02	5.6E+00	1.6E+02	9.9E+00
	Nickel	mg/kg	70	194	2.3E+00	2.4E+01	4.9E+02	4.1E+01
	Plutonium-238	pCi/g	53	100	4.5E-03	6.1E-01	1.7E+01	1.3E+00
	Plutonium-239	pCi/g	52	79	3.8E-03	5.8E-01	8.7E+00	9.5E-01
	Potassium	mg/kg	58	159	2.6E+02	1.2E+03	2.2E+03	1.4E+03
	Potassium-40	pCi/g	36	38	2.0E+01	3.2E+01	4.4E+01	3.4E+01
	Radium-226	pCi/g	22	37	1.8E+00	2.7E+00	4.2E+00	3.0E+00
	Selenium	mg/kg	11	194	6.2E-01	3.6E+01	3.6E+02	1.0E+02
	Silver	mg/kg	18	194	7.9E-01	4.3E+01	1.8E+02	7.2E+01
	Sodium	mg/kg	12	157	5.2E+01	2.0E+02	6.3E+02	3.2E+02
	Thallium	mg/kg	33	194	4.0E-02	7.0E+00	2.3E+02	2.1E+01
	Thorium-228	pCi/g	92	103	3.0E-02	5.2E-01	1.8E+00	6.0E-01
	Thorium-230	pCi/g	94	103	3.4E-02	4.2E-01	1.4E+00	4.9E-01
	Thorium-232	pCi/g	99	140	2.6E-02	7.1E-01	4.3E+00	8.8E-01
	Tritium	pCi/g	31	31	1.3E-02	6.2E-02	2.0E-01	7.6E-02
	Uranium-234	pCi/g	189	189	1.7E-01	1.1E+01	6.0E+02	2.0E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Cañada del Buey (Cont.)	Uranium-235	pCi/g	97	206	2.0E-02	1.2E+00	4.2E+01	2.3E+00
	Uranium-238	pCi/g	189	226	1.7E-01	1.2E+00	1.7E+01	1.5E+00
	Vanadium	mg/kg	80	157	2.5E+00	1.5E+01	7.6E+01	1.7E+01
	Zinc	mg/kg	157	157	1.1E+01	1.5E+02	3.4E+03	2.1E+02
Chaquehui Canyon	Acetone	mg/kg	1	3	4.5E-02	4.5E-02	4.5E-02	
	Aluminum	mg/kg	138	138	1.4E+03	5.3E+03	1.4E+04	5.7E+03
	Antimony	mg/kg	58	348	2.2E-02	3.2E+00	7.0E+01	6.6E+00
	Arsenic	mg/kg	233	345	6.2E-01	2.8E+00	1.8E+01	3.2E+00
	Barium	mg/kg	332	345	2.0E+01	1.0E+02	1.3E+03	1.1E+02
	Beryllium	mg/kg	219	345	1.6E-01	7.0E-01	7.8E+00	7.8E-01
	Cadmium	mg/kg	73	345	4.0E-01	1.1E+01	6.2E+02	2.8E+01
	Calcium	mg/kg	126	139	5.9E+02	3.8E+03	3.8E+04	4.7E+03
	Cesium-137	pCi/g	123	323	4.0E-02	9.4E-01	1.7E+01	1.2E+00
	Chromium, Total	mg/kg	325	344	1.4E+00	1.1E+01	6.7E+02	1.5E+01
	Cobalt	mg/kg	33	139	1.6E+00	4.3E+00	1.9E+01	5.7E+00
	Copper	mg/kg	123	139	3.1E+00	9.0E+02	2.5E+04	1.5E+03
	Cyanide, Total	mg/kg	15	27	2.2E-01	9.3E-01	2.6E+00	1.3E+00
	Iron	mg/kg	139	139	2.3E+03	8.2E+03	6.1E+04	9.7E+03
	Lead	mg/kg	323	350	2.9E+00	4.1E+01	2.0E+03	5.6E+01
	Magnesium	mg/kg	95	139	1.6E+02	1.4E+03	3.7E+03	1.5E+03
	Manganese	mg/kg	139	139	8.0E+01	2.3E+02	8.9E+02	2.5E+02
	Mercury	mg/kg	29	151	2.0E-02	2.0E+00	2.3E+01	3.9E+00
	Nickel	mg/kg	211	345	2.3E+00	4.2E+01	3.1E+03	7.4E+01
	Plutonium-238	pCi/g	1	112	1.7E-02	1.7E-02	1.7E-02	
	Plutonium-239	pCi/g	66	112	1.1E-02	5.4E-02	9.5E-01	8.4E-02
	Potassium	mg/kg	96	139	2.4E+02	1.4E+03	3.1E+03	1.6E+03

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Chaquehui Canyon (Cont.)	Selenium	mg/kg	27	345	5.8E-01	1.8E+00	1.1E+01	2.7E+00
	Silver	mg/kg	30	345	3.6E-01	1.0E+01	4.6E+01	1.5E+01
	Sodium	mg/kg	32	139	6.1E+01	1.3E+02	3.2E+02	1.6E+02
	Thallium	mg/kg	2	139	1.8E+00	2.0E+00	2.2E+00	2.4E+00
	Tritium	pCi/g	125	126	1.5E-02	1.9E+02	1.2E+04	4.1E+02
	Uranium	mg/kg	31	323	2.5E-01	8.3E+00	1.3E+02	1.7E+01
	Uranium-234	pCi/g	1	1	2.7E+00	2.7E+00	2.7E+00	
	Uranium-235	pCi/g	1	1	1.8E-01	1.8E-01	1.8E-01	
	Uranium-238	pCi/g	1	1	6.2E+00	6.2E+00	6.2E+00	
	Vanadium	mg/kg	57	139	4.2E+00	1.2E+01	2.8E+01	1.3E+01
	Zinc	mg/kg	345	345	1.2E+01	1.1E+02	9.4E+03	1.7E+02
DP Canyon (Part of Los Alamos Canyon)	Actinium-227	pCi/g	4	112	1.8E+01	5.5E+01	1.1E+02	9.5E+01
	Actinium-228	pCi/g	80	82	6.6E-01	3.6E+00	1.1E+02	6.7E+00
	Aluminum	mg/kg	713	936	6.3E+00	6.8E+03	3.4E+04	7.1E+03
	Americium-241	pCi/g	476	805	5.0E-03	1.1E+01	2.6E+03	2.2E+01
	Antimony	mg/kg	26	936	2.2E-01	1.4E+01	6.4E+01	2.0E+01
	Arsenic	mg/kg	649	935	4.8E-01	2.7E+00	3.5E+01	2.9E+00
	Barium	mg/kg	909	935	9.0E-01	1.5E+02	1.7E+03	1.6E+02
	Beryllium	mg/kg	462	936	1.1E-01	1.8E+00	1.2E+02	2.4E+00
	Bismuth-211	pCi/g	73	85	7.8E-02	3.7E+00	4.3E+01	4.9E+00
	Bismuth-212	pCi/g	22	76	8.7E-01	6.6E+00	7.4E+01	1.4E+01
	Bismuth-214	pCi/g	71	74	5.0E-01	1.1E+00	5.0E+00	1.3E+00
	Cadmium	mg/kg	205	936	6.0E-02	2.8E+00	1.1E+02	4.1E+00
	Cadmium-109	pCi/g	2	2	1.1E+00	6.6E+00	1.2E+01	1.8E+01
	Calcium	mg/kg	683	935	6.0E-02	3.1E+03	4.4E+04	3.3E+03
	Cerium-144	pCi/g	1	92	1.9E-01	1.9E-01	1.9E-01	

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Cesium-134	pCi/g	5	77	5.7E-02	1.4E+00	4.9E+00	3.3E+00
	Cesium-137	pCi/g	229	369	5.0E-02	3.7E+01	2.7E+03	6.6E+01
	Chromium, Total	mg/kg	857	936	1.7E+00	1.7E+01	1.0E+03	2.1E+01
	Cobalt	mg/kg	469	936	8.1E-01	7.1E+00	4.3E+02	9.8E+00
	Cobalt-57	pCi/g	4	85	5.2E-01	3.2E+00	8.1E+00	6.5E+00
	Cobalt-60	pCi/g	2	92	3.2E-02	4.5E-02	5.8E-02	7.1E-02
	Copper	mg/kg	731	936	1.4E+00	2.1E+01	1.9E+03	2.8E+01
	Cyanide, Total	mg/kg	3	5	7.6E-01	1.2E+00	2.0E+00	2.0E+00
	Europium-152	pCi/g	2	23	2.6E-01	4.9E-01	7.1E-01	9.4E-01
	Iron	mg/kg	705	936	5.9E+00	8.4E+03	1.1E+05	8.9E+03
	Lead	mg/kg	816	936	3.7E+00	4.1E+01	6.9E+03	5.9E+01
	Lead-210	pCi/g	46	162	1.7E+00	3.1E+00	1.1E+01	3.6E+00
	Lead-211	pCi/g	1	71	2.2E+01	2.2E+01	2.2E+01	
	Lead-212	pCi/g	205	207	3.4E-01	2.4E+00	1.2E+02	3.8E+00
	Lead-214	pCi/g	196	199	4.5E-01	1.2E+00	3.5E+00	1.2E+00
	Lithium	mg/kg	443	579	2.0E+00	1.6E+01	6.1E+01	1.7E+01
	Magnesium	mg/kg	619	936	1.1E+00	1.4E+03	4.7E+03	1.5E+03
	Manganese	mg/kg	933	935	1.2E+00	2.9E+02	9.2E+02	3.0E+02
	Manganese-54	pCi/g	4	72	3.7E-02	1.5E+00	4.9E+00	3.8E+00
	Mercury	mg/kg	91	355	4.0E-02	1.0E+00	1.8E+01	1.6E+00
	Molybdenum	mg/kg	29	601	1.6E+00	5.2E+00	2.1E+01	7.2E+00
	Nickel	mg/kg	338	935	1.9E+00	1.1E+01	2.7E+02	1.4E+01
	Plutonium-238	pCi/g	529	977	4.0E-04	1.2E+00	1.3E+02	1.8E+00
	Plutonium-239	pCi/g	910	946	3.9E-03	6.8E+00	7.7E+02	9.2E+00
	Potassium	mg/kg	556	937	1.4E+00	1.3E+03	4.2E+03	1.4E+03
	Potassium-40	pCi/g	214	221	1.4E+01	2.7E+01	7.2E+01	2.8E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Protactinium-231	pCi/g	18	72	2.1E+00	3.8E+00	1.2E+01	4.9E+00
	Protactinium-234M	pCi/g	6	72	9.3E+00	6.4E+01	2.9E+02	1.5E+02
	Radium-223	pCi/g	8	77	4.0E-01	9.8E+00	3.4E+01	1.9E+01
	Radium-224	pCi/g	90	107	5.0E-01	3.6E+00	5.8E+00	3.9E+00
	Radium-226	pCi/g	116	130	6.9E-01	2.5E+00	1.9E+01	2.9E+00
	Radium-228	pCi/g	1	1	1.4E+00	1.4E+00	1.4E+00	
	Radon-219	pCi/g	4	73	7.8E-01	1.1E+01	2.7E+01	2.4E+01
	Ruthenium-106	pCi/g	1	93	9.3E+00	9.3E+00	9.3E+00	
	Selenium	mg/kg	33	935	2.0E-01	2.5E+00	5.9E+01	6.0E+00
	Silver	mg/kg	33	933	2.0E-01	1.1E+01	1.1E+02	1.9E+01
	Sodium	mg/kg	263	855	4.0E+01	3.9E+02	2.1E+04	5.6E+02
	Sodium-22	pCi/g	2	94	2.3E-01	2.5E-01	2.7E-01	2.9E-01
	Strontium	mg/kg	577	587	2.5E+00	4.5E+01	2.7E+02	4.8E+01
	Strontium-85	pCi/g	1	2	1.8E-01	1.8E-01	1.8E-01	
	Strontium-90	pCi/g	169	969	3.7E-02	3.1E+01	1.8E+03	5.9E+01
	Thallium	mg/kg	44	938	1.1E-01	3.0E+00	5.9E+01	6.0E+00
	Thallium-208	pCi/g	119	121	1.4E-01	9.5E-01	3.8E+01	1.6E+00
	Thorium-227	pCi/g	13	75	4.3E+00	3.5E+01	2.4E+02	7.4E+01
	Thorium-228	pCi/g	114	130	7.0E-01	2.6E+00	9.1E+01	4.3E+00
	Thorium-229	pCi/g	1	3	2.9E-01	2.9E-01	2.9E-01	
	Thorium-230	pCi/g	109	114	6.0E-01	2.0E+00	5.7E+01	3.1E+00
	Thorium-232	pCi/g	111	114	6.4E-01	2.7E+00	1.1E+02	4.8E+00
	Thorium-234	pCi/g	98	166	1.1E+00	2.6E+00	1.6E+01	3.0E+00
	Tritium	pCi/g	386	406	1.7E-03	7.9E+00	8.9E+02	1.4E+01
	Uranium-234	pCi/g	178	178	5.8E-01	5.7E+02	7.2E+04	1.4E+03
	Uranium-235	pCi/g	78	306	3.0E-02	1.7E+02	4.6E+03	3.3E+02

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
DP Canyon (Part of Los Alamos Canyon) (Cont.)	Uranium-238	pCi/g	179	180	6.3E-01	5.7E+00	3.7E+02	1.1E+01
	Vanadium	mg/kg	826	936	2.6E+00	1.8E+01	1.3E+02	1.9E+01
	Zinc	mg/kg	934	936	2.4E+00	7.2E+01	3.0E+03	8.2E+01
Frijoles Canyon	Actinium-228	pCi/g	6	6	9.8E-01	1.4E+00	1.9E+00	1.7E+00
	Bismuth-214	pCi/g	6	6	6.0E-01	8.8E-01	1.0E+00	1.0E+00
	Cesium-137	pCi/g	5	6	3.3E-01	5.0E-01	1.0E+00	7.7E-01
	Lead	mg/kg	3	3	6.1E+00	1.3E+01	1.8E+01	2.0E+01
	Lead-212	pCi/g	6	6	1.1E+00	1.4E+00	1.7E+00	1.6E+00
	Lead-214	pCi/g	6	6	7.2E-01	1.0E+00	1.2E+00	1.2E+00
	Neptunium-237	pCi/g	1	6	9.4E-01	9.4E-01	9.4E-01	
	Potassium-40	pCi/g	6	6	2.5E+01	3.0E+01	3.5E+01	3.3E+01
	Radium-226	pCi/g	6	6	6.0E-01	8.8E-01	1.0E+00	1.0E+00
	Thallium-208	pCi/g	6	6	2.9E-01	4.1E-01	4.9E-01	4.7E-01
Graduation Canyon (Part of Pueblo/Acid Canyon)	Aluminum	mg/kg	8	8	3.6E+03	4.8E+03	6.6E+03	5.6E+03
	Americium-241	pCi/g	8	8	1.5E-02	2.2E-02	2.5E-02	2.4E-02
	Antimony	mg/kg	6	8	2.7E-01	4.6E-01	6.5E-01	6.0E-01
	Arsenic	mg/kg	7	8	1.1E+00	2.1E+00	3.2E+00	2.7E+00
	Barium	mg/kg	8	8	4.6E+01	8.5E+01	1.2E+02	1.0E+02
	Beryllium	mg/kg	8	8	3.9E-01	4.9E-01	5.5E-01	5.3E-01
	Cadmium	mg/kg	4	8	7.2E-01	8.5E-01	9.5E-01	9.5E-01
	Calcium	mg/kg	8	8	3.0E+03	4.8E+03	6.9E+03	6.0E+03
	Cesium-137	pCi/g	5	8	7.3E-01	1.5E+00	1.8E+00	1.9E+00
	Chromium, Total	mg/kg	8	8	3.0E+00	5.0E+00	7.2E+00	6.1E+00
	Cobalt	mg/kg	2	8	2.4E+00	3.0E+00	3.5E+00	4.1E+00
	Copper	mg/kg	8	8	4.4E+00	7.6E+00	1.6E+01	1.0E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Graduation Canyon (Part of Pueblo/Acid Canyon) (Cont.)	Iron	mg/kg	8	8	4.5E+03	6.2E+03	8.1E+03	7.0E+03
	Lead	mg/kg	8	8	2.0E+01	3.2E+01	4.7E+01	3.9E+01
	Lithium	mg/kg	8	8	2.8E+00	4.4E+00	5.6E+00	5.0E+00
	Magnesium	mg/kg	8	8	8.2E+02	1.2E+03	1.7E+03	1.4E+03
	Manganese	mg/kg	8	8	2.2E+02	3.1E+02	4.0E+02	3.5E+02
	Nickel	mg/kg	4	8	3.5E+00	4.6E+00	5.8E+00	5.5E+00
	Plutonium-239	pCi/g	8	8	1.7E-01	3.8E-01	6.2E-01	4.8E-01
	Potassium	mg/kg	8	8	4.9E+02	1.0E+03	1.6E+03	1.3E+03
	Selenium	mg/kg	1	8	6.4E-01	6.4E-01	6.4E-01	
	Strontium	mg/kg	8	8	1.7E+01	2.5E+01	4.0E+01	3.1E+01
	Tritium	pCi/g	7	8	1.1E-01	3.1E-01	7.9E-01	4.8E-01
	Uranium-234	pCi/g	8	8	1.9E+00	2.2E+00	2.8E+00	2.4E+00
	Uranium-238	pCi/g	8	8	1.8E+00	2.3E+00	3.0E+00	2.5E+00
	Vanadium	mg/kg	8	8	5.2E+00	9.2E+00	1.3E+01	1.1E+01
	Zinc	mg/kg	8	8	3.7E+01	4.9E+01	6.6E+01	5.6E+01
Los Alamos Canyon	Actinium-228	pCi/g	24	34	9.2E-01	1.6E+00	2.0E+00	1.7E+00
	Aluminum	mg/kg	133	145	3.7E+02	4.1E+03	2.7E+04	4.7E+03
	Americium-241	pCi/g	49	121	7.0E-03	3.2E-01	3.3E+00	5.2E-01
	Antimony	mg/kg	55	421	4.0E-02	2.1E+01	1.1E+02	3.0E+01
	Arsenic	mg/kg	277	416	2.6E-01	1.9E+00	1.8E+01	2.1E+00
	Barium	mg/kg	368	382	5.8E+00	8.0E+01	9.2E+02	8.9E+01
	Beryllium	mg/kg	163	383	4.0E-02	1.2E+00	1.0E+01	1.4E+00
	Bismuth-211	pCi/g	12	33	6.5E-01	9.4E-01	1.8E+00	1.1E+00
	Bismuth-214	pCi/g	18	34	8.4E-01	1.3E+00	2.1E+00	1.5E+00
	Boron	mg/kg	1	21	1.4E+00	1.4E+00	1.4E+00	
	Cadmium	mg/kg	51	383	5.0E-02	7.7E-01	5.6E+00	1.0E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Los Alamos Canyon (Cont.)	Calcium	mg/kg	129	145	3.1E+02	2.5E+03	2.2E+04	3.0E+03
	Cesium-137	pCi/g	78	147	8.2E-02	3.1E+00	4.5E+01	4.5E+00
	Chromium, Total	mg/kg	334	411	3.8E-01	2.9E+01	4.4E+02	3.7E+01
	Cobalt	mg/kg	102	145	5.2E-01	3.0E+00	1.6E+01	3.3E+00
	Cobalt-60	pCi/g	7	74	1.8E-01	7.4E-01	1.8E+00	1.3E+00
	Copper	mg/kg	123	145	1.6E+00	9.1E+00	1.7E+02	1.2E+01
	Europium-152	pCi/g	2	53	2.5E-01	3.2E-01	3.8E-01	4.5E-01
	Iron	mg/kg	132	144	2.1E+03	6.5E+03	2.2E+04	7.0E+03
	Lead	mg/kg	370	418	1.9E+00	5.2E+01	1.6E+03	6.4E+01
	Lead-210	pCi/g	1	12	7.9E+00	7.9E+00	7.9E+00	
	Lead-212	pCi/g	33	35	4.3E-01	1.5E+00	2.3E+00	1.6E+00
	Lead-214	pCi/g	22	35	7.1E-01	1.2E+00	1.8E+00	1.3E+00
	Lithium	mg/kg	24	109	5.7E+00	1.4E+01	2.5E+01	1.7E+01
	Magnesium	mg/kg	130	145	2.2E+02	8.9E+02	3.9E+03	9.9E+02
	Manganese	mg/kg	145	145	1.0E+02	2.6E+02	1.3E+03	2.8E+02
	Mercury	mg/kg	218	331	1.0E-04	1.9E+01	6.4E+02	2.8E+01
	Nickel	mg/kg	116	383	1.2E+00	8.0E+00	3.9E+01	9.4E+00
	Plutonium-238	pCi/g	107	451	5.0E-03	1.5E+00	4.4E+01	2.7E+00
	Plutonium-239	pCi/g	304	385	1.4E-02	9.7E+01	7.3E+03	1.6E+02
	Potassium	mg/kg	112	145	1.8E+02	8.3E+02	2.6E+03	9.0E+02
	Potassium-40	pCi/g	66	67	1.7E+01	2.6E+01	3.4E+01	2.7E+01
	Radium-224	pCi/g	1	33	1.4E+00	1.4E+00	1.4E+00	
	Radium-226	pCi/g	14	34	1.1E+00	1.8E+00	6.2E+00	2.5E+00
	Selenium	mg/kg	56	417	1.2E-01	2.7E+01	7.0E+01	3.3E+01
	Silicon	mg/kg	3	7	5.8E+01	6.9E+01	8.3E+01	8.4E+01
	Silver	mg/kg	34	383	5.2E-01	1.6E+01	1.5E+02	2.5E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Los Alamos Canyon (Cont.)	Sodium	mg/kg	82	144	2.8E+01	1.3E+02	5.7E+02	1.5E+02
	Strontium	mg/kg	98	109	4.8E+00	2.3E+01	1.3E+02	2.8E+01
	Strontium-90	pCi/g	4	122	1.8E-01	3.5E+00	1.2E+01	9.1E+00
	Thallium	mg/kg	21	392	2.0E-01	3.8E+01	1.7E+02	6.2E+01
	Thallium-208	pCi/g	29	34	2.8E-01	4.9E-01	8.1E-01	5.4E-01
	Thorium-228	pCi/g	5	5	7.3E-01	1.5E+00	2.3E+00	2.0E+00
	Thorium-230	pCi/g	5	5	5.7E-01	1.4E+00	1.9E+00	1.8E+00
	Thorium-232	pCi/g	5	5	7.0E-01	1.5E+00	2.1E+00	1.9E+00
	Thorium-234	pCi/g	1	33	6.6E+00	6.6E+00	6.6E+00	
	Tritium	pCi/g	11	12	1.8E-02	8.9E-02	1.8E-01	1.2E-01
	Uranium	mg/kg	14	253	3.7E-01	1.2E+00	2.2E+00	1.5E+00
	Uranium-234	pCi/g	155	155	3.4E-01	2.7E+00	4.4E+01	3.5E+00
	Uranium-235	pCi/g	53	177	3.2E-02	2.4E-01	1.3E+00	3.2E-01
	Uranium-238	pCi/g	155	155	3.0E-01	2.7E+00	3.9E+01	3.5E+00
	Vanadium	mg/kg	139	145	2.4E+00	9.9E+00	5.9E+01	1.1E+01
	Zinc	mg/kg	141	145	1.3E+01	5.2E+01	3.7E+02	6.1E+01
Mortandad Canyon	Actinium-228	pCi/g	23	25	8.1E-01	1.5E+00	7.2E+00	2.0E+00
	Aluminum	mg/kg	74	74	5.0E+02	6.0E+03	5.0E+04	7.8E+03
	Americium-241	pCi/g	23	100	7.1E-03	5.9E+00	2.4E+01	9.1E+00
	Antimony	mg/kg	23	100	8.5E-02	4.8E-01	1.6E+00	6.3E-01
	Arsenic	mg/kg	82	100	4.8E-01	2.0E+00	5.2E+00	2.2E+00
	Barium	mg/kg	102	102	1.1E+01	1.7E+02	4.6E+03	2.8E+02
	Beryllium	mg/kg	60	102	1.6E-01	1.4E+00	4.8E+01	3.0E+00
	Bismuth-212	pCi/g	1	25	3.8E+00	3.8E+00	3.8E+00	
	Bismuth-214	pCi/g	23	25	7.2E-01	1.1E+00	6.5E+00	1.6E+00
	Cadmium	mg/kg	17	102	1.2E-01	4.5E+00	5.4E+01	1.1E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Mortandad Canyon (Cont.)	Cadmium-109	pCi/g	6	25	2.2E+00	2.7E+00	3.8E+00	3.2E+00
	Calcium	mg/kg	73	73	2.1E+02	2.4E+03	5.7E+04	3.9E+03
	Cesium-137	pCi/g	49	79	4.7E-02	9.4E+00	7.8E+01	1.4E+01
	Chromium, Hexavalent	mg/kg	1	1	5.9E+00	5.9E+00	5.9E+00	
	Chromium, Total	mg/kg	90	102	8.8E-01	1.9E+01	4.5E+02	3.2E+01
	Cobalt	mg/kg	49	72	7.0E-01	2.4E+00	5.0E+00	2.7E+00
	Cobalt-60	pCi/g	14	79	9.3E-01	1.9E+00	3.2E+00	2.3E+00
	Copper	mg/kg	61	74	8.3E-01	2.7E+02	5.4E+03	5.2E+02
	Iron	mg/kg	74	74	1.4E+03	7.8E+03	5.0E+04	9.6E+03
	Lead	mg/kg	85	100	3.0E+00	4.4E+01	1.0E+03	7.5E+01
	Lead-212	pCi/g	25	25	1.1E+00	1.6E+00	8.2E+00	2.1E+00
	Lead-214	pCi/g	23	25	7.1E-01	1.2E+00	5.7E+00	1.6E+00
	Lithium	mg/kg	12	12	3.0E+00	7.0E+00	1.4E+01	9.4E+00
	Magnesium	mg/kg	73	73	1.3E+02	1.0E+03	8.8E+03	1.3E+03
	Manganese	mg/kg	74	74	5.9E+01	2.4E+02	1.6E+03	2.9E+02
	Mercury	mg/kg	16	63	4.0E-02	8.6E+00	4.6E+01	1.6E+01
	Molybdenum	mg/kg	2	12	1.8E+00	2.5E+00	3.2E+00	3.9E+00
	Nickel	mg/kg	86	102	1.3E+00	1.1E+01	5.3E+02	2.3E+01
	Plutonium-238	pCi/g	73	122	2.0E-03	1.3E+00	8.4E+00	1.9E+00
	Plutonium-239	pCi/g	76	108	5.0E-03	3.6E+00	2.8E+01	5.0E+00
	Potassium	mg/kg	74	74	1.5E+02	8.3E+02	5.6E+03	1.0E+03
	Potassium-40	pCi/g	54	54	2.1E+01	3.3E+01	2.2E+02	4.0E+01
	Protactinium-231	pCi/g	1	25	3.5E+00	3.5E+00	3.5E+00	
	Radium-224	pCi/g	3	25	1.7E+00	4.4E+00	8.9E+00	8.9E+00
	Radium-226	pCi/g	18	53	1.7E+00	2.8E+00	4.6E+00	3.1E+00
	Selenium	mg/kg	7	100	5.5E-01	8.0E-01	1.2E+00	9.8E-01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Mortandad Canyon (Cont.)	Silver	mg/kg	1	102	1.5E-01	1.5E-01	1.5E-01	
	Sodium	mg/kg	41	73	8.3E-01	1.7E+02	4.6E+02	2.0E+02
	Strontium	mg/kg	12	12	4.2E+00	2.3E+01	1.4E+02	4.5E+01
	Strontium-90	pCi/g	13	43	1.2E+00	2.0E+00	5.1E+00	2.6E+00
	Thallium	mg/kg	30	100	2.0E-02	1.1E-01	4.0E-01	1.4E-01
	Thallium-208	pCi/g	19	25	3.2E-01	5.9E-01	3.3E+00	9.0E-01
	Thorium-228	pCi/g	59	60	5.3E-01	1.2E+00	2.0E+00	1.3E+00
	Thorium-230	pCi/g	61	61	4.0E-01	9.4E-01	3.9E+00	1.1E+00
	Thorium-232	pCi/g	63	89	6.5E-01	1.3E+00	4.4E+00	1.5E+00
	Tritium	pCi/g	28	29	5.2E-02	8.6E+00	9.8E+01	1.7E+01
	Uranium-234	pCi/g	122	128	3.2E-01	1.7E+00	2.6E+01	2.1E+00
	Uranium-235	pCi/g	23	141	2.0E-02	1.3E-01	4.0E-01	1.7E-01
	Uranium-238	pCi/g	121	156	1.4E-01	1.7E+00	2.6E+01	2.2E+00
	Vanadium	mg/kg	74	74	1.1E+00	1.8E+01	6.0E+02	3.5E+01
	Zinc	mg/kg	74	74	7.4E+00	6.4E+01	1.2E+03	1.0E+02
Pajarito Canyon	Actinium-228	pCi/g	13	17	5.9E-01	1.0E+00	1.7E+00	1.2E+00
	Aluminum	mg/kg	118	118	5.4E+02	6.1E+03	2.6E+04	7.0E+03
	Antimony	mg/kg	3	117	1.8E+01	1.0E+02	2.7E+02	2.7E+02
	Arsenic	mg/kg	59	118	7.8E-01	5.8E+00	1.1E+02	9.6E+00
	Barium	mg/kg	109	118	2.4E+01	2.1E+02	2.1E+03	2.9E+02
	Beryllium	mg/kg	16	118	4.5E-01	7.9E-01	1.3E+00	9.5E-01
	Bismuth-211	pCi/g	4	17	6.1E-01	1.0E+00	1.6E+00	1.5E+00
	Bismuth-212	pCi/g	2	17	1.6E+00	2.1E+00	2.6E+00	3.1E+00
	Bismuth-214	pCi/g	14	17	1.6E-01	7.8E-01	2.4E+00	1.1E+00
	Cadmium	mg/kg	46	118	1.2E-01	5.0E+00	2.6E+01	6.7E+00
	Calcium	mg/kg	110	118	8.6E+02	6.8E+03	1.2E+05	1.0E+04

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Pajarito Canyon (Cont.)	Cesium-137	pCi/g	22	31	7.1E-02	4.2E-01	1.9E+00	6.0E-01
	Chromium, Total	mg/kg	113	119	1.7E+00	9.1E+00	7.3E+01	1.1E+01
	Cobalt	mg/kg	18	118	1.1E+00	8.1E+00	2.5E+01	1.2E+01
	Cobalt-60	pCi/g	1	28	1.5E-01	1.5E-01	1.5E-01	
	Copper	mg/kg	92	118	2.7E+00	2.9E+02	1.0E+04	5.5E+02
	Cyanide, Total	mg/kg	10	40	5.2E-01	9.5E-01	4.2E+00	1.7E+00
	Iron	mg/kg	118	118	4.9E+02	1.2E+04	8.9E+04	1.4E+04
	Lead	mg/kg	117	117	3.1E+00	3.9E+02	1.2E+04	7.1E+02
	Lead-212	pCi/g	14	17	3.8E-01	1.0E+00	1.6E+00	1.2E+00
	Lead-214	pCi/g	12	17	4.1E-01	7.7E-01	1.1E+00	8.8E-01
	Magnesium	mg/kg	73	117	4.9E+02	2.0E+03	1.0E+04	2.4E+03
	Manganese	mg/kg	117	117	3.6E+00	3.5E+02	1.3E+03	3.9E+02
	Mercury	mg/kg	18	165	8.0E-02	2.0E+00	2.9E+01	5.1E+00
	Nickel	mg/kg	34	117	2.3E+00	2.3E+01	8.6E+01	3.1E+01
	Plutonium-238	pCi/g	8	18	1.0E-02	1.9E-01	1.0E+00	4.2E-01
	Plutonium-239	pCi/g	8	18	1.0E-02	1.1E-01	7.0E-01	2.8E-01
	Potassium	mg/kg	84	117	4.4E+02	1.4E+03	3.2E+03	1.6E+03
	Potassium-40	pCi/g	21	24	1.4E+01	2.5E+01	4.0E+01	2.8E+01
	Protactinium-234M	pCi/g	1	17	9.8E+00	9.8E+00	9.8E+00	
	Radium-224	pCi/g	12	17	1.2E+00	2.4E+00	5.8E+00	3.4E+00
	Radium-226	pCi/g	9	17	1.2E+00	2.0E+00	2.8E+00	2.3E+00
	Selenium	mg/kg	3	117	8.3E-01	1.2E+00	1.7E+00	1.7E+00
	Silver	mg/kg	23	119	1.0E+00	4.4E+01	1.8E+02	6.5E+01
	Sodium	mg/kg	12	117	7.4E+01	4.7E+02	1.5E+03	6.8E+02
	Sodium-22	pCi/g	1	28	1.3E-02	1.3E-02	1.3E-02	
	Strontium-90	pCi/g	2	15	6.7E-01	1.6E+00	2.5E+00	3.3E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Pajarito Canyon (Cont.)	Thallium-208	pCi/g	13	17	2.6E-01	3.6E-01	5.2E-01	4.0E-01
	Thorium-227	pCi/g	3	17	8.1E-01	9.0E-01	9.6E-01	9.8E-01
	Thorium-228	pCi/g	34	34	5.3E-02	1.1E+00	2.5E+00	1.3E+00
	Thorium-230	pCi/g	32	34	7.1E-02	1.2E+00	5.6E+00	1.6E+00
	Thorium-232	pCi/g	34	34	7.4E-02	1.1E+00	2.5E+00	1.3E+00
	Uranium	mg/kg	8	69	2.2E+00	3.3E+00	5.0E+00	4.0E+00
	Uranium-234	pCi/g	5	5	5.2E-01	3.1E+01	1.5E+02	9.1E+01
	Uranium-235	pCi/g	5	22	2.9E-02	1.4E+00	7.0E+00	4.2E+00
	Uranium-238	pCi/g	5	5	5.3E-01	3.1E+01	1.5E+02	9.0E+01
	Vanadium	mg/kg	71	117	3.7E+00	1.6E+01	3.6E+01	1.8E+01
	Zinc	mg/kg	117	117	1.1E+01	2.6E+02	4.6E+03	3.8E+02
Pueblo Canyon (Part of Pueblo/ Acid Canyon)	Actinium-228	pCi/g	6	7	8.2E-01	1.6E+00	2.1E+00	2.0E+00
	Aluminum	mg/kg	7	7	8.8E+02	3.1E+03	4.8E+03	3.9E+03
	Arsenic	mg/kg	5	7	1.5E+00	1.8E+00	2.6E+00	2.2E+00
	Barium	mg/kg	7	7	1.5E+01	4.8E+01	8.9E+01	6.5E+01
	Beryllium	mg/kg	5	7	6.0E-01	7.0E-01	7.6E-01	7.6E-01
	Bismuth-214	pCi/g	6	7	1.0E+00	1.4E+00	2.1E+00	1.7E+00
	Cadmium-109	pCi/g	2	7	6.5E+00	6.7E+00	6.9E+00	7.0E+00
	Calcium	mg/kg	7	7	3.7E+02	1.5E+03	3.6E+03	2.2E+03
	Cesium-137	pCi/g	2	7	3.3E-01	4.5E-01	5.6E-01	6.8E-01
	Chromium, Total	mg/kg	7	7	1.3E+00	3.2E+00	5.3E+00	4.1E+00
	Cobalt	mg/kg	7	7	1.3E+00	2.3E+00	3.3E+00	2.8E+00
	Copper	mg/kg	7	7	3.9E+00	7.0E+00	9.7E+00	8.8E+00
	Iron	mg/kg	7	7	4.4E+03	6.0E+03	7.4E+03	6.8E+03
	Lead	mg/kg	7	7	6.4E+00	1.5E+01	2.4E+01	2.0E+01
	Lead-212	pCi/g	7	7	6.0E-01	1.6E+00	2.4E+00	2.1E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Pueblo Canyon (Part of Pueblo/ Acid Canyon) (Cont.)	Lead-214	pCi/g	7	7	4.2E-01	1.3E+00	2.2E+00	1.8E+00
	Magnesium	mg/kg	7	7	2.2E+02	6.7E+02	1.2E+03	8.8E+02
	Manganese	mg/kg	7	7	1.6E+02	2.6E+02	3.4E+02	3.0E+02
	Mercury	mg/kg	1	7	1.5E-01	1.5E-01	1.5E-01	
	Nickel	mg/kg	5	7	2.8E+00	3.6E+00	5.0E+00	4.4E+00
	Plutonium-238	pCi/g	1	51	2.0E-01	2.0E-01	2.0E-01	
	Plutonium-239	pCi/g	7	8	2.3E-01	1.1E+01	4.7E+01	2.4E+01
	Potassium	mg/kg	7	7	2.4E+02	8.3E+02	1.3E+03	1.1E+03
	Potassium-40	pCi/g	7	7	2.2E+01	2.6E+01	2.9E+01	2.8E+01
	Radium-226	pCi/g	2	6	3.6E+00	4.3E+00	5.1E+00	5.8E+00
	Selenium	mg/kg	4	7	5.0E-01	6.9E-01	9.8E-01	8.9E-01
	Sodium	mg/kg	2	7	1.5E+02	1.5E+02	1.5E+02	1.6E+02
	Thallium-208	pCi/g	6	7	3.7E-01	5.2E-01	7.6E-01	6.2E-01
	Vanadium	mg/kg	7	7	5.5E+00	7.6E+00	1.2E+01	9.1E+00
	Zinc	mg/kg	7	7	2.8E+01	3.5E+01	4.4E+01	3.9E+01
Rendija Canyon (Part of Guaje Canyon)	Aluminum	mg/kg	5	5	2.5E+03	6.3E+03	1.4E+04	1.1E+04
	Arsenic	mg/kg	3	5	1.1E+00	2.4E+00	3.9E+00	4.0E+00
	Barium	mg/kg	5	5	2.1E+01	5.6E+01	1.2E+02	9.9E+01
	Beryllium	mg/kg	5	5	2.0E-01	5.2E-01	1.0E+00	8.2E-01
	Calcium	mg/kg	5	5	1.0E+03	1.6E+03	2.2E+03	2.1E+03
	Chromium, Total	mg/kg	4	5	1.8E+00	6.0E+00	1.1E+01	1.1E+01
	Cobalt	mg/kg	2	5	5.0E+00	5.5E+00	6.0E+00	6.5E+00
	Copper	mg/kg	11	11	1.7E+00	4.4E+00	7.2E+00	5.5E+00
	Iron	mg/kg	5	5	2.6E+03	6.1E+03	1.2E+04	9.8E+03
	Lead	mg/kg	6	11	1.6E+00	8.2E+00	1.7E+01	1.3E+01
	Magnesium	mg/kg	5	5	5.7E+02	1.2E+03	2.4E+03	1.9E+03

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Rendija Canyon (Part of Guaje Canyon) (Cont.)	Manganese	mg/kg	5	5	6.7E+01	1.9E+02	3.4E+02	3.1E+02
	Nickel	mg/kg	2	5	7.6E+00	8.8E+00	1.0E+01	1.1E+01
	Potassium	mg/kg	5	5	3.3E+02	9.4E+02	1.9E+03	1.5E+03
	Selenium	mg/kg	1	5	8.0E-01	8.0E-01	8.0E-01	
	Sodium	mg/kg	5	5	8.1E+01	2.3E+02	4.3E+02	3.9E+02
	Vanadium	mg/kg	5	5	4.0E+00	1.0E+01	2.2E+01	1.8E+01
	Zinc	mg/kg	11	11	1.8E+01	3.1E+01	8.0E+01	4.2E+01
Rio Grande	Aluminum	mg/kg	6	6	3.0E+03	4.4E+03	6.9E+03	5.5E+03
	Arsenic	mg/kg	3	6	2.6E+00	1.8E+01	3.0E+01	3.4E+01
	Barium	mg/kg	6	6	5.4E+01	2.4E+02	5.3E+02	4.2E+02
	Cadmium	mg/kg	3	6	2.2E+00	2.6E+00	3.1E+00	3.1E+00
	Calcium	mg/kg	5	6	1.1E+03	2.4E+03	3.7E+03	3.5E+03
	Chromium, Total	mg/kg	5	6	2.6E+00	3.3E+00	3.9E+00	3.7E+00
	Copper	mg/kg	3	6	5.6E+00	6.5E+00	7.2E+00	7.4E+00
	Iron	mg/kg	6	6	4.0E+03	6.0E+03	8.2E+03	7.1E+03
	Lead	mg/kg	6	6	7.6E+00	5.5E+01	1.9E+02	1.1E+02
	Magnesium	mg/kg	1	6	1.3E+03	1.3E+03	1.3E+03	
	Manganese	mg/kg	6	6	2.5E+02	4.1E+02	8.6E+02	6.1E+02
	Mercury	mg/kg	3	6	4.3E-01	7.4E-01	1.1E+00	1.1E+00
	Potassium	mg/kg	1	6	1.4E+03	1.4E+03	1.4E+03	
	Zinc	mg/kg	6	6	3.5E+01	4.1E+01	5.2E+01	4.6E+01
Sandia Canyon	Actinium-228	pCi/g	12	13	1.1E+00	1.6E+00	2.1E+00	1.8E+00
	Aluminum	mg/kg	105	105	5.9E+02	5.8E+03	1.5E+04	6.2E+03
	Americium-241	pCi/g	1	60	6.8E-02	6.8E-02	6.8E-02	
	Antimony	mg/kg	37	135	3.0E-02	5.4E-01	5.5E+00	9.2E-01
	Arsenic	mg/kg	79	132	4.8E-01	3.5E+00	1.9E+01	4.1E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Sandia Canyon (Cont.)	Barium	mg/kg	117	132	2.3E+01	9.9E+01	3.4E+02	1.1E+02
	Beryllium	mg/kg	76	133	1.2E-01	6.9E-01	2.3E+00	7.8E-01
	Bismuth-211	pCi/g	8	13	3.6E+00	4.2E+00	4.9E+00	4.5E+00
	Bismuth-212	pCi/g	1	8	1.9E+00	1.9E+00	1.9E+00	
	Bismuth-214	pCi/g	11	13	1.2E+00	1.5E+00	2.2E+00	1.7E+00
	Cadmium	mg/kg	54	132	1.4E-01	3.2E+00	3.0E+01	4.5E+00
	Cadmium-109	pCi/g	3	4	1.7E+00	3.6E+00	4.7E+00	5.6E+00
	Calcium	mg/kg	97	105	5.5E+02	3.1E+03	1.6E+04	3.6E+03
	Cesium-137	pCi/g	40	87	6.7E-02	4.0E-01	2.4E+00	5.5E-01
	Chromium, Total	mg/kg	121	132	1.5E+00	2.2E+01	2.4E+02	3.0E+01
	Cobalt	mg/kg	51	105	9.5E-01	3.5E+00	7.2E+00	3.9E+00
	Cobalt-60	pCi/g	1	60	7.0E-02	7.0E-02	7.0E-02	
	Copper	mg/kg	106	124	1.8E+00	7.6E+01	5.7E+02	1.0E+02
	Cyanide, Total	mg/kg	5	25	9.3E-01	1.2E+01	3.4E+01	2.5E+01
	Europium-152	pCi/g	6	56	2.1E-01	3.0E-01	4.4E-01	3.7E-01
	Iron	mg/kg	104	104	2.9E+03	7.4E+03	1.7E+04	7.9E+03
	Lead	mg/kg	135	135	3.4E+00	7.1E+01	1.6E+03	1.1E+02
	Lead-212	pCi/g	12	13	9.6E-01	1.6E+00	1.9E+00	1.7E+00
	Lead-214	pCi/g	12	13	7.6E-01	1.7E+00	2.6E+00	2.0E+00
	Magnesium	mg/kg	79	105	4.9E+02	1.4E+03	3.6E+03	1.5E+03
	Manganese	mg/kg	124	124	5.4E+01	2.2E+02	1.4E+03	2.4E+02
	Mercury	mg/kg	85	155	2.4E-03	1.5E+02	5.7E+03	3.0E+02
	Nickel	mg/kg	68	132	2.5E+00	8.5E+00	4.4E+01	1.0E+01
	Plutonium-238	pCi/g	29	42	2.0E-03	4.1E-02	2.1E-01	6.2E-02
	Plutonium-239	pCi/g	32	36	5.0E-03	3.0E-01	1.4E+00	4.3E-01
	Potassium	mg/kg	62	105	3.1E+02	1.2E+03	2.0E+03	1.3E+03

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Sandia Canyon (Cont.)	Potassium-40	pCi/g	12	13	3.0E+01	3.3E+01	3.9E+01	3.5E+01
	Protactinium-234M	pCi/g	3	8	4.6E+01	5.4E+01	6.5E+01	6.5E+01
	Radium-226	pCi/g	7	10	8.7E-01	2.3E+00	4.4E+00	3.5E+00
	Selenium	mg/kg	29	132	1.6E-01	9.9E-01	2.6E+00	1.2E+00
	Silver	mg/kg	37	132	5.6E-01	2.6E+01	1.1E+02	3.6E+01
	Sodium	mg/kg	45	105	4.1E+01	1.9E+02	8.4E+02	2.4E+02
	Strontium-90	pCi/g	1	60	6.6E-01	6.6E-01	6.6E-01	
	Thallium	mg/kg	35	132	1.4E-01	4.5E-01	2.2E+00	5.7E-01
	Thallium-208	pCi/g	12	13	3.0E-01	5.2E-01	6.7E-01	5.8E-01
	Thorium-234	pCi/g	10	12	2.9E+00	1.0E+01	3.6E+01	1.8E+01
	Tritium	pCi/g	23	23	3.2E-02	8.3E+01	5.6E+02	1.6E+02
	Tritium		6	0				
	Uranium	mg/kg	47	48	1.5E+00	6.0E+00	6.9E+01	9.8E+00
	Uranium-234	pCi/g	67	69	4.8E-01	2.3E+00	3.5E+01	3.7E+00
	Uranium-235	pCi/g	46	73	1.1E-02	2.8E-01	2.0E+00	4.3E-01
	Uranium-238	mg/kg	1	1	5.3E-04	5.3E-04	5.3E-04	
	Uranium-238	pCi/g	64	68	5.0E-01	1.1E+00	2.6E+00	1.3E+00
	Vanadium	mg/kg	93	124	4.3E+00	1.7E+01	3.4E+01	1.8E+01
	Zinc	mg/kg	124	124	2.2E-02	1.2E+02	8.4E+02	1.5E+02
Starmer's Gulch (Part of Pajarito Canyon)	Aluminum	mg/kg	37	37	4.4E+03	7.7E+03	1.6E+04	8.5E+03
	Arsenic	mg/kg	16	37	2.2E+00	7.3E+00	2.1E+01	1.0E+01
	Barium	mg/kg	43	47	4.7E+01	1.9E+02	5.3E+02	2.2E+02
	Beryllium	mg/kg	10	47	1.9E-01	3.4E-01	5.0E-01	4.0E-01
	Cadmium	mg/kg	13	49	1.6E+00	1.5E+01	4.3E+01	2.2E+01
	Calcium	mg/kg	34	37	1.2E+03	2.7E+03	8.4E+03	3.4E+03
	Cesium-137	pCi/g	4	5	1.6E-01	2.9E-01	4.0E-01	4.0E-01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Starmer's Gulch (Part of Pajarito Canyon) (Cont.)	Chromium, Hexavalent	mg/kg	2	5	1.7E-01	1.8E-01	1.9E-01	2.0E-01
	Chromium, Total	mg/kg	49	49	3.5E+00	6.0E+01	5.9E+02	9.7E+01
	Cobalt	mg/kg	7	37	3.1E+00	8.8E+00	1.7E+01	1.3E+01
	Copper	mg/kg	35	37	6.0E+00	1.1E+03	1.2E+04	2.0E+03
	Cyanide, Total	mg/kg	3	21	1.0E+00	1.1E+00	1.1E+00	1.1E+00
	Iron	mg/kg	37	37	6.4E+03	1.2E+04	5.2E+04	1.5E+04
	Lead	mg/kg	43	49	7.6E+00	6.7E+01	4.2E+02	9.3E+01
	Magnesium	mg/kg	31	37	7.0E+02	1.4E+03	2.7E+03	1.6E+03
	Manganese	mg/kg	37	37	8.2E+01	3.5E+02	9.9E+02	4.2E+02
	Mercury	mg/kg	9	47	4.0E-02	2.1E-01	5.6E-01	3.2E-01
	Nickel	mg/kg	10	37	1.4E+02	8.2E+02	1.5E+03	1.1E+03
	Platinum	mg/kg	5	5	1.7E+01	2.0E+01	2.2E+01	2.1E+01
	Potassium	mg/kg	27	37	6.9E+02	1.4E+03	2.8E+03	1.5E+03
	Silver	mg/kg	14	39	2.5E+00	1.2E+01	3.4E+01	1.7E+01
	Sodium	mg/kg	6	37	1.0E+02	1.3E+02	1.6E+02	1.5E+02
	Strontium-90	pCi/g	6	9	7.1E-01	1.0E+00	1.7E+00	1.4E+00
	Thallium	mg/kg	1	37	1.9E+00	1.9E+00	1.9E+00	
	Vanadium	mg/kg	36	37	1.3E+01	2.3E+01	8.8E+01	2.8E+01
	Zinc	mg/kg	36	37	2.2E+01	8.0E+01	2.1E+02	9.8E+01
Ten-Site Canyon (Part of Mortandad Canyon)	Actinium-228	pCi/g	37	61	4.2E-01	1.4E+00	2.2E+00	1.5E+00
	Aluminum	mg/kg	108	108	1.6E+02	5.1E+03	1.5E+04	5.9E+03
	Americium-241	pCi/g	55	356	8.0E-03	3.6E+00	1.7E+02	9.8E+00
	Antimony	mg/kg	23	266	3.0E-02	8.1E-01	8.2E+00	1.7E+00
	Arsenic	mg/kg	215	267	2.4E-01	2.3E+00	1.2E+01	2.5E+00
	Barium	mg/kg	249	266	5.4E-01	8.9E+01	8.0E+02	9.8E+01
	Beryllium	mg/kg	212	266	6.0E-02	1.4E+00	1.5E+02	2.8E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ten-Site Canyon (Part of Mortandad Canyon) (Cont.)	Bismuth-211	pCi/g	7	61	1.6E+00	2.6E+00	3.7E+00	3.3E+00
	Bismuth-214	pCi/g	43	61	4.8E-01	9.1E-01	1.3E+00	9.8E-01
	Cadmium	mg/kg	42	266	3.6E-02	7.6E+00	1.7E+02	1.7E+01
	Calcium	mg/kg	107	108	1.6E+02	2.5E+03	1.1E+04	2.8E+03
	Cesium-137	pCi/g	58	292	1.2E-01	3.3E+00	7.3E+01	6.7E+00
	Chromium, Hexavalent	mg/kg	2	5	9.8E-01	1.7E+00	2.5E+00	3.3E+00
	Chromium, Total	mg/kg	256	267	1.1E+00	1.2E+01	8.1E+02	1.9E+01
	Cobalt	mg/kg	62	108	3.3E-01	3.2E+00	1.1E+01	3.6E+00
	Cobalt-60	pCi/g	8	292	1.0E-01	6.9E-01	1.5E+00	1.1E+00
	Copper	mg/kg	100	108	1.1E+00	2.6E+01	4.3E+02	3.7E+01
	Europium-152	pCi/g	3	134	3.6E-01	4.2E-01	4.7E-01	4.8E-01
	Iron	mg/kg	108	108	4.6E+02	6.6E+03	1.5E+04	7.3E+03
	Lead	mg/kg	249	272	1.1E+00	1.5E+01	9.8E+01	1.6E+01
	Lead-210	pCi/g	3	19	3.2E+00	4.7E+00	5.6E+00	6.3E+00
	Lead-212	pCi/g	59	62	1.9E-01	1.3E+00	3.3E+00	1.4E+00
	Lead-214	pCi/g	49	62	4.0E-01	9.2E-01	1.5E+00	1.0E+00
	Lithium	mg/kg	2	4	6.5E+00	6.7E+00	6.8E+00	7.0E+00
	Magnesium	mg/kg	102	108	4.0E+01	1.0E+03	2.7E+03	1.1E+03
	Manganese	mg/kg	108	108	1.7E+00	1.8E+02	3.7E+02	1.9E+02
	Mercury	mg/kg	36	168	2.0E-02	4.2E-01	4.0E+00	6.7E-01
	Nickel	mg/kg	187	266	2.0E+00	1.2E+01	8.7E+02	2.1E+01
	Plutonium-238	pCi/g	114	328	3.0E-03	4.8E+01	5.2E+03	1.4E+02
	Plutonium-239	pCi/g	185	262	2.0E-03	3.4E+00	4.5E+02	8.3E+00
	Potassium	mg/kg	102	110	6.9E+01	9.4E+02	3.1E+03	1.1E+03
	Potassium-40	pCi/g	228	282	7.0E+00	2.7E+01	4.7E+01	2.8E+01
	Radium-224	pCi/g	7	61	4.6E+00	1.3E+01	1.5E+01	1.5E+01

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Ten-Site Canyon (Part of Mortandad Canyon) (Cont.)	Radium-226	pCi/g	55	223	1.5E+00	3.2E+00	6.7E+00	3.5E+00
	Ruthenium-106	pCi/g	1	132	5.6E-01	5.6E-01	5.6E-01	
	Selenium	mg/kg	18	267	2.3E-01	5.9E-01	1.0E+00	6.8E-01
	Silver	mg/kg	25	266	3.9E-01	2.8E+01	4.1E+02	6.1E+01
	Sodium	mg/kg	91	108	2.6E+01	1.5E+02	3.7E+02	1.7E+02
	Strontium	mg/kg	3	4	3.8E+00	1.1E+01	1.5E+01	1.8E+01
	Strontium-90	pCi/g	12	223	1.2E+00	1.1E+02	9.0E+02	2.6E+02
	Thallium	mg/kg	122	268	3.0E-02	1.4E+00	1.4E+02	3.7E+00
	Thallium-208	pCi/g	40	62	1.7E-01	5.3E-01	1.6E+00	6.3E-01
	Thorium-227	pCi/g	3	61	2.0E+00	2.1E+00	2.2E+00	2.2E+00
	Thorium-228	pCi/g	5	5	1.9E-01	4.7E-01	7.2E-01	7.0E-01
	Thorium-230	pCi/g	4	5	2.9E-01	6.3E-01	8.2E-01	8.7E-01
	Thorium-232	pCi/g	27	164	2.1E-01	2.9E+00	4.8E+00	3.4E+00
	Tritium	pCi/g	185	217	4.7E-03	2.0E+00	1.8E+02	4.1E+00
	Uranium-234	pCi/g	328	383	1.6E-01	1.4E+00	4.9E+01	1.8E+00
	Uranium-235	pCi/g	56	521	2.0E-02	1.4E-01	1.5E+00	2.1E-01
	Uranium-238	pCi/g	328	435	1.5E-01	1.2E+00	3.6E+00	1.2E+00
	Vanadium	mg/kg	94	108	8.6E-01	1.3E+01	6.9E+01	1.5E+01
	Zinc	mg/kg	105	105	3.9E+00	7.2E+01	7.5E+02	9.6E+01
Three-Mile Canyon (Part of Pajarito Canyon)	Actinium-228	pCi/g	2	2	1.5E+00	1.7E+00	1.8E+00	1.9E+00
	Aluminum	mg/kg	145	145	6.1E+02	6.1E+03	9.7E+04	7.5E+03
	Antimony	mg/kg	25	145	1.1E-01	3.1E+00	1.8E+01	5.5E+00
	Arsenic	mg/kg	59	145	1.7E+00	1.2E+01	5.2E+02	2.9E+01
	Barium	mg/kg	130	145	2.8E+01	1.1E+02	8.7E+02	1.3E+02
	Beryllium	mg/kg	67	146	3.2E-01	7.3E+00	1.0E+02	1.1E+01
	Bismuth-211	pCi/g	2	2	6.0E-01	1.1E+00	1.6E+00	2.0E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Three-Mile Canyon (Part of Pajarito Canyon) (Cont.)	Bismuth-212	pCi/g	1	2	2.3E+00	2.3E+00	2.3E+00	
	Bismuth-214	pCi/g	2	2	1.1E+00	1.2E+00	1.3E+00	1.3E+00
	Cadmium	mg/kg	38	145	1.3E-02	6.8E-01	2.7E+00	9.6E-01
	Calcium	mg/kg	138	145	5.3E+02	2.6E+03	2.0E+04	3.0E+03
	Cesium-137	pCi/g	12	17	6.4E-02	5.5E-01	2.5E+00	9.3E-01
	Chromium, Total	mg/kg	140	144	1.3E+00	2.4E+01	8.8E+02	3.9E+01
	Cobalt	mg/kg	31	145	1.8E+00	5.4E+00	1.3E+01	6.2E+00
	Copper	mg/kg	126	145	2.8E+00	4.7E+02	7.2E+03	6.7E+02
	Cyanide, Total	mg/kg	3	5	1.6E+00	4.5E+01	1.3E+02	1.3E+02
	Europium-152	pCi/g	1	14	2.6E-01	2.6E-01	2.6E-01	
	Iron	mg/kg	145	145	1.0E+03	8.4E+03	9.8E+04	9.9E+03
	Lead	mg/kg	146	147	2.4E+00	1.0E+03	1.3E+05	2.8E+03
	Lead-212	pCi/g	4	4	1.5E+00	1.6E+00	1.8E+00	1.7E+00
	Lead-214	pCi/g	4	4	8.8E-01	1.2E+00	1.4E+00	1.4E+00
	Magnesium	mg/kg	100	145	3.8E+02	1.2E+03	2.8E+03	1.3E+03
	Manganese	mg/kg	145	145	6.5E+01	2.7E+02	1.3E+03	3.0E+02
	Mercury	mg/kg	36	207	5.1E-03	3.9E-01	2.8E+00	6.4E-01
	Nickel	mg/kg	46	145	4.3E+00	2.9E+01	4.1E+02	5.0E+01
	Plutonium-238	pCi/g	5	10	9.0E-03	1.8E-02	3.0E-02	2.5E-02
	Plutonium-239	pCi/g	1	10	7.0E-03	7.0E-03	7.0E-03	
	Potassium	mg/kg	104	145	2.6E+02	1.1E+03	2.8E+03	1.2E+03
	Potassium-40	pCi/g	4	4	2.0E+01	2.5E+01	2.9E+01	2.9E+01
	Protactinium-231	pCi/g	1	17	4.9E+00	4.9E+00	4.9E+00	
	Protactinium-234	pCi/g	1	17	8.2E-01	8.2E-01	8.2E-01	
	Protactinium-234M	pCi/g	1	17	5.6E+02	5.6E+02	5.6E+02	
	Radium-224	pCi/g	2	2	2.1E+00	2.5E+00	2.9E+00	3.2E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Three-Mile Canyon (Part of Pajarito Canyon) (Cont.)	Radium-226	pCi/g	4	4	9.6E-01	1.6E+00	2.9E+00	2.5E+00
	Ruthenium-106	pCi/g	1	16	6.6E-01	6.6E-01	6.6E-01	
	Selenium	mg/kg	11	145	1.4E-01	9.5E-01	2.0E+00	1.3E+00
	Silver	mg/kg	14	145	3.1E+00	1.1E+02	4.1E+02	1.9E+02
	Sodium	mg/kg	25	145	5.4E+01	1.4E+02	7.8E+02	2.1E+02
	Thallium	mg/kg	3	145	2.0E-01	2.2E+00	4.6E+00	4.8E+00
	Thallium-208	pCi/g	3	3	4.5E-01	5.2E-01	6.0E-01	6.1E-01
	Thorium-228	pCi/g	29	29	1.8E-01	1.1E+00	3.0E+00	1.3E+00
	Thorium-230	pCi/g	44	44	1.2E-01	1.0E+00	1.8E+00	1.1E+00
	Thorium-231	pCi/g	1	15	9.0E-01	9.0E-01	9.0E-01	
	Thorium-232	pCi/g	29	29	1.4E-01	1.1E+00	2.4E+00	1.2E+00
	Thorium-234	pCi/g	15	17	2.9E+00	2.2E+01	2.8E+02	5.9E+01
	Tritium	pCi/g	27	32	3.9E-01	1.1E+01	3.8E+01	1.5E+01
	Uranium-234	pCi/g	20	20	9.1E-01	1.4E+00	1.8E+00	1.5E+00
	Uranium-235	pCi/g	8	22	4.1E-02	2.3E+00	1.7E+01	6.4E+00
	Uranium-238	pCi/g	11	20	8.6E-01	2.7E+01	2.6E+02	7.5E+01
	Vanadium	mg/kg	97	145	4.5E+00	1.2E+01	2.8E+01	1.4E+01
	Zinc	mg/kg	145	145	1.2E+01	9.5E+01	2.9E+03	1.4E+02
Two-Mile Canyon (Part of Pajarito Canyon)	Acetone	mg/kg	1	61	2.2E-02	2.2E-02	2.2E-02	
	Actinium-228	pCi/g	2	16	1.6E+00	1.8E+00	2.0E+00	2.2E+00
	Aluminum	mg/kg	267	267	1.2E+03	6.9E+03	2.5E+04	7.4E+03
	Antimony	mg/kg	19	273	1.0E-01	7.7E+00	2.3E+01	1.1E+01
	Arsenic	mg/kg	201	273	3.7E-01	5.5E+00	1.7E+02	7.5E+00
	Barium	mg/kg	254	273	2.8E+01	3.2E+02	1.6E+04	5.1E+02
	Beryllium	mg/kg	106	274	1.0E-01	6.4E-01	3.3E+00	7.2E-01
	Bismuth-214	pCi/g	1	16	1.5E+00	1.5E+00	1.5E+00	

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Two-Mile Canyon (Part of Pajarito Canyon) (Cont.)	Cadmium	mg/kg	82	273	5.0E-02	8.5E+00	1.4E+02	1.3E+01
	Calcium	mg/kg	249	267	6.1E+02	4.3E+03	1.9E+05	6.2E+03
	Cesium-137	pCi/g	119	159	3.9E-02	7.9E-01	5.4E+00	9.1E-01
	Chromium, Total	mg/kg	268	273	1.2E+00	5.0E+01	1.7E+03	7.3E+01
	Cobalt	mg/kg	110	267	7.7E-01	6.0E+00	2.3E+01	6.8E+00
	Copper	mg/kg	234	273	1.1E+00	5.5E+02	2.8E+04	8.9E+02
	Cyanide, Total	mg/kg	24	160	3.8E-01	2.0E+00	6.6E+00	2.8E+00
	Fluorine	mg/kg	12	12	2.0E+00	5.2E+00	1.1E+01	7.0E+00
	Gold	mg/kg	5	25	7.1E+00	7.0E+02	3.1E+03	1.9E+03
	Iron	mg/kg	267	267	1.4E+03	1.1E+04	2.2E+05	1.3E+04
	Lead	mg/kg	273	273	1.0E+00	1.1E+02	7.3E+03	1.8E+02
	Lead-212	pCi/g	4	16	7.8E-01	1.3E+00	1.7E+00	1.7E+00
	Lead-214	pCi/g	4	16	5.3E-01	1.0E+00	1.4E+00	1.3E+00
	Magnesium	mg/kg	218	267	3.8E+02	1.4E+03	4.3E+03	1.5E+03
	Manganese	mg/kg	273	273	1.7E+01	3.4E+02	4.0E+03	3.7E+02
	Mercury	mg/kg	39	278	5.0E-02	1.2E+01	1.2E+02	2.0E+01
	Nickel	mg/kg	147	273	1.4E+00	1.1E+02	1.6E+03	1.6E+02
	Platinum	mg/kg	17	25	1.4E+01	4.6E+01	1.9E+02	6.7E+01
	Plutonium-238	pCi/g	2	7	1.4E-02	2.1E-02	2.8E-02	3.5E-02
	Plutonium-239	pCi/g	5	7	3.8E-02	6.1E-01	1.6E+00	1.1E+00
	Potassium	mg/kg	195	267	1.0E+02	1.3E+03	3.1E+03	1.4E+03
	Potassium-40	pCi/g	5	19	3.3E+01	3.4E+01	3.6E+01	3.5E+01
	Radium-226	pCi/g	6	16	5.6E-01	1.0E+00	1.4E+00	1.3E+00
	Selenium	mg/kg	27	273	2.2E-01	9.5E-01	5.7E+00	1.3E+00
	Silver	mg/kg	55	273	1.4E+00	2.3E+01	2.7E+02	3.4E+01
	Sodium	mg/kg	103	267	3.3E+01	1.1E+02	8.0E+02	1.3E+02

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Two-Mile Canyon (Part of Pajarito Canyon)	Strontium-90	pCi/g	35	153	1.7E-01	9.8E-01	8.4E+00	1.5E+00
	Thallium	mg/kg	15	273	1.2E-01	2.9E-01	5.5E-01	3.7E-01
	Thallium-208	pCi/g	10	16	2.0E-01	5.0E-01	6.5E-01	5.8E-01
	Thorium-234	pCi/g	1	16	4.1E+00	4.1E+00	4.1E+00	
	Tritium	pCi/g	6	6	2.2E-02	1.2E+01	3.5E+01	2.4E+01
	Uranium	mg/kg	21	22	1.4E+00	4.5E+00	9.3E+00	5.6E+00
	Uranium-234	pCi/g	80	80	3.7E-01	1.1E+00	1.2E+01	1.4E+00
	Uranium-235	pCi/g	76	96	2.0E-02	4.9E-02	4.8E-01	6.0E-02
	Uranium-238	pCi/g	80	80	3.6E-01	1.2E+00	1.2E+01	1.4E+00
	Vanadium	mg/kg	230	273	3.5E+00	2.2E+01	2.3E+02	2.4E+01
	Zinc	mg/kg	269	273	4.9E+00	1.7E+02	1.5E+04	2.8E+02
Walnut Canyon (Part of Pueblo/ Acid Canyon)	Aluminum	mg/kg	5	5	1.7E+03	2.0E+03	2.6E+03	2.3E+03
	Americium-241	pCi/g	1	2	4.3E-01	4.3E-01	4.3E-01	
	Arsenic	mg/kg	5	5	1.1E+00	1.3E+00	1.6E+00	1.5E+00
	Barium	mg/kg	5	5	1.7E+01	3.1E+01	5.0E+01	4.4E+01
	Beryllium	mg/kg	2	5	1.9E-01	2.1E-01	2.2E-01	2.4E-01
	Cadmium	mg/kg	2	5	2.0E-01	2.1E-01	2.2E-01	2.3E-01
	Calcium	mg/kg	5	5	6.7E+02	9.9E+02	1.7E+03	1.4E+03
	Cesium-137	pCi/g	5	5	2.5E-01	3.6E-01	5.6E-01	4.8E-01
	Chromium, Total	mg/kg	4	5	3.1E+00	3.6E+00	4.9E+00	4.5E+00
	Cobalt	mg/kg	4	5	2.2E+00	3.0E+00	4.4E+00	3.9E+00
	Copper	mg/kg	2	2	6.7E+00	7.7E+00	8.7E+00	9.7E+00
	Iron	mg/kg	5	5	4.6E+03	6.4E+03	7.6E+03	7.5E+03
	Lead	mg/kg	5	5	2.5E+01	2.7E+01	3.2E+01	3.0E+01
	Magnesium	mg/kg	5	5	3.5E+02	4.5E+02	5.6E+02	5.3E+02
	Manganese	mg/kg	2	2	2.3E+02	3.3E+02	4.3E+02	5.3E+02

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Walnut Canyon (Part of Pueblo/ Acid Canyon) (Cont.)	Mercury	mg/kg	2	5	6.0E-02	1.9E-01	3.2E-01	4.5E-01
	Nickel	mg/kg	2	5	1.0E+00	1.1E+00	1.2E+00	1.3E+00
	Plutonium-238	pCi/g	1	16	1.4E-01	1.4E-01	1.4E-01	
	Plutonium-239	pCi/g	3	3	5.2E+00	6.8E+00	8.4E+00	8.7E+00
	Potassium	mg/kg	2	5	3.7E+02	4.8E+02	5.9E+02	7.0E+02
	Potassium-40	pCi/g	2	2	2.7E+01	2.8E+01	2.9E+01	3.0E+01
	Silver	mg/kg	1	5	6.7E-01	6.7E-01	6.7E-01	
	Sodium	mg/kg	5	5	3.8E+01	8.8E+01	1.4E+02	1.3E+02
	Tritium	pCi/g	2	6	2.2E-02	2.3E-02	2.4E-02	2.5E-02
	Uranium-234	pCi/g	3	3	4.8E-01	6.1E-01	7.4E-01	7.6E-01
	Uranium-238	pCi/g	3	3	5.0E-01	5.1E-01	5.5E-01	5.5E-01
	Vanadium	mg/kg	5	5	5.6E+00	7.8E+00	9.2E+00	9.1E+00
	Zinc	mg/kg	5	5	3.4E+01	4.5E+01	5.8E+01	5.4E+01
Water Canyon	Actinium-228	pCi/g	17	24	5.8E-01	1.6E+00	2.5E+00	1.8E+00
	Aluminum	mg/kg	587	587	9.1E+02	7.9E+03	3.4E+04	8.3E+03
	Americium-241	pCi/g	3	112	2.0E-01	3.3E+00	5.8E+00	6.6E+00
	Antimony	mg/kg	118	587	3.8E-02	1.3E+00	1.4E+01	1.7E+00
	Arsenic	mg/kg	494	587	4.4E-01	2.7E+00	2.1E+01	2.8E+00
	Barium	mg/kg	564	587	2.4E+00	1.2E+03	3.8E+04	1.5E+03
	Beryllium	mg/kg	401	614	1.1E-01	1.7E+00	2.6E+02	3.0E+00
	Bismuth-211	pCi/g	8	18	3.1E-01	2.4E+00	3.9E+00	3.4E+00
	Bismuth-212	pCi/g	3	19	1.0E+00	1.2E+00	1.6E+00	1.6E+00
	Bismuth-214	pCi/g	13	20	1.2E-01	1.4E+00	3.4E+00	1.9E+00
	Cadmium	mg/kg	168	586	1.9E-02	1.0E+00	1.3E+01	1.2E+00
	Cadmium-109	pCi/g	1	10	4.9E+00	4.9E+00	4.9E+00	
	Calcium	mg/kg	556	587	3.1E+02	2.6E+03	3.9E+04	2.9E+03

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Water Canyon (Cont.)	Cesium-137	pCi/g	89	129	5.9E-02	5.2E-01	3.3E+00	6.4E-01
	Chromium, Total	mg/kg	571	587	7.6E-01	9.5E+00	4.1E+02	1.1E+01
	Cobalt	mg/kg	415	587	2.8E-01	5.2E+00	1.1E+02	5.9E+00
	Copper	mg/kg	567	603	9.1E-01	7.1E+01	7.7E+03	1.0E+02
	Cyanide, Total	mg/kg	4	216	8.1E-02	5.4E-01	1.6E+00	1.3E+00
	Europium-152	pCi/g	10	103	1.2E-01	2.1E-01	3.5E-01	2.5E-01
	Iron	mg/kg	586	587	9.2E+00	1.0E+04	1.1E+05	1.1E+04
	Lead	mg/kg	617	623	1.6E+00	3.8E+01	1.7E+03	4.6E+01
	Lead-210	pCi/g	11	27	1.8E+00	3.4E+00	8.6E+00	4.8E+00
	Lead-212	pCi/g	40	43	2.1E-01	1.5E+00	2.3E+00	1.6E+00
	Lead-214	pCi/g	43	47	2.8E-01	1.1E+00	2.4E+00	1.2E+00
	Magnesium	mg/kg	548	587	2.3E+02	1.4E+03	4.8E+03	1.5E+03
	Manganese	mg/kg	587	587	3.4E+01	3.3E+02	1.9E+03	3.4E+02
	Mercury	mg/kg	224	596	5.2E-03	5.2E-01	3.5E+01	8.6E-01
	Neodymium-147	pCi/g	1	1	3.9E+01	3.9E+01	3.9E+01	
	Neptunium-237	pCi/g	2	103	1.1E+00	1.3E+00	1.5E+00	1.7E+00
	Nickel	mg/kg	473	587	7.6E-01	1.4E+01	4.5E+02	1.7E+01
	Plutonium-238	pCi/g	18	33	2.0E-03	3.0E-02	1.0E-01	4.9E-02
	Plutonium-239	pCi/g	20	31	9.0E-03	5.6E-02	1.0E-01	7.3E-02
	Potassium	mg/kg	544	587	2.1E+02	1.3E+03	5.4E+03	1.4E+03
	Potassium-40	pCi/g	41	43	9.8E+00	2.3E+01	3.2E+01	2.4E+01
	Protactinium-231	pCi/g	26	64	2.9E-01	3.6E+00	5.0E+00	4.1E+00
	Protactinium-234	pCi/g	6	53	4.1E-01	6.5E+00	2.3E+01	1.4E+01
	Protactinium-234M	pCi/g	22	70	9.3E+00	3.1E+02	2.5E+03	5.4E+02
	Radium-224	pCi/g	10	23	2.3E+00	4.0E+00	5.1E+00	4.6E+00

TABLE C–9.—*Soil Detection Statistics by Watershed and by Analyte (ER Risk Database [LANL 1998]—Inorganics and Radiochemistry)*-Continued

WATERSHED	ANALYTE	UNITS	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	UCL
Water Canyon	Radium-226	pCi/g	41	54	7.5E-01	1.8E+00	1.5E+01	2.4E+00
	Radium-228	pCi/g	1	1	2.0E+00	2.0E+00	2.0E+00	
	Selenium	mg/kg	101	595	7.0E-02	5.5E-01	4.6E+00	6.9E-01
	Silver	mg/kg	96	587	9.7E-02	5.5E+00	1.1E+02	8.6E+00
	Sodium	mg/kg	431	587	3.4E+01	2.8E+02	1.4E+04	3.5E+02
	Sodium-22	pCi/g	2	110	3.1E-02	4.5E-02	6.0E-02	7.4E-02
	Strontium-85	pCi/g	1	10	1.1E-01	1.1E-01	1.1E-01	
	Thallium	mg/kg	96	587	1.4E-01	6.4E-01	1.8E+00	7.4E-01
	Thallium-208	pCi/g	35	39	1.2E-01	5.0E-01	1.3E+00	5.8E-01
	Thorium-227	pCi/g	2	17	2.4E+01	2.7E+01	3.1E+01	3.4E+01
	Thorium-228	pCi/g	25	29	1.5E-01	1.7E+00	9.5E+00	2.6E+00
	Thorium-230	pCi/g	64	70	9.4E-02	1.1E+00	5.4E+00	1.3E+00
	Thorium-231	pCi/g	16	46	2.8E-01	4.5E-01	6.3E-01	5.0E-01
	Thorium-232	pCi/g	24	24	2.0E-01	1.1E+00	1.7E+00	1.3E+00
	Thorium-234	pCi/g	64	92	1.1E+00	7.2E+01	1.9E+03	1.4E+02
	Uranium	mg/kg	119	272	9.7E-01	3.3E+00	1.1E+01	3.7E+00
	Uranium-234	pCi/g	84	89	5.8E-01	2.1E+01	1.7E+03	6.0E+01
	Uranium-235	pCi/g	39	121	4.1E-02	6.2E+00	8.7E+01	1.2E+01
	Uranium-238	pCi/g	65	89	6.7E-01	4.4E+01	1.7E+03	9.7E+01
	Vanadium	mg/kg	547	587	8.9E-01	1.8E+01	1.1E+02	1.9E+01
	Zinc	mg/kg	587	587	9.3E+00	7.2E+01	1.6E+03	8.3E+01

Note: Watersheds are defined in ER Project FIMAD map G105700, July 24, 1997.

Note: The analytical data provided in these tables were obtained from the Facility for Information Management, Analysis, and Display (FIMAD) in August, 1998. The data represent analytical results for surface soil samples collected by the ER Project with a begin depth equal to 0 inches and an end depth less than or equal to 12 inches. The data were obtained from ER Project-approved fixed-site analytical laboratories using standard analytical methods (EPA methods for organics and inorganics; LANL-approved methods for radionuclides). Field measurements, non-standard measurements (e.g. x-ray fluorescence), and measurements for non-chemical specific data (e.g. gross radioactivity) were excluded. Quality assurance/quality control data were also excluded. The ER Project may have removed contaminated soil in voluntary corrective actions subsequent to sampling; therefore, some analytical results may represent contaminants that have been removed since the samples were taken.

REFERENCES

Environmental Surveillance Report Data	See individual entries for LANL Environmental Surveillance Reports (ESRs): LANL 1993 (1991 ESR), LANL 1994 (1992 ESR), LANL 1995 (1993 ESR), LANL 1996a (1994 ESR), LANL 1996b (1995 ESR), LANL 1997 (1996 ESR).
LANL 1993	*Environmental Surveillance at Los Alamos During 1991*. Los Alamos National Laboratory. LA-12572-ENV, UC-902. Los Alamos, New Mexico. August 1993.
LANL 1994	*Environmental Surveillance at Los Alamos During 1992.*. Los Alamos National Laboratory. LA-12764-MS, UC-902. Los Alamos, New Mexico. July 1994.
LANL 1995	*Environmental Surveillance at Los Alamos During 1993.* Los Alamos National Laboratory. LA-12973-ENV, UC-902. Los Alamos, New Mexico. October 1995.
LANL 1996a	*Environmental Surveillance at Los Alamos during 1994.* Los Alamos National Laboratory, Environmental Assessments and Resource Evaluations Group. LA-13047-ENV. Los Alamos, New Mexico. July 1996.
LANL 1996b	*Environmental Surveillance at Los Alamos During 1995.* Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.
LANL 1997	*Environmental Surveillance and Compliance at Los Alamos During 1996.* Los Alamos National Laboratory. LA-13343-ENV. Los Alamos, New Mexico.
LANL 1998	Environmental Restoration Project data from the ECO_ANAL static data table in the FIMAD Oracle database. February 1998.
NPDES Data	Data on Water Quality, obtained from the LANL Water Quality and Hydrology Group (ESH-18) NPDES Chemical Database. Only 1994–1996 data available currently.

APPENDIX D
HUMAN HEALTH

D.1 PUBLIC HEALTH CONSEQUENCES: PRIMER AND RECENT STUDIES NEAR LANL

In this appendix, supplemental information is presented on the effects on human health of radioactive and chemical exposures. The information is presented in two sections: that addressing our general knowledge and understanding (section D.1.1) and that presenting in more detail the findings of the recent studies of public health in the community of Los Alamos, and New Mexico and U.S. studies (including Native Americans in New Mexico, Hispanic white and nonhispanic white populations throughout the U.S. (section D.1.2). The presentation in section D.1.1 is useful to the reader as a primer on human health effects of exposures to radioactivity or to chemicals. The summaries presented in section D.1.2 are the results of descriptive epidemiology studies. That is, they are analyses of disease incidence rates and causes of death using statistical analytical methodologies.

Exposure to toxic chemicals is regulated by other agencies, and DOE subscribes to and applies those regulations without change to its own activities. The Occupational Safety and Health Administration (OSHA) promulgates and enforces regulations for the protection of workers, and EPA regulates exposures to the public. Chapter 7 provides a detailed review of the regulatory requirements for the operation of LANL.

D.1.1 Primer on Human Health Consequences of Radiological and Chemical Exposures

Table D.1.1–1 summarizes the differences in consequences between exposures to radioactive materials and exposures to chemicals. More detailed information on the modes of exposure and potential effects of these exposures are given in the sections below.

D.1.1.1 *About Radiation and Radioactivity*

In the simplest sense, radiation is defined as energy propagated through space (NBS 1952). This definition covers a broad range, including visible light, radio and television transmissions, microwaves, and emissions from atomic and nuclear reactions and interactions. The method by which radiation interacts with matter is by transferring its energy to the atoms of the matter. The amount of energy transferred determines the effect that it will have on matter. The broad spectrum of radiation can be subdivided into two groups, ionizing and nonionizing. Ionization occurs when the radiation transfers enough energy to strip one or more electrons from the interacting atom. When ionization takes place in the body, it can cause chemical and physical changes that are of concern to human health. Radiation that does not have enough energy to strip electrons is called “nonionizing” (discussed further in appendix D, section D.2.2.2).

Ionizing radiation is used in a variety of ways, many of which are familiar to us in our everyday lives. The machines used by doctors to diagnose and treat medical patients typically use x-rays, which is one form of ionizing radiation. The process by which a television displays a picture is by ionizing coatings on the inside of the screen with electrons. Most home smoke detectors use a small source of ionizing radiation to detect smoke particles in the room’s air.

TABLE D.1.1–1.—*Comparison of Consequences of Radioactivity and Toxic Chemicals*

	RADIOACTIVE MATERIALS	TOXIC CHEMICALS
Threshold for effects?	Assume no threshold (stochastic effects).	Yes, and different thresholds for different effects.
Accumulative effects?	Assumed exposures accumulate over a lifetime, with no repair.	Typically, the body repairs itself between exposures; may build sensitive allergic reaction or interact with cells.
Sensory perception?	We do not feel, smell, or otherwise sense ionizing radiation.	Very low concentrations not sensed. Often an annoying odor and irritating effects at low concentrations. Some gases are visible when in high concentrations.
Carcinogenic?	All ionizing radiation is regulated as carcinogenic.	Only some chemicals are confirmed human carcinogens. Some others are suspected, and some are animal (mammal, or closer to human, primate) carcinogens.
Effects-exposure relationship?	Usually treated as linear at low doses, although this is a conservative simplification (BEIR V 1990).	Typically nonlinear and nonadditive. Thresholds exist. For some chemicals, effects can be treated as linear with exposures, but only over small ranges. Synergisms among chemicals are not understood.
Acute effects?	Acute deterministic effects are soon observed, but occur only above a threshold of about 50 rem (less for the eye).	Effects may be immediately observed for levels of exposures above the thresholds.
Entry paths of particulates into the body?	Radionuclides enter through inhalation, ingestion, and wounds. A few are absorbed through the skin.	Same routes, except a greater percentage of chemicals than of radionuclides are absorbed through the skin.
Target organs?	The chemistry of the radionuclide determines its residence time and location in the body.	Same as for radionuclides. Except, the body also metabolizes chemicals, sometimes into more toxic chemicals.
Penetrating?	Alpha and beta radiation do not penetrate skin. In contrast, dense materials are needed to shield against gamma and x-ray radiation.	About 20% of OSHA-regulated chemicals have skin as an import route of entry. Only corrosive chemicals penetrate protective gear rapidly.

Ionizing radiation is generated through many mechanisms. The two most common mechanisms are the electrical acceleration of atomic particles such as electrons, as in x-ray machines, and the emission of energy from nuclear reactions in atoms. This second process is termed "radioactive decay." Atoms are made up of various combinations of particles called protons, neutrons, and electrons. In most cases, the numbers of neutrons and protons are balanced such that the atom will stay together forever. An atom formed with too many of either the neutrons or protons will attempt to change itself into a more stable form. To do this, the atom will emit an atomic particle, such as an electron, normally called a beta particle, or a "packet" of energy called a photon. This is the process of radioactive decay. The time that it takes for the atom to decay is characterized by a value called the half-life. This is the time it takes for a quantity of radioactive material to decay to one-half its original amount. In general, radioactive materials are identified by their half-lives and the type and energy of their emissions. In some cases, atoms may emit a highly energetic, ionized, helium atom, called an alpha particle. The energy carried away by these emissions is normally capable of creating a large number of ionizations in matter.

Besides ionization, other particles can often be emitted during interactions between radiation and matter, depending upon the type and energy of the interaction. Neutrons, protons, and some other more exotic particles are often emitted during various processes. Nuclear reactors use neutrons to break apart, or fission, particular isotopes of uranium and plutonium in order to release heat and more neutrons to continue the reaction. Large machines, often called "atom smashers," cause atoms at high energies to collide and break apart, releasing particles in order to study their nuclear structure. However, due to the design and operation of these types of facilities, it would be highly unlikely for these types of radiations to reach the public outside the boundaries of the facility.

When an individual is in the presence of an unshielded radiation source, this is referred to as being exposed. The amount of ionizing radiation that the individual receives during the exposure is referred to as dose. The measurement of radiation dose is called radiation dosimetry, and is done by a variety of methods depending upon the characteristics of the incident radiation. The units of measure for radiation doses are normally rads and rem. (Note that the term millirem [mrem] is also used often. A millirem is one one-thousandth of a rem.) The rad is a measure of the energy deposited in the body by the radiation, regardless of the type of emission. The rem is a measure of the biological effect, by including the effectiveness of the particular type and energy of the incident radiation for causing biological effects. This is due to the fact that some heavier or higher energy radiations, such as alpha particles or neutrons, can deposit their energy into much smaller volumes, and consequently, cause more intense damage through localized, chemical changes.

When an individual is exposed to an unshielded radiation source, this is called external radiation. If radioactive material is incorporated into the body and consequently decays, it is called internal radiation. The external radiation is measured as a value called the deep dose equivalent (DDE). Internal radiation is measured in terms of the committed effective dose equivalent (CEDE). More information about the CEDE is presented in the discussion about the processes by which radioactive material enters the body. The sum of the two contributions (DDE and CEDE) provides the total dose to the individual, called the total effective dose equivalent (TEDE). Often the radiation dose to a selected group or population is of interest, and is referred to as the collective dose equivalent, with the measurement units of person-rem.

D.1.1.2 *About Radiation and the Human Body*

Ionizing radiation affects the body through two basic mechanisms. The ionization of atoms can generate chemical changes in body fluids and cellular material. Also, in some cases the amount of energy transferred can be sufficient to actually knock an atom out of its chemical bonds, again resulting in chemical changes. These chemical changes can lead to alteration or disruption of the normal function of the affected area. At low levels of exposure, such as the levels experienced in occupational or environmental settings, these chemical changes are very small and ineffective. The body has a wide variety of mechanisms that repair the damage induced. However, occasionally, these changes can cause irreparable damage that could ultimately lead to initiation of a cancer, or changes to genetic material that could be passed to the next generation. The probability for the occurrence of health effects of this nature depends upon the type and amount of radiation received, and the sensitivity of the part of the body receiving the dose.

At much higher levels of exposure, at least 10 to 20 times higher than the legal limits for occupational exposures, the body is unable to recover from the large amount of chemical changes occurring during the exposure. At these levels, damage is much more immediate, direct, and observable. Health effects range from reversible changes in the blood to vomiting, loss of hair, temporary or permanent sterility, and other changes leading ultimately to death at exposures above about 100 times the regulatory limits. In these cases, the severity of the health effect is dependent upon the amount and type of radiation received. Exposures to radiation at these levels are quite rare, and, outside of intentional medical procedures for cancer therapy, are always due to accidental circumstances.

For low levels of radiation exposure, the probabilities for induction of various cancers or genetic effects have been extensively studied by both national and international expert groups. The problem is that the potential for health effects at low levels is extremely difficult to determine without extremely large, well-characterized exposed populations. Therefore, only particular groups with fairly high exposures, such as atomic bomb survivors, radiation accident victims, and some groups receiving large medical exposures, can be studied to evaluate the probabilities. Unfortunately, the levels and rates of exposures, and the conditions under which they occurred, are very different from those in which the normal population is exposed to background radiation or to normal operational releases from nuclear operations. Therefore, expert groups must make significant approximations and assumptions in order to apply the study results to the lower levels of exposure. This is done in a manner that attempts to ensure that the resulting risk factors are conservative estimates of the actual probabilities. In other words, it is unlikely that the actual risks are greater than the estimates, while it is fairly likely that the actual risk is smaller than the estimate.

There is another type of study, referred to as an epidemiology study, that attempts to estimate the risk factors in populations with much lower doses than mentioned above. These studies are even more difficult to perform. There are two types of epidemiology studies: descriptive (based on statistical analyses of death and disease incidences) and analytical (case studies and observational analysis within a community or work force). The studies summarized in chapter 4, section 4.6.1.2, and appendix D, section D.1.2, are descriptive. The risk factors for radiation-induced cancer at low levels of exposure are very small, and it is extremely important to account for the many nonradiation related mechanisms for cancer induction, such as smoking, diet, lifestyle, and chemical exposures. These multiple factors also make it difficult to establish cause-and-effect relationships that could attribute high or low cancer rates to specific initiators. As a consequence, the results of such studies have not been generally accepted within the scientific community and are not currently used as the primary basis for establishing the risk factors.

Risk factors are estimated for a large number of fatal and nonfatal cancers, for hereditary effects, and a few other identified radiation-induced health effects. Table D.1.1.2–1 lists the fatal cancer risk factors used in this SWEIS, which are based upon the recommendations of a recognized authoritative international expert group, the International Commission on Radiological Protection (ICRP). The other, smaller risk factor in the table for nonfatal cancer and hereditary effects may be similarly applied by interested readers.

In keeping with the previous discussion of the difficulties in determining the risk factors used in this document, it is worthwhile to discuss the level of confidence that is associated with those factors. The ICRP, in the recommendation that established the risk factors used here, stated that, "The nominal values of fatal cancer risk, which form the basis of the detriment following radiation exposure, are not to be regarded as precise and immutable. They are, unfortunately, at this time still subject to many uncertainties and to many assumptions involving factors which may be subject to change. ...It is hoped, and indeed expected, that these uncertainties will diminish in the future as the accumulated experience in exposed populations such as the Japanese survivors increases and as more information develops from a broader variety of human experiences" (ICRP 1991). The Committee on the Biological Effects of Ionizing Radiations (BEIR), which developed the risk factors that the ICRP recommends, also discussed the uncertainty of the factors: "Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of model involves assumptions that remain to be validated. ...Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert (1 millisievert = 100 millirem) dose range. Thus the background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero" (BEIR V 1990).

Given these concerns, the reader should recognize that these risk factors are intended to provide a conservative estimate of the potential impacts to be used in the decision-making process, and are not necessarily an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated

TABLE D.1.1.2–1.—*Risk Factors for Cancer Induction and Heritable Genetic Effects from Exposure to Ionizing Radiation*

EXPOSED POPULATION[a]	FATAL CANCER[b]	NONFATAL CANCER	HEREDITARY EFFECTS (SEVERE)[d]	TOTAL DETRIMENT
Adult Workers	0.0004[c]	0.00008	0.00008	0.00056
Whole Population	0.0005[c]	0.0001	0.00013	0.00073

[a] The distinction between the worker risk and the general public risk is attributable to the fact that sensitivities vary with age, general health, and other factors that contribute more to the general population than to the worker population.
[b] When applied to an individual, units are lifetime probability of excess cancer fatalities per rem of radiation dose. When applied to a population of individuals, units are excess numbers of fatal cancers per person-rem of radiation dose.
c This is the source of the 4 x 10^{-4} worker and 5 x 10^{-4} public risk factors used in this SWEIS.
[d] Heritable genetic effects as used here apply to populations, not individuals. For the other columns, the units would change accordingly, in terms of number of effects per unit dose.
Source: ICRP 1991

impacts from an activity or accident form an envelope around the situation, and that actual consequences could be less, but probably would not be worse.

When considering the risks from exposure to ionizing radiation, it is important to remember that we are always being exposed to the radiation in the environment around us. Natural background radiation is the collective term for all of the sources that occur naturally, such as cosmic radiation and naturally occurring radioactive materials, such as potassium, uranium, thorium, radium, and others. These sources contribute an average of 0.3 rem per year to each individual. Manufactured radiation sources contribute another 0.06 rem per year on the average, with the majority coming from medical procedures. Fallout from the atmospheric testing of nuclear weapons currently contributes less than 0.001 rem per year to our doses (NCRP 1987).

D.1.1.3 *About Radioactive Material Within the Body*

Typically, radioactive material that is released into the environment is in the form of very fine particulates, gases, or liquids. That is usually because these forms are the hardest to contain in a facility. This material is easily carried into and spread around the air, soil, and water. As these materials move through the environment, it is possible for them to be taken into the body, through breathing, eating, or drinking. During normal operations of a facility, every effort is made to minimize these releases to levels well below natural background. During accidents, it is possible that higher levels may be released; but, the facilities are designed and operated to control these releases as much as possible.

Radioactive material normally enters the body through one of three mechanisms. When the material is in the air, it is inhaled into the lungs, where a fraction will be trapped, depending upon the size of the particles. When it is ingested by eating or drinking, or by clearing of the respiratory tract, it passes through the stomach and into the gastrointestinal tract. Under the right conditions, it can also be absorbed through the skin or enter through open wounds.

Once in the body, the fate of the material is determined by its chemical behavior. Some material will be dissolved into bodily fluids and transferred into various organs of the body. Remaining material may either be retained at its point of entry, such as in the lungs, or pass through the body rapidly, as in the gastrointestinal tract. The effect of material in the body is characterized by the type of radiation it delivers and the organs in which it tends to collect. The rate at which the material is removed from the body is represented by a value called effective biological half-life (the time it takes for the activity in the body to be reduced to one-half as a consequence of radioactive decay and biological turnover of the radionuclide).

When radioactive material is in the body, it irradiates the living tissue around it. Some radiation types, like beta and alpha particles, are much more effective at causing changes when inside the body than when outside. This is because these types of radiation cannot effectively penetrate the dead layer of the skin from an external source. As mentioned above, the radiation dose from material inside the body is called the CEDE. Remember that the dose from an external source stops when you walk away or are shielded from it. But you cannot walk away from an internal source. Therefore, the CEDE is designed to determine the risk commitment from the intake. It is the dose that will be received over the next 50 years from the material in the body. Because of the assumptions that doses are cumulative and their effects are not repaired, this means that the lifetime risk from an internal source in rem CEDE can be directly compared to the risk from an external source in rem DDE.

D.1.1.4 *About the Material of Interest at LANL*

LANL has a large involvement in nuclear science and applications. Therefore, there are many types of radioactive material and radiation sources in use. However, many of the uses require only very small amounts of material. Note that all radioactive materials are considered in this SWEIS; but, there are three types that tend to dominate the human health effects and DOE accident scenarios. This is due to either their particular radioactive and biological characteristics, the quantities of material being used, or the potential for dispersion in an accident. These materials are plutonium, uranium, and tritium.

Plutonium is a man-made element that has several applications in weapons, nuclear reactors, and space exploration. There are several types of plutonium atoms, called isotopes, which are distinguished by the different numbers of neutrons in their nucleus. (Note that isotopes of a particular atom all behave the same chemically.) In most cases, the isotopes of plutonium of interest here decay by alpha particle emission with radioactive half-lives ranging from tens to thousands of years. There is nothing unique about plutonium as a health risk compared to other radioactive materials. It is only that once incorporated into the body, it tends to stay for a very long time and deposits a lot of localized energy due to its alpha particles.

Uranium is a naturally occurring radioactive element. The discovery that an atom of uranium could be fissioned with neutrons was the starting point of the Nuclear Age. Uranium-235 is one of several fissile materials that fission with the release of energy.

Various applications require the use of different isotopes of uranium. Because isotopes cannot be chemically separated, processes have been developed to enrich uranium to various isotopic ratios. Enriched uranium is uranium that is enhanced in the isotope uranium-235 above its natural ratio of 0.72 percent. Highly enriched uranium (HEU) is where the uranium-235 content is 20 percent or greater. Depleted uranium (DU) is where the content of uranium-235 is below its natural value. Obviously, natural uranium is where the material is in its natural isotopic ratios.

Most uranium isotopes of interest here have very long half-lives and are alpha emitters. Their half-lives are much longer than the plutonium isotopes, and as a result uranium is generally of lower radiological concern than plutonium. However, its actual radiological concern varies with its enrichment. As a heavy metal, uranium also can be chemically toxic to the kidneys. Depending upon the enrichment and chemical form, either chemical or radiological considerations will dominate.

Tritium is a radioactive isotope of hydrogen. It is generated at low levels in the environment by interactions of cosmic radiation with the upper atmosphere, but for practical applications it is normally produced in a nuclear reactor. Tritium has a half-life of around 12 years and decays by emitting a low energy beta particle. Because tritium is an isotope of hydrogen, it can be incorporated into the water molecule, forming tritiated water. In the environment, tritium is most often found either in its elementary form as a gas, or as water. Tritiated water is a significant concern to the human body because the body is composed mostly of water. This actually is a mixed blessing. Tritiated water will easily and rapidly enter the body and irradiate it rather uniformly; however, it also is removed from the body rather quickly, being easily displaced with regular water and with a biological half-life of about 12 days under normal conditions.

D.1.1.5 *How DOE Regulates Radiation and Radioactive Material*

Radiation doses to workers and the public and the release of radioactive materials are regulated by DOE for its contractor facilities. Under the conditions of the *Atomic Energy Act* (as amended by the *Price-Anderson Amendments Act of 1988)*, DOE is authorized to establish federal rules controlling radiological activities at DOE sites. The act also authorizes DOE to impose civil and criminal penalties for violations of these requirements. Some activities are also regulated through a DOE Directives System that uses contractual means to regulate the contractor activities.

Occupational radiation protection is regulated by the *Occupational Radiation Protection Rule*, Title 10 of the Code of Federal Regulations, Part 835 (10 CFR 835). Environmental radiation protection is currently regulated contractually with DOE Order 5400.5, which is in the process of being converted to a rule. There is a process by which these regulations are developed. The EPA, working with other agencies such as DOE and the NRC, develops a federal guidance document that is signed by the President (52 *Federal Register* [FR] 2822–2834). This document is based upon the recommendations of the National Council on Radiation Protection and Measurements (NCRP), and considers recommendations of international expert groups such as the ICRP. This federal guidance then becomes the basis for all federal regulations for radiation protection, including DOE's and also U.S. Nuclear Regulatory Commission (NRC) rules. This process ensures a common, scientifically based approach to all radiation protection in the U.S.

D.1.1.6 *About Chemicals and Human Health*

The characteristics and consequences of exposures to chemicals are quite different from those of exposure to ionizing radiation. Table D.1.1–1 summarizes the differences.

For noncarcinogens, there are threshold concentrations that must be exceeded for observable adverse effects to happen; whereas, for ionizing radiation it is assumed that the integrated (accumulated) exposure determines the likelihood of observable effects.

The threshold values for effects from toxic chemicals vary somewhat among individuals, but values can be determined that represent most of the more vulnerable people among the general population. The several different effects from a chemical each have different thresholds. For instance, there may be different concentrations that produce odor, irritation, effects that last only a short time, permanent effects, and death. Older and ill people, and those with a particular sensitivity such as respiratory problems, are more vulnerable and will have lower thresholds for effects.

Using human inhalation of chlorine in illustration, 0.2 to 0.4 parts per million (parts of chlorine per million parts of air) is the odor threshold; 1 to 3 parts per million for periods less than an hour produce burning eyes, scratchy or irritated throat, and headache; 15 parts per million is the lowest concentration observed to cause respiratory distress; no deaths were observed in any animals exposed to 50 parts per million for 30 minutes; and 210 parts per million has been estimated to be the 30-minute LC50 for humans, although 50 parts per million might cause death in some vulnerable individuals. (The 30-minute LC50 is defined as the concentration that produces 50 percent fatalities among individuals exposed for 30 minutes.)

The ability to resist a potential effect and to recover from that effect clearly depends upon a person's health and age. For the population of workers, presumed to have few individuals who are especially vulnerable, regulatory agencies set permissible exposure limits and average concentrations for the 8-hour and 10-hour work day. Lower values than these would be appropriate to public exposures; whereas, higher values are deemed acceptable for military personnel under military exigencies.

Again using inhalation of chlorine gas in illustration, the OSHA permissible exposure limit is a time-weighted average (TWA) over the 8-hour work day of 0.5 parts per million[1]. There also is an OSHA short-term exposure limit of a 1-part-per-million 15-minute TWA that should not be exceeded at any time during the work day. The immediately dangerous to life and health (IDLH) value is 30 parts per million; this is the concentration from which a worker could escape within 30 minutes without a respirator and without escape-impairing or irreversible effects.

This SWEIS analysis uses the TWA as a convenient measure for screening the chemical inventory at LANL, and then uses Emergency Response Planning Guidelines (ERPGs) or their surrogate Temporary Emergency Exposure Limits (TEELs) for bounding the consequences to persons exposed to a release to the atmosphere. ERPGs are provided by the American Industrial Hygiene Association (AIHA) for planning for emergencies, rather than for determining consequences. ERPG–1, ERPG–2, and ERPG–3 are defined and described in detail in appendix G, Accident Analysis. They are intended to provide protection for most members of the public, and so their exposure time (up to one hour) and their concentrations are directly related to effects (no safety factor of ten was applied).

1. The definition of the TWA is the sum of all the instantaneous air concentrations over the 8 hours, averaged by dividing by the 8 hours.

Again using chlorine in illustration, the ERPG–2 is 3 parts per million, the concentration at which nearly all individuals could be exposed without irreversible or other serious health effects or impairment of ability to take protective actions. The ERPG–3 is 20 parts per million, below which nearly all individuals could be exposed without life-threatening effects.

Only for some chemicals and only for a limited extent, effects are directly related to the product of the concentration and length of exposure ("Haber's Law"). Chlorine is not such a chemical. When attempting to apply an existing guideline to a different exposure period than for which the guideline applies, toxicologists must be consulted, and they will consider actual effects data.

D.1.1.7 *How Toxic Chemicals Affect the Body*

Some toxic chemicals can have direct effects upon the eyes and the skin through contact and can enter the body by absorption through the skin. These are considered in the derivation of guides and limits for airborne concentration. Toxic chemicals also can enter the body via ingestion (eating and drinking). All the LANL accidents considered in the SWEIS that pose significant risk to the public produce their exposure through airborne releases, and so airborne concentrations guides and limits are used in the screening and consequence analyses.

After intake, the chemical may follow primarily one or more routes within the body, involving the respiratory system and digestive system, the blood circulatory system, and the urinary tract. The route and residence time before excretion is strongly determined by the chemical's solubility, and if particulate, by its particle size. The chemical may be metabolized, usually in the liver, into other chemicals that are either more or less toxic. For carcinogens, the principal target organs (i.e., where the effects primarily occur) are the respiratory tract, urinary bladder, and to a lesser extent the bone marrow, gastrointestinal tract, and liver.

D.1.1.8 *About Chemical Carcinogens*

Some chemicals are regulated as carcinogens because they or their metabolites may cause cancer. There are limited data on chemical carcinogens for humans, and there are problems with applying the results of animal studies to humans. Therefore, these chemicals are classified as known human carcinogens, potential or suspected carcinogens, and chemicals that cause cancer in animals. Exposure to chemical carcinogens is treated in the same manner as cumulative exposure to ionizing radiation; that is, exposures are assumed to be additive in producing cancer.

Some chemicals are carcinogenic at concentrations that do not produce observable effects from acute (short-term) exposures. For these, the airborne exposure limits and guidelines are based on their carcinogenicity. Some chemicals may produce an irreversible change to cells (tumor initiation), which then may be submitted to chemicals that are promoters of cancer. Such promoters must be given repeatedly to be effective. For this reason, chemical carcinogens are regarded as additive to one another, and individual chemicals are regulated at 1/100 of the exposure level regarded as hazardous, perhaps to account for the conservative possibility of having 100 such chemicals in one's environment.

The carcinogenic effects of certain chemicals are similar to those of ionizing radiation and have been noted in virtually every organ, depending on the chemical, the species, and conditions of exposure. The cancers induced by chemicals and by ionizing radiation cannot be distinguished from cancers induced by other causes. Therefore, the effects of chemicals and ionizing radiation are inferred only on a statistical basis, and must inferred from exposures at higher doses and dose rates. The choice of model has a large influence on the estimated excess cancer risk. The extrapolation is made by assuming an uncertain and controversial no-threshold, linear mathematical relationship between dose and resultant effects. This model is usually thought likely to overestimate the risk at low doses, and so is often said to estimate the "upper limit" of risk (NCRP 1989).

Chemicals vary widely in their capacity to induce cancer. There are even fewer data on the carcinogenic effects for chemicals than for radiation. With most chemicals, assessment of risks for humans must be based on extrapolation from laboratory animals or other experimental systems. Hence, the risk assessment for chemicals has even more uncertainty than risk assessment for ionizing radiation (NCRP 1989). Ultimately, the desired certainty in risk assessment at low-level exposures to chemicals and radiation will require better understanding of their effects at all stages of carcinogenesis.

The EPA, in setting standards for compliance with the *Clean Air Act*, is required by judicial decision and the *Clean Air Act* to determine a "safe" level with an "ample margin of safety to protect public health" without consideration as to cost or technology feasibility (Bork 1987). After that level is determined, costs and feasibility can be considered in setting the standard. Although this decision applied specifically to vinyl chloride and the *Clean Air Act*, it aids in understanding the EPA challenge faced in determining what is "safe," "adequate," or "acceptable" when setting standards for protection of workers, public, and environment. In the attempt to provide an objective context for evaluating the risks posed by LANL operations, the SWEIS authors have searched for authoritative statement on acceptable risk levels. A few such statements and inferences can be found in ICRP, NCRP, EPA, and OSHA documents.

EPA regulations provide goals for environmental remediation (cleanup). The EPA goals "for acceptable exposure levels to known or suspected carcinogens are generally concentration levels that represent an excess upper bound lifetime cancer risk between 10^{-4} and 10^{-6}. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals" when existing and relevant requirements are not available or sufficiently protective because there are multiple contaminants or pathways. When the combined risk from multiple contaminants exceed 10^{-4}, then factors such as detection limits and uncertainties may be considered in determining the cleanup level to be attained (40 CFR 300.430). Note that this is the lifetime risk to an undetermined public population group.

OSHA (OSHA 1997) expressed that its proposed worker permissible exposure limit for methylene chloride of 25 parts per million (average for 8 hours per day) would entail an employment lifetime risk of 3.62×10^{-3}, and that this was "clearly well above any plausible upper boundary of the significant risk range defined by the Supreme Court and used by OSHA in its prior rulemaking." OSHA noted that typical lifetime occupational risk for all manufacturing industries is 1.98×10^{-3}, and that the risk in occupations of relatively low risk, like retail trade, is 8.2×10^{-4}. Note that worker risk is generally accepted at a higher level than public dose because it is an accepted risk of employment. This is compatible with the EPA upper bound lifetime public cancer risk of between 10^{-4} and 10^{-6}.

D.1.1.9 *Radionuclides and Chemicals of Interest at LANL*

Radionuclides of interest at LANL are discussed with their respective emission facilities in appendix B, section B.1. Chemicals of interest are presented in appendix B, section B.2. LANL has used, uses, and will use a wide variety of chemicals because of its research mission. LANL has a chemical database that tracks the quantity and location of chemicals on site. About 51 of the chemicals tracked in the database are carcinogenic. A large number of the chemicals tracked in the database are toxic; that is, they are able to produce harm to humans. The analysis of the consequences to the public from chemical emissions under normal operations of LANL is provided in chapter 5, sections 5.2.4 and 5.2.6. Methodology is provided in section 5.1.4 and 5.1.6. Those of risk to the public, should they be accidentally released to the atmosphere, were determined by screening the entire database. Details on the accidental release screening and its results are presented in appendix G, Accident Analysis.

D.1.2 Supplemental Information on Public Health: U.S., New Mexico, and the Local LANL Community

The information presented below is supplemental to the information presented in chapter 4, section 4.6. It is presented to provide the context of the human health analysis provided in chapter 5, which estimates potential consequence to public health.

The population of Los Alamos County has grown primarily by immigration. The average annual fertility rate has remained at approximately 48/1,000 women across all races (DOC 1990 and Athas and Key 1993), which would produce annual growth of only 2.4 percent if there were no deaths. However, the growth rate has been approximately 25 percent between 1950 and 1960, more than 16 percent between 1960 and 1970 as well as between 1970 and 1980, and approximately 3 percent between 1980 and 1990.

Several studies have been conducted in the community due to concerns expressed within the community concerning the rates of some cancers. While these are summarized in section

4.6 of the SWEIS, additional information is presented here in order to meet the request of many during the scoping meetings for presentation of these results in the SWEIS.

These studies are largely descriptive; that is, they use statistical analyses to identify patterns of disease or death in a community. The thyroid cancer study (Athas 1996) reported below is a mixture of descriptive and analytical approaches (based on case studies and observational analyses). All epidemiological studies are subject to limitations in attempting to determine cause and effect relationships. Some of these limitations are:

- Small population sizes in the community to be studied
- Relatively few total numbers of cases of the specific disease or cancer to be studied
- High mobility in the population to be studied (if a large portion of the community has been in the community for shorter periods of time than that necessary to detect chronic disease, results are inconclusive)
- Disease etiology—one may have received the causative exposure decades before its diagnosis; households in the U.S. move on average every 3 years; in Los Alamos County in 1980, 45 percent of residents had been in the same home for 5 years; earlier census data showed lesser periods of time in the same residence
- Comparability—for instance, the makeup of Los Alamos County is quite dissimilar from its surrounding counties in ethnic distribution and in socioeconomic and occupational conditions
- Natural variability in disease incidence within the human population from any and all sources
- Increased technology efficiency used in disease detection, therefore, causing apparent increases in rates of incidence of the better-detected disease
- More than one causal agent suspected or known to cause the disease being studied, including lifestyle choices such as smoking and dietary patterns
- Disease cause from multiple sources in the same community
- Methodology limitations such as multiple comparison across differing time periods, across studies made for different purposes, consideration of all combinations across the study time frame, etc.

D.1.2.1 *Public Health: United States*

Heart disease remains the leading cause of death in the U.S. (Table D.1.2.1–1). There has been a significant decrease in mortality in the U.S. attributable to heart disease and cerebrovascular disease over the last 20 years. Cancer remains the second leading cause of death.

Table D.1.2.1–2 identifies the lifetime risk of dying from cancer for men and women by cancer type. Over all cancer types, the lifetime risk of dying from cancer is approximately 24 percent for men and 21 percent for women.

TABLE D.1.2.1–1.—*Leading Causes of Death in U.S.: Percent of All Causes of Death (1973 Versus 1993)*

CAUSE OF DEATH	PERCENT OF ALL CAUSES (1973)	PERCENT OF ALL CAUSES (1993)
Heart Disease	38.4	32.8
Cerebrovascular	10.9	6.6
Cancer	17.1	23.4
Pneumonia and Influenza	3.2	3.7
Chronic Lung Disease	1.5	1.2
Accidents	5.9	4.0
All Other Causes	22.5	28.4

Source: Ries et al. 1996

TABLE D.1.2.1–2.—*Lifetime Risk (Expressed as Percent) of Dying from Cancer: SEER[a] Areas (1973 Through 1993), All Races*

TYPE OF CANCER	MEN	WOMEN
All Types	23.77	20.66
Oral and Pharynx	0.45	0.24
Esophagus	0.65	0.23
Stomach	0.81	0.53
Colon and Rectum	2.54	2.54
Liver and Bile Duct	0.52	0.33
Pancreas	1.11	1.21
Larynx	0.25	0.07
Lung and Bronchus	7.11	4.35
Melanomas of Skin	0.31	0.20
Breast	0.03	3.54
Cervix Uteri	—	0.27
Corpus and Uterus	—	0.53
Ovary	—	1.12
Prostate	3.62	—
Testis	0.02	—
Urinary Bladder	0.69	0.34
Kidney and Renal Pelvis	0.49	0.33
Brain and Other Nervous	0.51	0.41
Thyroid	0.04	0.07
Hodgkin's Disease	0.06	0.05
Non-Hodgkin's Lymphoma	0.90	0.85
Multiple Myeloma	0.47	0.43
Leukemias	0.93	0.74

[a] SEER is the NIH/NCI Surveillance, Epidemiology, and End Results Program.
Source: Ries et al. 1996

Cancer incidence and mortality trends have changed over the last 20 years (Table D.1.2.1–3). Melanoma of the skin, for example, has increased in both incidence and mortality rate, as has brain and other nervous system cancers. Leukemia incidence and mortality rates have decreased.

D.1.2.2 *Comparison of Cancer Mortalities Between the U.S. and New Mexico*

A comparison of cancer mortality rates between the U.S. as a whole and New Mexico is given in Table D.1.2.2–1. These comparisons were made for 1989 through 1993 based on the National Institute of Health/National Cancer Institute (NIH/NCI) Surveillance, Epidemiology, and End Results (SEER) Program (Ries et al. 1996). For most cancers, differences were insignificant.

However, New Mexico had significantly higher mortality from thyroid cancer. (The reader is referred also to Athas 1996 for the local Los Alamos County study of thyroid cancer presented below.) New Mexico deaths due to thyroid cancers ranked 4th among the states. Thyroid cancers are associated with some types of radiological processes and research applications, principally those that could result in emitted radio-iodine. LANL has historically not used more than research amounts of radio-iodine. Radio-iodine emissions from LANL have been measured and have continually been very low (chapter 4, section 4.4 and the tables of emissions estimated for key LANL facilities, in chapter 3, section 3.6 discuss this further).

New Mexico had statistically lower rates of cancer mortalities for several cancers (Table D.1.2.2–1) relevant to the Los Alamos cancer studies, specifically, brain and other nervous system cancers and breast cancer.

TABLE D.1.2.1–3.—*Trends in Cancer Incidence and Mortality for Selected Cancers (1973 Through 1993), All Races, Both Sexes*

DECREASING INCIDENCE; DECREASING MORTALITY	INCREASING INCIDENCE; DECREASING MORTALITY	INCREASING INCIDENCE; INCREASING MORTALITY
Oral Cavity and Pharynx	Ovary	Total Cancers
Stomach	Testis	Esophagus
Colon and Rectum	Urinary Bladder	Liver and Bile Duct
Pancreas	Thyroid	Lung and Bronchus
Larynx		Melanoma of Skin
Cervix Uteri		Breast
Corpus and Uterus		Prostate
Hodgkin's Disease		Kidney and Renal Pelvis
Leukemia		Brain and Other Nervous
		Non-Hodgkin's Lymphoma
		Multiple Myeloma

Source: Ries et al. 1996

TABLE D.1.2.2–1.—*Comparison of Cancer Mortality Rates for the United States and New Mexico (1989 Through 1993), All Races, Both Sexes (Rate per 100,000 Population, Age Adjusted to 1970 U.S. Standard Population)*

TYPE OF CANCER	U.S. RATE	NEW MEXICO RATE	RANKING (AMONG STATES)	COMPARISON U.S. VS. NEW MEXICO
Breast	26.8	23.4	49th	NM < U.S.
Colon and Rectum	18.4	14.2	50th	NM < U.S.
Esophagus	3.5	2.4	49th	NM < U.S.
Hodgkin’s Disease	0.6	0.6	25th	NSD
Larynx	1.4	1.2	34th	NSD
Leukemia	6.4	6.1	40th	NSD
Liver and Bile Duct	3.0	3.2	15th	NSD
Lung and Bronchus	49.9	35.0	49th	NM < U.S.
Melanomas of Skin	2.2	2.1	49th	NSD
Non-Hodgkin’s Lymphoma	6.4	5.6	46th	NSD
Brain and Nervous	4.2	3.5	48th	NM < U.S.
Stomach	4.6	5.0	12th	NSD
Testis	0.3	0.2	43rd	NM < U.S.
Urinary Bladder	3.3	2.7	47th	NM < U.S.
Oral/Pharynx	2.9	2.6	32nd	NSD
Pancreas	8.4	8.1	40th	NSD
Thyroid	0.3	0.4	4th	NM > U.S.
Prostate	26.4	23.2	49th	NM < U.S.
Ovary	7.8	6.7	47th	NSD
Kidney and Renal Pelvis	3.5	3.4	36th	NSD
Multiple Myeloma	3.0	3.0	30th	NSD
Corpus and Uterus	3.4	3.0	43rd	NSD
Cervix Uteri	2.9	2.7	33rd	NSD

Sources: SEER Database and Ries et al. 1996
NSD = No significant difference

D.1.2.3 *Cancer Incidence and Mortality Among Ethnic Groups Relevant to the LANL Area*

While the Native American population within Los Alamos County remains less than 3 percent (DOC 1990), the populations down gradient (with respect to air emissions and water flow) in the adjacent Santa Fe County Area are dominantly Native American (San Ildefonso Pueblo).

Table D.1.2.3–1 summarizes the findings regarding the top five cancers (both incidence and mortality) among nonhispanic whites (U.S.), Hispanic whites (U.S.), and Native Americans (New Mexico). The Native American cancer incidence and cancer mortality rates are lower than either of the other examined populations for both men and women. This is the case for all cancer types, not just the top five cancers with respect to incidence and mortality rate.

Among men, lung and prostate cancer dominate incidence and mortality. Among women, breast and lung cancer dominate cancer incidence and mortality. A fairly rare cancer, gall bladder, is the leading cause of cancer mortality among New Mexican Native American women. However, because there were so few cases, and the uncertainty level thus associated with the observation is so high, it is inappropriate to draw conclusions even regarding gall bladder cancer incidence in this population of women.

D.1.2.4 *Supplemental Information on Recent Studies of Los Alamos County Cancer*

Objectives

The primary objective of the study was to review Los Alamos County incidence rates for brain and nervous system cancer and other major cancers during the 21-year time period 1970 to 1990 (Athas and Key 1993). Secondary objectives were to review mortality rate data for select cancers of concern and to review Los Alamos County mortality data relating to benign brain and nervous system tumors.

Specific aims developed for incidence study were as follows:

- To calculate age-adjusted cancer incidence rates for Los Alamos County and a New Mexico state reference population using data of the New Mexico Tumor Registry (NMTR)
- To compare Los Alamos County cancer incidence rates to (1) incidence rates calculated for a New Mexico state reference population, and (2) national rates obtained from the SEER Program of the National Cancer Institute
- To determine if any of the Los Alamos County cancer incidence rates were elevated in comparison to rates observed in the reference population

The study protocol specified that statistical tests would be used to determine whether any of the Los Alamos County rates were elevated in comparison to the reference populations. Early in the course of the study, however, it became apparent that the small number of cases for virtually all of the Los Alamos County cancers reviewed would make the finding of statistical significance unlikely for small to modest elevations in a rate. Consequently, the analysis of the Los Alamos County incidence data was expanded to include not only statistical considerations but other types of information such as temporal patterns of cancer occurrence, prevalence of established risk factors, case characteristics, and tumor cell types. Cancers of concern were: oral cavity and pharynx, digestive system, respiratory system, melanoma of the skin, female breast, female genital system, urinary system, male genital system, lymphoreticular system, childhood cancers

TABLE D.1.2.3–1.—*The Five Most Frequently Diagnosed Cancer and the Five Most Common Types of Cancer Death (1988 Through 1992) Among White Non-Hispanics (all U.S.), White Hispanics (all U.S.), Native Americans (New Mexico)*

POPULATION GROUP	CANCER INCIDENCE[a]		CANCER MORTALITY[a]	
	CANCER TYPE (RATES/100,000 POPULATION, AGE ADJUSTED TO 1970 U.S. STANDARD)			
	MEN	WOMEN	MEN	WOMEN
White, Non-Hispanic	Prostate (137.9)	Breast (115.7)	Lung (74.2)	Lung (32.9)
	Lung (79.0)	Lung (43.7)	Prostate (24.4)	Breast (27.7)
	Colon/Rectum (57.6)	Colon/Rectum (39.2)	Colon/Rectum (23.4)	Colon/Rectum (15.6)
	Bladder (33.1)	Corpus Uteri (23.0)	Pancreas (9.8)	Ovary (8.2)
	Non-Hodgkin's Lymphoma (19.1)	Ovary (16.2)	Leukemia (8.6)	Pancreas (7.0)
White, Hispanic	Prostate (92.8)	Breast (73.5)	Lung (33.6)	Breast (15.7)
	Lung (44.0)	Colon/Rectum (25.9)	Prostate (15.9)	Lung (11.2)
	Colon/Rectum (40.2)	Lung (20.4)	Colon/Rectum (13.4)	Colon/Rectum (8.6)
	Bladder (16.7)	Cervix (17.1)	Stomach (8.8)	Pancreas (5.4)
	Stomach (16.2)	Corpus Uteri (14.5)	Pancreas (7.4)	Ovary (5.1)
Native American, NM	Prostate (52.5)	Breast (31.6)	Prostate (16.2)	Gallbladder (8.9)[b]
	Colon/Rectum (18.6)	Ovary (17.5)	Stomach (11.2)[b]	Breast (8.7)[b]
	Kidney (15.6)	Colon/Rectum (15.3)	Liver (11.2)[b]	Cervix (8.0)[b]
	Lung (14.4)	Gallbladder (13.2)	Lung (10.4)[b]	Pancreas (7.4)[b]
	Liver (13.1)[b]	Corpus Uteri (10.7)	Colon/rectum (8.5)[b]	Ovary (7.3)[b]

[a] NIH/NCI SEER Program statistics from several regions around the U.S.
[b] Statistics calculated with extremely high uncertainty because they are based on fewer than 25 cases. Other rates (not footnoted) were calculated from larger total numbers of cases and, therefore, have less uncertainty associated with them.
Source: Miller et al. 1996

(ages 0 to 19 years) thyroid, and brain and nervous system cancers.

Following a review of tabulated incidence rate data for 23 major cancers, nine were selected for additional review and evaluation: liver and intrahepatic bile duct cancer, non-Hodgkin's lymphoma, leukemia, melanoma of skin, ovarian cancer, breast cancer, childhood cancers, thyroid cancer, and brain and nervous system cancer. The majority of these cancers were chosen on the basis of incidence rates, which were higher in Los Alamos County in comparison to the reference populations. Childhood cancer was chose for further review based on mortality rate data showing an apparent excess of childhood cancer deaths in Los Alamos County. Leukemia and liver cancer where chosen as cancers of concern specifically to examine tumor cell types. Cancers not chosen for further review included major sites in the respiratory, digestive, and urinary systems.

Incidence Data: Data Sources

Information regarding newly diagnosed cancers among Los Alamos County residents and New Mexico non-Hispanic Whites was compiled from records collected since 1969 by the NMTR at the University of New Mexico Cancer Center. Cancer is a reportable disease in New Mexico by regulation of the New Mexico Department of Health (NMDOH). Since the late 1960's, NMTR has been the repository of the confidential medical record abstracts and computerized masterfile for cancer in New Mexico. NMTR has been a part of the SEER Program since that program began in 1973.

Cancer Incidence Findings (1970 to 1990)

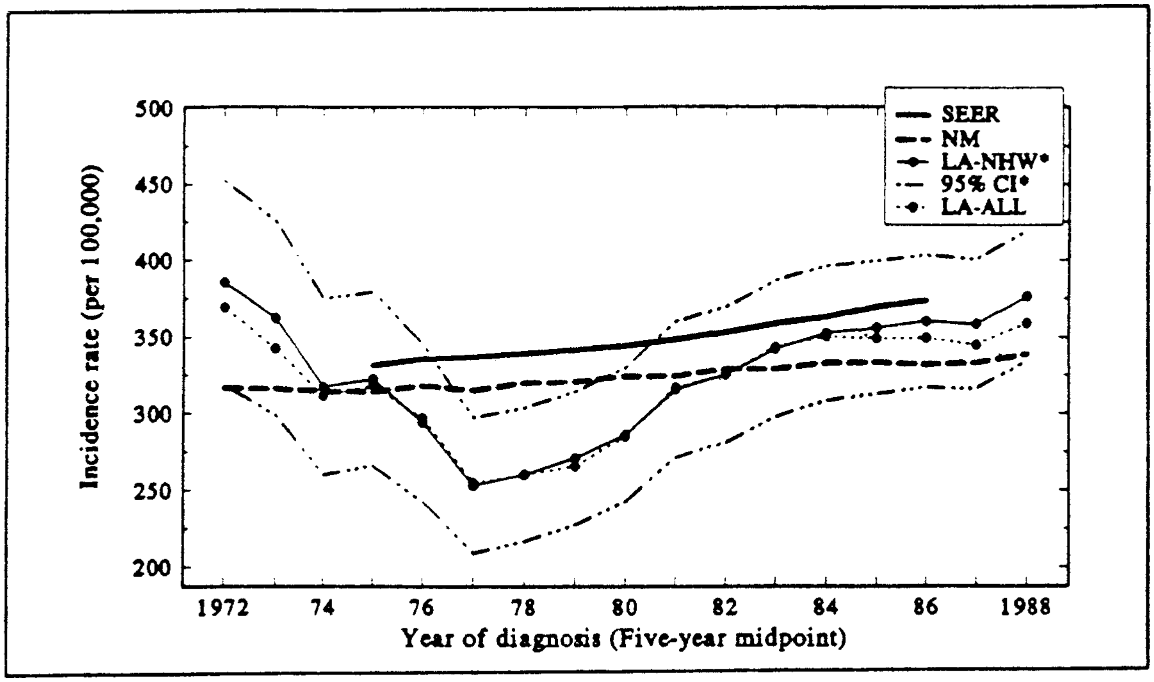
All Cancers. Figure D.1.2.4–1 shows that the Los Alamos County incidence rates for "all cancers" fluctuated considerably; but the rates generally were comparable to or lower than rates observed in the state and national reference populations.

Liver and Intra-Hepatic Duct Cancer. Seven cases of primary liver and intra-hepatic bile duct cancer occurred in Los Alamos County. Four of the seven cases (57 percent) were diagnosed between 1981 and 1982. Los Alamos County incidence rates were highly variable as a result of the small number of cases and the clustered temporal distribution of cases. No cases were reported up until the early 1980's, at which time the four cases diagnosed in 1981 to 1982 caused a marked elevation in the Los Alamos County rates in comparison to the state and national reference rates (Figure D.1.2.4–2). Los Alamos County rates subsequently diminished to a level consistent with the reference rates.

Non-Hodgkin's Lymphoma. Los Alamos County consistently experienced a small to modest elevation in incidence compared to the reference populations (Figure D.1.2.4–3). The magnitude of the elevated Los Alamos County incidence varied widely up to a two-fold higher than expected level. None of the Los Alamos County lower confidence limits excluded the reference rates. Incidence in the Los Alamos County non-Hispanic White population was consistently higher than that observed in the total county population. All Los Alamos County rates were based on 14 or fewer cases. For the most recent five-year time period (1986 to 1990), the rate for non-Hispanic Whites in Los Alamos County was 57 percent greater than the state reference rate.

Leukemia. The incidence of leukemia in Los Alamos County generally was the same or lower than that observed in the reference populations (Figure D.1.2.4.–4). Wide fluctuations in the Los Alamos County rates occurred as a result of low case numbers. All Los Alamos County rates were based on nine or fewer cases. For the most recent 5-year time period (1986 to 1990), the Los Alamos County rate equalled the state reference rate.

Melanoma. The incidence of melanoma consistently was around 50 percent higher in New Mexico non-Hispanic Whites compared



SOURCE: Athas and Key 1993

FIGURE D.1.2.4–1.—*5-Year Average Annual Incidence of All Cancer Sites, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

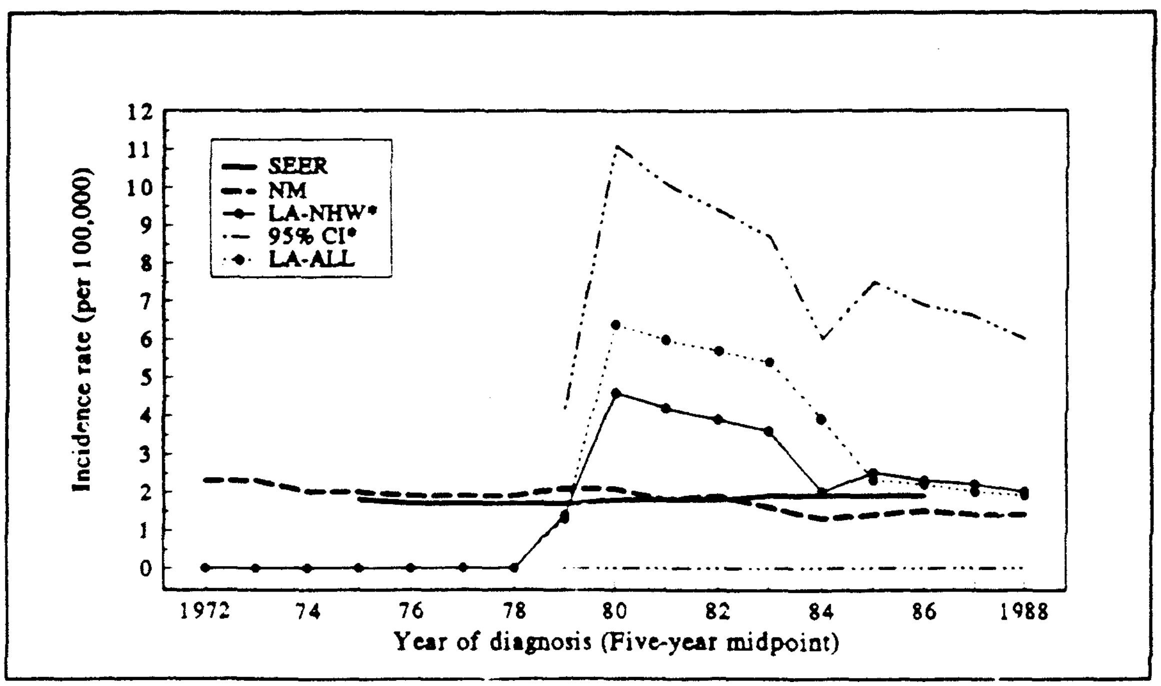


FIGURE D.1.2.4–2.—*5-Year Average Annual Incidence of Liver and Intra-Hepatic Bile Duct Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

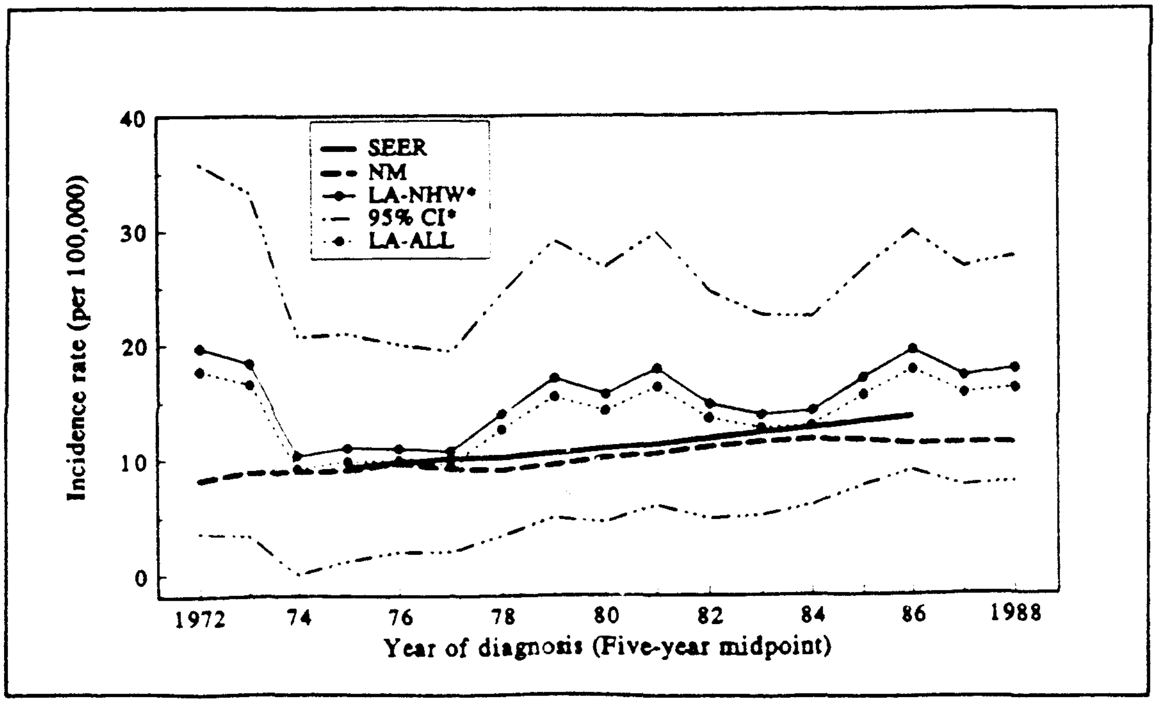


FIGURE D.1.2.4–3.—*5-Year Average Annual Incidence of Non-Hodgkin's Lymphoma, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

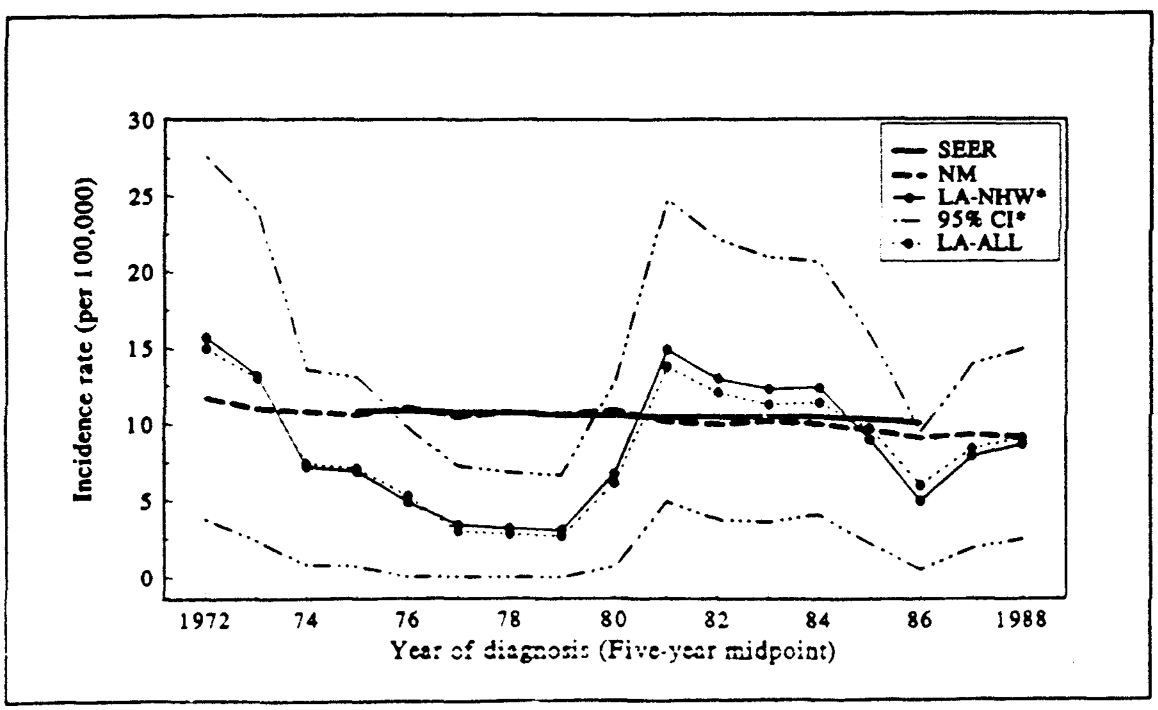


FIGURE D.1.2.4–4.—*5-Year Average Annual Incidence of Leukemia, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

with SEER Whites. Melanoma incidence steadily increased in both reference populations. Incidence rates in Los Alamos County were higher than the state reference rates over most of the 21-year study time period (Figure D.1.2.4–5). Early time periods were characterized by a small elevation in the Los Alamos County incidence; whereas, a more pronounced excess of melanoma in Los Alamos County began to appear in the mid 1980's. Beginning with the 1982 to 1986 period, and for all subsequent periods, the lower confidence limit of the Los Alamos County rate excluded the state reference rates. During these later periods, the incidence of melanoma in Los Alamos County increased roughly two-fold over that observed statewide.

Ovarian. Los Alamos County rates steadily rose by three-fold during 1970 to 1990, while both the sate and national reference rates remained essentially constant (Figure D.1.2.4–6). Initially lower than the reference rates, Los Alamos County incidence climbed to a statistically significant three-fold excess level during the 1982 to 1986 period. Half of all the Los Alamos County cases (15 out of 30) were diagnosed during these 5 years. Los Alamos County ovarian cancer incidence was two-fold higher than that observed in the state during the most recent 5-year period (1986 to 1990).

Breast. Breast cancer incidence in Los Alamos County women varied little over time; whereas, both reference populations displayed increasing incidence over time (Figure D.1.2.4–7). Los Alamos County incidence rates were 10 percent to 50 percent higher than the state and national reference rates over the entire study period. The lower confidence limits for the Los Alamos County rates consistently were near the reference rates, but excluded the reference rates in only several instances.

Childhood Cancers. Los Alamos County childhood cancer rates fluctuated around the more stable state and national reference population rates (Figure D.1.2.4–8). Following an initial two-fold elevation during the earliest

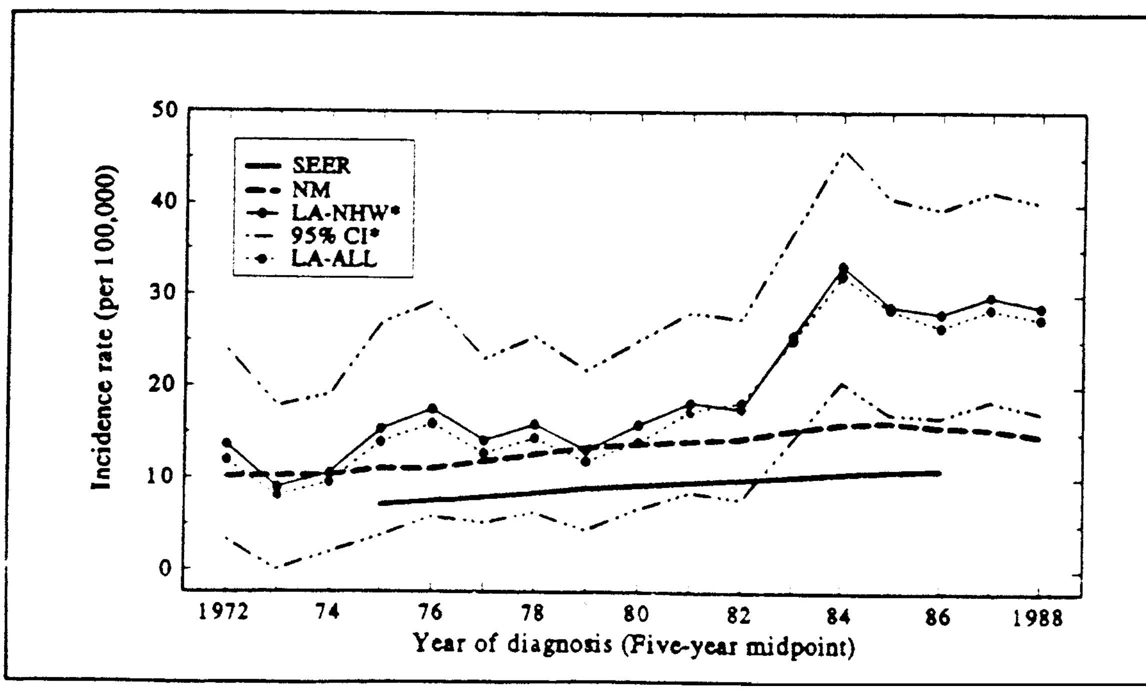


FIGURE D.1.2.4–5.—*5-Year Average Annual Incidence of Melanoma of Skin, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

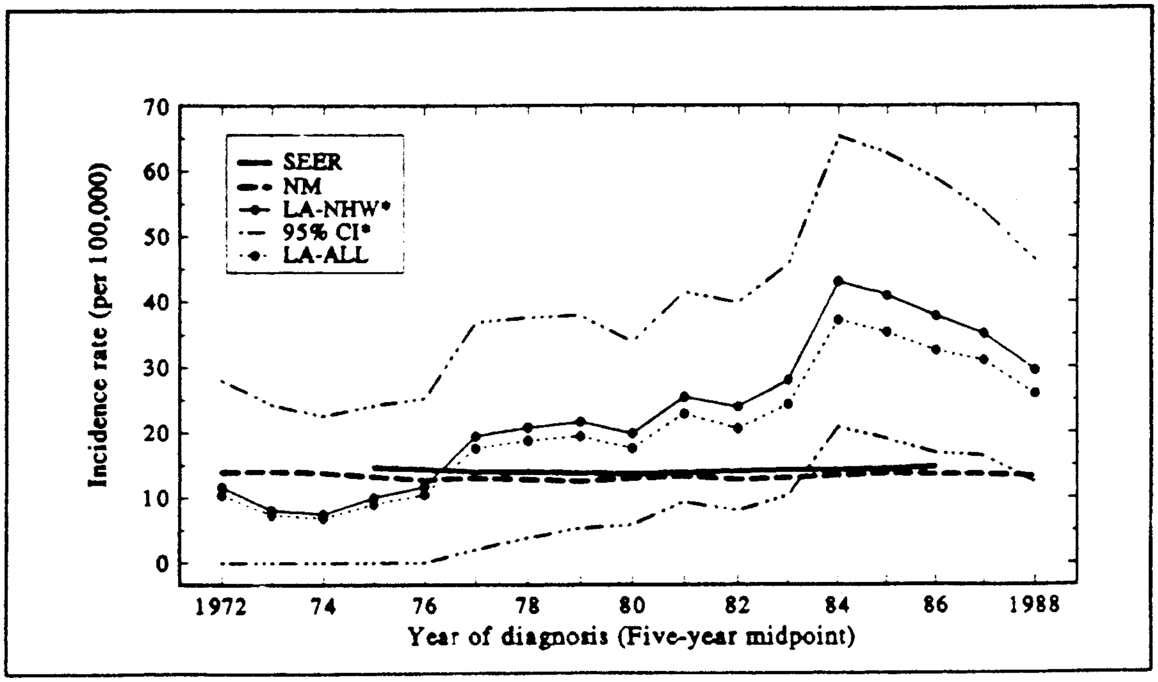


FIGURE D.1.2.4–6.—*5-Year Average Annual Incidence of Ovarian Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

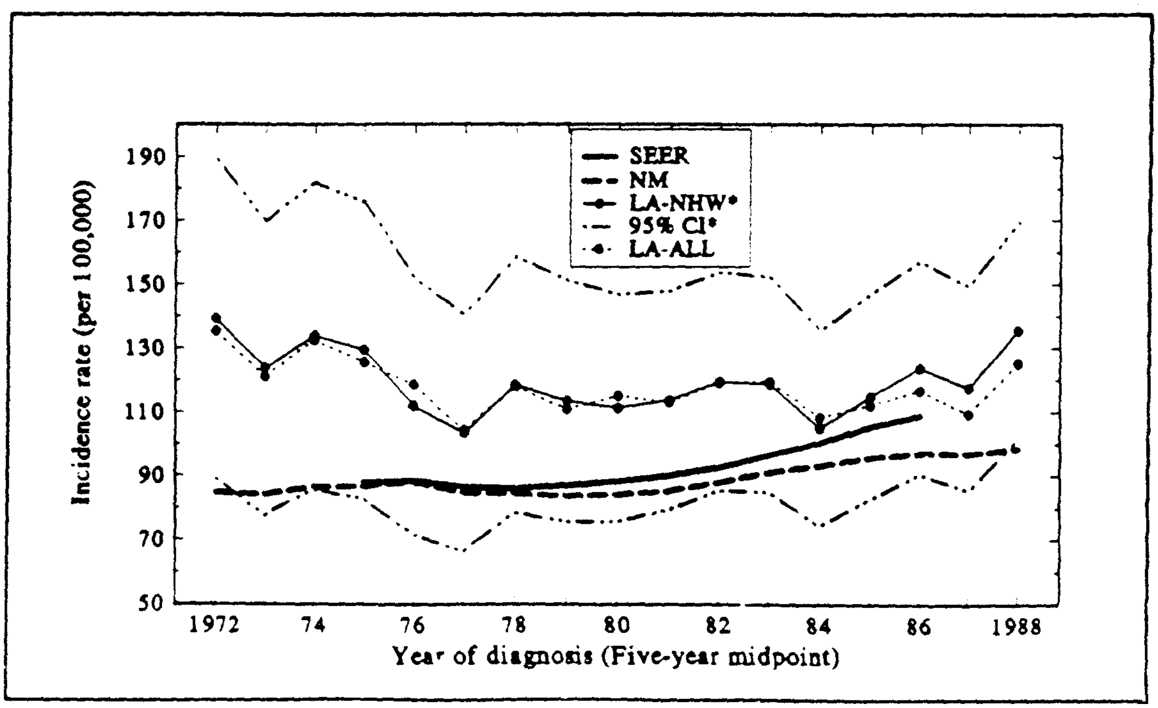


FIGURE D.1.2.4–7.—*5-Year Average Annual Incidence of Female Breast Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

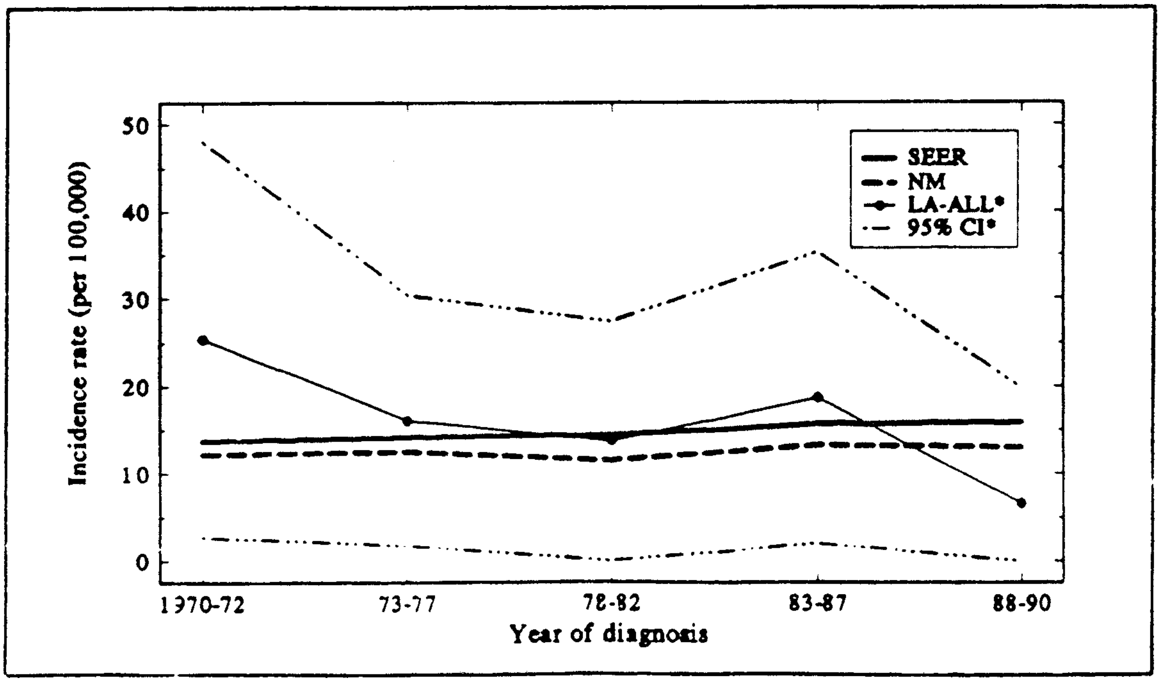


FIGURE D.1.2.4–8.—*Average Annual Incidence of Childhood Cancer (0 to 19 Years), Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.[a]*

[a] Incidence rate data based on independent time periods and not 5-year moving averages.

period (1970 to 1972), subsequent periods were characterized by incidence rates that were slightly higher than or lower than the reference incidence rates. Two childhood brain cancer cases not in the original childhood cancer data set were discovered through a supplemental review of childhood cancer mortality statistics. The two additional cases, diagnosed in 1978 and 1980, would raise the original 1978 to 1982 Los Alamos County rate (13.7 per 100,000) by about 50 percent to 20.3 cases per 100,000. For the latest period (1988 to 1990), the incidence of childhood cancers in Los Alamos County was roughly 50 percent lower than that seen in the state reference population; however, the Los Alamos County rate was based on only one case.

Thyroid. The incidence of thyroid cancer in Los Alamos County prior to the mid 1980's was roughly stationary and less than two-fold higher than that seen in the reference populations (Figure D.1.2.4–9). Los Alamos County incidence rates began to rise during the mid 1980's and continued to climb up until the latest time interval (1986 to 1990). The incidence of thyroid cancer in Los Alamos County during 1986 to 1990 was nearly four- fold higher than that observed in the state reference population. The near four-fold elevation for Los Alamos County was statically significant. Roughly half (17 out of 37) of all thyroid cancer cases that occurred in Los Alamos County between 1970 and 1990 were diagnosed during the 1986 to 1990 interval.

Brain and Nervous System. The incidence of brain cancer in Los Alamos County increased over time (Figure D.1.2.4–10). Los Alamos County incidence rates were lower than or comparable to the reference rates up until the mid 1980's. Increases in Los Alamos County brain cancer incidence became apparent during the mid to late 1980's. Los Alamos County incidence rates (all races) during this period were 60 to 80 percent higher than rates for the state and national reference populations. Diagnosed in 1978 and 1980, two additional

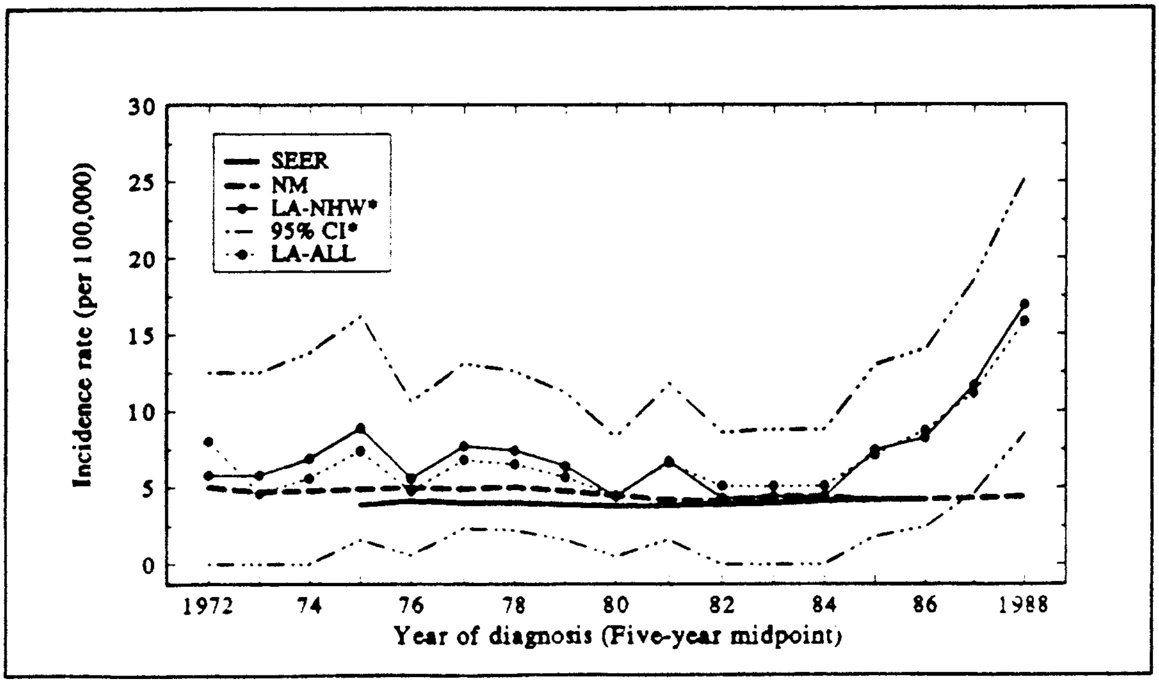


FIGURE D.1.2.4–9.—*5-Year Average Annual Incidence of Thyroid Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

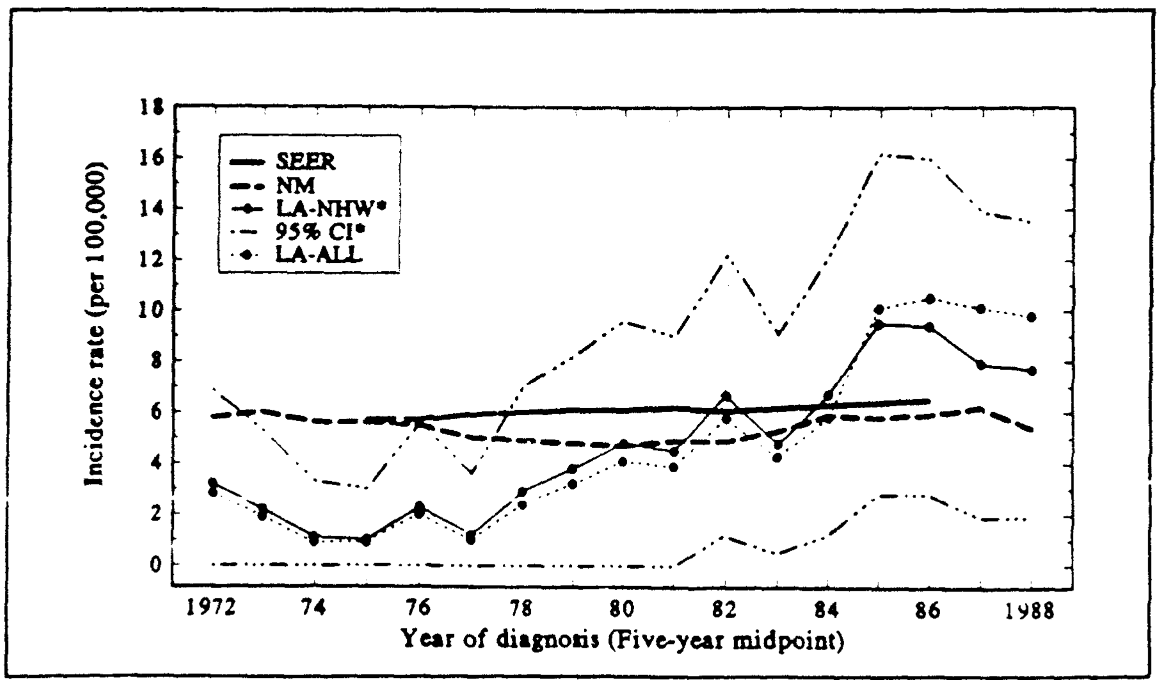


FIGURE D.1.2.4–10.—*5-Year Average Annual Incidence of Brain and Nervous System Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

cases raised the central portion of the incidence rate curve to a range more comparable with the reference rates, but had no effect on the rates observed during the period of elevated incidence.

Mortality

Mortality rates for Los Alamos County and the U.S. were obtained as age-adjusted average annual mortality rates from the National Center for Health Statistics (NCHS) and the National Cancer Institute. All rates were standardized to the 1970 U.S. standard population and were race-specific for Whites. Site-specific Los Alamos County mortality rates were available for the periods 1969 to 1972, 1973 to 1977, 1978 to 1982, and 1983 to 1987. U.S. rates were available for the time period 1968 to 1972. For some cancers, both Los Alamos County and U.S. rates were available for the period 1968 to 1972. The confidence intervals that accompany the mortality rates were calculated as described for the incidence rates. Table D.1.2.4–1 summarizes the mortality rates by cancer type for Los Alamos County. Nationwide rates are also reported for comparison.

Subcounty Cancer Incidence

Table D.1.2.4–2 describes the cancer incidence for the five census tracts within Los Alamos County for all races, 1980 to 1990. The New Mexico non-Hispanic White population rates are provided also.

TABLE D.1.2.4–1.—*Average Annual Age-Adjusted Mortality Rates by Cancer Type for Los Alamos County and U.S. Whites (1969 to 1987)*

CANCER TYPE	LOCATION	MORTALITY RATE[a]			
		1969 TO 1972	1973 TO 1977	1978 TO 1982	1983 TO1987
Liver and Bile	Los Alamos	14.6 (2)[b]	0 (0)	5.4 (3)	7.1 (4)
	U.S.	—	2.1	2.1	2.3
Non-Hodgkin's Lymphoma	Los Alamos	13.5 (2)	5.8 (2)	12.0 (6)	2.3 (2)
	U.S.	NA[c]	4.9	5.2	5.9
Leukemia	Los Alamos	1.2 (1)	11.2 (6)	1.3 (1)	4.5 (4)
	U.S.	NA	6.8	6.7	6.5
Melanoma	Los Alamos	0 (0)	6.5 (3)	2.9 (2)	1.0 (1)
	U.S.	1.7	1.9	2.2	2.3
Ovarian	Los Alamos	19.7 (3)	5.7 (1)	8.9 (3)	3.8 (2)
	U.S.	NA	8.6	8.1	7.9
Breast	Los Alamos	39.6 (8)	17.4 (7)	60.7 (20)	29.7 (12)
	U.S.	26.9	26.9	26.6	27.2
Childhood Cancer	Los Alamos	3.6 (1)	12.3 (4)	16.1 (5)	10.6 (3)
	U.S.	6.6	5.4	4.6	4.0
Brain and Nervous System	Los Alamos	0 (0)	6.3 (4)	5.8 (5)	5.8 (5)
	U.S.	NA	4.0	4.1	4.3
Thyroid	Los Alamos	0 (0)	0 (0)	0 (0)	0 (0)
	U.S.	NR[d]	NR	NR	NR

[a] Rates per 100,000 and are age-adjusted to the 1970 U.S. standard population.
[b] Number of deaths given in parentheses.
[c] NA = Not available
[d] NR = Not reported

TABLE D.1.2.4–2.—*Average Annual Age-Adjusted Cancer Incidence Rates for Sub-County Regions of Los Alamos County, All Races (1980 to 1990)*[a]

SITE	CENSUS TRACT[b]					CDP[c]		LOS ALAMOS COUNTY	NEW MEXICO NHW[d]
	1	2	3	4	5	LOS ALAMOS	WHITE ROCK		
Non-Hodgkin's Lymphoma	18.9 (2)	4.5 (2)	20.4 (5)	11.1 (5)	16.7 (10)	12.6 (14)	16.7 (10)	14.3 (24)	11.0
	{0.0 to 45.6}	{0.0 to 11.0}	{2.2 to 38.7}	{1.2 to 21.0}	{6.1 to 27.2}	{5.8 to 19.3}	{6.1 to 27.2}	{8.5 to 20.1}	
Leukemia	1.9 (1)	10.3 (4)	17.5 (2)	5.5 (3)	11.8 (7)	7.1 (10)	11.8 (7)	8.5 (17)	9.5
	{0.0 to 5.7}	{0.0 to 20.6}	{0.0 to 42.2}	{0.0 to 11.8}	{2.9 to 20.7}	{2.6 to 11.6}	{2.9 to 20.7}	{4.4 to 12.6}	
Melanoma[e]	33.8 (10)	22.0 (10)	35.8 (7)	13.5 (6)	21.7 (11)	23.2 (32)	21.7 (11)	22.0 (43)	14.5
	{12.4 to 55.2}	{8.1 to 35.9}	{8.7 to 62.9}	{1.5 to 24.5}	{8.6 to 34.8}	{15.0 to 31.4}	{8.6 to 34.8}	{15.3 to 28.7}	
Ovary (Female)	76.7 (9)	19.4 (4)	19.5 (2)	14.0 (3)	12.7 (4)	27.4 (18)	12.7 (4)	23.0 (22)	12.8
	{25.6 to 127.8}	{0.0 to 38.8}	{0.0 to 47.0}	{0.0 to 30.2}	{0.0 to 25.4}	{14.5 to 40.3}	{0.0 to 25.4}	{13.2 to 32.8}	
Breast (Female)	145.3 (28)	120.5 (21)	159.2 (16)	85.3 (21)	116.0 (41)	119.8 (86)	116.0 (41)	119.0 (127)	92.2
	{90.4 to 200.2}	{67.9 to 173.1}	{79.6 to 238.9}	{48.1 to 122.5}	{79.8 to 152.3}	{93.9 to 145.6}	{79.8 to 152.3}	{97.9 to 140.1}	
Childhood (< 20 years)	21.9 (2)	6.7 (1)	0.0 (0)	24.5 (2)	16.9 (4)	14.2 (5)	16.9 (4)	15.2 (9)	14.8
	{0.0 to 52.8}	{0.0 to 20.2}	{ - }	{0.0 to 59.2}	{0.0 to 33.9}	{1.5 to 26.9}	{0.0 to 33.9}	{5.1 to 25.3}	
Thyroid	16.0 (6)	3.8 (2)	5.8 (1)	8.7 (4)	9.3 (9)	9.0 (13)	9.3 (9)	9.8 (22)	4.3
	{2.9 to 29.1}	{0.0 to 9.1}	{0.0 to 17.5}	{0.0 to 17.4}	{3.1 to 15.4}	{4.0 to 14.0}	{3.1 to 15.4}	{5.6 to 14.0}	
Brain	7.3 (2)	5.7 (3)	14.2 (3)	7.4 (2)	8.2 (7)	7.4 (10)	8.2 (7)	7.9 (17)	5.1
	{0.0 to 17.5}	{0.0 to 12.4}	{0.0 to 30.6}	{0.0 to 18.0}	{2.0 to 14.3}	{2.7 to 12.1}	{2.0 to 14.3}	{4.1 to 11.7}	

[a] Rates are for residence at diagnosis for all races per 100,000, age-adjusted to U.S. 1970 standard population; number of cases in parentheses ( ); 95% confidence limits in brackets { }, truncated at zero.
[b] Census Tract Designations: (1) North/Barranca Mesa; (2) North Community; (3) Western Area; (4) Eastern Area; (5) White Rock.
[c] Los Alamos Census Designated Place (CDP) comprises census tracts 1 through 4, White Rock CDP comprises census tract 5.
[d] Non-Hispanic Whites
[e] Excludes two cases with unknown residence at diagnosis.
Source: New Mexico Tumor Registry

D.2 METHODS USED FOR THE ESTIMATION OF HUMAN HEALTH CONSEQUENCES OF CONTINUED LANL OPERATIONS

The consequences of continued operations of LANL to public health and to LANL workers are evaluated in this SWEIS. The consequence analysis is based on several exposure scenarios that are conservatively defined in order to estimate potential maximum doses and risks (e.g., excess latent cancer fatality [LCF]) to the public and workers under normal operations in each of the four alternatives examined. (The consequences of credible and less than credible accidents on workers and the public are detailed in appendix G.)

D.2.1 Methods Used to Evaluate Public Health Consequences from Routine Operations

Public health consequences of continued LANL operations were based on several exposure scenarios, including exposure to external radiation, inhalation of airborne radioactivity and chemical emissions, ingestion of water and foodstuffs and inadvertent ingestion of sediments and soils, and dose received due to incident-free transportation to or from LANL. The methodology used to estimate dose to the public from external radiation and airborne radioactive and chemical emissions is given in appendix B. The methodology used to estimate dose from transportation to or from LANL is given in appendix F. The methods used to estimate dose, hazard, and cancer risk from radioactive and chemical intakes (inhalation and ingestion) are detailed below.

The estimation of potential dose and risk used in the public health consequence analysis was directed at estimating total risk. That is, the risks posed by all sources, including LANL, other anthropogenic sources, fallout and regional depositions such as through rainfall, and naturally occurring radionuclides and chemicals, were evaluated. For those radionuclides and chemicals shown to have risk probabilities greater than 1 in 1 million (1×10^{-6}) per year, the relative contribution of LANL operations versus other sources of risk was examined.

D.2.1.1 *Methods for Evaluation for External Radiation Risk and Inhalation Dose/Risk from Airborne Radionuclides and Chemicals*

The exposure pathways for members of the public were estimated for specific exposure scenarios and are "hypothetical" (that is, a person hypothesized to be present for a portion of the time or all the time that is conservatively located rather than by using actual location, such as assuming that a person is resident at the fenceline of a facility) members of the public. These include ingestion exposure scenarios for Los Alamos County residents, non-Los Alamos County residents, nonresident recreational users of canyons, resident recreational users of canyons, and people who could be exposed via special pathways. Special pathway exposures are through culturally associated lifestyle patterns such as increased use of herbal teas made from local vegetation, use of locally collected herbal smoking materials, working with clays, or increased consumption of local foodstuffs including game species resident/ migrating through the LANL reservation.

External Radiation and Airborne Radioactivity

For radioactive emissions from LANL facilities, population consequences were estimated to a radial distance of 50 miles (80 kilometers). Both point-source and diffuse source emissions were included in the analysis. Using the model CAP–88 (EPA 1992), the direct exposures (the sum of external radiation and inhalation and ingestion of airborne emissions) were estimated for each of the four alternatives for continued operations of LANL. The maximally exposed individual (MEI) was determined to be near the Los Alamos Neutron Science Center (LANSCE) (appendix B).

For individuals, the risk of excess LCFs was estimated for each alternative based on the recommendations of the International Commission on Radiological Protection (ICRP 1991), which provide the conversion of 0.0005 excess LCFs per rem of exposure (Table D.1.1.2–1).

Toxic Chemicals

Inhalation of airborne chemicals was evaluated on a TA-specific basis in the nonradiological air quality analysis presented in appendix B. The chemicals identified in this screening for public health consequence analysis were reviewed as described in section B.2.3.1.

First, a qualitative evaluation was made of the chemical's reference dose, toxicity, potential carcinogenicity, and chemical form(s) likely in the LANL area (both as released and upon deposition onto soils, waters, and sediments). Several chemicals identified in the very conservative nonradiological air screening process were eliminated from subsequent public health consequence analysis using these qualitative evaluations.

For the remaining chemicals, quantitative evaluation was made based on the modeled predicted concentrations at the nearest location where a member of the public could be exposed. The modeling methods are described in appendix B, as are the results for the modeled chemicals at specific TAs.

The factors used for quantitative analysis are those given in the *EPA Exposures Factors Handbook* (EPA 1997a). The exposure scenario assumed that a member of the public could be exposed to the average and 95th percentile concentrations of the chemical at that nearest location to the source. Average and worst-case (95th percentile) uptakes were calculated as milligram per kilogram-day for a standard adult human male.

Average and worst-case hazard indices were calculated (EPA 1997a): milligram per kilogram-day estimated per milligram per kilogram-day reference dose for the chemical. In some cases, no reference dose has been provided by EPA's IRIS (EPA 1997b). In instances where carcinogens or suspected carcinogens had no hazard index available, if unit risk factors were available, they were used to estimate potential risk to the MEI.

D.2.1.2 *Methods for Estimation of Ingestion Risks from Radionuclides and Chemicals*

Concentrations of radionuclides and chemicals in environmental media were used in dose/risk analysis. The data used were those from LANL's Environmental Surveillance Reports 1991 to 1996 (appendix C). The 95th percentile upper confidence level (95 percent UCL) values were used in order to provide a conservative analysis (calculated using only measurements above zero or the detection threshold).

Data from specific contaminated sites were used to provide insight to potential additional but short-term exposures that could contribute to dose/risk. These datasets are also provided in appendix C.

Table D.2.1.2–1 presents the specific exposure pathways evaluated for the five exposure scenarios: residents (both Los Alamos and non-Los Alamos County), recreational users (residents and nonresidents), and special pathways. These exposure scenarios are defined below.

TABLE D.2.1.2–1.—*Ingestion and Hypothetical Receptors Used to Evaluate Radiological Dose and Potential Public Health Consequence*

EXPOSURE PATHWAY	RECEPTOR[a]				
	OFF-SITE RESIDENT LOS ALAMOS COUNTY	OFF-SITE RESIDENT NON-LOS ALAMOS COUNTY	NONRESIDENT RECREATIONAL USER[b]	RESIDENT RECREATIONAL USER[b]	SPECIAL PATHWAYS RECEPTORS[c]
Produce:					
Fruit	ESD	ESD	NA	NA	NA
Vegetables	ESD	ESD	NA	NA	NA
Meat (Cattle: Free-Ranging Steer)	NA	ESD	NA	NA	NA
Milk	ESD	ESD	NA	NA	NA
Fish	NA	ESD	NA	NA	ESD
Honey	ESD	ESD	NA	NA	NA
Elk	ESD[d]	ESD[d]	NA	NA	ESD[e]
Deer	ESD	ESD	NA	NA	TBD
Pinyon Nuts	NA	ESD	NA	NA	NA
Indian Tea (Cota)	NA	NA	NA	NA	ESD
Groundwater	ESD	ESD	NA	NA	NA
Surface Water:					
Creeks	NA	NA	ESD	ESD	NA
NPDES Discharge	NA	NA	ESD	ESD	NA
Soils	ESD	ESD	ESD	ESD	NA
Sediments	ESD	ESD	ESD	ESD	NA

[a] Receptor is a hypothetical person who is conservatively estimated to have intake of the 95th upper confidence limit (UCL) concentration of a contaminant in the specific medium evaluated for ingestion.

[b] The resident recreational user lives in Los Alamos County or a neighboring county and is in the Los Alamos canyons 24 visits per year, approximately 8 hours per visit. The nonresident recreational user lives outside the region of influence of LANL but hikes into the canyons 12 visits per year, approximately 6 hours per visit.

[c] Special pathways receptors are those who have traditional Native American or Hispanic lifestyles.

[d] Elk muscle.

[e] Elk heart and liver.

ESD = Environmental Surveillance Data

NA = Not applicable

The doses/risks from ingestion pathways were examined as total ingestion risk, resulting from all contributors to the concentrations of radionuclides and chemicals in foodstuffs, water, and soils/sediments. The concentrations include naturally occurring radionuclides and chemicals, residual contamination from worldwide fallout and earlier LANL operations, and small quantities of contamination from more recent operations. Because it is difficult to differentiate among these sources for most materials, this SWEIS analysis calculates the total risk from all these sources. (If this analysis demonstrated elevated risks from a particular contributor, then it would be investigated to determine its possible sources.)

The exposures through ingestion were calculated using the 95 percent upper confidence limit (UCL) concentrations. In calculating the UCL, all samples of zero or negative value or less than the detection limit were rejected. This significantly increases the average value and the UCL, and especially so when a large fraction of the samples show no detectable contamination. Based on the projected emissions and effluents under the four alternatives (section 3.6), there are no incremental differences in dose/risk from operations continuing at LANL for the next 10 years. Therefore, the ingestion dose/risk analysis was provided only in the No Action Alternative.

The consumption rates used for estimating dose/risks at both 50^{th} and 95^{th} percentile were taken from the *EPA Exposure Factors Handbook* (EPA 1997a, except where only available in 1989 edition). In each dose/risk ingestion analysis provided, the specific data used were identified as well as the intake rates and any conversion factors. Because these differ among radionuclides and chemicals analyzed, they are only provided in the dose/risk analysis detailed tables (section D.3.3).

Off-Site Resident

Two different types of off-site resident were analyzed: one of these represents Los Alamos County residents; the other represents non-Los Alamos County residents and was located near the Otowi Bridge (outside Los Alamos County) in an agricultural area.

Los Alamos County Off-Site Resident. Because there is no meat or milk production from Los Alamos County, there are no viable meat or milk ingestion pathways for any doses to residents in Los Alamos County. The Los Alamos County resident was assumed to have a garden at his or her home, and it was conservatively assumed that a portion of the resident's produce (fruit and vegetables) was obtained from this garden. The resident in Los Alamos County would use water from the Los Alamos County water supply.

Thus, the pathways for the off-site resident in Los Alamos County would include ingestion of produce, fish, honey, game animals, pinyon nuts, groundwater, and inadvertent ingestion of sediments and soil. Doses for ingestion pathways were primarily determined using the concentrations in the various media measured in LANL environmental surveillance programs (LANL 1992, LANL 1993, LANL 1994, LANL 1995, LANL 1996a, and LANL 1996b). These consumption rates are provided in Table D.2.1.2–2.

Non-Los Alamos County Off-Site Resident. The exposure pathways that are applicable to this off-site resident are the same as those for the Los Alamos County off-site resident, with the following exceptions. Two additional pathways were evaluated for non-Los Alamos County residents: ingestion of meat and ingestion of milk from sources outside of Los Alamos County but within the LANL region of influence (based on current LANL surveillance data, 1991 to 1996).

TABLE D.2.1.2–2.—*Consumption Rates Used for Public Health Consequence Analysis*

INGESTION PATHWAY	INGESTION RATE PER YEAR	
	AVERAGE VALUE (50%)	WORST-CASE VALUE (95%)
Produce	202 kg	587 kg
Milk Products	210 liters	778 liters
Meat	55 kg	134 kg
Fish	7 kg	7 kg
Honey	1.4 kg	5.0 kg
Pinyon Nuts	1.5 kg	none given
Water	550 liters	891 liters (90th percentile)
Soil and Sediments	0.036 kg	0.146 kg
Homegrown Fraction: Vegetables[a]	25%	40%
Homegrown Fraction: Fruit[a]	20%	30%

[a] EPA 1989

Recreational Users

The nonresident recreational user was defined in this analysis as a person who occupies on-site canyons during 12 visits per year, for 6 hours per visit. The resident recreational user was hypothesized to be resident in Los Alamos or neighboring counties and to spend an average of 2 visits per month, 8 hours per visit, in the canyons as an avid local outdoor enthusiast.

Special Pathways

Special pathways were also evaluated to assess potential impacts to Native American, Hispanic, and other traditional lifestyle receptors that might not be bounded by the hypothetical MEIs of residents and recreational users. The following exposure pathways were evaluated:

- Ingestion of game animals from the LANL area
- Ingestion of fish from the Cochiti reservoir
- Ingestion of native vegetation through the use of herbal teas
- Dermal absorption of sediments during craft or ceremonial use of clays
- Inhalation of local herbaceous plant materials via smoking
- Ingestion of surface waters from LANL
- Ingestion of soils and sediments from LANL
- Ingestion of locally grown produce

After investigations via interviews, it was determined that potential dermal absorption of contaminants from use of native clays for pottery is not a viable pathway. Clays are taken from specific areas and at depths that are not subject to appreciable contamination. Also, it was determined that potential uptakes via bathing or ceremonial uses of springs is not a viable pathway at LANL because there are no known permanent springs of sufficient size for such use. Finally, smoking use of herbs was not evaluated as a pathway because these are used in concert with tobaccos and do not significantly differ in risk than the risk posed by commercial tobacco use.

D.2.2 Worker Health

The methods used to estimate potential consequences to the health of workers from continued operations of LANL are given below.

These methods address: ionizing and nonionizing radiation, chemical exposures, and physical safety hazards during normal operations in LANL. The methods and consequences of accidents are addressed in appendix G.

D.2.2.1 *Radiological Consequences to Workers*

The worker radiation dose projected for this SWEIS is the total effective dose equivalent incurred by workers as a result of routine operations. The dose is the sum of the external whole body dose as monitored by personnel dosimeters, including dose from both photons and neutrons, and internal dose, as required by 10 CFR 835. The internal dose is the 50-year CEDE. However, the internal dose being projected is that for tritium, and does not include dose from incidents with plutonium or other nuclides. The internal dose from inhalation of plutonium occurs almost entirely from a breakdown of control or equipment, and is not predictable. Past plutonium exposures, such as the examples described in chapter 4 of volume I (Table 4.6.2.1.–1), are reported to DOE and have been included in the 1993 to 1995 baseline. Note that in 1996, plutonium produced measurable dose in two workers, contributing 4.8 person-rem to the worker collective dose. These incidental exposures are small compared to the total collective dose, which runs about 200 person-rem.

The collective doses for each LANL group and contractor, as monitored by the LANL Radiation Protection Program, were collected for 1993, 1994, and 1995 (LANL 1995, LANL 1996a, and LANL 1996b). The collective doses for the 3 years were summed for each group, and the groups were ranked by their total collective doses. Because of a major LANL reorganization in 1993 and 1994, many groups that were operating in 1993 and 1994 disappeared in 1995. Their functions were typically assumed by another group. This did not affect the major groups receiving radiation doses at LANL, which are listed in Table D.2.2.1–1 except for some groups at LANSCE (then called the Los Alamos Meson Physics Facility [LAMPF]). For these exceptions, the old groups were tracked to their new LANSCE counterparts through interviews with LANSCE personnel.

The 12 groups with the greatest total collective doses from 1993 through 1995 comprised more than 80 percent of the total collective dose for all LANL workers during that period. In addition to these 12 groups, groups that contributed more than 1 percent of the total LANL collective dose during this timeframe were interviewed to determine whether they would become major contributors to the collective dose in the future.

This process resulted in the identification of 15 groups that combined to contribute more than 84 percent of the collective LANL worker dose from 1993 to 1995 (Table D.2.2.1–1). These groups are included in the detailed radiation dose projections and analyses under each of the four SWEIS alternatives, based on the alternative descriptions and on historical exposure information. The following data were obtained for each of these groups:

- The group collective dose under each SWEIS alternative
- The group total collective dose from all programs for each alternative
- The number of workers with nonzero doses for each of the alternatives, as defined by LANL (Workers with measurable doses are referred to as nonzero dose workers.)

In order to obtain the total number of workers with nonzero dose for the entire laboratory, the index data were used to calculate a ratio of the number of workers with nonzero doses to the total number of workers monitored for radiation doses for the entire laboratory. Approximately 51 percent of the workers receiving a nonzero dose belong to the 12 groups that received the

TABLE D.2.2.1–1.—*Groups Used in the Projection of the Worker Doses*

RANK	GROUP	PERCENT OF LANL COLLECTIVE DOSE (1993 TO 1995)	CUMULATIVE PERCENT OF LANL COLLECTIVE DOSE (1993 TO 1995)[a]	KEY FACILITY
1	Operational Health Physics	17	17	LANL-wide
2	Actinide Ceramics and Fabrication	14	30	TA–55
3	Nuclear Materials Management	11	41	TA–55
4	LANL Craft Subcontractor	8.9	50	LANL-wide
5	Actinide Process Chemistry	8.7	59	TA–55
6	Weapons Component Technology[b]	8.2	67	TA–55
7	Particle Physics Studies	4.0	71	LANSCE
8	Weapons Component Technology[b]	2.9	74	TA–55
9	Target Area Maintenance	2.6	76	LANSCE
10	Facility Management Operations	1.9	78	TA–55
11	Actinide Research and Development	1.6	80	TA–55
12	Beam Alignment and Maintenance	1.5	81	LANSCE
13	Advanced Nuclear Technology	1.3	83	TA–18
14	Weapons Neutron Research/Manuel Lujan Center Experimenters	1.0	84	LANSCE
15	LANSCE Experimenters[c]	0.7	84.4	LANSCE

[a] Numbers may not total exactly due to rounding.
[b] These groups were combined in 1996.
[c] Refers to a group of workers and not to the entire key facility known as LANSCE.

largest dose from 1993 to 1995, and 49 percent belong to the rest of the laboratory.

Once the above group data were collected, the following steps were taken to determine the worker collective dose, the average nonzero worker dose, and the cancer risk associated with these doses:

- For each alternative, the dose projections for the groups listed in Table D.2.2.1–1 were totaled. The sum was then divided by 0.844 (the fraction of the total laboratory dose comprised by these groups from 1993 to 1995) to estimate the total collective dose for LANL.
- The total collective dose was then divided by the fraction of workers projected to have nonzero doses to obtain the average nonzero worker dose for the entire laboratory.
- A dose-to-risk conversion factor of 4×10^{-4} excess LCF per person-rem (Table D.1.1.2–1) was used to determine the risks associated with the above doses in Table D.2.2.1–2.

It should be noted that actual doses received by workers will vary to some degree based on the actual work assignments made at LANL. For example, the Particle Physics Studies group may again become involved in activities at LANSCE and may again incur some worker dose. Other groups may incur more or less dose than is projected using this methodology. The approach taken in this analysis is considered conservative (in particular, use of the 0.844 normalization factor changes the entire LANL

TABLE D.2.2.1–2.—*Worker Dose for Baseline and Alternatives*

ALTERNATIVE	COLLECTIVE DOSE (PERSON-REM/ YEAR)	COLLECTIVE EXCESS LCF RISK (LCF/YEAR)	AVERAGE DOSE (MILLIREM/ YEAR)	INDIVIDUAL EXCESS LCF RISK (LCF/YEAR)
Baseline (1993 to 1995)	208	0.083	0.097	3.9×10^{-5}
No Action	446	0.178	0.135	5.4×10^{-5}
Expanded Operations	833	0.333	0.235	9.4×10^{-5}
Reduced Operations	170	0.068	0.083	3.3×10^{-5}
Greener	472	0.189	0.141	5.6×10^{-5}

collective worker dose in a manner proportional to the changes incurred by the 15 groups with the greatest doses).

The collective and average measurable dose for the No Action Alternative are larger than those for the baseline. This is because the No Action Alternative includes projects that are not now being performed and that were not performed in 1993 to 1995. The average dose is expected to increase significantly in the Expanded Operations Alternative because the programs are expected to expand at a greater rate than is the number of radiation workers. As noted earlier, the dose projections include the doses from external radiation and tritium, but not from other radionuclides (such as plutonium). This is because past and present bioassay for radionuclides within the body are not sensitive to the low intakes typical of normal operations. A new method having significantly improved sensitivity for analyzing bioassay samples is now under development. This will not change the dominance of external radiation and tritium, however, but will permit a more accurate quantification of the internal doses from other radionuclides.

Despite the appearance in Table D.2.2.1–2 of the three significant digits that resulted from the process, the projected doses are, at best, only approximations. The parameters that affect the dose estimates have considerable variability, such as whether a program will be funded and at what level, what the final work practices will be, and mitigating factors such as shielding and controls that will be employed in implementing the as low as reasonably achievable (ALARA) process. Because of these uncertainties, an attempt was made to maximize the estimates given here by using the upper limit of the dose that could arise from a particular operation. This may have had an effect on the differences between the alternatives, but not likely upon their relative ranking as to worker dose. In any case, for all alternatives the average individual worker dose and the administrative control level for the individual are much lower than the standard of 5 rem per year.

DOE (10 CFR 835) requires that the ALARA process be applied to reduce worker exposure to ionizing radiation. The DOE also has set an administrative control level of 2 rem per year for an individual worker exposure, and LANL has set a level of 1 rem per year. These levels can be intentionally exceeded only with higher level management approvals.

Occasionally, however, individual radiation workers might be given permission to exceed this level if sufficient justification exists. It is not anticipated that any of the groups will request permission to exceed the DOE administrative control level (ACL) of 2 rem per year. Therefore, the maximum worker dose for any of the SWEIS alternatives was estimated to be approximately 1.95 rem per year for the purposes of this SWEIS. This maximum dose estimate would not vary across alternatives and would remain below 5 rem per year in the absence of accidental exposures.

D.2.2.2 *Nonionizing Radiation Consequences to Humans and Other Biota*

A review of the LANL OSHA 200 Logs (LANL 1990 to 1996) and of DOE's Occurrence Reporting and Processing System (ORPS) reports (LANL 1990 to 1995) was performed to identify any reported injuries to workers from nonionizing radiation. Because there are no incidences of nonionizing radiation injuries to workers, a hypothetical analysis of a worst-case exposure was hypothesized for the SWEIS.

In order to perform this analysis, a methodology was needed to relate a transmitter output to biological effect. The methodology developed was consistent with NCRP 67 (1981), NCRP 86 (1986) NCRP 119 (1993), Cember (1996), and Calder (1984). A spreadsheet was developed that allows the input of transmitter parameters (power, frequency, and antenna size), receptor parameters (exposure area, organism density, organism specific heat rate), and exposure parameters (distance and exposure time) to be used to determine the rise in receptor temperature due to an exposure. Additionally, the spreadsheet was used to determine the power densities at specific distances or the distance to a specific power density.

Four typical targets of interest were chosen for microwave radiation exposure at the TA–49 microwave transmitter: human, to represent both workers and the public at the nearest potential exposure point; zone-tailed hawk, to represent birds of all sizes in the Jemez Mountains; coyote, to represent middle-range animals; and elk, to represent large grazing animals. Exposure duration is governed by the operation of the microwave transmitter and is typically limited to short bursts. These give the range of potential effects of nonionizing radiation on higher order complex animals.

The area immediately around the transmitter(s) is secured. The closest that a member of the general public can get to a transmitter is approximately 1,640 feet (500 meters) to the southwest, along State Route 4. By procedure, all microwave experiments are directed east, away from State Route 4. Procedures do not permit directing the microwave beam above the horizontal plane. On site, the downrange microwave beam path is secured to a distance of 3,280 feet (1,000 meters). The receiving antenna(s) can be positioned anywhere along the beam path. Beyond 3,280 feet (1,000 meters), the beam path is uncontrolled other than by the remoteness of the facility.

The results are expressed as increased body temperature as a result of a short burst exposure. This estimate is conservative because even exposure to 1 second from the source is extremely unlikely. Results for potential microwave exposures for the targets of interest are given in Table D.2.2.2–1. Beyond the distances given in Table D.2.2.2–1, and more typical of the distances humans would be from the microwave source, body temperature increase would be less than that given in the table.

There is no increase in body temperature of humans or other animals evaluated for a 1-second exposure to microwaves. The negligible consequences resulting from body temperature rise of a target would not approach any critical metabolic temperature. However, body temperature changes could be greater if the person or animal were exposed for long periods, or were closer to the source, or if there were increased power output.

D.2.2.3 *Chemical Exposures Consequences to Workers*

There have been no fatal or disabling chemical exposures at LANL in the 1990's, and there is no reason to expect that this would change under any of the alternatives analyzed in this SWEIS.

TABLE D.2.2.2–1.—*Temperature Rise Due to Microwave Exposure (1-Second Exposure Duration)*

TARGET	DISTANCE IN FEET (METERS)	BODY TEMPERATURE RISE (°C)
Zone-Tailed Hawk	1,640 (500)	0.016
Coyote	3,280 (1,000)	0.0055
Elk	3,280 (1,000)	0.0036
Human	1,640 (500)	0.021
	3,280 (1,000)	0.0052

°C = degrees centigrade

It is anticipated that there would continue to be a few, less serious exposures annually, particularly exposures to: airborne asbestos, lead paint particulates, crystalline silica, fuming perchloric acid, hydrofluoric acid, or skin contact with acids or alkalis. These would be similar to those listed in Table 4.6.2.1–2.

Rates of such chemical exposures were projected by alternative on the basis of changes in the LANL worker population. During the recent years (1990 to 1996) reportable chemical exposures occurred at a rate of one to three incidents per year at LANL, and the worker population was approximately 9,000 individuals. Therefore, the current rate of injuries was used to estimate the number of injuries occurring during continuing operations of LANL, assuming the same rate is experienced in the projected workforce for each of the four alternatives. Although LANL has undertaken a chemical hygiene program that should reduce the rate of chemical exposures in the future, this methodology assumes no additional benefits from implementation of this program.

Beryllium

There is an ongoing beryllium worker monitoring program at LANL within the facility (Sigma) where beryllium is processed in quantities and chemical forms posing worker hazards.

The Chronic Beryllium Disease (CBD) Program Plan elements consist of conducting a baseline inventory and sampling, conducting hazard assessments, conducting exposure monitoring, reducing and minimizing exposures, conducting medical surveillance, providing training, keeping records, and providing performance feedback. Exposure reduction and minimization includes reducing airborne levels of beryllium as-low-as-practical, minimizing the number of current workers exposed and potentially increasing the number of early treatment options that may slow the progression of CBD and reduce health impacts and reduce mortality incidence. The disability associated with CBD is believed to be minimized by early detection of the disease. Workers sensitized to beryllium or with CBD are offered placement in positions without beryllium exposure to maintain employment, and are assured of secure benefits that provide medical care.

The presentation and progression of CBD are highly variable. A percentage of individuals with positive peripheral blood beryllium-induced lymphocyte proliferation test (Be-LPT) results go on to be diagnosed with CBD even though clinical signs and symptoms of CBD are not present at the time of the test.

The qualitative consequence analysis presented in chapter 5 was based on (1) engineering controls and the health and safety program to be implemented when the Beryllium Technology Center is opened in late 1998, and (2) industry standards and exposure limits under OSHA, as well as recommendations of American Conference of Governmental Industrial Hygienists (ACGIH) and National Institute for Occupational Safety and Health (NIOSH). These are summarized below.

OSHA Beryllium Exposure Limits

The OSHA General Industry Standard (20 CFR 1910.1000) establishes the following permissible exposure limits for beryllium:

- *8-Hour Time Weighted Average, 2 micrograms per cubic meter*—An employee's exposure to beryllium and its compounds in any 8-hour work shift of a 40-hour work week shall not exceed 2 micrograms per cubic meter.
- *Acceptable Ceiling Concentration, 5 micrograms per cubic meter*—An employee's exposure to beryllium and its compounds shall not exceed at any time during an 8-hour shift the 5 micrograms per cubic meter acceptable ceiling concentration limit.
- *Acceptable Maximum Peak Concentration, 25 micrograms per cubic meter*—An employee's exposure to beryllium and its compounds shall not exceed 25 micrograms per cubic meter, the acceptable maximum peak above the acceptable ceiling concentration, for a maximum duration of 30 minutes.

These exposure limits are repeated in 29 CFR 1926 for construction and were adopted from the American National Standards Institute (ANSI) standard, ANSI Z37.29–1970.

OSHA has specific beryllium requirements for welding and cutting on beryllium-containing base or filler metals in 29 CFR 1910.252(c)(8):

> Welding or cutting indoors, outdoors, or in confined spaces involving beryllium-containing base or filler metals shall be done using local exhaust ventilation and airline respirators unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentrations defined by 29 CFR 1910.1000. In all cases, workers in the immediate vicinity of the welding or cutting operations shall be protected as necessary by local exhaust ventilation or airline respirators.

These requirements are repeated in 29 CFR 1926 for construction activities. In addition, OSHA Technical Manual CPL 2-2.20B references beryllium in Chapter 1, "Personal Sampling for Air Contaminants," Appendix 1–E, "Sampling for Special Analyses," under "Samples Analyzed by Inductively Coupled Plasma" and in Chapter 2, "Sampling for Surface Contamination," which suggests swipe sampling of surfaces since accumulated toxic materials such as beryllium "may become suspended in air, and may contribute to airborne exposures. Bulk and wipe samples are used as aids in determining this possibility."

NIOSH Recommendation for Beryllium

The NIOSH Recommended Exposure Level (Ceiling) is 0.5 $\mu g/m^3$.

NIOSH also identifies beryllium as an occupational carcinogen.

American Conference of Governmental Industrial Hygienists Beryllium TLV

The ACGIH has established a threshold limit value (TLV) for beryllium and beryllium compounds. The TLV 8-hour TWA is 2 micrograms per cubic meter. The ACGIH lists beryllium and beryllium compounds as an A1 carcinogen, a confirmed human carcinogen. ACGIH explains this classification in their documentation of TLVs by indicating that the weight of evidence supports the view that beryllium is a confirmed human carcinogen but is of such low potency that only persons exposed to levels similar to those existing in the

Lorain and Reading plants in the 1940's would be at significant risk of developing lung cancer[1] (ACGIH 1997).

The ongoing medical surveillance program provides assurance that the processing level industrial hygiene monitoring measures are effective at detecting any beryllium exposure during beryllium operations. Worker exposure to beryllium from HE processing and testing would be the same as that experienced by the public and is discussed in section D.3.2.

D.2.2.4 *Worker Physical Safety Consequences*

Rates of accidents and injuries which are potentially within normal operations at LANL were projected by alternative on the basis of changes in the LANL worker population. Physical hazards include exposures to such hazards as slow leaks from compressed air cylinders of toxic gases such as acetylene, used in welding, or small "pony" bottles of specialized gases used in chemical processing or bench-scale research and development. Electrical hazards, industrial hazards associated with building maintenance and renovation, and ergonomic hazards are typical throughout LANL facilities and field sites. During 1995, reportable accidents and injuries occurred at a rate of 4.6 per 100 workers at LANL, and this rate was used in the SWEIS analyses to generate Table D.2.2.4–1. Although LANL has initiated a program to improve worker health and safety performance, no credit was taken for implementation of this program in the projections of accidents and injuries.

1. As an example, data for the Lorain plant found exposures ranging from 411 micrograms per cubic meter ($\mu g/m^3$) in the general area near a mix operation to 43,300 $\mu g/m^3$ in the breathing zone at an alloy operation.

TABLE D.2.2.4–1.—*Projected Recordable Cases per Alternative at LANL*

ALTERNATIVE	WORKER POPULATION	PROJECTED RECORDABLE CASES	PERCENT CHANGE FROM BASE CASE
Base Case	9,081	418	--
No Action	9,667	445	6.5
Expanded Operations	11,003	507	21.3
Reduced Operations	9,052	417	-0.2
Greener	9,656	445	6.5

D.3 ANALYSIS OF POTENTIAL PUBLIC HUMAN HEALTH CONSEQUENCES DUE TO THE CONTINUED OPERATION OF LANL

This section presents the detailed analyses performed with regard to the potential for the continued operation of LANL to affect public health.

D.3.1 Public Health Consequence Analysis

The analysis presented on human health consequences is extremely conservative. That is, DOE has used as a methodology to identify possible consequences based on maximum concentration estimates of radionuclides and chemicals in the environment, maximum exposure durations, and maximum estimates of ingestion or inhalation intake rates. The slope factors used to estimate carcinogenic risk and the reference doses used to estimate hazard indices, as well as the unit risk concentration used to evaluate outcomes were all established by EPA to be protective of human health, and therefore, include safety factors in order to avoid potential underestimation of impacts.

The conservatism is used in analysis of potential consequences because of the high degree of uncertainty associated with attempting to realistically estimate exposure, resulting dose, and resulting health effects. Therefore, the resulting values of risk (such as excess LCFs or hazard index) are believed to be worst-case consequences to a hypothetical receptor. The hypothetical receptor is not a person living in the community but an analytical construct representing a person who would be in the location of maximum concentrations of radionuclides or chemicals, take the maximum amounts of these contaminants into the person's body, and experience the worst outcome.

Uncertainties in public health consequence analysis include:

- Actual exposures to radionuclides and chemicals in each exposure pathway (inhalation, ingestion and immersion)
- Exposure durations to radionuclides and chemicals present in low concentrations in air, soils and sediments, water, and foodstuffs
- Variability among humans in reaction to exposure to radionuclides and chemicals
- Synergisms among chemicals/radionuclides in the exposed person, synergisms between chemical/radionuclides and natural phenomena (such as solar radiation and exposure to ultraviolet sources, as well as inhalation of radionuclides from LANL operations), and interactions between some chemicals/radionuclides and other stressors or behaviors such as smoking

D.3.1.1 *Inhalation Radiological Doses Estimated to the Public from LANL and Specific Key Facilities Under the Four Alternatives for Continued Operations*

The methods used to estimate the radiological dose from air emissions from specific facilities and from LANL as a site are summarized in sections 5.1.4 and 5.1.6 and are detailed in appendix B. The estimated doses to both the facility-specific and LANL-wide MEI are presented in Table D.3.1.1–1 for each of the four alternatives for continued operations. These values are also presented by alternative in sections 5.2.6.1 (No Action), 5.3.6.1 (Expanded Operations), 5.4.6.1 (Reduced Operations), and 5.5.6.1 (Greener). As detailed in section 5.1.6 and appendix D, section D.2, the ICRP methodologies for estimated cancer risk per rem dose received were applied to these estimates and are reported in chapter 5 in the referenced sections.

TABLE D.3.1.1–1.—*Facility-Specific and LANL-Wide MEI Doses and 50-Mile (80-Kilometer) Population Doses from LANL Continued Operations*[a]

FACILITY	MEI DISTANCE FT (M)[b]	MEI DIRECTION[b]	NO ACTION MREM/YR	EXPANDED OPERATIONS MREM/YR	REDUCED OPERATIONS MREM/YR	GREENER MREM/YR
CMR (TA–3–39)	3,576 (1,090)	N	0.43	1.32	0.36	0.35
Sigma (TA–3–66)	3,560 (1,085)	N	0.43	1.32	0.36	0.35
Machine Shops (TA–3–102)	3,379 (1,030)	N	0.34	1.02	0.29	0.28
HE Testing (TA–11)	4,298 (1,310)	S	0.31	0.73	0.31	0.31
HE Testing (TA–15 and TA–36)	7,415 (2,260)	NE	2.26	4.99	1.76	2.17
WETF (TA–16)	2,886 (880)	SSE	0.31	0.70	0.22	0.31
Pajarito Site (TA–18)	2,821 (860)	NE	1.73	4.39	1.51	1.93
TSTA/TSFF (TA–21)	1,050 (320)	N	1.41	2.55	1.22	1.54
Radiochemistry (TA–48)	2,920 (890)	NNE	1.66	3.67	1.08	1.64
LANSCE (TA–53)	2,625 (800)	NNE	3.11	5.44	1.88	4.52
Area G (TA–54)	1,197 (365) bndry	NE	0.75	1.81	0.68	0.79
	5,331 (1,625) WR	SW	0.43	1.07	0.39	0.45
Plutonium Facility (TA–55)	3,691 (1,125)	N	1.66	3.67	1.08	1.64
LANL-Wide MEI	2,625 (800)[c]	NNE	3.11	5.44	1.88	4.52
Regional Population Dose	50-mi (80-km) radius		13.59	33.09	10.83	13.79

[a] *Source*: Appendix B, sections B.1.1 and B.1.2.
[b] MEI direction and distance are from the stated facility.
[c] The LANL-wide MEI is the LANSCE MEI.
CMR = Chemistry and Metallurgy Research, HE = high explosives, WETF = Weapons Engineering Tritium Facility, TSTA = Tritium System Test Assembly, TSFF = Tritium Science and Fabrication Facility

D.3.1.2 *Public Radiological Doses from Ingestion for all Four Alternatives*

The methodology for estimating the public doses through ingestion is described in section D.2.1.2. Because there is no release that would increase existing concentrations in the environmental media comprising the ingestion pathways (food, soil, sediment, water), the projected doses are the same for the baseline and all four alternatives. These are given in Table 5.2.6.1–2 for an average (50th percentile) intake of contaminated media, and in Table 5.2.6.1–3 for the worst-case (95th percentile) consumption of contaminated media.

D.3.2 Analysis of Public Health Consequences from High Explosives Testing Site Chemical Emissions

In applying the nonradiological air quality methodology as presented in section 5.1.4.1, three chemicals (depleted uranium, beryllium, and lead) were identified from one or more of four TAs (TA–14, TA–15, TA–36 and TA–39) in which high explosives are tested as being of sufficient concentrations to require human health analysis. While a few other metals were identified using the screen (appendix B, section B.2), their reference doses (EPA 1997b) were high, potential concentrations in air were overestimated using the conservative screening methodologies applied, and have low toxicities and low probabilities of carcinogenicity. Therefore, they were not quantitatively evaluated for human health consequences. These metals were:

- Aluminum
- Copper
- Iron
- Tantalum
- Tungsten

The modeling used to estimate exposures to the public from HE chemical emissions under the No Action and Expanded Operations Alternatives is presented in section 5.1.4.1 and detailed in appendix B (sections B.2.3.2 and B.2.3.3). (The quantities of expended materials were the same for the Reduced Operations and Greener Alternatives as for No Action.)

Tables D.3.2–1 (No Action, Reduced Operations, and Greener) and D.3.2–2 (Expanded Operations) present the results of the modeling performed to estimate the concentration of specific chemicals at the MEI location for each TA. The chronic daily uptake was calculated as presented in appendix D.2.1 for both the average uptake and worst-case uptake, using EPA's *Exposure Factors Handbook* (EPA 1997a). The hazard index is presented for uranium and lead, based on the reference dose give in EPA's Integrated Risk Information System (EPA 1997b). A hazard index of 1 or greater than one is considered indicative of a potential health hazard to exposed individuals. EPA has not published a reference dose for inhalation of beryllium. Therefore, a hazard index could not be calculated for beryllium.

TABLE D.3.2–1.—*Analysis of Public Health Consequences from Specific Chemicals Emitted from the High Explosives Test Areas (TA–14, TA–15, TA–36, and TA–39) in the No Action, Reduced Operations, and Greener Alternatives*[a,c]

TECHNICAL AREA	CHEMICAL	ANNUAL RESPIRABLE EMISSION RATE (kg/yr)	MODELED HOURLY EMISSIONS RATE (g/sec)	CONCENTRATION AT MEI LOCATION (μg/m^3)	CHRONIC DAILY UPTAKE (mg/kg-day) AVERAGE	CHRONIC DAILY UPTAKE (mg/kg-day) WORST CASE	HAZARD INDEX AVERAGE	HAZARD INDEX WORST CASE
TA–14	Depleted Uranium	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	< 1.6E-6	< 3.0E-6
	Lead	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	< 4.9E-6	< 9.8E-6
TA–15	Beryllium	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	b	b
	Depleted Uranium	90	2.9E-3	1.5E-4	3.2E-9	6.2E-9	2.3E-6	4.5E-6
	Lead	5	1.7E-4	1.0E-5	2.1E-9	4.2E-9	4.9E-6	9.7E-6
TA–36	Beryllium	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	b	b
	Depleted Uranium	40	1.3E-5	1.3E-4	2.8E-8	5.4E-8	2.0E-5	3.9E-5
	Lead	1.0	3.0E-5	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 4.6E-6	< 9.8E-6
TA–39	Beryllium	1.0	3.0E-5	< 1.0E-5	< 2.1E-9	< 4.2E-9	b	b
	Lead	1.0	3.0E-5	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 4.9E-6	< 9.8E-6

Source: Appendix B, sections B.2.3.2 and B.2.3.3.

[a] Depleted uranium, beryllium, and lead were identified in the nonradiological air quality evaluation as requiring public health consequence analysis under the Expanded Operations Alternative. For the No Action, Reduced Operations, and Greener Alternatives, emissions were estimated as one-third that of the Expanded Operations emissions based on the annual expenditures of materials projected for these alternatives for continued HE testing.

[b] There is currently no reference dose for beryllium inhalation (EPA 1997b); therefore, no hazard index could be calculated. Based on the inhalation unit risk factor (EPA 1997b) of 2.4E-3 per μg/m^3, the maximum beryllium carcinogenic risk would be < 3.6E-8/year.

[c] Values rounded to 2 significant figures.

TABLE D.3.2–2.—*Analysis of Public Health Consequences from Specific Chemicals Emitted from the High Explosives Test Areas (TA–14, TA–15, TA–36, and TA–39) in the Expanded Operations Alternative (Values Rounded to 2 Significant Digits)*[a]

TECHNICAL AREA	CHEMICAL	ANNUAL RESPIRABLE EMISSION RATE (kg/yr)	MODELED HOURLY EMISSIONS RATE (g/sec)	CONCENTRATION AT MEI LOCATION (μg/m^3)	CHRONIC DAILY UPTAKE (mg/kg-Day) AVERAGE	CHRONIC DAILY UPTAKE (mg/kg-Day) WORST CASE	HAZARD INDEX AVERAGE	HAZARD INDEX WORST CASE
TA–14	Depleted Uranium	3.1	1.0E-4	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 1.5E-6	< 3.0E-6
	Lead	3.1	1.0E-4	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 4.9E-6	< 9.8E-6
TA–15	Beryllium	3.0	1.0E-4	1.0E-5	2.1E-9	4.2E-9	[b]	[b]
	Depleted Uranium	270	8.6E-3	4.3E-4	9.1E-8	1.8E-7	6.5E-5	1.3E-4
	Lead	15	5.0E-4	3.0E-5	6.4E-8	1.3E-8	1.5E-5	2.9E-5
TA–36	Beryllium	3.0	1.0E-4	1.0E-5	2.1E-9	4.2E-9	[b]	[b]
	Depleted Uranium	120	3.8E-3	3.9E-4	8.3E-8	1.6E-7	5.9E-5	1.2E-4
	Lead	3.0	1.0E-4	1.0E-5	2.2E-9	4.2E-9	4.9E-6	9.7E-6
TA–39	Beryllium	3.0	1.0E-4	1.0E-5	2.2E-9	4.2E-9	[b]	[b]
	Lead	3.0	1.0E-4	1.0E-5	2.2E-9	4.2E-9	4.91E-6	9.7E-6

Source: Appendix B, sections B.2.3.2 and B.2.3.3.

[a] Depleted uranium, beryllium, and lead were identified in the nonradiological air quality evaluation as requiring public health consequence analysis under the Expanded Operations Alternative.

[b] There is currently no reference dose for beryllium inhalation (EPA 1997b); therefore, no hazard index could be calculated. Based on the inhalation unit risk factor (EPA 1997b) of 2.4E-3 per μg/m^3, the beryllium carcinogenic risk would be approximately 3.6E-8/year.

[c] Values rounded to 2 significant figures.

D.3.3 Estimates of Dose and Risk from Radiological and Metallic Contaminants Potentially Ingested by Residents, Recreational Users of LANL Lands, and via Special Pathways

The methodology for estimating dose and risk from contaminants that could be ingested as or with food and water is given in section 5.1.6 and detailed in appendix D, section D.2.1.2. The data on which the estimates of ingestion and risk were based were environmental surveillance data, which are presented in appendix D, section D.3.5.

Each table presented in this section (Tables D.3.3–1 through D.3.3–50, provided as an attachment to this appendix) contains the concentration data used for calculations. The 95 percent UCL was used for the concentrations. The 95 percent UCL was determined as the average value, plus twice the standard deviation. In calculating the UCL, all samples of zero or negative value or less than the detection limit were rejected. This significantly increases the UCL, and especially so when a large fraction of the samples show no detectable contamination. In other words, in this conservative approach, a few samples that show measurable contamination will receive disproportionate weighting in the distribution. Both the average intake and worst-case intake were estimated using EPA's *Exposures Factors Handbook* (EPA 1997a). All dose conversion factors are given in the tables.

These tables represent the risk estimated from all alternatives based on ingestion. The risk factors used are conservative and represent the upper bound of the risk. The risk is uncertain and could be much smaller, as discussed in section D.1.1.8. Note that for ingestion pathways, exposure limits for exposure by inhalation are not applicable. There are no estimated differences in contaminant levels that would result from implementation of any of the four alternatives for continued operations. There is a discussion of concentrations of radiological and metallic contaminants in media in the region of Los Alamos versus background concentrations of these in the region presented in section D.3.4. Total risks estimated for ingestion are presented in chapter 5, specifically in section 5.2.6.1 (No Action).

D.3.3.1 *Potential Exposures to Tritium via Los Alamos Canyon*

As a result of recent studies and concerns with regard to tritium in groundwater from recent and historical releases in and near Los Alamos Canyon, this section briefly summarizes the present status of knowledge found in the LANL annual environmental reports.

In the past, Los Alamos Canyon received treated and untreated industrial effluents containing some radionuclides. In the upper reach of Los Alamos Canyon there were releases of treated and untreated radioactive effluents during the earliest Manhattan Project operations at TA–1 (late 1940's) and some release of water and radionuclides from the research reactors at TA–2. Los Alamos Canyon also received discharges containing radionuclides from the sanitary sewage lagoon system at LANSCE (formerly Los Alamos Meson Physics Facility) (TA–53). The low-level radioactive waste stream was separated from the sanitary system at TA–53 in 1989 and directed into a total retention evaporation lagoon. An industrial liquid waste treatment plan that served the old plutonium processing facility at TA–21 discharged effluent containing radionuclides into DP Canyon, a tributary to Los Alamos Canyon, from 1952 to 1986.

The reach of Los Alamos Canyon within the LANL boundary currently carries flow from the Los Alamos Reservoir (west of LANL), as well as National Pollutant Discharge Elimination System (NPDES)-permitted effluents from TA–2, TA–53, and TA–21. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains a shallow body of groundwater in the alluvium of Los Alamos Canyon within the LANL boundary west of State Road 4. Groundwater levels are highest in late spring from snowmelt runoff and in late summer from thundershowers. Water levels decline during the winter and early summer when runoff is at a minimum. Depth to water is typically in the range of 4 feet to 15 feet (1.2 meters to 4.6 meters). Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within LANL boundaries, and can be sampled utilizing wells installed by the Bureau of Indian Affairs.

The EPA primary drinking water standard and the New Mexico livestock watering standard are both 20,000 picocuries per liter. No tritium has been detected in surface or groundwater samples using the EPA-specified method with a detection limit of 700 picocuries per liter. LANL reported a sample of surface water with 200 picocuries per liter in 1995, and samples ranging from 78 to 428 picocuries per liter in 1994. Intermediate groundwater in 1994 and 1995 had a concentration of only 27 picocuries per liter. However, these values may be meaningless, in that the past detection limit may actually be 800 to as much as 2,000 picocuries per liter, as discussed in section 5 of the 1995 annual environmental surveillance report (LANL 1996b). In any event, the tritium concentrations are well below the standards for drinking water. Tritium content of sediments could not be measured due to insufficient moisture content.

Special study samples analyzed by Miami University with a detection limit of 0.3 picocuries per liter have demonstrated minimal recharge of the regional aquifer by surface waters. Details of special and routine measurements of tritium are found in the 1996 environmental surveillance report (LANL 1997).

D.3.3.2 *Mortandad Canyon*

Mortandad Canyon has a small drainage area that heads at TA–3. Its drainage area currently receives inflow from natural precipitation and a number of NPDES-permitted effluents, including one from the existing Radioactive Liquid Waste Treatment Facility at TA–50. The TA–50 facility began operations in 1963. In six cases during the period from 1993 through 1995, the derived concentration guide (DCG) was exceeded for: americium-241 in 1993; americium-241 and plutonium-238 in 1994; and plutonium-238, plutonium-239, plutonium-240, and americum-241 in 1995. For each of these years, the effluent nitrate concentrations exceeded the New Mexico groundwater standard of 10 milligrams per liter (nitrate as nitrogen). The groundwater standard applies because the TA–50 effluent infiltrates the alluvium in the canyon. In order to address these problems, LANL is working to upgrade the TA–50 treatment process. These effluents infiltrate the stream channel and maintain a saturated zone in the alluvium extending about 2.2 miles (3.5 kilometers) downstream from the TA–50 NPDES-permitted outfall. The easternmost extent of saturation is on site, about 1 mile (1.6 kilometers) west of the LANL boundary with the Pueblo of San Ildefonso. Surface flow in the drainage has not reached the Pueblo since observations began in the early 1960's.

Radioanalytical results for sediments collected from Mortandad Canyon in 1996 were modeled using the RESRAD model, version 5.61 (LANL 1997). The pathways evaluated are the external gamma pathway from radioactive material deposited in the sediments, the inhalation pathway from materials resuspended by winds, and the soil ingestion pathway. Because water in the canyon is not used for drinking water or irrigation, and there are no cattle grazing in the canyon or gardens in the canyon, the drinking water, meat ingestion, and fruit/vegetable ingestion pathways were not considered.

The RESRAD model was run for each sampled location and for the entire canyon system, with 10 to 14 samples per analyte collected throughout the canyon. For modeling purposes, it is assumed that the area of interest around each monitored location is 1,076 square feet (100 square meters). The site is part of an industrial complex where access to the monitored location is somewhat limited; thus, the amount of time a person spends in the canyon is limited to approximately 87 hours per year (Robinson and Thomas 1991), and there is no cover material over the site of interest that would reduce external exposure to radionuclides. The input parameters for the RESRAD model are summarized in LANL 1997. RESRAD calculates the daughter radionuclides based on the initial radionuclide concentration and time since placement of material.

The TEDE (i.e., the sum of the effective dose equivalents from the external gamma, and the inhalation and soil ingestion pathways) is presented in Table D.3.3.2–1. For comparison, the 1995 TEDE for each monitoring location is shown also. The TEDE, using the average concentration of all monitoring locations in Mortandad Canyon, is 6.0 millirem. The error term associated with this average value is extremely large, reflecting the high degree of variability in the concentrations throughout the canyon. In 1996, the average TEDE plus twice the error term (Table D.3.3.2–1) ranged from 0.19 millirem near the Chemistry and Metallurgy Research (CMR) Building to 27 millirem at the GS–1 sampling location.

TABLE D.3.3.2–1.—*Total Effective Dose Equivalent[a] for Mortandad Canyon (mrem)*

LOCATION	1996		1995	
Near CMR Building	0.16	(± 0.032)[b]	0.10	(± 0.14)[b]
West of GS–1	3.3	(± 0.60)[b]	0.17	(± 0.081)[b]
GS–1	24	(± 3.4)[b]	37	(± 5.9)[b]
MCO–5	21	(± 3.2)[b]	19	(± 3.3)[b]
MCO–7	8.8	(± 1.4)[b]	4.3	(± 0.95)[b]
MCO–9	0.78	(± 0.21)[b]	0.62	(± 0.20)[b]
MCO–13 (A–5)	0.65	(± 0.19)[b]	0.43	(± 1.1)[b]
A–6	0.41	(± 0.097)[b]	0.79	(± 1.2)[b]
A–7	0.36	(± 0.072)[b]	0.19	(± 0.10)[b]
A–8	—[c]		0.30	(± 0.15)[b]
SR–4 (A–9)	0.19	(± 0.057)[b]	0.17	(± 0.088)[b]
A–10	—[c]		0.061	(± 0.028)[b]
Rio Grande (A–11)	0.16	(± 0.12)[b]	0.10	(± 0.054)[b]
Average for Entire Mortandad Canyon	6.0	(± 22)[b]	6.8	(± 0.30)[b]

[a] Based on results from RESRAD (version 5.61) using three exposure pathways: ingestion, inhalation, and external.
[b] ±2 sigma in parenthesis
[c] No sample collected at these locations in 1996.

The maximum TEDE for monitoring sites surrounding the GS–1 site (i.e., west of GS–1, MCO–5, MCO–7, and MCO–9) increased in 1996 over the 1995 values. These five monitoring locations represent 96 percent of the 1996 maximum TEDE for the entire canyon system. The only radionuclide that contributed more than 5 percent to the TEDE at these locations is cesium-137 for each of the five sites. For the other monitoring locations (i.e., near the CMR Building, MCO–13 [A–5], A–6, A–7, A–9, and A–11), the naturally occurring radionuclides of uranium, and strontium-90 and cesium-137 from nuclear atmospheric testing contributed more than 5 percent to the TEDE at these monitoring locations. Averaged over the entire canyon system, cesium-137 and americium-241 contributed more than 5 percent to the canyon TEDE. The external pathway contributed more than 88 percent (with the cesium-137 contribution being more than 86 percent) to the total TEDE for the entire canyon system. Because there is a pathway approximately 10 feet (3 meters) from the stream channel and the external component falls off with distance from the source, the estimated TEDE is reduced to approximately 6 millirem in a year (i.e., 2.7 millirem from the external pathway and 3.3 millirem from all other pathways considered).

TABLE D.3.3–1.—*Ingestion of Radioactive Isotopes from LANL Supply Wells for an Off-Site Los Alamos County Resident (From ESR 1991–1996 Data, see Table D.3.5–2)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	9.31E-02	4.50E-06	2.30E-04	3.73E-04
Cesium-137[1]	2.30E+00	5.00E-08	6.33E-05	1.02E-04
Plutonium-238	2.40E-02	3.80E-06	5.02E-05	8.13E-05
Plutonium-239 and Plutonium-240	2.39E-01	4.30E-06	5.65E-04	9.16E-04
Strontium-90	4.48E+00	1.30E-07	3.20E-04	5.19E-04
Tritium	8.44E+02	6.30E-11	2.92E-05	4.74E-05
Uranium[2]	1.29E+00	2.60E-07	1.85E-04	2.99E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.44E-03	2.34E-03
Cancer Risk yr^{-1}			7.22E-07	1.17E-06

[1] Cesium-137 from ESR 1992–1996 data (see text).
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).

Average-Case Consumption			
5.50E+02 L/yr	=number of liters per year		
Worst-Case Consumption			
8.91E+02 L/yr	=number of liters per year		
1 yr	=exposure duration		
Uranium Conversion:	**U=**	**1.82**	**µg/L**

pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF

RMA = relative mass abundance (g isotope per g total U)

SA = specific activity (pCi/g)

CF = conversion factor (1E-06 g/µg)

		RMA	SA
U-238 =	6.05E-01 pCi/L	0.9928	3.35E+05
U-235 =	2.83E-02 pCi/L	0.0072	2.16E+06
U-234 =	6.59E-01 pCi/L	0.000058	6.24E+09
Total U Activity =	**1.29E+00 pCi/L**		

TABLE D.3.3–2.—*Ingestion of Metals in LANL Supply Wells to Off-Site Los Alamos County Residents (From ESR 1991–1996 Data, see Table D.3.5–2)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	8.20E+01	1.72E-03	2.79E-03	5.0E-03	-	3.44E-01	5.58E-01		
AL	2.97E+02	6.23E-03	1.01E-02	1.8E-01	-	3.46E-02	5.61E-02		
AS[1]	4.00E+01	8.39E-04	1.36E-03	3.0E-04	1.5E+00	2.80E+00	4.53E+00	1.26E-03	2.04E-03
B	2.01E+02	4.22E-03	6.83E-03	9.0E-02	-	4.69E-02	7.59E-02		
BA	8.35E+01	1.75E-03	2.84E-03	7.0E-02	-	2.50E-02	4.06E-02		
BE[2]	2.50E+00	5.25E-05	8.50E-05	5.0E-03	4.3E+00	1.05E-02	1.70E-02	2.26E-04	3.65E-04
CD	7.93E+00	1.66E-04	2.70E-04	5.0E-04	1.8E-03	3.33E-01	5.39E-01	3.00E-07	4.85E-07
CN *	1.00E+01	2.10E-04	3.40E-04	2.0E-02	-	1.05E-02	1.70E-02		
CO	2.46E+02	5.16E-03	8.36E-03	6.0E-02	-	8.60E-02	1.39E-01		
CR	1.87E+01	3.92E-04	6.36E-04	1.0E+00	-	3.92E-04	6.36E-04		
CU	3.33E+01	6.99E-04	1.13E-03	1.9E-02	-	3.68E-02	5.96E-02		
HG	2.70E-01	5.67E-06	9.18E-06	3.0E-04	-	1.89E-02	3.06E-02		
LI *	4.58E+01	9.61E-04	1.56E-03	2.0E-02	-	4.81E-02	7.79E-02		
MN	4.91E+01	1.03E-03	1.67E-03	1.4E-01	-	7.36E-03	1.19E-02		
MO	1.81E+01	3.80E-04	6.15E-04	5.0E-03	-	7.60E-02	1.23E-01		
NI	2.66E+01	5.58E-04	9.04E-04	2.0E-02	-	2.79E-02	4.52E-02		
NO3-N *	3.47E+03	7.28E-02	1.18E-01	1.6E+00	-	4.55E-02	7.37E-02		
PB[3]	6.40E+01	1.34E-03	2.18E-03	1.4E-03	no data	9.59E-01	1.55E+00		
SB	3.45E+00	7.24E-05	1.17E-04	4.0E-04	-	1.81E-01	2.93E-01		
SE	3.03E+00	6.36E-05	1.03E-04	5.0E-03	-	1.27E-02	2.06E-02		
SN	3.85E+01	8.08E-04	1.31E-03	6.0E-01	-	1.35E-03	2.18E-03		
SR	1.52E+02	3.19E-03	5.17E-03	6.0E-01	-	5.32E-03	8.61E-03		

TABLE D.3.3–2.—*Ingestion of Metals in LANL Supply Wells to Off-Site Los Alamos County Residents (From ESR 1991–1996 Data, see Table D.3.5–2)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
TI	1.00E+01	2.10E-04	3.40E-04	-					
TL[4]	2.64E+01	5.54E-04	8.98E-04	8.0E-05	-	6.93E+00	1.12E+01		
U	1.82E+00	3.82E-05	6.19E-05	3.0E-03	no data	1.27E-02	2.06E-02		
V	1.14E+02	2.39E-03	3.88E-03	9.0E-03	-	2.66E-01	4.31E-01		
ZN	4.93E+01	1.03E-03	1.68E-03	3.0E-01	-	3.45E-03	5.59E-03		

[1] Arsenic concentrations ranged from 2 to 48 µg/L in 33 of 56 samples analyzed with a mean of 12.4 µg/L for detected values.
[2] Beryllium concentrations ranged from 1 to 2 µg/L in 5 of 56 samples analyzed with a mean of 1.4 µg/L for detected values.
[3] Lead concentrations ranged from 1 to 95 µg/L in 17 of 59 samples with a mean of 14.6 µg/L for detected values
[4] Thallium concentrations ranged from 0.3 to 19 µg/L in 4 of 56 samples analyzed with a mean of 9.83 µg/L for detected values.
Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–2.—*Ingestion of Metals in LANL Supply Wells to Off-Site Los Alamos County Residents (From ESR 1991–1996 Data, see Table D.3.5–2)*-Continued

Groundwater Ingestion Factors

Intake (mg/kg-day) = (CW x IR x EF x ED x CF)/(BW x AT)

Note: modified from 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = LANL Supply Well concentration
1.51E+00	L/day	IR = **Average-Case** ingestion rate
365	days/yr	EF = **Average-Case** exposure frequency
2.44E+00	L/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 550 liters per year yields 1.51 liters per day for Average-Case.
Note: 891 liters per year yields 2.44 liters per day for Worst-Case.

TABLE D.3.3–3.—*Ingestion of Radioactive Isotopes from Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.37E-02	4.50E-06	8.34E-05	1.35E-04
Cesium-137[1]	1.70E+00	5.00E-08	4.68E-05	7.57E-05
Plutonium-238	6.49E-02	3.80E-06	1.36E-04	2.20E-04
Plutonium-239 and Plutonium-240	4.69E-02	4.30E-06	1.11E-04	1.80E-04
Strontium-90	8.44E-01	1.30E-07	6.03E-05	9.78E-05
Tritium	2.91E+02	6.30E-11	1.01E-05	1.63E-05
Uranium[2]	9.09E-01	2.60E-07	1.30E-04	2.11E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			5.77E-04	9.35E-04
Cancer Risk yr^{-1}			2.89E-07	4.67E-07

[1] Cesium-137 was detected in 1991 (LANL 1993) and 1993 (LANL 1995). However, due to concerns with the 1991 - 1992 data (see text), only the 1993 sample is used.
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).

Average-Case Consumption			
5.50E+02 L/yr	=number of liters per year		
Worst-Case Consumption			
8.91E+02 L/yr	=number of liters per year		
1 yr	=exposure duration		
Uranium Conversion:	**U=**	**1.28**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 =	4.26E-01 pCi/L	0.9928	3.35E+05
U-235 =	1.99E-02 pCi/L	0.0072	2.16E+06
U-234 =	4.63E-01 pCi/L	0.000058	6.24E+09
Total U Activity =	**9.09E-01 pCi/L**		

TABLE D.3.3–4.—*Ingestion of Metals in Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AL	6.20E+01	1.30E-03	2.11E-03	1.8E-01	-	7.23E-03	1.17E-02		
AS[1]	3.82E+00	8.02E-05	1.30E-04	3.0E-04	1.5E+00	2.67E-01	4.33E-01	1.20E-04	1.95E-04
B	3.10E+01	6.51E-04	1.05E-03	9.0E-02	-	7.23E-03	1.17E-02		
BA	6.84E+01	1.44E-03	2.33E-03	7.0E-02	-	2.05E-02	3.32E-02		
BE	not detected			5.0E-03	4.3E+00				
CD	not detected			5.0E-04	1.8E-03				
CN *	not detected			2.0E-02	-				
CO	not detected			6.0E-02	-				
CR	3.58E+01	7.51E-04	1.22E-03	1.0E+00	-	7.51E-04	1.22E-03		
CU	not detected			1.9E-02	-				
F *	not detected			6.0E-02	-				
FE	8.50E+02	1.78E-02	2.89E-02	-	-				
HG	1.00E-01	2.10E-06	3.40E-06	3.0E-04	-	7.00E-03	1.13E-02		
LI *	not detected			2.0E-02	-				
MN	4.92E+01	1.03E-03	1.67E-03	1.4E-01	-	7.38E-03	1.19E-02		
MO	1.70E+00	3.57E-05	5.78E-05	5.0E-03	-	7.14E-03	1.16E-02		
NI	not detected			2.0E-02	-				
NO2-N *	not detected			1.0E-01	-				
NO3-N *	9.16E+02	1.92E-02	3.11E-02	1.6E+00	-	1.20E-02	1.95E-02		
PB	not detected			1.4E-03	no data				
SB	3.00E-01	6.30E-06	1.02E-05	4.0E-04	-	1.57E-02	2.55E-02		
SE	2.00E+00	4.20E-05	6.80E-05	5.0E-03	-	8.39E-03	1.36E-02		

TABLE D.3.3–4.—*Ingestion of Metals in Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
SN	1.00E+01	2.10E-04	3.40E-04	6.0E-01	-	3.50E-04	5.67E-04		
SR	2.62E+02	5.50E-03	8.91E-03	6.0E-01	-	9.16E-03	1.48E-02		
TL	4.00E-02	8.39E-07	1.36E-06	8.0E-05	-	1.05E-02	1.70E-02		
U	1.28E+00	2.69E-05	4.35E-05	3.0E-03	no data	8.95E-03	1.45E-02		
V	3.65E+01	7.66E-04	1.24E-03	9.0E-03	-	8.51E-02	1.38E-01		
ZN	1.61E+03	3.38E-02	5.47E-02	3.0E-01	-	1.13E-01	1.82E-01		
Chloroethane	1.30E+01	2.73E-04	4.42E-04	1.0E-01	-	2.73E-03	4.42E-03		

[1] Arsenic concentrations ranged from 2 to 3 µg/L in 3 of 4 samples analyzed with a mean of 2.67 µg/L for detected values.
Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–4.—*Ingestion of Metals in Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*-Continued

Groundwater Ingestion Factors

Intake (mg/kg-day) = (CW x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = LA-5 supply well concentration
1.51E+00	L/day	IR = **Average-Case** ingestion rate
365	days/yr	EF = **Average-Case** exposure frequency
2.44E+00	L/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 550 liters per year yields 1.51 liters per day for Average-Case.
Note: 891 liters per year yields 2.44 liters per day for Worst-Case.

TABLE D.3.3–5.—*Ingestion of Radioactive Isotopes from San Ildefonso Supply Wells for an Off-Site Non-Los Alamos County Resident (From ESR 1991–1996 Data, see Table C-6 but without LA-5 Well)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	6.10E-02	4.50E-06	1.51E-04	2.45E-04
Cesium-137[1]	3.56E+00	5.00E-08	9.79E-05	1.59E-04
Plutonium-238	8.69E-02	3.80E-06	1.82E-04	2.94E-04
Plutonium-239 and Plutonium-240	1.47E-01	4.30E-06	3.48E-04	5.63E-04
Strontium-90	3.84E+00	1.30E-07	2.75E-04	4.45E-04
Tritium	1.13E+03	6.30E-11	3.92E-05	6.34E-05
Uranium[2]	2.14E+01	2.60E-07	3.07E-03	4.97E-03
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			4.16E-03	6.74E-03
Cancer Risk yr^{-1}			2.08E-06	3.37E-06
[1] Cesium-137 from ESR 1992–1996 (see text). [2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).				
Average-Case Consumption				
5.50E+02 L/yr		=number of liters per year		
Worst-Case Consumption				
8.91E+02 L/yr		=number of liters per year		
1 yr		=exposure duration		
Uranium Conversion:		**U=**	**30.2**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.00E+01 pCi/L		0.9928	3.35E+05
U-235 =	4.70E-01 pCi/L		0.0072	2.16E+06
U-234 =	1.09E+01 pCi/L		0.000058	6.24E+09
Total U Activity =	**2.14E+01 pCi/L**			

TABLE D.3.3–6.—*Ingestion of Metals in San Ildefonso Supply Wells for an Off-Site Non-Los Alamos County Resident (From ESR 1991–1996 Data, see Table C-6 But Without LA-5 Well)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	6.76E+01	1.42E-03	2.30E-03	5.0E-03	-	2.84E-01	4.60E-01		
AL	1.97E+02	4.13E-03	6.70E-03	1.8E-01	-	2.30E-02	3.72E-02		
AS[1]	2.18E+01	4.58E-04	7.41E-04	3.0E-04	1.5E+00	1.53E+00	2.47E+00	6.86E-04	1.11E-03
B	1.68E+03	3.53E-02	5.71E-02	9.0E-02	-	3.92E-01	6.35E-01		
BA	3.33E+01	6.99E-04	1.13E-03	7.0E-02	-	9.98E-03	1.62E-02		
BE[2]	2.04E+01	4.28E-04	6.94E-04	5.0E-03	4.3E+00	8.56E-02	1.39E-01	1.84E-03	2.98E-03
CD	5.49E+00	1.15E-04	1.87E-04	5.0E-04	1.8E-03	2.30E-01	3.73E-01	2.07E-07	3.36E-07
CN *	3.00E+01	6.30E-04	1.02E-03	2.0E-02	-	3.15E-02	5.10E-02		
CO	5.61E+01	1.18E-03	1.91E-03	6.0E-02	-	1.96E-02	3.18E-02		
CR	3.58E+01	7.51E-04	1.22E-03	1.0E+00	-	7.51E-04	1.22E-03		
CU	5.98E+01	1.26E-03	2.03E-03	1.9E-02	-	6.61E-02	1.07E-01		
HG	1.36E+00	2.85E-05	4.62E-05	3.0E-04	-	9.51E-02	1.54E-01		
LI *	2.80E+02	5.88E-03	9.52E-03	2.0E-02	-	2.94E-01	4.76E-01		
MN	1.62E+01	3.40E-04	5.51E-04	1.4E-01	-	2.43E-03	3.93E-03		
MO	4.50E+01	9.44E-04	1.53E-03	5.0E-03	-	1.89E-01	3.06E-01		
NI	4.47E+01	9.38E-04	1.52E-03	2.0E-02	-	4.69E-02	7.60E-02		
NO3-N *	1.15E+04	2.41E-01	3.91E-01	1.6E+00	-	1.51E-01	2.44E-01		
PB	5.78E+00	1.21E-04	1.97E-04	1.4E-03	no data	8.66E-02	1.40E-01		
SB	6.88E+00	1.44E-04	2.34E-04	4.0E-04	-	3.61E-01	5.85E-01		
SE	6.49E+00	1.36E-04	2.21E-04	5.0E-03	-	2.72E-02	4.41E-02		
SR	1.22E+03	2.56E-02	4.15E-02	6.0E-01	-	4.27E-02	6.91E-02		
TL	7.66E-01	1.61E-05	2.60E-05	8.0E-05	-	2.01E-01	3.26E-01		

TABLE D.3.3–6.—*Ingestion of Metals in San Ildefonso Supply Wells for an Off-Site Non-Los Alamos County Resident (From ESR 1991–1996 Data, see Table C-6 But Without LA-5 Well)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	3.02E+01	6.34E-04	1.03E-03	3.0E-03	no data	2.11E-01	3.42E-01		
V	3.94E+01	8.27E-04	1.34E-03	9.0E-03	-	9.19E-02	1.49E-01		
ZN	2.76E+02	5.79E-03	9.38E-03	3.0E-01	-	1.93E-02	3.13E-02		

[1] Arsenic concentrations ranged from 2 to 41 µg/L in 44 of 48 samples analyzed with a mean of 9.07 µg/L for detected values.
[2] Beryllium concentrations ranged from 1 to 17 µg/L in 6 of 48 samples analyzed with a mean of 7 µg/L for detected values.
Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Groundwater Ingestion Factors

Intake (mg/kg-day) = (CW x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = San Ildefonso supply well concentration
1.51E+00	L/day	IR = **Average-Case** ingestion rate
365	days/yr	EF = **Average-Case** exposure frequency
2.44E+00	L/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 550 liters per year yields 1.51 liters per day for Average-Case.
Note: 891 liters per year yields 2.44 liters per day for Worst-Case.

TABLE D.3.3–7.—*Ingestion of Radioactive Isotopes in Surface Water for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.20E+00	4.50E-06	2.88E-05	4.67E-05
Cesium-137[1]	2.49E+01	5.00E-08	6.64E-06	1.08E-05
Plutonium-238	1.10E+00	3.80E-06	2.23E-05	3.61E-05
Plutonium-239 and Plutonium-240	1.00E+01	4.30E-06	2.29E-04	3.72E-04
Strontium-90	2.40E+02	1.30E-07	1.66E-04	2.70E-04
Tritium	7.70E+00	6.30E-11	2.59E-09	4.19E-09
Uranium[2]	2.41E+00	2.60E-07	3.35E-06	5.42E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			4.57E-04	7.40E-04
Cancer Risk yr^{-1}			2.28E-07	3.70E-07

[1] Cesium-137 from ESR 1993–1996 data (see text).
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg 36 (see below).

Average-Case Consumption	
2.78E-02 L/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
5.33E+00 L/yr	=number of liters per year

Worst-Case Consumption	
4.50E-02 L/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
8.64E+00 L/yr	=number of liters per year
1 yr	=exposure duration

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

Uranium Conversion:		**U=**	**3.4**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.13E+00 pCi/L		0.9928	3.35E+05
U-235 =	5.29E-02 pCi/L		0.0072	2.16E+06
U-234 =	1.23E+00 pCi/L		0.000058	6.24E+09
Total U Activity =	**2.41E+00 pCi/L**			

TABLE D.3.3–8.—*Ingestion of Metals in Surface Water to Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	3.50E+02	7.12E-05	1.15E-04	5.0E-03	-	1.42E-02	2.31E-02		
AL	2.40E+04	4.88E-03	7.91E-03	1.8E-01	-	2.71E-02	4.40E-02		
AS	1.00E+01	2.04E-06	3.30E-06	3.0E-04	1.5E+00	6.78E-03	1.10E-02	3.05E-06	4.95E-06
B	2.50E+02	5.09E-05	8.24E-05	9.0E-02	-	5.65E-04	9.16E-04		
BA	4.70E+02	9.56E-05	1.55E-04	7.0E-02	-	1.37E-03	2.21E-03		
BE	8.40E+01	1.71E-05	2.77E-05	5.0E-03	4.3E+00	3.42E-03	5.54E-03	7.35E-05	1.19E-04
CD	1.30E+02	2.65E-05	4.29E-05	5.0E-04	1.8E-03	5.29E-02	8.57E-02	4.76E-08	7.71E-08
CN *	7.90E+01	1.61E-05	2.60E-05	2.0E-02	-	8.04E-04	1.30E-03		
CO	1.10E+02	2.24E-05	3.63E-05	6.0E-02	-	3.73E-04	6.04E-04		
CR	2.80E+02	5.70E-05	9.23E-05	1.0E+00	-	5.70E-05	9.23E-05		
CU	2.80E+02	5.70E-05	9.23E-05	1.9E-02	-	3.00E-03	4.86E-03		
F *	1.80E+03	3.66E-04	5.93E-04	6.0E-02	-	6.11E-03	9.89E-03		
FE	2.00E+04	4.07E-03	6.59E-03	-	-				
HG	7.40E-01	1.51E-07	2.44E-07	3.0E-04	-	5.02E-04	8.13E-04		
LI *	6.40E+01	1.30E-05	2.11E-05	2.0E-02	-	6.51E-04	1.05E-03		
MN	8.20E+02	1.67E-04	2.70E-04	1.4E-01	-	1.19E-03	1.93E-03		
MO	8.60E+02	1.75E-04	2.84E-04	5.0E-03	-	3.50E-02	5.67E-02		
NI	6.80E+02	1.38E-04	2.24E-04	2.0E-02	-	6.92E-03	1.12E-02		
NO2-N *	4.60E+02	9.36E-05	1.52E-04	1.0E-01	-	9.36E-04	1.52E-03		
NO3-N *	1.40E+04	2.85E-03	4.62E-03	1.6E+00	-	1.78E-03	2.88E-03		
PB	2.80E+01	5.70E-06	9.23E-06	1.4E-03	no data	4.07E-03	6.59E-03		
SB	2.50E+00	5.09E-07	8.24E-07	4.0E-04	-	1.27E-03	2.06E-03		

TABLE D.3.3–8.—*Ingestion of Metals in Surface Water to Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
SE	4.50E+02	9.16E-05	1.48E-04	5.0E-03	-	1.83E-02	2.97E-02		
SN	1.90E+02	3.87E-05	6.26E-05	6.0E-01	-	6.44E-05	1.04E-04		
SO4 *	9.30E+04	1.89E-02	3.07E-02		-				
SR	3.90E+02	7.94E-05	1.29E-04	6.0E-01	-	1.32E-04	2.14E-04		
TL	4.30E+00	8.75E-07	1.42E-06	8.0E-05	-	1.09E-02	1.77E-02		
U	3.40E+00	6.92E-07	1.12E-06	3.0E-03	no data	2.31E-04	3.74E-04		
V	6.00E+01	1.22E-05	1.98E-05	9.0E-03	-	1.36E-03	2.20E-03		
ZN	2.20E+02	4.48E-05	7.25E-05	3.0E-01	-	1.49E-04	2.42E-04		
Acetone	6.10E+01	1.24E-05	2.01E-05	1.0E-01	-	1.24E-04	2.01E-04		
Benzoic acid	1.10E+01	2.24E-06	3.63E-06	4.0E+00	-	5.60E-07	9.07E-07		
Bis(2-ethylhexyl) phthalate	1.90E+01	3.87E-06	6.26E-06	2.0E-02	1.4E-02	1.93E-04	3.13E-04	5.41E-08	8.77E-08
Di-n-butyl phthalate	1.80E+01	3.66E-06	5.93E-06	1.0E-01	-	3.66E-05	5.93E-05		
Di-n-octyl phthalate	8.00E+00	1.63E-06	2.64E-06	2.0E-02	-	8.14E-05	1.32E-04		
HMX	4.90E+00	9.97E-07	1.62E-06	5.0E-02	-	1.99E-05	3.23E-05		
RDX	7.60E-01	1.55E-07	2.51E-07	3.0E-03	1.1E-01	5.16E-05	8.35E-05	1.70E-08	2.76E-08

Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–8.—*Ingestion of Metals in Surface Water to Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

Surface Water Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–9.—*Ingestion of Radioactive Isotopes in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.20E+00	4.50E-06	1.08E-05	1.75E-05
Cesium-137[1]	2.49E+01	5.00E-08	2.49E-06	4.03E-06
Plutonium-238	1.10E+00	3.80E-06	8.36E-06	1.35E-05
Plutonium-239 and Plutonium-240	1.00E+01	4.30E-06	8.60E-05	1.39E-04
Strontium-90	2.40E+02	1.30E-07	6.24E-05	1.01E-04
Tritium	7.70E+00	6.30E-11	9.70E-10	1.57E-09
Uranium[2]	2.41E+00	2.60E-07	1.26E-06	2.03E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.71E-04	2.78E-04
Cancer Risk yr^{-1}			8.57E-08	1.39E-07

[1] Cesium-137 from ESR 1993–1996 data (see text).
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).

Average-Case Consumption	
2.78E-02 L/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
2.00E+00 L/yr	=number of liters per year

Worst-Case Consumption	
4.50E-02 L/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
3.24E+00 L/yr	=number of liters per year
1 yr	=exposure duration

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

Uranium Conversion:		**U=**	**3.4**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.13E+00 pCi/L		0.9928	3.35E+05
U-235 =	5.29E-02 pCi/L		0.0072	2.16E+06
U-234 =	1.23E+00 pCi/L		0.000058	6.24E+09
Total U Activity =	**2.41E+00 pCi/L**			

TABLE D.3.3–10.—*Ingestion of Metals in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	3.50E+02	2.67E-05	4.33E-05	5.0E-03	-	5.34E-03	8.65E-03		
AL	2.40E+04	1.83E-03	2.97E-03	1.8E-01	-	1.02E-02	1.65E-02		
AS	1.00E+01	7.63E-07	1.24E-06	3.0E-04	1.5E+00	2.54E-03	4.12E-03	1.14E-06	1.85E-06
B	2.50E+02	1.91E-05	3.09E-05	9.0E-02	-	2.12E-04	3.43E-04		
BA	4.70E+02	3.59E-05	5.81E-05	7.0E-02	-	5.12E-04	8.30E-04		
BE	8.40E+01	6.41E-06	1.04E-05	5.0E-03	4.3E+00	1.28E-03	2.08E-03	2.76E-05	4.47E-05
CD	1.30E+02	9.92E-06	1.61E-05	5.0E-04	1.8E-03	1.98E-02	3.21E-02	1.79E-08	2.89E-08
CN *	7.90E+01	6.03E-06	9.77E-06	2.0E-02	-	3.01E-04	4.88E-04		
CO	1.10E+02	8.39E-06	1.36E-05	6.0E-02	-	1.40E-04	2.27E-04		
CR	2.80E+02	2.14E-05	3.46E-05	1.0E+00	-	2.14E-05	3.46E-05		
CU	2.80E+02	2.14E-05	3.46E-05	1.9E-02	-	1.12E-03	1.82E-03		
F *	1.80E+03	1.37E-04	2.23E-04	6.0E-02	-	2.29E-03	3.71E-03		
FE	2.00E+04	1.53E-03	2.47E-03	-	-				
HG	7.40E-01	5.65E-08	9.15E-08	3.0E-04	-	1.88E-04	3.05E-04		
LI *	6.40E+01	4.88E-06	7.91E-06	2.0E-02	-	2.44E-04	3.96E-04		
MN	8.20E+02	6.26E-05	1.01E-04	1.4E-01	-	4.47E-04	7.24E-04		
MO	8.60E+02	6.56E-05	1.06E-04	5.0E-03	-	1.31E-02	2.13E-02		
NI	6.80E+02	5.19E-05	8.41E-05	2.0E-02	-	2.59E-03	4.20E-03		
NO2-N *	4.60E+02	3.51E-05	5.69E-05	1.0E-01	-	3.51E-04	5.69E-04		
NO3-N *	1.40E+04	1.07E-03	1.73E-03	1.6E+00	-	6.68E-04	1.08E-03		
PB	2.80E+01	2.14E-06	3.46E-06	1.4E-03	no data	1.53E-03	2.47E-03		

TABLE D.3.3–10.—*Ingestion of Metals in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
SB	2.50E+00	1.91E-07	3.09E-07	4.0E-04	-	4.77E-04	7.73E-04		
SE	4.50E+02	3.43E-05	5.56E-05	5.0E-03	-	6.87E-03	1.11E-02		
SN	1.90E+02	1.45E-05	2.35E-05	6.0E-01	-	2.42E-05	3.91E-05		
SR	3.90E+02	2.98E-05	4.82E-05	6.0E-01	-	4.96E-05	8.04E-05		
TL	4.30E+00	3.28E-07	5.32E-07	8.0E-05	-	4.10E-03	6.65E-03		
U	3.40E+00	2.59E-07	4.20E-07	3.0E-03	no data	8.65E-05	1.40E-04		
V	6.00E+01	4.58E-06	7.42E-06	9.0E-03	-	5.09E-04	8.24E-04		
ZN	2.20E+02	1.68E-05	2.72E-05	3.0E-01	-	5.60E-05	9.07E-05		
Acetone	6.10E+01	4.66E-06	7.54E-06	1.0E-01	-	4.66E-05	7.54E-05		
Benzoic acid	1.10E+01	8.39E-07	1.36E-06	4.0E+00	-	2.10E-07	3.40E-07		
Bis(2-ethylhexyl) phthalate	1.90E+01	1.45E-06	2.35E-06	2.0E-02	1.4E-02	7.25E-05	1.17E-04	2.03E-08	3.29E-08
Di-n-butyl phthalate	1.80E+01	1.37E-06	2.23E-06	1.0E-01	-	1.37E-05	2.23E-05		
Di-n-octyl phthalate	8.00E+00	6.11E-07	9.89E-07	2.0E-02	-	3.05E-05	4.95E-05		
HMX	4.90E+00	3.74E-07	6.06E-07	5.0E-02	-	7.48E-06	1.21E-05		
RDX	7.60E-01	5.80E-08	9.40E-08	3.0E-03	1.1E-01	1.93E-05	3.13E-05	6.38E-09	1.03E-08

Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–10.—*Ingestion of Metals in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

Surface Water Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	**Units**	**Parameter**
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
365	d	AT = ED* 365 days

TABLE D.3.3–11.—*Ingestion of Radioactive Isotopes in NPDES Discharge Water for a Resident Recreational User (From NPDES Data, 1994–1996, see Table D.3.5–4)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Tritium	3.70E+04	6.30E-11	1.24E-05	2.01E-05
Radium-226 and Radium-228	7.30E+00	1.20E-06	4.67E-05	7.57E-05
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			5.92E-05	9.58E-05
Cancer Risk yr^{-1}			2.96E-08	4.79E-08
Average-Case Consumption				
2.78E-02 L/hr	=ingestion rate per hour			
8 hr/event	=number of hours per visit			
24 events/yr	=number of visits per year			
5.33E+00 L/yr	=number of liters per year			
Worst-Case Consumption				
4.50E-02 L/hr	=ingestion rate per hour			
8 hr/event	=number of hours per visit			
24 events/yr	=number of visits per year			
8.64E+00 L/yr	=number of liters per year			
1 yr	=exposure duration			

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

TABLE D.3.3–12.—*Ingestion of Metals in NPDES Discharge for a Resident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AL	7.50E+02	1.53E-04	2.47E-04	1.8E-01	-	8.48E-04	1.37E-03		
AS	2.60E+01	5.29E-06	8.57E-06	3.0E-04	1.5E+00	1.76E-02	2.86E-02	7.94E-06	1.29E-05
B	5.40E+02	1.10E-04	1.78E-04	9.0E-02	-	1.22E-03	1.98E-03		
CD	1.00E+01	2.04E-06	3.30E-06	5.0E-04	1.8E-03	4.07E-03	6.59E-03	3.66E-09	5.93E-09
CO	1.70E+01	3.46E-06	5.60E-06	6.0E-02	-	5.77E-05	9.34E-05		
CR	3.80E+01	7.73E-06	1.25E-05	1.0E+00	-	7.73E-06	1.25E-05		
CU	2.50E+02	5.09E-05	8.24E-05	1.9E-02	-	2.68E-03	4.34E-03		
HG	1.70E+00	3.46E-07	5.60E-07	3.0E-04		1.15E-03	1.87E-03		
PB	3.20E+01	6.51E-06	1.05E-05	1.4E-03	no data	4.65E-03	7.54E-03		
SE	4.60E+00	9.36E-07	1.52E-06	5.0E-03	-	1.87E-04	3.03E-04		
V	4.70E+01	9.56E-06	1.55E-05	9.0E-03	-	1.06E-03	1.72E-03		
ZN	3.40E+02	6.92E-05	1.12E-04	3.0E-01	-	2.31E-04	3.74E-04		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–12.—*Ingestion of Metals in NPDES Discharge for a Resident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*-Continued

NPDES Discharge Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–13.—*Ingestion of Radioactive Isotopes in NPDES Discharge Water for a Nonresident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Tritium	3.70E+04	6.30E-11	4.66E-06	7.55E-06
Radium-226 and Radium-228	7.30E+00	1.20E-06	1.75E-05	2.84E-05
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			2.22E-05	3.59E-05
Cancer Risk yr^{-1}			1.11E-08	1.80E-08
Average-Case Consumption				
2.78E-02 L/hr	=ingestion rate per hour			
6 hr/event	=number of hours per visit			
12 events/yr	=number of visits per year			
2.00E+00 L/yr	=number of liters per year			
Worst-Case Consumption				
4.50E-02 L/hr	=ingestion rate per hour			
6 hr/event	=number of hours per visit			
12 events/yr	=number of visits per year			
3.24E+00 L/yr	=number of liters per year			
1 yr	=exposure duration			

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

TABLE D.3.3–14.—*Ingestion of Metals in NPDES Discharge for a Nonresident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AL	7.50E+02	5.72E-05	9.27E-05	1.8E-01	-	3.18E-04	5.15E-04		
AS	2.60E+01	1.98E-06	3.21E-06	3.0E-04	1.5E+00	6.61E-03	1.07E-02	2.98E-06	4.82E-06
B	5.40E+02	4.12E-05	6.68E-05	9.0E-02	-	4.58E-04	7.42E-04		
CD	1.00E+01	7.63E-07	1.24E-06	5.0E-04	1.8E-03	1.53E-03	2.47E-03	1.37E-09	2.23E-09
CO	1.70E+01	1.30E-06	2.10E-06	6.0E-02	-	2.16E-05	3.50E-05		
CR	3.80E+01	2.90E-06	4.70E-06	1.0E+00	-	2.90E-06	4.70E-06		
CU	2.50E+02	1.91E-05	3.09E-05	1.9E-02	-	1.00E-03	1.63E-03		
HG	1.70E+00	1.30E-07	2.10E-07	3.0E-04		4.32E-04	7.01E-04		
PB	3.20E+01	2.44E-06	3.96E-06	1.4E-03	no data	1.74E-03	2.83E-03		
SE	4.60E+00	3.51E-07	5.69E-07	5.0E-03	-	7.02E-05	1.14E-04		
V	4.70E+01	3.59E-06	5.81E-06	9.0E-03	-	3.99E-04	6.46E-04		
ZN	3.40E+02	2.59E-05	4.20E-05	3.0E-01	-	8.65E-05	1.40E-04		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–14.—*Ingestion of Metals in NPDES Discharge for a Nonresident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*-Continued

NPDES Discharge Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	μg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-03	mg/μg	CF = Conversion factor
71.8	kg	BW = Body weight
365	d	AT = ED* 365 days

TABLE D.3.3–15.—*Ingestion of Radioactive Isotopes in Perimeter Soil for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table D.3.5–5)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.70E-02	4.50E-06	6.08E-06	2.43E-05
Cesium-137	9.80E-01	5.00E-08	1.79E-06	7.15E-06
Plutonium-238	2.90E-02	3.80E-06	4.02E-06	1.61E-05
Plutonium-239 and Plutonium-240	2.13E-01	4.30E-06	3.34E-05	1.34E-04
Strontium-90	7.00E-01	1.30E-07	3.32E-06	1.33E-05
Tritium[1]	8.44E-02	6.30E-11	1.94E-10	7.77E-10
Uranium[2]	3.12E+00	2.60E-07	2.96E-05	1.19E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			7.83E-05	3.13E-04
Cancer Risk yr^{-1}			3.91E-08	1.57E-07

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
1.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
3.65E+01 g/yr	=number of grams per year

Worst-Case Consumption	
4.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
1.46E+02 g/yr	=number of grams per year
1 yr	=exposure duration

Tritium Conversion:	**H^3=**	**0.76**	**pCi/mL**

pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])

fraction soil moisture = 10%

soil moisture density = 1 g/mL

Tritium Activity (pCi/g) = 8.44E-02

TABLE D.3.3–15.—*Ingestion of Radioactive Isotopes in Perimeter Soil for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table D.3.5–5)*-Continued

Uranium Conversion:		**U=**	**4.4**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.46E+00 pCi/g		0.9928	3.35E+05
U-235 =	6.84E-02 pCi/g		0.0072	2.16E+06
U-234 =	1.59E+00 pCi/g		0.000058	6.24E+09
Total U Activity =	**3.12E+00 pCi/g**			

TABLE D.3.3–16.—*Ingestion of Metals in Perimeter Soil to an Off-Site Resident (Nonspecific County) (From ESR 1992–1996 Data, see Table D.3.5–5)*

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.40E+00	1.95E-06	7.80E-06	5.0E-03	-	3.90E-04	1.56E-03		
AL	3.50E+00	4.87E-06	1.95E-05	1.8E-01	-	2.71E-05	1.08E-04		
AS[1]	3.90E+00	5.43E-06	2.17E-05	3.0E-04	1.5E+00	1.81E-02	7.24E-02	8.15E-06	3.26E-05
B	1.40E+01	1.95E-05	7.80E-05	9.0E-02	-	2.17E-04	8.67E-04		
BA	1.60E+02	2.23E-04	8.91E-04	7.0E-02	-	3.18E-03	1.27E-02		
BE[2]	9.90E-01	1.38E-06	5.52E-06	5.0E-03	4.3E+00	2.76E-04	1.10E-03	5.93E-06	2.37E-05
CD	6.00E-01	8.36E-07	3.34E-06	5.0E-04	1.8E-03	1.67E-03	6.69E-03	1.50E-09	6.02E-09
CO	8.20E+00	1.14E-05	4.57E-05	6.0E-02	-	1.90E-04	7.61E-04		
CR	1.30E+01	1.81E-05	7.24E-05	1.0E+00	-	1.81E-05	7.24E-05		
CU	9.00E+00	1.25E-05	5.01E-05	1.9E-02	-	6.60E-04	2.64E-03		
HG	5.00E-02	6.96E-08	2.79E-07	3.0E-04	-	2.32E-04	9.29E-04		
MN	6.50E+02	9.05E-04	3.62E-03	1.4E-01	-	6.47E-03	2.59E-02		
MO	8.50E-01	1.18E-06	4.74E-06	5.0E-03	-	2.37E-04	9.47E-04		
NI	8.60E+00	1.20E-05	4.79E-05	2.0E-02	-	5.99E-04	2.40E-03		
PB	3.60E+01	5.01E-05	2.01E-04	1.4E-03	no data	3.58E-02	1.43E-01		
SB	1.70E-01	2.37E-07	9.47E-07	4.0E-04	-	5.92E-04	2.37E-03		
SE	6.40E-01	8.91E-07	3.57E-06	5.0E-03	-	1.78E-04	7.13E-04		
SN	1.00E+01	1.39E-05	5.57E-05	6.0E-01	-	2.32E-05	9.29E-05		
SR	3.60E+01	5.01E-05	2.01E-04	6.0E-01	-	8.36E-05	3.34E-04		
TL	1.70E+00	2.37E-06	9.47E-06	8.0E-05	-	2.96E-02	1.18E-01		

TABLE D.3.3–16.—*Ingestion of Metals in Perimeter Soil to an Off-Site Resident (Nonspecific County) (From ESR 1992–1996 Data, see Table D.3.5–5)*-Continued

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.40E+00	6.13E-06	2.45E-05	3.0E-03	no data				
V	2.90E+01	4.04E-05	1.62E-04	9.0E-03	-	4.49E-03	1.80E-02		
ZN	4.90E+01	6.82E-05	2.73E-04	3.0E-01	-	2.27E-04	9.10E-04		

[1] Detected values of Arsenic had a mean of 2.37 ± 1.53 µg/g (2 sigma).
[2] Detected values for Beryllium had a mean of 0.66 ± 0.33 µg/g (2 sigma).
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

Perimeter Soil Ingestion Factors

Intake (mg/kg-day) = (CS x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CS = perimeter soil concentration
1.00E+02	mg/day	IR = **Average-Case** ingestion rate
365	day/yr	EF = **Average-Case** exposure frequency
4.00E+02	mg/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–17.—*Ingestion of Radioactive Isotopes in Soil for a Resident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.90E-02	4.50E-06	9.12E-08	3.65E-07
Cesium-137	1.01E+00	5.00E-08	5.39E-08	2.15E-07
Plutonium-238	2.20E-02	3.80E-06	8.92E-08	3.57E-07
Plutonium-239 and Plutonium-240	4.03E-01	4.30E-06	1.85E-06	7.39E-06
Strontium-90	7.80E-01	1.30E-07	1.08E-07	4.33E-07
Tritium[1]	2.59E-01	6.30E-11	1.74E-11	6.96E-11
Uranium[2]	3.41E+00	2.60E-07	9.45E-07	3.78E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			3.14E-06	1.25E-05
Cancer Risk yr^{-1}			1.57E-09	6.27E-09

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
1.07E+00 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
4.27E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–17.—*Ingestion of Radioactive Isotopes in Soil for a Resident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*-Continued

Tritium Conversion:	**H^3=**	**2.33**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])			
Fraction soil moisture = 10%			
Soil moisture density = 1 g/mL			
Tritium Activity (pCi/g) =	**2.59E-01**		
Uranium Conversion:	**U=**	**4.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 =	1.60E+00 pCi/g	0.9928	3.35E+05
U-235 =	7.46E-02 pCi/g	0.0072	2.16E+06
U-234 =	1.74E+00 pCi/g	0.000058	6.24E+09
Total U Activity =	**3.41E+00 pCi/g**		

TABLE D.3.3–18.—*Ingestion of Metals in Soil for a Resident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	2.30E+00	9.36E-08	3.74E-07	5.0E-03	-	1.87E-05	7.49E-05		
AL	4.30E+00	1.75E-07	7.00E-07	1.8E-01	-	9.72E-07	3.89E-06		
AS	3.70E+00	1.51E-07	6.02E-07	3.0E-04	1.5E+00	5.02E-04	2.01E-03	2.26E-07	9.04E-07
B	2.40E+01	9.77E-07	3.91E-06	9.0E-02	-	1.09E-05	4.34E-05		
BA	1.70E+02	6.92E-06	2.77E-05	7.0E-02	-	9.88E-05	3.95E-04		
BE	1.00E+00	4.07E-08	1.63E-07	5.0E-03	4.3E+00	8.14E-06	3.26E-05	1.75E-07	7.00E-07
CD	2.70E-01	1.10E-08	4.40E-08	5.0E-04	1.8E-03	2.20E-05	8.79E-05	1.98E-11	7.91E-11
CO	7.90E+00	3.22E-07	1.29E-06	6.0E-02	-	5.36E-06	2.14E-05		
CR	1.20E+01	4.88E-07	1.95E-06	1.0E+00	-	4.88E-07	1.95E-06		
CU	9.70E+00	3.95E-07	1.58E-06	1.9E-02	-	2.08E-05	8.31E-05		
FE	1.80E+00	7.33E-08	2.93E-07	-	-				
HG	4.00E-02	1.63E-09	6.51E-09	3.0E-04	-	5.43E-06	2.17E-05		
MN	6.10E+02	2.48E-05	9.93E-05	1.4E-01	-	1.77E-04	7.09E-04		
MO	9.30E-01	3.79E-08	1.51E-07	5.0E-03	-	7.57E-06	3.03E-05		
NI	9.70E+00	3.95E-07	1.58E-06	2.0E-02	-	1.97E-05	7.90E-05		
PB	3.00E+01	1.22E-06	4.88E-06	1.4E-03	no data	8.72E-04	3.49E-03		
SB	4.50E-01	1.83E-08	7.33E-08	4.0E-04	-	4.58E-05	1.83E-04		
SE	4.80E-01	1.95E-08	7.81E-08	5.0E-03	-	3.91E-06	1.56E-05		
SN	1.20E+01	4.88E-07	1.95E-06	6.0E-01	-	8.14E-07	3.26E-06		
SR	3.90E+01	1.59E-06	6.35E-06	6.0E-01	-	2.65E-06	1.06E-05		
TL	9.30E-01	3.79E-08	1.51E-07	8.0E-05	-	4.73E-04	1.89E-03		

TABLE D.3.3–18.—*Ingestion of Metals in Soil for a Resident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*-Continued

ANALYTES	95% UCL (μg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.80E+00	1.95E-07	7.81E-07	3.0E-03	no data	6.51E-05	2.60E-04		
V	3.00E+01	1.22E-06	4.88E-06	9.0E-03	-	1.36E-04	5.43E-04		
ZN	4.90E+01	1.99E-06	7.98E-06	3.0E-01	-	6.65E-06	2.66E-05		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

On-Site Soil Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–19.—*Ingestion of Radioactive Isotopes in Soil for a Nonresident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.90E-02	4.50E-06	3.42E-08	1.37E-07
Cesium-137	1.01E+00	5.00E-08	2.02E-08	8.08E-08
Plutonium-238	2.20E-02	3.80E-06	3.34E-08	1.34E-07
Plutonium-239 and Plutonium-240	4.03E-01	4.30E-06	6.93E-07	2.77E-06
Strontium-90	7.80E-01	1.30E-07	4.06E-08	1.62E-07
Tritium[1]	2.59E-01	6.30E-11	6.52E-12	2.61E-11
Uranium[2]	3.41E+00	2.60E-07	3.54E-07	1.42E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.18E-06	4.70E-06
Cancer Risk yr^{-1}			5.88E-10	2.35E-09

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
4.00E-01 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
1.60E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–19.—*Ingestion of Radioactive Isotopes in Soil for a Nonresident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*-Continued

Tritium Conversion:	**H^3=**	**2.33**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture /soil moisture density X [1-fraction soil moisture])			
fraction soil moisture = 10%			
soil moisture density = 1 g/mL			
Tritium Activity (pCi/g) =	**2.59E-01**		
Uranium Conversion:	**U=**	**4.8**	**μg/g**
pCi U isotope / g soil = μg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/μg)		**RMA**	**SA**
U-238 =	1.60E+00 pCi/g	0.9928	3.35E+05
U-235 =	7.46E-02 pCi/g	0.0072	2.16E+06
U-234 =	1.74E+00 pCi/g	0.000058	6.24E+09
Total U Activity =	**3.41E+00 pCi/g**		

TABLE D.3.3–20.—*Ingestion of Metals in Soils to a Nonresident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	2.30E+00	3.51E-08	1.40E-07	5.0E-03	-	7.02E-06	2.81E-05		
AL	4.30E+00	6.56E-08	2.63E-07	1.8E-01	-	3.65E-07	1.46E-06		
AS	3.70E+00	5.65E-08	2.26E-07	3.0E-04	1.5E+00	1.88E-04	7.53E-04	8.47E-08	3.39E-07
B	2.40E+01	3.66E-07	1.47E-06	9.0E-02	-	4.07E-06	1.63E-05		
BA	1.70E+02	2.59E-06	1.04E-05	7.0E-02	-	3.71E-05	1.48E-04		
BE	1.00E+00	1.53E-08	6.11E-08	5.0E-03	4.3E+00	3.05E-06	1.22E-05	6.56E-08	2.63E-07
CD	2.70E-01	4.12E-09	1.65E-08	5.0E-04	1.8E-03	8.24E-06	3.30E-05	7.42E-12	2.97E-11
CO	7.90E+00	1.21E-07	4.82E-07	6.0E-02	-	2.01E-06	8.04E-06		
CR	1.20E+01	1.83E-07	7.33E-07	1.0E+00	-	1.83E-07	7.33E-07		
CU	9.70E+00	1.48E-07	5.92E-07	1.9E-02	-	7.79E-06	3.12E-05		
FE	1.80E+00	2.75E-08	1.10E-07	-	-				
HG	4.00E-02	6.11E-10	2.44E-09	3.0E-04	-	2.04E-06	8.14E-06		
MN	6.10E+02	9.31E-06	3.72E-05	1.4E-01	-	6.65E-05	2.66E-04		
MO	9.30E-01	1.42E-08	5.68E-08	5.0E-03	-	2.84E-06	1.14E-05		
NI	9.70E+00	1.48E-07	5.92E-07	2.0E-02	-	7.40E-06	2.96E-05		
PB	3.00E+01	4.58E-07	1.83E-06	1.4E-03	no data	3.27E-04	1.31E-03		
SB	4.50E-01	6.87E-09	2.75E-08	4.0E-04	-	1.72E-05	6.87E-05		
SE	4.80E-01	7.33E-09	2.93E-08	5.0E-03	-	1.47E-06	5.86E-06		
SN	1.20E+01	1.83E-07	7.33E-07	6.0E-01	-	3.05E-07	1.22E-06		
SR	3.90E+01	5.95E-07	2.38E-06	6.0E-01	-	9.92E-07	3.97E-06		
TL	9.30E-01	1.42E-08	5.68E-08	8.0E-05	-	1.77E-04	7.10E-04		

TABLE D.3.3–20.—*Ingestion of Metals in Soils to a Nonresident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.80E+00	7.33E-08	2.93E-07	3.0E-03	no data	2.44E-05	9.77E-05		
V	3.00E+01	4.58E-07	1.83E-06	9.0E-03	-	5.09E-05	2.04E-04		
ZN	4.90E+01	7.48E-07	2.99E-06	3.0E-01	-	2.49E-06	9.97E-06		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

On-Site Soil Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–21.—*Ingestion of Radioactive Isotopes in Perimeter Sediment for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	2.20E-01	4.50E-06	3.61E-05	1.45E-04
Cesium-137	9.90E-01	5.00E-08	1.81E-06	7.23E-06
Plutonium-238	2.70E-02	3.80E-06	3.74E-06	1.50E-05
Plutonium-239 and Plutonium-240	3.70E+00	4.30E-06	5.81E-04	2.32E-03
Strontium-90	9.30E-01	1.30E-07	4.41E-06	1.77E-05
Tritium[1]	2.11E-01	6.30E-11	4.85E-10	1.94E-09
Uranium[2]	2.98E+00	2.60E-07	2.83E-05	1.13E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			6.55E-04	2.62E-03
Cancer Risk yr^{-1}			3.28E-07	1.31E-06

[1] Tritium was converted from pCi/ml using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
1.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
3.65E+01 g/yr	=number of grams per year

Worst-Case Consumption	
4.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
1.46E+02 g/yr	=number of grams per year
1 yr	=exposure duration

Tritium Conversion:	**H^3=**	**1.9**	**pCi/mL**

pCi/g = pCi/ml X (fraction soil moisture /soil moisture density X [1-fraction soil moisture])

fraction soil moisture = 10%

soil moisture density = 1 g/ml

Tritium Activity (pCi/g) = 2.11E-01

TABLE D.3.3–21.—*Ingestion of Radioactive Isotopes in Perimeter Sediment for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*-Continued

Uranium Conversion:		**U=**	**4.2**	**μg/g**
pCi U isotope / g soil = μg total Uranium/g soil X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/μg)			**RMA**	**SA**
U-238 =	1.40E+00 pCi/g		0.9928	3.35E+05
U-235 =	6.53E-02 pCi/g		0.0072	2.16E+06
U-234 =	1.52E+00 pCi/g		0.000058	6.24E+09
Total U Activity =	**2.98E+00 pCi/g**			

TABLE D.3.3–22.—*Ingestion of Metals in Perimeter Sediments to an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	2.10E+01	2.92E-05	1.17E-04	5.0E-03	-	5.85E-03	2.34E-02		
AL	1.20E+04	1.67E-02	6.69E-02	1.8E-01	-	9.29E-02	3.71E-01		
AS[1]	1.50E+01	2.09E-05	8.36E-05	3.0E-04	1.5E+00	6.96E-02	2.79E-01	3.13E-05	1.25E-04
B	1.60E+01	2.23E-05	8.91E-05	9.0E-02	-	2.48E-04	9.90E-04		
BA	2.40E+02	3.34E-04	1.34E-03	7.0E-02	-	4.78E-03	1.91E-02		
BE[2]	1.10E+00	1.53E-06	6.13E-06	5.0E-03	4.3E+00	3.06E-04	1.23E-03	6.59E-06	2.64E-05
CD	1.60E+00	2.23E-06	8.91E-06	5.0E-04	1.8E-03	4.46E-03	1.78E-02	4.01E-09	1.60E-08
CO	8.00E+00	1.11E-05	4.46E-05	6.0E-02	-	1.86E-04	7.43E-04		
CR	1.00E+01	1.39E-05	5.57E-05	1.0E+00	-	1.39E-05	5.57E-05		
CU	1.60E+01	2.23E-05	8.91E-05	1.9E-02	-	1.17E-03	4.69E-03		
HG	6.70E-02	9.33E-08	3.73E-07	3.0E-04	-	3.11E-04	1.24E-03		
MN	5.00E+02	6.96E-04	2.79E-03	1.4E-01	-	4.97E-03	1.99E-02		
MO	2.50E+00	3.48E-06	1.39E-05	5.0E-03	-	6.96E-04	2.79E-03		
NI	1.10E+01	1.53E-05	6.13E-05	2.0E-02	-	7.66E-04	3.06E-03		
PB	2.30E+01	3.20E-05	1.28E-04	1.4E-03	no data	2.29E-02	9.15E-02		
SB	9.70E-01	1.35E-06	5.40E-06	4.0E-04	-	3.38E-03	1.35E-02		
SE	2.40E+01	3.34E-05	1.34E-04	5.0E-03	-	6.69E-03	2.67E-02		
SN	2.30E+01	3.20E-05	1.28E-04	6.0E-01	-	5.34E-05	2.14E-04		
SR	3.70E+01	5.15E-05	2.06E-04	6.0E-01	-	8.59E-05	3.44E-04		
TL	4.30E+00	5.99E-06	2.40E-05	8.0E-05	-	7.49E-02	2.99E-01		

TABLE D.3.3–22.—*Ingestion of Metals in Perimeter Sediments to an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*-Continued

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.20E+00	5.85E-06	2.34E-05	3.0E-03	no data	1.95E-03	7.80E-03		
V	2.40E+01	3.34E-05	1.34E-04	9.0E-03	-	3.71E-03	1.49E-02		
ZN	1.10E+02	1.53E-04	6.13E-04	3.0E-01	-	5.11E-04	2.04E-03		

[1] Detected values of Arsenic had a mean of 2.1 ± 12.9 µg/g (2 sigma).
[2] Detected values for Beryllium had a mean of 0.49 ± 0.51 µg/g (2 sigma).
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

Perimeter Sediment Ingestion Factors

Intake (mg/kg-day) = (CS x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CS = perimeter sediment concentration
1.00E+02	mg/day	IR = **Average-Case** ingestion rate
365	day/yr	EF = **Average-Case** exposure frequency
4.00E+02	mg/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–23.—*Ingestion of Radioactive Isotopes in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.80E+00	4.50E-06	1.82E-05	7.30E-05
Cesium-137	1.80E+01	5.00E-08	9.60E-07	3.84E-06
Plutonium-238	1.70E+00	3.80E-06	6.89E-06	2.76E-05
Plutonium-239 and Plutonium-240	3.70E+00	4.30E-06	1.70E-05	6.79E-05
Strontium-90	1.60E+00	1.30E-07	2.22E-07	8.87E-07
Tritium[1]	3.11E+00	6.30E-11	2.09E-10	8.36E-10
Uranium[2]	2.70E+00	2.60E-07	7.48E-07	2.99E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			4.40E-05	1.76E-04
Cancer Risk yr^{-1}			2.20E-08	8.81E-08

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
1.07E+00 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
4.27E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–23.—*Ingestion of Radioactive Isotopes in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

Tritium Conversion:		**H^3=**	**28**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])				
Fraction soil moisture = 10%				
Soil moisture density = 1 g/mL				
Tritium Activity (pCi/g) =		**3.11E+00**		
Uranium Conversion:		**U=**	**3.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.26E+00 pCi/g		0.9928	3.35E+05
U-235 =	5.91E-02 pCi/g		0.0072	2.16E+06
U-234 =	1.38E+00 pCi/g		0.000058	6.24E+09
Total U Activity =	**2.70E+00 pCi/g**			

TABLE D.3.3–24.—*Ingestion of Metals in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.00E+01	4.07E-07	1.63E-06	5.0E-03	-	8.14E-05	3.26E-04		
AL	1.50E+04	6.11E-04	2.44E-03	1.8E-01	-	3.39E-03	1.36E-02		
AS	3.40E+00	1.38E-07	5.54E-07	3.0E-04	1.5E+00	4.61E-04	1.85E-03	2.08E-07	8.30E-07
B	3.90E+01	1.59E-06	6.35E-06	9.0E-02	-	1.76E-05	7.05E-05		
BA	2.90E+02	1.18E-05	4.72E-05	7.0E-02	-	1.69E-04	6.74E-04		
BE	1.70E+00	6.92E-08	2.77E-07	5.0E-03	4.3E+00	1.38E-05	5.54E-05	2.98E-07	1.19E-06
CD	1.50E+00	6.11E-08	2.44E-07	5.0E-04	1.8E-03	1.22E-04	4.88E-04	1.10E-10	4.40E-10
CO	8.40E+00	3.42E-07	1.37E-06	6.0E-02	-	5.70E-06	2.28E-05		
CR	1.80E+02	7.33E-06	2.93E-05	1.0E+00	-	7.33E-06	2.93E-05		
CU	1.20E+01	4.88E-07	1.95E-06	1.9E-02	-	2.57E-05	1.03E-04		
FE	1.50E+04	6.11E-04	2.44E-03	-	-				
HG	8.70E-02	3.54E-09	1.42E-08	3.0E-04	-	1.18E-05	4.72E-05		
LI	2.90E+01	1.18E-06	4.72E-06	2.0E-02	-	5.90E-05	2.36E-04		
MN	5.00E+02	2.04E-05	8.14E-05	1.4E-01	-	1.45E-04	5.81E-04		
MO	6.40E+00	2.60E-07	1.04E-06	5.0E-03	-	5.21E-05	2.08E-04		
NI	1.30E+01	5.29E-07	2.12E-06	2.0E-02	-	2.65E-05	1.06E-04		
PB	3.80E+01	1.55E-06	6.19E-06	1.4E-03	no data	1.10E-03	4.42E-03		
SB	9.80E+00	3.99E-07	1.60E-06	4.0E-04	-	9.97E-04	3.99E-03		
SE	6.00E-01	2.44E-08	9.77E-08	5.0E-03	-	4.88E-06	1.95E-05		
SN	7.30E+01	2.97E-06	1.19E-05	6.0E-01	-	4.95E-06	1.98E-05		
SR	1.80E+02	7.33E-06	2.93E-05	6.0E-01	-	1.22E-05	4.88E-05		
TL	1.00E+01	4.07E-07	1.63E-06	8.0E-05	-	5.09E-03	2.04E-02		

TABLE D.3.3–24.—*Ingestion of Metals in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	3.80E+00	1.55E-07	6.19E-07	3.0E-03	no data	5.16E-05	2.06E-04		
V	3.90E+01	1.59E-06	6.35E-06	9.0E-03	-	1.76E-04	7.05E-04		
ZN	1.60E+02	6.51E-06	2.60E-05	3.0E-01	-	2.17E-05	8.68E-05		
Bis(2-ethylhexyl) phthalate	3.50E+02	1.42E-05	5.70E-05	2.0E-02	1.4E-02	7.12E-04	2.85E-03	1.99E-07	7.98E-07
Di-n-butyl phthalate	9.90E+02	4.03E-05	1.61E-04	1.0E-01		4.03E-04	1.61E-03		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

TABLE D.3.3–24.—*Ingestion of Metals in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

On-Site Sediment Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–25.—*Ingestion of Radioactive Isotopes in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.80E+00	4.50E-06	6.84E-06	2.74E-05
Cesium-137	1.80E+01	5.00E-08	3.60E-07	1.44E-06
Plutonium-238	1.70E+00	3.80E-06	2.58E-06	1.03E-05
Plutonium-239 and Plutonium-240	3.70E+00	4.30E-06	6.36E-06	2.55E-05
Strontium-90	1.60E+00	1.30E-07	8.32E-08	3.33E-07
Tritium[1]	3.11E+00	6.30E-11	7.84E-11	3.14E-10
Uranium[2]	2.70E+00	2.60E-07	2.81E-07	1.12E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.65E-05	6.60E-05
Cancer Risk yr^{-1}			8.26E-09	3.30E-08

[1] Tritium was converted from pCi/mL using the formulas from Fresquez, 1996 et al. Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
4.00E-01 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
1.60E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–25.—*Ingestion of Radioactive Isotopes in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

Tritium Conversion:	**H^3=**	**28**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])			
Fraction soil moisture = 10%			
Soil moisture density = 1 g/mL			
Tritium Activity (pCi/g) =	**3.11E+00**		
Uranium Conversion:	**U=**	**3.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 = 1.26E+00 pCi/g		0.9928	3.35E+05
U-235 = 5.91E-02 pCi/g		0.0072	2.16E+06
U-234 = 1.38E+00 pCi/g		0.000058	6.24E+09
Total U Activity = 2.70E+00 pCi/g			

TABLE D.3.3–26.—*Ingestion of Metals in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.00E+01	1.53E-07	6.11E-07	5.0E-03	-	3.05E-05	1.22E-04		
AL	1.50E+04	2.29E-04	9.16E-04	1.8E-01	-	1.27E-03	5.09E-03		
AS	3.40E+00	5.19E-08	2.08E-07	3.0E-04	1.5E+00	1.73E-04	6.92E-04	7.78E-08	3.11E-07
B	3.90E+01	5.95E-07	2.38E-06	9.0E-02	-	6.61E-06	2.65E-05		
BA	2.90E+02	4.43E-06	1.77E-05	7.0E-02	-	6.32E-05	2.53E-04		
BE	1.70E+00	2.59E-08	1.04E-07	5.0E-03	4.3E+00	5.19E-06	2.08E-05	1.12E-07	4.46E-07
CD	1.50E+00	2.29E-08	9.16E-08	5.0E-04	1.8E-03	4.58E-05	1.83E-04	4.12E-11	1.65E-10
CO	8.40E+00	1.28E-07	5.13E-07	6.0E-02	-	2.14E-06	8.55E-06		
CR	1.80E+02	2.75E-06	1.10E-05	1.0E+00	-	2.75E-06	1.10E-05		
CU	1.20E+01	1.83E-07	7.33E-07	1.9E-02	-	9.64E-06	3.86E-05		
FE	1.50E+04	2.29E-04	9.16E-04	-	-				
HG	8.70E-02	1.33E-09	5.31E-09	3.0E-04	-	4.43E-06	1.77E-05		
LI	2.90E+01	4.43E-07	1.77E-06	2.0E-02	-	2.21E-05	8.85E-05		
MN	5.00E+02	7.63E-06	3.05E-05	1.4E-01	-	5.45E-05	2.18E-04		
MO	6.40E+00	9.77E-08	3.91E-07	5.0E-03	-	1.95E-05	7.81E-05		
NI	1.30E+01	1.98E-07	7.94E-07	2.0E-02	-	9.92E-06	3.97E-05		
PB	3.80E+01	5.80E-07	2.32E-06	1.4E-03	no data	4.14E-04	1.66E-03		
SB	9.80E+00	1.50E-07	5.98E-07	4.0E-04	-	3.74E-04	1.50E-03		
SE	6.00E-01	9.16E-09	3.66E-08	5.0E-03	-	1.83E-06	7.33E-06		
SN	7.30E+01	1.11E-06	4.46E-06	6.0E-01	-	1.86E-06	7.43E-06		
SR	1.80E+02	2.75E-06	1.10E-05	6.0E-01	-	4.58E-06	1.83E-05		
TL	1.00E+01	1.53E-07	6.11E-07	8.0E-05	-	1.91E-03	7.63E-03		

TABLE D.3.3–26.—*Ingestion of Metals in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RFD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	3.80E+00	5.80E-08	2.32E-07	3.0E-03	no data	1.93E-05	7.73E-05		
V	3.90E+01	5.95E-07	2.38E-06	9.0E-03	-	6.61E-05	2.65E-04		
ZN	1.60E+02	2.44E-06	9.77E-06	3.0E-01	-	8.14E-06	3.26E-05		
Bis(2-ethylhexyl) phthalate	3.50E+02	5.34E-06	2.14E-05	2.0E-02	1.4E-02	2.67E-04	1.07E-03	7.48E-08	2.99E-07
Di-n-butyl phthalate	9.90E+02	1.51E-05	6.04E-05	1.0E-01		1.51E-04	6.04E-04		

TABLE D.3.3–26.—*Ingestion of Metals in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

On-Site Sediment Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
365	d	AT = ED* 365 days

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–27.—*Ingestion of Honey for Off-Site Residents (Note: Includes LANL 1990–1994 Los Alamos and White Rock County Data for Los Alamos County and San Ildefonso Data for Non-Los Alamos County Resident) (Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE		95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Los Alamos County Tritium[1]		4.64E+01	6.30E-11	7.37E-07	2.63E-06
Non-Los Alamos County Tritium		7.92E-01	6.30E-11	1.26E-08	4.49E-08
[1] 95% UCL concentration in % of food that is water					
		LOS ALAMOS COUNTY Average-Case	LOS ALAMOS COUNTY Worst-Case	NON-LOS ALAMOS COUNTY Average-Case	NON-LOS ALAMOS COUNTY Worst-Case
Total Dose (rem/yr)		7.37E-07	2.63E-06	1.26E-08	4.49E-08
Cancer Risk yr-1		3.69E-10	1.32E-09	6.29E-12	2.25E-11
Average-Case Consumption		(LANL 1997, Table 3-1)			
3.84 g/day		= number of grams of honey ingested per day			
0.69 g/day		= number of grams per day wet weight ingested			
Worst-Case Consumption		(LANL 1997, Table 3-1)			
13.7 g/day		= number of grams of honey ingested per day			
2.47 g/day		= number of grams per day wet weight ingested			
Moisture Content		(LANL 1997)			
0.18 unitless		= LANL fraction of honey that is water			
Exposure Duration					
365 days		= 1 yr exposure duration			
LAC Tritium Conversion		**H^3=**	**46.4**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	46.4	pCi/g			
Non-LAC Tritium Conversion		**H^3=**	**0.792**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	0.792	pCi/g			

TABLE D.3.3–28.—*Ingestion of Free-Range Steer for an Off-Site Non-Los Alamos County Resident (see Table D.3.5–7)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Americium-241	6.70E-05	4.50E-06	4.48E-06	1.09E-05	
Cesium-137	2.10E-02	5.00E-08	1.56E-05	3.79E-05	
Plutonium-238	3.00E-05	3.80E-06	1.69E-06	4.11E-06	
Plutonium-239	1.50E-04	4.30E-06	9.58E-06	2.33E-05	
Strontium-90	2.60E-02	1.30E-07	5.02E-05	1.22E-04	
Tritium	2.00E+02	6.30E-11	1.87E-04	4.55E-04	
Uranium	1.28E-03	2.60E-07	4.94E-06	1.20E-05	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			2.74E-04	6.65E-04	
Cancer Risk yr-1			1.37E-07	3.32E-07	
Average-Case Consumption		(EPA 1997a, 71.8 kg Man)			
2.10 g/kg-day		= number of grams per day ingested			
40.71 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, 71.8 kg Man)			
5.10 g/kg/day		= number of grams per day ingested			
98.87 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.27 unitless		= LANL dry/wet weight ratio			
Exposure Duration					
365 days		= 1 yr exposure duration			
Tritium Conversion		**H^3=**	**200**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	200	pCi/g			
Uranium Conversion		**U=**	**1.80E-03**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	5.99E-04	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.80E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	6.51E-04	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.28E-03**	**pCi/g**			

TABLE D.3.3–29.—*Ingestion of Elk for an Off-Site Los Alamos County Resident (Note: Includes LANL 1990–1994 Off-Site Road Kills (from Chama, Lindreth, and Tres Piedras, see Table D.3.5–6)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Cesium-137	6.26E-01	5.00E-08	7.57E-05	1.84E-04
Plutonium-238	0.00E+00	3.80E-06	0.00E+00	0.00E+00
Plutonium-239	0.00E+00	4.30E-06	0.00E+00	0.00E+00
Strontium-90	0.00E+00	1.30E-07	0.00E+00	0.00E+00
Tritium[1]	(not analyzed)	6.30E-11		
Uranium	2.49E-03	2.60E-07	1.57E-06	3.80E-06

[1] 95% UCL concentration in % of food that is water

	Average-Case	Worst-Case
Total Dose (rem/yr)	7.73E-05	1.87E-04
Cancer Risk yr-1	3.87E-08	9.37E-08

Average-Case Consumption	(EPA 1997a, General Population)
26 g/day	= number of grams per day ingested
6.63 g/day	= number of grams per day dry weight ingested
Worst-Case Consumption	(EPA 1997a, General Population)
63 g/day	= number of grams per day ingested
16.065 g/day	= number of grams per day dry weight ingested
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)
0.255 unitless	= LANL dry/wet weight ratio
Exposure Duration	
365 days	= 1 yr exposure duration

Uranium Conversion — **U= 3.51E-03 µg/g**

pCi U isotope/g = µg total uranium/g X RMA X SA X CF

RMA = relative mass abundance (g isotope per g total U)

SA = specific activity (pCi/g)

CF = conversion factor (1E-06 g/µg)

			RMA	SA	CF
U-238=	1.17E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	5.46E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	1.27E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**2.49E-03**	**pCi/g**			

TABLE D.3.3–30.—*Ingestion of Elk for an Off-Site Non-Los Alamos (Note: includes LANL 1990–1994 On-Site Road Kills from TA–5, TA–16, TA–18, TA–46, and TA–49, see Table D.3.5–6)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Cesium-137	2.98E-01	5.00E-08	3.61E-05	8.74E-05	
Plutonium-238	2.00E-05	3.80E-06	1.84E-07	4.46E-07	
Plutonium-239	3.08E-04	4.30E-06	3.20E-06	7.77E-06	
Strontium-90	1.66E-02	1.30E-07	5.22E-06	1.27E-05	
Tritium[1]	6.86E+00	6.30E-11	3.06E-06	7.40E-06	
Uranium	7.67E-03	2.60E-07	4.83E-06	1.17E-05	
[1] 95% UCL concentration in % of food that is water					
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			5.25E-05	1.27E-04	
Cancer Risk yr-1			2.63E-08	6.37E-08	
Average-Case Consumption		(EPA 1997a, General Population)			
26 g/day		= number of grams per day ingested			
6.63 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, General Population)			
63 g/day		= number of grams per day ingested			
16.065 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.255 unitless		= LANL dry/wet weight ratio			
Exposure Duration					
365 days		= 1 yr exposure duration			
Tritium Conversion		**H^3=**	**6.86**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**6.86**	**pCi/g**			
Uranium Conversion		**U=**	**1.08E-02**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	3.59E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	1.68E-04	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	3.91E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**7.67E-03**	**pCi/g**			

TABLE D.3.3–31.—*Ingestion of Deer for an Off-Site Los Alamos County Resident (Note: Includes Off-Site Road Kills from Cuba and El Vado, LANL 1997, see Table D.3.5–8)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	0.00E+00	4.50E-06	0.00E+00	0.00E+00
Cesium-137	2.65E-02	5.00E-08	3.14E-06	7.62E-06
Plutonium-238	4.60E-05	3.80E-06	4.15E-07	1.00E-06
Plutonium-239	1.91E-04	4.30E-06	1.95E-06	4.72E-06
Strontium-90	3.83E-02	1.30E-07	1.18E-05	2.86E-05
Tritium[1]	8.60E-01	6.30E-11	1.29E-07	3.11E-07
Uranium	1.04E-03	2.60E-07	6.40E-07	1.55E-06

[1] 95% UCL concentration in % of food that is water

			Average-Case	Worst-Case
Total Dose (rem/yr)			1.81E-05	4.38E-05
Cancer Risk yr-1			9.04E-09	2.19E-08

Average-Case Consumption	(EPA 1997a, General Population)
26 g/day	= number of grams per day ingested
6.5 g/day	= number of grams per day dry weight ingested
Worst-Case Ingestion	(EPA 1997a, General Population)
63 g/day	= number of grams per day ingested
15.75 g/day	= number of grams per day dry weight ingested
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)
0.25 unitless	= LANL dry/wet weight ratio
Exposure Duration	
365 days	= 1 yr exposure duration

Tritium Conversion		**H^3=**	**0.86**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**0.86**	**pCi/g**			
Uranium Conversion		**U=**	**1.46E-03**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	4.86E-04	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.27E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	5.28E-04	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity=	**1.04E-03**	**pCi/g**			

TABLE D.3.3–32.—*Ingestion of Deer for an Off-Site Non-Los Alamos County Resident (Note: Includes LANL Road Kills from TA–8, TA–16, TA–21, and TA–55, LANL 1997, see Table D.3.5–8)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	7.90E-05	4.50E-06	8.43E-07	2.04E-06
Cesium-137	5.00E-01	5.00E-08	5.93E-05	1.44E-04
Plutonium-238	5.00E-05	3.80E-06	4.51E-07	1.09E-06
Plutonium-239	5.60E-05	4.30E-06	5.71E-07	1.38E-06
Strontium-90	2.30E-02	1.30E-07	7.09E-06	1.72E-05
Tritium[1]	9.90E-01	6.30E-11	1.48E-07	3.59E-07
Uranium	4.97E-01	2.60E-07	3.07E-04	7.43E-04
[1] 95% UCL concentration in % of food that is water				
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			3.75E-04	9.09E-04
Cancer Risk yr-1			1.88E-07	4.54E-07
Average-Case Consumption	(EPA 1997a, General Population)			
26 g/day	= number of grams per day ingested			
6.5 g/day	= number of grams per day dry weight ingested			
Worst-Case Ingestion	(EPA 1997a, General Population)			
63 g/day	= number of grams per day ingested			
15.75 g/day	= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)			
0.25 unitless	= LANL dry/wet weight ratio			
Exposure Duration				
365 days	= 1 yr exposure duration			

TABLE D.3.3–32.—*Ingestion of Deer for an Off-Site Non-Los Alamos County Resident (Note: Includes LANL Road Kills from TA–8, TA–16, TA–21, and TA–55, LANL 1997, see Table D.3.5–8)*-Continued

Tritium Conversion		**H^3=**	**0.99**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**0.99**	**pCi/g**			
Uranium Conversion		**U=**	**7.00E-01**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/ g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	2.33E-01	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	1.09E-02	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	2.53E-01	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**4.97E-01**	**pCi/g**			

TABLE D.3.3–33.—*Ingestion of Fish for an Off-Site Non-Los Alamos County Resident (Note: Includes all Game and Nongame Fish from Abiquiu and Cochiti, Foodstuffs Database 1990–1994, see Table D.3.5–9)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Cesium-137	2.36E-01	5.00E-08	2.22E-05	6.95E-05	
Plutonium-238	8.22E-05	3.80E-06	5.87E-07	1.84E-06	
Plutonium-239	1.50E-04	4.30E-06	1.21E-06	3.80E-06	
Strontium-90	1.03E-01	1.30E-07	2.51E-05	7.88E-05	
Uranium	1.05E-02	2.60E-07	5.13E-06	1.61E-05	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			5.42E-05	1.70E-04	
Cancer Risk yr-1			2.71E-08	8.50E-08	
Average-Case Consumption		(EPA 1997a, General Population)			
20.1 g/day		= number of grams per day ingested			
5.1456 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, General Population)			
63 g/day		= number of grams per day ingested			
16.128 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.256 unitless		= LANL dry/wet weight ratio in fish 1990–1995			
Exposure Duration					
365 days		= 1 yr exposure duration			
Uranium Conversion		**U=**	**1.48E-02**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	4.92E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.30E-04	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	5.36E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.05E-02**	**pCi/g**			

TABLE D.3.3–34.—*Ingestion of Metals in Bottom-Feeding Fish for an Off-Site Non-Los Alamos County Resident (Note: Includes Abiquiu, Heron, and El Vado Data, which is higher than Cochiti Data, LANL 1997, Table D.3.5–10)*

ANALYTES	MEAN[1] (µg/g-wet)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.25E-01	3.50E-05	1.10E-04	5.0E-03	-	7.00E-03	2.19E-02		
AS	2.50E-01	7.00E-05	2.19E-04	3.0E-04	1.5E+00	2.33E-01	7.31E-01	1.05E-04	3.29E-04
BA	6.30E-02	1.76E-05	5.53E-05	7.0E-02	-	2.52E-04	7.90E-04		
BE	5.30E-02	1.48E-05	4.65E-05	5.0E-03	4.3E+00	2.97E-03	9.30E-03	6.38E-05	2.00E-04
CD	1.14E-01	3.19E-05	1.00E-04	5.0E-04	1.8E-03	6.38E-02	2.00E-01	5.74E-08	1.80E-07
CR	6.25E-01	1.75E-04	5.48E-04	1.0E+00	-	1.75E-04	5.48E-04		
CU	8.15E-01	2.28E-04	7.15E-04	1.9E-02		1.20E-02	3.76E-02		
HG	3.42E-01	9.57E-05	3.00E-04	3.0E-04	-	3.19E-01	1.00E+00		
NI	1.13E+00	3.15E-04	9.87E-04	2.0E-02	-	1.57E-02	4.94E-02		
PB	1.25E+00	3.50E-04	1.10E-03	1.4E-03	no data	2.50E-01	7.83E-01		
SB	1.25E+00	3.50E-04	1.10E-03	4.0E-04	-	8.75E-01	2.74E+00		
SE	2.75E-01	7.70E-05	2.41E-04	5.0E-03	-	1.54E-02	4.83E-02		
TL	1.25E+00	3.50E-04	1.10E-03	8.0E-05	-	4.37E+00	1.37E+01		
ZN	5.78E+00	1.62E-03	5.07E-03	3.0E-01		5.39E-03	1.69E-02		

[1] 95% UCL Values not available for all analytes, mean values used for consistency.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–34.—*Ingestion of Metals in Bottom-Feeding Fish for an Off-Site Non-Los Alamos County Resident (Note: Includes Abiquiu, Heron, and El Vado Data, which is higher than Cochiti Data, LANL 1997, Table D.3.5–10)*-Continued

Average-Case Ingestion	(EPA 1997a, General Population)	
20.1 g/day	= number of grams per day ingested	
5.1456 g/day	= number of grams per day dry weight ingested	
Worst-Case Ingestion	(EPA 1997a, General Population)	
63 g/day	= number of grams per day ingested	
16.128 g/day	= number of grams per day dry weight ingested	
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)	
0.256 unitless	= LANL dry/wet weight ratio in fish 1990-1995	
Unit Conversion Factor	1.00E-03 mg/μg	= number of milligrams per microgram
Average Man Weight	71.8 kg	= number of kg for an average man

TABLE D.3.3–35.—*Ingestion of Fruits and Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos and White Rock Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE	HOMEGROWN 95% UCL (pCi/g)	STORE-BOUGHT 95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
			FRUITS		
Cesium-137	4.87E-01	2.67E-01	5.00E-08	2.08E-04	8.12E-04
Plutonium-238	9.69E-04	4.15E-04	3.80E-06	2.67E-05	1.08E-04
Plutonium-239	9.87E-03	6.50E-04	4.30E-06	1.43E-04	7.16E-04
Strontium-90	1.22E-01	7.30E-02	1.30E-07	1.44E-04	5.56E-04
Tritium[1]	9.14E+00	9.34E-01	6.30E-11	1.23E-05	5.91E-05
Uranium	3.20E-02	2.88E-02	2.60E-07	1.02E-04	3.77E-04
			VEGETABLES		
Cesium-137	4.40E-01	3.47E-01	5.00E-08	3.13E-04	7.55E-04
Plutonium-238	6.46E-04	4.22E-04	3.80E-06	3.07E-05	7.64E-05
Plutonium-239	7.59E-03	1.17E-03	4.30E-06	2.02E-04	6.32E-04
Strontium-90	3.41E-01	1.06E-01	1.30E-07	3.62E-04	1.02E-03
Tritium[1]	1.13E+00	7.91E-01	6.30E-11	5.28E-06	1.30E-05
Uranium	8.02E-03	1.89E-02	2.60E-07	7.11E-05	1.49E-04

[1] 95% UCL concentration in % of food that is water

		Fruit Average-Case	Fruit Worst-Case	Vegetables Average-Case	Vegetables Worst-Case
Total Dose (rem/yr)		6.36E-04	2.63E-03	9.84E-04	2.65E-03
Cancer Risk yr-1		3.18E-07	1.31E-06	4.92E-07	1.32E-06

Average-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
3.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.20 fraction	= % homegrown (EPA 1989)
4.30 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
12.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.30 fraction	= % homegrown (EPA 1989)
10.00 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.40 fraction	= % homegrown (EPA 1989)

TABLE D.3.3–35.—*Ingestion of Fruits and Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos and White Rock Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Exposure Duration					
365 days		= 1 yr exposure duration			
(Note: Dry weight fractions are from Fresquez and Ferenbaugh 1998.)					
Fruit Tritium Conversion					
	HG	**SB**	**HG H^3=**	**9.14**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**9.34E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**9.14**	**0.934**	**pCi/g**		
Vegetable Tritium Conversion					
	HG	**SB**	**HG H^3=**	**1.13**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**7.91E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**1.13**	**0.791**	**pCi/g**		
Fruit Uranium Conversion			**HG U=**	**4.50E-02**	**µg/g**
			SB U=	**4.06E-02**	**µg/g**
pCi U isotope/g fruit = µg total uranium/g fruit X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	1.50E-02	1.35E-02	9.93E-01	3.35E+05	1.00E-06
U-235=	7.00E-04	6.31E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	1.63E-02	1.47E-02	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**3.20E-02**	**2.88E-02**	**pCi/g**		
Vegetable Uranium Conversion			**HG U=**	**1.13E-02**	**µg/g**
			SB U=	**2.66E-02**	**µg/g**
pCi U isotope/g vegetable = µg total uranium/g vegetable X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	3.76E-03	8.85E-03	9.93E-01	3.35E+05	1.00E-06
U-235=	1.76E-04	4.14E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	4.09E-03	9.63E-03	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**8.02E-03**	**1.89E-02**	**pCi/g**		

TABLE D.3.3–35.—*Ingestion of Fruits and Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos and White Rock Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Intermediate Step Calculation	(Assumes a body wt. of 71.8 kg)			
Fruit	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	6.51E-05	1.43E-04	3.56E-04	4.56E-04
Plutonium-238	9.84E-06	1.69E-05	5.38E-05	5.38E-05
Plutonium-239	1.13E-04	2.99E-05	6.21E-04	9.54E-05
Strontium-90	4.24E-05	1.01E-04	2.32E-04	3.24E-04
Tritium[1]	8.72E-06	3.57E-06	4.77E-05	1.14E-05
Uranium	2.22E-05	8.02E-05	1.21E-04	2.56E-04
Vegetables	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	9.30E-05	2.20E-04	3.46E-04	4.09E-04
Plutonium-238	1.04E-05	2.03E-05	3.86E-05	3.78E-05
Plutonium-239	1.38E-04	6.38E-05	5.13E-04	1.19E-04
Strontium-90	1.87E-04	1.75E-04	6.97E-04	3.25E-04
Tritium[1]	1.70E-06	3.58E-06	6.34E-06	6.66E-06
Uranium	8.82E-06	6.23E-05	3.28E-05	1.16E-04

TABLE D.3.3–36.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	5.40E-01	8.71E-05	3.24E-04	5.0E-03	-	1.74E-02	6.48E-02		
AS	1.00E-01	1.61E-05	6.00E-05	3.0E-04	1.5E+00	5.38E-02	2.00E-01	2.42E-05	9.00E-05
BA	2.50E+01	4.03E-03	1.50E-02	7.0E-02	-	5.76E-02	2.14E-01		
BE	6.00E-02	9.68E-06	3.60E-05	5.0E-03	4.3E+00	1.94E-03	7.20E-03	4.16E-05	1.55E-04
CD	1.20E-01	1.94E-05	7.20E-05	5.0E-04	1.8E-03	3.87E-02	1.44E-01	3.48E-08	1.30E-07
CR	2.50E+00	4.03E-04	1.50E-03	1.0E+00	-	4.03E-04	1.50E-03		
HG	5.00E-02	8.06E-06	3.00E-05	3.0E-04	-	2.69E-02	1.00E-01		
NI	1.70E+01	2.74E-03	1.02E-02	2.0E-02	-	1.37E-01	5.10E-01		
PB	3.90E+01	6.29E-03	2.34E-02	1.4E-03	no data	4.49E+00	1.67E+01		
SB	3.90E-01	6.29E-05	2.34E-04	4.0E-04	-	1.57E-01	5.85E-01		
SE	4.40E-01	7.10E-05	2.64E-04	5.0E-03	-	1.42E-02	5.28E-02		
TL	1.50E-01	2.42E-05	9.00E-05	8.0E-05	-	3.02E-01	1.13E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–36.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.4 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–37.—*Ingestion of Metals in Store Bought Vegetables for Off-Site Los Alamos and Non-Los Alamos County Residents (Note: Includes Española, Santa Fe, Jemez, Cochiti, Peña Blanca, Santo Domingo, LANL 1997, see Table D.3.5–11)*

ANALYTES	VEGETABLES (µg/g-dry) 95% UCL	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	4.70E-01	2.27E-04	4.23E-04	5.0E-03	-	4.55E-02	8.46E-02		
AS	7.30E-01	3.53E-04	6.57E-04	3.0E-04	1.5E+00	1.18E+00	2.19E+00	5.30E-04	9.86E-04
BA	1.70E+01	8.22E-03	1.53E-02	7.0E-02	-	1.17E-01	2.19E-01		
BE	6.00E-02	2.90E-05	5.40E-05	5.0E-03	4.3E+00	5.81E-03	1.08E-02	1.25E-04	2.32E-04
CD	2.50E-01	1.21E-04	2.25E-04	5.0E-04	1.8E-03	2.42E-01	4.50E-01	2.18E-07	4.05E-07
CR	4.00E+00	1.94E-03	3.60E-03	1.0E+00	-	1.94E-03	3.60E-03		
HG	8.20E-02	3.97E-05	7.38E-05	3.0E-04	-	1.32E-01	2.46E-01		
NI	2.50E+01	1.21E-02	2.25E-02	2.0E-02	-	6.05E-01	1.13E+00		
PB	2.80E+01	1.35E-02	2.52E-02	1.4E-03	no data	9.68E+00	1.80E+01		
SB	1.50E-01	7.26E-05	1.35E-04	4.0E-04	-	1.81E-01	3.38E-01		
SE	4.40E-01	2.13E-04	3.96E-04	5.0E-03	-	4.26E-02	7.92E-02		
TL	1.50E-01	7.26E-05	1.35E-04	8.0E-05	-	9.07E-01	1.69E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–37.—*Ingestion of Metals in Store Bought Vegetables for Off-Site Los Alamos and Non-Los Alamos County Residents (Note: Includes Española, Santa Fe, Jemez, Cochiti, Peña Blanca, Santo Domingo, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.75 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.6 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–38.—*Ingestion of Metals in Homegrown Fruit for Off-Site Los Alamos County Residents (Note: Includes Los Alamos Townsite Data, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (μg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/ day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	8.60E-01	8.77E-05	4.80E-04	5.0E-03	-	1.75E-02	9.60E-02		
AS	1.00E-01	1.02E-05	5.58E-05	3.0E-04	1.5E+00	3.40E-02	1.86E-01	1.53E-05	8.37E-05
BA	2.60E+00	2.65E-04	1.45E-03	7.0E-02	-	3.79E-03	2.07E-02		
BE	6.00E-02	6.12E-06	3.35E-05	5.0E-03	4.3E+00	1.22E-03	6.70E-03	2.63E-05	1.44E-04
CD	1.20E-01	1.22E-05	6.70E-05	5.0E-04	1.8E-03	2.45E-02	1.34E-01	2.20E-08	1.21E-07
CR	2.40E+00	2.45E-04	1.34E-03	1.0E+00	-	2.45E-04	1.34E-03		
HG	5.00E-02	5.10E-06	2.79E-05	3.0E-04	-	1.70E-02	9.30E-02		
NI	7.20E+00	7.34E-04	4.02E-03	2.0E-02	-	3.67E-02	2.01E-01		
PB	3.80E+00	3.88E-04	2.12E-03	1.4E-03	no data	2.77E-01	1.51E+00		
SB	1.50E-01	1.53E-05	8.37E-05	4.0E-04	-	3.83E-02	2.09E-01		
SE	1.00E-01	1.02E-05	5.58E-05	5.0E-03	-	2.04E-03	1.12E-02		
TL	1.50E-01	1.53E-05	8.37E-05	8.0E-05	-	1.91E-01	1.05E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–38.—*Ingestion of Metals in Homegrown Fruit for Off-Site Los Alamos County Residents (Note: Includes Los Alamos Townsite Data, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
3.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.2 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
12.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.3 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–39.—*Ingestion of Fruits and Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes San Ildefonso Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE	HOMEGROWN 95% UCL (pCi/g)	STORE-BOUGHT 95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
			FRUITS		
Cesium-137	1.81E-01	2.67E-01	5.00E-08	1.67E-04	5.88E-04
Plutonium-238	2.12E-04	4.15E-04	3.80E-06	1.90E-05	6.56E-05
Plutonium-239	1.79E-03	6.50E-04	4.30E-06	5.05E-05	2.08E-04
Strontium-90	8.41E-02	7.30E-02	1.30E-07	1.31E-04	4.84E-04
Tritium[1]	7.57E-01	9.34E-01	6.30E-11	4.29E-06	1.53E-05
Uranium	5.52E-03	2.88E-02	2.60E-07	8.40E-05	2.77E-04
			VEGETABLES		
Cesium-137	1.99E+00	3.47E-01	5.00E-08	6.40E-04	1.97E-03
Plutonium-238	2.80E-03	4.22E-04	3.80E-06	6.53E-05	2.05E-04
Plutonium-239	7.92E-04	1.17E-03	4.30E-06	7.82E-05	1.72E-04
Strontium-90	2.83E-01	1.06E-01	1.30E-07	3.30E-04	9.04E-04
Tritium[1]	1.14E+00	7.91E-01	6.30E-11	5.30E-06	1.31E-05
Uranium	1.41E-01	1.89E-02	2.60E-07	2.17E-04	6.91E-04

[1] 95% UCL concentration in % of food that is water

		Fruit Average-Case	Fruit Worst-Case	Vegetables Average-Case	Vegetables Worst-Case
Total Dose (rem/yr)		4.55E-04	1.64E-03	1.34E-03	3.96E-03
Cancer Risk yr-1		2.28E-07	8.19E-07	6.68E-07	1.98E-06

Average-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
3.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.20 fraction	= % homegrown (EPA 1989)
4.30 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
12.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.30 fraction	= % homegrown (EPA 1989)
10.00 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.40 fraction	= % homegrown (EPA 1989)

TABLE D.3.3–39.—*Ingestion of Fruits and Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes San Ildefonso Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Exposure Duration					
365 days		= 1 yr exposure duration			
(Note: Dry weight fractions are from Fresquez and Ferenbaugh 1998.)					
Fruit Tritium Conversion					
	HG	**SB**	**HG H^3=**	**7.57E-01**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**9.34E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**0.757**	**0.934**	**pCi/g**		
Vegetable Tritium Conversion					
	HG	**SB**	**HG H^3=**	**1.14**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**7.91E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**1.14**	**0.791**	**pCi/g**		
Fruit Uranium Conversion			**HG U=**	**7.78E-03**	**µg/g**
			SB U=	**4.06E-02**	**µg/g**
pCi U isotope/g fruit = µg total uranium/g fruit X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	2.59E-03	1.35E-02	9.93E-01	3.35E+05	1.00E-06
U-235=	1.21E-04	6.31E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	2.82E-03	1.47E-02	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**5.52E-03**	**2.88E-02**	**pCi/g**		
Vegetable Uranium Conversion			**HG U=**	**1.98E-01**	**µg/g**
			SB U=	**2.66E-02**	**µg/g**
pCi U isotope/g vegetable = µg total uranium/g vegetable X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	6.59E-02	8.85E-03	9.93E-01	3.35E+05	1.00E-06
U-235=	3.08E-03	4.14E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	7.17E-02	9.63E-03	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.41E-01**	**1.89E-02**	**pCi/g**		

TABLE D.3.3–39.—*Ingestion of Fruits and Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes San Ildefonso Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Intermediate Step Calculation		Body wt. kg = 71.8		
Fruit	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	2.42E-05	1.43E-04	1.32E-04	4.56E-04
Plutonium-238	2.15E-06	1.69E-05	1.18E-05	5.38E-05
Plutonium-239	2.06E-05	2.99E-05	1.13E-04	9.54E-05
Strontium-90	2.92E-05	1.01E-04	1.60E-04	3.24E-04
Tritium[1]	7.22E-07	3.57E-06	3.95E-06	1.14E-05
Uranium	3.84E-06	8.02E-05	2.10E-05	2.56E-04
Vegetables	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	4.20E-04	2.20E-04	1.56E-03	4.09E-04
Plutonium-238	4.50E-05	2.03E-05	1.67E-04	3.78E-05
Plutonium-239	1.44E-05	6.38E-05	5.36E-05	1.19E-04
Strontium-90	1.55E-04	1.75E-04	5.78E-04	3.25E-04
Tritium[1]	1.72E-06	3.58E-06	6.40E-06	6.66E-06
Uranium	1.54E-04	6.23E-05	5.75E-04	1.16E-04

TABLE D.3.3–40.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.60E-01	2.58E-05	9.60E-05	5.0E-03	-	5.16E-03	1.92E-02		
AS	4.20E-01	6.77E-05	2.52E-04	3.0E-04	1.5E+00	2.26E-01	8.40E-01	1.02E-04	3.78E-04
BA	3.60E+01	5.81E-03	2.16E-02	7.0E-02	-	8.29E-02	3.09E-01		
BE	6.00E-02	9.68E-06	3.60E-05	5.0E-03	4.3E+00	1.94E-03	7.20E-03	4.16E-05	1.55E-04
CD	1.20E-01	1.94E-05	7.20E-05	5.0E-04	1.8E-03	3.87E-02	1.44E-01	3.48E-08	1.30E-07
CR	4.60E-01	7.42E-05	2.76E-04	1.0E+00	-	7.42E-05	2.76E-04		
HG	1.00E-01	1.61E-05	6.00E-05	3.0E-04	-	5.38E-02	2.00E-01		
NI	4.10E+00	6.61E-04	2.46E-03	2.0E-02	-	3.31E-02	1.23E-01		
PB	3.00E+01	4.84E-03	1.80E-02	1.4E-03	no data	3.46E+00	1.29E+01		
SB	1.50E-01	2.42E-05	9.00E-05	4.0E-04	-	6.05E-02	2.25E-01		
SE	7.80E-01	1.26E-04	4.68E-04	5.0E-03	-	2.52E-02	9.36E-02		
TL	1.50E-01	2.42E-05	9.00E-05	8.0E-05	-	3.02E-01	1.13E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–40.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.4 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–41.—*Ingestion of Milk for Off-Site Residents (Note: Includes Albuquerque Data for Los Alamos County and Nambe Data for Non-Los Alamos County Resident, Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE	MEAN[1] (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
LOS ALAMOS COUNTY				
Cesium-137	2.41E+00	5.00E-08	1.32E-05	3.52E-05
Iodine-131	1.00E+01	5.30E-08	5.80E-05	1.55E-04
Plutonium-238	0.00E+00	3.80E-06	0.00E+00	0.00E+00
Plutonium-239	0.00E+00	4.30E-06	0.00E+00	0.00E+00
Strontium-90	0.00E+00	1.30E-07	0.00E+00	0.00E+00
Tritium	0.00E+00	6.30E-11	0.00E+00	0.00E+00
Uranium	7.10E-02	2.60E-07	2.02E-06	5.39E-06
NON-LOS ALAMOS COUNTY				
Cesium-137	3.10E+00	5.00E-08	1.70E-05	4.53E-05
Iodine-131	4.70E+00	5.30E-08	2.73E-05	7.27E-05
Plutonium-238	3.00E-03	3.80E-06	1.25E-06	3.33E-06
Plutonium-239	0.00E+00	4.30E-06	0.00E+00	0.00E+00
Strontium-90	0.00E+00	1.30E-07	0.00E+00	0.00E+00
Tritium	1.00E+02	6.30E-11	6.90E-07	1.84E-06
Uranium	1.70E-01	2.60E-07	4.85E-06	1.29E-05

[1] 95% UCL concentration not available, value not converted from % moisture or dry/wet weight

		LOS ALAMOS COUNTY Average-Case	LOS ALAMOS COUNTY Worst-Case	NON- LOS ALAMOS COUNTY Average-Case	NON-LOS ALAMOS COUNTY Worst-Case
Total Dose (rem/yr)		7.33E-05	1.95E-04	5.10E-05	1.36E-04
Cancer Risk yr-1		3.66E-08	9.77E-08	2.55E-08	6.81E-08
Average-Case Consumption		(EPA 1997a, Table 3-26, pg. 3-23)			
0.30 L/day		= number of liters of milk ingested per day			
Worst-Case Consumption		(EPA 1997a, Table 3-26, pg. 3-23)			
0.80 L/day		= number of liters of milk ingested per day			
		(NOTE: assumes pregnant woman ingestion rate)			
Exposure Duration					
365 days		= 1 yr exposure duration			

TABLE D.3.3–41.—*Ingestion of Milk for Off-Site Residents (Note: Includes Albuquerque Data for Los Alamos County and Nambe Data for Non-Los Alamos County Resident, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Los Alamos County Uranium Conversion			**U=**	**1.00E-01**	**µg/L**
pCi U isotope/L milk = µg total uranium/L milk X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	3.33E-02	pCi/L	9.93E-01	3.35E+05	1.00E-06
U-235=	1.56E-03	pCi/L	7.20E-03	2.16E+06	1.00E-06
U-234=	3.62E-02	pCi/L	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**7.10E-02**	**pCi/L**			
Non-Los Alamos County Uranium Conversion			**U=**	**2.40E-01**	**µg/L**
pCi U isotope/L milk = µg total uranium/L milk X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	7.98E-02	pCi/L	9.93E-01	3.35E+05	1.00E-06
U-235=	3.73E-03	pCi/L	7.20E-03	2.16E+06	1.00E-06
U-234=	8.69E-02	pCi/L	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.70E-01**	**pCi/L**			

TABLE D.3.3–42.—*Ingestion of Fish for a Special Pathway Receptor (Note: Includes all Game and Nongame Fish from Abiquiu and Cochiti, Foodstuffs Database 1990–1994, see Table D.3.5–9)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Cesium-137	2.36E-01	5.00E-08	7.72E-05	1.87E-04	
Plutonium-238	8.22E-05	3.80E-06	2.04E-06	4.96E-06	
Plutonium-239	1.50E-04	4.30E-06	4.22E-06	1.02E-05	
Strontium-90	1.03E-01	1.30E-07	8.76E-05	2.13E-04	
Uranium	1.05E-02	2.60E-07	1.79E-05	4.34E-05	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			1.89E-04	4.59E-04	
Cancer Risk yr-1			9.44E-08	2.29E-07	
Average-Case Consumption		(EPA 1997a, Native American Subsistence)			
70 g/day		= number of grams per day ingested			
17.92 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, Native American Subsistence)			
170 g/day		= number of grams per day ingested			
43.52 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.256 unitless		= LANL dry/wet weight ratio in fish 1990–1995			
Exposure Duration					
365 days		= 1 yr exposure duration			
Uranium Conversion		**U=**	**1.48E-02**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	4.92E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.30E-04	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	5.36E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.05E-02**	**pCi/g**			

TABLE D.3.3–43.—*Ingestion of Metals in Bottom-Feeding Fish for a Special Pathway Receptor (Note: Uses Regional Statistical Reference Level (RSRL) Data, LANL 1997, see Table D.3.5–12)*

ANALYTES	95% UCL (µg/g-wet)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.20E+00	1.17E-03	2.84E-03	5.0E-03	-	2.34E-01	5.68E-01		
AS	4.00E-01	3.90E-04	9.47E-04	3.0E-04	1.5E+00	1.30E+00	3.16E+00	5.85E-04	1.42E-03
BA	1.20E+00	1.17E-03	2.84E-03	7.0E-02	-	1.67E-02	4.06E-02		
BE	1.30E+00	1.27E-03	3.08E-03	5.0E-03	4.3E+00	2.53E-01	6.16E-01	5.45E-03	1.32E-02
CD	3.00E-01	2.92E-04	7.10E-04	5.0E-04	1.8E-03	5.85E-01	1.42E+00	5.26E-07	1.28E-06
CR	1.50E+00	1.46E-03	3.55E-03	1.0E+00	-	1.46E-03	3.55E-03		
CU	1.40E+00	1.36E-03	3.31E-03	1.9E-02		7.18E-02	1.74E-01		
HG	4.00E-01	3.90E-04	9.47E-04	3.0E-04	-	1.30E+00	3.16E+00		
NI	1.50E+00	1.46E-03	3.55E-03	2.0E-02	-	7.31E-02	1.78E-01		
PB	4.00E+00	3.90E-03	9.47E-03	1.4E-03	no data	2.79E+00	6.76E+00		
SB	2.10E+00	2.05E-03	4.97E-03	4.0E-04	-	5.12E+00	1.24E+01		
SE	4.00E-01	3.90E-04	9.47E-04	5.0E-03	-	7.80E-02	1.89E-01		
TL	2.10E+00	2.05E-03	4.97E-03	8.0E-05	-	2.56E+01	6.22E+01		
ZN	6.60E+00	6.43E-03	1.56E-02	3.0E-01		2.14E-02	5.21E-02		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–43.—*Ingestion of Metals in Bottom-Feeding Fish for a Special Pathway Receptor (Note: Uses Regional Statistical Reference Level (RSRL) Data, LANL 1997, see Table D.3.5–12)*-Continued

Average-Case Ingestion	(EPA 1997a, Native American Subsistence)
70 g/day	= number of grams per day ingested
17.92 g/day	= number of grams per day dry weight ingested
Worst-Case Ingestion	(EPA 1997a, Native American Subsistence)
170 g/day	= number of grams per day ingested
43.52 g/day	= number of grams per day dry weight ingested
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)
0.256 unitless	= LANL dry/wet weight ratio in fish 1990 to 1995
Unit Conversion Factor	
1.00E-03 mg/µg	= number of milligrams per microgram
Average Man Weight	
71.8 kg	= number of kg for an average man

TABLE D.3.3–44.—*Ingestion of Elk for a Special Pathway Receptor (Note: Includes Elk from Chama, Lindreth, and Tres Piedras, Fresquez et al. 1994, see Table D.3.5–13)*

ANALYTE	HEART 95% UCL (pCi/g) dry wt.	LIVER 95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	HEART AVERAGE-CASE DOSE (rem/year)	LIVER AVERAGE-CASE DOSE (rem/year)
Cesium-137	6.79E-02	5.96E-01	5.00E-08	1.48E-06	2.27E-05
Plutonium-238	0.00E+00	7.50E-05	3.80E-06	0.00E+00	2.17E-07
Plutonium-239	6.55E-04	9.50E-05	4.30E-06	1.23E-06	3.11E-07
Strontium-90	6.50E-03	8.20E-03	1.30E-07	3.68E-07	8.12E-07
Uranium	3.47E-02	1.60E-02	2.60E-07	3.93E-06	3.18E-06
				Heart Average-Case	**Liver Average-Case**
Total Dose (rem/yr)				7.01E-06	2.72E-05
Cancer Risk yr-1				3.51E-09	1.36E-08
Heart Average-Case Consumption	(Fresquez et al. 1994)				
3.98 g/day	= number of grams per day ingested (at 3.2 lbs/yr)				
1.194 g/day	= number of grams per day dry weight ingested				
Liver Average-Case Consumption	(Fresquez et al. 1994)				
6.96 g/day	= number of grams per day ingested (at 5.6 lbs/yr)				
2.088 g/day	= number of grams per day dry weight ingested				
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)				
0.3 unitless	=LANL dry/wet weight ratio				
Exposure Duration					
365 days	= 1 yr exposure duration				
Uranium Conversion		**Heart U=**	**4.89E-02**	**μg/g**	
		Liver U=	**2.26E-02**	**μg/g**	
pCi U isotope/g = μg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/μg)					
	Heart	**Liver**	**RMA**	**SA**	**CF**
U-238=	1.63E-02	7.52E-03	9.93E-01	3.35E+05	1.00E-06
U-235=	7.60E-04	3.51E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	1.77E-02	8.18E-03	5.80E-05	6.24E+09	1.00E-06
Total U Activity (pCi/g) =	**3.47E-02**	**1.60E-02**			

TABLE D.3.3–45.—*Ingestion of Herbal Tea (Cota) for Special Pathway Receptors (Note: Includes Data from San Ildefonso, LANL 1997, see Table D.3.5-14)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Americium-241	7.30E-02	4.50E-06	7.00E-05	2.43E-04	
Cesium-137	5.30E+01	5.00E-08	5.65E-04	1.96E-03	
Plutonium-238	2.80E-02	3.80E-06	2.27E-05	7.88E-05	
Plutonium-239	2.20E-02	4.30E-06	2.02E-05	7.01E-05	
Strontium-90	1.20E+00	1.30E-07	3.33E-05	1.16E-04	
Tritium	1.60E+02	6.30E-11	2.15E-06	7.47E-06	
Uranium	6.46E-01	2.60E-07	3.58E-05	1.24E-04	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			7.49E-04	2.60E-03	
Cancer Risk yr-1			3.74E-07	1.30E-06	
Average-Case Consumption		(EPA 1997a, pg 3-16, Table 3-18)			
0.58 L/day		= mean number of liters per day ingested			
Worst-Case Ingestion		(EPA 1997a, pg 3-16, Table 3-18)			
2.03 L/day		= 99% number of liters per day ingested			
Exposure Duration					
365 days		= 1 yr exposure duration			
Uranium Conversion		U=	9.10E-01	µg/L	
pCi U isotope/L water = µg total uranium/L water X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	3.03E-01	pCi/L	9.93E-01	3.35E+05	1.00E-06
U-235=	1.42E-02	pCi/L	7.20E-03	2.16E+06	1.00E-06
U-234=	3.29E-01	pCi/L	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**6.46E-01**	**pCi/L**			

TABLE D.3.3–46.—*Ingestion of Radionuclides in Vegetables Grown in Contaminated Soil for Comparison Purposes (No Receptor Identified) (Note: On-Site Los Alamos Canyon Data for Pinto Beans, Sweet Corn, and Zucchini Squash, Fresquez et al. 1997, see Table D.3.5–15)*

ANALYTE	WEIGHTED[1] 95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.68E-04	4.50E-06	8.50E-05	1.98E-04
Cesium-137	1.47E+00	5.00E-08	8.26E-03	1.92E-02
Plutonium-238	1.90E-04	3.80E-06	8.12E-05	1.89E-04
Plutonium-239	5.21E-05	4.30E-06	2.53E-05	5.88E-05
Strontium-90	4.52E+00	1.30E-07	6.63E-02	1.54E-01
Tritium[2]	1.10E+00	6.30E-11	7.79E-06	1.81E-05
Uranium	6.92E-04	2.60E-07	2.03E-05	4.72E-05

[1] Values represent the 95% UCL of the mean of the individual isotopic means for the three vegetable types, weighted by the appropriate dry weight fractions: Pinto Beans, 0.64; Sweet Corn, 0.26; and Zucchini Squash, 0.049 (Fresquez and Ferenbaugh 1998).
[2] 95% UCL concentration in % of food that is water, also corrected for the water fractions.

			Vegetables Average-Case	Vegetables Worst-Case
Total Dose (rem/yr)			7.48E-02	1.74E-01
Cancer Risk yr-1			3.74E-05	8.69E-05

Average-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)			
4.30	g/kg-day	= grams of **vegetables** ingested per day per kg body wt.			
Worst-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)			
10.00	g/kg-day	= grams of **vegetables** ingested per day per kg body wt.			
Exposure Duration					
365	days	= 1 yr exposure duration			
Vegetable Tritium Conversion			**H^3=**	**1.097**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**1.097**	**pCi/g**			
Vegetable Uranium Conversion			**U=**	**9.75E-04**	**µg/g**
pCi U isotope/g vegetable = µg total uranium/g vegetable X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
			RMA	**SA**	**CF**
U-238=	3.24E-04	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	1.52E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	3.53E-04	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**6.92E-04**	**pCi/g**			

TABLE D.3.3–47.—*Ingestion of Metals in Vegetables Grown in Contaminated Soil (No Identified Receptor) (Note: On-Site Los Alamos Canyon Data for Pinto Beans, Sweet Corn, and Zucchini Squash, Frequez et al., 1997, see Table D.3.5–15)*

ANALYTES	WEIGHTED[1] 95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AS	8.70E-02	3.74E-04	8.70E-04	3.0E-04	1.5E+00	1.25E+00	2.90E+00	5.61E-04	1.31E-03
CD	1.07E-01	4.60E-04	1.07E-03	5.0E-04	1.8E-03	9.20E-01	2.14E+00	8.28E-07	1.93E-06
CR	1.14E-01	4.90E-04	1.14E-03	1.0E+00	-	4.90E-04	1.14E-03		
HG	4.60E-02	1.98E-04	4.60E-04	3.0E-04	-	6.59E-01	1.53E+00		
PB	1.21E+01	5.20E-02	1.21E-01	1.4E-03	no data	3.72E+01	8.64E+01		
SB	1.37E-01	5.89E-04	1.37E-03	4.0E-04	-	1.47E+00	3.43E+00		
ZN	3.31E+01	1.42E-01	3.31E-01	3.0E-01		4.74E-01	1.10E+00		

[1] Values represent the 95% UCL of the mean of the individual means of metal concentrations for the three vegetable types, weighted by the appropriate dry weight fractions: Pinto Beans, 0.64; Sweet Corn, 0.26; and Zucchini Squash, 0.049 (Fresquez and Ferenbaugh 1998).

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.

Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Average-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.	
Worst-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.	
Units Conversion		
1.00E-03 mg/µg	= number of milligrams per microgram	

TABLE D.3.3–48.—*Ingestion of Regional Vegetables for Comparison to Table D.3.3-48 (Note: Regional Data for Pinto Beans, Sweet Corn, and Zucchini Squash, Fresquez et al. 1997, see Table D.3.5–15)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AS	1.00E-01	1.36E-04	3.16E-04	3.0E-04	1.5E+00	4.53E-01	1.05E+00	2.04E-04	4.74E-04
CD	1.20E-01	1.63E-04	3.79E-04	5.0E-04	1.8E-03	3.26E-01	7.58E-01	2.94E-07	6.83E-07
CR	8.00E-02	1.09E-04	2.53E-04	1.0E+00	-	1.09E-04	2.53E-04		
HG	5.00E-02	6.79E-05	1.58E-04	3.0E-04	-	2.26E-01	5.27E-01		
PB	7.60E+00	1.03E-02	2.40E-02	1.4E-03	no data	7.38E+00	1.72E+01		
SB	1.50E-01	2.04E-04	4.74E-04	4.0E-04	-	5.10E-01	1.19E+00		
ZN	5.10E+01	6.93E-02	1.61E-01	3.0E-01		2.31E-01	5.37E-01		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.316 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.316 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–49.—*Ingestion of Metals in LANL On-Site Fruit (No Identified Receptor) (Note: Includes On-Site LANL Data, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.60E-01	8.16E-05	2.98E-04	5.0E-03	-	1.63E-02	5.95E-02		
AS	4.20E-01	2.14E-04	7.81E-04	3.0E-04	1.5E+00	7.14E-01	2.60E+00	3.21E-04	1.17E-03
BA	3.60E+01	1.84E-02	6.70E-02	7.0E-02	-	2.62E-01	9.57E-01		
BE	6.00E-02	3.06E-05	1.12E-04	5.0E-03	4.3E+00	6.12E-03	2.23E-02	1.32E-04	4.80E-04
CD	1.20E-01	6.12E-05	2.23E-04	5.0E-04	1.8E-03	1.22E-01	4.46E-01	1.10E-07	4.02E-07
CR	4.60E-01	2.35E-04	8.56E-04	1.0E+00	-	2.35E-04	8.56E-04		
HG	1.20E-01	6.12E-05	2.23E-04	3.0E-04	-	2.04E-01	7.44E-01		
NI	4.10E+00	2.09E-03	7.63E-03	2.0E-02	-	1.05E-01	3.81E-01		
PB	3.00E+01	1.53E-02	5.58E-02	1.4E-03	no data	1.09E+01	3.99E+01		
SB	1.50E-01	7.65E-05	2.79E-04	4.0E-04	-	1.91E-01	6.98E-01		
SE	7.80E-01	3.98E-04	1.45E-03	5.0E-03	-	7.96E-02	2.90E-01		
TL	1.50E-01	7.65E-05	2.79E-04	8.0E-05	-	9.56E-01	3.49E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Average-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
3.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.	
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)	
Worst-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
12.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.	
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)	
Units Conversion		
1.00E-03 mg/µg	= number of milligrams per microgram	

TABLE D.3.3–50.—*Ingestion of Pinyon Nuts for a Non-Los Alamos County Resident and a Special Pathway Receptor (Note: Non-Los Alamos County includes Pinyon Nuts from Santa Fe, Nambe, and Abiquiu. Special Pathway includes Pinyon Nuts from LANL TA–15, TA–18, TA–21/53, TA–49, TA–2, and TA–54, 1979, Salazar 1979, see Table D.3.5–16)*

ANALYTE	NON-LOS ALAMOS COUNTY 95% UCL (pCi/g) dry wt.	SPECIAL PATHWAY 95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	NON-LOS ALAMOS COUNTY AVERAGE-CASE DOSE (rem/year)	SPECIAL PATHWAY AVERAGE-CASE DOSE (rem/year)
Beryllium-7	1.40E-01	2.80E-02	1.10E-10	1.39E-09	2.77E-10
Cesium-137	2.00E-02	2.40E-02	5.00E-08	9.00E-08	1.08E-07
Plutonium-238	1.70E-02		3.80E-06	5.81E-06	
Plutonium-239	1.30E-02	2.70E-01	4.30E-06	5.03E-06	1.04E-04
Strontium-90	2.30E-01	9.20E-01	1.30E-07	2.69E-06	1.08E-05
Tritium[1]	5.70E+00	2.80E+01	6.30E-11	5.06E-07	2.49E-06
Uranium	5.68E-02	5.54E-01	2.60E-07	1.33E-06	1.30E-05

[1] Tritium is determined for the percent that is water.
Special pathway tritium is affected by tritium-contaminated soil.

				NON-LOS ALAMOS COUNTY	SPECIAL PATH
Total Dose (rem/yr)				1.55E-05	1.31E-04
Cancer Risk yr-1				7.73E-09	6.54E-08
Non-Los Alamos County Average-Case Consumption (Salazar 1979)					
1500	g/yr	= number of grams ingested per year			
Special Pathway Average-Case Consumption (Salazar 1979)					
1500	g/yr	= number of grams ingested per year			
Dry/Wet Weight Fraction (Salazar 1979)					
0.06	unitless	= dry/wet weight ratio (mean of 90% to 98% water content)			
Tritium Conversion		**Non-Los Alamos County H^3=**		**5.7**	**pCi/mL**
		Special Pathway H^3=		**28**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
	Non-Los Alamos County	**Spec. Path.**			
Tritium Activity =	**5.7**	**28**	**pCi/g**		

TABLE D.3.3–50.—*Ingestion of Pinyon Nuts for a Non-Los Alamos County Resident and a Special Pathway Receptor (Note: Non-Los Alamos County includes Pinyon Nuts from Santa Fe, Nambe, and Abiquiu. Special Pathway includes Pinyon Nuts from LANL TA–15, TA–18, TA–21/53, TA–49, TA–2, and TA–54, 1979, Salazar 1979, see Table D.3.5–16)*-Continued

Uranium Conversion		**Non-Los Alamos County U=**		**8.00E-02**	**µg/g**
		Special Pathway U=		**7.80E-01**	**µg/g**
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Non-LAC	**Spec. Path.**	**RMA**	**SA**	**CF**
U-238=	2.66E-02	2.59E-01	9.93E-01	3.35E+05	1.00E-06
U-235=	1.24E-03	1.21E-02	7.20E-03	2.16E+06	1.00E-06
U-234=	2.90E-02	2.82E-01	5.80E-05	6.24E+09	1.00E-06
Total U (pCi/g) =	**5.68E-02**	**5.54E-01**			

D.3.4 Comparison of Concentrations of Selected Radionuclides and Metals in Regional and LANL Perimeter/On-Site Samples of Environmental Media

Table D.3.4–1 summarizes an analysis of differences between samples taken on site or at the perimeter of LANL versus those taken in the general region of northern New Mexico. (The network of annual sampling stations for surface water, groundwater, and sediment surveillance includes a set of regional [or background] stations and a group of stations near or within the LANL boundary—these data are addressed in section D.3.5 and are provided in appendix C.) The concentrations of plutonium-239 were found to be elevated from that of the region in the media at the perimeter of LANL. Values for fruits grown on site, honey from on-site TAs, and deer (road kills) on site showed elevated plutonium-239 concentrations. These foodstuffs are not consumed, but were collected to determine concentrations in biological media in known contaminated areas of the LANL reservation.

D.3.4.1 *Arsenic*

For most people, the primary mode of arsenic exposure is from food and water consumption. The average ingestion rate for members of the public is about 25 to 50 micrograms per day in food alone (ATSDR 1989 and EPA 1997b). Typically, exposure from water is less. The estimated maximum exposures (95th percentile) to arsenic from ingestion near LANL are:

- Store-bought vegetables (Table D.3.3–37): approximately 31 micrograms per day
- On-site fruit (not consumed, Table D.3.3–49): approximately 61 micrograms per day
- Fish (special pathways consumption rate, Table D.3.3–43): approximately 68 micrograms per day
- Surface waters (Table D.3.3–8): approximately 0.24 microgram per day
- NPDES discharge (Table D.3.3–12): approximately 0.62 microgram per day
- Groundwater (Los Alamos supply, Table D.3.3–2): approximately 98 micrograms per day
- Groundwater (San Ildefonso supply, Table D.3.3–6): approximately 53 micrograms per day

The primary source of arsenic in food and water sources in the LANL area are naturally occurring in soil and basalt minerals and are almost entirely inorganic in form (LANL 1997) The concentrations of arsenic in groundwater supply wells are not significantly different between Los Alamos and San Ildefonso (appendix C).

The main uses of arsenic in the U.S. are in pesticide formulation. LANL does not utilize arsenic in manufacturing levels in its research and development or processing activities. Arsenic is known to be beneficial or necessary for human metabolism in micro-quantities (ATSDR 1989).

When amounts less than 200 to 250 micrograms per day of arsenic are ingested, the human body can detoxify the inorganic form of arsenic by "methylation" (that is, by the addition of methyl groups to the ionic form). This does provide protection from toxic effects of inorganic arsenic. It does not necessarily protect against carcinogenesis. One hypothesis suggests that the natural methylation are "stolen" from deoxyribonucleic acid (DNA) synthesis making chromosome damage more probable (CLAWS 1997).

The single most characteristic system of ingestion exposure to inorganic arsenic is a pattern of skin abnormalities including the

TABLE D.3.4–1.—*Comparison of Concentrations of Selected Radionuclides and Metals in Regional and Perimeter or On-Site Media*

MEDIUM	NUCLIDE/ METAL	SIGNIFICANT DIFFERENCES IN PROPORTION OF SAMPLES HAVING ABOVE DETECTION CONCENTRATIONS	SIGNIFICANT DIFFERENCES IN CONCENTRATIONS
Surface Water	Cesium-137	NSD	NSD
	Plutonium-239	Perimeter > Regional	Perimeter > Regional
	Strontium-90	Regional > Perimeter	Perimeter > Regional
	Uranium	Regional > Perimeter	Regional > Perimeter
	Arsenic	Regional > Perimeter	Regional > Perimeter
	Beryllium	NSD	NSD
	Lead	Regional > Perimeter	Regional > Perimeter
Sediment	Cesium-137	NSD	NSD
	Plutonium-239	NSD	Perimeter > Regional
	Strontium-90	NSD	NSD
	Uranium	NSD	NSD
	Arsenic	NSD	NSD
	Beryllium	NSD	NSD
	Lead	NSD	NSD
Groundwater	Cesium-137	NSD	San Ildefonso Wells > LA Supply Wells
	Plutonium-239	NSD	NSD
	Strontium-90	NSD	NSD
	Uranium	NSD	NSD
	Arsenic	San Ildefonso Wells > LA Supply Wells	NSD
	Beryllium	San Ildefonso Wells > LA Supply Wells	San Ildefonso Wells > LA Supply Wells
	Lead	NSD	NSD
Soils	Cesium-137	NA	NSD
	Plutonium-239	NA	NSD
	Strontium-90	NA	NSD
	Uranium	NA	NSD
	Arsenic	NA	NSD
	Beryllium	NA	NSD
	Lead	NA	NSD

TABLE D.3.4–1.—*Comparison of Concentrations of Selected Radionuclides and Metals in Regional and Perimeter or On-Site Media*-Continued

MEDIUM	NUCLIDE/ METAL	SIGNIFICANT DIFFERENCES IN PROPORTION OF SAMPLES HAVING ABOVE DETECTION CONCENTRATIONS	SIGNIFICANT DIFFERENCES IN CONCENTRATIONS
Fruit	Cesium-137	NA	NSD
	Plutonium-239	NA	Los Alamos[a] > Neighboring Counties > Store Bought
	Strontium-90	NA	NSD
	Uranium	NA	NSD
Elk	Cesium-137	NA	NSD
	Plutonium-239	NA	insufficient data
	Strontium-90	NA	insufficient data
	Uranium	NA	NSD
Deer	Cesium-137	NA	NSD
	Plutonium-239	NA	Los Alamos[a] > neighboring counties
	Strontium-90	NA	insufficient data
	Uranium	NA	NSD
Honey	Tritium	NA	Los Alamos[a] > neighboring counties
Vegetables	Cesium-137	NA	NSD
	Plutonium-239	NA	NSD
	Strontium-90	NA	NSD
	Uranium	NA	NSD
	Arsenic	NA	NSD
	Beryllium	NA	NSD
	Lead	NA	NSD
Milk	Cesium-137	NA	NSD
	Iodine-131	NA	NSD
	Plutonium-239	no detects	insufficient data
	Strontium-90	no detects	insufficient data
	Tritium	no detects	insufficient data
	Uranium	NA	NSD

Source: Tables D.3.3–1 through D.3.3–49, and D.3.5–1 through D.3.5–9.
NSD = No (statistically) significant difference
NA = Not applicable
[a] These values are for samples collected in known contaminated areas on site. These foodstuffs are not consumed as home produce and are not allowed to be placed into commerce.

appearance of dark and light spots on the skin and small "corns" on the palms, soles, and trunk. While these skin changes are not considered to be a health concern in their own right, some may progress toward skin cancer. In addition, arsenic ingestion has been reported to increase the risk of certain cancers: liver, bladder, kidney, and lung. Organic forms of arsenic such as that found in fish seem to be less toxic than inorganic forms (ATSDR 1989).

EPA has recently held public meetings regarding its activity to develop proposed National Primary Drinking Water Regulations. The current Interim Water Primary Standard for arsenic is 50 micrograms per liter in drinking water and was established in 1976 to protect against skin cancer. This standard was scheduled for finalization with the other phase II compounds in 1991. However, due to new evidence (from Taiwanese epidemiological studies) implicating arsenic in the development of other and more serious internal cancers, the maximum contaminant level (MCL) for arsenic was delayed.

EPA has discussed in public meetings a new MCL between 0.5 and 2 micrograms per liter based on a multistage, linear modeling study of potential human risk. Based on this model, a 1 in 1,000,000 cancer risk level would be 2 parts per billion (2 parts per billion or 2 microgram per liter). The groundwater supplies used in Los Alamos County and San Ildefonso have a 95th percentile UCL of 40 micrograms per liter and 22 micrograms per liter, respectively, based on the 1991 to 1996 LANL Environmental Surveillance Reports. The concentrations are lower than the current MCL for arsenic of 50 micrograms per liter. These concentrations are in and above the ranges EPA is considering in the new MCL for arsenic. While LANL operations do not affect arsenic risk to the public, the range of arsenic concentrations in the region of LANL are in the range that may be potentially be in the range for carcinogenesis at a rate in excess of 1 in 1,000,000.

D.3.4.2 *Beryllium*

Beryllium is a hard grayish metal that, in nature, is usually found in mineral compounds, especially in coal and in volcanic rock and weathered volcanic soils. Some beryllium is soluble but most is insoluble. Most soil beryllium-containing minerals have low solubilities (ATSDR 1993).

Ingestion risks from beryllium are very low, but beryllium is a suspected human carcinogen (EPA 1997b). The oral (ingestion) reference dose (RfD) is limited to soluble beryllium salts and is 5 x 10^{-3} milligrams per kilograms-day. The estimated maximum exposures (95th percentile) from ingestion of total beryllium near LANL range from 10^{-3} to 10^{-5} milligrams per kilograms-day. The concentrations of beryllium in the waters in the LANL area are in the 1 to 10 micrograms per liter range.

The primary risk from beryllium is from inhalation, which can lead to Chronic Beryllium Disease. Beryllium workers at LANL are protected from beryllium in the workplace under the Guidance for Implementation of DOE Order 440.1 section addressing "Chronic Beryllium Disease Prevention Program." The potential consequences of beryllium emissions from HE testing at LANL is discussed in sections 5.2.6.1 and 5.3.6.1.

D.3.4.3 *Lead*

Lead is an element found throughout the Earth's crust. Inorganic lead compounds are much less toxic than organic lead compounds. Exposure is primarily by inhalation and ingestion. Exposure to environmental media containing lead is the primary source of elevated blood levels of lead in children. Lead-containing paint in the home is the principal environmental lead source. At levels less than 20 micrograms per deciliter in the blood of a pregnant woman for even a short term (less than 14 days), low birth rate and learning impairment in the infant may occur. Longer exposures of young children can result in reduced IQ and slowed growth rates. Brain and kidney damage in children can result from blood levels of lead between 70 and 100 micrograms per deciliter.

Concentrations of lead in soil/sediments and water are in the range of 10 to 100 milligrams per kilogram and 1 to 10 micrograms per liter, respectively. In Los Alamos County supply wells, the concentrations of lead are not significantly different from the oral reference dose (1.4 x 10^{-3} milligrams per kilograms-day). Lead in environmental media near LANL is not significantly different from that in the entire region. Concentrations of lead are not expected to be affected by continued LANL operations, even in the Expanded Operations Alternative for HE testing (sections 5.2.6.1 and 5.3.6.1). Although lead is a suspected carcinogen, EPA has not established an oral or inhalation slope factor for risk estimation.

D.3.5 Data Used in the Human Health Analysis

Data used for estimating dose and risk for various pathways and receptors are provided in Tables C–1, C–2, C–4, and C–6 in appendix C as well as the tables included in this section (Tables D.3.5–1 through D.3.5–16). These data were taken from sampling locations that form the network of monitors on and around LANL. These data are routinely reported in the LANL annual environmental surveillance reports (such as LANL 1994).

Not all data sets were collected for the same years. Each data table in this SWEIS specifies the years reported.

Environmental restoration site data are presented in Tables C–8 and C–9 in appendix C. In general, these were not used to estimate risk to MEIs because they are in known contaminated areas that are not subject to public exposure. In cases where use of this data was considered appropriate, the discussion of the methodology and analysis identified the data used.

TABLE D.3.5–1.—*Location of Foodstuffs and Receptors Used for Consequence Analysis (ESH–20 Foodstuffs Database, 1990 to 1994)*

RECEPTOR	MATRIX	LOCATION
Los Alamos Resident	Elk (Bone)	Chama
	Elk (Bone)	Lindreth
	Elk (Bone)	Tres Piedras
	Elk (Muscle)	Chama
	Elk (Muscle)	Lindreth
	Elk (Muscle)	Tres Piedras
	Fruit	Los Alamos
	Fruit	White Rock
	Honey	Los Alamos
	Honey	White Rock
	Milk	Albuquerque
	Vegetable	Los Alamos
	Vegetable	White Rock
Non-Los Alamos Resident	Elk (Bone)	TA–16/S-Site Road
	Elk (Bone)	TA–18/Pajarito Road
	Elk (Bone)	TA–46/Pajarito Road
	Elk (Bone)	TA–49/State Road 4
	Elk (Bone)	TA–49/Water Canyon
	Elk (Bone)	TA–5/Mortandad Canyon
	Elk (Muscle)	TA–16S-Site Road
	Elk (Muscle)	TA–18/Pajarito Road
	Elk (Muscle)	TA–46/Pajarito Road
	Elk (Muscle)	TA–49/State Road 4
	Elk (Muscle)	TA–49/Water Canyon
	Elk (Muscle)	TA–5/Mortandad Canyon
	Fish (Game)	Cochiti
	Fish (Nongame)	Cochiti
	Fruit	San Ildefonso
	Honey	Pojoaque
	Honey	San Ildefonso
	Milk	Nambe
	Vegetable	San Ildefonso

TABLE D.3.5–1.—*Location of Foodstuffs and Receptors Used for Consequence Analysis (ESH–20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	LOCATION
On-Site, No Receptor	Fruit	LANL
	Honey	TA–15
	Honey	TA–16
	Honey	TA–21
	Honey	TA–33
	Honey	TA–35
	Honey	TA–49
	Honey	TA–5
	Honey	TA–53
	Honey	TA–54
	Honey	TA–8
	Honey	TA–9
	Vegetable	LANL
Regional	Fish (Game)	Abiquiu
	Fish (Nongame)	Abiquiu
	Fruit	Cochiti/Peña Blanca/Santo Domingo
	Fruit	Española/Santa Fe/Jemez
	Honey	San Pedro
	Vegetable	Cochiti/Peña Blanca/Santo Domingo
	Vegetable	Española/Santa Fe/Jemez

TABLE D.3.5–2.—*Los Alamos Water Supply Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*

ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Americium-241	pCi/l	29	37	0.002	0.04	0.109	0.093
Cesium-137	pCi/l	28	50	0.08	59.0	431	280.0
Gross Alpha	pCi/l	33	52	0.2	1.3	3	2.7
Gross Beta	pCi/l	52	52	1	3.6	9	7.0
Gross Gamma	pCi/l	32	48	10	140.0	552	410.0
Tritium	nCi/l	30	54	0.003	0.39	1.1	0.84
Plutonium-238	pCi/l	33	60	0.00010	0.01	0.026	0.024
Plutonium-239, Plutonium-240	pCi/l	44	60	0.00010	0.038	0.669	0.24
Strontium-90	pCi/l	10	25	0.2	1.3	4.6	4.5
Uranium	µg/l	34	55	0.15	0.89	2.2	1.8
Silver	µg/l	10	55	2	37.0	58	82.0
Aluminum	µg/l	6	56	30	140.0	280	300.0
Arsenic	µg/l	33	56	2	12.0	48	40.0
Boron	µg/l	37	56	10	44.0	500	200.0
Barium	µg/l	39	45	5	38.0	88	84.0
Beryllium	µg/l	5	56	1	1.4	2	2.5
Cadmium	µg/l	2	56	1.8	3.4	5	7.9
Cobalt	µg/l	2	54	3	67.0	130	250.0
Chromium	µg/l	31	56	2	8.1	30	19.0
Copper	µg/l	27	56	1	12.0	51	33.0
Iron	µg/l	12	56	10	200.0	830	680.0
Mercury	µg/l	6	45	0.1	0.17	0.2	0.27
Manganese	µg/l	11	56	1	8.8	69	49.0
Molybdenum	µg/l	19	56	1	4.7	30	18.0
Nickel	µg/l	3	56	10	16.0	20	27.0

TABLE D.3.5–2.—*Los Alamos Water Supply Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*-Continued

ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Lead	µg/l	17	59	1	15.0	95	64.0
Antimony	µg/l	12	56	0.7	1.5	4	3.4
Selenium	µg/l	4	56	1.7	2.2	2.7	3.0
Tin	µg/l	5	44	10	19.0	34	39.0
Strontium	µg/l	52	56	38	87.0	170	150.0
Thallium	µg/l	4	56	0.3	9.8	19	26.0
Vanadium	µg/l	48	56	7	32.0	260	110.0
Zinc	µg/l	26	56	5	23.0	54	49.0
Calcium	mg/l	56	56	5	15.0	32	28.0
Chlorine	mg/l	52	53	2	3.9	8	7.0
Cyanide	mg/l	1	46	0.01	0.01	0.01	
Carbonate	mg/l	1	56	2	2.0	2	
Fluorine	mg/l	56	56	0.2	0.9	28	8.3
Hardness	mg/l	56	56	5	51.0	119	100.0
Bicarbonate	mg/l	56	56	47	84.0	152	130.0
Potassium	mg/l	48	56	1	2.6	4.4	4.0
Lithium	mg/l	9	9	0.024	0.033	0.043	0.046
Magnesium	mg/l	50	56	0.2	3.4	9.4	8.4
Sodium	mg/l	56	56	10	20.0	45	37.0
Nitrate as Nitrogen	mg/l	58	60	0.1	0.81	9.9	3.5
Phosphate as Phosphorous	mg/l	23	56	0.02	0.15	0.3	0.37
Silica	mg/l	55	56	24	73.0	98	110.0
Sulfate	mg/l	52	53	2	4.2	6.34	6.4
Total Dissolved Solids	mg/l	54	60	90	180.0	320	270.0
Total Suspended Solids	mg/l	4	24	1	1.5	2	2.5

[a] Analytes and number of analyses from Guaje and Pajarito Mesa well fields only. No analyses from the LA well field or the Otowi well field are included here.
[b] pCi/l is picocuries per liter, nCi/l is nanocuries per liter, µg/l is micrograms per liter, and mg/l is milligrams per liter.
[c] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE D.3.5–3.—*Well LA–5 Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*

ANALYTE[a]	UNITS[b]	DETECTED	MINIMUM	MEAN	MAXIMUM	95% UCL [c]
Americium-241	pCi/l	2	0.028	0.03	0.031	0.034
Cesium-137	pCi/l	2	1.7	38.0	74.0	140.0
Gross Alpha	pCi/l	2	0.92	0.96	1.0	1.1
Gross Beta	pCi/l	4	2.0	2.7	4.0	4.7
Gross Gamma	pCi/l	3	50.0	120.0	190.0	270.0
Tritium	nCi/l	2	0.1	0.15	0.2	0.29
Plutonium-238	pCi/l	2	0.0086	0.023	0.038	0.065
Plutonium-239, Plutonium-240	pCi/l	3	0.01	0.022	0.034	0.047
Strontium-90	pCi/l	3	0.1	0.27	0.6	0.84
Uranium	µg/l	3	1.0	1.1	1.2	1.3
Chloroethane	µg/l	1	13.0	13.0	13.0	
Aluminum	µg/l	1	62.0	62.0	62.0	
Arsenic	µg/l	3	2.0	2.7	3.0	3.8
Boron	µg/l	2	8.0	14.0	20.0	31.0
Barium	µg/l	3	58.0	61.0	65.0	68.0
Chromium	µg/l	3	4.8	13.0	26.0	36.0
Iron	µg/l	3	160.0	330.0	630.0	850.0
Mercury	µg/l	1	0.1	0.1	0.1	
Manganese	µg/l	3	8.0	18.0	36.0	49.0
Molybdenum	µg/l	1	1.7	1.7	1.7	
Antimony	µg/l	1	0.3	0.3	0.3	
Selenium	µg/l	1	2.0	2.0	2.0	
Tin	µg/l	1	10.0	10.0	10.0	
Strontium	µg/l	4	160.0	200.0	230.0	260.0
Thallium	µg/l	1	0.04	0.04	0.04	

TABLE D.3.5–3.—*Well LA–5 Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*-Continued

ANALYTE[a]	UNITS[b]	DETECTED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Vanadium	µg/l	4	10.0	19.0	31.0	37.0
Zinc	µg/l	4	3.9	380.0	1,300	1,600
Calcium	mg/l	4	18.0	20.0	21.0	23.0
Chlorine	mg/l	4	3.0	3.9	5.5	6.2
Fluorine	mg/l	4	0.5	13.0	49.0	61.0
Hardness	mg/l	4	46.0	52.0	56.0	61.0
Bicarbonate	mg/l	4	68.0	75.0	88.0	93.0
Potassium	mg/l	3	2.0	2.0	2.0	2.0
Magnesium	mg/l	3	0.8	0.84	0.9	0.95
Sodium	mg/l	4	14.0	20.0	34.0	39.0
Nitrate as Nitrogen	mg/l	4	0.2	0.45	0.76	0.92
Phosphate as Phosphorous	mg/l	1	0.1	0.1	0.1	
Silica	mg/l	4	40.0	42.0	43.0	44.0
Sulfate	mg/l	4	4.0	5.6	6.5	7.8
Total Dissolved Solids	mg/l	4	140.0	160.0	180.0	200.0

[a] Analytes and number of detected analyses from LA–5 only.
[b] pCi/l is picocuries per liter, nCi/l is nanocuries per liter, µg/l is micrograms per liter, and mg/l is milligrams per liter.
[c] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE D.3.5–4.—*NPDES Analyte Summary Statistics Used in Consequence Analysis (ESH NPDES Data, 1994 to 1996)*

ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL
Aluminum (T)	mg/l	40	117	0.06	0.24	1.2	0.75
Arsenic (T)	mg/l	60	99	0.0016	0.0062	0.072	0.026
Boron (T)	mg/l	118	118	0.01	0.082	2.5	0.54
Cadmium (T)	mg/l	27	117	0.0001	0.0015	0.023	0.01
Chromium (T)	mg/l	79	115	0.004	0.012	0.07	0.038
Cobalt (T)	mg/l	23	118	0.0005	0.0062	0.028	0.017
Copper (T)	mg/l	69	115	0.004	0.044	0.59	0.25
Lead (T)	mg/l	24	117	0.0002	0.0084	0.045	0.032
Mercury (T)	mg/l	6	117	0.0003	0.00063	0.0017	0.0017
Radium-226, Radium-228	pCi/l	117	117	0.02	1.7	18.503	7.3
Selenium (T)	mg/l	18	118	0.001	0.0021	0.0063	0.0046
Tritium	pCi/l	65	118	6	2,900	134143	37,000
Vanadium (T)	mg/l	111	117	0.003	0.018	0.12	0.047
Zinc (T)	mg/l	106	117	0.016	0.082	1.2	0.34

[a] (T) signifies that the total amount of the analyte in the sample was measured (both the dissolved amount and the amount adsorbed to suspended particles).
[b] mg/l is milligrams per liter; pCi/l is picocuries per liter.

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
On-Site (used for both Resident, Recreational User, and Nonresident Recreational User)	Tritium	pCi/ml				0.67		2.3
	Cesium-137	pCi/g				0.45		1.0
	Plutonium-238	pCi/g				0.008		0.02
	Plutonium-239, Plutonium-240	pCi/g				0.077		0.4
	Strontium-90	pCi/g				0.42		0.78
	Uranium	µg/g				3.0		4.8
	Americium-241	pCi/g				0.009		0.019
	Gross Alpha	pCi/g				6.5		14.0
	Gross Beta	pCi/g				6.6		19.0
	Gross Gamma	pCi/g				3.5		4.1
	Silver	µg/g	11			0.9		2.3
	Aluminum	µg/g	10			3.4		4.3
	Arsenic	µg/g	11			2.6		3.7
	Boron	µg/g	10			16.0		24.0
	Barium	µg/g	11			120.0		170.0
	Beryllium	µg/g	11			0.74		1.0
	Cadmium	µg/g	11			0.2		0.27
	Chromium	µg/g	11			8.3		12.0
	Cobalt	µg/g	10			5.2		7.9
	Copper	µg/g	10			6.0		9.7
	Iron	µg/g	10			1.3		1.8
	Mercury	µg/g	11			0.03		0.04
	Manganese	µg/g	10			350.0		610.0
	Molybdenum	µg/g	10			0.66		0.93
	Nickel	µg/g	11			6.3		9.7
	Lead	µg/g	11			17.0		30.0
	Antimony	µg/g	10			0.17		0.45

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
On-Site (used for both Resident, Recreational User, and Nonresident Recreational User) (cont.)	Selenium	µg/g	11			0.31		0.48
	Tin	µg/g	10			8.7		12.0
	Strontium	µg/g	10			27.0		39.0
	Thallium	µg/g	10			0.52		0.93
	Vanadium	µg/g	10			21.0		30.0
	Zinc	µg/g	10			34.0		49.0
Perimeter (used for both Los Alamos County Resident and Non-Los Alamos County Resident)	Tritium	pCi/ml				0.24		0.76
	Cesium-137	pCi/g				0.38		0.98
	Plutonium-238	pCi/g				0.007		0.029
	Plutonium-239, Plutonium-240	pCi/g				0.051		0.21
	Strontium-90	pCi/g				0.34		0.7
	Uranium	µg/g				3.0		4.4
	Americium-241	pCi/g				0.011		0.037
	Gross Alpha	pCi/g				4.6		8.6
	Gross Beta	pCi/g				5.2		8.2
	Gross Gamma	pCi/g				3.7		4.5
	Silver	µg/g	10			0.66		1.4
	Aluminum	µg/g	7			3.3		3.5
	Arsenic	µg/g	10			2.4		3.9
	Boron	µg/g	7			8.0		14.0
	Barium	µg/g	10			96.0		160.0
	Beryllium	µg/g	10			0.66		0.99
	Cadmium	µg/g	10			0.27		0.6
	Chromium	µg/g	10			8.0		13.0
	Cobalt	µg/g	7			4.7		8.2
	Copper	µg/g	7			5.9		9.0
	Iron	µg/g	7			1.2		1.6

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
Perimeter (used for both Los Alamos County Resident and Non-Los Alamos County Resident) (cont.)	Mercury	µg/g	10			0.03		0.05
	Manganese	µg/g	7			380.0		650.0
	Molybdenum	µg/g	7			0.68		0.85
	Nickel	µg/g	10			5.5		8.6
	Lead	µg/g	10			19.0		36.0
	Antimony	µg/g	7			0.14		0.17
	Selenium	µg/g	10			0.34		0.64
	Tin	µg/g	7			7.7		10.0
	Strontium	µg/g	7			23.0		36.0
	Thallium	µg/g	7			0.68		1.7
	Vanadium	µg/g	7			15.0		29.0
	Zinc	µg/g	7			33.0		49.0
Regional	Tritium	pCi/ml				-0.1		0.36
	Cesium-137	pCi/g				0.28		0.54
	Plutonium-238	pCi/g				0.004		0.008
	Plutonium-239, Plutonium-240	pCi/g				0.011		0.019
	Strontium-90	pCi/g				0.3		0.44
	Uranium	µg/g				1.9		2.7
	Americium-241	pCi/g				0.006		0.008
	Gross Alpha	pCi/g				4.8		7.2
	Gross Beta	pCi/g				4.5		5.9
	Gross Gamma	pCi/g				2.8		3.6
	Silver	µg/g	6			1.1		2.1
	Aluminum	µg/g	6			2.9		3.7
	Arsenic	µg/g	6			3.1		6.1
	Boron	µg/g	6			12.0		17.0
	Barium	µg/g	6			130.0		190.0

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
Regional (cont.)	Beryllium	µg/g	6			0.49		0.74
	Cadmium	µg/g	6			0.2		0.2
	Chromium	µg/g	6			10.0		15.0
	Cobalt	µg/g	6			4.8		6.7
	Copper	µg/g	6			7.8		11.0
	Iron	µg/g	6			1.5		2.2
	Mercury	µg/g	6			0.02		0.02
	Manganese	µg/g	6			280.0		420.0
	Molybdenum	µg/g	6			0.63		0.79
	Nickel	µg/g	6			8.0		11.0
	Lead	µg/g	6			11.0		14.0
	Antimony	µg/g	6			0.14		0.2
	Selenium	µg/g	6			0.38		0.62
	Tin	µg/g	6			11.0		16.0
	Strontium	µg/g	6			89.0		260.0
	Thallium	µg/g	6			0.3		0.84
	Vanadium	µg/g	6			26.0		40.0
	Zinc	µg/g	6			34.0		49.0

[a] On-site, perimeter and regional designations in accordance with Environmental Surveillance Program.
[b] pCi/g is picocuries per gram, pCi/ml is picocuries per milliliter, µg/g is micrograms per gram.
[c] Number of detected analyses not available. Values represent the number of means (from Fresquez et al. 1997).
[d] Number of analyses not available.
[e] Minimum and maximum values not available.
[f] Values are means for radiochemical constituents and mean of means for trace metal constituents.

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
Los Alamos County Resident	Elk (Muscle)	Cesium-137	pCi/g dry	5	5	0.0118	0.21	0.504	0.63
	Elk (Muscle)	Uranium	µg/g dry	3	5	0.0005	0.0016	0.0022	0.0035
	Fruit	Cesium-137	pCi/g dry	19	31	0.0076	0.12	0.6427	0.49
	Fruit	Tritium	nCi/l	27	31	0.2	2.1	16	9.1
	Fruit	Plutonium-238	pCi/g dry	15	31	0.000056	0.00032	0.001231	0.00097
	Fruit	Plutonium-239	pCi/g dry	22	31	0.00003	0.0013	0.020374	0.0099
	Fruit	Strontium-90	pCi/g dry	25	25	0.0069	0.042	0.1647	0.12
	Fruit	Uranium	µg/g dry	30	30	0.0006	0.012	0.08278	0.045
	Honey	Tritium	nCi/l	4	4	0.2	10.0	37.3	46.0
	Milk	Cesium-137	pCi/l	1	1	2.41	2.4	2.41	
	Milk	Iodine-131	pCi/l	1	1	10	10.0	10	
	Milk	Uranium	µg/l	1	1	0.1	0.1	0.1	
	Vegetable	Cesium-137	pCi/g dry	27	45	0.0031	0.13	0.7328	0.44
	Vegetable	Tritium	nCi/l	41	45	0.1	0.52	1.3	1.1
	Vegetable	Plutonium-238	pCi/g dry	29	45	0.000015	0.00021	0.00098	0.00065
	Vegetable	Plutonium-239	pCi/g dry	33	45	0.000023	0.00083	0.0196	0.0076
	Vegetable	Strontium-90	pCi/g dry	36	36	0.0053	0.064	0.855	0.34
	Vegetable	Uranium	µg/g dry	43	45	0.00026	0.0042	0.02085	0.011
Non-Los Alamos County Resident	Elk (Muscle)	Cesium-137	pCi/g dry	6	8	0.0113	0.12	0.2504	0.3
	Elk (Muscle)	Tritium	nCi/l	3	3	0.1	1.8	4.7	6.9
	Elk (Muscle)	Plutonium-238	pCi/g dry	1	8	0.00002	0.00002	0.00002	
	Elk (Muscle)	Plutonium-239	pCi/g dry	4	8	0.00002	0.000086	0.000252	0.00031
	Elk (Muscle)	Strontium-90	pCi/g dry	3	8	0.0042	0.0072	0.0126	0.017
	Elk (Muscle)	Uranium	µg/g dry	4	7	0.0001	0.0028	0.0086	0.011
	Fish (Game)	Cesium-137	pCi/g dry	4	5	0.006	0.093	0.203	0.28
	Fish (Game)	Plutonium-238	pCi/g dry	5	5	0.00003	0.000049	0.00008	0.000088
	Fish (Game)	Plutonium-239	pCi/g dry	4	5	0.00004	0.000062	0.00009	0.00011
	Fish (Game)	Strontium-90	pCi/g dry	5	5	0.041	0.072	0.092	0.11

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
Non-Los Alamos County Resident (cont.)	Fish (Game)	Uranium	µg/g dry	5	5	0.0048	0.0054	0.00664	0.0069
	Fish (Nongame)	Cesium-137	pCi/g dry	5	5	0.001	0.059	0.178	0.22
	Fish (Nongame)	Plutonium-238	pCi/g dry	4	5	0.00003	0.000047	0.000076	0.000087
	Fish (Nongame)	Plutonium-239	pCi/g dry	3	5	0.00002	0.000044	0.00006	0.000087
	Fish (Nongame)	Strontium-90	pCi/g dry	5	5	0.015	0.026	0.049	0.057
	Fish (Nongame)	Uranium	µg/g dry	5	5	0.0059	0.011	0.02042	0.022
	Fruit	Cesium-137	pCi/g dry	8	12	0.007	0.058	0.1588	0.18
	Fruit	Tritium	nCi/l	5	11	0.1	0.28	0.7	0.76
	Fruit	Plutonium-238	pCi/g dry	6	11	0.000058	0.000098	0.000205	0.00021
	Fruit	Plutonium-239	pCi/g dry	8	12	0.000019	0.00034	0.002132	0.0018
	Fruit	Strontium-90	pCi/g dry	9	11	0.0026	0.023	0.0896	0.084
	Fruit	Uranium	µg/g dry	12	12	0.0007	0.003	0.00788	0.0078
	Honey	Tritium	nCi/l	6	9	0.1	0.38	0.7	0.79
	Milk	Cesium-137	pCi/l	1	1	3.1	3.1	3.1	
	Milk	Tritium	nCi/l	1	1	0.1	0.1	0.1	
	Milk	Iodine-131	pCi/l	1	1	4.7	4.7	4.7	
	Milk	Plutonium-238	pCi/l	1	1	0.003	0.003	0.003	
	Milk	Uranium	µg/l	1	1	0.24	0.24	0.24	
	Vegetable	Cesium-137	pCi/g dry	11	13	0.0119	0.46	2.484	2.0
	Vegetable	Tritium	nCi/l	9	13	0.1	0.53	1	1.1
	Vegetable	Plutonium-238	pCi/g dry	6	13	0.000025	0.001	0.0024	0.0028
	Vegetable	Plutonium-239	pCi/g dry	10	13	0.000036	0.00025	0.000959	0.00079
	Vegetable	Strontium-90	pCi/g dry	11	11	0.0252	0.12	0.2898	0.28
	Vegetable	Uranium	µg/g dry	13	13	0.00066	0.046	0.27489	0.2
On-Site, No Receptor	Fruit	Cesium-137	pCi/g dry	11	27	0.0004	0.061	0.2427	0.21
	Fruit	Tritium	nCi/l	25	27	0.1	2.2	8.9	7.0
	Fruit	Plutonium-238	pCi/g dry	14	26	0.000025	0.00017	0.000778	0.00055
	Fruit	Plutonium-239	pCi/g dry	17	27	0.00005	0.00018	0.000488	0.00043
	Fruit	Strontium-90	pCi/g dry	20	21	0.005	0.044	0.1344	0.12

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
On-Site, No Receptor (cont.)	Fruit	Uranium	µg/g dry	27	27	0.00027	0.011	0.0394	0.034
	Honey	Tritium	nCi/l	49	54	0.1	62.0	1300	460.0
	Vegetable	Cesium-137	pCi/g dry	4	10	0.0014	0.0042	0.0092	0.011
	Vegetable	Tritium	nCi/l	10	10	0.1	0.78	2.7	2.6
	Vegetable	Plutonium-238	pCi/g dry	5	10	0.000047	0.00023	0.000363	0.00055
	Vegetable	Plutonium-239	pCi/g dry	8	10	0.000044	0.00029	0.000678	0.00079
	Vegetable	Strontium-90	pCi/g dry	9	10	0.0154	0.038	0.059	0.065
	Vegetable	Uranium	µg/g dry	10	10	0.00132	0.0036	0.00655	0.0074
Regional	Fish (Game)	Cesium-137	pCi/g dry	5	5	0.001	0.046	0.108	0.15
	Fish (Game)	Plutonium-238	pCi/g dry	3	5	0.00002	0.000032	0.000045	0.000057
	Fish (Game)	Plutonium-239	pCi/g dry	4	5	0.00003	0.000068	0.00014	0.00017
	Fish (Game)	Strontium-90	pCi/g dry	5	5	0.01	0.043	0.116	0.13
	Fish (Game)	Uranium	µg/g dry	5	5	0.00091	0.0021	0.0033	0.0043
	Fish (Nongame)	Cesium-137	pCi/g dry	5	5	0.008	0.11	0.268	0.31
	Fish (Nongame)	Plutonium-238	pCi/g dry	5	5	0.00001	0.000041	0.000076	0.00009
	Fish (Nongame)	Plutonium-239	pCi/g dry	4	5	0.000029	0.000067	0.00018	0.00022
	Fish (Nongame)	Strontium-90	pCi/g dry	5	5	0.026	0.038	0.047	0.056
	Fish (Nongame)	Uranium	µg/g dry	5	5	0.0043	0.0057	0.00748	0.0082
	Fruit	Cesium-137	pCi/g dry	22	45	0.0005	0.075	0.374	0.27
	Fruit	Tritium	nCi/l	27	44	0.1	0.41	1	0.93
	Fruit	Plutonium-238	pCi/g dry	21	45	0.000023	0.00016	0.0005	0.00041
	Fruit	Plutonium-239	pCi/g dry	32	45	0.000023	0.00017	0.00117	0.00065
	Fruit	Strontium-90	pCi/g dry	32	34	0.0019	0.026	0.0798	0.073
	Fruit	Uranium	µg/g dry	45	45	0.00052	0.011	0.08295	0.041
	Honey	Tritium	nCi/l	2	5	0.2	0.25	0.3	0.39
	Vegetable	Cesium-137	pCi/g dry	44	59	0.0004	0.12	0.4133	0.35
	Vegetable	Tritium	nCi/l	44	58	0.1	0.35	0.9	0.79
	Vegetable	Plutonium-238	pCi/g dry	21	58	0.00001	0.00016	0.000492	0.00042
	Vegetable	Plutonium-239	pCi/g dry	32	59	0.00001	0.00025	0.002394	0.0012

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
Regional (cont.)	Vegetable	Strontium-90	pCi/g dry	43	45	0.003	0.038	0.1592	0.11
	Vegetable	Uranium	µg/g dry	58	59	0.0003	0.0089	0.03991	0.027

[a] pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight, nCi/l is nanocuries per liter, and µg/l is micrograms per liter.
[b] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE D.3.5–7.—*Free-Range Steer Muscle Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data for 1996)*

LOCATION	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Perimeter	Tritium	nCi/l				-0.4		0.2
San Ildefonso (used for Non-Los Alamos County Resident)	Strontium-90	pCi/g dry				0.011		0.026
	Plutonium-238	pCi/g dry				0.0		0.00003
	Plutonium-239	pCi/g dry				0.000074		0.00015
	Cesium-137	pCi/g dry				0.014		0.021
	Americium-241	pCi/g dry				0.000037		0.000067
	Uranium	µg/g dry				0.0015		0.0018

[a] nCi/l is nanocuries per liter, pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–8.—*Deer Muscle Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data for 1996)*

LOCATION	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
On-Site (Non-Los Alamos County Resident)	Tritium	nCi/l				0.36		0.99
	Strontium-90	pCi/g dry				-0.0023		0.023
	Plutonium-238	pCi/g dry				0.000012		0.00005
	Plutonium-239	pCi/g dry				0.000016		0.000056
	Cesium-137	pCi/g dry				0.11		0.5
	Americium-241	pCi/g dry				0.000023		0.000079
	Uranium	µg/g dry				0.7		0.7
Regional (Los Alamos County Resident)	Tritium	nCi/l				0.15		0.86
	Strontium-90	pCi/g dry				0.01		0.038
	Plutonium-238	pCi/g dry				-0.000025		0.000046
	Plutonium-239	pCi/g dry				0.00005		0.00019
	Cesium-137	pCi/g dry				0.018		0.027
	Americium-241	pCi/g dry				0.0		0.0
	Uranium	µg/g dry				0.00075		0.0015

[a] nCi/l is nanocuries per liter, pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–9.—*Analysis of Fish Used in Consequence Analysis (ESH–20 Foodstuffs Database, 1990 to 1994)*

ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL
Cesium-137	pCi/g dry	19	20	0.001	0.075	0.268	.024
Plutonium-238	pCi/g dry	17	20	0.00001	0.000043	0.00008	0.000082
Plutonium-239	pCi/g dry	15	20	0.00002	0.000061	0.00018	0.00015
Strontium-90	pCi/g dry	20	20	0.01	0.045	0.116	0.1
Uranium	µg/g dry	20	20	0.00091	0.0061	0.02042	0.015

[a] pCi/g dry is picocuries per gram dry weight, and µg/g dry is micrograms per gram dry weight.

TABLE D.3.5–10.—*Bottom-Feeding Fish Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*

RECEPTOR[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
Non-Los Alamos County Resident	Silver	µg/g wet				0.13		0.13
	Arsenic	µg/g wet				0.25		0.25
	Barium	µg/g wet				0.063		0.063
	Beryllium	µg/g wet				0.053		0.053
	Cadmium	µg/g wet				0.11		0.11
	Chromium	µg/g wet				0.63		0.63
	Copper	µg/g wet				0.82		0.82
	Mercury	µg/g wet				0.34		0.34
	Nickel	µg/g wet				1.1		1.1
	Lead	µg/g wet				1.3		1.3
	Antimony	µg/g wet				1.3		1.3
	Selenium	µg/g wet				0.28		0.28
	Thallium	µg/g wet				1.3		1.3
	Zinc	µg/g wet				5.8		9.1

[a] Data from Abiquiu, Heron, and El Vado.
[b] µg/g wet is micrograms per gram wet.
[c] Number of detected analyses not available.
[d] Number of analyses not available.
[e] Minimum and maximum values not available.
[f] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–11.—*Produce Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Los Alamos County Resident	Fruit	Silver	µg/g dry		2	0.27	0.43	0.58	0.86
		Arsenic	µg/g dry		2	0.1	0.1	0.1	0.1
		Barium	µg/g dry		2	1.91	2.1	2.27	2.6
		Beryllium	µg/g dry		2	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		2	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		2	0.5	1.0	1.51	2.4
		Mercury	µg/g dry		2	0.05	0.05	0.05	0.05
		Nickel	µg/g dry		2	2.76	3.9	5.09	7.2
		Lead	µg/g dry		2	2.8	3.1	3.3	3.8
		Antimony	µg/g dry		2	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		2	0.1	0.1	0.1	0.1
		Thallium	µg/g dry		2	0.15	0.15	0.15	0.15
	Vegetable	Silver	µg/g dry		12	0.27	0.32	0.56	0.54
		Arsenic	µg/g dry		12	0.1	0.1	0.1	0.1
		Barium	µg/g dry		12	0.26	10.0	27.7	25.0
		Beryllium	µg/g dry		12	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		12	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		12	0.13	0.7	3.09	2.5
		Mercury	µg/g dry		12	0.05	0.05	0.05	0.05
		Nickel	µg/g dry		12	1.36	5.6	17	17.0
		Lead	µg/g dry		12	0.6	8.7	48	39.0
		Antimony	µg/g dry		12	0.15	0.19	0.4	0.39
		Selenium	µg/g dry		12	0.1	0.22	0.4	0.44
		Thallium	µg/g dry		12	0.15	0.15	0.15	0.15

TABLE D.3.5–11.—*Produce Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Non-Los Alamos County Resident	Vegetable	Silver	µg/g dry		5	0.16	0.16	0.16	0.16
		Arsenic	µg/g dry		5	0.15	0.2	0.4	0.42
		Barium	µg/g dry		5	0.82	13.0	29.9	36.0
		Beryllium	µg/g dry		5	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		5	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		5	0.08	0.17	0.4	0.46
		Mercury	µg/g dry		5	0.05	0.06	0.1	0.1
		Nickel	µg/g dry		5	0.36	1.2	3.6	4.1
		Lead	µg/g dry		5	1	6.8	27.1	30.0
		Antimony	µg/g dry		5	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		5	0.1	0.34	0.7	0.78
		Thallium	µg/g dry		5	0.15	0.15	0.15	0.15
On-Site, No Receptor	Fruit	Silver	µg/g dry		6	0.16	0.16	0.16	0.16
		Arsenic	µg/g dry		6	0.1	0.17	0.5	0.49
		Barium	µg/g dry		6	2.49	6.7	16.7	17.0
		Beryllium	µg/g dry		6	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		6	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		6	0.08	0.1	0.22	0.22
		Mercury	µg/g dry		6	0.05	0.067	0.1	0.12
		Nickel	µg/g dry		6	0.36	0.86	1.43	1.7
		Lead	µg/g dry		6	2.9	7.0	12.6	15.0
		Antimony	µg/g dry		6	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		6	0.1	0.15	0.3	0.32
		Thallium	µg/g dry		6	0.15	0.15	0.15	0.15

TABLE D.3.5–11.—*Produce Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Regional	Vegetable	Silver	µg/g dry		13	0.16	0.24	0.58	0.47
		Arsenic	µg/g dry		13	0.1	0.18	1.1	0.73
		Barium	µg/g dry		13	0.35	6.0	18.4	17.0
		Beryllium	µg/g dry		13	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		13	0.12	0.14	0.32	0.25
		Chromium	µg/g dry		13	0.13	1.0	4.35	4.0
		Mercury	µg/g dry		13	0.05	0.054	0.1	0.082
		Nickel	µg/g dry		13	0.36	6.5	28.6	25.0
		Lead	µg/g dry		13	1.1	8.4	26.4	28.0
		Antimony	µg/g dry		13	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		13	0.1	0.22	0.4	0.44
		Thallium	µg/g dry		13	0.15	0.15	0.15	0.15

[a] µg/g dry is micrograms per gram dry weight.
[b] Number of detected analyses not available. The dataset included substituted values in place of nondetects, and then all analyses were used in calculating the summary statistics.
[c] Data are 1996 surveillance data.

TABLE D.3.5–12.—*Bottom-Feeding Fish Regional Statistic Reference Levels Used in Consequence Analysis (ESH-20 Data, 1996)*

RECEPTOR	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN	MAXIMUM	95% UCL[e]
Special Pathway	Silver	µg/g wet						1.2
	Arsenic	µg/g wet						0.4
	Barium	µg/g wet						1.2
	Beryllium	µg/g wet						1.3
	Cadmium	µg/g wet						0.3
	Chromium	µg/g wet						1.5
	Copper	µg/g wet						1.4
	Mercury	µg/g wet						0.4
	Nickel	µg/g wet						1.5
	Lead	µg/g wet						4.0
	Antimony	µg/g wet						2.1
	Selenium	µg/g wet						0.4
	Thallium	µg/g wet						2.1
	Zinc	µg/g wet						6.6

[a] µg/g wet is micrograms per gram wet.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum, maximum, and mean values not available.
[e] Upper confidence limit, given as the regional statistical reference level, was obtained from 1996 surveillance data. The calculations includes negative and zero values.

TABLE D.3.5–13.—*Elk Tissue Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data for 1991 to 1993)*

LOCATION	TISSUE	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
On-Site (No Receptor)	Heart	Cesium-137	pCi/g dry				0.041		0.12
		Plutonium-238	pCi/g dry				0.00005		0.00017
		Plutonium-239	pCi/g dry				0.000023		0.000065
		Strontium-90	pCi/g dry				0.002		0.009
		Uranium	µg/g dry				0.0007		0.0041
	Liver	Cesium-137	pCi/g dry				0.17		0.49
		Plutonium-238	pCi/g dry				0.000013		0.000059
		Plutonium-239	pCi/g dry				0.000033		0.000095
		Strontium-90	pCi/g dry				0.004		0.012
		Uranium	µg/g dry				0.0046		0.017
Regional (Special Pathways)	Heart	Cesium-137	pCi/g dry				0.058		0.068
		Plutonium-238	pCi/g dry				0.0		0.0
		Plutonium-239	pCi/g dry				0.00015		0.00066
		Strontium-90	pCi/g dry				0.0023		0.0065
		Uranium	µg/g dry				0.011		0.049
	Liver	Cesium-137	pCi/g dry				0.22		0.6
		Plutonium-238	pCi/g dry				0.000017		0.000075
		Plutonium-239	pCi/g dry				0.000033		0.000095
		Strontium-90	pCi/g dry				0.003		0.0082
		Uranium	µg/g dry				0.0052		0.023

[a] pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from Frequez et al. 1994. The calculation of mean values may include negative and zero values in their calculation.

TABLE D.3.5–14.—*Navajo Tea (Cota) Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*

LOCATION	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Perimeter San Ildefonso (Special Pathway)	Tritium	nCi/l				-0.11		0.16
	Strontium-90	pCi/l				0.4		1.2
	Plutonium-238	pCi/l				0.018		0.028
	Plutonium-239	pCi/l				0.011		0.022
	Cesium-137	pCi/l				18.0		53.0
	Americium-241	pCi/l				0.015		0.073
	Uranium	µg/l				0.75		0.91

[a] nCi/l is nanocuries per liter, pCi/l is picocuries per liter, µg/l is micrograms per liter.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–15.—*Edible Portions of Beans, Corn, and Squash Used in Consequence Analysis (ESH-20 Data, 1996)*

LOCATION	FOODSTUFF	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
On-Site (Special Pathway)	Vegetables	Tritium	nCi/l				0.9		1.3
		Cesium-137	pCi/g dry				3.0		5.5
		Strontium-90	pCi/g dry				11.0		14.0
		Plutonium-238	pCi/g dry				0.000056		0.00022
		Plutonium-239	pCi/g dry				0.00032		0.0006
		Americium-241	pCi/g dry				0.00077		0.0013
		Uranium	µg/g dry				0.002		0.0044
		Arsenic	µg/g dry				0.14		0.34
		Cadmium	µg/g dry				0.15		0.22
		Chromium	µg/g dry				0.16		0.5
		Mercury	µg/g dry				0.05		0.05
		Lead	µg/g dry				7.5		9.4
		Antimony	µg/g dry				0.15		0.15
		Zinc	µg/g dry				47.0		71.0
Regional	Vegetables	Tritium	nCi/l				0.03		0.66
		Cesium-137	pCi/g dry				0.021		0.069
		Strontium-90	pCi/g dry				0.038		0.06
		Plutonium-238	pCi/g dry				0.000019		0.000097
		Plutonium-239	pCi/g dry				0.000054		0.00013
		Americium-241	pCi/g dry				0.00013		0.00025
		Uranium	µg/g dry				0.0034		0.0042
		Arsenic	µg/g dry				0.1		0.1
		Cadmium	µg/g dry				0.12		0.12
		Chromium	µg/g dry				0.08		0.08
		Mercury	µg/g dry				0.05		0.05
		Lead	µg/g dry				4.6		7.6
		Antimony	µg/g dry				0.15		0.15
		Zinc	µg/g dry				31.0		51.0

TABLE D.3.5–15.—*Edible Portions of Beans, Corn, and Squash Used in Consequence Analysis (ESH-20 Data, 1996)*-Continued

[a] nCi/l is nanocuries per liter, pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from Frequez et al. 1997. The calculation of mean values includes negative and zero values.

TABLE D.3.5–16.—*Analysis of Pinyon Nuts Used in Consequence Analysis (Salazar 1979)*

RECEPTOR[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Special Pathways	Beryllium-7	pCi/g dry	6	6	0.005	0.013	0.024	0.028
	Cesium-137	pCi/g dry	6	6	0.003	0.0092	0.019	0.024
	Tritium	nCi/l	5	5	5.6	13.0	24.2	28.0
	Plutonium-239	pCi/g dry	4	6	0.007	0.068	0.22	0.27
	Strontium-90	pCi/g dry	6	6	0.01	0.33	0.84	0.92
	Uranium	µg/g dry	6	6	0.05	0.21	0.79	0.78
Non-Los Alamos County Resident	Beryllium-7	pCi/g dry	NA	NA	NA	0.023	NA	0.14
	Cesium 137	pCi/g dry	NA	NA	NA	0.004	NA	0.02
	Tritium	nCi/l	NA	NA	NA	4.9	NA	5.7
	Plutonium-238	pCi/g dry	NA	NA	NA	0.007	NA	0.017
	Plutonium-239	pCi/g dry	NA	NA	NA	0.003	NA	0.013
	Strontium-90	pCi/g dry	NA	NA	NA	0.17	NA	0.23
	Uranium	µg/g dry	NA	NA	NA	0.08	NA	0.08

[a] Special pathway receptor data is from on-site locations (TA–15, TA–18, TA–21/53, TA–49, TA–52, and TA–54). Non-Los Alamos County Resident data is from regional locations (Nambe, Santa Fe, and Abiquiu).
[b] pCi/g dry is picocuries per gram dry weight, nCi/l is nanocuries per liter, and µg/g dry is micrograms per gram dry weight.
[c] Upper Confidence Limits (UCL) calculated as the mean plus two standard deviations.
NA = Not available

REFERENCES

ACGIH 1997 — "Beryllium and Compounds," 1997 Supplement, Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th Edition. American Conference of Governmental Industrial Hygienists. Cincinnati, Ohio. 1997.

Athas 1996 — *Investigation of Excess Thyroid Cancer Incidence in Los Alamos*. W. F. Athas. New Mexico Department of Health. April 1996.

Athas and Key 1993 — *Cancer Incidence in Los Alamos County, 1970-1990,* Final Report—*Los Alamos Cancer Rate Study: Phase I*. W. F. Athas and C. R. Key. New Mexico Department of Health. Santa Fe, New Mexico. March 1993.

ATSDR 1989 — *Arsenic*. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registering. Available on-line at: http://www.enznetinc.net/users/ themissinglink/Arsenic.htm.

ATSDR 1993 — *Toxic Substances: Beryllium.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registering. Available on-line at: http://www. enznetinc.net/users/themissinglink/ beryllium.htm.

BEIR V 1990 — *Health Effects of Exposures to Low Levels of Ionizing Radiation.* National Research Council, Committee on the Biological Effects of Ionizing Radiation. National Academy Press. Washington, D.C. 1990.

Bork 1987 — *Natural Resources Defense Council vs. U.S. Environmental Protection Agency*. Opinion, Bork, Circuit Judge. 263 U.S. Appeals, D.C. 166. Decided July 28, 1987.

Calder 1984 — *Size, Function, and Life History*. William Calder. Harvard College. Boston Massachusetts. 1984.

Cember 1996 — *Introduction to Health Physics*, 3d ed. Herman Cember. McGraw-Hill. New York, New York. 1996.

CLAWS 1997 — *Arsenic*. City of Los Angeles Water Services. Available on-line at: http://www.dwp.ci.la.ca.us/ water/quality/wq-arsnc.htm.

DOC 1990 — *1990 Census of Population: Social and Economic Characteristics, New Mexico*. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1990.

EPA 1989 — *Exposure Factors Handbook*. U.S. Environmental Protection Agency. Washington, D.C. 1989.

EPA 1990 — *Protection of Environment*. 40 CFR 300.430. U.S. Environmental Protection Agency. July 1, 1990.

EPA 1992 — *User's Guide for CAP–88 PC.* U.S. Environmental Protection Agency, Air and Radiation Office. 402-B-92-001. Washington, D.C. 1992.

EPA 1997a — *Exposure Factors Handbook*. U.S. Environmental Protection Agency. Washington, D.C. 1997.

EPA 1997b — *Integrated Risk Information System (IRIS) Data Base.* U.S. Environmental Protection Agency, Office of Research and Development. Washington, D.C. 1997.

ESR Data — See individual entries for LANL Environmental Surveillance Reports: LANL 1992 (1990 ESR), LANL 1993 (1991 ESR), LANL 1994 (1992 ESR), LANL 1995 (1993 ESR), LANL 1996a (1994 ESR), LANL 1996b (1995 ESR), LANL 1997 (1996 ESR).

Foodstuffs Database — Data on Food Consumption, obtained from LANL ESH-20 database.

Fresquez et al. 1994 — *Radionuclide Concentrations in Elk that Winter on Los Alamos National Laboratory Lands.* P. R. Fresquez, D. R. Armstrong, and J. G. Salazar. Los Alamos National Laboratory. LA-12795-MS. Los Alamos, New Mexico. 1995.

Fresquez et al. 1996 — *Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons.* P. R. Fresquez, M. A. Mullen, J. K. Ferenbaugh, and R. A. Perona. Los Alamos National Laboratory. LA-13149-MS. Los Alamos, New Mexico. April 1996.

Fresquez et al. 1997 — *Radionuclide Concentrations in Pinto Beans, Sweet Corn, and Zucchini Squash Grown in Los Alamos Canyon at Los Alamos National Laboratory.* P. R. Fresquez, D. R. Armstrong, M. A. Mullen, and L. Narranjo, Jr. Los Alamos National Laboratory. LA-13304-MS. Los Alamos, New Mexico.

Fresquez and Ferenbaugh 1998 — *Moisture Conversion Ratios for the Foodstuffs and Biota Environmental Surveillance Programs at Los Alamos National Laboratory*. P. R. Fresquez and J. K. Ferenbaugh. Los Alamos National Laboratory. LA-UR-98-1054. Los Alamos, New Mexico. March 1998.

ICRP 1991 — "1990 Recommendations of the International Commission on Radiological Protection." Publication 60, Volume 21, No. 1-3. *Annals of the ICRP*. Pergamon Press. New York, New York. 1991.

LANL 1992 — *Environmental Surveillance at Los Alamos During 1990*. Los Alamos National Laboratory. LA-12271-M8. UC-1990. Los Alamos, New Mexico. March 1992.

LANL 1993 — *Environmental Surveillance at Los Alamos During 1991.* Los Alamos National Laboratory. LA-12572-ENV, UC-902. Los Alamos, New Mexico. August 1993.

LANL 1994 — *Environmental Surveillance at Los Alamos During 1992.* Los Alamos National Laboratory. LA-12764-MS, UC-902. Los Alamos, New Mexico. July 1994.

LANL 1995 — *Environmental Surveillance at Los Alamos During 1993.* Los Alamos National Laboratory. LA-12973-ENV, UC-902. Los Alamos, New Mexico. October 1995.

LANL 1996a — *Environmental Surveillance at Los Alamos during 1994.* Los Alamos National Laboratory, Environmental Assessments and Resource Evaluations Group. LA-13047-ENV. Los Alamos, New Mexico. July 1996.

LANL 1996b — *Environmental Surveillance at Los Alamos During 1995.* Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.

LANL 1997 — *Environmental Surveillance and Compliance at Los Alamos During 1996.* Los Alamos National Laboratory. LA-13343-ENV. Los Alamos, New Mexico.

Miller et al. 1996 — *Racial/Ethic Patterns of Cancer in the United States 1988–1992.* B. A. Miller, L. N. Kolonel, L. Bernstein, J. L. Young, Jr., G. M. Swanson, D. West, C. R. Key, J. M. Liff, C. S. Glover, G. A. Alexander, et al. (eds). National Cancer Institute. NIH Pub. No. 96-4104. Bethesda, Maryland. 1996.

NBS 1952 — *Radiological Monitoring Methods and Instruments.* National Bureau of Standards Handbook #51. April 1952.

NCRP 1981 — *Radiofrequency Electromagnetic Fields–Properties, Quantities and Units, Biophysical Interaction, and Measurements.* National Council on Radiation Protection. NCRP Report No. 67. Bethesda, Maryland. 1981.

NCRP 1986 — *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields.* National Council on Radiation Protection and Measurements. NCRP Report No. 86. Bethesda, Maryland. 1986.

NCRP 1987 — *Exposure of the Population in the United States and Canada from Natural Background Radiation*. Recommendations of the National Council on Radiation Protection and Measurements. NCRP Report No. 94. Bethesda, Maryland. December 1987.

NCRP 1989 — *Comparative Carcinogenicity of Ionizing Radiation and Chemicals*. National Council on Radiation Protection and Measurements. NCRP Report No. 96. March 1, 1989.

NCRP 1993 — *A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields.* National Council on Radiation Protection. NCRP Report No. 119. Bethesda, Maryland. December 31, 1993.

NPDES Data — Data on Water Quality, obtained from the LANL Water Quality and Hydrology Group (ESH-18) NPDES Chemical Database. Only 1994–1996 data available currently.

OSHA 1997 — "Quantitative Risk Assessment." Occupational Safety and Health Administration. *Federal Register*, Vol. 62, No. 7, pp. 1516–1563. January 10, 1997.

Ries et al. 1996 — *SEER Cancer Statistics Review*, 1973-1993, tables and graphs. L. A. G. Ries, C. L. Kosary, B. F. Hankey, A. Harras, B. A. Miller, and B. K. Edwards (eds.). National Institute of Health/National Cancer Institute. Bethesda, Maryland. 1996.

Robinson and Thomas 1991 — *Time Spent in Activities, Locations and Microenvironments: A California-National Comparison Project Report.* J. P. Robinson and J. Thomas. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory. Las Vegas, Nevada. 1991.

Salazar 1979 — *Radionuclide Content of Pinyon Nuts in the Vicinity of the Los Alamos Scientific Laboratory.* J. G. Salazar. Los Alamos Scientific Laboratory. LA-UR-79-238. Los Alamos, New Mexico. 1979.

APPENDIX E
CULTURAL RESOURCES

E.1 OVERVIEW

This appendix provides supplemental information regarding the prehistoric and historic cultural resources present at LANL, including traditional cultural properties (TCP), that may be affected by ongoing and proposed LANL operations. Cultural resources are any prehistoric or historic sites, buildings, structures, districts, or other places or objects (including biota of importance) considered to be important to a culture, subculture, or community for scientific, traditional, or religious purposes, or for any other reason. While not all cultural resources need to be preserved, those with cultural significance require identification and protection so that future generations may be informed and enriched by the past.

In section E.2, information is presented regarding the results of previous cultural resource research in the LANL region. Section E.3 provides a summary of the background of the LANL region that led to a classification system developed for LANL, based on the regional cultural context of prehistoric and historic development on the Pajarito Plateau and the traditional cultures of the region. Section E.4 contains an overview of the major federal and state regulatory requirements concerning cultural resources. Section E.5 contains information regarding the research methods employed to identify, document, and assess the cultural resources likely to be affected by LANL operations. Detailed information is provided in section E.6 on the existing cultural resources that are protected by the *National Historic Preservation Act* (NHPA) (16 U.S.C. §470). Section E.7 is a list of references used in conducting this assessment and preparing this report.

Cultural resources are location-specific; therefore, the cultural resource study area is defined as the area within LANL's physical boundaries and those areas surrounding LANL that may be potentially affected by LANL activities. A broader study area has been defined for the identification and assessment of TCPs, because the TCP evaluation includes an assessment of historical use and value placed on cultural resources by existing cultural groups with current or ancestral ties to the LANL region, irrespective of their current locations.

E.2 PREVIOUS STUDY OF CULTURAL RESOURCES IN THE LANL REGION

The following subsections contain a history and summaries of previous studies of cultural resources in the LANL region.

E.2.1 Studies of Prehistoric Resources

The Pajarito Plateau is among the most intensively studied archaeological regions in the U.S. due in part to the density of archaeological sites. Archaeological study began in 1880 when Adolph Bandelier visited the Puye ruins and Rito de los Frijoles, measuring and taking notes on the ruins (Bandelier 1892). A survey of the Pajarito Plateau was made by Edgar Lee Hewett in 1896 and the results were published in 1904 (Hewett 1904). In 1916, Hewett helped establish Bandelier National Monument (BNM) as one of the first facilities in the region to protect outstanding archeological ruins (Steen 1977).

The School of American Archaeology conducted many field schools at BNM. However, no major reports resulted from these excavations (Mathien et al. 1993 and Powers and Orcutt 1988). In 1935, the National Park Service (NPS) (which controlled the land on the Pajarito Plateau outside the BNM) produced a map of 200 sites on the Ramon Vigil Grant. Other material from the survey has been lost (Mathien et al. 1993).

Archaeological investigations on the Pajarito Plateau continued after World War II at BNM (Powers 1988, Caywood 1966, and Powers and Orcutt 1988), on the Los Alamos Scientific Laboratory (LASL) (Steen 1982, Worman 1967, and Worman and Steen 1978), and on privatized land in what is now the city of Los Alamos and the community of White Rock (Maxon 1969, Hill and Trierweiler 1986, and Kohler 1989). LASL hired archaeologist F.V. Worman in 1950, and since then, regular archaeological surveys and excavations have been made prior to all construction at LASL/LANL (Mathien et al. 1993, LANL 1986–1995, Steen 1982).

LASL and LANL archaeologists have conducted hundreds of site excavations and surveys and have compiled and published numerous documents over the past 47 years. Although approximately 75 percent of LANL has been archaeologically surveyed (LANL 1995c), the number of cultural resources at LANL, the complexity of their cultural affiliations and types, and the manner in which they have been studied and recorded make systematic classification difficult. A cultural resources bibliography has been compiled for the Pajarito Plateau (Mathien et al. 1993). In addition, the resource records have been included in a relational database and many resurveys and refinements have been made to the original field data (PC 1996).

E.2.2 Studies of Historic Resources at LANL

Increased interest in the documentation and preservation of Nuclear Energy Period resources has come about since the end of the Cold War and publishing of the National Register of Historic Places (NRHP) guidance on the eligibility of resources less than 50 years old (U.S. Department of Defense [DOD] 1993 and NPS 1990). Citizens of Los Alamos County have supported historic preservation efforts that have focused on the legacy of the Manhattan Project. Survey work conducted in December of 1966 and 1968 resulted in the nomination for listing on the NRHP of the Los Alamos Historic District, including Ashley Pond, Fuller Lodge, Central Avenue LANL Administration Building, Los Alamos County Historical Museum and Archives, and other Manhattan Project properties outside the boundaries of LANL (NMHPD 1995).

While the potential significance of LANL as a site of outstanding importance in the development of nuclear energy is recognized by DOE, the State Historic Preservation Office(r) (SHPO), and the LANL Cultural Resources Management Team, comprehensive surveys have yet to be conducted for Nuclear Energy Period resources at LANL. A survey of 28 Cold War Period resources was conducted in 1995 by the LANL Cultural Resources Management Team prior to decontamination and decommissioning of buildings on the S-Site (TA–16), a critical area of high-explosive atomic research activity for the Manhattan Project. The results of this survey have been published as an Historic Building Survey Report (McGehee 1995). In the report, all 28 buildings were recommended as eligible for listing in the NRHP because of primary or secondary contributions to events of exceptional international importance. These buildings were also identified as contributing properties to a potential World War II and Cold War historic district at TA–16. According to McGehee, “A formal evaluation of the proposed district will be included in an overall evaluation and management document currently being drafted for all historic properties at LANL” (McGehee 1995).

E.2.3 Studies of Traditional Cultural Properties

Previously conducted TCP studies, identified during the course of this study, are summarized below. One problem encountered in compiling this review was a lack of comprehensive files available to researchers conducting ethnographic research in New Mexico. There is no central facility for ethnographic reports or lists of TCP sites.

In the past 5 years, as laws have changed to include protection of traditional places, several studies of TCPs have been conducted in central and northern New Mexico. In 1992, the Fence Lake Ethnographic Study was completed for the Salt River Project's proposed Fence Lake Mine in western New Mexico (Hart and Ferguson 1993). The Pueblos of Zuni and Acoma, the Hopi Tribe, and the Ramah Band of the Navajo Nation participated in this study. Information was collected through a literature study, meetings, and field work with the consulting tribes to document tribal use of the area as well as concerns revolving around proposed development. Several cultural resources significant to the consulting tribes were documented in or adjacent to the LANL region. These resources include the Zuni Salt Lake, the Zuni Salt Lake Neutral Zone, seven historic American Indian trails, numerous sacred places, ancestral homesites, ancestral graves and collection areas, prehistoric Pueblo ruins, and Cerro Prieto, a black volcanic cone. With the exception of the ancestral graves, most of these sites were recommended as eligible as a TCP for inclusion in the NRHP (Hart and Ferguson 1993).

A rapid ethnographic assessment of the Petroglyph National Monument was conducted in 1991 to 1992 to identify those American Indian tribes and Spanish heritage groups who were interested in participating in a long-term consultation process with the NPS concerning the management of the PNM (Evans et al. 1993). Once the groups were identified, cultural resource concerns were identified through letters and meetings with various tribal and Hispanic groups. Although specific cultural resource information was not made public, the consulting parties set forth several recommendations pertaining to management of the Petroglyph National Monument (Evans et al. 1993).

The Office of Contract Archeology at the University of New Mexico completed an ethnographic study of the Fort Wingate Depot Activity in 1994, as part of the closure process of the facility by the U.S. Army (Perlman 1995). The purpose of the study was to conduct a sample survey and an initial TCP assessment of sites located on the base that are of significance to the Navajo and Zuni people. This study was accomplished through a series of meetings and field work with the Church Rock, Iyanbito, and Bread Springs Chapters of the Navajo Nation and the Zuni Heritage and Historic Preservation Office. Through this TCP study and previous investigations, 24 cultural sites were identified, 15 of which were recommended for nomination to the NRHP as TCPs. Eight burials sites were identified and recommended as eligible for protection under the *Native American Graves Protection and Repatriation Act* (NAGPRA) (25 U.S.C. §3001).

American Indian concerns regarding traditional places in the Paseo del Volcan transportation corridor were documented in a study done in 1993 and 1994 as part of a project sponsored by the Federal Highway Administration and the New Mexico State Highway and Transportation Department (SWCA 1995). The purpose of the project was to identify a corridor that could be used to serve future transportation needs in the Albuquerque area. Nineteen New Mexico Pueblos, the Canoncito Navajo Chapter, the Hopi Tribe, and the Jicarilla and Mescalero Apache Tribes were initially contacted. Of this original group, ten expressed concerns about the project. Through a series of letters, meetings, and field work with these groups, concerns were identified regarding traditional use of the project area. This was only a preliminary study, and no TCPs were identified by the consulting tribes. It became apparent during the study that unless a specific corridor was selected from the alternatives, the tribal consultants would not identify specific places of concerns (SWCA 1995). The Paseo del Volcan corridor study also identified three Hispanic TCPs in the Bernalillo area, including a historic neighborhood, the location of a religious fiesta that includes Matachines dances, and a pilgrimage route (SWCA 1996a).

Three TCP studies have been completed for the U.S. Bureau of Reclamation (Reclamation). In 1995, an initial TCP study was completed of Heron and El Vado Reservoirs in Rio Arriba County (SWCA 1996b). Initial contact letters were mailed to 11 tribes and 3 parish priests in the Chama area. In response to these letters, meetings were held with two of the tribes and one parish priest. The priest also participated in a field visit to the reservoirs. In response to these letters, meetings, and field visit, four Pueblos, the Jicarilla Apache Tribe, and Hispanic communities were identified as having concerns about the protection of potential cultural resources in the area of the two reservoirs (SWCA 1996a). As funding becomes available, a more intensive TCP study will be done for these two reservoirs.

In early 1996, an initial TCP study was completed at the White Ranch Property in Saguache County, in southern Colorado (SWCA 1996c). Contact was initiated with ten tribes in an effort to determine if these groups had concerns regarding the transfer of the White Ranch parcel from Reclamation to the U.S. Department of the Interior (DOI), U.S. Fish and Wildlife Service (FWS). Through this initial consultation, which included letters and meetings, five tribes indicated that they had concerns regarding cultural resources on the parcel. Two tribes requested field visits to the study area. As a result of this initial study, several recommendations were made, mainly in the form of further consultation and field visits with consulting tribes. Because this parcel is scheduled to be transferred to the FWS, it is anticipated that additional TCP investigations will be conducted (SWCA 1996c).

From 1992 through 1995, one of the more extensive TCP studies was conducted of the Animas-La Plata Project in southwestern Colorado and northwestern New Mexico (NAU and SWCA 1996). At the conclusion, 26 American Indian tribes had become involved in a complex consultation process involving contacts by letters, telephone calls, meetings, and field work. An extensive literature review also provided valuable information to the study. Through this study, TCPs and sacred places were identified, an assessment of the project impacts on these properties and places was made, and management recommendations were provided. The potential TCPs identified in the project area were a prehistoric/historic trail, puebloan habitation and ceremonial archaeological sites, and a traditional collections area (NAU and SWCA 1996).

In July 1995, an initial TCP study was conducted of the Westland Sector Plan Property in Bernalillo County (SWCA 1996d). The client and the city of Albuquerque Planning Department identified the groups to be contacted. These groups included one Pueblo, heirs and stockholders in the Westland Development Company, and two Hispanic community organizations. Consultation took the form of contact through letters, meetings, and interviews. The results of the literature review indicated the presence of various cultural resources on the West Mesa, with the heaviest incidence of use being within the boundaries of the Petroglyph National Monument. With the exception of one land rights organization, these groups did not have concerns regarding cultural resources located within the sector.

E.3 CULTURAL BACKGROUND OF THE LANL REGION

The following subsections contain a history and summaries of previous studies of the cultural background in the LANL region.

E.3.1 Prehistoric Background of the LANL Region

Previous archaeological investigations in the vicinity of the Pajarito Plateau indicate that the area has a history dating back many thousands of years. Researchers have developed socio-historical schemes to describe the cultural periods of the region (Kidder 1927). In 1954, Fred Wendorf defined five major periods for the northern Rio Grande Valley: Preceramic, Developmental, Coalition, Classic, and Historic (Wendorf 1954). These period classifications, with some modifications, are still in use (Pratt and Scurlock 1993). The Preceramic Period has been divided into Paleo-Indian and Archaic, based upon changes in settlement patterns and subsistence over time as reflected by material culture. The Historic Period includes both American Indian sites, where people abandoned their homelands and changed their ways of life in response to Euro-American and other influences, and sites that reflect the European and American settlement of the Rio Grande Valley. A summary of these periods is presented in Table E.3.1–1. Brief discussions of the highlights of each period follow.

E.3.1.1 *Paleo-Indian Period (10,000 Through 4000 B.C.)*

By the end of the Wisconsin glacial stage, 10,000 years ago, the entire area of the North American continent, including New Mexico, was occupied by people whose subsistence was based on hunting and gathering (Willey 1966). Archaeological sites dating from this period contain bones of mammoths and bison and distinctive lanceolate projectile points, in association with a variety of stone butchering tools and lithic debitage. Paleo-Indian artifacts made of obsidian from the Jemez Mountains have been found in other parts of the Southwest (Broster 1983). Obsidian deposits were exposed in ancient landslides at higher elevations and around the margins of Valle Grande to the northwest (Powers 1988). Sites of the Paleo-Indian Period may be found in any part of LANL; however, no discoveries of Paleo-Indian remains have been made (Wolfman 1994 and LANL 1995c). Paleo-Indian materials have been reported near Cochiti; however, these were confined to surface finds of projectile points and lithic debitage (Biella 1977, Biella and Chapman 1977–1979). Because any information concerning the Paleo-Indian Period would contribute to the development of the historical context, all sites of this period are likely to be significant.

E.3.1.2 *Archaic Period (4000 B.C. Through A.D. 600)*

American Indians altered their lifestyles in response to a continuing shift of the climate toward present-day conditions at the end of the Pleistocene Period. By this period, the big game of the Pleistocene era had died out and a heavier reliance was placed on hunting and gathering. Although bison hunting continued to be important (Stuart and Gauthier 1981), small game such as deer, raccoon, turkey, and squirrel became an increasingly significant component of the diet (Larson 1991). Group movements became tied to the seasonal availability of plants. This change in subsistence was accompanied by a change in the tool assemblage, with broad-stemmed projectile points, stone knives, fish hooks, jewelry, and grinding stones becoming common. Archaic Period sites include cave and rock shelter sites, burned rock features, scatters of tools and lithic debitage, and isolated hearths. On the Pajarito Plateau, Archaic Period sites are most likely to

TABLE E.3.1–1.—*Archaeological Periods of Northern New Mexico*

TIME PERIOD	PREHISTORIC PERIOD	CHARACTERISTIC SITE TYPES
10,000 through 4000 B.C.	Paleo-Indian	• Bones of mammoth or bison • Stone butchering tools • Flakes and chips of stones from making stone tools • Distinctive lance-shaped projective points
4000 B.C. through A.D. 600	Archaic	• Caves and rock shelters • Burned rock features • Scatters of tools and stone flakes and chips • Isolated hearths • End of the Archaic period (approximately A.D. 1 to 700) may have pottery grinding stones, and charred corn
A.D. 600 through 1100	Developmental	• Ceramic storage and service vessels • Smaller projectile points reflecting the adoption of the bow and arrow • Grinding tools • Dwellings increased in size and complexity from semisubterranean pithouses to small adobe or crude masonry structures
A.D. 1100 through 1325	Coalition	• Early sites are rectangular structures of adobe and masonry with basin-shaped, abobe-lines fire pits, usually in the center of the room or against a wall • Comparatively small; pueblos average 28 rooms • Later coalition sites contain plazas and room blocks of more than 100 rooms
A.D. 1325 through 1600	Classic	• Large masonry structures of multiple-room blocks • For the Pajarito Plateau, three site clusters, one of which includes Navawi, Otowi, Tsankawi, and Tsirege • Associated one- to two-room isolated structures

Sources: Cordell 1979, Cordell 1984, LANL 1995c, Stuart and Gautheir 1981, Wendorf 1954, and Wolfman 1994.

be represented by concentrations of lithic debitage.

E.3.1.3 *Developmental Period (A.D. 600 Through 1100)*

About A.D. 600, the prehistoric occupants shifted their subsistence and settlement patterns toward a more sedentary lifestyle and intensified horticultural practices (Powers 1988), including the cultivation of maize, beans, and squash. In the LANL region, the Developmental Period has been subdivided into early and late phases (Wolfman 1994). These subdivisions appear to reflect observable trends in increased sedentary behavior and social complexity. Additional attributes of the Developmental Period include the advent of ceramic storage and service vessels, smaller projectile points, the adoption of the bow and arrow, continued use of grinding tools, and increases in size and complexity of houses. During the Early Developmental Period (A.D. 600 through 900), single family units were built in semi-subterranean pit houses. Late Developmental Period sites (A.D. 900 through 1099) were typically small adobe or crude masonry structures. Although they are scarce on the Pajarito Plateau (Wolfman 1994), sites attributable to the Developmental Period have been identified at LANL.

E.3.1.4 *Coalition Period (A.D. 1100 Through 1325)*

During the Coalition Period, the local populations coalesced into larger societal units. Subsistence was based on maize horticulture. The early sites are rectangular structures of adobe and masonry. Basin-shaped, adobe-lined fire pits are usually in the centers of the rooms, or sometimes against a wall. Circular or D-shaped semi-subterranean kivas are often in front of the room blocks (Larson 1991). Fairly small Pueblos, averaging 28 rooms, were typical of the Coalition Period (Wolfman 1994), although late Coalition Period sites are large masonry structures exhibiting plazas and room blocks of over 100 rooms (LANL 1995c). Over 700 Coalition Period ruins have been found within LANL boundaries.

E.3.1.5 *Classic Period (A.D. 1325 Through 1600)*

During the Classic Period, maize-based horticulture intensified and settlements on the Pajarito Plateau further coalesced into three main population centers. One of these site clusters consists of four sites that temporally overlapped: Navawi, Otowi, Tsankawi, and Tsirege (LANL 1995c). These sites are large masonry structures of multiple room blocks, with associated one- or two-room isolated structures. Otowi and Tsirege appear to be the ancestral sites of the Pueblo of San Ildefonso. Severe droughts in the 1500's led to abandonment of many of the Pueblos and the Pajarito Plateau. The scarcity of water and crop failures probably forced gradual relocations to more reliable water sources in the Rio Grande Valley (Sando 1992). Tree-ring dating (dendrochronology) from the Frijoles Canyon Pueblos indicates that the last roof beams were cut around 1550 (Robinson et al. 1972). The exodus probably took place over many years. At the time of the Spanish arrival in 1597, most activity had ended on the Pajarito Plateau and four Pueblos were established in the adjoining Rio Grande Valley: the Pueblos of Santa Clara, Jemez, San Ildefonso, and Cochiti.

E.3.2 Historic Background of the LANL Region

This subsection presents highlights of historic events that occurred in the LANL region.

E.3.2.1 *Spanish Colonial Period (A.D. 1600 Through 1849)*

The inhabitants of the Rio Grande Pueblos still remember their ancestral homes on the Pajarito Plateau at the time of the Spanish Conquest (Hewett and Dutton 1945). There is archaeological evidence that the abandoned canyons with their Pueblos and caves were visited for ceremonial purposes. Pictographs of horse figures exist in some kiva ruins at BNM and on canyon walls in White Rock Canyon (Kessell 1979). These may indicate that the area was occupied by a small remnant population after the Spanish occupation of the Rio Grande Valley. Game pits on the Pajarito Plateau could also date from the time of the Spanish occupation or later. The use of the area from that time forward seems to have been for occasional hunting and gathering or ceremonial use, including burials (Steen 1977). American Indian sites relating to this early Historic Period are classified as historic sites.

The Coronado expedition entered the region of the Rio Grande Pueblos in 1540. Hernando de Alvarado and his commander, Francisco Coronado, waged intermittent battles with individual Pueblos for food and supplies (Kessell 1979). The Spanish did not meet with much success in New Mexico and retreated to Mexico in April 1542 (Jenkins and Schroeder

1974). The 1598 expedition by Juan de Oñate arrived in Northern New Mexico with strong military backing, livestock, and equipment for full colonization. The Pueblos of the Rio Grande Valley continued to shrink in size during this 50-year interlude, and some locations inhabited when Coronado first entered the Valley were no longer occupied when Oñate arrived (Schroeder 1979). Pueblo leaders voluntarily took oaths of allegiance to the Spanish Crown and accepted the Franciscans who took up residence in each Pueblo. Churches were added to each Pueblo early in the seventeenth century (Simmons 1979a).

In 1610, the Spanish capital of New Mexico was relocated to Santa Fe by Governor Pedro de Peralta (Kessell 1979). The extensive Palace of the Governors was built to serve the administration of New Mexico as the settlement of the area continued (Kessell 1979). This Spanish Colonial Period was not peaceful, and the Pueblos were beset by incursions from the Spanish settlers, epidemics of smallpox and other deadly diseases, and continual attacks by Apaches (Simmons 1979a). In 1680, the Pueblos openly revolted against Spanish rule, attacking the Spanish settlers and Franciscans in the Rio Grande Valley and laying siege to the Palace of the Governors in Santa Fe. The Spanish Governor, Otermin, and most other Spanish settlers were forced south to El Paso (Hendricks 1993). American Indian governors ruled New Mexico from the Palace of the Governors for 12 years, until 1693 when Spanish control was reestablished. In 1821, the Spanish population in New Mexico had reached 20,000 to 25,000 (Simmons 1979b).

In the late seventeenth century, the Spanish Crown provided land grants adjoining the Pajarito Plateau to four Pueblos in New Mexico (Brayer 1938). The Jemez Pueblo was originally granted 17,331 acres (7,014 hectares) in 1689. Pueblo de Cochiti was granted over 20,000 acres (8,094 hectares); Santa Clara Pueblo was granted 44,818 acres (18,138 hectares); and San Ildefonso Pueblo was granted 15,413 acres (6,237 hectares) during this period (Simmons 1979a). American Indian populations continued to decline from disease during the Spanish occupation. The Pueblos surrounding the Pajarito Plateau suffered tremendous population losses. According to published records of the Spanish census of New Mexico, population totals fell from a combined 6,400 in Jemez, San Ildefonso, Santo Domingo, Santa Clara, and Cochiti Pueblos in 1630 to 1,374 in 1821 (Simmons 1979b).

Mexico was granted independence from Spain with the signing of the Treaty of Córdova in 1821. The treaty granted full Mexican citizenship to all American Indians (Kessell 1979). The quarter-century of Mexican administration in New Mexico was not marked by any major changes in the legal or cultural affairs of the state. However, it did open up major new trade routes and commerce between Santa Fe and the U.S. By 1824, New Mexicans were, for the first time, buying more from U.S. merchants than from their traditional Chihuahuan sources, and the Santa Fe Trail became important for U.S. traders selling goods to Mexico (Jenkins and Schroeder 1974).

Use of the Pajarito Plateau during the Spanish Colonial and Territorial Periods is not well documented (LANL 1995c). Grazing, seasonal gathering of firewood and timber, and hunting were probably practiced by the growing Hispanic population and by the nearby American Indian communities.

E.3.2.2 *Early U.S. Territorial/ Statehood Period (A.D. 1849 Through 1942)*

U.S. Army General Stephen Watts Kearny occupied New Mexico when the Mexican War broke out in 1846. The Pueblos of the Rio Grande Valley and the rural Spanish culture of northern New Mexico had become accustomed to changing political authority in Santa Fe and generally did not resist the change in power. However, in 1847, a rebellion broke out at Taos Pueblo. The brief revolt was bloody and rapidly put down by the U.S. Army (Jenkins and Schroeder 1974). The Treaty of Guadalupe-Hidalgo (1849) formally ended the question of authority in New Mexico and the new administration soon took effect. U.S. policy toward American Indians, including lands and citizenship, was very different from that of Spanish or Mexican administrators. The cornerstones of U.S. American Indian relations were isolation of tribes into separate reservation lands and provision of military protection and education. The first American Indian agent was assigned to New Mexico in 1849, as part of the territorial administration. In the shaping of the first steps toward statehood, the original Spanish and Mexican land grants in New Mexico were formally recognized (Leonard 1970 and Carlson 1990).

The early U.S. homesteaders may have informally begun using the Pajarito Plateau shortly after the U.S. Territory was established by the *Homestead Act of 1862*, which officially opened any untitled lands in New Mexico to settlement. By 1890, the Pajarito Plateau was still only sparsely settled by Hispanic and Anglo homestead ranches (Seidel 1995). The remains of these homesteads usually consist of wooden cabins, corrals, rock and cement cisterns, and agricultural debris such as barbed wire, wagon parts, horseshoes, and other evidence of livestock raising and transportation methods.

Since 1900, the remote and scenic location of the Pajarito Plateau has attracted outdoorsmen for hunting and fishing. The Jemez Mountains and antiquities of the Pajarito Plateau brought many visitors to the area once BNM was established in 1916 (Seidel 1995). The present site of Los Alamos was purchased in 1917 by Ashley Pond. In 1918, Pond established the Los Alamos Ranch School, a private boys' school. The school specialized in residential secondary education and attracted many young men from wealthy eastern families seeking robust physical development as well as academic education (Seidel 1995). The main recreation lodge and dining hall of the school, Fuller Lodge, is now part of a National Historic District and is a registered national historic landmark. The lodge, built in 1928, is constructed of logs and was designed by John Gaw Meem. The school operated from 1918 until 1943, when the facilities were acquired by the U.S. government for the Manhattan Project (Seidel 1995).

E.3.2.3 *Nuclear Energy Period (A.D. 1943 to Present)*

Because of very well-defined changes in the function of LASL/LANL, the Nuclear Energy Period is further broken into three periods: World War II/Early Nuclear Weapon Development, Early Cold War, and Late Cold War.

World War II/Early Nuclear Weapon Development Period (A.D. 1943 Through 1948)

The latest era in the historic development of the LANL region began in 1943 with the purchase of the Los Alamos Ranch School by the Secretary of War, as part of the wartime effort to build a secret nuclear weapons program (Seidel 1995). LASL was involved from the very inception of the U.S. government's program to develop nuclear weapons for the war effort (Truslow 1991). LASL was not only representative of wartime research and development facilities, but it provided innovative scientific and technological research and development activities for the U.S. nuclear weapons program from 1943 until the end of the Cold War in 1989. Los Alamos was the original site selected for the design and construction of the first nuclear bomb because of its remote and secret location (Truslow 1991).

The Los Alamos Early Nuclear Weapon Development Period facilities at LASL were built and used in the creation of the first atomic bomb, which was detonated successfully in July 1945. The design and manufacture of the Trinity bomb; the Hiroshima bomb, Little Boy; and the Nagasaki bomb, Fat Man; took place at LASL (Truslow 1991). LASL and the Trinity Test Site near Alamogordo, New Mexico, represent World War II nuclear weapon development events of exceptional importance on an international scale.

World War II research and development activities were concentrated around the Los Alamos Boys Ranch School, which became the living center for scientists during the war. Laboratories were erected at more remote locations. The S-Site, for example, was developed for high explosives research (Truslow 1991). This set a pattern for later development at LASL, where housing and administration remained concentrated around the present Los Alamos townsite and the former site of the Los Alamos Boys Ranch School. A back gate was erected to control access to the remote laboratories of the S- and V-Sites (Truslow 1991). From 1946 through 1950, all nuclear weapons were made at Los Alamos (DOE 1995). Common remains from this period and the following Early Cold War Period consist of laboratory and administration buildings, security facilities, experimental areas, infrastructure support facilities, berms and barricades, and paved and unpaved roads.

Early Cold War Period (A.D. 1949 Through 1956)

The mission of nuclear weapons development did not end with the close of World War II. In 1946, the Atomic Energy Commission (AEC) became the administrator of LASL, and nuclear weapons research and development continued (Seidel 1995). The Early Cold War Period began when the Union of Soviet Socialist Republics (U.S.S.R.) exploded its first atomic bomb in 1949 and the U.S. government became dedicated to nuclear weapons development and production in a nuclear arms race (LaFeber 1993). The Early Cold War Period was characterized by international tensions, armament buildup, and mostly military conflict by proxy waged in remote areas of the developing world.

LASL was the first, and later, one of only 13 sites in the U.S. devoted to nuclear weapons development and production (Seidel 1995). During the Early Cold War, LASL became a primary research and development center for U.S. nuclear programs, while production was shifted to other facilities. The period from 1949 to 1956 brought a considerable amount of new construction to LASL to meet the research needs of rapid nuclear armament buildup and international tensions between the U.S. and the U.S.S.R.

From 1943 until 1957, the entire Pajarito Plateau was shielded from public access. Los Alamos was closed and the mission and activities at LASL were classified (Seidel 1995). The city had grown to approximately 5,000 scientists and their families by 1945. In 1941, Los Alamos County was partitioned from Sandoval County and Santa Fe County, with the AEC controlling nearly all acreage in the new county (Seidel 1995).

Late Cold War Period (A.D. 1957 Through 1989)

In 1957, parts of the Pajarito Plateau, including the Los Alamos townsite, were opened to the public, marking the beginning of the Late Cold War (Seidel 1995). Throughout the Cold War, the LASL mission continued to be one of innovation and the scientific development of more powerful and efficient nuclear weapons and delivery systems. The Late Cold War was marked by more diversified research goals. Several periods of construction have occurred at LASL since 1956, but have yet to be analyzed. In 1977, the present boundaries were established, the name was changed to LANL (Steen 1977), and management of LANL was awarded to the University of California (UC) (Seidel 1995).

The international events that may be reflected in the physical record at LANL during this period include (DOD 1993):

- *1957*. First underground nuclear test, first intercontinental ballistic missile (ICBM) developed, first successful test of Atlas missiles.
- *1958*. First Nike-Hercules missile.
- *1961*. U.S. resumes underground testing of nuclear weapons; U.S.S.R. resumes atmospheric testing.
- *1962*. East-West conference on banning nuclear weapons tests takes place; U.S. resumes atmospheric testing of nuclear weapons.
- *1967*. Treaty of Tlatelcoco prohibits introduction and manufacture of nuclear weapons in Latin America (signed by all Latin American countries except Cuba).
- *1968*. Nuclear Arms Non-proliferation Treaty signed by U.S., U.S.S.R., and 58 other nations.
- *1970*. Nuclear Arms Non-proliferation Treaty goes into effect.
- *1976*. U.S. and U.S.S.R. sign peaceful nuclear explosions treaty limiting testing.
- *1979*. North Atlantic Treaty Organization (NATO) announces "dual-track" intermediate-range nuclear forces to intercept Warsaw Pact SS-20 missiles.
- *1983*. Congress authorizes MX missile procurement and development; Scowcroft Commission calls for modernizing U.S. strategic weapons.
- *1985*. Nuclear and space talks open in Geneva.
- *1986*. Peacekeeper ICBM becomes operational.
- *1987*. U.S. and U.S.S.R. sign Nuclear Risk Reduction Agreement, eliminating intermediate range nuclear weapons.
- *1989*. Fall of the Berlin Wall.
- *1991*. Presidents Bush and Gorbachev sign Strategic Arms Reduction Treaty (START); dissolution of the Warsaw Pact.

LANL's nuclear mission continued to be the primary focus of Los Alamos County until the end of the Cold War in 1989, creating a uniquely specialized scientific community in this remote region of New Mexico. The fall of the Berlin Wall in 1989 and the dissolution of the Warsaw Pact in 1991 effectively ended the international tensions that drove the nuclear development mission at LANL (DOD 1993).

E.3.3 Traditional Cultural Background in the LANL Region

A TCP is a significant place or object associated with historical and cultural practices or beliefs of a living community that is rooted in that community's history and is important in maintaining the continuing cultural identity of the community (Parker and King 1990). TCPs are essential in preserving cultural identity through social, spiritual, political, and economic uses. Federal guidelines established by the NPS (Parker and King 1990) identify TCPs to include

- Natural resources.
- Prehistoric and historic archaeological sites.
- Traditional use areas in the cultural landscape that do not reveal evidence of human use.
- Rural communities whose organization, buildings and structures, or patterns of land use reflect the cultural traditions valued by its long-term residents.
- An urban neighborhood that is the traditional home of a particular cultural group and that reflects its beliefs and practices.
- A location where a community has traditionally carried out economic, artistic, or other cultural practices important in maintaining its historical identity.

For TCPs on other lands, tribal rights have been established in the federal decision-making process. SWEIS consultations have been conducted in accordance with applicable federal requirements to include NHPA (16 U.S.C. §470), NAGPRA, *American Indian Religious Freedom Act* (AIRFA) (42 U.S.C. §1996; EO 13007), and DOE and LANL Accord Agreements with the Pueblo de Cochiti and the Pueblos of Jemez, Santa Clara, and San Ildefonso (DOE et al. 1992).

TCPs are not limited to ethnic minority groups, and traditional cultural contexts of northern New Mexico include cultural groups other than American Indians. Americans of every ethnic origin have properties to which they ascribe traditional cultural value. The Hispanic culture, in particular, has maintained traditional communities, practices, beliefs, and subsistence patterns in northern New Mexico.

E.3.3.1 *American Indian Cultures in the LANL Region*

The diversity of American Indian traditional cultural practices in the Southwest is reflected in the number of languages and complex cultures that occur there. Language is essential to the preservation of these cultural practices.

There are five different language families in the LANL region: Tanoan, Keres, Zuni, Uto-Aztecan, and Athabaskan (Hale and Harris 1979). These languages are presented in Table E.3.3.1–1 to show the relationships among the American Indian communities that speak each of the languages. The diversity of the languages also illustrates the complexity of multicultural relations in the region.

Every recognized American Indian community is a sovereign nation with limited powers. In accordance with the DOE American Indian

TABLE E.3.3.1–1.—*Languages of American Indian Communities within the LANL Region*

LANGUAGE FAMILY	SUBFAMILIES	COMMUNITIES THAT SPEAK THE LANGUAGE	
Tanoan	Tiwa (Northern and Southern dialects)	Pueblo of Taos Pueblo of Picuris	Pueblo of Sandia Pueblo of Isleta
	Tewa	Pueblo of San Juan Pueblo of Santa Clara Pueblo of San Ildefonso	Pueblo of Pojoaque Pueblo of Nambe Pueblo of Tesuque Arizona-Tewa
	Towa	Pueblo of Jemez	
Keres	(Eastern and Western dialects)	Pueblo de Cochiti Pueblo of Santo Domingo	Pueblo of Santa Ana Pueblo of San Felipe Pueblo of Zia
Zuni		Pueblo of Zuni	
Uto-Aztecan	Shoshonean	Hopi Tribe (Several villages on the First, Second, and Third Mesas, Arizona)	
Southern Athabascan	Eastern Apache	Jicarilla Apache Tribe	Mescalero Apache Tribe
	Western Apache	Navajo Nation (Navajo language)	

Source: Hale and Harris 1979.

Policy, DOE interacts with federally recognized tribes on a government-to-government basis (DOE 1994). In 1992, DOE and the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez, which are located near or directly adjacent to LANL, entered into formal agreements called Accords. The purpose of the Accords was to improve communication and cooperation among federal and tribal governments. In 1994 and in 1996, the Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara also signed cooperative agreements with DOE and UC to promote a meaningful participation and consultation on Pueblo environment, safety, health, and religious-culturally significant matters. The Accords and cooperative agreements are discussed further in chapter 7, section 7.2.9.

In Apache and Navajo communities (Athabascan cultures), tribal governments are based on the electoral process. Tribal members select a president and vice president during the summer for a 4-year term of office. The Navajo Nation has 110 political subdivisions, called "Chapter Houses" (e.g., Alamo, Cañoncito), that are represented in the Council. Initially, federal agencies must consult with the President of the Navajo Nation directly, but later requests may be referred to specific tribal departments or chapters.

The role of tribal governments is to interact with outside organizations such as county, state, and federal bureaucracies on a variety of issues. These issues include casinos and economic development, litigation, tribal court systems, land claims, hazardous waste transportation through tribal lands, construction projects compliance with tribal environmental standards, Indian health clinics, grave repatriation issues, language preservation programs, and cultural resources management.

E.3.3.2 *Traditional Hispanic Communities in the LANL Region*

LANL is located near numerous traditional Hispanic communities in four counties: Santa Fe, Sandoval, Rio Arriba, and Taos. While many of the cultural characteristics and demographics of the larger towns and cities of northern New Mexico have changed in recent years, many small, rural, and primarily Spanish-speaking communities, identified as traditional communities, continue to exist. Many communities were first settled during the Spanish Colonial Period and were given their land by the Spanish Crown (Weigle 1978). The identity of traditional Hispanic communities is maintained partly through archaic linguistic patterns and vocabulary carried over from early Spanish colonization of the area and partly through the traditional beliefs and practices unique to the region. Traditional Hispanic communities in northern New Mexico also maintain religious practices, art and craft traditions, folklore, and traditional medical practices (Ahlborn 1968, Briggs 1980, Weigle 1978, and Carlson 1990).

A traditional element present in these communities is the use of shared community ditches, or acequias, for irrigation (Carlson 1990). For that reason, these communities are sometimes known as acequia communities. (Campa 1979). Acequias are not only ditches but also traditional cultural systems that organize allocating, distributing, and sharing water in an arid land. Acequia systems are governed by traditional practices that are derived from Spanish Colonial laws of the seventeenth and eighteenth centuries (Weigle 1978 and Carlson 1990). The social labor systems necessary to operate the ditches include commissioners (elected representatives), mayordomos/mayordomas (ditch managers), and parcipiantes (landowners/shareholders) (Meyer 1984). Acequias are also political subdivisions of the State of New Mexico, recognized for their role in the development and administration of water resources for irrigation. The acequia system in the region is also closely intertwined with the Catholic Church.

E.3.3.3 *Traditional Cultural Property Categories*

Because of the numerous traditional cultures present in the region, the discussion of TCPs will be based on resource categories as well as the particular cultural affiliation of the community. The traditional cultures of the region have had many generations of interaction with one another and often have overlapping subsistence, artistic, and religious practices with unique cultural importance attached to similar types of sites. Several general categories of TCPs have been identified in the literature on American Indian and Hispanic cultures in northern New Mexico. Each of these categories represents specific cultural and physical sensitivity and susceptibility to adverse impacts from LANL operations. TCP resource types or categories in northern New Mexico include:

- Ceremonial and archaeological sites
- Natural features mentioned in stories, myths, and legends
- Ethnobotanical plant-gathering sites
- Artisan material-gathering sites
- Places used in traditional subsistence activities

These resource types are described in the following subsections, providing an overview of the range and diversity of potential TCPs in northern New Mexico.

Ceremonial and Archaeological Sites

Religious and ceremonial sites may be TCPs if they are still a part of the living memory and practices of traditional communities. Both American Indian and Hispanic communities have many ceremonial sites in northern New Mexico, including American Indian shrines and places of ceremony, Hispanic shrines, sanctuaries and meeting houses of the Catholic lay-brotherhood, known as Los Hermanos Penitentes.

American Indian groups visit and use a variety of ceremonial sites and shrines that are part of the landscape. The locations of tribal ceremonial sites and shrines are often held in secret by religious societies in the Pueblos (Starr 1900). Some American Indian ceremonial sites are marked with stones or other man-made features, while others are preserved in the living memory of the societies that visit them (Harrington 1916 and Douglas 1917). Some sites are visited only on rare occasions as particular circumstances demand it (Lange 1959 and Nordhaus 1995). The locations of some shrines have been previously published, but in the interest of preserving the privacy of the tribes, only general locations have been indicated throughout this technical report.

Most American Indian ceremonial sites remain unrecorded. Examples of recorded American Indian ceremonial sites within or near LANL boundaries include shrines that are known to exist around Mount Pelado, Redondo Peak (Akins 1993 and Ellis 1979); around Ovahwi Peak, Capulin Canyon, and Black Mesa (Akins 1993, Harrington 1916, and Douglas 1917); and along the Rio Grande, Tsikomo Peak, Nipple Mountain, Potrero de los Idolos, Peña Blanca, and Canada de Peralta. Shrines are also recorded for several caves in the area (Akins 1993, Harrington 1916, and Lange 1959).

Sanctuaries, shrines, and religious structures dating from the Colonial Period in New Mexico, are still widely revered and used by traditional communities, both Hispanic and American Indian. These sanctuaries may be completely ruined at this time or may have been extensively restored. The Santuario de Chimayo is widely visited by pilgrims from traditional Hispanic villages around New Mexico (Treib 1993). Sanctuaries at Cochiti, Santa Domingo, San Felipe, Zia, and Picuris Pueblos are enduring locations of traditional ceremonial practice (Treib 1993). The Oratorio of San Ysidro, the sanctuary of San Vicente De Paul in Punta de Agua, the church of San Miguel in La Bajada, and the church of San Jose de Gracia de Las Trampas are other examples of important Hispanic sanctuaries (Treib 1993). The ruins of San Jose de Giusewa in Jemez Springs are no longer in use as a sanctuary, but remain part of the continuing Catholic traditions of the Jemez Valley.

Moradas are ceremonial features unique to the Spanish traditions of northern New Mexico (Ahlborn 1968 and Wallis 1994). These structures serve as chapter houses for the lay-brotherhood of La Fraternidad Piadosa de Nuestro Padre Jesus Nazareno, also known as Los Hermanos Penitentes (Wallis 1994). Los Hermanos Penitentes originated in Spanish Colonial New Mexico and were formally organized between 1776 and 1833 during a period when there were insufficient priests to serve the needs of the Hispanic communities. The village moradas still serve to bring the traditional Hispanic community together and preserve teaching and values unique to the region through their community meetings, teachings, and ceremonies (Ahlborn 1968 and Wallis 1994).

Community members who move away for work often return for annual ceremonials that provide continuing identity with their Spanish ancestors. One Penitente writes,

> I am a member in good standing in the Brotherhood as were my forefathers, yet as is true of many Brothers of my generation, I no longer live in the village of my ancestors. Still I always return to the Morada. The Morada is a symbol of continuity, a reminder that those who went before us made many sacrifices to maintain something for succeeding generations (Wallis 1994).

Ancestral villages, archaeological sites, and petroglyphs, so numerous in the LANL region, are considered sacred areas by American Indian tribes. Pueblo de Cochiti inhabitants, for example, have many stories about their ancestors and the ruins in the region. Their stories indicate that originally all their people came up from Shipap (an unknown place of great antiquity) and lived together on the Mesa of the Stone Lions (Frijoles Canyon) in different villages: White House and the Village of the Two Lions (Benedict 1931, Akins 1993, and Douglas 1917). Then, the people split apart and the Santo Domingo went down the east bank of the Rio Grande to Cactus Village while the people of San Felipe, Laguna, and Acoma traveled west, down Peralta Canyon, and built the Pueblo of Peralta Canyon (Benedict 1931, Lange 1959, and Akins 1993). At the same time, the people of Cochiti went down Kapolin Canyon to settle in San Miguel on the west side of the river. Hainayasta and Tiputse are mentioned as Cochiti villages "across the river." Later the Pueblo de Cochiti people came from San Miguel to the "Plateau of the Buildings" where a new Pueblo was built. They lived there many years before coming down from the plateau (Benedict 1931 and Akins 1993).

Each of the physical places mentioned in such legends is a sacred link between the traditional community and the lives and traditional ways of their ancestors. The importance of ancestral villages is often reinforced by ceremonies held at ancestral ruins (Douglas 1917 and Akins 1993).

Natural Features

A variety of features in the landscape have special meaning for traditional cultures of northern New Mexico because of their association with the stories, myths, and legends that are shared by the community. Sites in this category may not need to be visited on a regular basis to retain cultural value and, in fact, may be inaccessible. The cultural value derives from the knowledge of their existence in relation to the ongoing history and values of the community.

Some natural features may resemble an animal, person, or mythological creature, and traditional stories may explain their existence and relationship to the traditional culture. Examples of this resource category include Camel Rock on Pueblo of Tesuque tribal lands and Black Mesa on Pueblo of San Ildefonso tribal lands. Black Mesa is known in stories as the home of Tsah-ve-yoh, a dreaded child-eating giant from Tewa stories, who returns to the surrounding Pueblos every year at Christmas time to whip any bad children who do not behave (DeHuff 1931). The same feature is also known from Tewa legends as a stronghold to which the people fled during the Navajo siege of ancient times and again when the Tewa were besieged by the Spaniards in 1694 (DeHuff 1931). Black Mesa does not have to be visited to maintain cultural value for the communities; its visibility is a daily reminder to children of the need to be obedient members of the Pueblo and of the bravery of their ancestors. Camel Rock, along U.S. Highway 84 between Santa Fe and Pojoaque Pueblo, is likewise a TCP that is mentioned in stories of the Tsah-ve-yoh. It is told that the giant would take four long strides from Black Mesa to Pojoaque to grab up the children of the Pueblo, then sit down on the rock formation (Camel Rock) to eat them alive (DeHuff 1931).

Stories and myths of Pueblo de Cochiti mention other prominent natural features: "Cave Place" and Peralta Canyon are mentioned in stories as places where giants lived. The giants are known to carry Cochiti children from the old Pueblo at Hainaysta (across the river from the modern Pueblo) through "Fissure Place" and to the "Giants Boiling Place." One giant, Schkoio schkaka haush, is known in myths to have been killed and shut up in his cave (Benedict 1931). Another natural feature is the "Stone Lions," a stone carved to resemble two resting lions, which gives the name "Village of Stone Lions" to an ancient Pueblo on the mesa above Frijoles Canyon (Hendron 1946 and Benedict 1931).

Mountain peaks, lakes, springs, and petroglyphs are often natural features in the sacred legends of traditional cultures in northern New Mexico (Akins 1993). Sacred peaks are part of the iconography of the Navajo Nation and of the Jicarilla Apache Tribe (Nordhaus 1995). Peaks sacred to the Tewa tribes include Conjilon, Chicoma Mountain, Sandia Crest, Truchas Peak (Friedlander and Pinyan 1980), San Antonio Peak, Lake Peak, and Cerro Pelado (Hewett and Dutton 1945). Sandia Pueblo considers Puye National Monument pictographs to be sacred to the tribe (Parker 1993). Hewett and Dutton reported in 1945 that the San Ildefonso and other Pueblos hold five area lakes and springs to be sacred (Hewett and Dutton 1945). These springs and lakes mark the four directions around San Ildefonso.

Ethnobotanical Gathering Sites

American Indian and traditional Hispanic communities rely on the use of wild native plants for ceremonial and medicinal purposes such as foods, dyes, and utilitarian objects (Dunmire and Tierney 1995, Robbins et al. 1916, and Toll 1992). Through the everyday use of native plants, there is a sense of connection with the land and continuity with the previous generations who were part of the land (Ford 1976, Cajete 1994, and Wetterstrom 1986). The continued use of botanicals in traditional cultures confirms a body of unwritten knowledge about the values and purposes of plants as part of a particular world-view or belief system unique to each culture (Wetterstrom 1986 and Toll 1992). This subsection contains information regarding plants that are ingested or used for ceremonial purposes. Plants used for dyes, construction, and other utilitarian purposes will be discussed as artisan materials in the following subsection.

American Indian ceremonies make use of specific wild plants and cultivated plants as foods, beverages, smoke, and coloring agents, or for ritual chewing. They are also incorporated into ceremonial implements or objects (Hiles 1992, Moerman 1986, and Dunmire and Tierney 1995). One such example of ceremonial use occurs each year at Sandia Pueblo when bundles of wood and snakeweed are taken to the cacique or Pueblo leader. This is done for 12 days following the winter solstice in ceremonies to nurture and bless the village (Dunmire and Tierney 1995). The use of smudges of big sage is recorded from Jemez Pueblo and the Navajo Nation for fumigating and purifying houses (Young 1940 and Dunmire and Tierney 1995). Douglas fir boughs and branches are incorporated into the traditional dances of several Rio Grande Pueblos (Dunmire and Tierney 1995), and cattails are also frequently featured in Pueblo ceremonies because of their symbolic association with water (Ford 1968 and Robbins et al. 1916). Navajo ceremonies use several plants such as bitterball and ironwood (Young 1940 and Elmore 1944). Ceremonial use of plants may require that they be gathered from specific places in order to increase their potency or ritual significance (Ford 1968). Pueblo practices may require ritualized gathering of medicinal plants and wild foods or may be undertaken only by certain sodalities (Ford 1968).

It is uncertain from the literature if there are Hispanic ritual or ceremonial uses for plants. Knowledge about the use of native food plants was undoubtedly shared among the Pueblo cultures and the Spanish colonists, for Hispanic knowledge and use of native plants for food and medicine overlaps a great deal with Pueblo uses. Pueblo uses of wild plants also seem to have been altered by Spanish contact (Toll 1992 and Ford 1968).

The Rio Grande Pueblo people gather many wild plants as foods and beverages (Dunmire and Tierney 1995). Documented food use includes three-leafed sumac, acorns from Gambel's oak, and ripe fruit from the chokecherry, gooseberry, and currant. Since ancient times, the fleshy fruit of the banana yucca has continuously been harvested and used as food by Pueblo people (Minnis 1991, Ford 1968, Toll 1983, and Toll 1992). The use of Indian tea is also very common as a beverage among Pueblo, Navajo, Apache, and Hispanic people in the region (Dunmire and Tierney 1995, Moerman 1986, and Elmore 1944). Prickly pear fruit, Indian rice grass seeds, and tubers of wild potato are believed to have been important "famine foods" of the region in past times of drought and may still be gathered and encouraged to grow near Pueblos (Minnis 1991). Pinyon nuts are the most important of all wild food sources for Pueblos and traditional Hispanic communities in the region. Families will frequently travel great distances to collect nuts in the autumn, and individuals may gather and sell the nuts in their communities (Ford 1968 and Dunmire and Tierney 1995).

Medicinal use of wild plants is common in northern New Mexico among the Pueblo, Apache, and Navajo people and traditional Hispanics. Dunmire and Turney (1995) assert that 180 different species of wild plants in the region have medicinal uses among 1 or more of the 19 New Mexico Pueblos. Regular medicine gathering trips are conducted to the Pajarito Plateau and other high elevation sites by the Pueblo's medicine societies (Dunmire and Tierney 1995 and Ford 1968). Commonly known medicinal plants include joint-fir, broom snakeweed, sage, and four-o'clocks (Dunmire and Tierney 1995 and Curtin 1947). Osha root is also an important medicinal plant used by American Indians and Hispanics in the region (Ford 1968, Hiles 1992, and Dunmire and Tierney 1995). The locations of collection areas for some of the rarer medicinal plants that grow in the mountains, such as Osha root, may be a closely kept secret of village healers.

Artisan Material Gathering Sites

The gathering of raw materials for numerous commercial and non-commercial utilitarian objects is common in the American Indian and Hispanic traditional communities. While some utilitarian objects, such as handmade plant fiber cordage, woven yucca sandals, and wooden arrowheads, have generally been replaced by modern products, there are still enduring traditions of weaving, tanning, wood carving, jewelry making, joinery and construction, and pottery making that use native materials gathered locally. The products of these traditional arts have become internationally prized not only because of the aesthetic quality they demonstrate, but also because of their continued use of native woods, fibers, dyes, and minerals. The continued access of traditional communities to the natural resources of the region is vital to the continuation of these traditional arts.

The use of natural dyes, pigments, and tanning agents is still a characteristic of traditional American Indian and Hispanic communities in northern New Mexico (Dunmire and Tierney 1995 and Dickey 1990). Weaving is a very important traditional art form, and many traditional weavers still produce dyes from native plants they have gathered locally (Dickey 1990, Minge 1979, and Dunmire and Tierney 1995).

Three of the important dyes used by traditional Hispanic weavers are imported from Mexico: indigo, cochineal, and brasilwood (logwood) (Anonymous 1976 and Minge 1979). Other important dye-producing plants are gathered from village roadsides, acequia banks, mountain habitats, or the nearby desert (Dunmire and Tierney 1995 and Dickey 1990). These plants include goldenrod, cocklebur, sumac, sunflower, dahlia, chokecherry, chamisa, snakeweed, slatbush, mountain mahogany, oak and alder bark, lichens, caniegra, Virginia creeper, cota or Indian tea, juniper, madder, black walnut, onion skins, and marigold (Anonymous 1976, Minge 1979, Dunmire and Tierney 1995, and Young 1944). Rocky mountain beeplant, wild dock, pinyon pitch, and tansy mustard are used for pottery paints (Dunmire and Tierney 1995), and red clay is sometimes used as a red fabric dye (Young 1944).

Construction woods and adobe clays are also gathered from sources in northern New Mexico. Pueblo and traditional Hispanic construction uses whole logs for vigas (roof beams) made of cottonwood, Ponderosa pine, and Douglas fir (Dickey 1990 and Dunmire and Tierney 1995). Latillas (roof cross-supports) are usually made of split aspen, mountain-mahogany, or oak; roof thatching is made of four-winged saltbush or common reeds (Young 1944, Dickey 1990, and Dunmire and Tierney 1995).

Adobe clay is gathered from many sites near Pueblos and Hispanic villages and mixed with dried plants to form the walls of most buildings in traditional communities (Dickey 1990, Weigle 1978, and Hill 1982). Potter's clay, however, comes from very specialized sites that contain very fine clays without impurities (Dickey 1990 and Peterson 1977).

Wood carving is an artistic tradition in some Hispanic communities (Briggs 1980), and carved wooden Santos are an important tradition of the local churches and Moradas (Dickey 1990 and Briggs 1980). Santos are carved depictions of the saints and allegorical stories in the Catholic traditions and traditionally are of two forms: bultos, or three-dimensional carvings; and retablos, or bas-relief carvings on hinged wooden panels (Briggs 1980). The wood may be augmented with gypsum, metals, and other materials. Paints were originally of natural pigments, but increasingly include commercial products (Briggs 1980). Native wood of outstanding carving characteristics is gathered from the national forests. Preferred wood comes from aspen, berried juniper, willow, and pine (Briggs 1980).

Drums and many other articles are carved from the aspen and cottonwood found in the Pueblo communities (Dunmire and Tierney 1995), and bows are made from pliable woods such as wild currant, New Mexico locust, and chokecherry (Dunmire and Tierney 1995). Arrows are crafted from various woods and common reeds. Apache plume is most commonly used for making brooms (Dunmire and Tierney 1995).

E.3.3.4 *Traditional Subsistence Features*

Traditional subsistence practices in use in northern New Mexico include community-maintained irrigation ditches, called acequias, traditional trails and hunting areas, traditionally used fields, grazing areas, firewood-gathering sites, and Spanish land grants. While subsistence functions may not be unique to tribal or Hispanic communities, the traditional community is often brought together and identified through their annual subsistence cycle, and these subsistence activities reinforce a world-view and values unique to the community. As such, the protection of these properties ensures the ability to continue traditional community values and identity.

Acequias are the best known example of traditional subsistence features in northern New Mexico. Acequia communities are complex social institutions that have developed around the Hispanic water supply and irrigation systems known as the Acequia Madre (Arellano 1994). Irrigation systems require not only a sedentary lifestyle but also a complex system of social participation and control because of the intense labor required to build, maintain, and regulate them. Many areas in the arid southwest have developed unique traditional practices surrounding the acquisition of water rights and the development and use of irrigation systems. In northern New Mexico, the acequia communities have developed through the commingling of Pueblo and Spanish traditions and the particular demands of the environment (Campa 1979 and Jenkins 1972).

The fertile flood plains of northern New Mexico required tapping the rivers for a reliable water supply for people, crops, and livestock. Wide fluctuations in annual rainfall characterize the region, making the regulation of hydrological systems essential for a sedentary population (Ackerly et al. 1993). Irrigated agriculture, including terraces and reservoirs, has been present in the Rio Grande Valley since A.D. 1400. The Tewa Pueblos produced crops of maize, squash, beans, melons, cotton, and chile using simple but effective irrigation techniques (Arellano 1994). In an early expedition into northern New Mexico, Antonio Espejo observed the agricultural systems at Acoma Pueblo, stating that they had "... found many irrigated corn fields with canals and dams" (Hammond and Rey 1966).

The Spaniards were already familiar with a variety of irrigation techniques dating back to the Roman and Moorish civilizations. In the years after Spanish settlement of northern New Mexico, they augmented native methods of irrigation with those brought from the Iberian peninsula, including social community cooperation and control mechanisms. Eventually, the physical and social practices of Hispanic irrigation became codified legal institutions as well as traditional cultural systems. These are still reflected in New Mexico water law, as well as in the traditional practices of some Hispanic communities.

Acequia systems did not develop without a good deal of contention and social conflict. Spanish and Pueblo traditions differed considerably in the cultural perspective on the relationship of water, religion, and society. Early Spanish water tradition was relatively compatible with Pueblo traditions in that water resources were considered to belong to the community rather than the individual (Ackerly et al. 1993). The concept of the community gradually gave way to privatization and the pursuit of private wealth in the New World (Meyer 1984). Conflicts over water rights and the shared responsibility for acequia maintenance among the Spanish

Colonials increased over time, as did conflicts over water rights between acequia users and neighboring Pueblos.

Article 6 of the *Plan de Pitic*, 1789, specified that all new lands in the northern provinces, subject to irrigation, would receive equal benefits of water from the Acequia Madre through individual outlets and ditches (Meyer 1984). Each landowner, or parcipiante, was to be informed of his outlet location and was not to abuse any neighbor's access to water. Outlets were to be made of stone and mortar, at the individual's expense, to prevent losses to downstream users. Article 19 of the *Plan de Pitic* specifies the fair apportionment of water to the community. Responsibility is given annually to the town council to appoint an overseer, called the alcalde or mayordomo, for each outlet of the Acequia Madre. This person was to apportion the water to all fields in proportion to the needs of each, with each individual landowner having posted hours for irrigation. The alcalde was authorized to hire an assistant to check the outlets for compliance at the proper times and to charge a fee to the landowner if the assistant was required to open the outlet for him. This basic political/agricultural institution has been followed by Hispanic and Hispanic-influenced communities in Texas, California, parts of Colorado and Arizona, as well as throughout New Mexico (Meyer 1984).

The affairs of the acequia are handled in many Hispanic areas of New Mexico at meetings of La Junta del Agua, a problem-solving-oriented assembly of landowners. This tradition dates back to the Tribunal de las Aguas, which met regularly since the Middle Ages on the steps of the Cathedral of Valencia, Spain, (Campa 1979). The members of La Junta del Agua were respected members of the community. Within this context, important issues of water rights and local power were decided. All the landowners using water from the Acequia Madre still gather in the spring with horses, scrapers, and manpower to clear out debris and rocks and to make any necessary repairs (Meyer 1984). This communal activity, guided by the mayordomo, is called La Fatiga in New Mexico and is often a significant community event for Hispanic villages (Campa 1979).

Pueblo irrigation predates Spanish contact. Centuries of excavation, routine maintenance, and repairs mask any clear-cut evidence of their prehistoric origins (Ford 1976 and Meyer 1984). Acequias are integral to the technological and ceremonial life of the Pueblo. Their use, while very similar to the use in the Hispanic communities, is punctuated by religious and ceremonial events unique to each Pueblo (Ford 1968, Ford 1976, and Hill 1982).

Land grants form the basis of title and land use for many of the traditional communities in northern New Mexico. Land grants were dispensed by the Spanish Crown and Mexican government to the Pueblos and to Spanish settlers "to advance civilized life" in the region. The land grants were of three types: those for individual tracts of irrigable farmland, those that were granted as commons or pasture lands for a community, and those that were given to each Pueblo to regulate for their own purposes (Leonard 1970). The Pueblo land grants only affirmed the Pueblos' rights to existing patterns of land use, but the Hispanic land grants, upheld by U.S. law, shaped the lifestyles of traditional communities in the region (Leonard 1970 and Carlson 1990). Modern Pueblos, including their fields and commons, are considered to be TCPs in their own right. Traditional Hispanic land grant communities may also be considered TCPs in that all of the parts (e.g., individual holdings, commons, acequias, village) are interrelated and required for the continuation of the whole (Leonard 1970, Carlson 1990, Ackerly et al. 1993, and Arellano 1994).

An example of an existing traditional Hispanic Land Grant community in the LANL region is the Canyon de San Diego Land Grant near Jemez Springs (Cline 1972). The grant includes 110,000 acres (44,517 hectares) of commons or grazed community lands and 6,000 acres (2,428 hectares) of individual farms irrigated by acequias (Cline 1972). The individual farms were granted as parcels along the acequia system. Over generations, the allotments have been further divided as a result of inheritance practices into thin parcels called strip holdings or long fields (Carlson 1990 and Cline 1972). Each borders the acequia on a narrow side. The village is thus characterized by the existence of long fields in the bottomland where corn, beans, squash, alfalfa, and other crops are irrigated by the acequias (Carlson 1990 and Weigle 1978). The acequias and the grazing commons are the shared responsibility of the villagers, and the commons provide not only grazing for livestock but also many other natural resources gathered by individual families (Weigle 1978 and Carlson 1990). Pinyon nuts, firewood, construction wood, ethnobotanicals, and other resources come from the commons, which are frequently mountainous (Carlson 1990). The houses and church or Morada of the village are clustered tightly, reducing any waste of valuable bottomland and providing community solidarity. The routine of community life is punctuated by agricultural, irrigation and religious events, and is broken by periodic treks into the mountains to gather wood and other resources. All elements are necessary not only for subsistence but also to maintain a unique cultural identity in the face of the modern cash economy.

Traditionally used trails and hunting areas form another subsistence element of traditional cultures of northern New Mexico, particularly of the American Indians. Communal hunts are conducted by Pueblo sodalities or moeities, which are often ritualized and geographically specific (Ford 1968). The mountains are generally shared territory among several tribes. Not only are they areas to hunt or gather specific plants, but they are also locations of important shrines with ritual obligations for visitation (Ford 1968 and Nordhaus 1995). Trails to hunting sites, ceremonial sites, and grazing areas were documented for the Jicarilla Apache Tribe (Nordhaus 1995), and Harrington's maps of Pueblo sites also show trails (Harrington 1916). Zuni trails are indicated on a map by Ferguson and Hart (1985). Their trails lead as far as the Great Salt Lake in Utah. The Zuni tribe has also documented ritual hunting areas and deer trap areas (Akins 1993 and Ferguson and Hart 1985).

E.4 Federal and State Regulations Related to Cultural Resources at LANL

The NHPA (16 U.S.C. §470) was passed in 1966. Under the NHPA, federal agencies (in this case, DOE) have specific responsibilities toward cultural resources that are on their lands or that may be affected by their activities. Section 106 of the NHPA requires that DOE take into account the effects of activities on significant cultural resources. DOE is also required to allow the Advisory Council on Historic Places (ACHP) the opportunity to comment on any DOE plan that may affect such resources. Under the ACHP's regulations for implementing Section 106 of the NHPA (published in the Code of Federal Regulations as 36 CFR 800), the ACHP's right to comment is often delegated to the SHPO. The regulations specifically require that DOE identify cultural resources that may be affected by its "undertakings," evaluate the significance of those resources, and assess the effects of its undertakings on those resources. This process must be completed in consultation with the New Mexico SHPO.

Under Section 106, cultural resources are considered significant if they are eligible for inclusion on the NRHP. Federal regulation 36 CFR 60.4 states that cultural resources may be eligible to the NRHP if they meet one or more of the following criteria:

- They are associated with events that have made a significant contribution to the broad patterns of history.
- They are associated with the lives of persons significant to our past.
- They embody the distinctive characteristics of a type, period, or method of construction, or they represent the work of a master; possess high artistic values, and/or represent a significant and distinguishable entity whose components may lack individual distinction.
- They have yielded or may be likely to yield, important information to prehistory or history.

The SHPO and other personnel of the Historic Preservation Division of the New Mexico Office of Cultural Affairs, operate under the NHPA and in particular monitor Section 106 compliance. The Historic Preservation Division also provides technical services, a state-wide database, and Section 106 compliance advisors (18 New Mexico Statutes Annotated [NMSA] §6–1 through 6–17 and 8–1 through 8–8). In addition to assisting DOE in determining cultural resource significance, the New Mexico SHPO is responsible for coordinating state participation in implementing the NHPA (16 U.S.C. §470). The New Mexico SHPO represents the interests of the state and its citizens in the preservation of their cultural heritage and assists DOE in identifying historic properties and assessing impacts of activities. The SHPO may agree or disagree with the responsible agency's assessment of the eligibility of its cultural resources. Ultimately, the determination of eligibility of any cultural resource is made by the keeper of the National Register, DOI (36 CFR 63.2).

To determine the scope of the SWEIS cultural resources evaluation, DOE first met with the New Mexico SHPO. The meeting resulted in a decision that the SWEIS does not, in and of itself, constitute an undertaking; therefore, compliance with Section 106 of the NHPA (16 U.S.C. §470) is not required (PC 1996). However, individual actions covered by the SWEIS might be undertakings requiring Section 106 compliance.

Through development of the LANL SWEIS, the DOE evaluated the potential impacts of proposed actions on cultural resources in order to mitigate impacts, if required, and to ensure compliance with all applicable federal and state requirements.

Of interest in this process are actions that might adversely affect or diminish the integrity of the location, design, setting, materials, workmanship, feeling, or association of a TCP. Adverse effects evaluated for the SWEIS include, but are not limited to

- Physical destruction, damage, or alteration of all or part of the property.
- Isolation of the property from or alteration of the character of the setting when that character contributes to the qualification of the property for nomination to the NRHP.
- Introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting.
- Neglect of the property resulting in deterioration or destruction (36 CFR 800.9).

The scientific community has concerns that compliance with federal historic preservation law might impede efforts to remain at the forefront of international research and achievement. In 1989, in response to these concerns, Congress directed the ACHP to study the designation of scientific research institutions as historically significant. Concerns were raised by agencies faced with altering or renovating existing or abandoned research facilities that were considered eligible for the NRHP by the ACHP. The resulting document, titled "Balancing Historic Preservation Needs with the Operations of Highly Technical or Scientific

Facilities," discusses the needs of research institutions to upgrade their facilities and the responsibilities of preservation agencies to implement the requirements of federal historic preservation regulations (ACHP 1991). The following are among the recommendations outlined in the 1991 report:

- Future authorizations for major scientific and technological programs should include public education components focusing, in part, on the communication of the relevant history of science.
- Decisions about projects that may affect historic properties need to be made with as complete an understanding as possible of those effects. However, considerations of preservation options should be kept distinct from the peer review process of awarding research grants and the determination of research priorities central to the scientific research process.
- The ACHP and affected federal agencies should jointly subscribe to a statement of policy that acknowledges the sensitive relationship between scientific research and the evolving history of science and its physical manifestations.
- Federal agencies should determine how they might better coordinate historic preservation programs and planning among facilities managers, public affairs officers, archivists, historians, external affairs officers, and other staff. The ACHP should recommend measures to these agencies to improve the effectiveness, coordination, and consistency of procedures with the purposes of the NHPA (16 U.S.C. 470 §202[a][6]).
- Future scientific achievement, as well as adequately serving the public interest, depends on an understanding of past scientific successes and failures. Federal agencies, in cooperation with other concerned parties, should explore innovative ways for minimizing and meeting the costs of historic preservation that may be associated with the operations and management of historic facilities.
- The ACHP, in cooperation with the Smithsonian Institution, the NPS, and federal agencies, should establish a consensus about what kinds of scientific facilities and objects should be physically preserved for the future. This should include deciding how the historic value of facilities and objects can be determined and which facilities and objects can be "preserved" through documentation. The ACHP suggests that the documentation option would be best suited to historic facilities that are still active.

The study concluded that the ACHP regulations and the Section 106 review process are flexible enough to accommodate the legitimate needs of the scientific and engineering community and their activities at historic facilities (ACHP 1991).

The NPS's *National Register Bulletin 22*, "Guidelines for Evaluating and Nominating Properties that Have Achieved Significance Within the Last Fifty Years" (NPS 1990), emphasizes the importance of carefully establishing the cultural context of properties and evaluating them based on comparisons with other possible properties within the same historical context. A justification or rationale of exceptional importance should be an explicit part of a statement of significance. Such properties frequently qualify for nomination to the NRHP under more than one of the criteria for evaluation for nomination (36 CFR 60.4).

The NPS's *National Register Bulletin 38*, "Guidelines for Evaluating and Documenting Traditional Cultural Properties" (Parker and King 1990) indicates that objects, trails, pathways, physical features, or resource gathering sites that are significant to a living community's historically rooted beliefs, customs, and practices, may be eligible for protection under the NHPA. Within LANL's boundaries, TCPs exist that have both a current and a traditional importance to existing American Indian and other local communities. Although TCPs have been eligible for the NRHP since its creation (Parker 1993), it was not until *National Register Bulletin 38* was published that their importance was recognized by federal agencies, SHPOs, and other cultural resources managers.

Other pieces of legislation, including the AIRFA of 1978 (42 U.S.C. §1996), the NAGPRA of 1990 (25 U.S.C. §3001), and Executive Order (EO) 13007, deal mostly with religious, ceremonial, or burial sites.

The AIRFA is a joint resolution of Congress stating that the policy of the U.S. is to protect and preserve the right of American Indians to have access to sites, possess and use sacred objects, and worship through traditional rights and ceremonials. The AIRFA is simply a policy statement; no regulations implementing the AIRFA have been promulgated. (However, within DOE, DOE Order 1230.2, *American Indian Policy*, is the implementing regulatory mechanism.)

The NAGPRA places ownership or control of American Indian human remains or funerary objects, excavated or discovered on federal or tribal lands after the date of the act, in the hands of the lineal descendants of the Indian tribe. Moreover, the NAGPRA requires agencies and museums with collections of American Indian human remains or associated funerary objects to inventory those remains; identify their geographic and cultural affiliations, in consultation with tribal governments and religious leaders. They then must provide each Indian tribe with a copy of the inventory of remains associated with that tribe, an inventory of remains not clearly associated, and access to records, catalogues, and studies. If the cultural affiliation is established or demonstrated through "geographical, kinship, biological, archaeological, anthropological, linguistic, folkloric, oral traditional, historical, or other relevant information, or expert opinion" (43 CFR 10.7[a][4]), the remains must be returned, if requested. The regulations implementing the NAGPRA, published in 1995 (43 CFR 10), provide a systematic process for determining the rights of lineal descendants and Indian tribes to the remains, and instructions for consultation.

Consultation with lineal descendants and affiliated tribes is required at several stages of NAGPRA compliance. Intentional archaeological excavations of human remains, funerary objects, sacred objects, or objects of cultural patrimony on federal lands are permitted only after consultation with appropriate Indian tribes (43 CFR 10.3). Consultation must include any tribes that are likely to be culturally affiliated with or to have occupied the area, or that have a demonstrated cultural relationship to the remains (43 CFR 10.5). Prior notification of Indian tribes who have likely affiliation, have aboriginal use of the area, or who are otherwise culturally related to the remains is required if an activity may result in the excavation of such remains (43 CFR 10.3[c]). Inadvertent discoveries require notification of "likely to be culturally affiliated" Indian tribes within three working days and cessation of all disturbance in the area. In addition, the person or agency responsible for the discovery must protect the site from further disturbance. The project may resume in 30 days after notification unless a plan, such as a memorandum of agreement (MOA) is in place. In the event of emergency discoveries, consultation should be coordinated with the reporting responsibilities of other legislation. Additionally, 43 CFR 10.6 recommends that federal agencies enter into comprehensive agreements with Indian tribes, addressing all federal agency land management activities that could result in the intentional excavation or inadvertent discovery of such remains, and that they establish a process for effectively carrying out the NAGPRA requirements. LANL has completed an inventory in compliance with the NAGPRA;

however, to date, the NAGPRA consultations have included only the four Accord Pueblos.

EO 13007 directs agencies to accommodate access to and ceremonial use of Indian sacred sites on federal lands by Indian religious practitioners, and to avoid adversely affecting the physical integrity of such sites. A sacred site is defined as a "discrete, narrowly delineated location of federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance or for ceremonial use by an Indian religion." EO 13007 is applicable to some TCPs and adds protection to newly established ceremonial sites; however, it does not apply to subsistence features, artisan gathering sites, and ethnobotanical gathering sites.

Within 1 year of the effective date of EO 13007, the head of each agency was directed to report the following to the President:

- Changes necessary to accommodate access to Indian sacred sites.
- Changes necessary to avoid adversely affecting the physical integrity of sacred sites.
- Procedures implemented or proposed to facilitate consultation with appropriate Indian tribes and religious leaders and resolution of disputes.

A draft report for compliance with EO 13007, prepared by DOE in May 1997, states that DOE will accommodate access to sites by working directly with tribes to identify their needs for access or barriers to access, developing MOAs with tribes, and developing and implementing cultural resource plans in consultation with tribal officials. Changes necessary to avoid adversely affecting Indian sacred sites are continuing outreach to tribes to expand DOE's ability to identify sites, to develop and to implement cultural resource plans in consultation with tribes, and to incorporate tribal representatives into cultural resource planning. Consultation with Indian tribes will be facilitated by training DOE personnel, with assistance from tribal members; developing specific consultation procedures or using existing procedures such as those for the *National Environmental Policy Act* (NEPA) (42 U.S.C. §4321) and Section 106 compliance, and seeking to resolve disputes with tribes.

Other legislation explicitly requires inventories of significant resources. Section 110 of the NHPA requires agencies to inventory significant sites under their jurisdiction and to develop plans to manage those resources. Also, EO 11593, §2(a) (1971) orders agencies to "locate, inventory, and nominate to the Secretary of the Interior all sites, buildings, and objects under their jurisdiction or control that appear to qualify for listing in the NRHP." Furthermore, it directs agencies to submit to the Secretary of the Interior procedures for the maintenance and preservation of historic and archaeological sites under their control (EO 11593, §2[d]). This legislation forms the basis for protecting cultural resources.

E.5 RESEARCH METHODOLOGY

Anthropologists and historians have developed the concept of historical context as a framework to facilitate the evaluation of significance. Historical context facilitates the evaluation process by grouping information about cultural resources based on a shared theme, specific time period, and geographical area (48 *Federal Register* [FR] 44739). Historical context provides a flexible and legitimate basis for site-wide planning decisions that may affect cultural resources, and is developed by the SHPO to provide a basis for evaluating prehistoric and historic sites by identifying patterns or research problems in the historical and prehistoric record. Patterns or research problems include (48 FR 44718–44719):

- The chronological period and geographical area of each context.
- A compilation of existing information obtained through literature and background searches.
- The identification of trends in research and cultural values of the settlement, architecture, and art.
- A definition of property or site types by characteristics of each type.
- The identification of gaps in the body of information concerning historical context.

Historical context, then, includes both temporal and spatial information as well as artifacts and structures. It is ideal for incorporating cultural resources into the SWEIS because it is nonjudgmental; it includes elements of significance without implicating sites or localities as significant or insignificant. While the development of context is beyond the scope of the SWEIS, the SWEIS research methodology used the paradigm outlined above to categorize cultural resources.

Historical contexts are not well defined for New Mexico. Researchers in the state generally apply a research design published in 1981 by the State of New Mexico, Office of Cultural Affairs, Historic Preservation Division, titled "Prehistoric New Mexico; Background for Survey" (Stuart and Gauthier 1981). Although this research is applicable, it lacks the framework to evaluate site significance that is intended for contexts. Several Historic Period contexts were defined in a manuscript titled "New Mexico Historic Contexts" (Pratt and Scurlock 1993). Pratt and Scurlock (1993) recommended the development of a nuclear energy context, extending in time from 1943 to the present and including Los Alamos, Albuquerque, the Trinity Site, and southeastern New Mexico, with associated property types (laboratories, reactors, nuclear development and testing sites, and waste storage sites). The absence of a defined nuclear energy context makes classification and evaluation of historic resources at LANL difficult and results in a data gap for the SWEIS and for the cultural resources management program at LANL.

E.5.1 Research Methods for Acquiring Data on Prehistoric Cultural Resources

Archaeological and cultural data on the existing prehistoric cultural resources at LANL were acquired from the LANL Cultural Resources Management Team; the New Mexico Office of Cultural Affairs, Historic Preservation Division; the New Mexico State Register of Cultural Properties; and the Museum of New Mexico, Laboratory of Anthropology, Archaeological Records Management Systems (ARMS). A review of published records and literature about the history and cultures of northern New Mexico was also conducted as part of the SWEIS.

Comprehensive data on cultural resources at LANL are maintained in paper and electronic databases and Geographic Information System (GIS) by the LANL Cultural Resource Management Team and include both compliance information and cultural/ archaeological data (PC 1995). The LANL Cultural Resources electronic database was reviewed. Some sites have been recorded or confirmed recently by the LANL Cultural Resource Management Team, while others have been previously recorded, using methods and controls that may be different from present standards. Sites are classified in the electronic database according to available information on location, site type, and eligibility status. They are not, however, classified according to age or cultural affiliation. Cultural resource data are transferred, using site forms, from LANL to the New Mexico ARMS database at the Museum of New Mexico, Laboratory of Anthropology. A lag of approximately 10 years exists in the processing and transfer of some data to ARMS, resulting in differences in the numbers of sites in each electronic database as well as in the types of information conveyed in each database.

Attempts were made to reconcile the two electronic databases in order to obtain information about the historical context of prehistoric resources and the numbers and types of cultural components of each site. Discrepancies were found between the two electronic databases that prevented the inclusion of ARMS data in the SWEIS. Therefore, the site numbers, locations, and site type data provided by the LANL Cultural Resources Team form the basis of this study. Prehistoric resources were incorporated into a GIS for overlay impacts analysis. Methods were developed to ensure that sensitive cultural resource information was not jeopardized during the study.

E.5.2 Research Methods for Acquiring Data on Historic Cultural Resources

Data on Historic Period resources were obtained from several sources. Data relating to the Spanish Colonial and U.S. Territorial periods were obtained from the LANL Cultural Resource Management Team database and publications. Data about cultural resources constructed at LANL during the Nuclear Energy Period were obtained from the LANL report, *Capital Asset Management Process, Fiscal Year 1997* (LANL 1995a), the Facility for Information Management, Analysis, and Display (FIMAD) database (LANL 1996), the as-built structure location maps for LANL (GITL 1997), the Environmental Restoration Program Decommissioning Summary Site Plan (LANL 1995b), and the LANL Cultural Resource Management Team database and publications. The locations of known structures dating from the Nuclear Energy Period were determined from facility maps and incorporated into a GIS for overlay impacts analysis. These data do not include non-building remains of those periods and do not fully identify the numerous interrelated infrastructure support systems and functional systems present at LANL. The LANL Cultural Resource Management Team has a database of potential historic facilities that includes many existing and demolished structures (LANL Cultural Resource Database). These data have been excluded from the list of known resources until further documentation can be obtained to link them with the historical context of the Nuclear Energy Period.

E.5.3 Research Methods for Acquiring Data on Traditional Cultural Properties

TCPs were studied, using methods designed to identify categories and specific resources, to assess potential impacts from LANL operations and to provide recommendations to protect those resources from adverse effects from future LANL activities. The purpose of the study was to determine if properties exist within the LANL region that continue to hold cultural significance to those groups claiming traditional use or affiliation with the LANL area. TCP identification, evaluation, and documentation processes were conducted using the guidelines specified in *National Register Bulletin 38* (Parker and King 1990), which addresses eligibility to the NRHP. Natural, physical, biological, political, ideological, and man-made places significant to the local communities for ideological, economic, or historic reasons were identified in this study.

The goals of the SWEIS TCP study were to identify:

- Those American Indian, Hispanic, and other communities with cultural affiliations in the LANL area.

- The types of TCPs in the LANL region that could be affected by LANL and the kinds of LANL activities that could affect them.
- Potential avenues of mitigation that would avoid or minimize impacts to traditional properties.

The primary focus of the TCP study was American Indian and Hispanic traditional communities. However, if TCPs associated with other cultures or groups were identified during the course of this study, they were also acknowledged here.

The TCP research methods used in this study include the following elements:

- *Identify Traditional Communities That Maintain Affiliation with or Traditional Use of the LANL Area*. A 50-mile (80-kilometer) radius around LANL was used to identify communities to establish consultations. Other communities identified through the literature review were then added to the list.
- *Conduct Initial Consultations with Potential TCP Communities*. This level of consultation includes identifying appropriate contacts, making telephone calls, and setting up meetings with communities to introduce the SWEIS and inquire about their desire to participate in the SWEIS process.
- *Enter into Agreements for TCP Community Consultations*. Interested traditional communities established the methods for identifying TCPs of concern to them in the LANL area. Most traditional communities completed TCP field survey forms and provided either written or oral commentary on the cultural resource reference materials used in preparing sections of the Draft SWEIS. Participating traditional communities had review and editing rights regarding sensitive information prior to publication.
- *Review Ethnographic Literature*. Ethnographic literature was reviewed to understand the range and types of TCPs for selected traditional communities that have documented affiliations to the study area or have expressed a cultural affiliation to the affected environment on the basis of TCP community histories. The list of American Indian cultures covered in the ethnographic literature review includes approximately 17 Pueblo and Athabaskan cultures that have vested interests in the protection of traditional places in the LANL region. These cultures include the following:
  - — Pueblo of Nambe
  - — Hispanic Communities
  - — Pueblo of Taos
  - — Pueblo de Cochiti
  - — Pueblo of Picuris
  - — Pueblo of Jemez
  - — Pueblo of San Ildefonso
  - — Pueblo of Sandia
  - — Jicarilla Apache Tribe
  - — Pueblo of Santo Domingo
  - — Pueblo of San Juan
  - — Pueblo of Zia
  - — Pueblo of Santa Clara
  - — Pueblo of Zuni
  - — Pueblo of Pojoaque
  - — Hopi Tribe
  - — Pueblo of Tesuque
  - — Navajo Nation
- *Conduct the Consultations with Communities or Groups Identified*. Consultations are meetings held within the potentially affected community. They include community/tribal representatives, leaders, elders, and resource specialists identified during the research and networking efforts outlined above. A field survey form was designed to facilitate discussions with traditional communities, assist in the recording and classification of TCPs, record concerns of potential effects of LANL operations, record suggestions for

mitigation measures, and suggest methods to preserve TCPs. The methods used at TCP consultations were flexible in order to respond to the needs of different communities. For example, some communities conducted their own consultations. A Consultation Recording Sheet and a map showing LANL and surrounding areas were left with the communities. The consultations were completed by community members or staff and returned to the researchers.

- *Identify and Contact Traditional Hispanic Community Leaders*. Similar to Pueblo/ Tribal consultations, consultations with Hispanic weavers, herbalists, lay-brotherhood members, artisans, acequia (shared community ditch) commissioners, mayordomos/mayordomas, and acequia federation offices were conducted to obtain information for the TCP study, solicit participation, and make possible the assessment of impacts. Consultations were conducted by letter, follow-up phone calls, group consultations, and site visits.
- *Identify and Invite the Participation of Regional Traditional Hispanic Organizations*. Hispanic organizations that represent the interests of traditional communities, such as artisan guilds, rural development organizations, and others were contacted and invited to participate in group consultations to identify Hispanic TCPs and possible impacts of LANL activities.
- *Conduct Hispanic Community Meetings and Interviews*. Hispanic TCPs were identified through two community meetings: one held in Jemez Springs, New Mexico, and the other held in Española, New Mexico. The general format of the meetings included a presentation on the goals and purpose of the SWEIS and definitions and examples of TCPs, followed by responses to questions regarding the TCP field survey forms. Records of the meetings were transcribed and submitted to the communities for review and comment.
- *Analyze Findings in TCP Field Survey Forms*. A classification system was developed for TCPs, based on the results of the literature search and consultations. This system was organized by category, including shrines, plant gathering areas, clay procurement areas for pottery making, hunting areas, technology sites (tool-making), and acequias. The analysis included synthesizing information from the literature review and consultations.
- *Review of TCP Information for the Draft SWEIS*. Consultations included a 30-day period to review the reference materials used for preparation of cultural resource sections of the Draft SWEIS. This was a separate review process that was limited strictly to the cultural resource sections. Upon receipt of review comments, the draft cultural resource sections were edited to reflect relevant comments.

E.5.4 Impacts Analysis Methods

The goals of the SWEIS cultural resources impacts analysis were to assess the general scale and intensity of impacts to the cultural resources from activity levels in each of the SWEIS alternatives. The cultural resource impacts analysis is not intended to take the place of project-specific NHPA and NEPA reviews, but to provide a comparative assessment of the impacts to cultural resources to be expected from each alternative.

The following parameters were established for impacts analysis:

- All cultural resources were considered in the cultural resource impacts analysis regardless of eligibility. These resources were from three broad categories: prehistoric archaeological sites, historic resources, and TCPs.
- The impacts analysis considers general categories of cultural resource types (e.g., simple and complex pueblos, scientific

laboratories, ceremonial sites) rather than impacts to individual resources. The types of effects and levels of adversity were determined for each resource class.

- Impacts are evaluated in a general manner and according to four broad categories that reflect the criteria of effect (36 CFR 800.9): destruction/alteration; isolation and restriction of access; introduction of visual, audible, or atmospheric elements out of character with the resource; and neglect leading to deterioration and vandalism. Not all classes of cultural resources will be affected by every category of effect.
- Adverse effects to any resource category were evaluated for each of the four SWEIS alternatives by means of a data matrix. Geographic overlay analysis and detailed project descriptions were used to assist in identifying the numbers and types of cultural resources that might be affected by the alternatives. Results of the consequence analysis for air quality, surface and groundwater, human health risk, and noise and vibration will be used to evaluate impacts to human users of TCPs and other potential impacts to cultural resources.
- Data from recent LANL operations were used as points of comparison for the relative severity of cultural resource impacts under each alternative. The degree of adverse impacts were qualitatively assessed according to the approximate number of resources adversely affected, the intensity of the impact, and the duration of the impact.

Table E.5.4–1 summarizes the potential for effects of various actions on categories of prehistoric cultural resources found at LANL. Table E.5.4–2 provides the potential for effects of various actions on historic resources at LANL, while Table E.5.4–3 gives the potential for effects of various actions on TCPs. LANL operations and projects reflected in the SWEIS alternatives were evaluated according to their potential effects on nearby resources, as described in these tables.

E.6 EXISTING CONDITIONS FOR CULTURAL RESOURCES AT LANL

The following subsections contain discussions of LANL's cultural resource management and the existing prehistoric, historic, and traditional cultural resources within the boundaries defined in the SWEIS or within the areas of potential impact. All data on existing conditions within LANL boundaries, including policy, procedural issues, and existing resources, were obtained for 1995 conditions. It is assumed that both policies and known resources are constantly changing within a facility as large as LANL. One area of cultural resource management, in particular, has been undergoing rapid change at LANL: the development of new contacts among LANL and the various American Indian tribal governments.

E.6.1 Cultural Resource Management at LANL

Issues regarding cultural resources at LANL are handled by the LANL Cultural Resources Management Team (CRMT) of the Environmental Assessments and Resource Evaluations Group of the Environment, Safety, and Health Division at LANL.

In a memorandum from the Director of the Environmental Guidance Division, DOE Headquarters, dated February 23, 1990, DOE was directed to ensure that management of cultural resources at all DOE facilities is in compliance with all cultural resource executive orders, laws, and regulations. The memo further stipulates that DOE programs must budget sufficient funds to support cultural resource compliance actions and programs. The CRMT follows the LANL compliance procedure outlined in the LANL *Cultural Resource*

TABLE E.5.4–1.—*Potential Impacts of Actions on Prehistoric Resource Types*

ACTION TYPE	PUEBLO STRUCTURES	ERODED PUEBLOS/ RUBBLE/ ARTIFACT SCATTER	CAVATE PUEBLOS/ROCK ART/SHELTERS AND OVERHANGS	TRAILS/STEPS/ ROCK RINGS OR STONE ARRANGEMENTS
New Construction (direct)	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites
Increased Vibrations (from traffic, explosive testing, etc.	Destruction/alteration Damage to sites	None	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites
Increased Erosion or Siltation	Destruction/alteration Damage to sites	Destruction/alteration Damage to sites	Destruction/alteration Damage to sites	Destruction/alteration Damage to sites
Shrapnel Scatter from Firing Points	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions
Explosives (direct hits)	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites	Destruction/alteration Removal of or damage to sites
Radiation Hazards (from airborne or waterborne contamination)	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions
Noise	None	None	None	None
Hazardous Material (nonradiological from airborne or waterborne contamination)	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions
Reduced Security	Destruction/neglect, alteration Removal of or damage to sites Deterioration and damage to sites from vandalism	Destruction/neglect, alteration Removal of or damage to sites Deterioration and damage to sites from vandalism	Destruction/neglect, alteration Removal of or damage to sites Deterioration and damage to sites from vandalism	Destruction/neglect, alteration Removal of or damage to sites Deterioration and damage to sites from vandalism

Note: For archaeological sites that are also TCPs, refer to Table E.5.4–3.

TABLE E.5.4–2.—*Potential Impacts of Actions on Historic Resource Categories*

ACTION TYPE	U.S. TERRITORIAL AND HOMESTEAD SITES	NUCLEAR ENERGY PERIOD BUILDINGS, DISTRICTS AND SITES (1943 TO 1989)			
		ADMINISTRATION BUILDINGS	STORAGE AND SERVICE	LABORATORIES AND PRODUCTION	HOUSING AND OTHER
New Construction (direct or indirect)	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting
Increased Noise and Vibrations	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites
Increased Erosion or Siltation	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites
Explosives Testing (direct hits or shrapnel scatter)	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites
Radiation and Nonradiological Hazards (from airborne or waterborne contamination)	Isolation Inability to access sites because of hazardous conditions	Isolation Inability to access sites because of hazardous conditions	Isolation Inability to access sites because of hazardous conditions	Isolation Inability to access sites because of hazardous conditions	Isolation Inability to access sites because of hazardous conditions
Decommissioning and Demolition	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites
Refurbishing Buildings; Changing Building Function	None	Destruction/ alteration Removal of or damage to significant components Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to significant components Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to significant components Introduction of elements out of character with setting	Destruction/ alteration Removal of or damage to significant components Introduction of elements out of character with setting

TABLE E.5.4–2.—*Potential Impacts of Actions on Historic Resource Categories*-Continued

ACTION TYPE	U.S. TERRITORIAL AND HOMESTEAD SITES	NUCLEAR ENERGY PERIOD BUILDINGS, DISTRICTS AND SITES (1943 TO 1989)			
		ADMINISTRATION BUILDINGS	STORAGE AND SERVICE	LABORATORIES AND PRODUCTION	HOUSING AND OTHER
Reduced Security/ Abandonment/Lack of Use	Neglect Deterioration and damage to sites from vandalism Destruction/ alteration Removal of or damage to sites	Neglect Deterioration and damage to sites from vandalism Destruction/ alteration Removal of or damage to sites	Neglect Deterioration and damage to sites from vandalism Destruction/ alteration Removal of or damage to sites	Neglect Deterioration and damage to sites from vandalism Destruction/ alteration Removal of or damage to sites	Neglect Deterioration and damage to sites from vandalism Destruction/ alteration Removal of or damage to sites

TABLE E.5.4–3.—*Potential Impacts of Actions on Traditional Cultural Property Categories*

ACTION TYPE	CEREMONIAL AND ARCH. SITES	NATURAL FEATURES	ETHNOBOTANICAL GATHERING SITES	ARTISAN MATERIALS GATHERING SITES	SUBSISTENCE FEATURES
New Construction (direct)	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal or damage to sites
New Construction (roads, towers, fences, signs or buildings that would be visible from TCPs or make TCPs more visible)	Introduction of elements out of character with setting Isolation Sites separated from trails and/or linked sites	Introduction of elements out of character with setting Isolation View interference	Introduction of elements out of character with setting Isolation Sites separated from trails and/or linked sites	Introduction of elements out of character with setting Isolation Sites separated from trails and/or linked sites	Destruction/ alteration Disturbance of wildlife Isolation Sites separated from trails and/ or linked sites
Increased Vibrations (from traffic, explosive testing, etc.	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/alteration Damage to sites Introduction of elements out of character with setting	Destruction/ alteration Damage to sites Introduction of elements out of character with setting	Destruction/ alteration Disturbance of wildlife
Increased Erosion or Siltation (from changes in runoff)	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/alteration Damage to sites	Destruction/ alteration Damage to sites	Destruction/ alteration Damage to sites
Shrapnel from Firing Points	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting Inability to access sites because of hazardous conditions	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting Inability to access sites because of hazardous conditions	Destruction/alteration Damage to sites Isolation/restriction of access Inability to access sites because of hazardous conditions	Destruction/ alteration Damage to sites Isolation/ restriction of access Inability to access sites because of hazardous conditions	Destruction/ alteration Disturbance of wildlife Isolation Inability to access sites because of hazardous conditions

TABLE E.5.4–3.—*Potential Impacts of Actions on Traditional Cultural Property Categories*-Continued

ACTION TYPE	CEREMONIAL AND ARCH. SITES	NATURAL FEATURES	ETHNOBOTANICAL GATHERING SITES	ARTISAN MATERIALS GATHERING SITES	SUBSISTENCE FEATURES
Explosives (direct hits from testing)	Destruction/ alteration Removal of or damage to sites Introduction of physical changes in setting Isolation/ restriction of access Inability to access sites because of hazardous conditions	Destruction/ alteration Removal of or damage to sites Introduction of physical changes in setting Isolation/ restriction of access Inability to access sites because of hazardous conditions	Destruction/ alteration Removal of or damage to sites Isolation/restriction of access Inability to access sites because of hazardous conditions	Destruction/ alteration Removal of or damage to sites Isolation/ restriction of access Inability to access sites because of hazardous conditions	Destruction/ alteration Disturbance to wildlife Isolation/ restriction of access Inability to access sites because of hazardous conditions
Radiation Hazards (from airborne or waterborne contamination)	Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites because of hazardous conditions	Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites because of hazardous conditions	Isolation/restriction of access Inability to access sites because of hazardous conditions	Isolation/ restriction of access Inability to access sites because of hazardous conditions	Isolation/ restriction of access Inability to access sites because of hazardous conditions
Noise	Introduction of elements out of character with setting	Introduction of elements out of character with setting	Introduction of elements out of character with setting	Introduction of elements out of character with setting	Destruction/ alteration Disturbance to wildlife
Hazardous Material (Nonradiological from airborne or waterborne contamination)	Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites because of contamination	Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites because of contamination	Destruction/alteration Removal or damage to sites Isolation/restriction of access Inability to access sites because of contamination	Destruction/ alteration Removal or damage to sites Isolation/ restriction of access Inability to access sites because of contamination	Destruction/ alteration Removal or damage to sites Isolation/ restriction of access Inability to access sites because of contamination

TABLE E.5.4–3.—*Potential Impacts of Actions on Traditional Cultural Property Categories*-Continued

ACTION TYPE	CEREMONIAL AND ARCH. SITES	NATURAL FEATURES	ETHNOBOTANICAL GATHERING SITES	ARTISAN MATERIALS GATHERING SITES	SUBSISTENCE FEATURES
Increased Security Restrictions	Isolation/ restriction of access Inability to access sites	Isolation/ restriction of access Inability to access sites	Isolation/restriction of access Inability to access sites	Isolation/ restriction of access Inability to access sites	Isolation/ restriction of access Inability to access sites
Changed Water Quality in Natural Springs/ Streams	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites	Destruction/alteration Removal of or damage to sites Introduction of elements out of character with setting Isolation/restriction of access Inability to access sites	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites	Destruction/ alteration Removal of or damage to sites Introduction of elements out of character with setting Isolation/ restriction of access Inability to access sites
Hydrologic Changes	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites	Destruction/ alteration Removal of or damage to sites
Changes in Maintenance	Destruction/ alteration Erosion of archeological sites	Destruction/ alteration Erosion of natural features	Destruction/alteration Erosion of natural features	Destruction/ alteration Erosion of natural features	Destruction/ alteration Erosion of natural features
Reduced Security	Destruction/ alteration Removal of or damage to sites from vandalism	Destruction/ alteration Vandalism and damage from lack of protection	Destruction/ alteration Increased visitation and damage from lack of protection	Destruction/ alteration Increased use and damage from lack of protection	Destruction/ alteration Loss of wildlife from increased hunting or visitation
Transfer of Ownership (to ownership outside SHPO review)	Destruction/ alteration Removal of or damage to sites Neglect Damage from vandalism, loss of protected status	Destruction/ alteration Removal of or damage to sites Neglect Damage from vandalism, loss of protected status	Destruction/ alteration Removal of or damage to sites Neglect Damage from vandalism, loss of protected status	Destruction/ alteration Removal of or damage to sites Neglect Damage from vandalism, loss of protected status	Destruction/ alteration Removal of or damage to sites Neglect Damage from vandalism, loss of protected status

TABLE E.5.4–3.—*Potential Impacts of Actions on Traditional Cultural Property Categories*-Continued

ACTION TYPE	CEREMONIAL AND ARCH. SITES	NATURAL FEATURES	ETHNOBOTANICAL GATHERING SITES	ARTISAN MATERIALS GATHERING SITES	SUBSISTENCE FEATURES
New Fencing	Isolation/ restriction of access Inability to access sites Introduction of elements out of character with setting	Isolation/ restriction of access Inability to access sites Introduction of elements out of character with setting	Isolation/restriction of access Inability to access sites Introduction of elements out of character with setting	Isolation/ restriction of access Inability to access sites Introduction of elements out of character with setting	Isolation/ restriction of access Inability to access sites Introduction of elements out of character with setting

Overview and Data Inventory 1995. The procedure was designed to keep LANL in compliance with the NHPA of 1966, as amended (16 U.S.C. §470); the *Archaeological Resource Protection Act* (ARPA) of 1979; AIRFA of 1978 (42 U.S.C. §1996); Executive Order 13007, Section 2(b); NAGPRA of 1990 (25 U.S.C. §3001); NEPA (42 U.S.C. §4321); and DOE's American Indian Policy (DOE Order 1230.2).

According to the LANL compliance procedure, the CRMT follows a step-by-step process to evaluate LANL actions for cultural resource compliance.

- The CRMT reviews all proposed LANL actions to determine if they are undertakings as defined in 36 CFR Part 800. According to the LANL compliance procedure, "Undertakings are activities that have the potential to affect a cultural resource and are typically activities outside buildings that disturb the ground" (LANL 1995c).
- Once an action is determined to be an undertaking, the CRMT conducts surveys of the affected area to determine if eligible cultural resources are likely to be affected by the proposed action. Cultural resource surveys are LANL controlled-release documents that are sent to the SHPO for concurrence with findings and for making determinations of eligibility. The surveys are also sent to the governors of the four Accord tribes (San Ildefonso, Santa Clara, Jemez, and Cochiti) for comment and identification of TCPs in the affected area.
- If both the DOE and the SHPO agree that a particular undertaking will have an adverse affect on eligible cultural resources, the CRMT develops a mitigation plan, specifying how the adverse effect will be mitigated. The mitigation plan is reviewed and approved by the SHPO and the National Advisory Council on Historic Preservation. According to the LANL compliance procedure, input from the public and interested American Indian groups is also solicited.
- Implementation of the mitigation plan may involve excavation of prehistoric sites if they are eligible for the NRHP under Criterion D alone. Data are analyzed by the CRMT as specified by the mitigation plan, and all recovered artifacts are curated at the Museum of New Mexico in Santa Fe, New Mexico.

In addition to the steps outlined above, measures are taken by the CRMT to provide American Indian tribes with access to information and input to the process of cultural resource management. Monthly meetings are held among DOE, the CRMT, LANL's legal counsel, LANL's Government Relations Office, and representatives of the four Accord tribes: San Ildefonso, Santa Clara, Jemez, and Cochiti. At these meetings, tribal representatives are advised of projects that may have impacts to cultural resources. According to the LANL compliance procedure, "...their input is invited on all phases of cultural resource survey, report preparation, determination of effects to cultural resources, and design of mitigation measures" (LANL 1995c). Any other tribes that identify themselves to LANL as having cultural affiliation with the region may also take part in these meetings or may be notified of LANL actions and included in consultations (Oakes 1997).

For purposes of compliance with NAGPRA, since 1995 the CRMT policy has been to contact local pueblo groups believed to be culturally affiliated with prehistoric sites at LANL, whenever human remains are uncovered. These pueblo groups would be asked for direction in the treatment and disposition of human remains.

The CRMT maintains a cultural resource administrative paper database and an electronic database and GIS of archaeological survey data. Administrative and compliance data are maintained on paper and electronically. These data include project review information, cultural resource survey data, and data on any subsequent reports. Archaeological data files include location data, site type, age, cultural affiliation, survey information, TA numbers, eligibility information, and any associated report numbers. As of 1995, the electronic prehistoric database did not contain data on the age or cultural affiliation of archaeological resources at LANL; however, these data could be found in the CRMT's paper database.

A separate electronic database has been maintained for historic resources at LANL from the Nuclear Energy Period (post-1942). This database is organized by LANL facility number and includes information about building or structure type, location, construction date, and current status or use. Some data have been added in 1995 from surveys that were conducted prior to demolition of a number of structures from this period. Comprehensive surveys have not been conducted to identify Nuclear Energy Period resources, including those from the World War II/Early Nuclear Weapons Development Period at LANL.

An archaeological site number is assigned to each new archaeological site that is encountered at LANL and a site form is filled out for most, but not all sites (LANL 1995c). Data included on the site forms have changed over the years, producing inconsistencies in the database. Beginning in 1995, the state's standard site form (used in the New Mexico Cultural Resource Information System) has been used by the CRMT. Prior to 1978, data on the site type and the age of the site were not consistently included on site forms used at LANL (PC 1995 and LANL 1995c). Site forms should be submitted to the SHPO for inclusion in the state database and the New Mexico Historic Preservation Division's ARMS. Some submittals to the SHPO are several years behind (PC 1995).

As a result of differences in information recorded on site forms at LANL and delays in the submittal of site forms to the SHPO, discrepancies exist between the state site records and LANL records.

E.6.2 Prehistoric Resources Within LANL Boundaries

A total of 1,302 prehistoric archaeological sites (sites with unique Laboratory of Anthropology numbers) have been identified within or very near LANL boundaries during archaeological investigations (LANL 1995c). The areas being considered in the SWEIS contain 1,295 sites, according to GIS overlay analysis. A breakdown of archaeological site types is provided in Table E.6.2–1. The site types have been grouped in this table according to the manner in which they respond to various impacts, such as vibration, erosion, corrosion, or explosions.

Eligibility assessments have been made on 1,192 prehistoric sites, with 770 sites found to be eligible for inclusion in the NRHP. There are 322 sites that are potentially eligible, and only 100 sites have been determined ineligible for nomination to the NRHP. The remaining 103

TABLE E.6.2–1.—*Prehistoric Cultural Resource Sites Within LANL Boundaries*

SITE TYPE	NUMBER OF SITES
Simple Pueblos	665
Complex Pueblos	62
Rock Shelters, Cavate (small caves) Pueblos	213
Rock Art	40
Water Control Features, Game Traps	56
Trails, Steps	20
Highly Eroded Pueblos, Rubble	29
Artifact Scatter, Stone Chips (lithic scatter), Rock Rings	210
TOTAL	1,295

Source: LANL 1995c

sites have not been assessed for eligibility, but are assumed to be potentially eligible by the LANL CRMT until further assessment is completed (PC 1995).

Archaeological survey work has been extensive at LANL. Several hundred small, project-related archaeological surveys have been conducted since the implementation of the NHPA at LANL in the early 1970's (LANL 1995c). Only 25 percent of LANL remains completely unsurveyed (LANL 1995c). Many LANL areas have been surveyed for archaeological resources at 100 percent coverage; others have been surveyed with only 60 percent coverage.

E.6.3 Historic Cultural Resources Within LANL Boundaries

A total of 2,319 cultural resources date from the Historic Period. There are 87 known cultural resources within LANL boundaries that date from the Early U.S. Territorial/Statehood Period, as shown in Table E.6.3–1. Most of these cultural resources have been recorded and their eligibility has been established in some cases. Of the 87 homestead resources, 22 are eligible for the NRHP. One site is also listed on the State Register of Cultural Properties. Three of these sites have been excavated (LANL 1995c).

Most cultural resources attributed to the Historic Period date from the Nuclear Energy Period, beginning with World War II and continuing through the end of the Cold War in 1989. However, no systematic survey has been conducted of the Historic Period cultural resources within LANL boundaries, nor have these resources been uniformly evaluated for eligibility for nomination to the NRHP.

Historic data about resources constructed at LANL during the World War II and the Cold War Periods have been obtained for purposes of the SWEIS from the LANL report, *Capital Asset Management Process, Fiscal Year 1997* (LANL 1995a). These data do not include non-building remains of those periods, and the numerous interrelated infrastructure support systems and functional systems present at LANL are not fully identified (LANL 1995c). The LANL Cultural Resources Database of potential historic facilities includes many existing and demolished structures.

A search of available data indicates that about 2,232 buildings, structures, or trailers that date from the Nuclear Energy Period existed at LANL in 1995. Analysis of the data shows that about 515 resources date from 1943 through 1956, and 1,717 date from 1957 through 1989. These numbers are approximate because nonbuilding resources have not been identified and demolition actions are ongoing.

E.6.4 Traditional Cultural Properties in the LANL Region

Within LANL's limited access boundaries, there are ancestral villages, shrines, petroglyphs, sacred springs, trails, and traditional use areas that could be identified by Pueblo and Athabascan communities as TCPs. The LANL CRMT has a program in place to manage on-site cultural resources for compliance with NAGPRA and AIRFA (LANL 1995c). The Pueblos of San Ildefonso and Santa Clara are considered to be most directly affiliated with archaeological sites at LANL (PC 1995 and Oakes 1997). When there is an undertaking, LANL arranges site visits by tribal representatives of the four Accord Pueblos to solicit their concerns and to comply with applicable requirements and agreements. However, this notification has been limited to Section 106 and NAGPRA compliance. Until recently, there has never been a systematic study of the TCPs at LANL that would identify other communities with potential concerns. Furthermore, TCPs that are natural features, resource gathering places, or hunting areas,

TABLE E.6.3–1.—*Historic Sites Identified by the SWEIS*

HISTORIC PERIOD	DATES	CHARACTERISTIC CULTURAL EVIDENCE	NUMBER OF KNOWN ARTIFACTS OR SITES	NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILITY
Spanish Colonial	A.D. 1600 to 1849	• Wagons • Iron hardware • Horse equipment • Pueblo V artifacts	0	
Early U.S. Territorial/ Statehood	A.D. 1850 to 1942	• European and Hispanic homesteads • Commercial ranching concerns/guest ranches: Pond cabin, Anchor Ranch, and the Los Alamos Ranch School	87	Twenty-two sites are eligible for the NRHP. One site is also listed on the State Register of Cultural Properties.[a]
Nuclear Energy	A.D. 1943 to present			
a. World War II/ Early Nuclear Weapon Development Period	A.D. 1943 through 1948	• Original Los Alamos townsite • World War II Manhattan Project facilities where the design and manufacture of the "Trinity Site: bomb; Hiroshima bomb, "Little Boy;" and Nagasaki bomb, "Fat Man" occurred • LANL sites where all U.S. Nuclear Weapons were made from 1946 to 1950 • Common artifacts consist of buildings, security fences and stations, barricades, roads, reinforced protective structures	515 (1943 to 1956)	Seventy-seven sites are eligible for the NRHP (1943–1956). One is also listed on the State Register of Cultural Properties.[a]
b. Early Cold War Period	A.D. 1949 through 1956	Pronounced expansion of facilities		
c. Late Cold War Period	A.D. 1957 through 1989	Continued expansion of facilities	1,717	These LANL buildings have not been assessed for NRHP eligibility.
Total Number of Sites			2,319	

Sources: LANL 1995–1996, LANL 1995b, LANL 1995c, McGehee 1995, and NMHPD 1995.
[a] The Ashley Pond cabin is listed twice because its occupation and use spans two historic periods.

have neither been identified nor considered in the evaluation of effects from LANL undertakings.

According to the LANL compliance procedure, American Indian tribes may request permission for visits to sacred sites within LANL boundaries for ceremonies (Oakes 1997). However, the procedure takes time, and no instances were found to indicate that tribes access ceremonial or other traditional sites by this means.

American Indian TCPs, located on lands outside LANL boundaries, such as tribal lands, state lands, federally managed lands, and private lands, may be potentially affected by LANL activities. Other federal agencies with land holdings in the area that may have TCPs include:

- U.S. Forest Service, Santa Fe and Carson National Forests
- NPS, BNM
- DOI, Bureau of Land Management, Taos Resource Area

Consultations were held with 19 American Indian tribes and two Hispanic communities as part of the SWEIS TCP study. Several contacts were made with 23 American Indian tribes; however, four did not participate in the consultations. Of the contacted communities, only the Pueblo of Santa Ana did not wish to participate at this time. The Pueblo of San Felipe showed interest during repeated telephone contacts and presentations; however, they did not elect to hold consultations during the SWEIS TCP study. All of the consulting groups indicated that they had at least some TCPs present on or near LANL, as summarized in Table E.6.4–1. These resources are present throughout LANL and adjacent lands, including the neighboring BNM, reservation lands, Santa Fe National Forest and U.S. Forest Service land.

The following subsections outline the results of consultations with American Indian and Hispanic communities. These subsections comprise statements made during the consultations, classified by the following categories: ceremonial and archaeological sites, natural features, ethnobotanical gathering sites, artisan material gathering sites, and subsistence features.

E.6.4.1 *Ceremonial Sites*

- *Pueblo of Acoma*—Pueblo of Acoma officials do not claim cultural affiliation to sites in the LANL area except in a general sense as Pueblo people. They do, however, have concerns about the treatment of human remains that may exist in the LANL area. In addition, all archaeological sites in the area are considered sacred to all Pueblo people.
- *Pueblo of Cochiti*—Tribal representatives stated that LANL is part of their ancestral domain.
- *Pueblo of Jemez*—Although LANL is on the periphery of the ancestral Jemez

TABLE E.6.4–1.—*Traditional Cultural Properties Identified by Consulting Communities on or near LANL Property*

	CEREMONIAL AND ARCHAEOLOGICAL SITES	NATURAL FEATURES	ETHNO-BOTANICAL SITES	ARTISAN MATERIAL SITES	SUBSISTENCE FEATURES
Number of Consultations Indicating the Presence of TCPs on or near LANL	15	14	10	7	8

domain, since the days of prehistory, the Jemez people have continued to make pilgrimages to sacred sites in the vicinity of Los Alamos. The Jemez people have shrines in the Los Alamos area, but not in the LANL compound.

- *Pueblo of Laguna*—Representatives from the Pueblo of Laguna indicated that the LANL area is part of Laguna's traditional use area and BNM is an important area to the tribe.
- *Mescalero Apache Tribe*—Tribal representatives stated that at least three ceremonial feast areas are located in the LANL area.
- *Navajo Nation*—Navajo tribal records document that the LANL area is a very old traditional use area with at least 20 ceremonial/archaeological sites in the area.
- *Pueblo of Picuris*—Representatives from the Pueblo of Picuris stated that their people have cultural affiliation with archaeological sites near and at LANL.
- *Pueblo of Pojoaque*—A representative from the Pueblo of Pojoaque stated that the Pueblo has traditional sites in the LANL area. Tribal members mostly travel to the east to hold ceremonies but go in all directions for prayers; e.g., towards Santa Fe and White Rock. Many tribal members long ago went to the Los Alamos area, traveling through San Ildefonso and Garcia Canyon to White Rock. Oral stories often pertain to Jacona Peak and the BNM area. A traditional trail traverses what is now LANL, but it is no longer used due to denied access.
- *Pueblo of Sandia*—Tribal officials from the Pueblo of Sandia said that archaeological sites in the LANL area are important. Sandia is concerned over the treatment of human remains. "They should be left alone," according to tribal representatives.
- *Pueblo of San Ildefonso*—The Pueblo of San Ildefonso recognizes the Los Alamos area as its ancestral domain. San Ildefonso claims to have over 1,500 TCPs within LANL boundaries.
- *Pueblo of Santo Domingo*—Officials from the Pueblo of Santo Domingo said tribal members use springs in the high country for ceremonial purposes, and they are concerned about pollution at these springs.
- *Pueblo of Taos*—Tribal representatives stated that tribal members travel to areas near LANL for ceremonial functions; and that, although they no longer conduct traditional activities in the immediate area of LANL, it is still considered to be sacred to them.
- *Pueblo of Zia*—Traditional routes to buffalo hunting areas in Colorado traverse LANL, along the Cuba Road and up the Rio Grande. Another route goes along the base of the Pajarito Plateau, east of LANL. These routes contain many shrines and many of these shrines are recounted in oral stories. There are also many archaeological sites, shrines, and springs in the LANL area that are important to the Zia people.
- *Pueblo of Zuni*—Representatives from the Pueblo of Zuni stated that they are concerned about the archaeological sites in the region; e.g, the Stone Lions at BNM. Prehistoric pottery affiliated with the Zuni people has been found at LANL.
- *Hispanic Communities*—Hispanic communities identified several ceremonial sites, such as traditional pilgrimage route that leads from the Jemez Springs area, through LANL, and along the highway to the Santuario de Chimayo. Another pilgrimage route exists between Wagon Mound and the Santuario de Chimayo. Pilgrimages are conducted on foot both at Christmas and during Lenten week. A third pilgrimage or procession area exists along Highway 84 near Abiquiu. Many pilgrimage trails converge on the Santuario de Chimayo in the Nambe area. Some representatives mentioned that privatization of some land had limited access to pilgrimage trails and sacred sites.

Descansos, crosses or stone markers along pilgrimage routes are used as sites to remember the dead. Ceremonies are also conducted along the acequias in some villages to protect the water and ensure good crops, according to Hispanic consultants.

E.6.4.2 *Natural Features*

- *Pueblo of Acoma*—Officials from the Pueblo of Acoma stated that the LANL area is sacred.
- *Hopi Tribe*—Hopi tribal representatives stated they hold the Jemez Mountains as traditionally significant, and Hopi Kachinas go to their home in these mountains.
- *Jicarilla Apache Tribe*—The Jemez Mountains were identified by the Jicarilla Apache Tribe as culturally significant. They have traditionally bathed in hot springs in various locations, including the Jemez area and Pagosa Springs.
- *Mescalero Apache Tribe*—The Mescalero Apache tribal officials indicated that Los Alamos Mountain is of traditional importance.
- *Navajo Nation*—Tribal documents of the Navajo Nation identify 19 natural features in the LANL area. The Jemez Mountains are significant and Pajarito Mountain and Pajarito Springs are considered sacred. Pajarito Mountain is tied to the Navajo creation story.
- *Pueblo of Picuris*—Tribal members of the Pueblo of Picuris have traditionally used the hot springs at Jemez.
- *Pueblo of Pojoaque*—Oral stories from the Pueblo of Pojoaque pertain to Jacoma Peak and BNM.
- *Pueblo of Sandia*—Springs in and around LANL are important to members of Sandia Pueblo. They consider all springs as shrines, sacred places for prayer.
- *Pueblo of San Juan*—Representatives from the Pueblo of San Juan stated that among the significant resources in the LANL area, Jacona Peak is one of the most important.
- *Pueblo of Santa Clara*—Tribal officials from the Pueblo of Santa Clara stated that the entire Pajarito Plateau is significant not only to Santa Clara but to all the Pueblos.
- *Zia Pueblo*—One of the important features to the Zia people is Santa Clara Peak.
- *Pueblo of Zuni*—Representatives from the Pueblo of Zuni said the LANL area is part of their traditional use area and tribal members collect water in the vicinity. They are concerned about the effects of LANL activities on springs.
- *Hispanic Communities*—Natural features were not mentioned as important Hispanic TCPs in any consultations.

E.6.4.3 *Ethnobotanical Gathering Sites*

- *Hopi Tribe*—Members of the Hopi Tribe gather cattails from the LANL area for dances.
- *Pueblo of Jemez*—The Jemez people have traditionally collected and continue to collect medicinal plants and other plants in the Los Alamos vicinity.
- *Jicarilla Apache Tribe*—Members of the Jicarilla Apache tribe collect willow, sumac, and medicinal plants in the LANL area.
- *Mescalero Apache Tribe*—Members of the Mescalero Apache tribe have plant gathering areas near LANL.
- *Pueblo of Nambe*—Officials from the Pueblo of Nambe stated that the Los Alamos area is a Nambe traditional use area and the people from the Pueblo gather plants in the vicinity.
- *Pueblo of Pojoaque*—Pojoaque tribal members go towards Santa Fe and White Rock for pinyon nut gathering and plant gathering.

- *The Pueblo of Sandia*—Tribal officials cannot give specific plant collection locations because weather patterns change and collection locations change annually with weather patterns. They collect wild tobacco, prickly pear, yucca root, gooseberries, chokecherries, osha, wild spinach, bee weed (for paint), wild garlic, and juniper roots from the Jemez Mountains and around Fenton Lake, as well as pinyon nuts and evergreens from the Jemez Mountains.
- *Pueblo of Zia*—Many herbs are collected by members of Zia Pueblo in the canyons around LANL, such as Pueblo Canyon.
- *Pueblo of Zuni*—Representatives of the Pueblo of Zuni said tribal members collect plants in the LANL vicinity.
- *Hispanic Communities*—Many wild plants are gathered for medicine and food by traditional Hispanic people in the LANL region. The Jemez Mountains were mentioned during the consultations as an important area for gathering pinyon nuts, wild fruit, and herbs. The areas where herbs are picked vary according to season and year. Some of the medicinal plants that are gathered in the LANL region include cota, osha, yerba buena, and chimaha. Participants mentioned that families and groups make outings to the mountains to gather plants. Barranca Mesa, north of LANL boundaries, and Ojo Caliente were identified as important areas to gather wild plants.

E.6.4.4 *Artisan Material Gathering Sites*

- *Pueblo of Jemez*—The Jemez people collect obsidian and other minerals from the area.
- *Jicarilla Apache Tribe*—Members of the Jicarilla Apache tribe collect clay, pigment, and plants for basketry in the LANL area, including the Jemez Mountains, the Santa Clara and Taos areas, and the Sangre de Cristo Mountains. Micaceous clay is collected in numerous places including the El Rito area.
- *Pueblo of Nambe*—Members of the Pueblo of Nambe gather minerals in the vicinity.
- *Navajo Nation*—Navajo tribal records document four resource gathering areas in the LANL area.
- *Pueblo of Picuris*—Tribal members of the Pueblo of Picuris have collected chert near Cochiti, and their ancestors collected obsidian in the LANL area.
- *Pueblo of Taos*—Tribal members collect clay and wood from the Santa Clara and San Juan areas.
- *Pueblo of Zia*—Obsidian is collected at Obsidian Ridge by tribal members of Zia Pueblo.
- *Hispanic Communities*—Members of the Hispanic communities mentioned wood for vigas and latillas, wood for carving, and plants to dye wool, as materials commonly gathered from the areas around LANL. Some dye plants such as goldenrod are gathered along acequias. Other plants are gathered along roadsides (chamisa and cota) or in the foothills (Mormon tea). Wood for carving Santos is collected in the Los Alamos area, including cottonwood and aspen from the Santa Fe National Forest. Juniper is gathered in bulk by families for carving. Santa Clara, El Rito, the Tecolote area near La Madera, and Dixon were mentioned as areas where clay is gathered. Micaceous clay is gathered at Petaca. Special crystals called Lagrimas de Dios are collected near Dixon by artisans. One consultant mentioned that she had formerly gathered ephedra and other plants to dye her wool along the roads around LANL, but had discontinued the practice because she believed the plants were contaminated.

E.6.4.5 *Traditional Subsistence Features*

- *Pueblo of Jemez*—The Jemez people collect water from ancient springs in the area and hunt deer and elk that have migrated into the ancestral Jemez domain from the LANL area.
- *Jicarilla Apache Tribe*—Members of the Jicarilla Apache Tribe hunt in the LANL area, and some of their livestock graze near the southern border of the Jicarilla Apache reservation.
- *Pueblo of Nambe*—Officials from the Pueblo of Nambe stated that the Los Alamos area is a Nambe traditional use area and the Pueblo has TCPs located within the vicinity. Many traditional, ceremonial, and culturally used products are gathered within the area that they feel may be affected by current and future LANL undertakings. The Pueblo of Nambe people use the Los Alamos area for hunting, fishing, and wood gathering. In addition, tribal members farm, raise crops, provide feed for livestock, and gather plants and minerals in the vicinity.
- *Navajo Nation*—Tribal documents of the Navajo Nation identified two trade centers in the LANL area.
- *Pueblo of Pojoaque*—Many tribal members from the Pueblo of Pojoaque went to the Los Alamos area long ago, traveling through San Ildefonso and Garcia Canyon to White Rock, and many still hunt in this vicinity.
- *Pueblo of Sandia*—Members of the Pueblo of Sandia hunt deer and elk in the Jemez Mountains and north to the Colorado Border. They fish in the Santa Clara and Jemez areas, Santa Cruz Lake, and at Nambe Falls.
- *Pueblo of Taos*—Tribal members use the Rio Pueblo and the Rio Grande for collection of water.
- *Pueblo of Zia*—Activities that historically have taken place in Pueblo Canyon include animal collection using deer traps. Tribal members consider these deer traps to be traditional properties. The area around LANL was a prime hunting area.
- *Hispanic Communities*—Protection of the water rights and water quality of the acequias are very important to traditional Hispanic communities. Rituals are performed in the springtime to bless the water, along with the annual cleaning of the acequias. This was mentioned by several informants as very important to the community. One informant said that this was the way her children learned about the ways of the people, by working together to keep the ditch clean and to allocate the water.

Hunting and fishing were mentioned by Hispanic informants as being important traditional subsistence activities that bring together families. Outings into the mountains to hunt also include gathering pinyon nuts and fruit or firewood and involve several family members. Informants mentioned that their families used to hunt in the LANL area, but now are prevented by LANL fences and private land. People in Jemez Springs said that hunting and fishing is important to their local traditions. Wild meat is a staple of their diet in many families, and teaching one’s children to provide their own meat and jerky was mentioned as an important tradition. A participant described hunting for deer in Guaje Canyon and wild turkey around Barranca Mesa many years ago, but he no longer has access to these areas.

REFERENCES

ACHP 1991 — *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities*. Advisory Council on Historic Preservation. A report to the U.S. House of Representatives, Committee on Interior and Insular Affairs, Subcommittee on National Parks and Public Lands, and the Committee on Science, Space, and Technology. Washington, D.C. 1991

Ackerly et al. 1993 — *Acequia Systems of the Velarde Region: North-Central New Mexico, Volume 1: Overview*. N. W. Ackerly, W. Malonic, M. Ernst, J. Wakeman, and L. Lopez. A report prepared by the Center for Anthropological Research, New Mexico State University. Las Cruces, New Mexico. 1993.

Ahlborn 1968 — *The Penitente Moradas of Abiquiu*. Richard E. Ahlborn. Contributions from the Museum of History and Technology. Paper 63. Smithsonian Institution Press. Washington, D.C. 1968.

Akins 1993 — *Traditional Use Areas in New Mexico*. Nancy J. Akins. Timothy D. Maxwell, Principal Investigator, Museum of New Mexico, Office of Archaeological Studies, Office of Cultural Affairs, Historic Preservation Division. Archaeology Note 141. Santa Fe, New Mexico. 1993.

Anonymous 1976 — “Rio Grande Weaving and Dyeing Workshop.” *National Endowment for the Arts and the New Mexico Arts Commission Handbook.* Santa Fe, New Mexico. 1976.

Arrellano 1994 — *The Acequia and Agricultural Tradition of New Mexico: Prehistoric Through the Present*. Anselmo Arrellano. Center for Land Grant Studies. Research Paper No. 22. Guadalupita, New Mexico. 1994.

Bandelier 1892 — “Final Report of Investigations Among the Indians of the Southwestern United States Carried on Mainly in the Years from 1880–1885.” A. Bandelier. *Papers of the Archaeological Institute of America*, American Series IV, Part II. Peabody Museum of American Archaeology and Ethnology, Harvard University. Cambridge, Massachusetts. 1892.

Benedict 1931 — “Tales of the Cochiti Indians.” Ruth Benedict. Smithsonian Institution, Bureau of American Ethnology Bulletin 98. Washington, D.C. 1931.

Biella 1977 — “Previous Anthropological Research in the Cochiti Study Area.” Jan V. Biella. *Archeological Investigations in Cochiti Reservoir, New Mexico. Volume 1: A Survey of Regional Variability*. Jan V. Biella and Richard C. Chapman, eds. University of New Mexico, Office of Contract Archeology. pp. 105-150. Albuquerque, New Mexico. 1977.

Biella and Chapman 1977–1979	*Archeological Investigations in Cochiti Reservoir,* Volumes 1-4. Jan V. Biella and Richard Chapman. University of New Mexico, Office of Contract Archaeology. Albuquerque, New Mexico. 1977–1979.
Brayer 1938	*Pueblo Indian Land Grants of the 'Rio Abajo,' New Mexico.* Herbert O. Brayer. University of New Mexico Bulletin 334. University of New Mexico Press. Albuquerque, New Mexico. 1938.
Briggs 1980	*The Wood Carvers of Cordova, New Mexico: Social Dimensions of an Artistic Revival*. Charles L. Briggs. University of New Mexico Press. Albuquerque, New Mexico. 1980.
Broster 1983	"Paleo-Indian Adaptations to High Altitudes on Cebolleta Mesa." John B. Broster. *High Altitude Adaptations in the Southwest.* Joseph C. Winter, ed. Cultural Resources Management Report No 2. U.S. Department of Agriculture, U.S. Forest Service. Albuquerque, New Mexico. 1983.
Cajete 1994	*Look to the Mountain, An Ecology of Indigenous Education*. G. Cajete. Kivaki Press. Durango, Colorado. 1994.
Campa 1979	*Hispanic Culture in the Southwest*. Arthur L. Campa. University of Oklahoma Press. Norman, Oklahoma. 1979.
Carlson 1990	*The Spanish-American Homeland*. Alvar W. Carlson. Johns Hopkins University Press. Baltimore, Maryland. 1990.
Caywood 1966	*Excavations at Rainbow House*. L. R. Caywood. Bandelier National Monument, U.S. Department of the Interior, National Park Service, Southwest Archaeological Center. Globe, Arizona. 1966.
Cline 1972	"Spanish and Mexican Land Grants in New Mexico, 1689–1848." H. F. Cline. Expert Testimony before the Indian Claims Commission. Clearwater Publishing. New York, New York. 1972.
Cordell 1979	*Cultural Resources Overview: Middle Rio Grande Valley, New Mexico*. L. S. Cordell. U.S. Department of Agriculture, Forest Service, Southwestern Region. Albuquerque, New Mexico. 1979.
Cordell 1984	*Prehistory of the Southwest.* L. S. Cordell. Academic Press. New York, New York. 1984.
Curtin 1947	*Healing Herbs of the Upper Rio Grande*. L. S. M. Curtin. Laboratory of Anthropology. Santa Fe, New Mexico. 1947.
DeHuff 1931	"Pojoaque Giant: An Indian Legend of the Black Mesa." Elizabeth W. DeHuff. *New Mexico Magazine.* pp. 18-19. Santa Fe, New Mexico. December 1931.

Dickey 1990 — *New Mexico Village Arts*, 3rd edition. R. F. Dickey. University of New Mexico Press. Albuquerque, New Mexico. 1990.

DOD 1993 — *Coming in From the Cold: Military Heritage in the Cold War*. U.S. Department of Defense, U.S. Air Force History Office. Washington, D.C. 1993.

DOE 1994 — *American Indian Policy*. U.S. Department of Energy. Washington, D.C. 1994.

DOE 1995 — *Final Draft Cultural Resources Survey Report*. Rocky Flats Environmental Technology Site. Rocky Flats, Colorado. 1995.

DOE et al. 1992 — *Interagency Agreement for Mutual Cooperation and Respect*. U.S. Department of Energy, Pueblo of San Ildefonso, Pueblo de Cochiti, Pueblo of Santa Clara, and Pueblo of Jemez. Washington, D.C. 1992.

Douglas 1917 — "Notes on the Shrines of the Tewa and Other Pueblo Indians of New Mexico." William Boone Douglas. *Proceedings of the Nineteenth Congress of Americanists*. pp. 334-378. Washington, D.C. 1917.

Dunmire and Tierney 1995 — *Wild Plants of the Pueblo Province: Exploring Ancient and Enduring Uses.* W. W. Dunmire and G. D. Tierney. Museum of New Mexico Press. Albuquerque, New Mexico. 1995.

Ellis 1979 — "The History of San Ildefonso and Its Irrigation System." Florence Hawley Ellis. *Summaries of the History of Water Use and the Tewa Culture of the Pojoaque Valley Pueblos*. Unpublished manuscript on file, Laboratory of Anthropology. Santa Fe, New Mexico. 1979.

Elmore 1944 — *Ethnobotany of the Navajo*. Francis H. Elmore. School of American Research. Monographs: 8. Santa Fe, New Mexico. 1944.

Evans et al. 1993 — *Petroglyph National Monument Rapid Ethnographic Assessment Project*. Michael J. Evans, Richard W. Stoffle, and Sandra Lee Pinel. University of Arizona, Bureau of Applied Research in Anthropology. Tucson, Arizona. 1993.

Ferguson and Hart 1985 — *A Zuni Atlas*. University of Oklahoma Press. Norman, Oklahoma. 1985.

Ford 1968 — "An Ecological Analysis Involving the Population of San Juan Pueblo, New Mexico." Richard Ford. Ph.D. dissertation. University of Michigan. Ann Arbor, Michigan. 1968.

Ford 1976	"The Technology of Irrigation in a Northern New Mexico Pueblo." Richard Ford. *Material Culture: Styles, Organization, and Dynamics of Technology*. 1975 Proceedings of the American Ethnological Society. Robert F. Spencer, general ed. Heather Lechtman and Robert Merrill, eds. West Publishing. New York, New York. 1976.
Friedlander and Pinyan 1980	*Indian Use of the Santa Fe National Forest: A Determination from Ethnographic Sources*. Eva Friedlander and Pamela J. Pinyan. Center for Anthropological Studies. Ethnohistorical Report Series No. 1. Albuquerque, New Mexico. 1980.
GITL 1997	Maps and overlays prepared for the Los Alamos National Laboratory Site-Wide Environmental Impact Statement. Geographic Information Technologies Laboratory, Geographic Information System. 1997.
Hale and Harris 1979	"Historical Linguistics and Archaeology." K. Hale and D. Harris. *Handbook of North American Indians*, Vol. 9, GPO, pp. 170-177. Alfonso Ortiz, ed. Smithsonian Institution. Washington, D.C. 1979.
Hammond and Rey 1966	*The Rediscovery of New Mexico, 1580–1594*. George P. Hammond and Agapito Rey, eds. University of New Mexico Press. Albuquerque, New Mexico. 1966.
Harrington 1916	"The Ethnogeography of the Tewa Indians." John Peabody Harrington. *Twenty-Ninth Annual Report of the Bureau of American Ethnology, 1907–1908*. GPO, Vol. 29, p. 636. Washington, D.C. 1916.
Hart and Ferguson 1993	*Ethnohistorical Reports Relative to the Pueblos of Zuni, Hopi and Acoma and the Ramah Band of the Navajo Nation.* E. Richard Hart and T. J. Ferguson. Institute of the North American West. Seattle, Washington. 1993.
Hendricks 1993	"Road to Rebellion, Road to Reconquest: The Camino Real and the Pueblo-Spanish War, 1680–1696." Rick Hendricks. *El Camino Real de Tierra Adentro,* Cultural Resources Series No. 11. Gabrielle Palmer, ed. New Mexico Bureau of Land Management. Albuquerque, New Mexico. 1993.
Hendron 1946	*Frijoles, A Hidden Valley in the New World*. J. W. Hendron. Rydal Press. Santa Fe, New Mexico. 1946.
Hewett 1904	"Archaeology of the Pajarito Park, New Mexico." Edgar L. Hewett. *American Anthropologist.* Vol. 6, No. 5, pp. 629-659. 1904.

Hewett and Dutton 1945	"The Pueblo Indian World." Edgar L. Hewett and Bertha P. Dutton. *Handbooks of Archaeological History*. University of New Mexico and School of American Research. University of New Mexico Press. Albuquerque, New Mexico. 1945.
Hiles 1992	"An Archaeologist Guide to Native American Use of Southwestern Plants." Harold T. Hiles. *Southwestern Research Native*. Fairacres, New Mexico. 1992.
Hill 1982	*An Ethnology of Santa Clara Pueblo, New Mexico*. W. W. Hill. University of New Mexico Press. Albuquerque, New Mexico. 1982.
Hill and Treirweiller 1986	"Prehistoric Response to Food Stress on the Pajarito Plateau: Results of Pajarito Research Project." James N. Hill and Treirweiller. Manuscript to National Science Foundation by Pajarito Archaeological Research Project. University of California at Los Angeles, Department of Anthropology. 1986.
Jenkins 1972	"Spanish Land Grants in the Tewa Area." M. E. Jenkins. *New Mexico Historical Review*. Vol. 47, No. 2, pp. 113-134. 1972.
Jenkins and Schroeder 1974	*A Brief History of New Mexico*. M. E. Jenkins and A. H. Schroeder. University of New Mexico Press. Albuquerque, New Mexico. 1974.
Kessell 1979	*Kiva, Cross, and Crown*. John L. Kessell. U.S. Department of the Interior, National Park Service. Washington, D.C. 1979.
Kidder 1927	"Southwestern Archaeological Conference." A. V. Kidder. *Science*. Vol. 68, pp. 489-491. 1927.
King 1993	"Beyond Bulletin 38: Comments on the Traditional Cultural Properties Symposium." T. King. Special Issue: *Cultural Resources Management Information for Parks, Federal Agencies, Indian Tribes, States, Local Governments, and the Private Sector*. Vol. 16, pp. 60-64. U.S. Department of the Interior, National Park Service, Cultural Resources Division. 1993
Kohler 1989	"Bandelier Archaeological Excavation Project, Research Design and Summer 1988 Sampling," T. A. Kohler, ed. *Department of Anthropology Reports of Investigations,* No. 61. Washington State University. Pullman, Washington. 1989.
LaFeber 1993	*America, Russia, and the Cold War, 1945–1992,* 7th edition. LaFeber. McGraw-Hill. New York, New York. 1993.
Lange 1959	*Cochiti: A New Mexico Pueblo, Past and Present,* 1990 edition. Charles H. Lange. University of New Mexico Press. Albuquerque, New Mexico. 1959.

LANL 1986–1995 “Cultural Resource Survey Report, No. 1 through No. 116.” Los Alamos National Laboratory, Cultural Resources Management Team. Los Alamos, New Mexico. 1986–1995.

LANL 1995a *Capital Asset Management Process, Fiscal Year 1997.* Los Alamos National Laboratory. LA-UR-95-1187. Los Alamos, New Mexico. 1995.

LANL 1995b *Decommissioning Summary Site Plan*, Attachment 7, pp. 26-41. Los Alamos National Laboratory, Environmental Restoration Project. Los Alamos, New Mexico. 1995.

LANL 1995c *LANL Cultural Resource Electronic Database of Archaeological Sites.* Los Alamos National Laboratory. Los Alamos, New Mexico. 1995.

LANL 1996 Electronic database files. Los Alamos National Laboratory, Facility for Information Management, Analysis, and Display (FIMAD). Los Alamos, New Mexico. 1995–1996.

Larson 1991 *Data Recovery Plan for Seven Coalition Period Pueblos on Mesita Del Buey: Laboratory of Anthropology (LA) 4620, 4621, 4622, 4623, 4624, 4625, and 4626, Los Alamos National Laboratory, New Mexico.* Beverly M. Larson. Los Alamos National Laboratory, Environmental Protection Group (HSE-8), Health, Safety and Environment Division. Los Alamos, New Mexico. 1991.

Leonard 1970 *The Role of the Land Grant in the Social Organization and Social Processes of a Spanish American Village in New Mexico.* Olen E. Leonard. Calvin Horn, ed. Albuquerque, New Mexico. 1970.

Mathien et al. 1993 “The Pajarito Plateau: A Bibliography.” F. J. Mathien, C. R. Steen, and C. D. Allen. *Southwest Cultural Resource Center*. U.S. Department of Interior, National Park Service, Division of Anthropology. Professional Paper No. 49. Santa Fe, New Mexico. 1993.

Maxon 1969 “A Study of Two Prehistoric Pueblo Sites on the Pajarito Plateau, New Mexico.” J. C. Maxon. Unpublished thesis presented to the faculty of the University of Wisconsin. 1969.

McGehee 1995 *Decontamination and Decommissioning of 28 ‘S-Site’ Properties: Technical Area 16.* Ellen D. McGehee. Los Alamos National Laboratory. Cultural Resources Survey Report Number 84. Los Alamos, New Mexico. 1995.

Meyer 1984 *Water in the Hispanic Southwest: A Social and Legal History 1550–1850.* Michael C. Meyer. The University of Arizona Press. Tucson, Arizona. 1984.

Minge 1979	"Effectos del Pais: A History of Weaving Along the Rio Grande." W. A. Minge. *Spanish Textile Tradition of New Mexico and Colorado.* Nora Fisher, ed. Museum of New Mexico Press. Santa Fe, New Mexico. 1979.
Minnis 1991	"Famine Foods of the Northern American Desert Borderlands in Historical Context." Paul E. Minnis. *Journal of Ethnobiology.* Vol. 11, No. 2, pp. 231-257. 1991.
Moerman 1986	*Medicinal Plants of Native America*. Daniel E. Moerman. University of Michigan, Museum of Anthropology. Technical Report No. 19, Vols. 1 and 2. 1986.
NAU and SWCA 1996	*Final Report, Animas-La Plata Ethnographic Study,* Vol. 1. Report prepared by Northern Arizona University, Flagstaff, Arizona, and SWCA, Inc., Environmental Consultants. Albuquerque, New Mexico. 1996.
NMHPD 1995	*New Mexico State Register of Cultural Properties and National Register of Historic Places, Listings for Los Alamos County.* New Mexico Office of Cultural Affairs, Historic Preservation Division. Santa Fe, New Mexico. February 8, 1995.
Nordhaus 1995	*Tipi Rings: A Chronicle of the Jicarilla Apache Land Claim*. Robert J. Nordhaus. Bowarrow. Albuquerque, New Mexico. 1995.
NPS 1990	*Guidelines for Evaluating and Documenting Traditional Cultural Properties,* U.S. Department of the Interior, National Park Service, Interagency Resources Division. National Register Bulletin 38. Washington, D.C. 1990.
Oakes 1997	C. L. Oakes, GRAM Team. Personal communication with Beverly Larson, Los Alamos National Laboratory, Cultural Resource Management Team. June 18, 1997.
Parker 1993	"New Coalition Joins Park Fight," R. Parker. *Albuquerque Journal*, "Metro Plus" Section. pp. 1 and 4. Albuquerque, New Mexico. August 26, 1993.
Parker and King 1990	*Guidelines for Evaluating and Documenting Traditional Cultural Properties.* Patricia L. Parker and Thomas F. King. U.S. Department of the Interior, National Park Service, Interagency Resources Division. *National Register* Bulletin 38. Washington, D.C. 1990.
PC 1995	L. Voellinger, GRAM Team. Personal communication with Beverly Larson, U.S. Department of Energy. Los Alamos, New Mexico. December 18, 1995.
PC 1996	L. Voellinger, GRAM Team. Personal communication with Lynn Sebastian, Deputy State Historic Preservation Officer. Santa Fe, New Mexico. February 21, 1996.

Perlman 1995	*Fort Wingate Depot Activity Ethnographic Study,* Draft. Susan E. Perlman. University of New Mexico, Office of Contract Archeology. Albuquerque, New Mexico. 1995.
Peterson 1977	*The Living Tradition of Maria Martinez*. Susan Peterson. Sunstone Press. Santa Fe, New Mexico. 1977.
Powers 1988	*Archeological Research Design for a Sample Inventory Survey of Bandelier National Monument*. R. P. Powers. U.S. Department of the Interior, National Park Service, Branch of Cultural Research. Santa Fe, New Mexico. 1988.
Powers and Orcutt 1988	*The Bandelier Survey, 1987,* Preliminary Report. R. P. Powers and J. D. Orcutt. U.S. Department of the Interior, National Park Service. Santa Fe, New Mexico. 1988.
Pratt and Scurlock 1993	"New Mexico Historic Contexts." Boyd Pratt and Dan Scurlock. Manuscript on file at the New Mexico Office of Cultural Affairs, Historic Preservation Division. Santa Fe, New Mexico. 1993.
Robbins et al. 1916	*Ethnobotany of the Tewa Indians.* W. W. Robbins, J. P. Huntington, and B. Freire-Marreco. Smithsonian Institution, Bureau of American Ethnology. Bulletin 55. Washington, D.C. 1916.
Robinson et al. 1972	*Tree-Ring Dates from New Mexico I, O, V: Central Rio Grande Area.* W. J. Robinson, John Hannah, and Bruce Harrill. University of Arizona, Laboratory of Tree-Ring Research. Tucson, Arizona. 1972.
Sando 1992	*Pueblo Nations: Eight Centuries of Pueblo Indian History*. J. S. Sando. Clear Light Publishers. Santa Fe, New Mexico. 1992.
Schroeder 1979	"Pueblos Abandoned In Historic Times." A. H. Schroeder. *Handbook of American Indians, Southwest*. Alfonso Ortiz, ed. Smithsonian Institution. Vol. 9, pp. 236-254. Washington, D.C. 1979.
Seidel 1995	*Los Alamos and the Development of the Atomic Bomb.* R. W. Seidel. Otowi Crossing Press. Los Alamos, New Mexico. 1995.
Simmons 1979a	"History of the Pueblos Since 1821." M. Simmons. W. C. Sturtevant, ed. *Handbook of North American Indians, Southwest.* Alfonso Ortiz, ed. Smithsonian Institution. Vol. 9, pp. 206-223. Washington, D.C. 1979.
Simmons 1979b	"History of Pueblo-Spanish Relations to 1821." *Handbook of North American Indians, Southwest.* Alfonso Ortiz, ed. Smithsonian Institution. Vol. 9, pp. 178-193. Washington, D.C. 1979.

Starr 1900	"Shrines Near Cochiti, New Mexico." Frederick Starr. *American Antiquarian*. Vol. 22, No. 4, pp. 219-223. 1900.
Steen 1977	*Pajarito Plateau Archaeological Survey and Excavations.* C. R. Steen. Los Alamos Scientific Laboratory, U.S. Energy Research and Development Administration. Publication 77-4. Los Alamos, New Mexico. 1977.
Steen 1982	*Pajarito Plateau Archaeological Surveys and Excavations, II*. C. R. Steen. Los Alamos National Laboratory. Los Alamos, New Mexico. 1982.
Stuart and Gauthier 1981	*Prehistoric New Mexico: A Background for Survey*. David E. Stuart and Rory P. Gauthier. New Mexico Historic Preservation Bureau. Santa Fe, New Mexico. 1981.
SWCA 1995	*Native American Concerns Regarding the Paseo Del Volcan Study Corridors.* Susan E. Perlman, Southwest Cultural Associates, Inc. Report to the Federal Highway Administration and the New Mexico State Highway and Transportation Department. 1995.
SWCA 1996a	*Initial Traditional Cultural Properties Study of Heron and El Vado Reservoirs, Rio Arriba County, New Mexico.* Susan E. Perlman, Southwest Cultural Associates, Inc. Report to the U.S. Bureau of Reclamation. Albuquerque, New Mexico. 1996.
SWCA 1996b	*A Study of Hispanic Traditional Practices Along the Paseo del Volcan Study Corridors, Bernalillo and Sandoval Counties, New Mexico.* David Phillips, Jr., and Kevin (Lex) Palmer, Southwest Cultural Associates, Inc. Report to the Federal Highway Administration and New Mexico State Highway and Transportation Department. Albuquerque, New Mexico. 1996.
SWCA 1996c	*Initial Traditional Cultural Properties Study of the White Ranch Property Saguache County, Colorado.* Susan E. Perlman, Southwest Cultural Associates, Inc. Report to the Bureau of Reclamation and the Fish and Wildlife Service, Albuquerque, New Mexico. 1996.
SWCA 1996d	*Initial Traditional Cultural Property Study of the Westland Sector Plan Bernalillo County, New Mexico.* Susan E. Perlman, Southwest Cultural Associates, Inc. Report to Westland Development Company and the Albuquerque Planning Department. Albuquerque, New Mexico. 1996.
Toll 1983	*Wild Plant Use in the Rio Abajo: Some Deviations from the Expected Pattern Throughout the Central and Northern Southwest*. Mollie S. Toll. Paper presented at the Rio Abajo Area Conference Seminar on the Archaeology and History of the Soccorro District, New Mexico Institute of Mining and Technology. Soccorro, New Mexico. March 18–19, 1983.

Toll 1992 — "Patterns of Plant Use from the Late Prehistoric to Spanish Contact in the Rio Grande Valley." Mollie S. Toll. *Current Research of the Late Prehistory and Early History of New Mexico.* New Mexico Archaeological Council Special Publication. Vol. 1, pp. 51-54. 1992.

Treib 1993 — *Sanctuaries of Spanish New Mexico*. Marc Treib. University of California Press. Berkeley, California. 1993.

Truslow 1991 — *Manhattan District History: Nonscientific Aspects of Los Alamos Project Y, 1942–1946*. Edith C. Truslow. Kasha V. Thayer, ed. Los Alamos Historical Society. Los Alamos, New Mexico. 1991.

Wallis 1994 — *En Divina Luz: The Penitente Moradas of New Mexico.* Michael Wallis. University of New Mexico Press. Albuquerque, New Mexico. 1994.

Weigle 1978 — *Hispanic Villages of Northern New Mexico*. M. Weigle, ed. A reprint of one volume of the 1935 Tewa Basin Study. Jene Lyon, Publisher. Santa Fe, New Mexico. 1978.

Wendorf 1954 — "A Reconstruction of Northern Rio Grande Prehistory." Fred Wendorf. *American Anthropologist.* Vol. 56, pp. 200-227. 1954.

Wetterstrom 1986 — "Food, Diet and Population at Prehistoric Arroyo Hondo Pueblo, New Mexico." W. Wetterstrom. *Arroyo Hondo Archaeological Series,* Vol. 6. American Research Press. Santa Fe, New Mexico. 1986.

Willey 1966 — "An Introduction to North American Archaeology." Gordon R. Willey. Vol.1, *North and Middle America*. 1966.

Wolfman 1994 — *Jemez Mountains Chronology Study*. Daniel Wolfman. Museum of New Mexico, Office of Archaeological Studies. Santa Fe, New Mexico. 1994.

Worman 1967 — *Archaeological Salvage Excavations on the Mesita del Buey, Los Alamos County, New Mexico*. F. C. V. Worman. Los Alamos Scientific Laboratory. LA-3636. Los Alamos, New Mexico. 1967.

Worman and Steen 1978 — *Excavations on Mesita de Los Alamos*. F. C. V. Worman and C. R. Steen. Los Alamos National Laboratory. LA-7043-MS. Los Alamos, New Mexico. 1978.

Young 1940 — "Navajo Native Dyes: Their Preparation and Use." Stella Young. Recipes by Nonabah G. Bryan. Willard W. Beatty, ed. *Indian Handcrafts*, Vol. 2. U.S. Bureau of Indian Affairs. Chilocco, Oklahoma. 1940.

APPENDIX F
TRANSPORTATION RISK ANALYSIS

F.1 INTRODUCTION

Following in this appendix are more detailed descriptions of the transportation risk analysis methodology and results that are summarized in the main volume of the SWEIS.

Section F.2 includes a description of the types of radioactive material (RAM) packaging required by the regulations of the U.S. Department of Transportation (DOT), the U.S. Nuclear Regulatory Commission (NRC), and DOE, and examples of how packaging is used at LANL. Containers for hazardous materials (HAZMAT) are also described in section F.2. Risk measures are described in section F.3.

The methodology for quantifying the risk measures is described in section F.4. The methodology incorporates truck accident data with an emphasis on routes between Interstate 25 (I–25) and the LANL site; a computer program to determine routes, mileages, and associated population densities; and other computer codes to quantify incident-free exposures and accident doses.

The methodology for determining the numbers and types of shipments for the baseline and the identified SWEIS alternatives (No Action, Expanded Operations, Reduced Operations, and Greener) is described in section F.5.

The risk analysis results are presented in section F.6 for the base case and in section F.7 for the Santa Fe relief route case. To aid in understanding and interpreting the results, specific areas of uncertainty are described in section F.8, with emphasis on how the uncertainties may affect comparison of SWEIS alternatives.

F.1.1 Purpose of the Analysis

Although in DOT regulations (49 CFR 171.8) RAM is a subset of HAZMAT, for this transportation analysis they are addressed separately. The purpose of the transportation risk analysis is to address the human health risks arising from the transport of HAZMAT and RAM associated with the operation of LANL. The human health risks associated with truck traffic arise from exposure to the truck exhaust and the possibility of an accident that could produce injuries or fatalities. These two health risks are independent of the truck cargo and exist for similar shipments of any commodity.

The human health risks associated with the radioactive or hazardous cargo result from the possibility of release of the cargo in an accident. In addition, the radioactive cargo produces a radiation field external to the packaging even for normal conditions. Persons exposed to the external field receive a small level of radiation, referred to as incident-free exposure.

These health risks are characterized in terms of four risk measures: truck-related emissions, which could cause fatalities from latent cancer; fatalities and injuries due to collisions with heavy trucks; incident-free exposures to radiation, which could cause fatalities from latent cancer; and accidental releases of the radioactive or hazardous cargo, which could cause immediate or latent fatalities. These risk measures are described in section F.3, and the methodology used to quantify them is described in section F.4 of this appendix.

F.1.2 Scope of the Analysis

The scope of the analysis includes the transport of RAM or HAZMAT on public roads within the LANL site and off-site shipments of materials by truck or air. Air shipments begin and end with a truck shipment. Rail transport is not addressed in this analysis, because there is no rail service to LANL. The risks to workers or to the public from loading or unloading trucks prior to or after shipment are considered part of normal facility operations and are not addressed as part of the transportation analysis (these are addressed in the analysis of worker health risks due to radiation exposure in sections 5.2.6, 5.3.6, 5.4.6, and 5.5.6); however, handling during shipment is included. Shipments while public roads are temporarily closed are also included in this analysis.

The methods and assumptions described in this appendix were selected to ensure meaningful comparisons among the SWEIS alternatives. A number of generic assumptions appropriate to the overview nature of the SWEIS were made. For example, because a detailed analysis of every type of LANL shipment would be impractical, shipments representative of classes of materials were selected as described in section F.5. Three examples of material class are bulk solid RAM, liquid RAM, and flammable materials. Also, because the different packaging used for RAM are too numerous to analyze individually to determine how severe an accident must be to cause a release, all packaging meeting the same regulatory criteria are assumed to fail at the same accident force magnitude (and hence probability). These parameters are described in subsection F.4.4.

In DOT regulations on the transportation of RAM, packaging is defined in 49 CFR 173.403 as:

> ...the assembly of components necessary to ensure compliance with the packaging requirements of this subpart. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shock.

A package is defined as "the packaging together with its radioactive contents as presented for transport."

The general rule used in this appendix is that all assumptions should be conservative enough to ensure that the results do not underestimate the level of transportation risk, but not so conservative that the risk calculation is knowingly orders of magnitude too conservative or the differences between alternatives are obscured.

The focus of the transportation accident analysis is on bounding accidents; i.e., the most severe, reasonably foreseeable accidents (DOE 1994a). Transportation accidents that may occur often but that do not involve major consequences are not addressed.

F.2 PACKAGING OVERVIEW

DOT is the lead federal agency for establishing and enforcing regulations regarding safe transportation of HAZMAT and RAM. Procedures to ensure safe packaging for HAZMAT and RAM include categorizing the material and requiring the use of a packaging or container appropriate to the category. In the case of RAM, the categorization is by form, quantity, and concentration of RAM. The premise underlying packaging design for most HAZMAT and RAM is that the packages must maintain their integrity in the normal transportation environment, which includes minor accidents. An exception is that highly RAM and their packaging must survive severe accident conditions without a dangerous release of contents. Because packaging represents the primary barrier between HAZMAT and RAM being transported and exposure of the public and the environment, the regulatory approach for ensuring safety is to specify standards for the packaging of HAZMAT and RAM. These packaging requirements are an important consideration for the transportation risk assessment, and typical packaging used at LANL are described in this section. Packaging and vehicles used for RAM are described first; then chlorine cylinders, propane cargo tanks, and explosives packaging are described.

DOT sets design and performance specifications for packaging that will carry up to Type A quantities of RAM. Under an agreement with DOT, NRC sets the standards for packages of Type A and Type B quantities of RAM (subsections F.2.3 and F.2.4). DOE meets NRC's standards for certain packages and follows DOT's regulations for shipping and packaging or provides equivalent protection for its shipments. Examples of general RAM packages are shown in Figure F.2–1.

F.2.1 Limited Quantity Packaging

Limited quantities are very small amounts of radioisotopes such as amounts found in smoke detectors, lantern mantles, watches, signs, and measuring devices. The level of radioactivity listed in 49 CFR 173.425 is so low that materials containing that level can be shipped without special packages, shipping papers, markings, and labeling requirements. The materials are packaged in accordance with the general design requirements of 49 CFR 173.410. Such packages must be designed for ease of handling and proper restraint during shipment. They must be free of protuberances, easily decontaminated, and capable of withstanding the effects of vibration during transport. All valves, through which the package contents could escape, must be protected (60 Federal Register [FR] [188] 50297).

F.2.2 Industrial Packaging

Industrial packaging (IP) are authorized as packaging for low-specific-activity (LSA) materials and surface-contaminated objects (SCOs). LSA materials are naturally occurring ores, concentrates, and other materials in which the activity is essentially uniformly distributed at low levels. In contrast, materials classified as SCO are not inherently radioactive; rather, they are objects with radioactive contamination on their surfaces, also at very low levels of activity. At a minimum, each IP must meet the general design requirements of 49 CFR 173.410: it must be designed for ease of handling and proper restraint during shipment; it must be free of protuberances, easily decontaminated, and capable of withstanding the effects of vibration during transport; and valves, through which the contents could escape, must be protected. These are the only requirements that apply to IP Type 1 (IP–1) (60 FR [188] 50297).

IP Type 2 (IP–2) must also survive the Type A free drop and stacking tests. Each IP Type 3 (IP–3) must meet the requirements for IP–1 and IP–2 and the following Type A package requirements (DOT 1995b):

- A seal must be incorporated on the outside of the packaging.
- Temperatures must be within a specified range.
- A containment system that is securely closed by a positive fastening device must be included.
- Any radiolytic decomposition of materials and generation of gas by chemical reaction and radiolysis must be taken into account.
- Radioactive contents must be retained under reduced pressure.
- Each valve (except a pressure-relief device) must have an enclosure to retain any leakage.
- Shielding must remain in place to protect the packaging components.
- The failure of any tie-down attachment must not impair the ability of the package to meet other requirements.
- No loss or dispersal of the radioactive contents or any significant increase in the

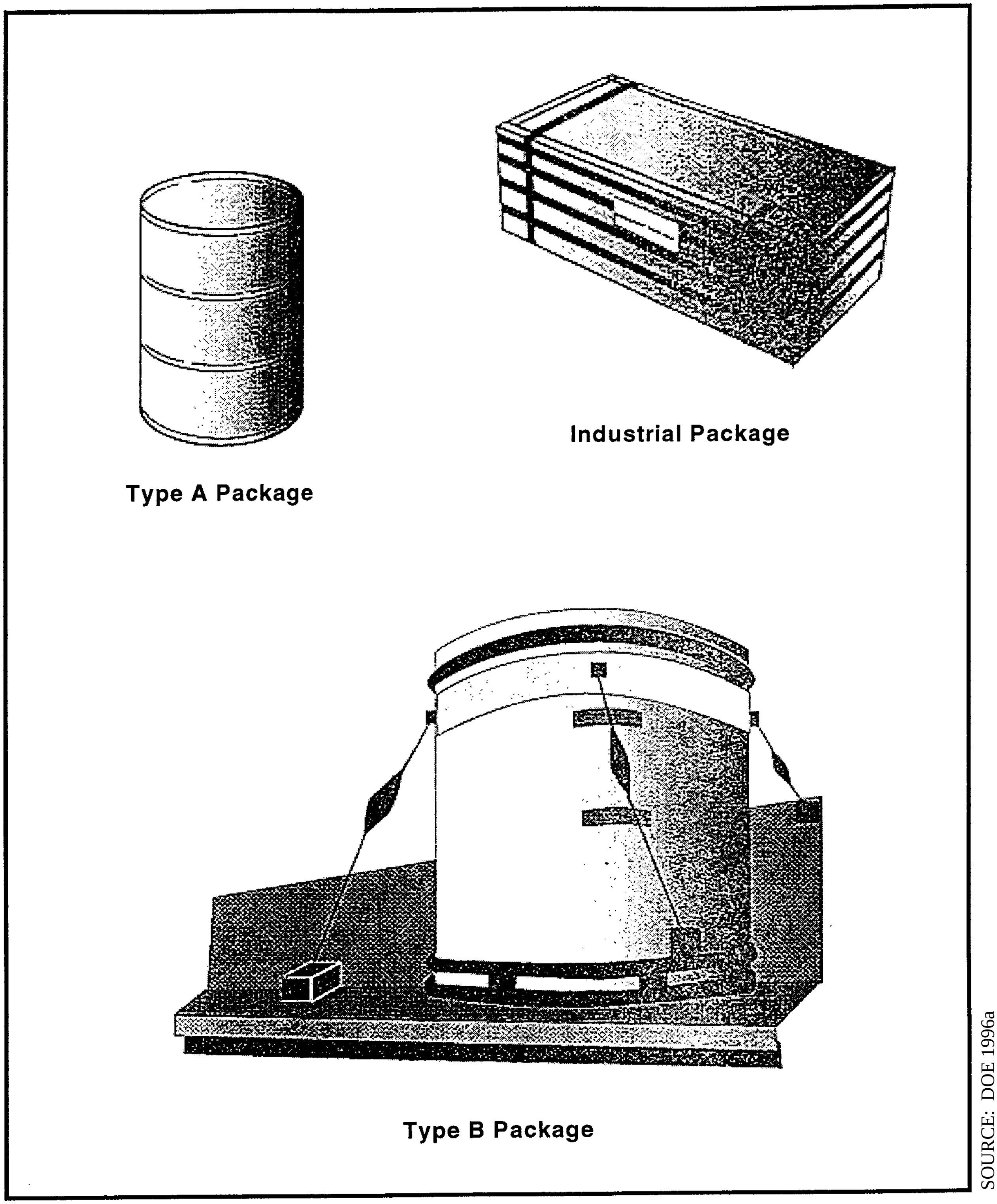


FIGURE F.2–1.—*Examples of Packaging Types.*

radiation levels at the external surfaces must occur when the IP–3 is evaluated against Type A packaging tests.

Solid depleted uranium is packaged in Type IP–1 packaging. Water with tritium concentrations up to 75.7 curies per gallon (20 curies per liter) is packaged in Type IP–2 packaging for exclusive-use shipments and Type IP–3 packaging for nonexclusive-use shipments. An exclusive-use shipment is one that is for the sole use of the consignor or consignee. SCOs such as decontamination and decommissioning wastes are packaged in Type IP–1 if the fixed alpha contamination is up to 6.45×10^{-7} curies per square inch (10^{-7} curies per square centimeter) and Type IP–2 if the fixed alpha contamination is up to 1.3×10^{-5} curies per square inch (2×10^{-6} curies per square centimeter) (60 FR [188] 50297).

F.2.3 Type A

Type A packaging are used for RAM with specific activities up to limits specified in the regulations. Type A packages must contain RAM under normal transportation conditions and must maintain sufficient shielding to limit exposure of handling personnel. Normal transportation refers to all transportation conditions except those resulting from major accidents or sabotage. Type A packages are generally steel drums or boxes made of steel, wood, or strong fiberboard (see Figure F.2.3–1 for an example of a Type A package). The packaging, with contents, must be capable of withstanding a series of tests (49 CFR 173.465) including: water spray, free drop (as high as 4 feet [1.2 meters], depending upon mass), compression, and penetration.

F.2.4 Type B

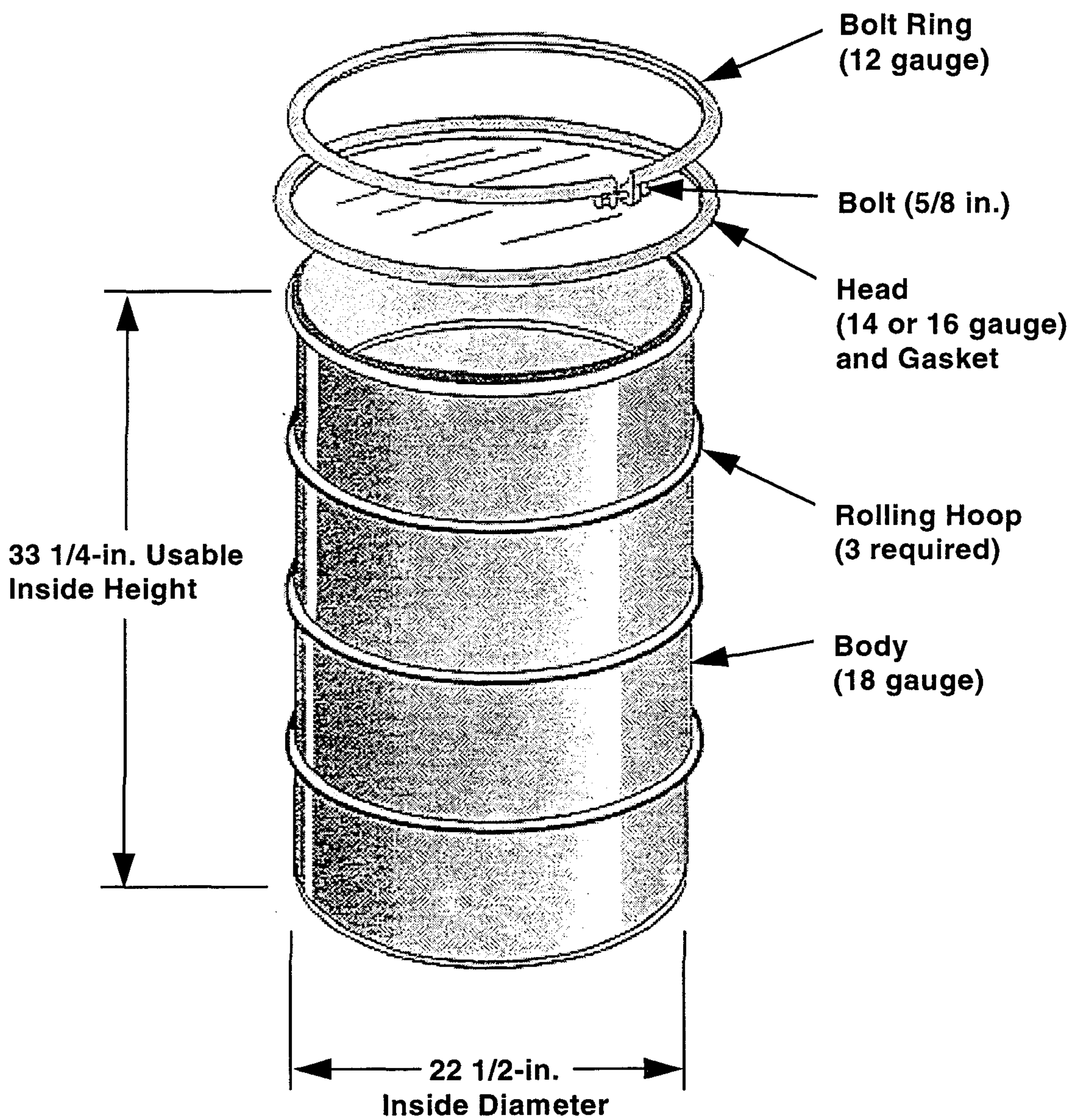
Type B containers are very durable packages used to contain and shield more hazardous amounts and forms of RAM than those contained in Type A packages. Type B packages are used to transport materials such as spent fuel and high-level radioactive waste that would present a radiation hazard to the public or the environment if a major release occurred. Type B packages must provide protection under both normal conditions of transport and severe accidents. The certified design and construction methods for Type B packages ensure the production of systems that will contain the packaged radioactive contents even after a series of rigorous accident tests. The tests for hypothetical accident conditions specified in 10 CFR 71.73 include free drop (30 feet [9 meters]), crush, puncture, thermal (exposure to 1,475°F [802°C] for 30 minutes), and immersion. The size of Type B packages can range from 40 pounds (18 kilograms) to over 100 tons (91 metric tons). Examples of Type B packages are presented in the following subsections.

F.2.4.1 *FL-Type Container*

The FL-Type container is currently the only certified container used for pit transport. It is a DOT Type B package with a 16-gage stainless steel outer containment drum surrounding a 12-gage stainless steel inner containment drum (Figure F.2.4.1–1). Fiberboard insulation is present between the inner and outer containment drums. Both the internal and external containment drums are constructed of stainless steel. The inner containment vessel is sealed with dual concentric silicone O-rings (DOE 1996c).

F.2.4.2 *Transuranic Packaging Transporter for Contact-Handled Transuranic Waste*

Contact-handled (CH) transuranic (TRU) waste is contaminated with man-made RAM with atomic numbers greater than uranium, such as plutonium, americium, and curium, which primarily emit alpha radiation. Because this type of radiation cannot penetrate human skin,



SOURCE: Cruse 1992

FIGURE F.2.3–1.—*Type A DOT–17H 55-Gallon (208-Liter) Steel Drum.*

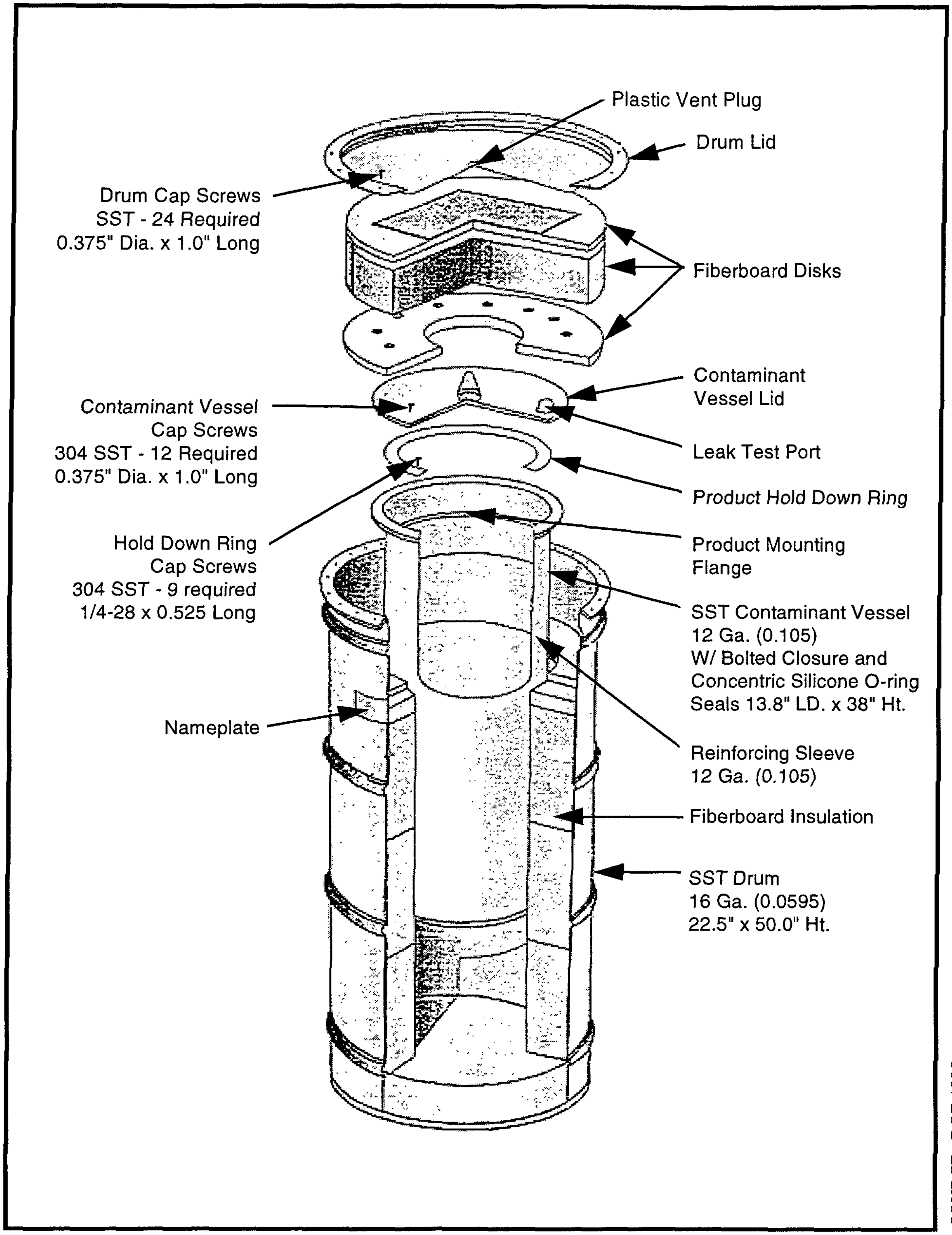


FIGURE F.2.4.1–1.—*Cross Section of an FL-Type Container.*

CH TRU waste is a hazard only if inhaled or ingested. The waste includes such materials as laboratory clothing, tools, glove boxes, plastic, rubber gloves, wood, metals, glassware, and solidified wastewater sludges contaminated with TRU materials. All CH TRU waste will be transported to the Waste Isolation Pilot Plant (WIPP) in the Transuranic Packaging Transporter (TRUPACT-II), a reusable shipping packaging. NRC certified this Type B package according to 10 CFR 71. As part of the certification process, full-scale TRUPACT-II prototypes were subjected to actual drop and fire tests to prove their ability to survive severe accident conditions.

The TRUPACT-II is a cylindrical metal container with a flat bottom and a domed top that is transported in an upright position (Figure F.2.4.2–1). Multi-layered wall design increases the package strength and provides the ability to withstand potential transportation incidents. The CH waste will be sealed in 55-gallon (208-liter) steel drums or waste boxes. Each TRUPACT-II can hold up to fourteen 55-gallon (208-liter) steel drums, or two standard waste boxes (WGA and DOE 1995).

F.2.4.3 *UC–609 for Tritium*

The UC–609 package consists of a containment vessel centered by fiberboard insulation inside a 100-gallon (379-liter) drum (Figure F.2.4.3–1). The tritium contents are carried in a storage vessel inside the containment vessel. The package gross weight is 500 pounds (227 kilograms). The drum is fabricated of 14-gage Type 304 stainless steel. The Type 316 stainless steel containment vessel is 18 inches (45 centimeters) in diameter and 44 inches (112 centimeters) long and is rated for service at 110 pounds per square inch (6.36 kilograms per square centimeter), gage (psig) at 293°F (145°C). To protect the storage vessel from the effects of an accident, the annular space between the storage vessel and the containment vessel wall is filled with aluminum honeycomb to absorb impact.

The allowable contents of the UC–609 is tritium in any form (except activated luminous paint) contained in a storage vessel. The maximum quantity of RAM per package is not more than 5.3 ounces (150 grams) of tritium with the decay heat not to exceed 48 watts. The oxygen content must be less than 5 percent by volume of the gas in the containment vessel. The maximum internal pressure of the containment vessel must not exceed 110 psig at 293°F (145°C) (Wangler 1995).

F.2.4.4 *DOT–6M*

The DOT–6M container is a metal packaging conforming to DOT Specification 6M (49 CFR 178.354). The sizes and payloads of DOT–6M containers vary. The rated capacity is not less than 10 gallons (38 liters) and no more than 110 gallons (416 liters) for the outer steel drum. The capacity of the inner containment vessel is not less than 0.33 gallon (1.24 liters). The inner containment vessel must conform to specification 2R or equivalent, with a maximum usable inside diameter of 5.25 inches (13.33 centimeters), a minimum usable inside diameter of 4 inches (10 centimeters), and a minimum height of 6 inches (15 centimeters). The inner containment vessel must be fixed within the outer shell by machined disks and rings made of solid industrial cane fiberboard, hardwood, or plywood. DOT Specification 6M metal packaging is used only for solid or gaseous RAM that will not undergo pressure-generating decomposition at temperatures up to 250°F (121°C) and that do not generate more than 10 watts of radioactive decay heat (49 CFR 173.416). A 55-gallon (208-liter) 6M packaging is shown in Figure F.2.4.4–1.

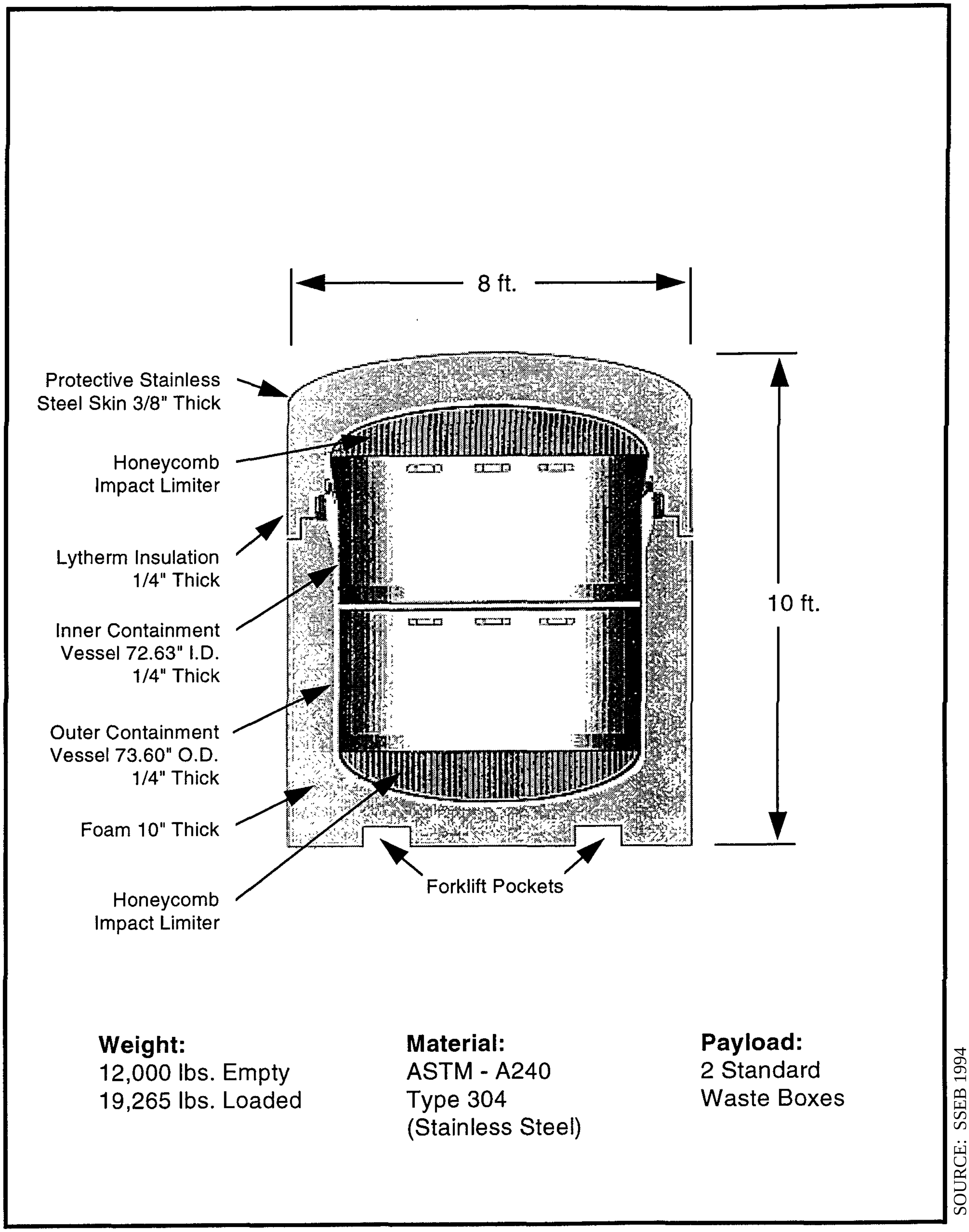


FIGURE F.2.4.2–1.—*TRUPACT-II.*

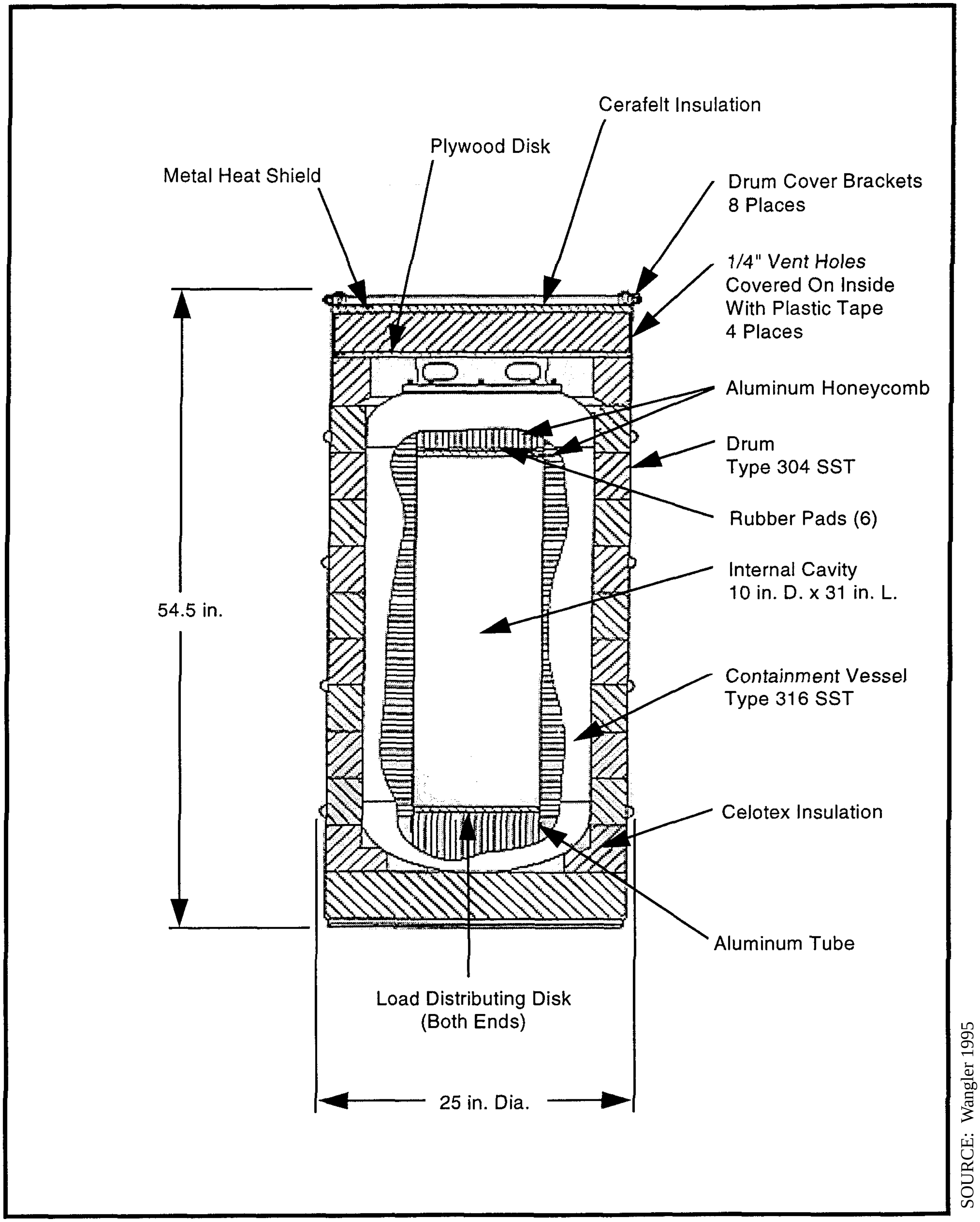


FIGURE F.2.4.3–1.—*Model No. UC–609 Shipping Package.*

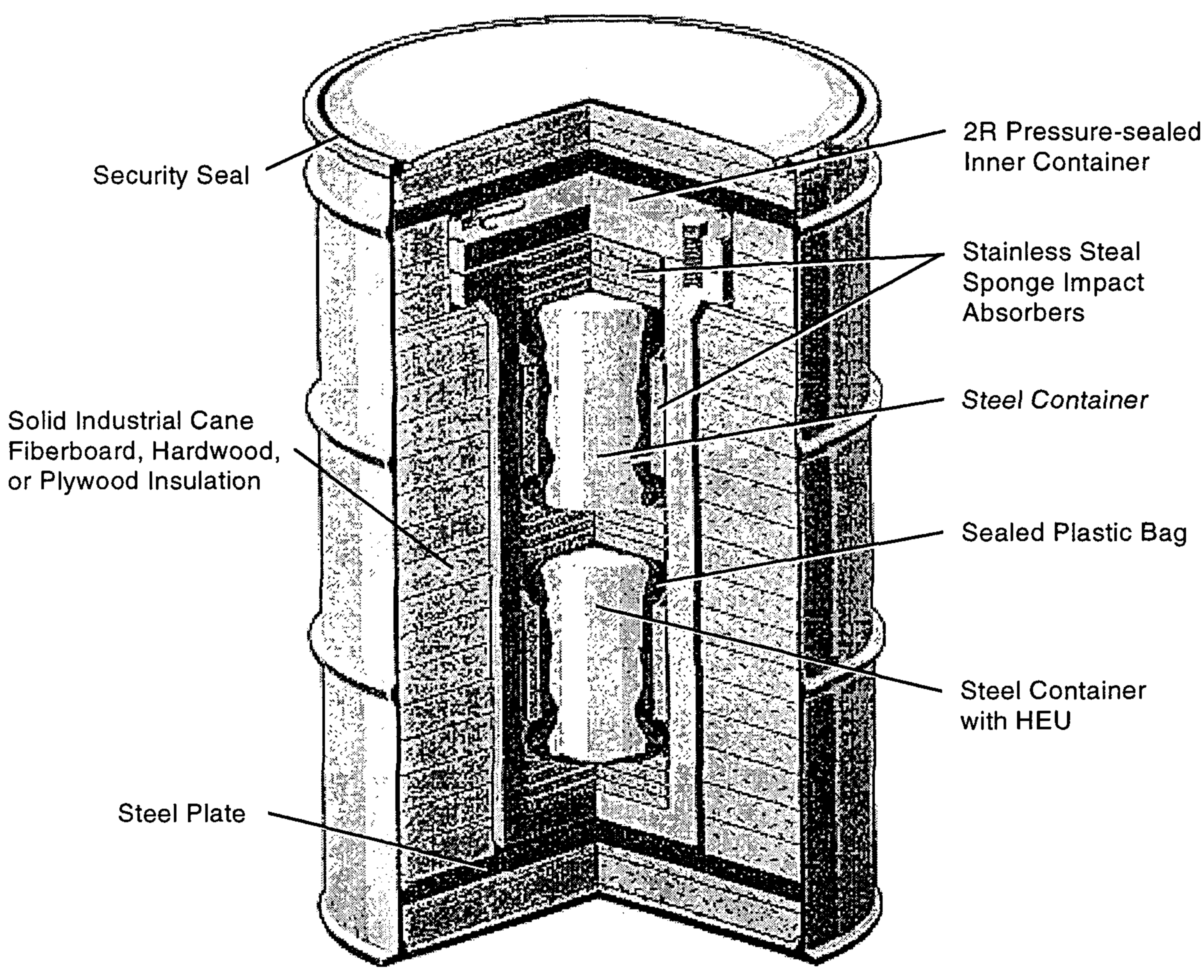


FIGURE F.2.4.4–1.—*55-Gallon (208-Liter) 6M Packaging.*

F.2.4.5 *5320 for Plutonium Oxide and Americium Oxide*

The basic arrangement of the 5320 shipping cask is an upright cylinder with a domed top (see Figure F.2.4.5–1). The weight of the cask is about 327 pounds (149 kilograms), the overall height is 32 inches (81.3 centimeters), and the diameter is 16.75 inches (42.55 centimeters). The cask cavity has a length of 17.5 inches (44.5 centimeters) and a diameter of 1.73 inches (4.39 centimeters). The nested primary and secondary containment vessels are surrounded by a finned aluminum shield tank filled with water-filled polyester. The containers are retained within the central sleeve of the shield tank by a bolt that holds the bottom of the secondary container against the baseplate. Heat from the package contents is conducted to the outer shell of the shield tank by radial aluminum plates that connect the central sleeve to the outer shell. Axial fins on the outer shell dissipate the heat to the environment. An expanded metal screen encloses and protects the fins. The screen also excludes personnel contact during handling operations.

A thermal shield protects the lid, flanges, flange bolts, and seals of the secondary container during thermal accident conditions. A “top hat” style impact limiter protects all of these components during impact accidents.

Secondary containment is provided by the EP–62, which is a cylindrical pressure vessel fabricated from Type 304 stainless steel. Primary containment is provided by the EP–61, which is a Type 316 stainless steel pressure vessel with a threaded plug and cap. The containment seal is provided by seal welding the cap to the body. The EP–61 is certified as a one-time-use container. It is opened by removing the welded cap, thus exposing the threaded plug. Energy absorbers are used to center the primary containment vessel inside the secondary containment vessel.

The americium and plutonium products placed inside handling or product canisters are contained in the primary containment vessel. Possible contents include plutonium oxide and its daughter products or americium oxide in any solid form such as granules, scrap, pellets, or powder. The maximum quantity allowed is 12.6 ounces (357 grams) of plutonium of any isotopic composition or 6.2 ounces (176 grams) of americium. The maximum permissible decay heat is 203 watts (Wangler 1996).

F.2.4.6 *Model 72–B for Remote-Handled Transuranic Waste*

Packaging for remote-handled (RH) TRU waste, which produces penetrating gamma radiation, is now going through the certification process. Compliance with the NRC requirements for Type B packaging has to be demonstrated for the 72–B cask by analysis or by combination of analysis and testing. The 72–B cask is a scaled-down version of the 125–B package, which has been certified by the NRC as a Type B package.

The 72–B (Figure F.2.4.6–1) consists of two concentric stainless steel containment vessels protected by impact limiters at each end. A 2-inch (5-centimeter) lead liner between the inner and outer containment vessels provides shielding against gamma radiation. Neither containment vessel is vented, and each is capable of withstanding an internal pressure of 150 psig. The capacity of the 72–B cask is 8,000 pounds (3,632 kilograms) of payload. The payload consists of RH TRU waste packed in 30- or 55-gallon (114- or 208-liter) drums, which are contained in a carbon steel canister. A shipment of RH TRU waste will involve only one 72–B cask, loaded onto a custom-designed trailer, for truck transport to WIPP (SSEB 1994).

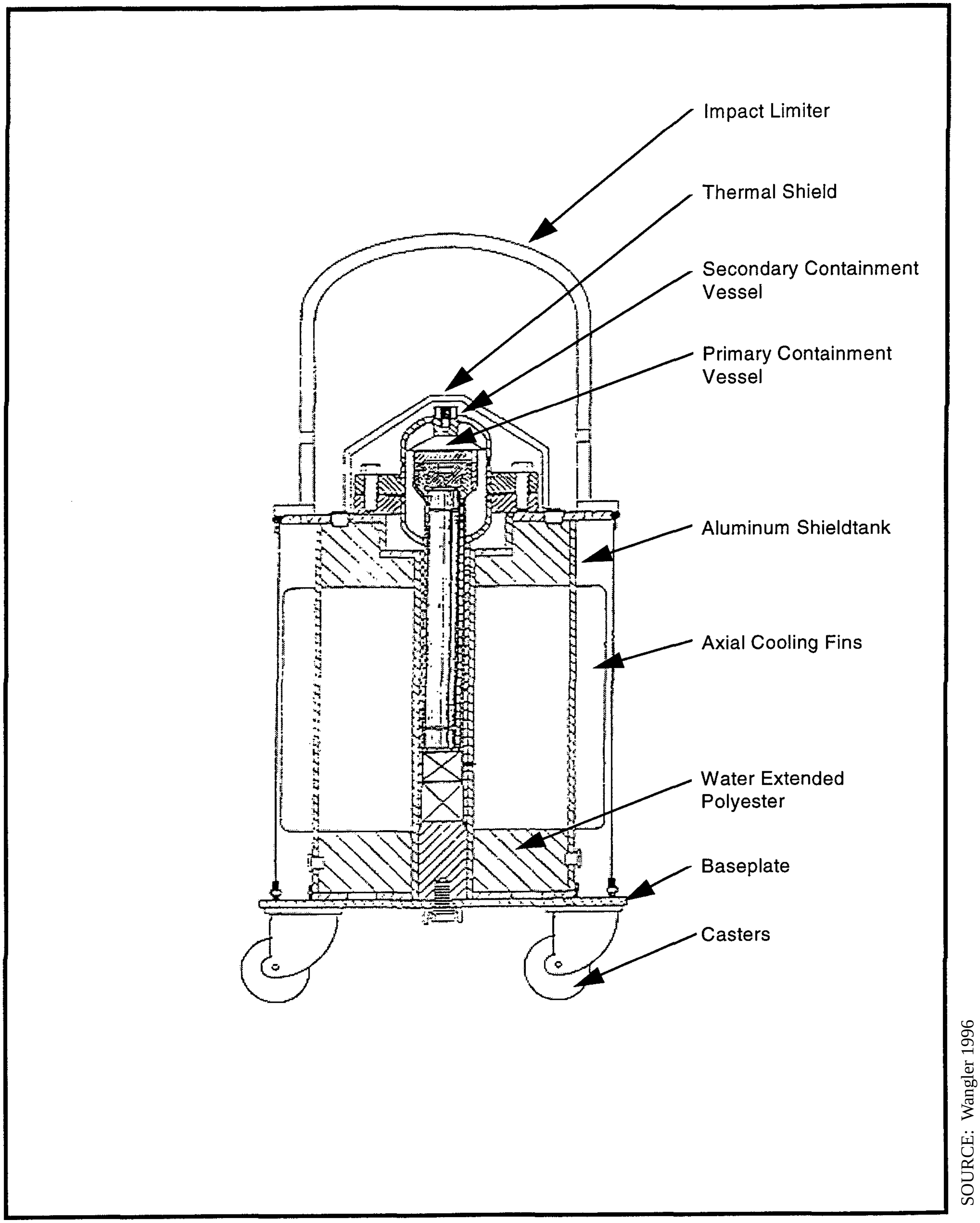


FIGURE F.2.4.5–1.—*5320 Plutonium Oxide and Americium Oxide Shipping Cask.*

SOURCE: DOE 1990

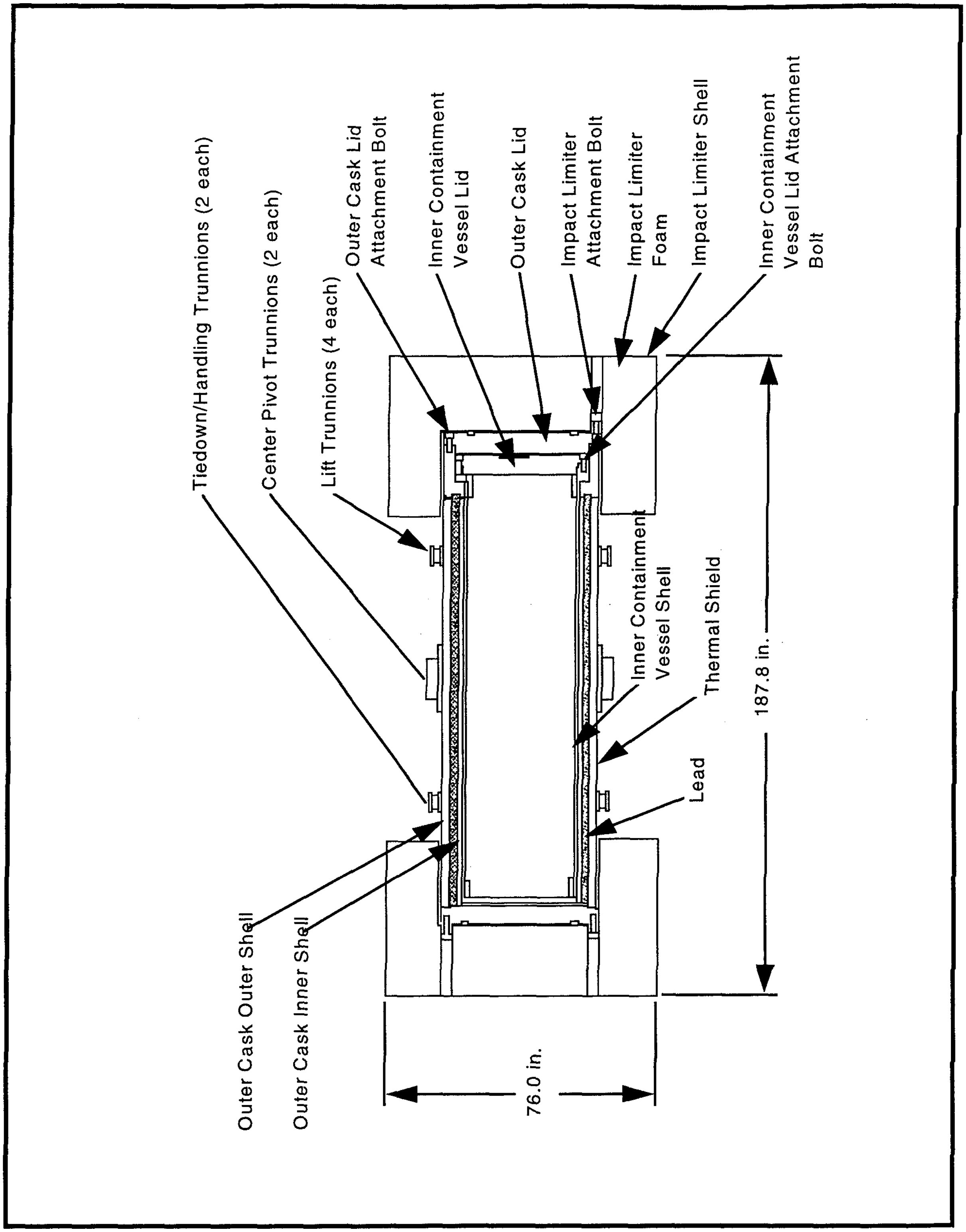


FIGURE F.2.4.6–1.—*Cross Section of Model 72–B Cask.*

F.2.5 Safe Secure Trailers

DOE maintains and operates a special fleet of trucks and trailers used to transport, in a safe and secure manner, SNM, classified configurations of nuclear weapons systems, and other forms and quantities of strategic materials between U.S. Department of Defense (DoD) sites and DOE production sites, laboratories, and test sites. DOE Albuquerque Operations Office, Transportation Safeguards Division, is responsible for the operation and maintenance of safe secure transport (SST) trailers and supporting vehicles. Because DOE exclusively operates and maintains the SST network, DOE is responsible for evaluating and approving the safe and secure use of the SSTs, both within DOE sites and between sites.

An SST trailer is a modified standard closed semi-trailer that includes necessary cargo tie-down equipment and temperature monitoring, fire alarm, and access denial systems. It is essentially a mobile vault that is highly resistant to unauthorized entry and provides a high degree of cargo protection under accident conditions. The SST trailer is pulled by an armored, penetration-resistant tractor.

SST trailers are accompanied by armed couriers in escort vehicles equipped with communications and electronics systems, radiological monitoring equipment, and other equipment to enhance safety and security. The escort vehicles must meet maintenance standards significantly more stringent than those for similar commercial transport equipment. All vehicles undergo an extensive maintenance check prior to every trip, as well as periodic preventive maintenance inspections. In addition, these vehicles are replaced more frequently than the vehicles used by commercial shippers. Every effort is made to ensure that the convoys do not travel during periods of inclement weather. Should the convoys encounter adverse weather, provisions exist for the convoys to seek secure shelter at previously identified facilities (DOE 1996a).

F.2.6 1-Ton Chlorine Containers

Chlorine is categorized as a Division 2.3 material by DOT. This division is composed of gases that are considered poisonous when inhaled (49 CFR 173.115[c]).

Regulations allow transport of chlorine by rail tank car, tank truck, 1-ton (908-kilogram) container, and gas cylinder. Only 1-ton (908-kilogram) containers and smaller gas cylinders have been used at LANL. (One-ton cylinders are no longer used at LANL as they once were; this type of container is retained for analysis because one cannot preclude their future use.) DOT specification classes for the 1-ton (908-kilogram) container are 106A and 110A. The typical chlorine 1-ton (908-kilogram) container is 81.5 inches (207 centimeters) long with an outside diameter of 30.1 inches (76.5 centimeters). The minimum actual wall thickness is usually 0.4375 inch (1.1 centimeters) (the regulatory minimum is 0.406 inch [1.0 centimeter]). The ends of the cylinder are recessed to protect valves, which are also covered by a protective bonnet. Fusible plugs in both ends are designed to open if the temperature exceeds 155°F (68°C). The capacity is 2,000 pounds (908 kilograms) of chlorine.

F.2.7 Liquid Propane Cargo Tank

Liquid propane is transported by rail tank car, tank truck, and cargo tank. The cargo tank is used primarily for local deliveries and will transport up to 2,500 gallons (9,463 liters) of liquid propane. Deliveries to LANL are by cargo truck and are usually in 2,000-gallon (7,570-liter) increments. The cargo tank is 15 feet (4.6 meters) long and 6 feet (1.8 meters) in diameter. Its walls are 0.394 inch (1.0 centimeter) thick. The tank is permanently mounted on a 14-ton (12,712-kilogram) truck body. Valves and piping are located at the rear of the truck. The tank pressure of 250 psi keeps the propane in a liquid state.

F.2.8 Explosives

Explosives are classified as Divisions 1.1 through 1.6 materials:

- *Division 1.1*—Materials that present a mass explosion hazard.
- *Division 1.2*—Materials that present a projection hazard, but not a mass explosion hazard.
- *Division 1.3*—Materials that present a fire hazard and a minor blast or project hazard (or both), but not a mass explosion hazard.
- *Division 1.4*—Materials that present minor explosion hazard.
- *Division 1.5*—Materials that present a mass explosion hazard, but that are also considered insensitive in terms of initiation of explosion.
- *Division 1.6*—Materials that are considered extremely insensitive and do not present a mass explosion hazard.

In the past, shipments to and from LANL have included materials in Divisions 1.1, 1.2, and 1.4.

Typical packages transported to LANL contain 50 pounds (22.7 kilograms) of explosives in a No. 4 fiber carton with a 4-millimeter-thick polyethylene liner. Up to 36 cartons are stacked on a wooden pallet and restrained by stretch netting. Up to 38,800 pounds (17,615 kilograms) of explosives may be transported to LANL in a tractor trailer.

F.3 RISK MEASURES

In this section, basic risk concepts are presented, key features of the transportation quantitative risk analysis are discussed, and the four risk measures used in the transportation risk analysis are described. The transportation risk analysis methodology is illustrated in Figure F.3–1.

F.3.1 Risk Concepts

The terms hazard and risk are synonymous in everyday usage but are quite different in technical language. A hazard is the inherent characteristic of a material, condition, or activity that has the potential to cause harm to people, property, or the environment. A tank pressurized with air has the potential to cause harm to people from flying fragments that would result should the tank fail. An unpressurized tank filled with HAZMAT has the potential to cause harm because of the hazardous nature and quantity of material that could be released.

Risk is the combination of the likelihood and the consequence of a specified hazard becoming uncontrolled. The specified uncontrolled hazard is the result of an accident scenario. A scenario usually consists of a sequence of events. The events are sometimes shown graphically in an event tree (section F.4.5). Likelihood can be expressed as either a frequency or a probability. Frequency is the rate at which events occur (e.g., events per year, accidents per mile). The frequency component of risk often consists of the initiating event frequency multiplied by several conditional probability terms. A probability is a number between 0 and 1 that expresses a degree of belief concerning the possible occurrence of an event. In this appendix, the term probability usually reflects a conditional probability. A conditional probability is a probability for an event that has been preceded by one or more specified events. Consequence is the direct effect, usually undesirable, of the accident scenario. Consequences usually are measured in health effects but may be expressed as cost of property loss or the amount of HAZMAT released.

Risk often is defined as frequency times consequence. However, important information

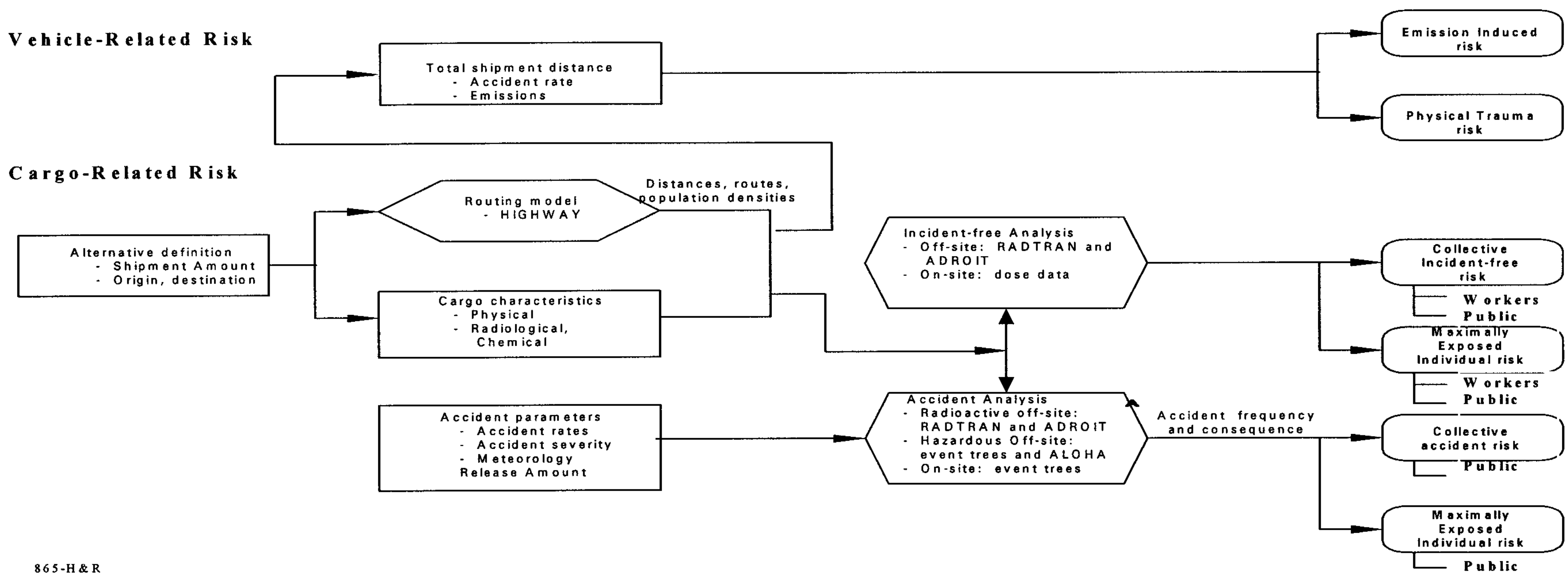


FIGURE F.3–1.—*Transportation Risk Analysis Methodology.*

may be lost when risk is expressed as the product of frequency and consequence. When frequency (or probability) is multiplied by consequence, an accident that is expected to cause one fatality and occur 10 times a year has the same mathematical risk as an accident that is expected to cause 1,000 fatalities and occur once every 100 years. Impact analysis results reported as risk values in sections F.6 and F.7 are the products of frequency and consequence to be consistent with the computer codes used to generate the results.

A quantitative risk analysis incorporates numerical estimates of the frequencies and the consequences in a sophisticated but approximate manner. In practice, few decisions require quantification of both frequency and consequence at equal levels of sophistication. Although risk assessment and risk analysis usually are used interchangeably, risk analysis is defined in the SWEIS as the computation of risks, whereas risk assessment is defined as the determination of risk acceptability. Taking action to mitigate risks is part of risk management.

F.3.2 Transportation Risk Key Parameters

A mathematical formulation specifically for transportation risk will illustrate the important parameters used in this appendix. The risk, R_i, for accident scenario *i* is a function of the scenario frequency, F_i, and the scenario consequence, C_i (Equation F-1).

$$R_i = f(F_i , C_i) \qquad \text{(F–1)}$$

The usual procedure for a quantitative transportation risk analysis is to divide the transport route into segments (also called links), along which the important parameters can be reasonably approximated by a single average value. A detailed expression for risk can then be formulated as follows (Equation F-2) (Rhyne 1994a):

$$R_i = f(F_{1a} \times M_a \times P_{2ab} \times P_{3abc} \times P_{4ad} \times P_{5ae} , N_{ad} \times A_{abc} \times X_{ace}) \qquad \text{(F–2)}$$

Where: F_{1a} = frequency of an accident per mile in transport link *a*, based, in the case of truck transport, primarily on highway type and conditions, vehicle type, and traffic conditions;

M_a = number of miles, or miles per year, in link *a*;

P_{2ab} = probability that the accident in link *a* results in accident forces of type *b* (e.g., mechanical or thermal forces);

P_{3abc} = probability that the magnitude of accident force type *b* in link *a* exceeds the container's capability to resist the force and causes release class *c* to occur;

P_{4ad} = probability that population distribution class *d* occurs in link *a*;

P_{5ae} = probability that meteorological condition *e* occurs in link *a*;

N_{ad} = number of persons per unit area in population class *d* in link *a*;

A_{abc} = release amount for release class *c*, given that force type *b* occurs in link *a*; and

X_{ace} = area that experiences the specified health effects from a unit release of the hazardous material for meteorological condition *e* for release class *c*.

The overall risk is obtained by summing all scenarios for each link or for the entire route (Equation F-3).

$$R = \sum Ri \qquad \text{(F–3)}$$

The risk expression (Equation F-2) shows that risk is directly proportional to nine parameters, the quantification of which is described in section F.4 of this appendix. The key parameters affecting the frequency term are accident rate (subsection F.4.2), mileage (subsection F.4.3), and accident severity and package release probabilities (subsection F.4.4.2). The key parameters affecting the consequence term are population density (subsection F.4.3), release amount (subsection F.4.4.3), and meteorological conditions.

Two of the parameters in Equation F-2 (specific population density and specific meteorology) are not mentioned in section F.4. These conditional probabilities are conservatively valued as 1.0 in this transportation risk analysis.

F.3.3 Truck-Related Risk Measures

Trucks carry cargo as varied as radioactive and HAZMAT, steel girders, and vegetables. Truck traffic on public highways presents two types of health risks independent of the nature of the cargo: the health effect of air pollutants, primarily the diesel fuel combustion products; and the injuries and fatalities caused by truck accidents.

F.3.3.1 *Truck Emissions*

Truck traffic produces air pollution from the diesel engine exhaust, fugitive dust generated by the vehicle wake on the highway surface dust, and particulates from tire wear on the paved surface. The primary health effect of diesel fuel combustion is caused by sulfur oxides and particulates, although nitrogen oxides and hydrocarbons are also produced. The health effect of these pollutants is increased sickness (morbidity) and death, generally occurring after a latency period of several years. The health effect has been evaluated by Rao, et al. (1982) as 1.0 x 10^{-7} fatalities per truck kilometer in urban areas. No analysis was made for morbidity because no data were available. The result is limited to urban areas because the available air pollution mortality data were limited to metropolitan population subgroups.

To evaluate this risk measure, the number of truck miles in urban areas (evaluated as described in subsection F.4.3) associated with RAM and HAZMAT shipments is multiplied by the health effect conversion factor described in the previous paragraph. Given truck travel in an urban area, the frequency of this consequence is 1; i.e., it is certain to occur.

F.3.3.2 *Truck Accident Injuries and Fatalities*

A truck accident can result in only minor property damage (fender bender) or major property damage, an injury to the truck driver or a member of the public, or a fatality. Saricks and Kvitek (1994) give state-by-state truck accident, fatality, and injury rates. The values used in the primary study area, in conjunction with the accident rates given in subsections F.4.2.2 and F.4.2.3, are 0.21 for the conditional probability of an injury in a truck accident, and 0.01 for the conditional probability of a fatality in a truck accident (DOT 1995a). To evaluate this risk, the appropriate truck accident rate (subsection F.4.2) is multiplied by the number of truck miles (subsection F.4.3).

F.3.4 Cargo-Related Risk Measures

The cargo-related health effects are a result of the intrinsic nature of the cargo; i.e., radioactive material and HAZMAT. HAZMAT presents no health risk unless the material is released in an accident. RAM can present a health risk caused by release in an accident as well as by the normally occurring (incident-free) low-level radiation field external to the packaging. The latter is referred to as incident-free risk.

F.3.4.1 *Incident-Free Risk Measure (Radioactive Materials Only)*

The doses to three groups of the public, truck and air crew members, and to the maximally exposed individual (MEI) are quantified separately for the SWEIS. Each of the dose calculations is based on parameters such as the number of shipments and the radiation level of the shipments. Either the RADTRAN or the ADROIT computer codes described in subsection F.4.4 is used to perform the calculations. The collective doses are expressed in person-rem, and the MEI dose is expressed in rem; the conversion from person-rem and rem to human health effects is described in subsection F.4.4.5. The dose calculations are described in the following subsections.

People Along the Truck Route

The dose each person would receive depends on his or her distance from the highway and the speed of the truck as it passed. The already low radiation level at the truck would drop off rapidly as distance from the truck increased. Also, the faster the truck passed, the less time there would be for people to be exposed. The collective doses are calculated for all people living or working within 0.5 mile (0.8 kilometer) on each side of the highway for each route considered.

People Sharing the Truck Route

People in vehicles traveling in the same or the opposite direction as the shipment, as well as people in vehicles passing the shipment, would have the potential for close exposure to the radiation level from the truck. The collective doses are calculated by considering traffic count and vehicle speeds for rural, suburban, and urban areas for each route considered.

People at Truck Stops

Typical truck shipments involve stops for meals, fuel, and rest or driver change. During these stops, the public in the vicinity of the truck would be exposed to a stationary source of radiation. A simple, conservative model is used to calculate the collective doses for each route considered.

Crew Members

Collective doses are calculated for truck and aircraft crew members as well as for handlers transferring the shipment from a truck to an aircraft and vice versa for each route considered. No air shipments from or to LANL use passenger aircraft.

Maximally Exposed Individual

A hypothetical MEI is assumed to live 98 feet (30 meters) from the highway, and all trucks are assumed to pass the MEI at a speed of approximately 15 miles per hour (24 kilometers per hour).

F.3.4.2 *Releases from Accidents*

Given a very severe transportation accident, packaging/containers for radioactive/HAZMAT could fail and release their contents. Except for some shipments with very high radiation levels, such as irradiated targets for production of medical isotopes, subsequent dispersion of the material into the atmosphere would be required to produce a significant exposure to members of the public. Either the RADTRAN or ADROIT computer code described in subsection F.4.4 is used to perform the calculations for RAM. The potential acute dose for an individual is expressed in rem, and the potential latent dose for collective population exposure is expressed in person-rem.

The effects of dispersing toxic materials are expressed as the number of persons who could be exposed to life-threatening or injury-producing concentrations. Detonation effects are expressed as the number of persons who could be killed as a result of a fireball or the number of severe burns that could result.

F.4 TRANSPORTATION RISK METHODOLOGY

F.4.1 Introduction and Overview

The analyses of both radioactive and HAZMAT risks are largely accomplished with standard computer codes; the computer code methodology is documented in more detail elsewhere and will not be repeated here. However, the standard parameters (also called the default values) used in the RADTRAN (Neuhauser and Kanipe 1995) code are presented in this section to ensure the repeatability of the results.

The first key parameter, truck and aircraft accident rates, is discussed in subsection F.4.2. State of New Mexico data are used to determine accident rates from the LANL site to I–25, and a standard state-by-state compilation is used for accident rates elsewhere. On-site truck accident rates and accident rates specific to the SST are presented. Aircraft accident rates are also described.

The second key parameter, truck mileage, is evaluated by using the HIGHWAY code (Johnson et al. 1993) as described in subsection F.4.3. The HIGHWAY code also produces population density values (a key parameter) based on 1990 census data as discussed in subsection F.4.3. State-by-state mileages are quantified by HIGHWAY in each of three population density categories: rural, suburban, and urban. The route between I–25 and Pojoaque and between Pojoaque and LANL is also subdivided by these population density categories.

The RADTRAN or ADROIT codes are used for incident-free dose calculations and for doses from accidents with RAM. An overview of the incident-free methodology and the specific input parameters is presented in subsection F.4.4, as is the accident calculation methodology. Event trees are used for defining HAZMAT and on-site RAM accident scenarios and determining their frequency. The ALOHA™ (NSC 1995) and DEGADIS (Havens and Spicer 1985) codes are used for chlorine accident dispersion calculations.

F.4.2 Accident Rates

Four sets of truck accident rates are used in the analysis: state-specific; route-specific, between I–25 and the LANL site; on-site roads with and without road closure; and the SST.

F.4.2.1 *State-Specific Truck Accident Rates*

Truck accident data for the years 1986, 1987, and 1988, from DOT Office of Motor Carriers, were divided by estimated truck miles data for the same years from DOT Federal Highway Administration (Saricks and Kvitek 1994). The average accident involvement rates for the U.S. and for the State of New Mexico are given in Table F.4.2.1–1. (Note that U.S. 285 to WIPP facility is a federal-aid primary highway.) Saricks and Kvitek point out that the New Mexico urban interstate computed value is more than two standard deviations greater than the national average and indicates decimal place errors in the New Mexico truck mileage data.

F.4.2.2 *Regional Truck Accident Rates*

Truck accident data for U.S. 84/285, NM 502, NM 4, and East Jemez Road were obtained from

TABLE F.4.2.1–1.—*Average Truck Accident Rates*

HIGHWAY TYPE	ACCIDENT RATE			
	ACCIDENTS PER KILOMETER		ACCIDENTS PER MILE	
	U.S.	NM	U.S.	NM
Urban Interstate	3.58×10^{-7}	9.64×10^{-7}	5.76×10^{-7}	1.55×10^{-6}
Rural Interstate	2.03×10^{-7}	1.92×10^{-7}	3.27×10^{-7}	3.09×10^{-7}
Federal-Aid Primary	3.94×10^{-7}	4.77×10^{-7}	6.34×10^{-7}	7.68×10^{-7}

Source: Saricks and Kvitek 1994.

the State of New Mexico (Fenner 1995 and Fenner 1996) for calendar years 1990 through 1994. Truck mileage data were obtained from the State of New Mexico (Vigil 1996) for the calendar years 1992 through 1994. The traffic count for East Jemez Road is assumed to be 65 percent of that on NM 4 on the basis of a different set of traffic counts (BAA 1993). The data and the computed accident rates are given in Table F.4.2.2–1.

Because no accidents occurred on NM 4, the East Jemez Road rate is used for conservatism. The truck accident rates in Table F.4.2.2–1 for primary highways are lower in low population areas and higher in high population areas than the corresponding values in Table F.4.2.1–1 for federal-aid primary highways in New Mexico. This difference is expected because the rate in Table F.4.2.1–1 is an average of rural, suburban, and urban areas.

F.4.2.3 *On-Site Truck Accident Rate*

In previous on-site transportation risk analyses at LANL, values from Harwood and Russell (1990) have been used for accident frequency. These values are the most widely used values for truck transport analysis. Their value for two-lane rural roads, 2.19 x 10^{-6} accidents per mile (1.36 x 10^{-6} accidents per kilometer) was considered representative for non-rush-hour traffic on the LANL site (Rhyne 1994b). (An urban rate of 8.66 x 10^{-6} accidents per mile would be appropriate for Diamond Drive and vicinity.) The representative value used here is a factor of two higher than values for NM 4 and East Jemez Road, but will be conservatively used in the SWEIS for on-site risk analyses. This analysis will also be consistent with the earlier risk analyses that are being incorporated into the SWEIS.

The rates in Tables F.4.2.1–1 and F.4.2.2–1 are averages for trucks traveling in all types of weather, day and night. However, trucking firms that strongly emphasize safety can achieve a factor of 10 reduction in accident rate (Anonymous 1994, Anonymous 1990, Wilson 1990, and OTA 1988). The emphasis on driver safety training and the vehicle maintenance program for RAM shipments on the LANL site are comparable to the safety programs at commercial trucking firms that produced a factor of 10 reduction in accident rate. RAM shipments are made only during daylight, non-rush-hour traffic, and good weather. Drivers work a regular schedule and 8-hour days. These precautions and possibly others lead to an accident rate reduction factor of at least ten for on-site shipments at LANL. As a result, the truck accident rate used in this appendix for on-site transport of RAM and HAZMAT, using DOE trucks and LANL drivers, is 2.19 x 10^{-7} accidents per mile (1.36 x 10^{-7} accidents per kilometer). The factor of 10 could also be applied to many off-site shipments. However, because it cannot be applied uniformly, it is conservatively not applied to any off-site shipments.

TABLE F.4.2.2–1.—*Truck Accident Rates in the Santa Fe to Los Alamos Area (1990 Through 1994)*

ROUTE	MILE MARKER RANGE	TOTAL NUMBER OF ACCIDENTS	AVERAGE TRUCK TRAFFIC (VEHICLES PER DAY)	TRUCK ACCIDENT RATE	
				ACCIDENTS PER KILOMETER	ACCIDENTS PER MILE
Route Through Santa Fe	160.7 to 167.6[a]	97[b]	2,104[c]	2.27×10^{-6}	3.66×10^{-6}
U.S. 84/285	167.6 to 180.2[a]	17[b]	1,677[c]	2.74×10^{-7}	4.41×10^{-7}
NM 502	18.5 to 6.3[a]	5[b]	462[c]	3.02×10^{-7}	4.86×10^{-7}
NM 4	67.8 to 66.5[a]	0[a]	520[d]	6.71×10^{-7}	1.08×10^{-6} [a]
East Jemez Road	NA (distance is 6 miles)	4[a]	520[c]	6.71×10^{-7}	1.08×10^{-6}

[a] *Source*: Fenner 1996
[b] *Source*: Fenner 1995
[c] *Source*: Vigil 1996
[d] See text
NA = Not applicable

In conformance with DOT regulations (60 FR [188] 50297), some on-site shipments are made by temporarily closing the affected portions of public roads through the LANL site. Under these conditions, many of the truck accident types can be reduced significantly or even eliminated. According to an analysis of the types of truck accidents and the LANL site administrative controls (Rhyne 1994b), the truck accident rate for closed roads is 1.44 x 10^{-8} accidents per mile (8.95 x 10^{-9} accidents per kilometer). This procedure has been used and defended previously (Rhyne 1985) and has compared well with data (Green et al. 1996). The on-site truck accident rates are given in Table F.4.2.3–1.

F.4.2.4 *Safe Secure Tractor Trailer Accident Rate*

The SST accident record is excellent. In the 9-year period between 1988 and 1996, the overall accident rate was 7.7 x 10^{-8} accidents per mile. The number of SST accidents is too small to support allocating this overall rate among the various types of routes used in the accident analyses (urban interstate, rural interstate, other urban, and other rural). Therefore, data for the relative rates of accidents on these route types for five-axle vans in the appropriate weight range (Phillips et al. 1994) was used to allocate SST rates among these route types. The resulting SST rate for each

TABLE F.4.2.3–1.—*Truck Accident Rates at the LANL Site*

TRANSPORT DESCRIPTION	ACCIDENT RATE	
	ACCIDENTS PER KILOMETER	ACCIDENTS PER MILE
Off-Site Trucks at LANL Site[a]	1.36×10^{-6}	2.19×10^{-6}
DOE Trucks with LANL Drivers[b]	1.36×10^{-7}	2.19×10^{-7}
Trucks with Road Closure[b]	8.95×10^{-9}	1.44×10^{-8}

[a] *Source*: Harwood and Russell 1990
[b] *Source*: Rhyne 1994b

route type is presented in Table F.4.2.4–1. The "other rural" value in Table F.4.2.4–1 corresponds to the "DOE trucks with LANL drivers" value in Table F.4.2.3–1. The first two values of Table F.4.2.4–1 can be compared with the first two values of Table F.4.2.1–1 to see the effect of the strong safety culture described in subsection F.4.2.3.

F.4.2.5 *Aircraft Accident Rate*

Air transport to and from LANL is assumed to be by commercial air-cargo carriers such as Federal Express to and from the Albuquerque International Airport (transport between this airport and LANL is by truck or van). Shipments are picked up in the carrier's van and taken to an airport, flown to the destination city, and taken to the final destination by the carrier's van. Commercial air-cargo carriers are categorized as large certified air carriers and are assumed to fall in the subcategory of "large nonscheduled service" for which the 1992 accident rate was 7.9 x 10^{-9} accidents per mile (DOT 1992). The accident rate has been at or below this value for 4 out of the 5 years between 1988 and 1992. The accident rate is about twice that for large, scheduled service.

Accidents involving air shipments were screened relative to truck shipments. The aircraft accident rate per mile is two orders of magnitude less than the truck accident rate per mile for similar shipments. The probability of a high severity accident is higher for aircraft, but not much higher (section F.4.4.3).

TABLE F.4.2.4–1.—*Safe Secure Trailer Accident Rates*

HIGHWAY TYPE	ACCIDENT RATE	
	ACCIDENTS PER KILOMETER	ACCIDENTS PER MILE
Urban Interstate	3.01×10^{-8}	4.85×10^{-8}
Rural Interstate	4.45×10^{-8}	7.16×10^{-8}
Other Urban	1.87×10^{-7}	3.01×10^{-7}
Other Rural	1.83×10^{-7}	2.95×10^{-7}

Source: Phillips et al. 1994

F.4.3 Route, Mileage, and Population Density Determination

The scope of the SWEIS calls for analysis of LANL shipments of RAM and HAZMAT to and from other DOE sites as well as to and from numerous educational or commercial sites. The calculation approach is to determine the RAM and HAZMAT shipments by alternative (section F.5). The routes between DOE sites are then determined for the shipments unique to those sites, and routes between geographical areas of the U.S. are determined for all other shipments. Five geographical areas are defined for RAM shipments: northeast, southeast, northwest, southwest, and New Mexico. The cities selected as representative of each area are Concord, Massachusetts; Aiken, South Carolina; Richland, Washington; Berkeley, California; and Albuquerque, New Mexico. The cities were chosen as conservatively representative on the basis of the number of shipments to various locations in the geographic area in the 1990 through 1994 baseline (see subsection F.5.2). In the northwest, southeast, and southwest, cities near DOE sites were chosen because they appeared to be reasonable choices for general shipments to and from the region. The routes for each shipment were then used to estimate shipment mileages (see Table F.6.1–1 for distances between LANL and the representative cities for RAM and HAZMAT shipments).

The representative truck routes were determined by using the routing code HIGHWAY, Version 3.3 (Johnson et al. 1993), available to the public and DOE users through the TRANSNET computer system at Sandia National Laboratories (SNL). The HIGHWAY code contains a database of at least 240,000 miles (386,000 kilometers) of roads.

The population densities along a route are derived from 1990 census data from the U.S. Bureau of the Census. Rural, suburban, and urban areas are characterized according to the following breakdown: rural population densities range from 0 to 139 persons per square mile (0 to 54 persons per square kilometer); the suburban range is 140 to 3,326 persons per square mile (55 to 1,284 persons per square kilometer); and urban areas encompass all population densities greater than 3,326 persons per square mile (1,284 persons per square kilometer).

All routes for shipment of radioactive or HAZMAT into or out of LANL are conservatively assumed to pass through Santa Fe for the baseline analysis (the comparative analysis of the proposed bypass route is discussed in section F.7 of this appendix). The route between the LANL site and I–25 in Santa Fe is subdivided into two segments. The corresponding HIGHWAY results are shown in Table F.4.3–1. Similar information was generated from I–25 in Santa Fe to each origin or destination on a state-by-state basis.

Cargo air shipments are also made to and from the LANL site. Air shipments arrive at the Albuquerque Airport and are transported by truck to the LANL site or vice versa. Air shipments are included in incident-free impact analyses, but screened from accident analyses, as discussed in section F.4.2.5.

F.4.4 RADTRAN and ADROIT Analyses for Radioactive Materials

Two of the four risk measures described in section F.3 are modeled by RADTRAN (Neuhauser and Kanipe 1995) (refer to Figure F.3–1). The RADTRAN code is designed to produce conservative estimates of the radiological dose to workers and the public during incident-free transportation and the radiological risks from potential accidents.

The RADTRAN code was originally developed in 1977 in conjunction with the preparation of NUREG–0170, *Final Environmental Statement on the Transportation of RAM by Air and Other Modes* (NRC 1977). Subsequent versions have expanded and refined the analytical capability of the code; the current version is RADTRAN 4 (Neuhauser and Kanipe 1995). RADTRAN is maintained, updated, and improved on a continuing basis by SNL for DOE. RADTRAN is available to the public as well as to DOE users through the TRANSNET computer system at SNL. RADTRAN is widely accepted and used both in the U.S. and internationally.

The ADROIT code was developed in the 1992 through 1994 time frame to replicate the RADTRAN incident-free and accident estimates specific to transport in an SST. The

TABLE F.4.3–1.—*Route Segment Information from I–25 to LANL*

ROUTE SEGMENT	TOTAL DISTANCE		AVERAGE POPULATION DENSITY (PERSONS/km^2)			DISTANCE BREAKDOWN (km)		
	km	MILES	RURAL	SUBURBAN	URBAN	RURAL	SUBURBAN	URBAN
I–25 Exit 282 to U.S. 285/84 Junction with NM 502	32.2	20.0	11	625	2,228	24.0	6.3	1.9
Junction of NM 502 and U.S. 285/84 to NM 4 and Junction of East Jemez Road and Diamond Drive	30.6	19.0	14	312	0	28.5	2.1	0.0

code was developed from first principles; and although the end results are very similar to RADTRAN, the specific models may vary. Significant differences include the use of an event tree rather than an accident severity matrix (subsection F.4.4.2). As used in this analysis, the codes can be considered equivalent.

F.4.4.1 *Incident-Free Risk Parameters*

The most important parameter for evaluation of incident-free risk is the package exterior radiation level. The transport index (TI) is used in RADTRAN to characterize the exterior radiation field. The TI is defined in 49 CFR 173.403(bb) as "the exposure rate in millirems per hour at a distance of 1 meter from the surface of the package," and DOT regulations limit the value of TI to 10 or less for general commerce shipments. The TIs for the LANL baseline shipments discussed in section F.5.0 are based on measurements. The average truck shipment TI is less than 2, and the average air shipment TI is approximately 0.1. During the data-gathering process for the SWEIS alternatives, LANL transportation specialists were asked to place a reasonable upper bound on the average for the entire shipment type being discussed. (An average is appropriate for incident-free risk in contrast to accident risk.) When there is little or no experience with a particular shipment type, the usual procedure is to use the legal limit as a conservative value.

The alternative-specific parameters are given in section F.5.0, and those generic to all alternatives are given in Table F.4.4.1–1. Two exceptions to Table F.4.4.1–1 are used: a value of 1.0 is used for the urban city street fraction in Santa Fe, and the fractions of rural and suburban travel on freeways are 0.347 between I–25 and Pojoaque and 0.525 between Pojoaque and LANL.

F.4.4.2 *Accident Severity Categories*

Accident forces include fire, crush, impact, and puncture, and many accidents involve a combination of thermal and mechanical forces. The severity of accidents is categorized in RADTRAN by up to 20 categories for the magnitudes of accident forces and the associated probabilities. The accident severity category approach seeks to relate the magnitude of an accident force with mode of package response (e.g., small structural strains produce no release; larger strains produce loss of containment function and gross rupture). Ideally, such an analysis is done for each type of package; however, as pointed out earlier, this level of detail is impractical for the SWEIS. Most DOE environmental impact statements (EISs) rely on the accident severity categorization scheme described in an NRC report commonly referred to as NUREG–0170 (NRC 1977). NRC divided the spectrum of accident severities into eight categories that are independent of a specific accident sequence. The eight categories are designed to take into account all credible accidents, including accidents with low probability but high consequence and those with high probability but low consequence. The probabilities that correspond to the accident forces characterizing a particular package response are based on analyses by Dennis et al. (1978) or Clarke et al. (1976) The NUREG–0170 accident severity categories and associated probabilities are given in Table F.4.4.2–1.

Category I accidents are the least severe and the most frequent. Category I is considered to include all those accidents less severe than the normal conditions of transport in which Type A packages are shown by tests to be capable of retaining all their contents (section F.2.0). Category II is considered to include accidents more severe than Category I but less severe than the accident conditions in which Type B packages are shown by tests to be capable of retaining all their contents. The percentage of

TABLE F.4.4.1–1.—*Parameter Values for Incident-Free Risk Quantification*

PARAMETER DESCRIPTION	TRACTOR-TRAILER	CARGO AIR	DELIVERY VAN
Speed in Rural Area, kilometers per hour	88.49	691.90	88.49
Speed in Suburban Area, kilometers per hour	40.25	691.90	56.34
Speed in Urban Area, kilometers per hour	24.16	691.90	24.16
Number of Crew	2	3	1
Average Distance from Radiation Source to Crew, meters	3.10	6.10	2.13
Number of Handlings per Shipment	0	4	6
Time Spent at Rest Stops, hours per kilometer	0.011	0.0016	0.0004
Minimum Rest Stop Time, hour	0.0	1.0	0.15
Number of Persons Exposed During Stops	50	10	100
Average Exposure Distance When Stopped, meters	20	50	10
Storage Time per Shipment, hour	0	0	10
Number of Persons Exposed During Storage	100	100	100
Average Exposure Distance When Stopped, meters	100	100	100
Number of Persons per Vehicle Sharing the Route	2	0	2
Fraction of Urban Travel During Rush Hour	0.08	0	0.08
Fraction of Urban Travel on City Streets	0.05	0	0.65
Fraction of Rural and Suburban Travel on Freeways	0.85	0	0.25
Ratio of Urban Pedestrian to Residential Population Densities	6	0	6
Rural Building Shielding Factor	1	0	1
Suburban Building Shielding Factor	0.87	0	0.87
Urban Building Shielding Factor	0.018	0	0.018

Source: Neuhauser and Kanipe 1992

TABLE F.4.4.2–1.—*Fractional Occurrences for Truck Accidents by Severity Category and Population Density Zone*

SEVERITY CATEGORY	FRACTIONAL OCCURRENCE	FRACTIONAL OCCURRENCE BY POPULATION DENSITY ZONE		
		RURAL	SUBURBAN	URBAN
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5×10^{-5}	0.8	0.1	0.1
VIII	1.5×10^{-5}	0.9	0.05	0.05

Source: NRC 1977

truck accidents less severe than Type B test conditions is 91 percent according to the 1977 NRC report. A 1987 NRC study (LLNL 1987) estimated that 99.4 percent of the truck accidents would not cause a release from a Type B package. The more conservative results from the older NRC study are used in the SWEIS transportation risk analyses. Packages for plutonium are required to have both inner and outer containment vessels (10 CFR 71.63). Tests with these packages produced no structural damage to the inner containment vessel after impacts with unyielding targets at speeds typical of a Category V impact accident. Several containment vessels exhibited minor damage for Category VI impacts, but no verified release occurred (NRC 1977).

F.4.4.3 *Package Release Fractions*

The release fraction is defined as the fraction of the RAM in a package that could be released from that package during an accident of a certain severity. Release fractions take into account all mechanisms necessary to create a release of RAM from a damaged package to the environment. Release fractions vary according to the package type. Type B packaging are designed to withstand the forces of severe accidents and, therefore, have smaller release fractions than Type A packaging. Plutonium packages are designed to even higher standards.

In a given accident involving a number of packages transported together, some of the packages could release part of their contents while others could have no release at all. The approach taken in an accident severity categorization scheme is to derive an estimate for the average release fraction for each severity category to support the assumption that all such packages in a shipment respond in the same way.

Release fractions for accidents of each severity category are given in Table F.4.4.3–1 for the package types considered in this appendix.

Note that the release fraction levels out at 100 percent for highest severity accidents. Since 82 percent of aircraft accidents are level III or less, as compared to 98 percent of truck accidents, the probability of a large release due to aircraft accidents is not much higher than that for truck accidents. For this reason, as well as the much higher frequency of truck accidents, aircraft accidents are screened from further analysis (Rhyne 1997).

TABLE F.4.4.3–1.—*Estimated Release Fractions for Shipping Packaging Under Various Accident Severity Categories*

SEVERITY CATEGORY	ESTIMATED RELEASE FRACTION	
	TYPE A	TYPE B
I	0	0
II	0.01	0
III	0.1	0.01
IV	1.0	0.1
V	1.0	1.0
VI	1.0	1.0
VII	1.0	1.0
VIII	1.0	1.0

Source: NRC 1977

F.4.4.4 *Respirable Fractions*

Subsequent to release, dispersion of the material into the atmosphere as an aerosol and, in most cases of interest, inhalation into the respiratory tract (respirable aerosols only) would be required to produce a significant exposure to members of the public. Therefore, in addition to determining the respirable fractions, the portion of that release which is respirable is also determined for risk analysis. Most solid materials are relatively nondispersible. Conversely, gaseous materials are easily dispersed. Liquid dispersibility depends on the liquid volatility. The aerosolization and respirable fractions depend on the physical form of the material.

The bounding off-site shipments described in subsection F.6.5.1 are plutonium powders. (The specific application of this methodology to the bounding shipments is also discussed in section F.6.5.1.) Generally the powder is pressed, reducing its dispersibility, and enclosed within four layers of metal containers: two associated with the plutonium packaging and two associated with handling outside the packaging. Should these four layers of containment fail in an impact accident, the mechanisms for converting the powder to a respirable aerosol would be the impact force itself and the release of gases.

Radioactive decay and solar insulation produce heat that causes gas within containers (including chemically inert gases, such as argon) to expand, thus raising the gas pressure inside the packaging. In addition to producing heat, radioactive decay produces helium, which further increases pressure. The average atmospheric pressure at LANL is 11.3 pounds per square inch absolute (psia), in contrast to 14.7 at sea level. The total pressure difference between the inner powder container and the environment from these factors can be as high as 30.1 psig. Tests with air injected into the bottom of a powder bed in an open-top container produced respirable fractions of 3×10^{-5}, 6.7×10^{-4}, and 6.1×10^{-4} for pressures of 9, 17.5, and 24.5 psig, respectively (DOE 1994b). The highest of the three values was used in this appendix. The fraction of powder aerosolized by depressurization is about a factor of 20 higher than the fraction aerosolized by impact forces (DOE 1994b) and the latter can be ignored in comparison to the former.

The use of the value of 6.7×10^{-4} for the respirable fraction of a release in this appendix is conservative since the four containment vessels would not be expected to completely open up, even in a severe impact accident.

Given an accident involving fire, the release mechanism would also be rapid depressurization since the packaging would contain no combustible material. Once a pathway from the powder cans to the environment is established, some additional powder may be aerosolized by updrafts from the fire. Review of DOE Handbook 3010-94 (DOE 1994b) shows that the depressurization effect is about 400 times larger than the updraft effect and the latter can be ignored in comparison to the former.

Exposure of a plutonium package to a 1,475°F fire for 30 minutes would produce a gas pressure of 64.5 psig in a container that has a rupture pressure of 123 psig (Barklay 1983). Longer fires would produce higher gas pressures and lower rupture pressures; therefore, the gas pressure at rupture would be no higher than 123 psig.

Table 4–12 in DOE Handbook 3010-94 (DOE 1994b) presents respirable fraction estimates from the aforementioned pressurized powder release tests for pressures of 9, 18, 24.5, 250, and 500 psig. For 250 psig, the maximum respirable fraction of a release is 2.5 x 10^{-2}. This value is judged to be conservative for the present case, because the test pressure was a factor of 2 higher than the expected package burst pressure and the tests involved blowing powder out of an open-topped container with a burst of air injected at the bottom of the powder bed.

The impact and fire values are combined for the RADTRAN severity categorization scheme by considering that fires occur in 1.6 percent of all truck accidents. The weighted value of the respirable fraction is then (0.984)(6.7 x 10^{-4}) + (0.016)(2.5 x 10^{-2}) = 1.06 x 10^{-3} for an open-top container. Table F.4.4.4–1 shows the results of combining the open-top container value of 1 x 10^{-3} with the Type B package release factors of Table F.4.4.3–1. The values for WIPP packaging, obtained by a similar analysis (DOE 1990), are also shown in Table F.4.4.4–1.

F.4.4.5 *Health Risk Conversion Factors*

The risk from ionizing radiation consists mostly of some number of excess latent cancer fatalities (LCFs). These are cancers resulting from, and that develop well after, the exposure to ionizing radiation. These represent an increase in the number of fatal cancers that occur from other causes. The excess LCF is the product of the dose and the risk conversion factor. The reader should recognize that these estimates are

TABLE F.4.4.4–1.—*Estimated Respirable Release Fractions for Shipping Packaging Under Various Accident Severity Categories*

SEVERITY CATEGORY	ESTIMATED RESPIRABLE RELEASE FRACTION		
	TYPE B[a]	TRUPACT-II[b]	NUPAC 72B[b]
I	0	0	0
II	0	0	0
III	1×10^{-5}	8×10^{-9}	6×10^{-9}
IV	1×10^{-4}	2×10^{-7}	2×10^{-7}
V	1×10^{-3}	8×10^{-5}	1×10^{-4}
VI	1×10^{-3}	2×10^{-4}	1×10^{-4}
VII	1×10^{-3}	2×10^{-4}	2×10^{-4}
VIII	1×10^{-3}	2×10^{-4}	2×10^{-4}

[a] For package contents of loose powder
[b] *Source:* DOE 1990

intended to provide a conservative measure of the potential impacts to be used in the decision-making process and do not necessarily portray an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated impacts form an upper bound and that actual consequences could be less, but probably would not be worse. Refer to appendix D, section D.1 for further discussion of the determination and application of risk factors for LCFs.

The health risk conversion factors used throughout this appendix to estimate the number of expected cancer-caused fatalities due to radiological exposures are 5.0×10^{-4} cases of expected excess LCFs per person-rem for members of the public, and 4.0×10^{-4} cases per person-rem for workers (ICRP 1991).

F.4.5 Event Tree Analysis

Event trees are used for the analyses of off-site accidents involving HAZMAT transportation and on-site accidents involving RAM transportation.

An event tree is a graphical model for identifying and evaluating potential outcomes from a specific initiating event. The event tree depicts the chronological sequence of events (accident scenario) that could result from the initiating event. The identification of accident scenarios are the first of two key results from the event tree analysis; quantification of the scenario frequencies from the event tree is the second key result.

Figure F.4.5–1 is a graphical representation of five accident scenarios. The frequency of an accident producing a puncture force is designated as the parameter A, which is inserted on the tree as illustrated in Figure F.4.5–1. The conditional probability that puncture force causes package failure designated as the parameter B. Because B is the conditional probability that puncture force causes package failure, then 1-B is the conditional probability that puncture force does not cause package failure. The parameter C designates the conditional probability that a fire occurs, and the parameter D is the conditional probability that the fire duration is sufficient to cause package failure. The frequency of a particular scenario (e.g., puncture failure without fire, which is designated as F_2), is evaluated by multiplying the initiating event frequency and the individual probabilities, [e.g., $F_2 = A \times B \times (1 - C)$].

The parameter A is the product of the accident rate from section F.4.2.3 and the fraction of the accidents producing puncture force. The latter is taken from Dennis et al or Clarke et al., as appropriate. The parameter C and the probabilistic force magnitude distributions needed to evaluate parameters B and D are from the same two references.

Event trees similar to Figure F.4.5–1 are used for impact, crush, puncture, and fire without mechanical forces. This approach is conservative because the failures from other mechanical forces are not excluded for failure from the specific mechanical force. Clearly, the package can fail only once and the mechanical failures are triple counted. The error is generally less than a few percent, but the event trees are greatly simplified. The simple form for each force results from the assumption that all failures for a single accident force can be aggregated for frequency analysis. In frequency analysis, one package failure mode for a particular transportation accident force usually dominates the others. Event trees for fixed facilities are generally more complicated than transportation event trees because there are usually more opportunities for safety systems or operator action to mitigate the accident initiator.

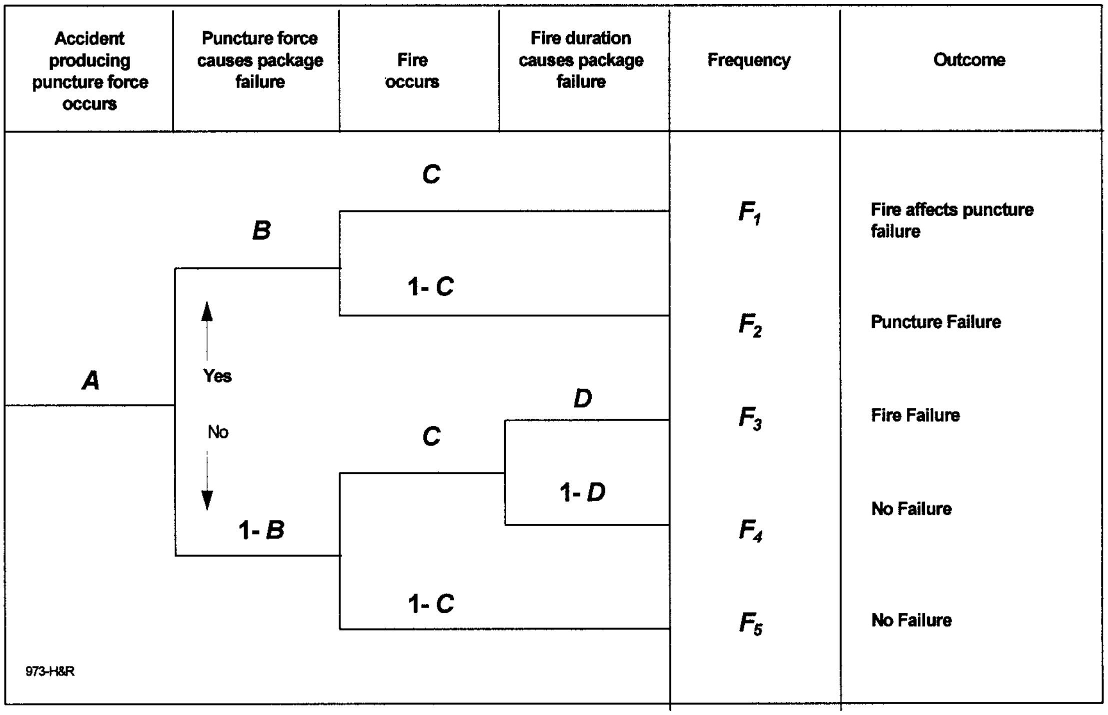


FIGURE F.4.5–1.—*Event Tree Analysis of Puncture Accidents.*

F.5 DETERMINATION OF SHIPMENTS BY ALTERNATIVE

F.5.1 Introduction

The determination of shipments of RAM and HAZMAT proceeded in three steps. First, historical databases were examined to get an overview, focus the subsequent data gathering to the most important risk contributors, and provide an accuracy check for the data-gathering process.

Data gathering, the second step, consisted of both interviews with cognizant persons and reviews of additional databases. The data-gathering process for RAM involved different databases, interviewees, and interviewers than the data-gathering process for HAZMAT.

The last step was the tabulation of results for each SWEIS alternative.

F.5.2 Baseline Shipments

DOE tracks unclassified shipments in a database called the Shipment Mobility/ Accountability Collection (SMAC). The tracking is based on shipping invoices paid by DOE and its contractors. Data on approximately 5,000 RAM and HAZMAT shipments to or from LANL were obtained from the SMAC for fiscal years 1990 through 1994. The shipments were first aggregated into 81 commodity groups, e.g., paint. The least HAZMAT were determined on the basis of the material maximum shipment weight compared with regulatory reporting thresholds in 40 CFR 302, Table 302.4, or 40 CFR 355, appendices A and B. The material was screened from further consideration if the maximum shipping amount was less than the threshold.

The remaining materials were grouped into four categories: radioactive, toxic, flammable, or explosive materials. A bounding material was picked as the most hazardous for each of these four groups on the basis of the toxicity of materials shipped in large amounts to or from LANL. The results are shown in Table F.5.2–1. Also shown in Table F.5.2–1 are the numbers of large and small shipments over the 5-year period. A large shipment is one that is greater than 10 percent of the maximum shipment quantity.

The materials screened from further consideration because of their low hazard are not listed in Table F.5.2–1. Some classified shipments, e.g., SST shipments, are also not included in Table F.5.2–1, since an invoice is not submitted for payment, however, classified shipments are considered in the risk analyses.

A recent annual shipment summary prepared by LANL is shown in Table F.5.2–2. Off-site shipments of RAM and HAZMAT total 3,526 per year in contrast to the SMAC results (Table F.5.2–1) of about 1,000 per year (when the screened shipments are considered). The large difference is due to the classified shipments mentioned previously and to other shipments for which LANL is not billed explicitly for transportation (e.g., contaminated-laundry shipments). Table F.5.2–2 was used to determine the number of HAZMAT shipments used in subsection F.5.3, and Table F.5.2–1 was used to help characterize those shipments

F.5.3 Shipments For SWEIS Alternatives

The determination of shipments by SWEIS alternative focused on ensuring that shipments were identified of both RAM and HAZMAT that could contribute significantly to accident risk. For example, bulk gas shipments were of special interest.

The RAM shipment characteristics were determined by interviewing cognizant LANL staff. Historical shipment data, on-site and off-site, were used to help ensure completeness. On-site shipments of SNM at the gram level were not individually accounted for because their contribution to risk would be minor; however, shipment projections were conservatively high to ensure that the transportation risks were bounded in this analysis. The off-site and on-site RAM shipments for each LANL SWEIS alternative are listed in Tables F.5.3–1 and F.5.3–2, respectively. The number of shipments projected is higher than those reflected in Table F.5.2–2 for a variety of reasons, including: the conservatism applied to shipment projections, the fact that several activities at LANL have been operating below planned levels, and the fact that some programs at LANL are increasing activity levels over recent levels due to DOE decisions made prior to this SWEIS (e.g., stockpile stewardship in the absence of underground testing, demonstration of accelerator production of tritium, and surveillance of stored materials).

The conservatism applied to the shipments is reflected in two ways. First, the number of shipments per year reflected in the table is typically at the high end of a range; this is done to ensure that impacts associated with total mileage are not underestimated. Second, the number of packages in a shipment is at the high end of a range; this is done to ensure that impacts associated with the shipment quantities (e.g., accidents that release cargo and worker and public exposures under no-incident conditions) are not underestimated. These shipments should not be used to estimate material flows/balances because the combination of bounding shipment numbers and bounding packages per shipment would yield overly conservative material flows. For those interested in such balances, the No Action Alternative would result in an average annual plutonium inventory increase of about 130 kilograms. The other alternatives would have slightly different average annual flows, but the inventory growth over the next 10 years can be accommodated in storage facilities, once the NMSF at TA–55 is operational. The enriched uranium inventory at LANL may actually

TABLE F.5.2–1.—*Summary of Radioactive and Hazardous Material Bounding Off-Site Shipments to and from LANL, 1990 Through 1994*

TRANSPORT MODE	MATERIAL CATEGORY	BOUNDING MATERIAL	MAXIMUM SHIPPING QUANTITY	NUMBER OF SMALL[a] SHIPMENTS	NUMBER OF LARGE[b] SHIPMENTS
Truck	Flammable	Hydrogen	50,000 ft^3	320	17
Truck	Toxic	Chlorine	2,000 lb	136	22
Truck	Radiological[c]	Tritium	29,160 Ci	406	11
Truck	Explosive	HMX	13,801 lb	102	24
Air	Toxic	Chlorine	7 lb	160	15
Air	Explosive	HMX	195 lb	21	80
Air	Radiological	Tritium	970,000 Ci	1,185	1

HMX = octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
[a] About 2,500 shipments screened because of low material toxicity
[b] Large shipments are greater than 10% of the maximum shipping quantity
[c] SST trailer shipments not included

TABLE F.5.2–2.—*Annual LANL On-Site and Off-Site Shipments*

TYPE	NONHAZARDOUS	HAZARDOUS (NONRADIOACTIVE)	RADIOACTIVE
Off-Site	327,939	2,592	934
On-Site	Not available	7,560	1,187

Source: Villa 1996

TABLE F.5.3–1.—*Off-Site Shipments of Radioactive Materials*

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Stabilization Project 345 for Plutonium-239	Salt	RFETS[c]	TA–55	500 g plutonium-239 in Type B	40 6M	1 (total)[b]	8 (total)[b]	1 (total)[b]	8 (total)[b]	SST
	Oxide	TA–55	RFETS[c]	As above	As above	1 (total)[b]	8 (total)[b]	1 (total)[b]	8 (total)[b]	SST
Pit Fabrication, P362	Plutonium Metal	Pantex	TA–55	FL	10	0	12	0	0	SST
	Plutonium Metal	TA–55	Pantex	FL	10	5	8	5	5	SST
Pit Surveillance, P301	Plutonium Metal	Pantex	TA–55	FL	4 to 6	5	10	5	10	SST
Pit Disassembly[d]	Plutonium Metal	Pantex RFETS SRS LLNL SRS	TA–55 TA–55 TA–55 TA–55 TA–55	FL FL FL FL FL	10 10 2 2 19	1 1 1 1 2	1 1 1 1 2	1 1 1 1 2	1 1 1 1 2	SST
Pit Disassembly	Enriched Uranium Metal	CMR and TA–55	Oak Ridge	Type B or equivalent	22	7	20	7	7	SST
MOX Fuel (Parallex)	Oxide in welded rods	TA–55	Canada	0.3 kg plutonium (weapons grade) 1.2-1.8 kg MOX Type B	1	2	2	2	2	SST
Plutonium-238 Operations	RTG	Pantex	TA–55	500 g plutonium-238 Type B	10	1	1	1	1	SST
	Oxide Powder	TA–55	SRS	500 g 83% plutonium-238 Type B	10	2	2	1	2	SST
Plutonium-238 Heat Source	Oxide Powder	SRS	TA–55	500 g plutonium-238 Type B	15 to 22	4	4	1	4	SST
NASA Plutonium-238 Heat Source	Encapsulated powder	TA–55	Mound	1,800 g Type B	2	10	12	8	12	SST
Actinide Processing & Recovery/ Plutonium (weapons grade)	Plutonium Metal	Pantex RFETS SRS LLNL	TA–55 TA–55 TA–55 TA–55	FL FL FL FL	2 to 8 2 to 8 2 to 4 2 to 4	5 5 1 1	5 5 2 2	0 0 0 0	0 0 0 0	SST
As Above/Uranium	Metal	Oak Ridge	TA–55	Type B	7 to 10	24	60	24	24	SST

TABLE F.5.3–1.—*Off-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Plutonium (weapons grade) Standards	Oxide	TA–55	Uniform U.S.	4 kg in 9,968 Type B	5	5	5	5	5	SST
	Oxide	Uniform U.S.	TA–55	4 kg in 9,968 Type B	5	5	5	5	5	SST
	Oxide	TA–55	Uniform U.S.	395 g Type B	5	24	24	24	24	
	Oxide	Uniform U.S.	TA–55	395 g Type B	5	24	24	24	24	
Americium-241 Standards Sales	Oxide	TA–55	Houston, TX	28 g in 6M	1	1	2	1	2	
	Oxide	TA–55	England	28 g in 6M	4	3	6	3	6	
	Oxide	TA–55	NY & CA	13 g in 6M	1	2	2	2	2	
Material Disposition	Plutonium Metal	Pantex	TA–55	FL	3 to 19	12	12	0	0	SST
	Plutonium Metal	RFETS	TA–55	FL	14	1 (total)[b]	1 (total)[b]	1 (total)[b]	1 (total)[b]	SST
Bulk Tritium	Solid storage	Mound	TA–16/21	120 g tritium in UC609	1	4 (total)[b]	4 (total)[b]	4 (total)[b]	4 (total)[b]	SST
Plutonium (weapons grade) (Pyrophoric)	Metal powder	Mound	TA–55	< 250 g plutonium in Type B	2	1 (total)[b]	1 (total)[b]	1 (total)[b]	1 (total)[b]	SST
Subcritical Test Program	Test assembly	TA–55	NTS	FL	1	4	6	4	4	SST
Weapons System Evaluation Program Number 301	Secondaries	Oak Ridge	CMR	CSA	1	1	10	1	1	SST
Molybdenum-99 Targets	Metal	CMR	SNL	30 g HEU/target 12 targets/6M	2	45	60	2	45	
Highly Enriched Uranium (HEU) Oxides, Carbides, Nitrides, and Fluorides	Powder	CMR	Oak Ridge	< 300 g HEU in Type A	10	5	5	3	5	SST, yearly values for 1998+2002 only
Secondaries Design Eval	Secondaries	Pantex	CMR	Type B	1	1	10	1	1	SST
	Secondaries	TA–18	Oak Ridge	Type B	--	1	10	1	1	SST
Secondaries	Secondaries	Pantex	TA–18	Type B	3 to 4	1 (total)[b]	2 (total)[b]	1 (total)[b]	1 (total)[b]	Initial receipt at TA–55 in SST, then to TA–18 for storage.
Sealed Sources	Double encapsulated	Uniform U.S.	TA–18	300 Ci iridium-92 shielded cask	1	3 (total)[b]	6 (total)[b]	3 (total)[b]	3 (total)[b]	
	Double encapsulated	Uniform U.S.	TA–18	few mCi	1	20	40	20	20	
Plutonium Objects	Metal	See comment	TA–18	5.85×10^3Ci plutonium-239 1.36×10^3Ci plutonium-240 in 50-gal. 6M	2	2 (total)[b]	3 (total)[b]	2 (total)[b]	2 (total)[b]	Assume 1 from INEL, 1 from RF, and 1 (Expanded Operations) from Pantex.

TABLE F.5.3–1.—*Off-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Unirradiated Low Enriched Uranium Fuel	Oxide in Al rods	See comment	TA–18	8.4×10^{-3}Ci uranium-235 2.9×10^{-3}Ci uranium-238 in 50-gal. 6M	10	3 (total)[b]	6 (total)[b]	3 (total)[b]	3 (total)[b]	Assume 1 from Hanford, 2 from SRS; times 2 for Expanded Operations.
Irradiated Highly Enriched Uranium Fuel	Metal or ceramic composite	Oak Ridge	TA–18	2.2×10^{-2}Ci uranium-235 2.6×10^{-4}Ci uranium-238 in 50-gal. 6M	20	4 (total)[b]	8 (total)[b]	4 (total)[b]	4 (total)[b]	SST
Highly Enriched Uranium	Metal or ceramic composite	TA–18	Oak Ridge	2.2×10^{-2}Ci uranium-235 2.6×10^{-4}Ci uranium-238 in 50-gal. 6M	20	1	1	1	1	
Feedstock Depleted Uranium	Bulk metal	SRS	Sigma	2,000 kg uranium total in STCs	25	45	232	45	45	
Depleted Uranium	Bulk metal	Oak Ridge	Sigma	500 kg uranium total in STCs	20	45	171	45	45	
	Bulk metal	Sigma	Oak Ridge	500 kg uranium total in STCs	20	45	171	45	45	
Depleted Uranium Parts	Bulk metal	Oak Ridge	Sigma	75 kg uranium total in STCs	10	60	165	60	60	
	Bulk metal	Sigma	Oak Ridge	75 kg uranium total in STCs	10	60	165	60	60	
	Bulk metal	Concord, MA	Sigma	75 kg uranium total in STCs	10	85	300	85	85	
	Bulk metal	Sigma	Concord, MA	75 kg uranium total in STCs	10	85	300	85	85	
Depleted Uranium Samples	Turnings	Sigma	Oak Ridge	7 vials (20 g uranium each) in STC	1	170	646	170	170	
Highly Enriched Uranium (research and manufacturing technologies)[e]	Bulk metal	Oak Ridge	CMR	250 kg total in Type B	____	25	25	25	25	SST
	Bulk metal	CMR	Oak Ridge	250 kg total in Type B	____	50	50	50	50	SST
Thorium-232 Oxide	Powder	Sigma	Oak Ridge	1,000 kg thorium-232 total in 55-gal. shielded drums	____	1	1	1	1	

TABLE F.5.3–1.—*Off-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Bulk Tritium	Gas or solid storage	SRS	TA–16/21	120 g tritium in UC609	up to 10	10	20	10	10	
	Gas or solid storage	TA–16/21	SRS	120 g tritium in UC609	up to 5	2	4	2	2	
	Gas or solid storage	SRS	TA–16/21	120 g tritium in H616-2	up to 10	10	20	10	10	
	Gas or solid storage	TA–16/21	Rochester, NY	≤ 1,000 Ci in Type A	up to 10	50	100	50	50	
	Gas or solid storage	Rochester, NY	TA–16/21	≤ 1,000 Ci in Type A	up to 10	100	100	100	100	
Tritiated Water Bound to Zeolite Matrix	Mole sieve	TA–16/21	NTS	10 g tritium in Type A w/ overpack	up to 10	1	2	1	1	
Dispersible Depleted Uranium	Powder	SRS	TA–16/21	6 kg uranium in STC	2	2	4	2	2	
Nondispersible Depleted Uranium	1/8-in. pellets	TA–16/21	Boston	6 kg uranium in STC	2	2	4	2	2	
Neutron Tube Target	Tritium in solid storage	TA–16/21	SNL	≤ 1,000 Ci in Type A	up to 20	50	100	50	50	
Off-Site Samples	Solid	TA–53	DOE Labs (uniform)	Type A	1 by FedEx	50	50	50	50	
Neutron Scattering Research	Pressed powders	TA–53	Uniform U.S.	≤ 0.5 Ci J-L	1 by FedEx	12	12	12	12	
Misc. Nuclear Materials	Double encapsulated	TA–53	Oak Ridge	1.4 mCi californium in 6M	1	1 (total)[b]	1 (total)[b]	1 (total)[b]	1 (total)[b]	
Medical Isotopes	Liquid	TA–48	Uniform U.S.	Bounded by 2 Ci strontium-82 in Type A box by FedEx	1	160	160	160	160	
Irradiated Targets	Nondispersible	TA–48	BNL	Shielded Type B	1	12	12	12	12	The unshielded radiation level is on the order of 10,000 rem/h.
Experimental Samples	Solids	TA–48	Uniform U.S.	Shielded Type A	1	20	40	20	40	
Inertial Confinement Fusion Program	Irradiated Targets	TA–35	Rochester, NY	0.5 Ci by FedEx	1	100	100	100	100	
Beryllium Targets	H_2 and H_3 gas	TA–35	LLNL	1 Ci by FedEx	1	50	50	50	50	
Phosphorus-32 and Sulfur-35 Isotopes	Liquid	Boston	HRL	0.5 mCi by FedEx	3	50	100	16	50	
Neutron Source Recovery	Encapsulated oxide	Uniform U.S.	CMR/TA–55	Type A, special form, 3 Ci plutonium-238	2	10	20	10	10	
Neutron Source Recovery	Encapsulated oxide	Uniform U.S.	CMR/TA–55	6M (Type B) normal form, ≤ 10 g plutonium-238	2	190	380	190	190	

TABLE F.5.3–1.—*Off-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Neutron Source Recovery	Encapsulated oxide	Uniform U.S.	CMR/TA–55	Heavily shielded Type B, 30 gm plutonium-238	1	2	4	2	2	
Plutonium Research	Powder	SRS	TA–55	Not specified in reference	26	1 (total)[b]	1 (total)[b]	1 (total)[b]	1 (total)[b]	SST
Contaminated Laundry	Particulate-contaminated solid	SM-30	CA	Duffle bag in STC, RAM is near zero	about 200	52	81	52	52	Shipment amount will vary with alternative
Contact-Handled TRU	Solid	TA–54	WIPP	TRUPACT-II	3	157	204	157	166	
TRU and Low-Level Waste	Solid	SNL	TA–54	17H Drum	——	——	——	——	——	Included in contact-handled TRU
Remote-Handled TRU	Solid	TA–54	WIPP	RH-72B	1	33	41	31	34	
Mixed Low-Level Waste	Solid/liquid/gas	TA–54	Various permitted facilities	17H Drum	65	33	33	33	33	Oak Ridge assumed
Low-Level Waste	Solid	TA–54	Utah/Nevada/ Hanford	17H Drum	65	377	0	942	1,050	Primarily soil and debris
Total						2,440	4,244	2,894	3,132	

[a] Refer to the packaging section F.2.0.
[b] The total number of shipments over 10 years is listed. The annual total is the value divided by 10.
[c] This reflects return of recovered plutonium to RFETS. It is possible that this material would remain at LANL, as reflected in the *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site* (DOE/EIS-0277) (DOE 1998).
[d] This surplus material is expected to leave LANL, eventually; however, without a site selection for the plutonium disposition program, the timing and location for such shipments is unknown. Except for material shipped as MOX fuel (see below), this material is expected to remain at LANL for the period addressed in the SWEIS.
[e] The shipments to Y–12 exceed the receipts from Y–12 because of an excess inventory that currently exists at LANL. This excess inventory of material from a variety of research and development activities is expected to be reduced over the next several years, at which point the HEU received will be approximately equal to the HEU shipped out.
RFETS = Rocky Flats Environmental Technology Site, SRS = Savannah River Site, LLNL = Lawrence Livermore National Laboratory, CMR = Chemistry and Metallurgy Research, HEU = highly enriched uranium, CSA = canned subassembly, STCs = standard transportation containers, NTS = Nevada Test Site, BNL = Brookhaven National Laboratory, HRL = Health Research Laboratory

TABLE F.5.3–2.—*On-Site Shipments of Radioactive Materials*

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Plutonium (weapons grade) samples	Solid	TA–55	CMR	200 g plutonium (weapons grade) in 6M	10	100	150[b]	100	100	
Plutonium (weapons grade) samples	Liquid	CMR	TA–55	6 L of plutonium (weapons grade) in 15-in. container	4	128	240[b]	128	128	Road closure
Plutonium-238 samples	Solid	TA–55	CMR	20 Ci plutonium-238 in 6M	10	——	——	——	——	Combined with Pu (WG) samples
Plutonium-238 samples	Liquid	CMR	TA–55	6 L of plutonium-238 in 15-in. container	4	——	——	——	——	Combined with Pu (WG) samples
Low-Level Waste	Solid	TA–55	TA–54	2 ft^3 cardboard box	90	52	73	52	52	Compactible and in dumpster
	Solid	TA–55	TA–54	STC, Type A, or plastic wrap	6+12	9	15	9	9	Noncompactible
Contaminated Laundry	Particulate-contaminated solid	TA–55	SM-30	Duffle bag	Up to 40	250	250	250	250	Shipment size will vary with alternative
Radiography	Metal	TA–55	Varies	FL	1	100	500	24	100	Return included
Contact-handled TRU	Particulate-contaminated solid	TA–55	TA–54	17H drum, < 100 g SNM	16+40	78	158	62	78	Road closure
Surveillance	Metal	TA–55	CMR	FL	1	0	200[b]	0	0	Return included
Research and Development	Metal	TA–55	CMR	FL	1	0	100[b]	0	0	Return included
Research and Development	Powder	TA–55	CMR	Type B, 500 g	1	0	100[b]	0	0	Return included
Contact-Handled TRU	Particulate-contaminated solid	CMR	TA–54	17H drum, < 100 g SNM	20+25	4	5	4	4	Road closure
HEU	Powder	TA–55	CMR	17H drum, < 300 g HEU	2	1	1	1	1	
Mixed Low-Level Waste	Liquid	CMR	TA–54	17H drum, 16 mg plutonium (weapons grade)	2	13	13	13	13	
	Particulate-contaminated solid	CMR	TA–54	17H drum, 16 mg plutonium (weapons grade)	2	13	13	13	13	
Mixed TRU	Particulate-contaminated solid	CMR	TA–54	17H drum, < 100 g SNM	1	——	——	——	——	Included in truck with C.12

TABLE F.5.3–2.—*On-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
CSA	Metal	TA–18	CMR	CSA	1	3	10	3	3	Road closure
	Metal	CMR	TA–18	CSA	1	3	10	3	3	Road closure
	Metal	CMR	TA–8	CSA	1	3	10	3	3	Road closure
CSA (continued)	Metal	TA–8	CMR	CSA	1	3	10	3	3	Road closure
TRU Waste Research and Development	Misc. solids	TA–54	TA–50/CMR	≤ 1.8 Ci plutonium-239 and americium-241	10+18	7 (total)[c]	7 (total)[c]	7 (total)[c]	7 (total)[c]	Road closure, 1998, 1999, 2002, Return included
	Cemented	CMR	TA–54	17H drum, mCi level	40	2 (total)[c]	2 (total)[c]	2 (total)[c]	2 (total)[c]	1998, 2002
Neutron Source Recovery	Encapsulated oxide	SM–30	TA–55 (bounds CMR)	6M	2	202	404	202	202	10 g Pu-238 is accident analysis value; see off-site NS.1
	Oxide	CMR	TA–55	Type B, 500 g	4+8	1 (total)[c]	1 (total)[c]	1 (total)[c]	1 (total)[c]	Bounding no action values are 1 kg Pu-238 and 3 kg Am-241
Contaminated Laundry	Particulate-contaminated solid	CMR	SM–30	Duffle bag	Up to 10	250	250	250	250	Shipment amount will vary with alternative
Contingency SNM	Metal	CMR	TA–18	Type B, 20 Ci plutonium-239	10	10	20	10	10	
	Liquid	CMR	TA–18	6 L of Highly Enriched Uranium in 15-in. container	4	1	2	1	1	Road closure
Plutonium Objects	Metal	TA–18	CMR (bounding)	17H, 40 kg plutonium (weapons grade)	2	8	16	8	8	Road closure
Molybdenum-99	Adsorbed	TA–18	TA–48	Shielded Type A	1	0	12	0	0	
Highly Enriched Uranium Samples	Liquid	TA–18	CMR	Type A, 20 g	1	6	18	6	6	Return shipments included
Low-Level Waste	Particulate-contaminated solid	TA–18	CMR/TA–54	17H drum	12	1	1	1	1	Mileage is to/from CMR then to TA–54
Plutonium Parts	Metal	TA–18	CMR	FL	1	84	220	84	96	Most are to TA–55; CMR is used as bounding
	Metal	CMR	TA–18	FL	1	84	220	84	96	
MOX Fuel	Ceramic	TA–55	TA–18	Type B, 20 kg plutonium (weapons grade)	5	2 (total)[c]	2 (total)[c]	2 (total)[c]	2 (total)[c]	Return included
Contaminated Laundry	Particulate-contaminated solid	TA–18	SM–30	Duffle bag	Up to 30	24	48	24	24	Shipment amount will vary with alternative

TABLE F.5.3–2.—*On-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
MC&A Highly Enriched Uranium Measurements	Metals, oxides, or ceramics	TA–18	CMR	20 to 40 kg	Unspecified	24	48	24	24	Return included
Radiography	Solids	TA–8	TA–18	Unspecified	Unspecified	12	24	12	12	Road closure
		TA–18	TA–55	Unspecified	Unspecified	12	24	12	12	Road closure
Tritiated Water Bound to Zeolite Matrix	Mole sieve	TA–21/16	TA–54	≤ 10 g in package	Up to 10	5	10	5	5	Road closure
Sealed Source	Triple encapsulated	TA–55	TA–16	Type A, special form 0.01 g plutonium-238	≤ 4	3	3	3	3	
Dispersible Depleted Uranium	Powder (assumed)	TA–21	TA–16	6 kg uranium in STC	2	4	8	4	4	Return included
Bulk Tritium	Gas or solid storage	TA–16/21	TA–16/21	≤ 120 g per shipment	Up to 10	20	20	20	20	May close roads
	Gas or solid storage	TA–16/21	TA–16/21	≤ 1,000 Ci per package	Up to 10	20	20	20	20	May close roads
Nondispersible Depleted Uranium	1/8-in. pellets	TA–16/21	TA–16/21	≤ 6 kg/STC	Up to 2	2	4	2	2	
Neutron Tube Target	H_3 in solid storage	TA–16/21	TA–16/21	≤ 1,000 Ci per package	Up to 5	50	100	50	50	
Depleted Uranium Materials	Bulk metal	TA–8 (bounds shops)	Sigma	200 kg uranium in STC	1	900	3,780	900	900	Return included
	Pyrophoric metal	Sigma	TA–54	60 kg uranium in 7A drum	7	12	48	12	12	Ash portion is not pyrophoric
Low-Level Waste	Fixed surface contamination	Sigma	TA–54	Low Depleted Uranium in STC	3	13	55	13	13	Noncompactible
Contaminated Laundry	Particulate-contaminated solid	Sigma	SM–30	Duffle bag	30	24	101	24	24	Shipment amount will vary with alternative
Highly Enriched Uranium	Bulk metal	CMR	TA–8 (bounds shops)	20 kg Highly Enriched Uranium in Type A	5	0	240	0	0	Closed roads, return included
Inserts and Beam Stops	Activated components	TA–53	TA–54	Shielded cask	1	12	12	12	12	Unshielded radiation levels from few to 2×10^5 R/h
Irradiated targets	Activated components	TA–53	TA–48	Shielded cask	1	15	17	8	17	Unshielded radiation level up to 5×10^4 R/h
Low-Level Waste	Solid	TA–53	TA–54	2 ft^3 cardboard box	80	5	5	5	5	Compactible and in dumpster
	Solid	TA–53	TA–54	B-25 box	1	2	2	2	2	

TABLE F.5.3–2.—*On-Site Shipments of Radioactive Materials*-Continued

PROGRAM/MATERIAL	FORM	ORIGIN	DESTINATION	PACKAGING AND AMOUNT[a]	PACKAGES PER SHIPMENT	SHIPMENTS PER YEAR BY ALTERNATIVE				COMMENT
						NO ACTION	EXPANDED	REDUCED	GREENER	
Misc. Material	Double encapsulated	TA–53	TA–55	6M, < 5 Ci americium-241	1	2 (total)[c]	2 (total)[c]	2 (total)[c]	2 (total)[c]	One shipment is 4.95 Ci Am-241, other 1.83 Ci Pu-238
	Liquid	TA–53	TA–48	17H drum, 525 kg D_2O	3	1 (total)[c]	1 (total)[c]	1 (total)[c]	1 (total)[c]	
Activated Material	Solid	TA–53	TA–54	Various	2	15	15	15	15	Number of shipments averaged over 10 years
Activated Components	Solid	TA–53	TA–54	Various	1	0	220	0	220	Number of shipments averaged over 10 years, but actually occur 2000 to 2005
Hot Cell Waste	Particulate-contaminated solids or liquids	TA–48	TA–54	Shielded Type A	1	3	3	3	3	Compactible, radiation levels up to 10 R/h
	Activated material	TA–48	TA–54	Shielded cask	1	18	18	18	18	Noncompactible radiation levels up to 300 R/h
	Solids or Tritium in solid storage	Various (TA–3 bounding)	TA–16, TA–15, or similar	Various	1	477	886	471	471	One shipment of DU, H_3, etc. per experiment assumed
	Solids or Tritium in solid storage	TA–16 or similar	TA–15 or similar	Various		477	886	471	471	One shipment per experiment assumed
Low-Level Waste	Solid	TA–3 or similar	TA–54	2 ft^3 cardboard box	90	284	418	271	335	Compactible and in dumpster
Low-Level Waste	Solid	TA–3 or similar	TA–54	B-25 box	2	193	278	181	205	Noncompactible
Low-Level Waste	Solid	TA–3 or similar	TA–54	Dump truck	1	215	269	361	259	Soil and building debris
Low-Level Waste	Solid	TA–3 or similar	TA–54	Various	Unspecified	33	77	105	47	Scrap metal
Low-Level Mixed Waste	Liquid	TA–3 or similar	TA–54	17H Drum	10	20	20	20	20	
Low-Level Mixed Waste	Solid	TA–3 or similar	TA–54	Dump truck	1	53	53	53	53	Soils and debris
Low-Level Mixed Waste	Solid	TA–3 or similar	TA–54	96 ft^3 box	2	18	20	18	18	Contaminated lead and non-RCRA
Total						4,372	10,754	4,454	4,727	

[a] Refer to the packaging section F.2.0.
[b] These shipments constitute the approximately 500-shipment increase discussed in volume II, part II (*PSSC Analysis for the Enhancement of Plutonium Pit Manufacturing*), section II.2.1.1.
[c] The total number of shipments over 10 years is listed. The annual total is the value divided by 10.
CSA = canned subassembly; MC&A = Materials Control and Accountability; STCs = standard transportation containers

decrease over time as the excess material in the current inventory is shipped off site.

The HAZMAT shipments were determined primarily by using LANL databases such as the Automated Chemical Inventory System (ACIS) and STORES as well as by using the SMAC data. Large inventories and bulk shipments were of special interest. When such inventories and bulk shipments were identified, responsible personnel were interviewed. The bounding historical material types and quantities identified in Table F.5.2–1 were validated for the toxic and explosive material categories. The bounding flammable material was changed from hydrogen to propane because the potential consequence of a propane release was determined to be larger as a result of the differing dispersion characteristics of lighter-than-air hydrogen and heavier-than-air propane (subsection F.6.5.4). The maximum future explosive shipment size for truck was determined to be 40,000 pounds (18,000 kilograms). Explosive shipments this large have been received in the past and could be received in the future.

An extensive analysis of on-site HAZMAT shipments determined that the large toxic, flammable, and explosive off-site shipments bound the accident risk both on site and off site.

Off-site shipments of toxic and flammable material classes were assumed to increase from the values in Table F.5.2–2 and vary with the SWEIS alternatives in the same way the off-site RAM shipments increase from the values in Table F.5.2–2 and vary with the SWEIS alternatives as described in Table F.5.3–1.

Although the number of many types of operational shipments associated with the Reduced Operations Alternative are lower than in the other alternatives, the number of low-level waste (LLW) shipments for off-site disposal increases substantially as compared to the number of LLW shipments under the No Action Alternative (since the Reduced Operations Alternative reflects off-site disposal of most LLW). This results in a total for off-site shipment mileage under the Reduced Operations Alternative, which is greater than the total off-site shipment mileage under the No Action Alternative. For this reason, the impacts that depend on the total off-site or radioactive shipment mileage are higher under the Reduced Operations Alternative than under the No Action Alternative.

The baseline value of off-site shipments in Table F.5.2–2 is the starting point for HAZMAT off-site shipments, after it is adjusted upward by the ratio of RAM shipments in Tables F.5.2–2 and F.5.3–1. In the case of toxic and flammable materials, the values are then adjusted for the SWEIS alternatives by the ratio of the number shipments under Expanded Operations, Reduced Operations, and Greener Alternatives to the No Action shipments in Table F.5.3–1. Projections, by alternative, were available for large off-site shipments of explosives. The on-site HAZMAT shipments were assumed to increase from the values in Table F.5.2–2 and vary with SWEIS alternatives in the same way as the on-site RAM shipments increase from Table F.5.2–2 to Table F.5.3–2 and vary with SWEIS alternative.

The resulting annual number of significant HAZMAT shipments for each alternative are given in Table F.5.3–3. The ratio of significant to total shipments is the same as that in Table F.5.2–1. As before, a large shipment is one that is greater than 10 percent of the maximum shipment quantity.

F.6 IMPACT ANALYSIS RESULTS

F.6.1 Introduction

To determine the impacts of the transportation of RAM and HAZMAT, four risk measures are defined in subsections F.3.3 and F.3.4: truck emissions in urban areas, truck accident injuries and fatalities that are independent of the nature

TABLE F.5.3–3.—*Annual Number of Hazardous Material Truck Shipments for SWEIS Alternatives*

SHIPMENT TYPE	ALTERNATIVE							
	NO ACTION		EXPANDED OPERATIONS		REDUCED OPERATIONS		GREENER	
	TOTAL SIGNIFICANT	TOTAL LARGE	TOTAL SIGNIFICANT	TOTAL LARGE	TOTAL SIGNIFICANT	TOTAL LARGE	TOTAL SIGNIFICANT	TOTAL LARGE
Off-Site, Toxic	645	90	1,439	200	606	84	645	90
Off-Site, Flammable	1,382	73	3,081	164	1,299	70	1,382	73
Off-Site, Explosive	518	2	1,155	2	487	1	518	1
On-Site	14,628	NA	34,231	NA	14,189	NA	15,068	NA

of the cargo, incident-free radiation exposure, and accidents resulting in a release of RAM or HAZMAT.

The RAM shipments presented by alternative (as in Tables F.5.3–1 and F.5.3–2) were identified for a specific origin/destination, or were categorized as going to one of five regions: northeast, southeast, northwest, southwest, or New Mexico. A centroid (central location) was picked for each of these regions on the basis of historical and projected shipments: Concord, Massachusetts; Aiken, South Carolina; Richland, Washington; Berkeley, California; and Albuquerque, New Mexico. The distances from LANL to the centroids are given in Table F.6.1–1. The shipment distances for explosives, flammable materials, and toxic materials were based on the corresponding large truck shipments in Table F.5.2–1. The centroids selected were Ft. Smith, Arkansas; Phoenix, Arizona; and Milwaukee, Wisconsin, respectively. All distances given in Table F.6.1–1 were determined from the HIGHWAY code (Johnson et al. 1993) and include the distances between LANL and I–25, as presented in Table F.4.3–1.

F.6.2 Truck Emissions in Urban Areas

The truck emission risk is based on 1.0 x 10^{-7} excess LCF per truck kilometer in urban areas where the number of kilometers is obtained as described in section F.4.3. Because Los Alamos is not an urban area, only off-site shipments were addressed in this analysis (off-site shipments by alternative are presented in Tables F.5.3–1 [RAM] and F.5.3–3 [HAZMAT]). The total distance traveled in urban areas in a year is calculated for these shipments using the distances in Table F.6.1–1, and the corresponding excess LCFs are calculated using the conversion factor presented above. The results are presented in Table F.6.2–1. Approximately 65 percent of the excess LCFs are due to RAM shipments and 35 percent are due to HAZMAT shipments. All shipments are conservatively assumed to result in an empty truck making the return trip. This is appropriate for WIPP shipments and many SST trailer shipments; however, most shipments are in general commerce and would not include the return of an empty truck.

TABLE F.6.1–1.—*Off-Site Shipment Distance per Trip*

ROUTE	MILES (KILOMETERS) IN URBAN AREAS	MILES (KILOMETERS) IN SUBURBAN AREAS	MILES (KILOMETERS) IN RURAL AREAS
Northeast, RAM	63 (102)	511 (823)	1,647 (2,652)
Southeast, RAM	20 (32)	275 (442)	1,312 (2,113)
Northwest, RAM	17 (27)	118 (190)	1,092 (1,759)
Southwest, RAM	20 (32)	75 (120)	1,094 (1,762)
Toxic Material	22 (36)	152 (245)	1,230 (1,981)
Flammable Material	13 (21)	50 (80)	496 (799)
Explosive Material	6 (10)	63 (102)	684 (1,102)

TABLE F.6.2–1.—*Number of Excess Latent Cancer Fatalities Due to Truck Emissions in Urban Areas*

RISK MEASURE	ALTERNATIVE			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Excess LCF per Year	3.2×10^{-2}	6.6×10^{-2}	3.4×10^{-2}	3.6×10^{-2}

F.6.3 Truck Accident Injuries and Fatalities

The HIGHWAY code (Johnson et al. 1993) was used to determine the distance traveled in each state for each of the centroids described in subsection F.6.1. The truck accident fatality, injury, and total accident rates in each state were taken from Saricks and Kvitek (1994). The rates in Table F.4.2.2–1 were used between Santa Fe and LANL, and the rates in Table F.4.2.3–1 were used on site. The results are given in Tables F.6.3–1 through F.6.3–3 for fatalities, injuries, and total accidents, respectively. Approximately 65 percent of the impacts are due to RAM shipments, and 35 percent are due to HAZMAT shipments. Again, all shipments are assumed to result in a return by an empty truck.

F.6.4 Incident-Free Radiation Exposure

The RADTRAN and ADROIT codes are used with the estimated number of off-site shipments in Tables F.5.3–1 and F.5.3–2 and with the estimated package surface radiation levels to obtain the results shown in Tables F.6.4–1 through F.6.4–4. The aircraft segment is for overnight carrier service; the truck segment to/from the airport is included in the truck results.

MEI dose occurs between LANL and I–25 and is 3.0×10^{-4}, 3.8×10^{-4}, 3.2×10^{-4}, and 3.4×10^{-4} rem for the No Action, Expanded Operations, Reduced Operations, and Greener Alternatives, respectively.

F.6.4.1 *Driver Doses from On-Site Shipments of Radioactive Materials*

The number of on-site shipments of RAM for the baseline year 1994, was 1,187 shipments, (taken from Table F.5.2–2). The baseline number of on-site shipments of RAM for the four SWEIS alternatives was taken from Table F.5.2–3. Table F.6.4.1–1 presents a summary of the total number of on-site shipments for all alternatives.

Dosimetry data for 25 on-site LANL drivers were provided by LANL. For identification purposes, the drivers were assigned numbers 1 through 25. Driver doses for 1994 were extracted from the dosimetry data package and are summarized in Table F.6.4.1–2. Driver number 2 did not have any dosimetry data for years beyond 1992, therefore, it was assumed that this driver is no longer working at LANL. He was dropped from further analysis. The driver doses were, therefore, based on 24 drivers.

To evaluate driver doses for the different SWEIS alternatives, it was assumed that the number of drivers (24) would be the same under each of the alternatives. In calculating the cancer risk associated with these doses, a dose-to-risk conversion factor 4×10^{-4} excess LCFs per person-rem was used (ICRP 1991).

To evaluate doses associated with on-site shipments for the different alternatives, the following procedure was followed:

- A dose per shipment was calculated for the baseline year as follows:
  - — Dose (person-rem per shipment) = (total collective dose) per number of shipments.
    $= 9.57 \times 10^{-4}$
  - — The baseline total dose of 1.136 person-rem was taken from Table F.6.4.1–2.
  - — The total number of shipments for each alternative was then multiplied by 9.57×10^{-4} to obtain the total collective dose per alternative.
  - — The total dose per alternative was then divided by 24 (the number of drivers) to obtain the average driver dose for each alternative.

TABLE F.6.3–1.—*Annual Truck Accident Fatalities*

ROUTE SEGMENT	ALTERNATIVE			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
On-Site	1.5×10^{-4}	3.3×10^{-4}	1.4×10^{-4}	1.5×10^{-4}
LANL to U.S. 84/285	1.7×10^{-3}	3.4×10^{-3}	1.8×10^{-3}	1.9×10^{-3}
U.S. 84/285 to I–25	4.1×10^{-3}	8.2×10^{-3}	4.3×10^{-3}	4.6×10^{-3}
Remainder of New Mexico	7.2×10^{-2}	1.5×10^{-1}	7.5×10^{-2}	8.0×10^{-2}
Outside New Mexico	3.0×10^{-1}	6.2×10^{-1}	3.3×10^{-1}	3.5×10^{-1}
Total	3.8×10^{-1}	7.8×10^{-1}	4.1×10^{-1}	4.4×10^{-1}

TABLE F.6.3–2.—*Annual Truck Accident Injuries*

ROUTE SEGMENT	ALTERNATIVE			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
On-Site	3.1×10^{-3}	7.0×10^{-3}	2.9×10^{-3}	3.2×10^{-3}
LANL to U.S. 84/285	3.5×10^{-2}	7.1×10^{-2}	3.7×10^{-2}	4.0×10^{-2}
U.S. 84/285 to I–25	8.6×10^{-2}	1.8×10^{-1}	9.1×10^{-2}	9.7×10^{-2}
Remainder of New Mexico	6.4×10^{-1}	1.3×10^{0}	6.8×10^{-1}	7.2×10^{-1}
Outside New Mexico	3.0×10^{0}	6.0×10^{0}	3.3×10^{0}	3.6×10^{0}
Total	3.8×10^{0}	7.6×10^{0}	4.1×10^{0}	4.5×10^{0}

TABLE F.6.3–3.—*Number of Annual Truck Accidents*

ROUTE SEGMENT	ALTERNATIVE			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
On-Site	1.5×10^{-2}	3.3×10^{-2}	1.4×10^{-2}	1.5×10^{-2}
LANL to U.S. 84/285	1.7×10^{-1}	3.4×10^{-1}	1.8×10^{-1}	1.9×10^{-1}
U.S. 84/285 to I–25	4.1×10^{-1}	8.2×10^{-1}	4.3×10^{-1}	4.6×10^{-1}
Remainder of New Mexico	6.7×10^{-1}	1.4×10^{0}	7.0×10^{-1}	7.6×10^{-1}
Outside New Mexico	3.2×10^{0}	6.4×10^{0}	3.6×10^{0}	3.8×10^{0}
Total	4.5×10^{0}	9.0×10^{0}	4.9×10^{0}	5.2×10^{0}

TABLE F.6.4–1.—*Annual Incident-Free Population Dose and Excess Latent Cancer Fatality for the No Action Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	PERSON-REM/YEAR	EXCESS LCF/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR
LANL to U.S. 84/285	5.9×10^{0}	2.4×10^{-3}	3.2×10^{-2}	1.6×10^{-5}	5.1×10^{-1}	2.6×10^{-4}	3.2×10^{0}	1.6×10^{-3}
U.S. 84/285 to I–25	7.9×10^{0}	3.2×10^{-3}	3.8×10^{-1}	1.9×10^{-4}	3.6×10^{0}	1.8×10^{-3}	3.3×10^{0}	1.6×10^{-3}
Remainder of New Mexico	4.5×10^{1}	1.8×10^{-2}	1.0×10^{-1}	5.0×10^{-5}	1.7×10^{0}	8.5×10^{-4}	2.4×10^{1}	1.2×10^{-2}
Outside New Mexico	4.1×10^{2}	1.6×10^{-1}	2.8×10^{0}	1.4×10^{-3}	2.4×10^{1}	1.2×10^{-2}	1.8×10^{2}	9.0×10^{-2}
Aircraft	2.4×10^{0}	1.2×10^{-3}	NA	NA	NA	NA	NA	NA

NA = Not applicable

TABLE F.6.4–2.—*Annual Incident-Free Population Dose and Excess Latent Cancer Fatality for the Expanded Operations Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	PERSON-REM/YEAR	EXCESS LCF/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR
LANL to U.S. 84/285	7.4×10^{0}	3.0×10^{-3}	4.0×10^{-2}	2.0×10^{-5}	6.5×10^{-1}	3.2×10^{-4}	4.0×10^{0}	2.0×10^{-3}
U.S. 84/285 to I–25	1.0×10^{1}	4.0×10^{-3}	4.9×10^{-1}	2.4×10^{-4}	4.6×10^{0}	2.3×10^{-3}	4.2×10^{0}	2.1×10^{-3}
Remainder of New Mexico	5.5×10^{1}	2.2×10^{-2}	1.2×10^{-1}	6.2×10^{-5}	2.1×10^{0}	1.0×10^{-3}	3.0×10^{1}	1.5×10^{-2}
Outside New Mexico	5.1×10^{2}	2.0×10^{-1}	3.5×10^{0}	1.8×10^{-3}	3.0×10^{1}	1.5×10^{-2}	2.3×10^{2}	1.2×10^{-1}
Aircraft	2.4×10^{0}	1.2×10^{-3}	NA	NA	NA	NA	NA	NA

NA = Not applicable

TABLE F.6.4–3.—*Annual Incident-Free Population Dose and Excess Latent Cancer Fatality for the Reduced Operations Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	PERSON -REM/ YEAR	EXCESS LCF/ YEAR	PERSON -REM/ YEAR	EXCESS LCF/ YEAR	PERSON-REM/ YEAR	EXCESS LCF/ YEAR	PERSON -REM/ YEAR	EXCESS LCF/ YEAR
LANL to U.S. 84/285	6.4×10^{0}	2.6×10^{-3}	3.4×10^{-2}	1.7×10^{-5}	5.6×10^{-1}	2.8×10^{-4}	3.4×10^{0}	1.7×10^{-3}
U.S. 84/285 to I–25	8.7×10^{0}	3.5×10^{-3}	4.2×10^{-1}	2.1×10^{-4}	3.4×10^{0}	1.7×10^{-3}	3.6×10^{0}	1.8×10^{-3}
Remainder of New Mexico	5.0×10^{1}	2.0×10^{-2}	1.2×10^{-1}	6.0×10^{-5}	1.9×10^{0}	9.5×10^{-4}	2.7×10^{1}	1.4×10^{-2}
Outside New Mexico	4.4×10^{2}	1.8×10^{-1}	2.9×10^{0}	1.4×10^{-3}	2.5×10^{1}	1.2×10^{-4}	2.0×10^{2}	1.0×10^{-1}
Aircraft	2.4×10^{0}	1.2×10^{-3}	NA	NA	NA	NA	NA	NA

NA = Not applicable

TABLE F.6.4–4.—*Annual Incident-Free Population Dose and Excess Latent Cancer Fatality for the Greener Alternative*

ROUTE SEGMENT	TRUCK OR AIR CREW		NONOCCUPATIONAL					
			ALONG ROUTE		SHARING ROUTE		STOPS	
	PERSON -REM/ YEAR	EXCESS LCF/ YEAR	PERSON -REM/ YEAR	EXCESS LCF/ YEAR	PERSON-REM/ YEAR	EXCESS LCF/ YEAR	PERSON -REM/ YEAR	EXCESS LCF/ YEAR
LANL to U.S. 84/285	6.8×10^{0}	2.7×10^{-3}	3.6×10^{-2}	1.8×10^{-5}	5.9×10^{-1}	3.0×10^{-4}	3.6×10^{0}	1.8×10^{-3}
U.S. 84/285 to I–25	9.2×10^{0}	3.7×10^{-3}	4.4×10^{-1}	2.2×10^{-4}	4.2×10^{0}	2.1×10^{-3}	3.8×10^{0}	1.9×10^{-3}
Remainder of New Mexico	5.2×10^{1}	2.1×10^{-2}	1.3×10^{-1}	6.5×10^{-5}	2.0×10^{0}	1.0×10^{-3}	2.8×10^{1}	1.4×10^{-2}
Outside New Mexico	4.6×10^{2}	1.8×10^{-1}	3.0×10^{0}	1.5×10^{-3}	2.6×10^{1}	1.3×10^{-4}	2.1×10^{2}	1.0×10^{-1}
Aircraft	2.4×10^{0}	1.2×10^{-3}	NA	NA	NA	NA	NA	NA

NA = Not applicable

TABLE F.6.4.1–1.—*Annual Doses and Cancer Risks to Drivers from On-Site Shipment of Radioactive Materials*

	BASELINE (1994)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Number of Shipments	1,187	4,372	10,754	4,454	4,728
Collective Driver Dose (person-rem)[a]	1.136	4.184	10.292	4.262	4.525
Average Driver Dose (rem)[b]	0.047	0.174	0.429	0.178	0.189
Cancer Risk[c]	4.54×10^{-4}	1.67×10^{-3}	4.12×10^{-3}	1.70×10^{-3}	1.81×10^{-3}

[a] This is the total collective dose to all 24 drivers working at LANL. This dose was obtained by multiplying the total number of shipments by 9.57×10^{-4}.
[b] This is the annual average dose to each of the 24 drivers, obtained by dividing the total dose by 24.
[c] This is the sum of the excess LCF to all drivers from exposure to low level radiation. A dose-to-risk conversion factor of 4×10^{-4} is used.

TABLE F.6.4.1–2.—*Driver Dose Data for On-Site Shipments in 1994*

DRIVER NUMBER	SKIN DOSE (REM)	DEEP DOSE (REM)	NEUTRON DOSE (REM)	TOTAL DRIVER DOSE (REM)
1	0	0	0	0
2[a]	—	—	—	—
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0.01	0	0	0.01
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0.031	0	0.008	0.039
16	0.017	0	0	0.017
17	0.212	0.169	0.01	0.391
18	0.216	0.163	0	0.379
19	0.013	0	0	0.013
20	0.116	0.01	0.059	0.185
21	0.029	0	0	0.029
22	0	0	0	0
23	0	0	0	0
24	0.03	0	0.015	0.045
25	0.014	0.014	0	0.028
Total Collective Dose (person-rem/year)	0.688	0.356	0.092	1.136
Average Driver Dose (rem/year)	0.029	0.015	0.004	0.047

[a] No 1994 dosimetry data were available for driver No. 2. It was assumed that the driver left the job prior to 1994, and therefore he was dropped from the analysis.

— The collective driver dose was multiplied by a dose-to-risk conversion factor of 4 x 10^{-4} (cancer deaths per person-rem) to obtain the cancer risk.

The results for driver doses and associated risks are presented in Table F.6.4.1–1. The average driver doses are well below the DOE radiation protection standard of 5 rem per year. The highest collective dose (under the Expanded Operations Alternative) is just over 10 person-rem per year. The cancer risk associated with this dose is 4.12×10^{-3} excess LCFs per year.

F.6.5 Accidents

Analyses are conducted for scenarios leading to the release of either RAM or HAZMAT. The materials selected for analysis are those that represent bounding risks. Results are given for off-site shipments of RAM and HAZMAT. This subsection concludes with results for on-site RAM shipment.

F.6.5.1 *Determination of Bounding Materials*

Selection of the bounding material shipments is described in the following subsections.

Radioactive Materials

The shipments described in Tables F.5.3–1 and F.5.3–2 were evaluated as described in this subsection to determine those that would likely present the largest risk. These are referred to as the bounding materials. To determine the transportation risk, the shipment of bounding materials is evaluated in more detail. The bounding materials are those that have the largest value of

$$MAR \times ARF \times RF \times ID, \qquad (F–4)$$

Where:

MAR = material at risk (gram),

ARF = airborne release fraction,

RF = respirable fraction, and

ID = inhalation dose conversion factor (rem per gram).

The ARF values used are the RADTRAN default values, e.g., 1 x 10^{-6} for bulk metal, 1 x 10^{-2} for chunks, 1 x 10^{-1} for powder, and 1.0 for gases and volatile liquids. The RADTRAN default value for RF is 1.0 for gases and volatile liquids and 0.05 otherwise.

The bounding shipments determined by this approach are as follows:

- Off-site in an SST, plutonium-238 oxide powder (Table F.5.3–1, entries for plutonium operations and plutonium-238 heat source shipments to SRS)
- Off-site, americium-241 standards (Table F.5.3–1, americium-241 standard sales entry)
- On-site, plutonium-238 solution samples (Table F.5.3–2, entries for weapons grade plutonium and plutonium-238 liquid samples)

Equation F–4 is for materials that are hazardous due to their dispersion and subsequent exposure of persons to the airborne material. Another hazard is direct radiation from irradiated targets should the packaging fail (entry for irradiated targets in Table F.5.3–2). This hazard is bounding for its type. Some shipments associated with the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility are explosively configured, and the quoted values for ARF do not apply. DARHT shipments were not considered explicitly as bounding material; instead, the results from the DARHT EIS (DOE 1995) were incorporated into subsection F.6.5.5.

Risk includes both the consequence and the frequency of an event (subsection F.3.2). The bounding shipments were selected to produce the highest calculated consequence. The frequency associated with the calculated bounding consequence is determined by adding together the number of bounding shipments and any other shipment that has a consequence (as estimated by using Equation F–4) that is greater than 10 percent of the bounding consequence. This approach is conservative and is used for both RAM and HAZMAT shipments.

Shipments of CH TRU to WIPP exceed the 10 percent criterion and would be included in the frequency term for off-site shipments of americium-241 standards, but RH TRU shipments do not exceed the 10 percent criterion. Both shipment types are analyzed explicitly in this appendix because of the potential public interest in the results. Off-site shipments of pits in an SST trailer were also analyzed explicitly for the same reason.

Off-site shipments of plutonium-238 oxide powder in an SST trailer were conservatively aggregated with other strategic nuclear material also shipped in SST trailers. (ADROIT analyses of SST shipments were provided by SNL).

On-site shipments of some activated components (e.g., beam stops) as a result of accelerator operations exceed the 10 percent criterion and are included in the frequency term for on-site shipments of irradiated targets, as are DARHT shipments. (Some activated components may exceed the radiation level for irradiated targets, but irradiated targets are judged to pose the greater risk due to the packaging.)

On-site shipments of weapons-grade plutonium solution samples are included in the plutonium-238 solution samples frequency term.

Description of Bounding Radioactive Material Shipments

Pressed plutonium-238 oxide powder is enclosed in a welded capsule that is then enclosed in a welded vessel. The vessel is loaded into the 5320 packaging described in subsection F.2.4.5. Powder is transported to LANL from the Savannah River Site (SRS) in an SST. The 5320 package limit is 12.6 ounces (357 grams) of plutonium, but 15.6 ounces (441 grams) (17.6 ounces [500 grams] as plutonium dioxide) was used in the analysis to allow for possible increases in loading with another package.

The FL-Type container described in subsection F.2.4.1 is used to transport pits in an SST.

Up to 1 ounce (28 grams) americium-241 may be shipped in oxide form in a 30-gallon (114-liter) 6M package (subsection F.2.4.4); up to four packages may be shipped at a time. The oxide is enclosed in a stainless steel vial with a screw top and the vial is enclosed in a crimped can. This assembly is then placed in a 2R container in the 6M package.

Wastes transported to WIPP are enclosed in either the TRUPACT–II packaging described in subsection F.2.4.2 or the 72–B cask described in subsection F.2.4.6. One 72–B cask or three TRUPACT–II packages are transported in a single shipment. The waste parameters are those used in the WIPP Draft Supplemental EIS (DOE 1990c); additional details can be obtained from that document.

Samples of plutonium-238 in solution are transported from the Chemistry and Metallurgy Research (CMR) Facility to TA–55 in an armored vehicle that carries one to four packages. Each package consists of a stainless steel container enclosing three 0.5-gallon (2-liter) bottles. Each bottle is double sealed in plastic bags. The maximum concentration is 0.07 ounce (2 grams) plutonium-238 per 0.5-gallon (2-liter) bottle; all shipments are conservatively assumed to be at the maximum concentration. The LANL roads used are closed to traffic during the shipment.

The irradiated target package is a cylinder measuring 44 inches (112 centimeters) high, with a 26-inch (66-centimeter) diameter. The packaging is constructed of 5.8 tons (5.266 kilograms) of depleted uranium, lead, and stainless steel. The package is equipped with a sliding door on the bottom so that targets can be loaded into the packaging by means of special remote handling tools. The package is transported on a dedicated truck that has a keyhole-shaped receptacle recessed into the bed.

F.6.5.2 *Analysis of Off-Site Accidents Producing Bounding Radioactive Materials Releases*

The RADTRAN and ADROIT codes were used to analyze the bounding off-site RAM shipments described in subsections F.6.5.1. The MEI doses do not vary with route segment or alternative and are given in Table F.6.5.2–1 for each material analyzed with RADTRAN. ADROIT results that are separated into frequency and consequence components are not readily available. The product, MEI dose risk, varies with the number of shipments and the various shipment types. The population dose risks (consequence times frequency) and corresponding excess LCF risks are given in Tables F.6.5.2–2 through F.6.5.2–5 for each alternative.

F.6.5.3 *Analysis of Accidents Producing Chlorine Releases*

An event tree analysis produced the following accident scenarios that could lead to a major chlorine release:

- Release from a small hole caused by a puncture of the cylinder or failure of a valve from puncture or impact accidents
- Opening of a fusible plug as a result of fire
- Catastrophic failure in an impact accident
- Catastrophic failure as a result of a fire

The probability of each of these scenarios was determined from the event trees by using 1-ton (908-kilogram) container failure thresholds (Rhyne 1994a) and force magnitude probabilities (Dennis et al.). (Although LANL is not expected to store or handle chlorine containers this large, they have in the past, and the risks associated with transport of this size container bound the risks of toxic material shipments.) The ALOHA computer model (NSC 1995) was used to estimate release rates from the 1-ton (908-kilogram) container, and the DEGADIS (Havens and Spicer 1985) dense gas dispersion model was used to predict downwind chlorine concentrations following the four postulated releases. (A separate version of DEGADIS is used because the version incorporated in ALOHA does not readily provide time variation of downwind concentrations.)

In this analysis, exposures to toxic chemicals are compared to Emergency Response Planning Guidelines (ERPGs). ERPGs are explained in detail in appendix G, section G.2.2. ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action. ERPG–3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects. The model predicts the length and width of the cloud for which concentrations are greater than those at ERPG–2 and ERPG–3. The area affected, the maximum exposure duration, the maximum downwind distance affected, and the maximum chlorine cloud width are shown in Table F.6.5.3–1 for the bounding release, which is release from a small hole with fire. (Catastrophic releases are of very short duration and a high escape fraction is likely.)

TABLE F.6.5.2–1.—*Maximally Exposed Individual Doses and Associated Frequencies for Off-Site Radioactive Materials Accidents*

ROUTE SEGMENT	SHIPMENT TYPE					
	AMERICIUM-241		CH TRU		RH TRU	
	MEI DOSE (REM)	FREQUENCY PER TRIP	MEI DOSE (REM)	FREQUENCY PER TRIP	MEI DOSE (REM)	FREQUENCY PER TRIP
LANL to U.S. 84/285	59	1.8×10^{-7}	21	6.4×10^{-8}	0.16	6.0×10^{-9}
U.S. 84/285 to I–25	59	2.5×10^{-7}	21	7.4×10^{-8}	0.16	5.6×10^{-9}
Remainder of New Mexico	59	9.9×10^{-7}	21	1.4×10^{-6}	0.16	1.3×10^{-7}
Rest of U.S.	59	1.1×10^{-5}	NA	NA	NA	NA

TABLE F.6.5.2–2.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the No Action Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM-241	CH TRU	RH TRU	PLUTONIUM-238	PITS	TOTAL	
	PERSON-REM/ YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/ YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	EXCESS LCF/ YEAR
LANL to U.S. 84/285	1.5×10^{-2}	1.4×10^{-3}	3.1×10^{-6}	4×10^{-7}	2×10^{-6}	1.6×10^{-2}	8.0×10^{-6}
U.S. 84/285 to I–25	2.4×10^{-1}	1.9×10^{-2}	4.2×10^{-5}	1×10^{-6}	1×10^{-5}	2.6×10^{-1}	1.3×10^{-4}
Remainder of New Mexico	3.1×10^{-2}	1.2×10^{-2}	2.6×10^{-5}	4×10^{-7}	4×10^{-6}	4.3×10^{-2}	2.2×10^{-5}
Rest of U.S.	2.5×10^{0}	NA	NA	4×10^{-6}	2×10^{-5}	2.5×10^{0}	1.2×10^{-3}

TABLE F.6.5.2–3.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the Expanded Operations Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM-241	CH TRU	RH TRU	PLUTONIUM-238	PITS	TOTAL	
	PERSON-REM/ YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/ YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	EXCESS LCF/ YEAR
LANL to U.S. 84/285	1.6×10^{-2}	1.9×10^{-3}	3.8×10^{-6}	1×10^{-6}	6×10^{-6}	1.8×10^{-2}	9.0×10^{-6}
U.S. 84/285 to I–25	2.5×10^{-1}	2.4×10^{-2}	5.3×10^{-5}	2×10^{-6}	2×10^{-5}	2.7×10^{-1}	1.4×10^{-4}
Remainder of New Mexico	3.3×10^{-2}	1.6×10^{-2}	3.3×10^{-5}	1×10^{-6}	8×10^{-6}	4.9×10^{-2}	2.4×10^{-5}
Rest of U.S.	2.7×10^{0}	NA	NA	8×10^{-6}	4×10^{-5}	2.7×10^{0}	1.4×10^{-3}

TABLE F.6.5.2–4.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the Reduced Operations Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM-241	CH TRU	RH TRU	PLUTONIUM-238	PITS	TOTAL	
	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR
LANL to U.S. 84/285	1.5×10^{-2}	1.4×10^{-3}	2.9×10^{-6}	4×10^{-7}	2×10^{-6}	1.6×10^{-2}	8.0×10^{-6}
U.S. 84/285 to I–25	2.4×10^{-1}	1.9×10^{-2}	4.0×10^{-5}	1×10^{-6}	8×10^{-6}	2.6×10^{-1}	1.3×10^{-4}
Remainder of New Mexico	3.1×10^{-2}	1.2×10^{-2}	2.5×10^{-5}	4×10^{-7}	4×10^{-6}	4.3×10^{-2}	2.2×10^{-5}
Rest of U.S.	2.5×10^{0}	NA	NA	4×10^{-6}	1×10^{-5}	2.5×10^{0}	1.2×10^{-3}

TABLE F.6.5.2–5.—*Bounding Radioactive Materials Off-Site Accident Population Risk for the Greener Alternative*

ROUTE SEGMENT	ANNUAL POPULATION DOSE RISK AND EXCESS LCF RISK						
	SHIPMENT TYPE						
	AMERICIUM-241	CH TRU	RH TRU	PLUTONIUM-238	PITS	TOTAL	
	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	PERSON-REM/YEAR	EXCESS LCF/YEAR
LANL to U.S. 84/285	1.6×10^{-2}	1.5×10^{-3}	3.2×10^{-6}	4×10^{-7}	2×10^{-6}	1.8×10^{-2}	9.0×10^{-6}
U.S. 84/285 to I–25	2.5×10^{-1}	2.0×10^{-2}	4.4×10^{-5}	1×10^{-6}	8×10^{-6}	2.7×10^{-1}	1.4×10^{-4}
Remainder of New Mexico	3.3×10^{-2}	1.3×10^{-2}	2.7×10^{-5}	4×10^{-7}	4×10^{-6}	4.6×10^{-2}	2.3×10^{-5}
Rest of U.S.	2.7×10^{0}	NA	NA	4×10^{-6}	1×10^{-5}	2.7×10^{0}	1.4×10^{-3}

TABLE F.6.5.3–1.—*Exposure Parameters of Bounding Chlorine Accident*

ACCIDENT DESCRIPTION	MAXIMUM EXPOSURE DURATION (MINUTES)	MAXIMUM DOWNWIND DISTANCE (KILOMETERS)		MAXIMUM CLOUD WIDTH (KILOMETERS)	
		EPRG-2	EPRG-3	EPRG-2	EPRG-3
Fire Causes Opening of a Fusible Plug	8.4	4.2	2.1	0.28	0.15

EPRG = Emergency Response Planning Guideline

(NSC 1995) was used to estimate release rates from the 1-ton (908-kilogram) container, and the DEGADIS (Havens and Spicer 1985) dense gas dispersion model was used to predict downwind chlorine concentrations following the four postulated releases. (A separate version of DEGADIS is used because the version incorporated in ALOHA does not readily provide time variation of downwind concentrations.)

In this analysis, exposures to toxic chemicals are compared to Emergency Response Planning Guidelines (ERPGs). ERPGs are explained in detail in appendix G, section G.2.2. ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action. ERPG–3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects. The model predicts the length and width of the cloud for which concentrations are greater than those at ERPG–2 and ERPG–3. The area affected, the maximum exposure duration, the maximum downwind distance affected, and the maximum chlorine cloud width are shown in Table F.6.5.3–1 for the bounding release, which is release from a small hole with fire. (Catastrophic releases are of very short duration and a high escape fraction is likely.)

The number of fatalities or injuries would depend on the population density and the ability of people to avoid harmful exposure by going indoors or leaving the affected area. The frequency of occurrence of this accident would depend on the truck accident rate. The accident rate and population density would vary for the different route segments. The ability of people to avoid harmful exposure (to escape) would depend on various factors; an escape fraction of 0.98 is used for all route segments. This fraction is based on analysis of a transportation accident producing fatal releases of ammonia (Glickman and Raj 1992) and should be applicable to chlorine because the same dispersion coefficients apply, resulting in similar plume shapes and gradients of concentration. For both, there will be objectionable odor a short period prior to concentrations that have serious effects. The plumes tend to be visible and of modest transverse dimension, with very objectionable odor and strong respiratory irritation at their edges, permitting recognition and urging prompt escape on foot. The estimated frequency of a major chlorine release and the estimated number of associated fatalities and injuries are given in Table F.6.5.3–2 for different population densities along the routes. The risk values (i.e., annual frequency times consequences analogous to Tables F.6.5.2–2 through F.6.5.2–5) are given for the SWEIS alternatives in Table F.6.5.3–3.

F.6.5.4 *Analysis of Accidents Producing Propane Releases*

The bounding consequence from a propane release would be the generation of a fireball. The fireball would likely occur too soon after the postulated truck accident for evacuation to be effective. The fireball would have a radius of about 148 feet (45 meters) and would burn for about 3 seconds. Many persons would be protected by buildings or automobiles for this short duration. It is assumed that 50 percent of the available population would be shielded from the fireball, 10 percent would be fatalities, and the remainder would be injured (PNL 1980). In addition, fatal second-degree burns might be experienced out to a radius of 620 feet (189 meters). The percentages of available persons that would be exposed to the radiant heat flux are assumed to be 0.16 percent, 12 percent, and 19 percent in urban, suburban, and rural areas, respectively (PNL 1980).

TABLE F.6.5.3–2.—*Frequencies and Consequences of a Major Chlorine Release*

ROUTE SEGMENT	AREA	FREQUENCY PER TRIP	ESTIMATED NUMBER OF FATALITIES	ESTIMATED NUMBER OF INJURIES
LANL to U.S. 84/ 285	Rural	3.1×10^{-7}	6.5×10^{-2}	2.4×10^{-1}
	Suburban	5.1×10^{-8}	1.5×10^{0}	5.6×10^{0}
U.S. 84/285 to I–25	Rural	2.4×10^{-7}	5.3×10^{-2}	2.0×10^{-1}
	Suburban	5.2×10^{-7}	3.0×10^{0}	1.1×10^{1}
	Urban	1.6×10^{-7}	1.1×10^{1}	4.0×10^{1}
Remainder of New Mexico	Rural	1.8×10^{-6}	1.5×10^{-2}	5.6×10^{-2}
	Suburban	1.9×10^{-7}	1.5×10^{0}	5.5×10^{0}
	Urban	3.1×10^{-8}	8.4×10^{0}	3.2×10^{1}
Remainder of U.S.	Rural	1.3×10^{-5}	2.8×10^{-2}	1.0×10^{-1}
	Suburban	3.3×10^{-6}	1.6×10^{0}	6.1×10^{0}
	Urban	7.8×10^{-7}	1.0×10^{1}	3.9×10^{1}

TABLE F.6.5.3–3.—*Major Chlorine Accident Risks*

ROUTE SEGMENT	ALTERNATIVE							
	NO ACTION		EXPANDED OPERATIONS		REDUCED OPERATIONS		GREENER	
	FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR
LANL to U.S. 84/285	8.6×10^{-6}	3.2×10^{-5}	1.9×10^{-5}	7.2×10^{-5}	8.0×10^{-6}	3.0×10^{-5}	8.6×10^{-6}	3.2×10^{-5}
U.S. 84/285 to I–25	2.9×10^{-4}	1.1×10^{-3}	6.4×10^{-4}	2.4×10^{-3}	2.7×10^{-4}	1.0×10^{-3}	2.9×10^{-4}	1.1×10^{-3}
Remainder of New Mexico	5.2×10^{-5}	1.9×10^{-4}	1.1×10^{-4}	4.2×10^{-4}	4.8×10^{-5}	1.8×10^{-4}	5.2×10^{-5}	1.9×10^{-4}
Remainder of U.S.	1.2×10^{-3}	4.7×10^{-3}	2.8×10^{-3}	1.0×10^{-2}	1.2×10^{-3}	4.4×10^{-3}	1.2×10^{-3}	4.7×10^{-3}

The number of fatalities or injuries would depend on the population density and the ability of people to avoid harmful exposure by going indoors or leaving the affected area. The frequency of occurrence of this accident would depend on the truck accident rate. The accident rate and population density would vary for the different route segments. The ability of people to avoid harmful exposure (to escape) would depend on various factors; an escape fraction of 0.98 is used for all route segments. This fraction is based on analysis of a transportation accident producing fatal releases of ammonia (Glickman and Raj 1992) and should be applicable to chlorine because the same dispersion coefficients apply, resulting in similar plume shapes and gradients of concentration. For both, there will be objectionable odor a short period prior to concentrations that have serious effects. The plumes tend to be visible and of modest transverse dimension, with very objectionable odor and strong respiratory irritation at their edges, permitting recognition and urging prompt escape on foot. The estimated frequency of a major chlorine release and the estimated number of associated fatalities and injuries are given in Table F.6.5.3–2 for different population densities along the routes. The risk values (i.e., annual frequency times consequences analogous to Tables F.6.5.2–2 through F.6.5.2–5) are given for the SWEIS alternatives in Table F.6.5.3–3.

F.6.5.4 *Analysis of Accidents Producing Propane Releases*

The bounding consequence from a propane release would be the generation of a fireball. The fireball would likely occur too soon after the postulated truck accident for evacuation to be effective. The fireball would have a radius of about 148 feet (45 meters) and would burn for about 3 seconds. Many persons would be protected by buildings or automobiles for this short duration. It is assumed that 50 percent of the available population would be shielded from the fireball, 10 percent would be fatalities, and the remainder would be injured (PNL 1980). In addition, fatal second-degree burns might be experienced out to a radius of 620 feet (189 meters). The percentages of available persons that would be exposed to the radiant heat flux are assumed to be 0.16 percent, 12 percent, and 19 percent in urban, suburban, and rural areas, respectively (PNL 1980).

The number of persons that would be affected depends on the population density; the frequency of the accident would depend on the truck accident rate. Both of these parameters would vary for the different route segments. The truck accident frequency of a major propane release and the estimated numbers of fatalities and injuries are given in Table F.6.5.4–1 for different population densities along the routes. The fatality and injury risks are given in Table F.6.5.4–2 for the four SWEIS alternatives. The frequency of large explosive shipments was added to the frequency of large flammable shipments.

F.6.5.5 *Analysis of On-Site Accidents Producing Bounding Radioactive Materials Releases*

The bounding on-site shipments involving RAM are the transport of plutonium-238 solution from CMR to TA–55 and the transport of irradiated targets from the LANSCE to TA–48. Both types of shipments are made with the roads closed to all persons except personnel directly involved in the transport. Therefore, no member of the public would be expected to be involved in the postulated truck accident or to be a bystander after the postulated truck accident.

MEI dose is calculated using the following assumptions. In the case of plutonium-238 solution, it is assumed that a person would stand very close to the evaporating liquid for 10 minutes before being warned away. In the case

TABLE F.6.5.4–1.—*Frequencies and Consequences of a Major Propane Release*

ROUTE SEGMENT	AREA	FREQUENCY PER TRIP	ESTIMATED NUMBER OF FATALITIES	ESTIMATED NUMBER OF INJURIES
LANL to U.S. 84/ 285	Rural	1.3×10^{-7}	2.8×10^{-1}	1.1×10^{0}
	Suburban	2.2×10^{-8}	4.2×10^{0}	1.7×10^{1}
U.S. 84/285 to I–25	Rural	1.0×10^{-7}	2.3×10^{-1}	9.2×10^{-1}
	Suburban	2.2×10^{-7}	8.4×10^{0}	3.4×10^{1}
	Urban	6.7×10^{-8}	1.8×10^{0}	7.3×10^{0}
Remainder of New Mexico	Rural	8.7×10^{-7}	1.5×10^{-1}	6.0×10^{-1}
	Suburban	2.8×10^{-7}	5.1×10^{0}	2.0×10^{1}
	Urban	3.5×10^{-8}	1.5×10^{0}	6.1×10^{0}
Remainder of U.S.	Rural	1.1×10^{-6}	9.0×10^{-2}	3.6×10^{-1}
	Suburban	1.4×10^{-7}	4.8×10^{0}	1.9×10^{1}
	Urban	7.2×10^{-8}	1.9×10^{0}	7.5×10^{0}

TABLE F.6.5.4–2.—*Major Propane Accident Risk*

ROUTE SEGMENT	ALTERNATIVE							
	NO ACTION		EXPANDED OPERATIONS		REDUCED OPERATIONS		GREENER	
	FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR
LANL to U.S. 84/285	9.7×10^{-6}	3.9×10^{-5}	2.2×10^{-5}	8.6×10^{-5}	9.2×10^{-6}	3.7×10^{-5}	9.7×10^{-6}	3.9×10^{-5}
U.S. 84/285 to I–25	1.5×10^{-4}	6.0×10^{-4}	3.3×10^{-4}	1.3×10^{-3}	1.4×10^{-4}	5.7×10^{-4}	1.5×10^{-4}	6.0×10^{-4}
Remainder of New Mexico	1.2×10^{-4}	4.8×10^{-4}	2.6×10^{-4}	1.1×10^{-3}	1.1×10^{-4}	4.5×10^{-4}	1.2×10^{-4}	4.8×10^{-4}
Remainder of U.S.	6.7×10^{-5}	2.7×10^{-4}	1.5×10^{-4}	5.9×10^{-4}	6.3×10^{-5}	2.5×10^{-4}	6.7×10^{-5}	2.7×10^{-4}

of the irradiated target cask failure, a narrow radiation beam would be produced that would be lethal after 10 minutes of continuous exposure at a distance of 6 feet (1.8 meters) from the cask, and it is assumed that a person would stand in this beam for 10 minutes.

The resulting MEI doses and frequencies are given in Table F.6.5.5–1, and MEI risk is given in Table F.6.5.5–2 for the four SWEIS alternatives. The plutonium-238 solution sample shipment frequency terms includes weapons-grade plutonium solution sample shipments, and the irradiated target shipment frequency term includes activated inserts and beam stops (Table F.5.3–2) shipments. DARHT shipment accidents could result in an off-site MEI dose of 76 rem and fatalities to LANL truck crews and other individuals within 80 feet (24 meters) of the explosion (DOE 1995). The frequency of DARHT shipments has been added to the frequency of irradiated target shipments.

F.6.6 Transportation of Waste Off Site

Transportation of waste is imbedded in the transportation risk assessment. Because the methodology is directed at identifying the greatest risks associated with shipments of materials, both from the standpoint of incident-free shipments as well as accidents, the lesser quantities of materials per package typically found in wastes (as compared to stock materials) tend to screen them from a detailed analytical presentation in this assessment. Waste shipments have been found to be of public interest; and it is useful, therefore, to discuss the manner in which the impacts of these shipments are considered. This qualitative presentation is also illustrative of the overall methodology.

Numbers of shipments of waste per year in the categories of radioactive and nonradioactive hazardous material were included in the mileage calculations for shipment of other materials in the same class for the purpose of evaluating impacts due to vehicle emissions, direct

TABLE F.6.5.5–1.—*Maximally Exposed Individual Doses and Frequencies for On-Site Radioactive Materials Accidents*

SHIPMENT TYPE	PER TRIP FREQUENCY	MEI DOSE
Plutonium-238 Solution	6.9×10^{-10}	8.7 rem
Irradiated Targets	3.4×10^{-8}	fatal

TABLE F.6.5.5–2.—*On-Site Radioactive Materials Accident Maximally Exposed Individual Risk*

SHIPMENT TYPE	MEI RISK PER ALTERNATIVE			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Plutonium-238 Solution	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCF/year)	1.4×10^{-6} rem/year (5.8×10^{-10} excess LCF/year)	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCF/year)	7.7×10^{-7} rem/year (3.1×10^{-10} excess LCF/year)
Irradiated Targets	3.1×10^{-6} fatalities/ year	3.2×10^{-6} fatalities/ year	2.9×10^{-6} fatalities/ year	3.2×10^{-6} fatalities/ year

exposure to radiation, and accidents not involving the release of cargo. Specifically, TRU waste shipments to WIPP are less than 10 percent of the total number of shipments under any alternative (and because of the relatively short distance between LANL and WIPP, these shipments would constitute an even smaller percentage contribution to incident-free impacts attributed to radioactive material shipments), LLW shipments for off-site disposal under the Reduced Operations and Greener Alternatives are about 30 percent of the total shipments under these alternatives (LLW constitutes about 15 percent and less than 1 percent of off-site shipments under the No Action and Expanded Operations Alternatives, respectively), and about 10 percent of the total number of hazardous (nonradioactive) shipments would be expected to be waste shipments. (This is based on historical information—hazardous waste shipments were not specifically projected and are not reflected as individual shipments in the off-site shipment projections in this appendix.) Although the numbers of hazardous waste shipments were not individually projected, they are included in the numbers of shipments in Table F.5.3–3 and considered in the total mileage and impacts projected for hazardous material shipments.

Routes for the shipment of waste are typical of, and represented by, the routes chosen for analysis that covered the U.S. by sector in terms of population density as well as the category of road (except that WIPP shipment routes, as noted above, are much shorter than most of the nonwaste radioactive material shipment routes); thus, the contribution of waste shipments to the total risks due to vehicle emissions and accidents without a cargo release could be estimated using the percentages in the previous paragraph (although this would be very conservative for WIPP shipments). The amount of material in a given container is orders of magnitude less for waste shipments than for product shipments (see accidents discussion below), so the incident-free radiation exposure attributable to waste shipments would be a very small percentage of that presented in this appendix and in chapter 5.

Accidents involving the release of cargo were based on factors such as the greatest quantity of the material known to be shipped, the most toxic, and the least protective packaging. Accident risk associated with the transportation of transuranic waste to WIPP was specifically analyzed and presented in this appendix and in chapter 5 due to public interest in such shipments, and they are not discussed further here. LLW and low-level mixed waste (LLMW) shipments involve, at most, from 0.001 percent (for plutonium-238) to 0.01 percent (for americium-241 and plutonium-239) of the total material considered in the off-site radioactive materials accidents specifically presented in this appendix. The mileage associated with LLW waste shipments is conservatively estimated at 30 percent of that used in the radioactive materials accident analyses presented in this appendix. Therefore, the risk associated with waste shipments is conservatively estimated to be 0.003 percent of that analyzed and presented for radioactive materials, as presented in this analysis.

Similarly, shipments of hazardous chemical (nonradioactive) waste contain much less of the hazardous material content than do the shipments of chlorine and propane analyzed and presented in this appendix and in chapter 5. While no estimates of waste contents were available for use in this SWEIS, such shipments would not be likely to exceed 10 percent of the amounts used for chlorine and propane accidents (and would likely be a much smaller fraction of these quantities). On that basis, hazardous chemical waste shipments, which constitute about 10 percent of the total number of hazardous chemical shipments, would not be expected (conservatively) to result in risks that exceed 1 percent of those presented in this SWEIS for hazardous material shipments.

F.7 ANALYSIS OF THE SANTA FE RELIEF ROUTE OPTION

F.7.1 Introduction

The effect of the proposed relief route would be to replace 6.5 miles (10.5 kilometers) on U.S. 84/285 through Santa Fe to exit number 282 of I–25 with 13.8 miles (22.2 kilometers) starting from U.S. 84/285 north of Santa Fe to exit number 276 of I–25, south of Santa Fe. Because of the location where the Relief Route meets I–25, travel on I–25 south of Santa Fe would be reduced by six miles of highway travel, and travel on I–25 north of Santa Fe would be increased by 6 miles of highway travel if the Relief Route were used. The route between exit number 282 of I–25 and the junction of U.S. 84/285 with NM 502 consists of 1.2 miles (1.9 kilometers) of urban, 3.9 miles (1.9 kilometers) of suburban, and 14.9 miles (24 kilometers) of rural highway (Table F.4.3–1). For this analysis, the 6.5 mile (10.5 kilometer) segment replaced is assumed to consist of all of the urban and suburban highway plus 1.4 miles (2.3 kilometers) of rural highway. The 13.8-mile (22.2-kilometer) relief route is assumed to consist of 9.6 miles (15.4 kilometers) of suburban and 4.2 miles (6.8 kilometers) of rural highway.

The four risk measures evaluated in section F.6 are evaluated in this section for the relief route option.

F.7.2 Results

The effect of the proposed relief route on truck emissions in urban areas would be to eliminate 1.2 miles (1.9 kilometers) of urban highway. The overall reduction in excess LCFs would be small, as shown in Table F.7.2–1.

A comparison of the annual number of fatalities and injuries from truck accidents is shown in Tables F.7.2–2 and F.7.2–3, respectively. The variation in truck accidents is shown in Table F.7.2–4.

Only the route segments affected by the relief route option are described. The effect of the relief route on the remainder of New Mexico route segment is negligible, but the effect on the U.S. 84/285 to I–25 route segment is reduced by about one-half for the relief route option. The reason is that the accident rate assumed on the relief route is approximately one order of magnitude less than that for some parts of the route through Santa Fe, in contrast to the distance which increases by 50 percent.

A comparison of the annual incident-free population doses for the No Action, Expanded Operations, Reduced Operations, and Greener Alternatives is given in Tables F.7.2–5 through F.7.2–8, respectively. In general, the changes are small with a few exceptions. The occupational and stops doses are directly proportional to the length and inversely proportional to the truck speed, and they increase for the relief route. The dose to those sharing the route is directly proportional to the traffic density, which is significantly reduced on the relief route. This dose decreases for the relief route.

A comparison of the change in accident frequencies is shown in Tables F.7.2–9 and F.7.2–10 for radioactive and HAZMAT, respectively. The change in the remainder of New Mexico route segment depends on whether the shipment direction is southwest or northeast. Chlorine is the representative material for all toxic materials, whose representative source is the northeast; and propane is the representative material for all flammable materials, whose representative source is the southwest. (The comment in the next paragraph about potential exaggeration applies to Tables F.7.2–9 and F.7.2–10.)

The changes in bounding RAM accident population dose risks are shown in Tables F.7.2–11 through F.7.2–14 for the four SWEIS

TABLE F.7.2–1.—*Comparison of Excess Latent Cancer Fatalities per Year Due to Truck Emissions*

ROUTE OPTION	ALTERNATIVE			
	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Route Through Santa Fe	3.2×10^{-2}	6.6×10^{-2}	3.4×10^{-2}	3.6×10^{-2}
Relief Route	3.1×10^{-2}	6.4×10^{-2}	3.3×10^{-2}	3.5×10^{-2}

TABLE F.7.2–2.—*Comparison of Annual Truck Accident Fatalities*

ROUTE OPTION	ROUTE SEGMENT	ALTERNATIVE			
		NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Route Through Santa Fe	U.S. 84/285 to I–25	4.1×10^{-3}	8.2×10^{-3}	4.3×10^{-3}	4.6×10^{-3}
	Remainder of New Mexico	7.2×10^{-2}	1.5×10^{-1}	7.5×10^{-2}	8.0×10^{-2}
Relief Route	U.S. 84/285 and Relief Route	2.3×10^{-3}	4.7×10^{-3}	2.4×10^{-3}	2.6×10^{-3}
	Remainder of New Mexico	7.2×10^{-2}	1.5×10^{-1}	7.6×10^{-2}	8.1×10^{-2}

TABLE F.7.2–3.—*Comparison of Annual Truck Accident Injuries*

ROUTE OPTION	ROUTE SEGMENT	ALTERNATIVE			
		NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Route Through Santa Fe	U.S. 84/285 to I–25	8.6×10^{-2}	1.8×10^{-1}	9.1×10^{-2}	9.7×10^{-2}
	Remainder of New Mexico	6.4×10^{-1}	1.3×10^{0}	6.8×10^{-1}	7.2×10^{-1}
Relief Route	U.S. 84/285 to I–25	4.9×10^{-2}	9.8×10^{-2}	5.2×10^{-2}	5.5×10^{-2}
	Remainder of New Mexico	6.5×10^{-1}	1.3×10^{0}	6.8×10^{-1}	7.3×10^{-1}

TABLE F.7.2–4.—*Comparison of Number of Annual Truck Accidents*

ROUTE OPTION	ROUTE SEGMENT	ALTERNATIVE			
		NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Route Through Santa Fe	U.S. 84/285 to I–25	4.1×10^{-1}	8.2×10^{-1}	4.3×10^{-1}	4.6×10^{-1}
	Remainder of New Mexico	6.7×10^{-1}	1.4×10^{0}	7.0×10^{-1}	7.6×10^{-1}
Relief Route	U.S. 84/285 to I–25	2.3×10^{-1}	4.7×10^{-1}	2.4×10^{-1}	2.6×10^{-1}
	Remainder of New Mexico	6.7×10^{-1}	1.4×10^{0}	7.1×10^{-1}	7.6×10^{-1}

TABLE F.7.2–5.—*Comparison of Annual Incident-Free Population Dose for the No Action Alternative*

ROUTE OPTION	ROUTE SEGMENT	OCCUPATIONAL (PERSON-REM/YEAR)	NONOCCUPATIONAL (PERSON-REM/YEAR)		
			ALONG ROUTE	SHARING ROUTE	STOPS
Route Through Santa Fe	U.S. 84/285 to I–25	7.9×10^{0}	3.8×10^{-1}	3.6×10^{0}	3.3×10^{0}
	Remainder of New Mexico	4.5×10^{1}	1.0×10^{-1}	1.7×10^{0}	2.4×10^{1}
Relief Route	U.S. 84/285 to I–25	1.1×10^{1}	3.8×10^{-1}	2.2×10^{0}	4.8×10^{0}
	Remainder of New Mexico	4.5×10^{1}	1.2×10^{-1}	1.7×10^{0}	2.4×10^{1}

TABLE F.7.2–6.—*Comparison of Annual Incident-Free Population Dose for the Expanded Operations Alternative*

ROUTE OPTION	ROUTE SEGMENT	OCCUPATIONAL (PERSON-REM/YEAR)	NONOCCUPATIONAL (PERSON-REM/YEAR)		
			ALONG ROUTE	SHARING ROUTE	STOPS
Route Through Santa Fe	U.S. 84/285 to I–25	1.0×10^{1}	4.9×10^{-1}	4.6×10^{0}	4.2×10^{0}
	Remainder of New Mexico	5.5×10^{1}	1.2×10^{-1}	2.1×10^{0}	3.0×10^{1}
Relief Route	U.S. 84/285 to I–25	1.5×10^{1}	4.8×10^{-1}	2.8×10^{0}	6.1×10^{0}
	Remainder of New Mexico	5.5×10^{1}	1.3×10^{-1}	2.1×10^{1}	3.0×10^{1}

TABLE F.7.2–7.—*Comparison of Annual Incident-Free Population Dose for the Reduced Operations Alternative*

ROUTE OPTION	ROUTE SEGMENT	OCCUPATIONAL (PERSON-REM/YEAR)	NONOCCUPATIONAL (PERSON-REM/YEAR)		
			ALONG ROUTE	SHARING ROUTE	STOPS
Route Through Santa Fe	U.S. 84/285 to I–25	8.7×10^{0}	4.2×10^{-1}	3.4×10^{0}	3.6×10^{0}
	Remainder of New Mexico	5.0×10^{1}	1.2×10^{-1}	1.9×10^{0}	2.7×10^{1}
Relief Route	U.S. 84/285 to I–25	1.2×10^{1}	4.1×10^{-1}	2.4×10^{0}	5.2×10^{0}
	Remainder of New Mexico	5.1×10^{1}	1.3×10^{-1}	1.9×10^{0}	2.7×10^{1}

TABLE F.7.2–8.—*Comparison of Annual Incident-Free Population Dose for the Greener Alternative*

ROUTE OPTION	ROUTE SEGMENT	OCCUPATIONAL (PERSON-REM/ YEAR)	NONOCCUPATIONAL (PERSON-REM/YEAR)		
			ALONG ROUTE	SHARING ROUTE	STOPS
Route Through Santa Fe	U.S. 84/285 to I–25	9.2×10^{0}	4.4×10^{-1}	4.2×10^{0}	3.8×10^{0}
	Remainder of New Mexico	5.2×10^{1}	1.3×10^{-1}	2.0×10^{0}	2.8×10^{1}
Relief Route	U.S. 84/285 to I–25	1.3×10^{1}	4.8×10^{-1}	2.5×10^{0}	5.5×10^{0}
	Remainder of New Mexico	5.3×10^{1}	1.3×10^{-1}	2.0×10^{0}	2.9×10^{1}

TABLE F.7.2–9.—*Comparison of Off-Site Radioactive Materials Release Frequencies*

ROUTE OPTION	ROUTE SEGMENT	FREQUENCY PER TRIP		
		AMERICIUM-241	CH TRU	RH TRU
Route Through Santa Fe	U.S. 84/285 to I–25	2.5×10^{-7}	7.4×10^{-8}	5.6×10^{-9}
	Remainder of New Mexico	9.9×10^{-7}	1.4×10^{-6}	1.3×10^{-7}
Relief Route	U.S. 84/285 to I–25	2.0×10^{-7}	6.8×10^{-8}	6.1×10^{-9}
	Remainder of New Mexico	1.0×10^{-6}	1.4×10^{-6}	1.3×10^{-7}

TABLE F.7.2–10.—*Comparison of Chlorine and Propane Major Release Frequencies*

ROUTE OPTION	ROUTE SEGMENT	FREQUENCY PER TRIP	
		CHLORINE	PROPANE
Route Through Santa Fe	U.S. 84/285 to I–25	9.1×10^{-7}	3.9×10^{-7}
	Remainder of New Mexico	2.0×10^{-6}	1.2×10^{-6}
Relief Route	U.S. 84/285 to I–25	4.6×10^{-7}	2.0×10^{-7}
	Remainder of New Mexico	2.3×10^{-6}	1.1×10^{-6}

TABLE F.7.2–11.—*Comparison of Bounding Radioactive Material Off-Site Accident Population Risk for the No Action Alternative*

ROUTE OPTION	ROUTE SEGMENT	POPULATION RISK (PERSON-REM/YEAR) FOR SHIPMENT TYPES					TOTAL	
		AMERICIUM -241	CH TRU	RH TRU	PLUTONIUM -238	PITS	PERSON-REM/YEAR	EXCESS LCF/ YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	2.4×10^{-1}	1.9×10^{-2}	4.2×10^{-5}	1×10^{-6}	1×10^{-5}	2.6×10^{-1}	1.3×10^{-4}
	Remainder of New Mexico	3.1×10^{-2}	1.2×10^{-2}	2.6×10^{-5}	4×10^{-7}	4×10^{-6}	4.3×10^{-2}	2.2×10^{-5}
Relief Route	U.S. 84/285 to I–25	6.8×10^{-2}	5.6×10^{-3}	1.2×10^{-5}	4×10^{-7}	4×10^{-6}	7.4×10^{-2}	3.7×10^{-5}
	Remainder of New Mexico	8.4×10^{-2}	1.9×10^{-2}	4.2×10^{-5}	4×10^{-7}	4×10^{-6}	1.0×10^{-1}	5.0×10^{-5}

TABLE F.7.2–12.—*Comparison of Bounding Radioactive Materials Off-Site Accident Population Risk for the Expanded Operations Alternative*

ROUTE OPTION	ROUTE SEGMENT	POPULATION RISK (PERSON-REM/YEAR) FOR SHIPMENT TYPES					TOTAL	
		AMERICIUM -241	CH TRU	RH TRU	PLUTONIUM-238	PITS	PERSON-REM/YEAR	EXCESS LCF/ YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	2.5×10^{-1}	2.4×10^{-2}	5.3×10^{-5}	2×10^{-6}	2×10^{-5}	2.7×10^{-1}	1.4×10^{-4}
	Remainder of New Mexico	3.3×10^{-2}	1.6×10^{-2}	3.3×10^{-5}	1×10^{-6}	8×10^{-6}	4.9×10^{-2}	2.4×10^{-5}
Relief Route	U.S. 84/285 to I–25	7.3×10^{-2}	7.3×10^{-3}	1.5×10^{-5}	1×10^{-6}	8×10^{-6}	8.0×10^{-2}	4.0×10^{-5}
	Remainder of New Mexico	9.0×10^{-2}	2.5×10^{-2}	4.9×10^{-5}	1×10^{-6}	8×10^{-6}	1.2×10^{-1}	6.0×10^{-5}

TABLE F.7.2–13.—*Comparison of Bounding Radioactive Materials Off-Site Accident Population Risk for the Reduced Operations Alternative*

ROUTE OPTION	ROUTE SEGMENT	POPULATION RISK (PERSON-REM/YEAR) FOR SHIPMENT TYPES					TOTAL	
		AMERICIUM -241	CH TRU	RH TRU	PLUTONIUM -238	PITS	PERSON-REM/YEAR	EXCESS LCF/ YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	2.4×10^{-1}	1.9×10^{-2}	4.0×10^{-5}	1×10^{-6}	8×10^{-6}	2.6×10^{-1}	1.3×10^{-4}
	Remainder of New Mexico	3.1×10^{-2}	1.2×10^{-2}	2.5×10^{-5}	4×10^{-7}	4×10^{-6}	4.3×10^{-2}	2.2×10^{-5}
Relief Route	U.S. 84/285 to I–25	6.8×10^{-2}	5.6×10^{-3}	1.2×10^{-5}	4×10^{-7}	2×10^{-6}	7.4×10^{-2}	3.7×10^{-5}
	Remainder of New Mexico	8.4×10^{-2}	1.9×10^{-2}	4.0×10^{-5}	4×10^{-7}	4×10^{-6}	1.0×10^{-1}	5.0×10^{-5}

TABLE F.7.2–14.—*Comparison of Bounding Radioactive Materials Off-Site Accident Population Risk for the Greener Alternative*

ROUTE OPTION	ROUTE SEGMENT	POPULATION RISK (PERSON-REM/YEAR) FOR SHIPMENT TYPES					TOTAL	
		AMERICIUM-241	CH TRU	RH TRU	PLUTONIUM-238	PITS	PERSON-REM/YEAR	EXCESS LCF/ YEAR
St. Francis Drive	U.S. 84/285 to I–25	2.5×10^{-1}	2.0×10^{-2}	4.4×10^{-5}	1×10^{-6}	8×10^{-6}	2.7×10^{-1}	1.4×10^{-4}
	Remainder of New Mexico	3.3×10^{-2}	1.3×10^{-2}	2.7×10^{-5}	4×10^{-7}	4×10^{-6}	4.6×10^{-2}	2.3×10^{-5}
Relief Route	U.S. 84/285 to I–25	7.3×10^{-2}	5.9×10^{-3}	1.3×10^{-5}	4×10^{-7}	2×10^{-6}	7.9×10^{-2}	4.0×10^{-5}
	Remainder of New Mexico	9.0×10^{-2}	2.0×10^{-2}	4.3×10^{-5}	4×10^{-7}	4×10^{-6}	1.1×10^{-1}	5.5×10^{-5}

alternatives. The change in injury and fatality risks of major releases of chlorine and propane is shown in Tables F.7.2–15 through F.7.2–18 for the four SWEIS alternatives. The RADTRAN results in Tables F.7.2–11 through F.7.2–14 show a major increase for the remainder of New Mexico route segment, but the ADROIT results show no change. The difference in these sets of results is due to the difference in the way the portion of I–25 between exits 276 and 282 was modeled in the two computer programs. All of the RAM shipments analyzed in Tables F.7.2–11 through F.7.2–14, as well as chlorine shipments in Tables F.7.2–15 through F.7.2–18, are expected to follow I–25 north for 6 miles further with the relief route option than for the route through Santa Fe, in contrast to propane shipments that would go south on I–25 and experience 6 miles less travel on I–25. The RADTRAN, chlorine, and propane analyses are based on the conservative assumption that the 6 miles on I–25 are in an area with a population density characteristic of suburban areas. The changes in the remainder of New Mexico values for americium-241, CH TRU, RH TRU, chlorine, and propane are therefore somewhat exaggerated. The changes for the 6 miles on I–25 are accurately computed in the ADROIT analysis of plutonium-238 and pits, but are tabulated in the U.S. 84/285 to I–25 route segment rather than the remainder of New Mexico route segment. The ADROIT computer code has the capability to access population data at the census block level.

F.8 UNCERTAINTY AND CONSERVATISM IN THE ANALYSIS

The major steps in the transportation risk analysis are as follows:

- Determination of the amount and characteristics of materials that will be needed or generated and thus moved to or from the LANL site.
- Estimation of the amount per shipment (e.g., packaging requirements and efficiency of truck capacity utilization, which may conflict with other logistics considerations such as storage requirements until a truck can be filled).
- Determination of the bounding material in a category and the number of shipments of this and similar materials that should be aggregated for frequency analysis.
- Selection of appropriate origin and destination and determination of the route and its characteristic population, accident rate, etc.
- Estimation of package release probabilities.
- Estimation of the amount released from the packaging and the fraction airborne that is respirable.
- Calculation of dispersion, exposure, and health effect.

Uncertainties are associated with each step. The overall approach to dealing with uncertainty is to estimate conservative values for parameters and to estimate consistently. On the other hand, estimates are not knowingly chosen to be conservative by orders of magnitude because that approach could obscure differences between alternatives. The focus of this analysis was on shipments that could contribute significantly to the transportation risk. The total number of shipments is important, as are the shipments of large amounts of dispersible and toxic material. The following subsections contain descriptions of sources of uncertainty and the resulting conservatism for each of the major analysis steps. Emphasis is placed on uncertainty unique to the SWEIS.

F.8.1 Material Amount and Characterization

Because a detailed analysis of every type of LANL shipment would be impractical, shipments of similar types were aggregated on the basis of the most hazardous material.

TABLE F.7.2–15.—*Comparison of Major Chlorine and Propane Accident Risks for the No Action Alternative*

ROUTE OPTION	ROUTE SEGMENT	CHLORINE		PROPANE	
		FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	2.9×10^{-4}	1.1×10^{-3}	1.5×10^{-4}	6.0×10^{-4}
	Remainder of New Mexico	5.2×10^{-5}	1.9×10^{-4}	1.2×10^{-4}	4.8×10^{-4}
Relief Route	U.S. 84/285 to I–25	4.2×10^{-5}	1.6×10^{-4}	4.4×10^{-5}	1.7×10^{-4}
	Remainder of New Mexico	8.4×10^{-5}	3.2×10^{-4}	7.4×10^{-5}	3.0×10^{-4}

TABLE F.7.2–16.—*Comparison of Major Chlorine and Propane Accident Risks for the Expanded Operations Alternative*

ROUTE OPTION	ROUTE SEGMENT	CHLORINE		PROPANE	
		FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	6.4×10^{-4}	2.4×10^{-3}	3.3×10^{-4}	1.3×10^{-3}
	Remainder of New Mexico	1.1×10^{-4}	4.2×10^{-4}	2.6×10^{-4}	1.1×10^{-3}
Relief Route	U.S. 84/285 to I–25	9.4×10^{-5}	3.6×10^{-4}	9.6×10^{-5}	3.8×10^{-4}
	Remainder of New Mexico	1.9×10^{-4}	7.0×10^{-4}	1.6×10^{-4}	6.6×10^{-4}

TABLE F.7.2–17.—*Comparison of Major Chlorine and Propane Accident Risks for the Reduced Operations Alternative*

ROUTE OPTION	ROUTE SEGMENT	CHLORINE		PROPANE	
		FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	2.7×10^{-4}	1.0×10^{-3}	1.4×10^{-4}	5.7×10^{-4}
	Remainder of New Mexico	4.8×10^{-5}	1.8×10^{-4}	1.1×10^{-4}	4.5×10^{-4}
Relief Route	U.S. 84/285 to I–25	3.9×10^{-5}	1.5×10^{-4}	4.1×10^{-5}	1.6×10^{-4}
	Remainder of New Mexico	7.8×10^{-5}	3.0×10^{-4}	7.1×10^{-5}	2.8×10^{-4}

TABLE F.7.2–18.—*Comparison of Major Chlorine and Propane Accident Risks for the Greener Alternative*

ROUTE OPTION	ROUTE SEGMENT	CHLORINE		PROPANE	
		FATALITIES PER YEAR	INJURIES PER YEAR	FATALITIES PER YEAR	INJURIES PER YEAR
Route Through Santa Fe	U.S. 84/285 to I–25	2.9×10^{-4}	1.1×10^{-3}	1.5×10^{-4}	6.0×10^{-4}
	Remainder of New Mexico	5.2×10^{-5}	1.9×10^{-4}	1.2×10^{-4}	4.8×10^{-4}
Relief Route	U.S. 84/285 to I–25	4.2×10^{-5}	1.6×10^{-4}	4.4×10^{-5}	1.7×10^{-4}
	Remainder of New Mexico	8.4×10^{-5}	3.2×10^{-4}	7.5×10^{-5}	3.0×10^{-4}

Chemicals were grouped in classes of materials such as flammable materials. RAMs were grouped in many more categories. First, general categories such as LLW, pits, samples, and irradiated targets were used. Then the general categories were divided into groups within which significant packaging differences could occur. For example, LLMW transported on site was aggregated into three groups: materials likely to be packaged in 55-gallon drums, materials likely to be transported in bulk, such as in covered dump trucks (soil and debris), and materials likely to be transported in 96-cubic foot boxes (contaminated lead and non-RCRA waste).

The incident-free risk is proportional to the TI value. The maximum legal value of 10 millirem was used unless there were data to the contrary. The conservatism in TI estimation is significant because most shipments are much less than the regulatory maximum.

Some small shipments are likely to have been missed. For example, on-site shipment of small quantities of special nuclear materials and chemicals are thought to have been overlooked in the data-gathering activity. These small shipments have no effect on the risk of bounding accidents and would contribute little to the incident-free and truck-related risk measures. The net effect is a significantly conservative estimate.

F.8.2 Amount per Shipment

In almost all cases, the number of packages per shipment was selected as less than full use of the truck capacity. In the case of contaminated laundry, for example, the current one truckload per week (sometimes with less than full capacity) is assumed to continue and the number of laundry bags is assumed to vary with alternative and with week-to-week and year-to-year variability in operations. The only exception to weekly shipments is that the increase for the expanded alternative was large enough to change the projection from a shipment every five working days to one every three working days.

Another example of less than full truck capacity is the case of LLW transported off-site. A waste volume equivalent to 65, 55-gallon drums, with an 80 percent volume utilization, was used for both LLMW and for LLW consisting of soil and debris. A tractor-trailer can hold 80 drums if weight limits are not exceeded. The volume per shipment, 389 cubic feet (10.9 cubic meters), also corresponds to that of a standard covered dump truck, but larger trucks could also be used. LLMW would likely go to several facilities, and full truck loads could be impractical. On the other hand, soil and debris would likely go to the same facility (in a given time frame), and full shipments would be a realistic expectation.

The objectives were to be conservative, but not overly so, in estimating amounts per shipment and to be consistent across alternatives.

F.8.3 Bounding Materials

It is impractical to compute the accident risk from every shipment. As described in subsection F.6.5.1, the approach is to select bounding materials for consequence analysis. Selection of the bounding materials was based on quantity, dispersibility, and health effects. Selection of bounding chemicals was straightforward: the toxic or flammable bulk gases are the obvious primary candidates. Highly dispersible actinides are the primary candidates for RAM; dispersion is enhanced by the physical form; e.g., powder, or by the presence of another dispersion-causing material; e.g., explosives. Highly irradiated materials are in a separate category, as are fissile materials.

Estimates of the number of bounding shipments are less straightforward because the frequency of shipments of similar materials should also be included. Obviously, shipments of materials that are slightly less dangerous than the bounding material should contribute to the frequency component of risk. The question is, how much less dangerous? As described in subsection F.6.5.1, the measure of danger chosen was the amount of material, and if the amount exceeded 10 percent of the bounding amount, then the shipment was counted in the frequency term. This is a conservative approach. The term "amount" for RAM was considered as the product of the weight in grams, the respirable airborne release fraction, and the health risk conversion factor of rem per gram.

F.8.4 Origin and Destination

A major simplification was the aggregation of the numerous origin and destination cities (other than the LANL site) to only a few cities. Doing otherwise would have been impractical. The methodology introduced major conservatism in the route length of most shipments. The centroid city of each of the five regions was chosen so that the great majority of shipments were going to a city no farther away than the one chosen. First, the average HAZMAT shipping distance was determined for historical large shipments. Then a city in the northeast (toxic), southeast (explosives), and southwest (flammable) that was at that average shipping distance or farther from LANL was chosen. The conservatism introduced for HAZMAT shipments is likely much less than that for RAM shipments, because an average distance was computed for HAZMAT shipments, and a near-upper-bound distance was chosen on the basis of historical shipments for the RAM shipments.

The choice of SRS for the southeast centroid, when material has historically also been shipped to Florida, illustrates the logic underlying the choice of a near-upper-bound distance. Portions of Florida are farther from LANL than is SRS. However, approximately 94 percent of the historical ground shipments are to destinations no farther from LANL than is the SRS, and approximately 80 percent are to destinations significantly closer than the SRS. Therefore, choosing the upper bound distance (Florida) would be overly conservative because only about 6 percent of the shipments actually go to Florida. The logical choice is the near-upper-bound distance to the SRS.

Given the chosen city, no special conservatism was introduced when choosing other factors such as route, population density, or accident rate.

F.8.5 Package Release Probability

The package release probability is based on performance requirements for all packages of a given type (e.g., Type B). The package release probability used in this analysis would correspond to the release probability of a package meeting the minimum performance requirements for its type. The conservatism would have to be quantified on a package-specific basis and such quantification would require substantial analyses.

F.8.6 Package Release Fractions and Respirable Airborne Release Fractions

The package release fraction is also based on performance for all packages of a given type, and the conservatism would have to be quantified for a specific package and contents.

The respirable airborne release fraction used for analysis for general commerce shipments corresponds to that for a loose, noncombustible powder that suddenly loses all barriers preventing its release (i.e., its packaging suddenly becomes equivalent to an open-top container). In fact, the actual powder is not loose, but compressed, and the packaging is unlikely to fail such that a line-of-sight opening develops. Rather, realistic package failures are more likely to produce an indirect path to the environment that would significantly reduce the fraction that could be made airborne and respirable in the environment. The respirable airborne release fraction used is estimated to be conservative by several orders of magnitude. Further definite quantitative refinement of the value used is not practical given the variety of packaging and release mechanisms considered.

F.8.7 Dispersion and Exposure

Standard dispersion computer programs (RADTRAN, ADROIT, DEGADIS, and ALOHA™) were used with the programs' default or recommended meteorological input. To establish population densities, most exposure calculations were based on census data; time-of-day variation could increase or decrease these values. The chlorine accident escape fraction and propane accident shielding fractions are intended to be average values, but few data are available to support the values used. The MEI doses are intended to be upper bounds for the default meteorological conditions.

F.8.8 Summary

Four risk measures (section F.3) are used in this appendix and each has a consequence and a frequency component. Although the uncertainties described previously do not apply uniformly to the eight risk components, a general statement can be made that each risk component is much more likely to be significantly conservative than to be slightly not conservative enough. This statement applies to all alternatives. A major ramification of the conservatism is that shipments in addition to those described in Tables F.5.3–1 and F.5.3.2–3 are enveloped by the present analysis.

REFERENCES

Anonymous 1990 — "Usher Transport Includes Customers, Others in Overall Safety Programs." *Modern Bulk Transporter*. Vol. 52, No. 12, pp. 36-43. June 1990.

Anonymous 1994 — "Manfredi Motor Transit Company Wins Back-To-Back Safety Awards." *Modern Bulk Transporter*. Vol. 56, No. 11, pp. 92-98. May 1994.

BAA 1993 — *Emergency Evacuation/Transportation Plan Update: Traffic Model Development and Evaluation of Early Closure Procedures*. Barton-Aschman Associates, Inc. Albuquerque, New Mexico. October 28, 1993.

Barklay 1983 — *Safety Analysis Report for Packaging (SARP) for the Mound 1-kW Package*, Revision 5. C. D. Barklay. EG&G Mound Applied Technologies. MLM-MU-91-64-001. Miamisburg, Ohio. 1983.

Clarke et al. 1976 — *Severities of Transportation Accidents*. R. K. Clarke et al. Sandia National Laboratories. SLA-74-0001. Albuquerque, New Mexico. July 1976.

Cruse 1992 — *Test and Evaluation Document for DOT Specification 7A Type A Packaging.* J. M. Cruse. Westinghouse Hanford Company. WHC-EP-0558. Richland, Washington. June 1992.

Dennis et al. 1978 — *Severities of Transportation Accidents Involving Large Packages*. A. W. Dennis et al. Sandia National Laboratories. SAND-77-0001. Albuquerque, New Mexico. 1978.

DOE 1990 — *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement.* U.S. Department of Energy, Albuquerque Operations Office. DOE/EIS-0026-S1. Albuquerque, New Mexico. 1990.

DOE 1994a — *Framework for Assessing the Effects of Radioactive Materials Transportation in Defense Programs NEPA Documents*, Revised Draft. U.S. Department of Energy, Office of Defense Programs. Washington, D.C. June 1994.

DOE 1994b — *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities.* U.S. Department of Energy. DOE Handbook 3010-94. Washington, D.C. October 1994.

DOE 1995 — *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement*. U.S. Department of Energy, Albuquerque Operations Office and Los Alamos Area Office. DOE/EIS-0228. Albuquerque, New Mexico. August 1995.

DOE 1996a — *The Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*, Draft. Vol. I, Appendix I, "Transportation Study." U.S. Department of Energy, Nevada Operations Office. DOE/EIS-0243. Las Vegas, Nevada. January 1996.

DOE 1996b — *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management.* U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. September 1996.

DOE 1996c — *Final Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components.* Appendix F, "Transportation Risk Analysis." U.S. Department of Energy. DOE/EIS-0225. Washington, D.C. November 1996.

DOE 1998 — *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site.* U.S. Department of Energy. DOE/EIS-0277. August 1998.

DOT 1992 — *FAA Statistical Handbook of Aviation: Calendar Year 1992.* U.S. Department of Transportation, Federal Aviation Administration. FAA APO-94-5. Washington, D.C. 1992.

DOT 1995a — *Traffic Safety Facts 1994: A Compilation of Motor Vehicle Crash Data from the Fatal Accident Reporting System and the General Estimates System.* U.S. Department of Transportation, National Highway Traffic Safety Administration. DOT HS 808 292. Washington, D.C. August 1995.

DOT 1995b — *Hazardous Materials, Transportation Regulations: Compatibility with Regulations of the International Atomic Energy Agency, Final Rule.* 60 FR (188) 50297. 1995.

Fenner 1995 — Letter from H. Allen Fenner, Transportation Planning Division, New Mexico Highway and Transportation Department, to Joe Matlock. Santa Fe, New Mexico. November 13, 1995.

Fenner 1996 — Letter from H. Allen Fenner, Transportation Planning Division, New Mexico State Highway Department, to W. R. Rhyne. Santa Fe, New Mexico. January 17, 1996

Glickman and Raj 1992 — "A Comparison of Theoretical and Actual Consequences in Two Fatal Ammonia Accidents." T. A. Glickman and P. K. Raj. *Transportation of Dangerous Goods: Assessing the Risks.* F. Frank Saccomanno and Keith Cassidy, eds. Institute for Risk Research, University of Waterloo. Ontario, Canada. 1992.

Green et al. 1996 — *Hanford Site Truck Accident Rate, 1990–1995*. J. R. Green, B. D. Flanagan, and H. W. Harris. Westinghouse Hanford Company. WHC-SD-TP-RPT-021. Richland, Washington. March 1996.

Harwood and Russell 1990 — *Present Practices of Highway Transportation of Hazardous Materials*. D. W. Harwood and E. R. Russell. U.S. Department of Transportation. FHWA-RD-89-0134. Washington, D.C. 1990.

Havens and Spicer 1985 — *Development of an Atmospheric Dispersion Model for Heavier-than-Air Gas Mixtures*. J. A. Havens and T. O. Spicer. U.S. Coast Guard. CG-D-22-85. Washington, D.C. 1985.

ICRP 1991 — *Recommendations of the International Commission on Radiological Protection*. International Commission on Radiological Protection. ICRP Publication No. 60. Pergamon Press. New York. 1991.

Johnson et al. 1993 — *HIGHWAY 3.1 + An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual.* P. E. Johnson, D. S. Joy, D. B. Clarke, and J. M. Jacobi. Oak Ridge National Laboratory. ORNL/TM-12124. Oak Ridge, Tennessee. March 1993.

LLNL 1987 — *Shipping Container Response to Severe Highway and Railway Accident Conditions*. L. E. Fischer et al. Lawrence Livermore National Laboratory. NUREG/CR-4829. Livermore, California. 1987.

Neuhauser and Kanipe 1992 — *RADTRAN 4, Volume III: User Guide.* K. S. Neuhauser and F. L. Kanipe. Sandia National Laboratories. SAND89-2370. Albuquerque, New Mexico. January 1992.

Neuhauser and Kanipe 1995 — *RADTRAN 4, Volume II: Technical Manual.* K. S. Neuhauser and F. L. Kanipe. Sandia National Laboratories. SAND89-2370. Albuquerque, New Mexico. 1995.

NRC 1977 — *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes.* U.S. Nuclear Regulatory Commission. NUREG-0170. Washington, D.C. December 1977.

NSC 1995 — *ALOHA™ + Areal Locations of Hazardous Atmospheres, User's Manual.* National Safety Council. Itasca, Illinois. 1995.

OTA 1988 — *Gearing Up for Safety: Motor Carrier Safety in a Competitive Environment.* Congress of the United States of America, Office of Technology Assessment. OTA-SET-382. Washington, D.C. 1988.

Phillips et al. 1994 *Determination of Influence Factors and Accident Rates for the Armored Tractor/ Safe Secure Trailer*. J. S. Phillips, D. B. Clauss, and D. F. Blower. Sandia National Laboratories. SAND93-0111. Albuquerque, New Mexico. 1994.

PNL 1980 *An Assessment of the Risk of Transporting Propane by Truck and Train*. C. A. Geffen et. al. Pacific Northwest Laboratory. PNL-3308. Richland, Washington. 1980.

Rao et al. 1982 *Non-Radiological Impacts of Transporting Radioactive Material*. R. K. Rao, E. L. Wilmot, and R. E. Luna. Sandia National Laboratories. DE8-2012844. Albuquerque, New Mexico. February 1982.

Rhyne 1985 *Probabilistic Analysis of Chemical Agent Release During Transport of M55 Rockets*. W. R. Rhyne. U.S. Department of the Army. M55-CD-4. Available from the Defense Technical Information Center. Washington, D.C. 1985.

Rhyne 1994a *Hazardous Materials Transportation Risk Analysis: Quantitative Approaches for Truck and Train*. W. R. Rhyne. Van Nostrand Reinhold. New York, New York. 1994.

Rhyne 1994b *Risk Management of the Transport of Irradiated Targets from LAMPF to TA-48.* W. R. Rhyne. H&R Technical Associates. SM-BUS-6-TQC-53.0. Oak Ridge, Tennessee. July 1994

Rhyne 1997 Correspondence from W. R. Rhyne, H&R Technical Associates, to C. A. Cruz, U.S. Department of Energy. September 11, 1997.

Saricks and Kvitek 1994 *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight*. C. Saricks and T. Kvitek. Argonne National Laboratory. ANL/ESD/ TM-68 (DE94-016625). Argonne, Illinois. March 1994.

SSEB 1994 *Transuranic Waste Transportation Handbook*. Southern States Energy Board. Prepared under U.S. Department of Energy Cooperation Agreement DE-FC04-93AL82966. Norcross, Georgia. 1994.

Vigil 1996 Letter from Alvaro Vigil, Transportation Planning Division, New Mexico State Highway and Transportation Department, to W. R. Rhyne, H&R Technical Associates. Santa Fe, New Mexico. January 25, 1996.

Villa 1996 Presentation Viewgraph from SWEIS Transportation Workshop. Sandra A. Villa. Los Alamos National Laboratory. Los Alamos, New Mexico. September 24, 1996.

Wangler 1995	*U.S. Department of Energy Certificate of Compliance for Radioactive Materials Packages*. M. E. Wangler. U.S. Department of Energy. Certificate No. 9932. Washington, D.C. December 1, 1995.
Wangler 1996	*U.S. Department of Energy Certificate of Compliance for Radioactive Materials Packages.* M. E. Wangler. U.S. Department of Energy. Certificate No. 5320. Washington, D.C. March 25, 1996.
WGA and DOE 1995	*WIPP Transportation Safety Program Implementation Guide.* Western Governors' Association Technical Advisory Group for WIPP Transport and the U.S. Department of Energy, Carlsbad Area Office. Carlsbad, New Mexico. November 1995.
Wilson 1990	"Enterprise Transportation Wins Big with Daily Focus on Fleet Safety." C. E. Wilson. *Modern Bulk Transporter.* Vol. 52, No. 12, pp. 24-34. 1990.

APPENDIX G
ACCIDENT ANALYSIS

G.1 INTRODUCTION

The NEPA decision maker and the stakeholders need to know the consequences of the different SWEIS alternatives. Some but not all of the consequences are those of the possible accidents. Accidents are defined as unexpected or undesirable events that lead to the release of hazardous material within a facility or into the environment (DOE 1996a), exposing workers and/or the public to hazardous materials or radiation.

There are two benefits from this SWEIS accident analysis. First, the analysis conservatively characterizes the overall risk posed by the operation, creating a context for the decision maker and putting the site in perspective for the public. Second, it quantifies the increment in risk among the several alternatives, as an input into the decision.

G.1.1 Characterization of the Risk from Accidents

Characterization includes a consideration of the type of the accident (e.g., fire, explosion, spill, leak, depressurization, criticality, etc.), the initiator (e.g., human error, chemical reaction, earthquake, strong wind, flood, vehicle accident, mechanical failure, etc.) the material at risk (e.g., plutonium, tritium, toxic chemical, explosives, inflammable gas, etc.). Characterization also considers the type of consequences of the accident (e.g., immediate fatalities, prompt reversible and irreversible health effects, latent cancers—some of which lead to eventual death), and the magnitude of the consequences (e.g., to workers only, to hypothetical members of the public, to a few, some or many real individuals off site, etc.). Finally, characterization considers the likelihood that an accident will occur.

Because LANL is a complex and diverse site, there are (as at any site) a wide range of accident scenarios that can be hypothesized, with a corresponding range of likelihoods and consequences, both realistic and imagined. For this SWEIS we analyze accidents that could result in the release of hazardous materials from particular facilities and operations. While such releases are not routinely expected, because controls are in place to prevent such releases or limit their consequences, there are many scenarios that could potentially end in such a release. The analyses in this SWEIS select the more probable scenarios.

To characterize the accident risk at LANL, this analysis has deliberately chosen a range of types of accidents and a range of consequences, including among these accidents for which the public has shown concern. This analysis does not attempt to identify every possible accident scenario, but instead selects accidents that characterize or dominate the risk to the public from site operations (referred to as risk-significant accidents). It thereby provides an objective context for the public to evaluate the risk posed by site operations and a context for the decision among alternatives.

Accident scenarios may be considered "risk-significant" when they pose risks that are significant in the context of the total risk posed by the site and when compared to other site accidents. The term "risk-significant" does not imply a threshold or particular magnitude of risk. If the risk posed by the site is small or very small, then a risk-significant accident at that site has a correspondingly small or very small risk.

By identifying the locations of appreciable quantities of hazardous material, the accidents associated with these materials can be assessed. By grouping these accidents according to their likelihood or frequency and the magnitude of their consequences, it is possible to select accidents for further characterization and qualitatively portray their relative risk. The accidents selected for this detailed analysis are those with bounding consequences as well as those that characterize the risk of operating LANL.

Such grouping or "binning" of accidents is illustrated in Figure G.1.1–1. Accidents assigned to bins within a row vary in terms of their consequences but not their frequencies. Accidents assigned to bins within a column vary in terms of their frequency but not their consequences. Accidents have an increasing level of risk going from left to right within a row or from bottom to top within a column. Accidents that are in the same bin have about the same risk. Thus, when accidents are considered within the context of this matrix, they can be compared qualitatively, and their relative risk ranking can be used for decision making.

There can be, however, a large number of different potential accidents or scenarios at a site such as LANL, especially of those in the high probability-low consequence bins (for example, minor industrial accidents). However, the risk changes exponentially as one goes from one column or row to another. Therefore, by selecting accidents with the highest consequences for a particular frequency row, the accidents that contribute the most to the overall risk to the public from site operations can be considered. Also, these accidents can be characterized by the type of material-at-risk, accident initiators, their scenario progression, and the type and magnitude of their consequences. In particular, the question can now be considered as to the degree by which the risk-significant accidents change across the alternatives. In other words, is there a decision within this SWEIS that could and should be influenced by a change in risk? Not until the potential accidents change, from at least one frequency range or consequence range to another, or accidents are added or deleted as a result of changes in mission and operations, does the risk profile for the site change significantly.

Any particular facility or inventory can be affected by a wide variety of accidents that may have about the same frequency and about the same consequences. For instance, some of the gases in cylinders at a gas cylinder storage facility can be released by fire or by impact from a variety of initial causes. All of these accidents might have similar frequencies and consequences, and so can be represented by a "representative accident." (In the analysis, the frequency of that representative accident might be increased to account for other initiators that lead to the same release.) Conversely, there may be at that storage facility, at times, a larger inventory of a particularly toxic gas whose probability of release is low but that would have larger consequences than releases of the other gases. This postulated accident would be a "bounding accident" whose consequences would not be exceeded with any reasonable possibility or probability. For purposes of a SWEIS, the bounding accidents are intended to provide an envelope that captures variations in routine operations and inventories whose details cannot be predicted.

These representative and bounding accidents characterize the many accidents that could be postulated for that material or facility. There would be no benefit gained in a SWEIS from analyzing each of the many accidents so characterized.

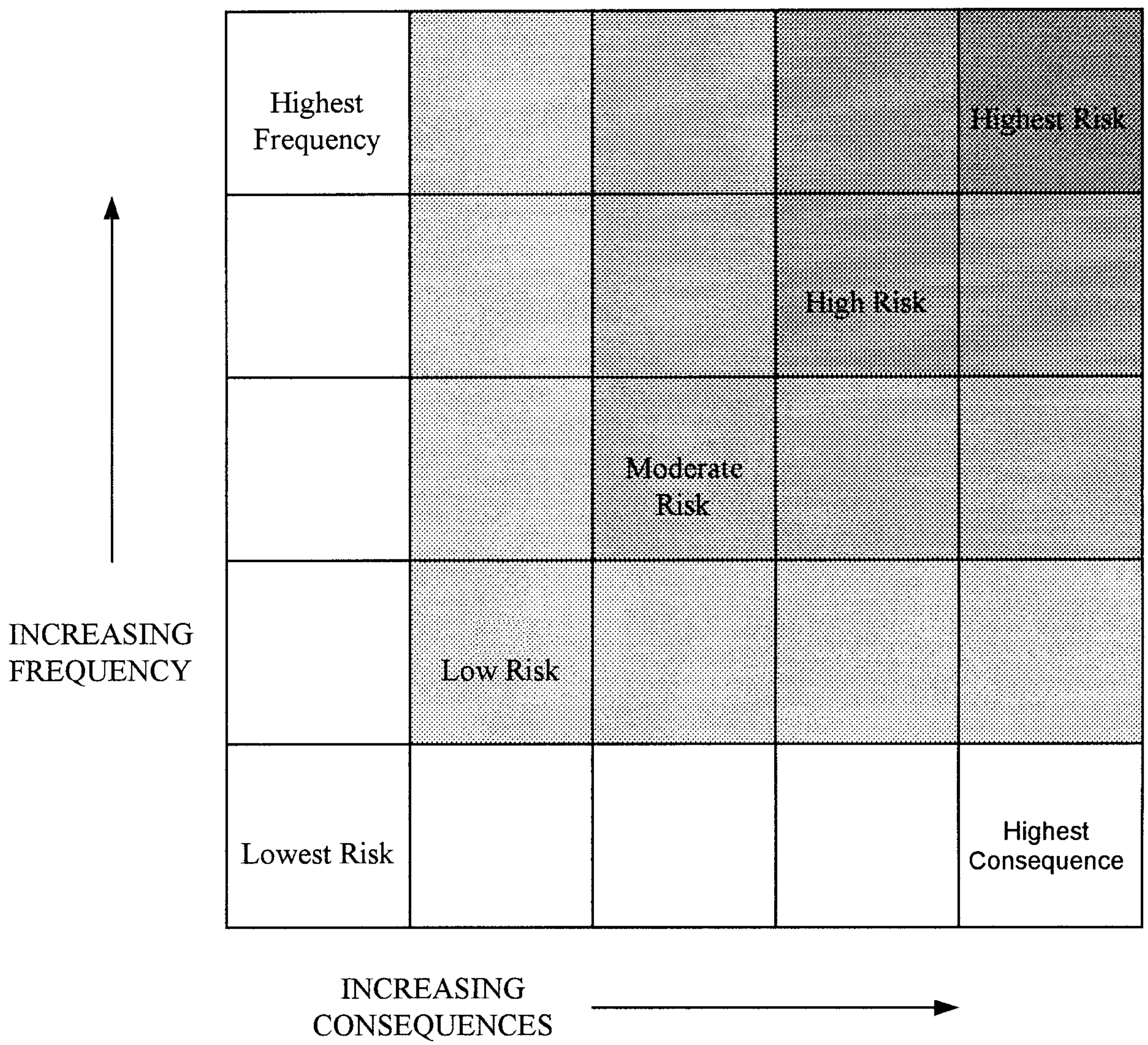


FIGURE G.1.1–1.—*Facility Accident Risk Matrix.*

G.1.2 The Meaning of Risk and Frequency as Used in this SWEIS

The word "risk" is defined in the dictionary as the probability that a specific loss or injury will occur. However, if the injury would be small, then most people would agree that the risk posed by the venture is small also. Therefore, DOE couples the consequence of an event with the probability that it will occur, and calls this combination the "risk." Note that a high-consequence event would not necessarily have significant risk (in the context of NEPA analysis) if its probability is very low.

For many events, the risk can be expressed mathematically as the product of the consequence and its probability. In illustration, if the expected public consequence of an accident at a particular facility is one cancer per accident, and if the accident has a probability of occurring once during a period of 1,000 years, then the continuing risk presented by that accident is 1 x 1/1000 or 0.001 excess latent cancer per year. This product of consequence and probability is called "societal risk" in this SWEIS. It permits the ready comparison of accidents and alternatives without the burden of the details. The details are presented in this appendix.

The probability of the accident is typically expressed as its estimated frequency; that is, an accident with a frequency of 1×10^{-3} per year has a probability of occurring once in 1,000 years and twice in 2,000 years. This is another way of saying that the probability of the accident occurring in any particular year is 1 in 1,000. In the case of natural phenomena, this is also expressed as a "return period" of 1,000 years. This does NOT mean that once the phenomenon occurs, it will be another 999 years before it occurs (returns) again, because the probability is with regard to its occurring in any selected 12-month period[1].

G.1.3 Determining the Increment in Risk Among Alternatives

Although it is possible to characterize or represent the risk posed by the operation, there are too many possibilities and uncertainties to quantify the total absolute risk. Any attempt to adjust the expected frequency and calculated consequences of risk-dominant accidents so that their sum would equal the total risk of all accidents would be self-deceptive, as all these innumerable possibilities are not independent of one another nor accurately quantifiable.

In this SWEIS analysis, it was found that the nature of the accidents did not change among the alternatives; but the frequency and consequence of some of the accidents did change somewhat. Recalling that risk is the product of the consequence and its probability, it is therefore possible to provide the decision maker with estimates of the difference in risk among the alternatives. These differences are discussed later (in summary) in Table G.5–1.

To communicate the types of risk present at LANL, the detailed methodology and results are described below. The methodology considers accidents that are reasonably foreseeable. Although "reasonably foreseeable" does not have a precise definition, the accident analysis is guided by the primary purpose of making reasonable choices among alternatives. "Reasonably foreseeable" includes impacts that may have very large or catastrophic

1. This statement is correct from a statistical standpoint but must be qualified for certain events. In the case of natural phenomena, every occurrence and every nonoccurrence adds to the database from which the probabilities are estimated, so the probabilities do change. In the case of earthquakes, an occurrence may relieve stresses and reduce the probability of another quake for some time; whereas, in the case of heavy flooding, several occurrences in a few years suggest that floods may be more likely than the original data indicated. The important point is that the frequency and/or return period are estimated measures of the probability of an occurrence, not predictions of when it will occur.

consequences, even if their frequency of occurrence is low, provided that the impact analysis is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

If an accident is not reasonably foreseeable (incredible), DOE does not consider that it contributes substantially to the risk of operating LANL (DOE 1993a). If, on the other hand, a hazardous material has a reasonable chance of being involved in an accident, then the consequences and the likelihood of the accident are considered.

Specific accidents that contribute substantially to, or envelop the risk, are considered risk-dominant accidents or bounding accidents. They are not exceeded by other accidents analyzed or believed to be possible that involve that inventory. For instance, there may be a number of accidents that could disperse plutonium, with different initiators or different mitigation; but they are represented by the risk-dominant accident involving plutonium dispersal. This accident also may bound the consequences for other facilities that may have more sensitive site characteristics, such as larger populations, but have lesser inventories than those addressed by the analyses.

There is no intent or expectation that the sum of the consequences of these accident scenarios will add quantitatively to the total risk of the LANL site. However, from the results of this methodology, the decision maker is informed of the nature and magnitude of the risk posed by operating LANL facilities.

G.1.4 The Methodology for Selection of Accidents for Analysis

The analysis began with the establishment of the baseline risk from current operations, plus planned activities, that together constitute the No Action Alternative. The baseline was established by a process of safety documentation review, interviews with facility management, physical inspections (walkdowns) of facilities, and discussions with facility management. Changes in the baseline risk were estimated for the Expanded Operations Alternative, the Reduced Operations Alternative, and the Greener Alternative to ascertain the human health impacts of the alternatives[2].

Assessing the human health consequences of accidents for the alternatives is a four-step process. The first step was to identify a broad spectrum of potential accident scenarios. These scenarios were obtained from available site-specific safety and environmental documents, programmatic documents, discussions with facility management, and physical inspections (walkdowns) of the facilities.

The second step in the process used screening techniques to identify the specific scenarios that contribute significantly to risk (i.e., the scenarios that contribute an appreciable fraction of the total risk). Due to the large number of potential accident scenarios that could impact human health, it is impractical to evaluate them all in detail. This is a common problem encountered in risk assessments, and the standard approach (which was adopted here) is to apply rough bounding calculations during the screening steps.

2. Recall, from chapter 3, that the No Action Alternative is the continuation of current operations without change in mission or the nature of operations. The Reduced Operations Alternative would be a reduction in activities to those necessary to maintain the capability in the near term. Under the Expanded Operations Alternative, operations could increase to the highest reasonably foreseeable levels over the next 10 years that can be supported by the existing infrastructure (including upgrades and construction). The Greener Alternative uses existing capabilities, but also places an emphasis on basic science, waste minimization, dismantlement of weapons, nonproliferation, and other nonweapons areas of importance, resulting in increased activities and operations in those areas of interest.

The calculations are performed to progressively greater degrees of detail until it becomes clear that the accident is either, not risk-significant, or requires a detailed analysis in order to determine the frequency and consequences of the accident (i.e., its risk).

Rigorous evaluations (the third step in the process) were only performed for the potentially risk-dominant scenarios identified in step two, that is, those which had a frequency of 10^{-6} or more and led to off-site consequences beyond insignificant.

During the third step in the process, it was determined that a number of scenarios that had appeared to be risk-significant during the earlier screening steps were in fact insignificant contributors to risk. This situation arises due to the conservative approaches to frequency binning used in safety analysis reports (SARs), as described in DOE Standard 3009-94 (DOE 1994a). DOE facilities for which SARs are prepared are subjected to the most detailed assessments; less hazardous facilities are the subject of less detailed evaluations, in accordance with the graded approach to safety analysis. For facilities with SARs, potential accidents are assigned to one of the frequency bins identified in Table G.1.4–1 (DOE 1994a). In the DOE Standard 3009-94 approach, accident frequency binning is essentially a qualitative process rather than the product of a rigorous quantitative analysis. Accordingly, frequency bin assignments are made conservatively such that if a detailed quantification were performed, the calculated frequency would not place the accident in a higher bin and would in fact be more likely to result in placement in a lower frequency bin. Sometimes, simple methods are used for frequency binning, such as assigning a conditional probability of 1 for dependent events, a conditional probability of 0.1 to human errors, and a conditional probability of 0.01 to genuinely independent events.

At the end of the detailed accident analyses, it was found that a number of accidents had been assigned to higher frequency bins than warranted. Specifically, this was the case for RAD–02, RAD–04, RAD–06, RAD–10, RAD–11, and RAD–14, all of which were found to have mean frequencies of less than 10^{-6} per year. (The sequence of events described for RAD–10 was found to be credible for worker consequences because release out of the building is not necessary to result in worker exposures.)

The fourth step in assessing the human health impact of accidents for the alternatives was to carefully evaluate the effect of the alternatives on the accident scenarios. The important considerations involved in this evaluation were whether the alternative would result in the elimination of some accidents and the addition of others, whether the alternative would result in an increase or decrease in the frequency of some accidents, and whether the alternative would result in an increase or decrease in the amount of hazardous materials released. The results of the analysis indicate that, while a number of accidents are potentially affected by the alternatives, few of them pose significant risk to the public.

In the context of LANL, it is important to recognize that, as a result of several factors (the nature of the activities performed, the design features of the facilities at which the activities are performed, the conditions under which the activities are performed, and the location of the facility vis-a-vis the public), accidents are more likely to impact facility workers than they are to impact the public. This is true even though at LANL the public has access to many areas of laboratory via roadway (public access to roads through LANL can be controlled by DOE in the event of an accident). Even for facility workers, the consequences in many cases would be dependent on the use by facility workers of personal protective equipment (PPE) and on the effectiveness of emergency response and mitigation actions taken to limit consequences (e.g., the timeliness of evacuation from the facility).

G.1.5 Comparison of Other Accident Analysis to the SWEIS

The DOE, through its safety and environmental programs, conducts a variety of hazard and safety analyses for various purposes. Because all of the safety and hazard analyses are performed for different purposes, varying levels of conservatism, and therefore, different assumptions are made about physical phenomena and preventive and mitigative controls. In the analysis, if the applicable safety objectives or standard criteria can be met with a very conservative set of assumptions, then detailed analysis is not considered necessary. Further analysis is generally done to more accurately predict an outcome when greater realism is sought, or when very conservative assumptions lead to results that exceed safety objectives or criteria. Detailed analysis requires sophisticated calculations, and therefore, greater expenditure of resources. If a very conservative estimate of consequences demonstrates that the impacts to the public, environment, and worker are acceptable within regulation or guidelines, then it is unnecessary to incur higher costs to more accurately predict the outcome. This fact may be acknowledged in the safety or hazard analysis, but no further quantification of actual doses is made. This graded approach to accident analysis is an explicit part of the DOE safety policy.

In order to understand the results of the accident analysis as presented in this SWEIS compared to other safety analyses and environmental assessments, a brief discussion of hazard assessments is given in the following sections. This discussion assumes a release of radiological material.

G.1.5.1 *DOE Hazard Assessments*

The hazard assessment is a comprehensive evaluation of hazards associated with a particular activity or operation. The hazard analysis provides a clear definition of the activity and the facilities in which the activities will be conducted. The hazard analysis identifies potential accident scenarios. From this preliminary analysis, preventative and mitigative equipment (i.e., systems, structures and components) are identified, and controls on features are established. Not every scenario is analyzed but several (often hundreds) are postulated, and those with the greatest potential for off-site consequences are usually selected as "bounding."

The hazard assessment starts with a very conservative analysis of an accident. Although activities are not conducted without the use of controls, a hypothetical baseline is established that considers only the physics of the accident, such as atmospheric dispersion, not the controls that would either prevent or mitigate the consequences. This accident may be referred to as a "parking lot scenario" or a "what-if" scenario. It is a hypothetical scenario used to gage the reduction in consequences or frequency provided by control mechanisms.

Given this estimate of a material release and considerations of atmospheric transport, the consequences are evaluated for a member of the public standing at the site boundary. This hypothetical individual receives a dose from their exposure to a passing cloud of hazardous material. The individual is assumed to remain at this location for the entire passage of the cloud or plume. These assumptions are designed to give a maximum exposure from the hazardous material release. If the dose to this individual is less than the DOE safety evaluation guideline, then the equipment associated with this activity does not need to be designated as safety class equipment. This implies that quantifying the reduction in consequences due to additional safety controls is not necessary. However, hazard assessments will often give an expected dose based on taking credit for barriers such as building high efficiency particulate air (HEPA) filters, building confinement, etc. This equipment will then have necessary controls placed on it in order to assure its operability in the event of the analyzed bounding accident.

G.1.5.2 *Accident Analysis for this SWEIS*

As described above, the hazard assessment may provide a more conservative value for the frequency of an event. This result usually reflects an estimate of the frequency of initiating events and not the overall frequency of public impacts. The final results for the SWEIS, however, included the consideration of multiple barriers; generally it considered administrative barriers, process design barriers, and facility design barriers, as appropriate. Although, the consequences of a what-if scenario were considered, they were placed in the context of their frequency of occurrence.

As a rule of thumb, most process events become "incredible." If an initiating event is considered anticipated, or has a frequency on the order of 10^{-1}, and there are three independent controls (each with an estimated probability of failure of 10^{-3}), then the overall frequency of the event becomes incredible at 10^{-10}. Therefore, once the SWEIS took credit for these barriers, the frequency of many of the accidents became less than 10^{-6}.

Several scenarios, even though they are incredible, are provided in this appendix to illustrate the defense-in-depth policy of the DOE. These accidents are retained in this appendix to preserve the information they contain, in illustration of the range of the analyses, and in demonstration of the conservative nature of the screening. Incredible accidents are not relevant to the decision and so are segregated from credible accidents in volume I of the SWEIS.

The lower frequencies are difficult to comprehend. To provide a perspective for these frequencies, some examples of natural phenomena events at LANL are provided in Table G.1.5.2–1. Estimates of large meteor impact frequencies are included in order to be able to attain the lowest frequency range.

Although specific scenarios were analyzed, the results of the detailed evaluation represent a risk profile for LANL, given the types of operations described under each alternative. As long as specific process configurations support the same type of operations as considered in these alternatives and are implemented consistent with the DOE safety program, then the risks would be represented by the same set of accidents as presented for each alternative in this SWEIS.

G.1.6 Conservatism in the Analyses

At all steps, when faced with uncertainties, the analysts selected the most probable or conservative value for accident likelihoods and the quantity of hazardous materials released. Accepted models and conservative atmospheric dispersion parameters were used in the modeling. Exposure conditions (e.g., location, material released, time in the plume) were used that would maximize exposure of the total population and of individuals. The maximum risk factor for excess latent cancer fatalities (LCFs) was used to calculate health effects; whereas, the true risk factor may be considerably less, as described in appendix D, section D.1. The resulting estimates of risks are considered to be quite conservative. Incredible accidents are not relevant to the decision and so are segregated from credible accidents in volume I of the SWEIS.

TABLE G.1.5.2–1.—*Frequency of Some Natural Phenomena Events at LANL*

DESCRIPTIVE WORDS	RANGE OF ANNUAL FREQUENCY OF OCCURRENCE	PHENOMENON AND ITS FREQUENCY
Anticipated	10^{-2} to 10^{-1}	[a]Wind of 80 mph, 10^{-2}. 11.2 inches precipitation in one month and 64.8 inches snowfall in one month[b], 1.2 x 10^{-2}.
Unlikely	10^{-4} to 10^{-2}	[a]Wind of 95 mph, 10^{-3}. [c]Snowfall adding 35.0 inches in depth in 24 hours, 5 x 10^{-3}, rainfall of 2.7 inches in 24 hours, 5 x 10^{-3}. [d]Meteor causing destructive tidal wave somewhere on earth, 2 x 10^{-4}. [e]Magnitude 6.5 earthquake causing walls to fall, houses to shift from unsecured foundation, and cracks to open in wet ground, 10^{-4}.
Extremely Unlikely	10^{-6} to 10^{-4}	[a]Straight line wind of 120 mph, 10^{-5}. Tornado with wind of 70 mph, 10^{-5}.
Incredible	< 10^{-6}	[a]Tornado with wind 150 mph or greater, 2.5 x 10^{-7}. [d]Meteor at least three miles in diameter striking somewhere on the earth, 10^{-7}.

[a] Reference for LANL wind and tornado frequency (LLNL 1985). mph = miles per hour
[b] Estimated from the record annual precipitation at LANL during November 1910 to December 1997 (*Source*: http://weather.lanl.gov)
[c] Reference for 24-hour precipitations: LANL 1990a
[d] Estimates of worldwide meteor probability: PC 1998
[e] LANL earthquake data from Tables 4.2.2.2–2 and 4.2.2.2–3 in chapter 4.

G.2 HAZARDOUS MATERIALS IMPACTS ON HUMAN HEALTH

This section addresses the human health impacts resulting from exposure to hazardous materials. The sources of radiation pertinent to this SWEIS are examined in the first subsection. This discussion is followed by a discussion of health impacts resulting from exposure to hazardous chemicals. Finally, the computer models used to evaluate the consequences from both chemical and radiological accidents are discussed to provide an understanding of the applications and limitations of the models.

G.2.1 Sources of Radiation

The sources of radiation pertinent to the accident analysis in this SWEIS are facility specific. These sources include industrial sources used to generate x-rays and other types of electromagnetic radiation for nondestructive examination of components and assemblies. Exposure to these sources of radiation only poses a potential risk to workers and to others with authorized access to the facilities where these sources are in use. Facility-specific sources of radiation also include materials released into the environment as a result of an accident. In most cases, these materials are tritium and various mixtures of uranium and plutonium isotopes. In some cases where experiments involve pulse reactors or critical assemblies, or where criticality occurs inadvertently, fission products also can be released. Each accident scenario that involves radioactive materials includes a discussion of the isotopes and quantities considered. (The nature of radiation, and its effects on human health are discussed in section D.1 of appendix D, Human Health.)

G.2.2 Human Health Effects of Exposure to Hazardous Chemicals

Human health effects resulting from exposure to hazardous chemicals vary according to the specific chemical of interest and the exposure route and concentration. The most immediate risks to human health from exposure to chemicals in the environment arise from airborne releases of toxic gases, and it is this route of exposure upon which the accident analysis for the SWEIS is focused. (The effects of toxic chemicals are discussed in section D.1 of appendix D, Human Health.) In this analysis, exposures to toxic chemicals are compared to Emergency Response Planning Guidelines (ERPGs). ERPGs are community exposure guidelines derived by groups of experts in industrial hygiene, toxicology, and medicine. ERPGs are then published by the American Industrial Hygiene Association (AIHA) after review and approval by their ERPG Committee. ERPGs are defined as follows (AIHA 1991):

- ERPG–1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild, transient adverse health effects or perceiving a clearly defined objectionable odor.
- ERPG–2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- ERPG–3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

Human responses to chemical exposure do not occur at precise exposure levels, but rather, extend over a wide range of concentrations. The values derived for ERPGs do not protect everyone, but are applicable to most individuals in the general population. Furthermore, the ERPG values are planning guidelines, not exposure guidelines. They do not contain the safety factors normally associated with exposure guidelines (AIHA 1991).

In developing an ERPG, emphasis is given to the use of acute or short-term exposure data. Human experience data are emphasized; but usually only animal exposure data are available. When it is believed that adverse reproductive, developmental, or carcinogenic effects might be caused by a single acute exposure, the data are considered in the ERPG derivation.

Unless one is provided information to the contrary by toxicologists, it is necessary to regard ERPGs as ceiling concentrations (i.e., the highest concentration acceptable for the time period). As such, the ERPG would be treated as an exposure that should not be exceeded within 1 hour. Any extrapolation from the ERPG is not to be made without significant considerations; specifically, to make such an adjustment, the ERPG documentation for each chemical must be reviewed fully by toxicologists. The effects of exposure times longer than 1 hour may not be limited to those associated with the ERPG.

In addition to ERPGs, this analysis incorporated the temporary emergency exposure limits (TEELs) developed by the DOE Emergency Management Advisory Committee, Subcommittee of Consequence Analysis and Protective Actions (SCAPA). Published ERPG values were available for only 69 chemicals. TEEL values are interim, temporary, or ERPG-equivalent exposure limits provided for an additional 297 chemicals. In the absence of ERPG or TEEL values, the hierarchy developed by SCAPA and published in the AIHA Journal was utilized (Craig et al. 1995).

ERPG–1 defines a level that does not pose a health risk to the community but that may be noticeable due to slight odor or mild irritation. Above ERPG–2, for some members of the community there may be significant adverse health effects or symptoms that could impair an individual's ability to take protective actions. These symptoms might include severe eye or respiratory irritation or muscular weakness. Above ERPG–3 there may be life-threatening effects and, at sufficiently high concentrations and exposure times that vary with the chemical, there could be death. The length of an individual's exposure to high concentrations will depend upon that individual's situation and response (that is, by his/her recognition of the threat and its location, attaining shelter, and escaping). Later in this analysis, consequences are presented as the number of people exposed to concentration greater than the ERPG–2 and ERPG–3 guidelines; but there are too many uncertainties to speculate as to the specific effects that would occur to those people.

G.2.3 Chemical Accidents—ALOHA™ Code

The Areal Locations of Hazardous Atmospheres (ALOHA™) code developed by EPA, the National Oceanographic and Atmospheric Administration (NOAA), and the National Safety Council (NSC), was used for the analysis of chemical releases. It is listed by DOE (DOE 1994c) and EPA (EPA 1996) as an acceptable code for air dispersion modeling.

The ALOHA™ code is designed to be used for emergency responders in the case of chemical accidents. The code predicts the rate at which chemical vapors may escape to the atmosphere from broken gas pipes, leaking tanks, and evaporating puddles and predicts how the resulting hazardous gas cloud disperses horizontally and vertically into the atmosphere following release (NSC 1995).

Especially near the source of a release, short-term gas concentrations depart markedly from average values in response to random turbulent eddies and are unpredictable. As the cloud moves downwind, concentrations within the cloud become more similar to ALOHA™ calculations. ALOHA™ shows concentrations that represent averages for time periods of several minutes and predicts that average concentrations will be highest near the release point and along the center line of the release cloud (this is typical Gaussian plume modeling). The concentration is modeled as dropping off smoothly and gradually in the downwind and crosswind directions.

ALOHA™ models neutrally buoyant gases with a Gaussian plume model. Airborne particulates are assumed to be passive; that is, they behave as nonbuoyant gases. Heavy gases are modeled using a variation of the DEGADIS heavy gas model. Some simplifications were implemented into ALOHA-DEGADIS to speed computational procedures and reduce the requirement for input data that would be difficult to obtain during an accidental release. These simplifications include the assumptions that: (1) all heavy gas releases originate close to ground level; (2) mathematical approximations are faster but less accurate than those in DEGADIS; and (3) modeling sources for which the release rate changes over time as a series of short, steady releases rather than a number of individual point source puffs. The authors worked closely to ensure a faithful representation of DEGADIS model dynamics, and the resulting ALOHA-DEGADIS model was checked to ensure that only minor differences existed in results.

Although ALOHA™ models the dispersion of heavy gases, the model assumes that the terrain is flat. Thus, if canyons are located between the release point and a potential receptor, ALOHA™ models the scenario as though the canyon were not present. This is a conservative approach because receptors are offered no protection from heavy gases by intervening canyons. Under the most stable atmospheric conditions (most commonly found late at night or very early in the morning), there is little wind, reduced turbulence, and less mixing of the release with the surrounding air. High gas concentrations can build up in small valleys or depressions and remain for long periods of time. ALOHA™ does not account for buildup of gas concentrations in low-lying areas. The properties of a heavy gas are discussed in section G.5.5.

ALOHA™ allows the user to enter only a single wind speed and wind direction, and assumes that these remain constant throughout the release and travel. In reality, air flow changes speed and direction when confronted with changes in terrain such as slopes, valleys, and hills. ALOHA™ ignores these effects. Because wind is likely to shift direction and change speed over both distance and time, ALOHA™ will not make predictions for more than 1 hour after a release begins, or for distances more than 6.2 miles (10 kilometers) from the release point. In general, wind direction is least predictable when the wind speed is low and at the lowest wind speed modeled in the code (1 meter per second), ALOHA™ presents the footprint as a circle. ALOHA™ does not calculate particulate settling and deposition. The ALOHA™ code presumes the ground beneath a leak or spill to be flat, so that the liquid expands evenly in all directions.

Combustion products rise rapidly while moving downwind, until they cool to the temperature of the surrounding air. ALOHA™ does not account for this rise. ALOHA™ models the release and dispersion of pure chemicals only, and the properties of chemicals in its chemical library are valid only for pure chemicals. ALOHA™ also does not account for chemical reactions of any kind. (This limitation can be avoided by modeling the resulting chemicals, if known. In the case of the seismic collapse of TA–3–66, the SWEIS has modeled the hydrogen cyanide that evolved from mixing metal cyanide solution and nitric acid.)

The limitations of ALOHA™ do not detract from its use in this SWEIS for screening chemical accidents and bounding their daytime consequences. During the preparation of this SWEIS, as upgrades to ALOHA™ code became available they were used. Trial calculations showed that the upgrades provided the same results as previous versions for the same inputs.

G.2.4 Radiological Accidents—MACCS 2 Code

The MACCS 2 computer code models the consequences of an accident that releases a plume of radioactive materials to the atmosphere. Should such an accident occur, the radioactive aerosols and/or gases in the plume would be transported by the prevailing wind while dispersing horizontally and vertically in the atmosphere. MACCS 2 uses a straight-line Gaussian plume model and the source term data input by the user to model the atmospheric dispersion and deposition of radionuclides released from facilities. Plume rise, dry deposition, and precipitation scavenging (below cloud washout) of aerosols, and resuspension of particulate matter that has deposited from the plume is explicitly modeled. The chronic exposure model calculates the resulting doses for all inhabitants living in the area. In the intermediate and long-term phases, the inhalation shielding factor for normal activity is used in the dose calculations. Decay of radionuclides to daughter products is accounted for.

The MACCS 2 calculations also estimate the range and probability of health effects caused by radiation exposures that are not avoided by protective actions. In these EIS calculations, no credit was taken for protective measures that might and would be used to decrease exposures. (MACCS 2 permits the modeling of various protective measures, such evacuation, sheltering, and relocation. A variety of protective measures can be taken in the long-term phase in order to reduce doses to acceptable levels: decontamination, interdiction, and condemnation of property.)

MACCS 2 divides the accident into three time phases: the emergency phase, the intermediate phase, and the long-term phase. The emergency phase begins immediately after the accident and could last up to 7 days following the accident. In this period, the exposure of the population to both radioactive clouds and contaminated ground is modeled. In the intermediate phase, the radioactive clouds are gone, and decisions are made regarding the type of protective actions that need to be taken; the only exposure pathways are those resulting from ground contamination. The long-term phase represents all time subsequent to the intermediate phase, and again, the only exposure pathways considered are those resulting from the contaminated ground.

In accidents there is an initial release, and there may be a continuing release thereafter. A single MACCS 2 calculation can handle four separate releases. To account for reduction of the source as it was depleted by the continuing suspension, the continuing release was treated as three consecutive continuing releases of 8 hours each. For those accidents that have both an initial and a continuing release, the releases were stopped no later than 24 hours after the initial release.

The region surrounding the site is divided into a polar coordinate grid centered on the facility from which the release originates. The angular divisions used to define the spatial grid correspond to the 16 directions of the compass. The user specifies the number of radial divisions as well as their endpoint distances. Up to 35 of these divisions may be defined, extending out to a maximum distance of 6,213 miles (10,000 kilometers).

The emergency phase calculations use dose-response models for early fatality and early injury, and are performed on a finer grid than the calculations of the intermediate and long-term phases. For this phase, the 16 compass sectors are divided into 3, 5, or 7 user-specified subdivisions in the calculations.

Each radiological release site was assigned to the closest one of the four weather stations (located in TA–6, TA–49, TA–53, and TA–54). The 1995 meteorological data were used for these calculations. Sensitivity calculations using data from 1991 to 1995 have been performed for one accident scenario to investigate the possible impact on consequences of using weather data from a particular year. In the near field (out to 1,312 feet [400 meters]), an approximate maximum 30 percent variation occurred in the calculated doses, depending upon which year is used. The results indicated that 1995 yields the largest consequence results of this 5-year period for the scenario modeled (Steele et al. 1997).

Consequence results were calculated for both ground level and elevated releases, according to the facility and the scenario. Downwind concentrations of radionuclides up to a distance of 50 miles (80 kilometers) were calculated for each of the 16 compass directions around the facility. Radiation doses to the on-site and off-site population were calculated by the dosimetry models within MACCS 2[3], using the concentrations. Exposure pathways were: direct radiation from the passing plume, direct radiation from radioactive material deposited on the ground and skin, inhalation while within the plume, and inhalation of resuspended ground contamination. Subsequent ingestion, which normally represents only a small fraction of total exposure and can be controlled, was not considered.

3. MACCS dosimetry models use risk factors that vary by nuclide, and result in approximately, but not exactly, an effective risk factor of 5×10^{-4} excess LCFs per person-rem of exposure. This is discussed in the primer on the effects of radiation in section D.1 of appendix D, Human Health.

Because population is not evenly distributed around the source, the consequences of an accident vary with wind direction. The probability of the consequence thus depends on the probability of that wind direction. Therefore, the results of the calculations are presented as the average of the consequences for all 16 directions weighted by the probability of the wind being toward that direction. Note that the calculations used both daytime and nighttime winds; whereas, the population distribution used was the daytime population described in section G.3.2. Because the daytime population is larger than the nighttime population, this overestimates the mean consequences.

Having the results from the multiple model runs, it was possible to calculate the mean dose to hypothetical individuals at points of closest public access; at points on the site boundary (referred to as doses to maximally exposed individuals [MEIs]); and mean doses at public population centers, such as towns, pueblos, and schools.

Note that these calculations capture all meteorological conditions, including the most adverse conditions, each weighted by its frequency of occurrence in the entire year. An alternative approach, use of the dispersion condition for which dispersion is greater than 95 percent the time (referred to as 95th percentile meteorology) is often used for screening. It maximizes the concentrations downwind, but does not consider the population distribution. Therefore, it does not provide as much useful information.

Note that uncertainties as to the models' abilities to predict concentrations and exposures, and uncertainties in the range of meteorological conditions, apply equally to all the alternatives.

G.3 ACCIDENT SCENARIO SCREENING

LANL is one of the largest multiprogram research laboratories in the world, and a number of factors combined to make the selection of accident scenarios for the SWEIS a challenging task. These factors included:

- DOE NEPA guidance that mandates consideration of accidents within the design basis, as well as those beyond the design basis, to identify a spectrum of potential accident scenarios that could occur during the activities encompassed by the proposed action and analyzed alternatives.
- The diversity of activities performed at LANL, including: pit production; high explosives research, development, production, and testing; special nuclear material (SNM) processing, research and development, and storage; hydrodynamic testing and dynamic experimentation; accelerator operations, research, and development; fusion power research and development; operation critical assemblies and fast burst reactors; and radioactive, chemical, and mixed waste processing, characterization, disposal, and storage.
- A wide range of accident initiators (including process hazards, man-made hazards, and natural phenomena hazards) and the resulting human, system, and structural responses to those initiators.
- A large number of accident scenarios identified in underlying programmatic and LANL-specific NEPA documents (e.g., the Stockpile Stewardship and Management PEIS, and the Dual Axis Radiographic Hydrodynamic Test [DARHT] Facility EIS).
- The availability and vintage of a variety of hazard assessment and safety analysis documentation, performed to evolving DOE guidance.

- The diversity of material that could potentially be released in an accident (referred to as "material-at-risk" or MAR), including: tritium, plutonium, various enrichments of uranium, toxic chemicals such as chlorine, bulk acid storage, high explosives, and a wide variety of other chemicals and radioactive materials.
- The presence of some relatively complex facilities such as the Plutonium Facility (TA–55–4), the Chemistry and Metallurgy Research (CMR) Building (TA–3–29), the Tritium System Test Assembly (TSTA) Facility (TA–21–155), the Tritium Science and Fabrication Facility (TSFF, TA–21–209), the Weapons Engineering Tritium Facility (WETF, TA–16–205), and the critical assembly and fast burst reactor facilities at the Pajarito site (TA–18), for which hazard and safety analyses have identified dozens to hundreds of credible accident scenarios for each of these facilities.

The large number of facilities and processes at LANL, combined with the diversity of MAR and the variety of accident initiators, produce credible accident scenarios numbering at least in the many thousands. Analyzing each of these scenarios in detail is neither required under NEPA nor practical. Ideally, a comprehensive risk assessment would express the total human health risk as the sum of all potential accident scenarios. It is neither practical (due to cost) or necessary (from a NEPA compliance standpoint) to rigorously quantify all of these to produce a summation of the total risk. The purpose of screening is to identify for detailed analysis a suite of accidents that constitute a large fraction of the total risk.

Accident analyses, for a NEPA document, involve considerably less detail than a formal probabilistic risk assessment (PRA), but make use of PRA techniques and insights (such as event trees, failure rate data, and initiating event occurrence data) to identify risk-significant accident scenarios.

G.3.1 Accident Initiator Screening

It was recognized, based on review of available safety documentation for several important facilities, that there would be a very large number of credible accident scenarios for LANL facilities. The SWEIS accident analysis began with a detailed examination and screening of accident initiators and accident types in order to focus the attention of the remainder of the analysis on those accident initiators most important to risk. Accident initiators and accident types were identified and categorized into three broad classes: (1) process hazards, (2) man-made hazards, and (3) natural phenomena hazards (NPHs). Military action, sabotage, terrorism, or other forms of deliberately malevolent actions were not included. The magnitudes of the likelihood and consequences of such acts are independent of the site operations, under the purview of security and protection forces, and are considered to be outside the purview of accident analysis.

The list of accident types and initiators, arrayed into these three categories, is provided as Table G.3.1–1. These accident types and initiators were evaluated in the context of their likelihood and their potential for resulting in a release of hazardous materials or for causing an event that could result in such a release (e.g., a fire or explosion). Hazardous materials at LANL include radioactive materials, chemicals, biohazards, and high explosives.

The intent is to capture all accidents that have a frequency in excess of 1×10^{-6} per year. It is not possible to estimate accurately the likelihood (frequency) of accidents with very low probability. Therefore, accident types and accident initiators that could produce an accident with a frequency in excess of 1×10^{-7} per year when realistically estimated, or a frequency in excess of 1 x 10^{-6} per year when conservatively estimated, were treated as “credible” and “reasonably foreseeable.”

Accidents with frequencies less than 1 x 10^{-6} were not dismissed without considering whether they were capable of producing worse consequences than credible accidents. Large earthquakes would affect the entire LANL site simultaneously. As a result, it is not considered plausible that many individual but unlikely accidents could rival earthquakes in overall risk, and thus, were not retained for detailed analysis.

A suite of accident type and accident initiator screening criteria was developed for the purpose of evaluating the master event list in Table G.3.1–1. It is important to recognize that, while some of the accident types or initiating events listed in Table G.3.1–1 may appear to some readers to stray into the realm of the absurd, the goal of the master listing and the screening process was to demonstrate that the consideration of accident types and accident initiators was as comprehensive as possible.

The accident types and initiators in the master list were screened, using the screening criteria in Table G.3.1–2. Results of the screening for process hazards, man-made hazards, and natural phenomena hazards are reported separately in Tables G.3.1–3, G.3.1–4, and G.3.1–5, respectively.

Table G.3.1–6 summarizes the three preceding tables as events the survived that screening. These were subsequently evaluated on a facility-specific basis, using detailed safety documentation review and facility walkdowns, as described in the following section G.3.2.

G.3.2 Facility Hazard Screening

DOE assigns different hazard categories to its facilities on the basis of the magnitude of maximum potential injuries and fatalities on site and off site. Although the system has a different purpose than identification of facilities to be considered in EIS analyses, the past categorization constituted an effective screening of facilities for this SWEIS.

In hazard classification, no credit is given designed active safety features[4], administrative controls (other than those limiting the total quantity of hazardous materials in the facility), or prompt emergency response. Credit for mitigation is assumed only for substantial passive primary barriers or natural removal or dispersal mechanisms associated with the distance between the facility and the receptor location (LANL 1995a). Hazard classification is therefore considered to represent an appropriate basis for an initial screening of LANL facilities to focus the attention of the SWEIS accident analysis on those facilities that have the most significant potential for causing impacts to workers, the public, and the environment.

This screening step is based on the hazard posed by the facility. There may be other reasons for including facilities in the accident analysis (e.g., stakeholder interest). Such additional facilities were selected by expert judgment. The facilities that were identified in the initial hazard categorization process are listed in Table G.3.2–1. Following detailed discussions with LANL, walkdowns of more than 40 facilities, and review of updated safety documentation, many of the facilities in Table G.3.2–1 were screened from further analysis. Table G.3.2–2 provides a listing of the facilities that were screened and a summary of the reasons for their exclusion from detailed analysis. Table G.3.2–3 provides the final list of facilities that were subjected to screening consequence analysis in

4. An “active safety feature” is one that is fallible, through its dependence upon maintenance, electrical power, human operation, etc. Examples would be a smoke alarm, filtering system or automatic electrical switch. A “passive” feature or barrier is one that does not require dependable human attention for its operation. Examples are a berm, catch basin, or firewall.

TABLE G.3.1–1.—*Accident Type and Initiating Event Master Classification List*

PROCESS HAZARDS	MAN-MADE HAZARDS	NATURAL PHENOMENA HAZARDS	NATURAL PHENOMENA HAZARDS (CONT.)
Biohazard Spill	Aircraft Crash[h]	Avalanche	Lightning Strike[bb]
Chemical Spill[a]	Arson	Barometric Pressure[s]	Liquefaction[cc]
Container Failure	Co-Located Facilities[i]	Biological Hazards[t]	Low Water Level
Criticality Event[b]	Dam Failure[j]	Blizzards[u]	Nontectonic Deformation
Explosion[c]	Dike Failure[j]	Climatic Change[v]	Precipitation Extremes
Fire[d]	Explosion[k]	Coastal Erosion	River Diversion
Flooding[e]	Fire[l]	Drought	Sand Storms
Hardware Failure[f]	Flooding[j]	Dust Storms	Seiche
Human Error[g]	Levee Failure[j]	Earthquakes[w]	Sink Holes and Collapse
Radioactive Spill	Military Action[m]	Extraterrestrial Objects[x]	Slope Stability
	Nuclear Detonation[n]	Fog	Snow
	Pipeline Failure[o]	Frost	Soil Consolidation
	Sabotage and Terrorism[p]	Glacial Activity[y]	Soil Shrink/Swell
	Satellite Orbital Decay	Hail	Storm Surge
	Shipwrecks	High Water[j]	Temperature Extremes[dd]
	Vandalism[q]	High Wind[z]	Tornadoes[ee]
	Transportation[r]	Hurricanes	Tsunami
		Ice and Ice Jams	Volcanism[ff]
		Landslides and Mudflows[aa]	Waves

Notes:

[a] Includes release of chemicals, including toxic gases, liquids, solids, high explosives, etc. that disperse into the facility or environment. Also includes uncontrolled chemical reactions due to inadvertent mixing of chemicals (e.g., mixing of metal cyanide solution and acid, which liberates hydrogen cyanide).

[b] Represents all accidental or unplanned nuclear criticality events, including criticality in solid systems, aqueous solutions, and waste forms. Does not include planned criticality during critical assembly experiments or fast burst reactor operations.

[c] Represents explosions due to sources of explosive materials (gases, etc.) originating within the facility. Does not include ingestion of explosive gases into the heating, ventilation, and air conditioning (HVAC) system from outside the facility. Explosions may be accompanied by a fire.

[d] Represents fires originating within a facility.

[e] Represents flooding originating within a facility (due, for example, to a pipe break or an inadvertent actuation of a fire sprinkler system).

[f] Includes hardware failures due to any cause (such as aging, overheating, overcooling, lubrication system failure, etc.) except military action, sabotage, terrorism, or other forms of deliberately malevolent actions.

[g] Includes human errors in any phase of design, construction, fabrication, operation, maintenance, modification, design control, management, emergency response, etc.

[h] Includes direct impact on the facility as well as a crash near the facility followed by the skidding of the aircraft or aircraft components into the facility. Also includes fires or explosions resulting from aircraft crash (due to combustion of aviation fuel and/or the contents of the aircraft), as well as impacts of missiles on the facility resulting from the aircraft crash or resulting fire/explosion.

[i] Represents accidents at nearby facilities (off-site industrial facilities, other on-site facilities, military facilities, etc.) that cause an impact at the facility under evaluation. Such accidents would include explosions, fires, chemical accidents, toxic gas releases, etc.).

TABLE G.3.1–1.—*Accident Type and Initiating Event Master Classification List*-Continued

[j] Includes failures due to human errors (such as design errors, failure to anticipate sufficiently severe flood and debris conditions, construction errors, etc.).
[k] Includes explosions from sources outside the facility, but does not include explosions due to pipeline accidents, sabotage, or military action.
[l] Includes fires from sources outside the facility, such as wildfires.
[m] Includes acts of war, as distinguished from sabotage, terrorism, arson, etc. Also includes war-like actions during internecine conflicts.
[n] Includes only the inadvertent detonation of a nuclear explosive device. No nuclear weapons or nuclear explosive devices will be assembled, disassembled, or otherwise handled at LANL under any of the alternatives.
[o] Includes accidents involving natural gas pipelines that can result in fires and/or explosions.
[p] Includes acts committed by authorized insiders (persons with authorized access to the facility) or outsiders (including visitors) that are committed with the intent of causing a release of radioactive materials, hazardous chemicals, high explosives, or biohazards or that are committed with the intent of causing a nuclear criticality event. The acts could take place at the facility or outside the facility (e.g., destruction of a dam, deliberate crash of an aircraft, etc.).
[q] Includes acts committed by authorized insiders or outsiders (including visitors) that are not intended to cause a release of radioactive materials, hazardous chemicals, high explosives, or biohazards or that are not intended to cause a criticality, but that nonetheless result in such occurrences contrary to the intent of the perpetrators.
[r] Includes accidents resulting in release of radioactive materials, hazardous chemicals, high explosives, or biohazards, or that result in a nuclear criticality event, occurring in all modes of transportation (truck, car, rail, aircraft, or ship) that involve material being shipped to or from the facility. Also includes impact of a vehicle from all modes of transportation (except aircraft, which is analyzed separately in this appendix) on the facility that causes damage to the facility (but that may or may not be transporting hazardous cargo).
[s] Includes normal changes in barometric pressure. Does not include changes in air pressure due to the passage of a tornado, which is analyzed separately.
[t] Includes accidents caused by biological factors such as ingestion of plant debris by cooling systems, blockage of cooling systems by mussel and clam infestations, excessive biological growth on the exterior of facility structures, etc. Does not include fire involving plants (wildfire), which is analyzed separately.
[u] Includes effects from excessive loads due to snow accumulation on or against facility structures.
[v] Includes such effects as global warming (and its impacts), glaciation (and its impacts), and other impacts of changes in weather that are not within the range of normally expected conditions. Does not include impacts due to existing glaciers.
[w] Includes effects such as seismically initiated liquefaction, dam failures, fires, and flooding, as well as surface deformation, tectonic subsidence, tectonic uplift, and damage due to ground accelerations (vertical and horizontal).
[x] Includes direct impact on the facility of meteorites, comets, asteroids, and other extraterrestrial bodies, as well as collateral damage resulting from impacts elsewhere (surface deformation, missile impacts, flooding, etc.).
[y] Includes impacts due to glaciers existing at the time of the analysis. Such impacts include the effects of both the advance and retreat of glaciers.
[z] Includes straight winds, as distinguished from hurricanes and tornadoes, and also includes wind-borne missiles.
[aa] Does not include landslides and mud flows due to volcanic activity.
[bb] Includes the impacts of fires caused by lightning strikes. For structures with lightning protection, this requires consideration of possible failures of lightning protection systems.
[cc] Does not include seismically initiated liquefaction, which is included under earthquakes.
[dd] Includes effects of freezing of equipment due to low external temperatures.
[ee] Includes impacts due to tornado-borne missiles, differential pressure due to nearby tornado passage, and lightning strikes, hail, rain, and other phenomena due to storms associated with the tornado weather system.
[ff] Includes such effects as ash falls, rock falls, nueé ardente, rapid snow-pack-melt-induced flooding, mud flows, siltation, sedimentation, phreatomagmatism, pyroclastic activity, etc. and fire/explosion.

TABLE G.3.1–2.—*Accident Type and Accident Initiator Screening Criteria*

SCREENING CRITERION	SCREENING CRITERION DESCRIPTION
1	The accident type or initiating event is within the facility design basis, and the frequency in combination with the conditional probability of a sufficiently severe design error affecting parameters that would cause failure of the facility is considered to be incredible (i.e., frequency less than 1 x 10^{-6} per year (conservatively evaluated); or
2	The initiating event does not occur close enough to the facility to affect it (this is a function of the magnitude of the event and the proximity of the facility to the event); or
3	The accident type or initiating event is included in the definition of another event due to the similarity of impacts on the facility, and the frequency contribution of the other event includes the contribution from this event; or
4	The event has a sufficiently cataclysmic impact on the facility as well as on the surrounding region such that the consequences of the event on the surrounding region would not be significantly affected by the destruction of the facility; or
5	The accident type or initiating event has a conservatively estimated mean frequency of less than 1 x 10^{-6} or a realistically estimated mean frequency of less than 1 x 10^{-7} per year; or
6	The accident type or initiating event is under the purview of the security and protection forces and the security and safeguards related administrative and physical controls, and is the result of deliberate act; these events are considered to be outside the purview of an “accident” analysis, which is concerned with unanticipated events that occur at random.

TABLE G.3.1–3.—*Process Hazards Screening Results*

ACCIDENT TYPE OR INITIATING EVENT	SCREENING CRITERIA						SCREENS OUT (Y/N)	NOTES
	1	2	3	4	5	6		
Biohazard Spill							No	Applicable to workers only; no credible scenario for spread of biohazard beyond the LANL workforce
Chemical Spill							No	Chemical spill hazards bounded by toxic gases and liquids that are easily dispersed
Container Failure			X				Yes	Contributing event to chemical spill and radioactive spill
Criticality Event							No	Applicable to workers only; public dose consequences of criticality event are less than 100 millirem
Explosion							No	
Fire							No	
Flooding	X		X				Yes	Possible contributing cause for criticality events; criticality retained
Hardware Failure			X				Yes	Embedded in other events as contributory causes; also represented as causes of system failures after an initiating event
Human Error			X				Yes	Embedded in other events as contributory causes; also represented as causes of system failures after an initiating event
Radioactive Spill							No	

TABLE G.3.1–4.—*Man-Made Hazards Screening Results*

ACCIDENT TYPE OR INITIATING EVENT	SCREENING CRITERIA						SCREENS OUT (Y/N)	NOTES
	1	2	3	4	5	6		
Aircraft Crash							No	Analysis to be performed per DOE Standard 3014-96 (DOE 1996c)
Arson						X	Yes	Malevolent act
Co-Located Facilities							No	
Dam Failure		X			X		Yes	
Dike Failure		X			X		Yes	
Explosion							No	
Fire							No	
Flooding							No	TA–18 only; other hazardous facilities located on mesa tops
Levee Failure		X			X		Yes	
Military Action						X	Yes	Malevolent act
Nuclear Detonation					X	X	Yes	No nuclear weapons or nuclear explosive devices are assembled, disassembled, handled, or otherwise processed at LANL
Pipeline Failure							No	TA–3–29 only
Sabotage and Terrorism						X	Yes	Malevolent acts
Satellite Orbital Decay					X		Yes	
Shipwrecks		X			X		Yes	
Transportation							No	Transportation analysis performed separately from accident analysis
Vandalism						X	Yes	Malevolent acts

TABLE G.3.1–5.—*Natural Phenomena Hazards Screening Results*

ACCIDENT TYPE OR INITIATING EVENT	SCREENING CRITERIA						SCREENS OUT (Y/N)	NOTES
	1	2	3	4	5	6		
Avalanche		X					Yes	
Barometric Pressure	X						Yes	
Biological Hazards		X					Yes	
Blizzards	X						Yes	
Climatic Change				X			Yes	
Coastal Erosion		X					Yes	
Drought	X						Yes	
Dust Storms	X						Yes	
Earthquakes							No	
Extraterrestrial Objects					X		Yes	
Fog	X						Yes	
Frost	X						Yes	
Glacial Activity				X			Yes	
Hail	X						Yes	
High Water		X					Yes	
High Wind							No	
Hurricanes		X					Yes	
Ice and Ice Jams		X					Yes	
Landslides and Mud Flows		X					Yes	
Lightning Strike							No	
Liquefaction	X						Yes	
Low Water Level		X					Yes	
Nontectonic Deformation	X						Yes	
Precipitation Extremes	X						Yes	
River Diversion		X					Yes	
Sand Storm	X						Yes	
Seiche		X					Yes	
Sink Holes and Collapse		X					Yes	
Slope Stability							No	
Snow	X						Yes	
Soil Consolidation	X						Yes	
Soil Shrink/Swell	X						Yes	
Storm Surge		X					Yes	
Temperature Extremes	X						Yes	
Tornado					X		Yes	
Tsunami		X					Yes	
Volcanism							No	

TABLE G.3.1–6.—*Credible Accident Types and Accident Initiators that Survived Early Screening*

PROCESS HAZARDS
Biohazard Spill
Chemical Spill
Criticality Event[a]
Explosion (Internal to Facility)
Fire (Internal to Facility)
Radioactive Spill
MAN-MADE HAZARDS
Aircraft Crash—analyzed based on DOE Standard 3014–96 (DOE 1996c)
Co-Located Facilities[b]
Explosion (External to Facility)[b]
Fire (External to Facility)
Flood (External to Facility)—TA–18 only[b]
Pipeline Failure—TA–3–29 only; other facilities screened
Transportation Accidents—analyzed separately from facility accidents
NATURAL PHENOMENA HAZARDS
Earthquakes
High Wind[b]
Lightning Strike[b]
Slope Stability—TA–18 only[b]
Volcanism[c]

[a] Screened out for public risk based on low dose; retained as a worker accident.
[b] Later screened out, based on subsequent facility- and site-specific review.
[c] Credible, but not used, based on higher level of risk posed by earthquakes.

order to select the final suite of facilities for detailed analysis.

G.3.2.1 *Description of the DOE Hazard Category System*

As background information only, this subsection describes the hazard categorization system used by DOE.

Facilities performing radiological operations are subdivided into hazard categories pursuant to DOE Order 5480.23 and DOE Standard 1027-92 (DOE 1992). There are three hazard categories based on the type of facility (Hazard Category 1) or the radiological inventory (Hazard Categories 2 and 3). These facilities are defined as nuclear facilities. Facilities that do not meet the threshold requirements for Hazard Category 3 but that still contain radioactive materials are categorized as radiological facilities.

The three hazard categories for these facilities are defined as follows (DOE 1992):

- *Hazard Category 1.* Hazard analysis shows the potential for significant off-site consequences (limited to Category A reactors and other facilities designated by the Program Secretarial Officer). (Note: There are no facilities at LANL designated by LANL or DOE as Hazard Category 1).
- *Hazard Category 2.* Hazard analysis shows the potential for significant on-site consequences (includes facilities with the potential for nuclear criticality events or with sufficient quantities of hazardous materials and energy that would require on-site emergency planning activities). Threshold quantities of radionuclides for Hazard Category 2 facilities are shown in Appendix A of DOE Standard 1027-92 (DOE 1992), with LANL-specific elaboration provided in a separate document (LANL 1995b).
- *Hazard Category 3.* Hazard analysis shows the potential for only significant localized consequences. Threshold quantities of radionuclides for Hazard Category 3 facilities are shown in Appendix A of DOE Standard 1027-92, with LANL-specific elaboration provided in a separate document (LANL 1994a).
- *Radiological Facilities.* Facilities not meeting at least Hazard Category 3 threshold criteria but that still possess some amount of radioactive materials. No other hazard identified than normal office or laboratory environment (electrical equipment, glassware, tools, etc.).

TABLE G.3.2–1.—*LANL Facilities Identified in Initial Hazard Categorization*

HAZARD CATEGORY 2 NUCLEAR FACILITIES	HAZARD CATEGORY 3 NUCLEAR FACILITIES	MODERATE HAZARD CHEMICAL FACILITIES	LOW HAZARD CHEMICAL FACILITIES	FACILITIES SELECTED BASED ON JUDGMENT
TA–2–1, Omega West Reactor	TA–3–66, Sigma Facility	TA–00–1109, Chlorinator	TA–3–39, Shops Building	TA–3–30, General Warehouse
TA–3–29, Chemistry & Metallurgy Research Building	TA–3–159, Sigma Thorium Storage Facility	TA–00–1110, Chlorinator	TA–3–141, Beryllium Technology Building	TA–3–35, Press Building
Dynamic experiment activities involving Special Nuclear Materials[a]	TA–18–23, Pajarito Site Kiva #1	TA–00–1113, Chlorinator	TA–3–1698, Materials Science Laboratory	TA–3–102, Shops Building
TA–16–205 Weapons Engineering Tritium Facility	TA–18–26, Pajarito Site Hillside Vault	TA–00–1114, Chlorinator	TA–21–5, Chemistry Building	TA–3–164, Uranium Storage Building
TA–18–32, Pajarito Site Kiva #2	TA–18–116, Pajarito Site Kiva #3	TA–3–31, Chemical Warehouse	TA–21–150, Molecular Chemistry Building	TA–3–166, Wastewater Treatment Plant
TA–21–155, Tritium Systems Test Assembly	TA–18–168, Pajarito Site Solution High-Energy Burst Assembly (SHEBA)	TA–3–170, Gas Plant	TA–43–1, Health Research Laboratory	TA–9–21, Analytical Chemistry Building
TA–21–209, Tritium Science and Fabrication Facility	TA–21–146, Filter Building	TA–3–476, Toxic Gas Storage Shed	TA–59–1, Occupational Health	TA–9–23, Shops Building
TA–50–37, Radioactive Materials Research, Operations, and Demonstration Facility	TA–35–2, Laboratory	TA–14–5, Toxic Gas Storage	TA–54–39, polychlorinated biphenyl (PCB) Waste Storage	TA–11–30, Vibration Test
TA–54–229, TA–54–230, TA–54–231, and TA–54–232, Transuranic Waste Inspectable Storage Project	TA–35–27, Nuclear Safeguards Laboratory	TA–16–560, Chlorinator	TA–60–29, Pesticide Storage	TA–15–184, Pulsed High-Energy Radiation Machine Emitting X-Ray (PHERMEX)
TA–54–48, TA–54–153, TA–54–224, TA–54–226, and TA–54–286, Transuranic Waste Storage Domes	TA–48–1, Radiochemistry Facility	TA–21–3, Chemistry Building		TA–16–260, High Explosives Processing (Example)
TA–55–4, Plutonium Facility	TA–50–1, Radioactive Liquid Waste Treatment Facility	TA–21–4, Chemistry Building		TA–16–305, High Explosives Chemical Storage (Example)

TABLE G.3.2–1.—*LANL Facilities Identified in Initial Hazard Categorization*-Continued

HAZARD CATEGORY 2 NUCLEAR FACILITIES	HAZARD CATEGORY 3 NUCLEAR FACILITIES	MODERATE HAZARD CHEMICAL FACILITIES	LOW HAZARD CHEMICAL FACILITIES	FACILITIES SELECTED BASED ON JUDGMENT
TA–55–41, Nuclear Materials Storage	TA–50–69, Waste Characterization, Reduction, and Repackaging Facility	TA–35–213, Target Fabrication Facility		TA–16–340, High Explosives Pressing (Example)
	Isotope production activities and radiation effects experiments at the Los Alamos Neutron Science Center (LANSCE)[b]	TA–46–340, Wastewater Treatment Facility Chlorination Building		TA–41–1, Ice House
	TA–54–38, Radioassay and Nondestructive Testing Facility	TA–54–216, Legacy Toxic Gas Storage		TA–46–154, Applied Photochemistry
	TA–55–185, Transuranic (TRU) Drum Staging Facility	TA–54–1008, Chlorinator		
		TA–72–3, Chlorinator		
		TA–73–9, Chlorinator		

[a] Activities utilize or occur at several host facilities at which special nuclear material associated with Hazard Category 2 may reside for short durations. These host facilities include TA–8–23 (Radiography), TA–16–411 (Assembly Building), and TA–15 (PHERMEX), and the DARHT facility when it is completed.

[b] LANSCE, TA–53, is a nonnuclear facility that hosts several activities typically of limited duration that are considered to be Hazard Category 3, including isotope production and experiments using small quantities of actinides. The risks associated with these occasional, short duration activities involving these materials at these facilities have been evaluated in DOE safety analyses and controls are in place while the material is in the facilities.

TABLE G.3.2–2.—*LANL Facilities Screened from Analysis, with Screening Rationale*

FACILITY	FACILITY NAME AND SCREENING RATIONALE
TA–0–1113	Potable Water Chlorinator—Located in canyon; chlorine is a heavy gas that in high concentrations will proceed down the canyon, away from populated areas; no unique worker accidents; no biohazards; no radioactive materials.
TA–0–1114	See TA–0–1113.
TA–2–1	Omega West Reactor—Not scheduled for operation in a SWEIS alternative. All nuclear material has been moved from this facility, and the facility has been removed from the site's nuclear facility list.
TA–3–30	General Warehouse—No radioactivity or biohazards; chemical inventory screened; no unique worker hazards.
TA–3–31	Chemical Warehouse—No radioactivity or biohazards; chemical inventory screened; no unique worker hazards.
TA–3–35	Press Building—Radiological facility only; radiological hazards bounded by other nearby facilities. No chemicals or biohazards. No unique worker hazards.
TA–3–39	Shops Building—No unique worker hazards; no biohazards. Impacts from depleted uranium or beryllium bounded by other facilities (TA–3–66, TA–3–141).
TA–3–102	See TA–3–39.
TA–3–141	Beryllium Technology Building—No credible public accidents. No biohazards; no radioactivity.
TA–3–142	Shipping and Receiving Warehouse—Transient radioactivity only (less than Hazard Category 3 quantities). Chemical inventory screened (ERPG–3 < 100 meters). No biohazards. No unique worker hazards.
TA–3–159	Sigma Thorium Storage Facility—Facility contains only thorium; consequences bounded by other facilities; passive storage only, nonpyrophoric forms, low combustible loading.
TA–3–164	Uranium Storage Facility—Inventory removed. No use projected for any SWEIS alternative.
TA–3–166	Wastewater Treatment Plant—Chlorine inventory removed; facility no longer treats wastewater. No biohazards or radioactivity. No unique worker hazards.
TA–3–170	Compressed Gas Processing Facility—No radioactivity or biohazards. No unique worker hazards. Chemical inventory screened (ERPG–3 <100 meters).
TA–3–1698	Materials Science Laboratory (MSL)—No credible accidents; radioactivity and chemical inventories screen. No unique worker hazards; no biohazards.
TA–8–22	Radiography—Facility performs radiography of (among other things) pits and DARHT assemblies. Low combustible loading and similar seismic resistance to other facilities at which these materials will be present for a much greater percentage of the time. The risks of accidents at TA–8–22 are bounded by the risks of accidents at the other facilities. No unique worker accidents (radiography performed at other facilities as well).
TA–8–23	See TA–8–22.
TA–9–23	Shops Building—Radiological inventory below Hazard Category 3; chemical inventory screens (ERPG–3 <100 meters). No biohazards. No unique worker hazards. Remote location.

TABLE G.3.2–2.—*LANL Facilities Screened from Analysis, with Screening Rationale*-Continued

FACILITY	FACILITY NAME AND SCREENING RATIONALE
TA–9–30	Nuclear Material Storage—Maximum radiological inventory is 100 kilograms of depleted uranium and less than 0.1 grams of tritium (less than Hazard Category 3). Chemical inventory screens (ERPG–3 < 100 meters). No biohazards. No unique worker hazards. Remote location; depleted uranium accident consequences bounded by other facilities with greater inventory and in more densely populated area.
TA–11–30	Vibration Test Building—Transient radiological inventory only (same materials present at other facilities in greater quantity and/or more frequently). No chemicals or biohazards. No unique worker hazards.
TA–14–5	Toxic Gas Storage Building—Inventory removed. No use projected for any SWEIS alternative.
TA–15–184	PHERMEX—Firing site with no unique hazards (any hazards at PHERMEX bounded by those at DARHT and other facilities). No unique worker hazards. No biohazards. More remote than other facilities with similar MAR.
TA–16–260	High Explosives Processing—No radioactivity or biohazards. No unique worker hazards. Detonation hazards limited to workers due to exclusion area and blowout panels.
TA–16–305	High Explosives Chemical Storage—No radioactivity or biohazards. No unique worker hazards. Chemical inventory screens (ERPG–3 < 100 meters). Contained in former high explosives magazine.
TA–16–340	High Explosives Pressing Facility—No radioactivity or biohazards. No unique worker hazards. Detonation hazards limited to workers due to exclusion area and blowout panels.
TA–16–410	Assembly Facility—Activities at TA–16–410 are comparable to those at TA–16–411, and the MAR at TA–16–410 is bounded in hazard and quantity by MAR at TA–16–411.
TA–16–560	Potable Water Chlorinator—Consequences limited to area containing few buildings. No public consequences (except possibly a limited number of commuters on West Jemez Road). No unique worker hazards; no biohazards; no radioactivity. Impacts bounded by other potable water chlorinators.
TA–18–26	Pajarito Site Hillside Vault—Passive vault storage of plutonium and highly enriched uranium (HEU) in a vault built into the side of a mesa. Very low combustible loading, no active HVAC systems. Infrequent access. Seismic collapse would bury MAR with no significant release to the environment. No credible accidents; very low frequency accidents bounded by those at other storage facilities (TA–3–29, TA–55–4).
TA–21–3	Chemistry Building—Facility undergoing decontamination and decommissioning; completion scheduled prior to final SWEIS issuance.
TA–21–4	See TA–21–3.
TA–21–5	See TA–21–3.
TA–21–146	Filter Building—Filter building for former plutonium activities at TA–21. Decontamination and decommissioning will be completed prior to final SWEIS issuance.
TA–21–150	See TA–21–3.
TA–35–2	Laboratory—The only MAR is radioactive sources, which screen under DOE Standard 1027-92 (DOE 1992).
TA–35–27	Nuclear Safeguards Laboratory—The only MAR is radioactive sources, which screen under DOE Standard 1027-92.

TABLE G.3.2–2.—*LANL Facilities Screened from Analysis, with Screening Rationale*-Continued

FACILITY	FACILITY NAME AND SCREENING RATIONALE
TA–35–213	Target Fabrication Facility—No radioactive materials (except less than Hazard Category 3 quantities of depleted uranium and tritium). No biohazards. Some toxic chemicals present, but located in fume hoods with active ventilation. Under seismic collapse conditions, toxic effects remain within TA (facility adjacent to canyon, which will preclude transport of high concentrations of heavy gases); workers would be impacted by the seismic collapse in any event.
TA–41–1	Ice House—Former radiological inventory removed (residual contamination only). No storage or processing in any SWEIS alternative. No chemicals or biohazards. No unique worker hazards.
TA–46–154	Applied Photochemistry—No radioactivity or biohazards. No unique worker hazards. Chemical inventory screens (ERPG–3 < 100 meters).
TA–48–1	Radiochemistry Facility—All MAR (radioactive and chemical) screen (i.e., radioactivity less than Hazard Category 3, except for hot cells; chemicals screen at ERPG–3 at less than 100 meters). Any impacts would be limited to the TA–48 site area.
TA–53	LANSCE and Manuel Lujan Neutron Scattering Center (MLNSC)—No credible accidents. No unique worker accidents. No biohazards.
TA–54–33	Drum Preparation Facility—No chemicals or biohazards. No unique worker hazards. MAR limited and bounded by other nearby facilities (TA–54–38, TA–54–G Transuranic Waste Inspectable Storage Project [TWISP]).
TA–54–49	Low-level Mixed Waste Storage Dome—No biohazards. No unique worker hazards. Radiological hazards bounded by other nearby facilities with much larger inventories (TA–54–G, TWISP).
TA–54–1008	Potable Water Chlorinator—No receptors within ERPG–2 distance. No unique worker hazards; no biohazards or radioactivity.
TA–55–5	Plutonium Facility Warehouse—Chemical inventory removed; staging area only with transitory chemical inventory. No changes expected for any SWEIS alternative. Bounded by TA–55–4 chemical accidents (e.g., chlorine, hydrogen fluoride gas, nitric acid, hydrochloric acid).
TA–55–41	Nuclear Materials Storage Facility (NMSF)—Storage activities at TA–55–41 mirror those at TA–55–4. No unique hazards at TA–55–41. TA–55–41 connected to TA–55–4 via an underground tunnel. Risks at TA–55–41 bounded by those at TA–55–4.
TA–60–29	Pesticide Storage Building—Passive storage facility; chemicals screen or are bounded by the effects of chemical releases at other nearby facilities. No biohazards or radioactivity.
TA–72–3	Potable Water Chlorinator—No receptors within ERPG–2 distance. No unique worker hazards; no biohazards or radioactivity.
TA–73–1	Los Alamos Airport—Covered under transportation accident analysis. Aircraft crash associated with missed landings, etc., covered in facility aircraft crash accident analysis (DOE Standard 3014-96, DOE 1996b).
TA–73–9	Potable Water Chlorinator—Located on steep hill. Chlorine is a heavy gas that in high concentrations will proceed downhill into a canyon. Any impacts to commuters on State Road 502 will be bounded by chlorine release from other potable water chlorinators (TA–0–1109, TA–0–1110).

TABLE G.3.2–3.—*Final List of LANL Facilities to be Subjected to Screening Consequence Analysis*

TECHNICAL AREA AND BUILDING NUMBER	FACILITY NAME
TA–0–1109	Potable Water Chlorinator
TA–0–1110	Potable Water Chlorinator
TA–3–29	CMR Building
TA–3–66	Sigma Facility
TA–3–476	Toxic Gas Storage Shed
TA–9–21	Analytical Chemistry Building (worker hazard only)
TA–15–312	DARHT Facility
TA–16–205	WETF
TA–16–411	Assembly Building
TA–18–23	Pajarito Site Kiva #1 (seismic and aircraft crash only)
TA–18–32	Pajarito Site Kiva #2 (seismic and aircraft crash only)
TA–18–116	Pajarito Site Kiva #3
TA–18–168	Pajarito Site SHEBA Building (seismic and aircraft crash only)
TA–21–155	TSTA
TA–21–209	TSFF
TA–43–1	Health Research Laboratory (HRL) (seismic only)
TA–46–340	Waste Water Treatment Facility (WWTF)
TA–50–1	Radioactive Liquid Waste Treatment Facility (seismic only)
TA–50–37	Radioactive Materials Research, Operations, and Demonstration Facility (RAMROD)
TA–50–69	Waste Characterization, Reduction, and Repackaging (WCRR) Facility
TA–54–G	TWISP (TA–54–229, TA–54–230, TA–54–231, and TA–54–232); Transuranic Waste Storage Domes (TA–54–48, TA–54–153, TA–54–224, TA–54–226, and TA–54–283); Tritium Waste Sheds (TA–54–1027, TA–54–1028, TA–54–1029, and TA–54–1041)
TA–54–38	Radioactive Assay and Nondestructive Test (RANT) Facility
TA–54–39	PCB Waste Storage Facility
TA–54–216	Legacy Toxic Gas Storage Facility
TA–55–4	Plutonium Facility
TA–55–185	Transuranic Waste Drum Staging Building
TA–59–1	Occupational Health Laboratory (worker hazard only)

Facilities that do not perform radiological operations are subdivided into three hazard classes based on the hazard potential of the chemical inventory according to guidance in DOE Order 5481.1B and DOE EM Standard 5502-94 (DOE 1994b). Facilities that do not fall into one of the three hazard classes are considered as nonhazardous facilities (i.e., no hazards identified other than a normal office environment) (LANL 1995a).

The four nonnuclear facility hazard classes are defined as follows (DOE 1994b):

- *High Hazard.* Hazards with a potential for on-site and off-site impacts to large numbers of people or for major impacts to the environment. (Note: There are no facilities at LANL designated by LANL or DOE as High Hazard).
- *Moderate Hazard.* Hazards that present considerable potential on-site impacts to people or the environment but at most only minor off-site impacts.
- *Low Hazard.* Hazards that present minor on-site and negligible off-site impacts to people and the environment.
- *Nonhazardous.* No hazards beyond those routinely encountered in an office environment (electrical equipment, glassware, tools, etc.).

G.3.2.2 *Use of Facility Safety Documentation and Walkdowns*

Based on the results of the accident initiator screening and facility screening, available facility safety documentation was reviewed. All other things being the same, potential accident scenarios with the largest release potential within each frequency row were selected for more detailed review and assessment. Prior to the conduct of facility interviews and walkdowns (in most cases), a preliminary list of accident scenarios was prepared based on facility safety documentation review in order to facilitate the walkdown and discussions with facility operations personnel.

A pre-visit facility walkdown/interview data collection form was prepared for each facility and transmitted to facility representatives (through the LANL SWEIS Project Office). Facility representatives, in coordination with the LANL SWEIS Project Office points-of-contact, then arranged for a facility discussion and walkdown. The walkdown/interview data collection forms were created to facilitate the collection of a consistent set of facility data. In preparing the forms, the previous experience of SWEIS accident analysis team in conducting previous accident evaluations (including safety analyses, probabilistic risk assessments, and process hazard analyses) was considered. In addition, the following specific source documents were considered:

- DOE Handbook 1100-96, *Chemical Process Hazard Analysis*, February 1996 (DOE 1996b).
- DOE EM Standard 5502-94, *Hazard Baseline Documentation*, August 1994 (DOE 1994b).
- DOE Standard 1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, December 1992 (DOE 1992).
- DOE Standard 3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, July 1994 (DOE 1994a).

During and subsequent to the walkdowns, revised safety documentation was provided by the facility representatives. This documentation was subsequently reviewed, and a draft data collection document was prepared for each facility. These draft data collection documents were reviewed by the LANL SWEIS Project Office and facility representatives to ensure that the information about the facilities and their operation was correctly noted by the data collection team.

Where a facility had current safety documentation, that documentation was used in the first instance to define accident scenarios. Owing to differences in scope between safety documentation and NEPA accident analyses, some supplementation of the safety documentation was necessary in a few instances in order to provide the required NEPA coverage (this was especially true in the area of seismically initiated sequences). The facility walkdowns were used to further evaluate the accident scenarios identified in the safety documentation, to evaluate whether additional accident scenarios were possible that were not included in the safety documentation, to evaluate whether there were accident frequency or accident consequence mitigation capabilities present that were not credited in the safety documentation, and to assess the impacts of the SWEIS alternatives on the accident scenarios. This latter consideration included the following aspects:

- Evaluation of whether accident frequencies could increase or decrease across the alternatives
- Evaluation of whether the MAR could increase or decrease across the alternatives
- Evaluation of whether accident scenarios identified for the No Action Alternative would be eliminated across the remaining alternatives
- Evaluation of whether any accident scenario not identified for the No Action Alternative would be possible in any of the other alternatives

As a result of the facility walkdowns and interviews and the review of revised safety documentation for many facilities, a large number of credible radiological accident scenarios were identified and grouped by MAR (e.g., weapons grade plutonium, source material plutonium, tritium, highly enriched uranium, depleted uranium, etc.) for further consideration.

G.3.2.3 *Population Distributions*

Population distributions were created (using the SECPOP90 program) based on 1990 Census data for residential population and based on 1996 LANL workforce populations by TA.

LANL workforce populations were included in the analysis by centering the total TA population in the direction from the accident origination facility that represents the largest concentration of TA population for each TA. Although this is an approximation method and results in some double counting because facility workers also may have residences within the 50-mile (80-kilometer) radius of LANL for which consequence calculations were performed, this is believed to be an appropriate means for including LANL workforce consequences.

The aggregation of workforce population data by TA is the only available aggregation for which substantial questions do not exist. Although data are available on a building-by-building basis, those data represent where the LANL employees collect their mail and do not necessarily represent where they spend most of their work day. Neither is the LANL workforce varied across the alternatives for accident analysis purposes, although it is recognized that the LANL workforce varies in size by alternative. There is much greater variation in LANL workforce from shift to shift during any given day than there is across the alternatives. It is not practical nor feasible to refine the population within a TA quite close to a release point because such data are not available and would not be stable. The consequences are given in terms of collective exposure and the exposure at the MEI locations, which are adequate for differentiating among the alternatives for decision making.

In all cases in this accident analysis, the accidents are assumed to take place during the day shift with the maximum workforce population present. (Indeed, the entire workforce is represented in the aggregated workforce population data by TA, not just the daytime workforce.) The assumption of daytime conditions is conservative for those accidents that occur at random and are unrelated to processes in operation at any given time.

G.3.2.4 *Dispersion Parameters Used in Screening and Consequence Calculations*

Daytime populations, which are larger than nighttime populations near the source, were used for screening and calculating the consequences of chemical and radiological accidents. Accordingly, the meteorological conditions used were: (1) wind speed of 9.2 feet per second (2.8 meters per second); (2) Pasquill-Gifford stability Class C; (3) ambient temperature of 48°F (8.9°C); (4) mostly sunny, cloud cover conditions; and (5) 51 percent relative humidity. These are representative of daytime conditions in this area (LANL 1990a). They provide conservative dispersion under daytime conditions and will be referred to as such in this SWEIS. (Class A and B stabilities also occur during the daytime, but their greater vertical air motions will produce lower ground level concentrations. Stable atmospheres, which will produce higher concentrations, can occur but are atypical and therefore not used for screening.)

For the consequence assessment of chemical accidents, both conservative daytime dispersion and adverse dispersion conditions (stable atmosphere) were used. For radiological accidents, all meteorological conditions, in the relative frequency as they occurred in 1995, were used.

G.3.3 Chemical Accident Screening

G.3.3.1 *Summary of Chemical Accident Screening*

Thirty-seven chemicals were identified in the 1992 LANL database that met all of the following criteria:

- Has a time-weighted-average (TWA) less than 2 parts per million
- Is found in readily dispersible form (i.e., a gas or liquid)
- Has a boiling point less than 212°F (100°C) and vapor pressure greater than 0.5 millimeter mercury

These 37 chemicals were modeled for release of their largest 1992 inventory, using adverse dispersion conditions. The ten releases that exceeded the ERPG–3 guideline at 328 feet (100 meters) distance were retained for further analysis. To these were added another eight chemicals of interest.

Releases of the actual inventories of these 18 chemicals at 78 locations were then modeled to see which would exceed the ERPG–3 concentration under conservative daytime dispersion conditions. In this modeling:

- Release was at surface level
- Gases were released over 10 minutes
- Liquids were spilled instantaneously and then evaporated from a puddle 0.4 inch (1 centimeter) deep

The releases that exceeded the ERPG–3 concentration were examined with consideration of:

- Whether there is a large workforce nearby or if there is public exposure
- If a heavy gas, whether the public is protected by intervening canyons

- Whether the consequences are less than a release of the chemical from a different facility
- Whether the consequences are less than those of another chemical released from the same facility

With these considerations, a number of releases were selected and retained for detailed analysis. Formaldehyde also was retained because it represents the largest LANL inventory of a readily dispersible chemical carcinogen. These final selections are shown in Table G.3.3.1–3. The above process is described in detail in the following.

Details of Chemical Screening

There is a wide variety of chemicals in storage and in use at LANL facilities. This analysis assumes that all chemicals that are regulated or have established exposure guidelines are listed in the MULTUS database (Dukes 1995). This commercially available database contains information on over 2,800 controlled chemicals and over 23,000 associated synonyms. Because there are far more TWAs than other guidelines for chemicals, TWAs were chosen to represent toxicity for screening purposes. An upper threshold value of 2 parts per million was selected because it is the TWA for nitric acid. (There is a 6,100-gallon [23,100-liter] nitric acid tank at TA–55 that, because of its volume, was likely to represent the bounding consequence chemical accident.) The MULTUS database was searched for chemicals with TWAs less than 2 parts per million, resulting in a list of 330 chemicals.

The 1992 LANL Automated Chemical Inventory System (ACIS) chemical database (which represented LANL baseline data) was searched for these same 330 chemicals. Only 190 were found. Of these, if the chemical is ordinarily in solid form (nondispersible), it was screened from further analysis. (Although particles smaller than about 10 micrometers diameter are respirable, a liquid or gas is expected to have greater consequences in terms of area of impact and time urgency; thus, the analysis was focused on liquids and gases.) Application of this criterion reduced the list to 74 chemicals.

If the chemical has a boiling point of greater than 212°F (100°C) and has a vapor pressure of less than 0.5 millimeters of mercury under ambient conditions, the material was screened from further analysis. This criterion was developed based on an American Conference of Governmental Industrial Hygienists (ACGIH 1992) hazard index (HI) (which assigns a low vaporization/dispersion hazard to materials with boiling points greater than 212°F [100°C]) and the EPA List of Regulated Substances and Thresholds for Accidental Release Prevention. (The latter establishes a criterion of a vapor pressure of less than 0.02 inch [0.5 millimeter] of mercury under ambient conditions for toxic liquids to capture most substances that have a relatively low volatility but may still pose an airborne hazard in accidental release [40 CFR 68].) Application of this criterion further reduced the list to 37 chemicals.

For each of the 37 chemicals, ALOHA™ dispersion modeling was performed using its largest inventory in the 1992 ACIS database. Adverse dispersion conditions were used to determine whether concentrations as great as ERPG–3 would occur at a distance of 328 feet (100 meters) (the approximate distance to noninvolved workers and general public access). Ten chemicals were found to produce ERPG–3 concentrations at distances beyond 328 feet (100 meters): boron trifluoride, bromine, chlorine, formaldehyde, methyl hydrazine, nitric acid, phosgene, phosphorous oxychloride, selenium hexafluoride, and thionyl chloride.

In addition to the ten chemicals to survive the above screening process, the following seven chemicals were identified in the "significant chemicals in hazard analysis" table of the

LANL hazard assessment document (LANL 1995a), and were included for analysis: diborane, fluorine, hydrogen cyanide, hydrogen fluoride, nickel carbonyl, perfluoroisobutylene, hydrochloric acid, and sulfur dioxide. In addition, a review of the TA–3–170 Compressed Gas Processing Facility inventory resulted in the addition of nitric oxide to the list of chemicals of concern.

An information request was submitted to LANL for storage locations, quantities, physical form, units of measurement, and other associated information for these 18 chemicals. Upon receipt of the information from LANL, the materials were aggregated into storage locations, converted into common units of measurement, and adjusted for concentration. This process resulted in 183 chemical sources at 78 storage locations. The resulting chemical inventories were then modeled to determine which facilities contained total quantities that, if released, would exceed ERPG–3 concentrations at 328 feet (100 meters) under conservative daytime atmospheric dispersion conditions. This modeling identified chemical sources at the storage locations shown in Table G.3.3.1–1.

The initial data source, as indicated above, was the 1992 ACIS baseline data. The following information sources were utilized to find additional storage locations and potential release sites for these chemicals:

- The 1995 ACIS Database, which contains a listing of the chemicals ordered on an annual basis
- TA–54 Area L (hazardous waste management facility) gas cylinder inventory
- STORES Database
- Cheaper Database (recycled chemicals) and Gas Plant Database
- Facility-Specific SARs, Safety Assessments (SAs), and other safety documentation

TABLE G.3.3.1–1.—*Preliminary ALOHA™ Chemical Screening Results*

CHEMICAL	LOCATION
Sulfur Dioxide	TA–54–216
Hydrochloric Acid	TA–55–249
Hydrogen Cyanide	TA–3–66
Nitric Acid	TA–50–1
	TA–50–5
	TA–55–4
	TA–59–1
Selenium Hexafluoride	TA–54–216
Chlorine	TA–00–1109
	TA–00–1110
	TA–00–1113
	TA–00–1114
	TA–3–476
	TA–16–560
	TA–33–200
	TA–46–340
	TA–54–1108
	TA–55–4
	TA–72–3
	TA–73–9
Fluorine	TA–54–216
Hydrogen Fluoride	TA–54–216
	TA–55–4

- LANL Spill Prevention, Control and Countermeasure (SPCC) Plan
- Facility interview and walkdown data collection forms

The results in Table G.3.3.1–1 were examined with a further consideration of population distributions surrounding the release sites and, for heavy gases, consideration of whether the potential atmospheric transport to populated areas would be interrupted by canyons. Based on these considerations, a number of release sites were screened from further consideration. The results of this initial binning effort are shown in Table G.3.3.1–2.

The release sites and chemicals surviving this initial binning effort were then plotted on a map

TABLE G.3.3.1–2.—*Preliminary Binning of Chemical Accident Release Sites*

CHEMICAL	RELEASE SITE	PRELIMINARY BINNING COMMENTS
Chlorine	TA–00–1109	Retained for detailed analysis; located on the edge of a neighborhood
	TA–00–1110	Retained for detailed analysis; located on the edge of a neighborhood
	TA–00–1113	Screened; located in a canyon; any impacts bounded by TA–0–1109/1110
	TA–00–1114	Screened; located in a canyon; any impacts bounded by TA–0–1109/1110
	TA–03–476	Retained for detailed analysis; large LANL workforce nearby; intervening canyon prevents heavy gas transport to Los Alamos townsite
	TA–16–560	Screened; located at a site with no public receptors; impacts bounded by TA–03–476
	TA–33–200	Screened; located at a remote site with no public receptors and a very small LANL workforce population (less than 10); impacts bounded by TA–03–476
	TA–46–340	Screened; no credible accidents; release site is in a canyon; heavy gas plume will dissipate prior to reaching distant public receptors
	TA–54–1008	Screened; located at a remote site with no public receptors; impacts bounded by other chemicals released from TA–54–216 (closer to LANL workforce)
	TA–55–4	Retained for detailed analysis; intervening canyon prevents transport to public receptors; large LANL workforce population (TA–35, TA–48, TA–50, & TA–55)
	TA–72–3	Screened; located at a remote site with no public receptors; canyon prevents transport of a heavy gas to populated areas
	TA–73–9	Screened; located on a hill; heavy gas transport will be predominantly downslope into a canyon, away from public receptors and LANL workforce at TA–00 locations
Fluorine	TA–54–216	Screened; impacts bounded by sulfur dioxide and selenium hexafluoride
Hydrochloric Acid	TA–55–249	Retained for detailed analysis
Hydrogen Cyanide	TA–03–66	Retained for detailed analysis
Hydrogen Fluoride	TA–54–216	Screened; impacts bounded by sulfur dioxide and selenium hexafluoride
	TA–55–4	Screened; bounded by release of chlorine at the same site
Nitric Acid (80%)	TA–50–1	Screened; impacts bounded by chlorine and nitric acid release at TA–55–4
	TA–50–5	Screened; impacts bounded by chlorine and nitric acid release at TA–55–4
	TA–55–4	Retained for detailed analysis (large LANL workforce population at TA–55)
	TA–59–1	Screened; largest container is 2.6 gallons, bounded by much larger potential releases at other facilities
Selenium Hexafluoride	TA–54–216	Retained for detailed analysis
Sulfur Dioxide	TA–54–216	Retained for detailed analysis; other sites screened, bounded by release at TA–59–216

of Los Alamos County and evaluated based on the population grids (on-site and off-site) surrounding the respective chemical storage location. The population distributions for chemical release sites were generated from 1990 Census data and current LANL TA populations as described above. The evaluation considered the probability that the wind would blow in the direction of the population at the time of release.

In addition, the chemical storage locations were separated into the following bins relating to the potential accident scenario: natural phenomena hazards (e.g., seismic events), process hazards, and man-made hazards. This final binning effort is portrayed in Table G.3.3.1–3.

Formaldehyde at TA–43–1, which was originally screened as resulting in concentrations less than ERPG–3 at 328 feet (100 meters) under conservative daytime dispersion conditions, was added back to the list on the basis that it represents the largest LANL inventory of a readily dispersible carcinogen from the 51 confirmed, suspected and animal carcinogens in the site inventory.

G.3.3.2 *Assumptions Inherent in the Screening*

The following assumptions are inherent in the process:

- All hazardous LANL chemicals are in the MULTUS database.
- All hazardous LANL chemicals of significant inventory are in the LANL ACIS database or otherwise captured in the safety documentation and walkdowns.
- There are no readily dispersible particles that pose significant accident release consequence and that are not otherwise captured in the human health analyses and/or in the site-wide and other accident scenarios.

TABLE G.3.3.1–3.—*Final Chemical Accident Binning*

CHEMICAL	RELEASE SITE	PROCESS HAZARD	MAN-MADE HAZARD	NATURAL PHENOMENA HAZARD	CARCINOGEN
Chlorine	TA–00–1109	X		X	
	TA–00–1110	X		X	
	TA–03–476		X		
	TA–55–4	X		X	
Formaldehyde	TA–43–1			X	X
Hydrochloric Acid	TA–55–249			X	
Hydrogen Cyanide	TA–03–66			X	
Nitric Acid	TA–55–4			X	
Selenium Hexafluoride	TA–54–216	X	X		
Sulfur Dioxide	TA–54–216	X	X		

Note: These releases are heavy gas releases except for selenium hexafluoride and hydrogen chloride. Heavy gases in high concentrations would not be capable of crossing canyons from mesa to mesa, but would instead flow down into the canyons and proceed downslope. Such diversion into canyons is not modeled by ALOHA™, which is a flat terrain model. Heavy gas behavior has been taken into account manually in the affected population results shown above. The formaldehyde release from TA–43–1 was screened on chemical consequence results. However, it was retained because it represents the largest inventory of a readily dispersible carcinogenic chemical.

- There are no solid (nondispersible) pyrophoric materials posing a release hazard of significant consequence that were not captured or bounded in one of the accidents considered.
- Gases were modeled as a 10-minute release (rather than an instantaneous release) in accordance with the EPA *Risk Management Plan Off-site Consequence Analysis Guidance* (EPA 1996) and the EPA/FEMA/DOT *Technical Guidance For Hazards Analysis* (EPA 1987). However, instantaneous release may be possible for some gases, producing much higher concentrations (though for a shorter time).
- The terrain around LANL facilities is relatively flat in the first several hundred meters, and when not, this does not dramatically change the concentrations from those produced by ALOHA™.
- The surface around LANL facilities is represented by the surface roughness in the ALOHA™ model, which in turn affects the dispersion rate.
- The averaging time inherent in ALOHA™ does not smooth, to an average less than 2 parts per million, dangerously high momentary concentrations that would exist beyond 328 feet (100 meters).

These assumptions are reasonable for screening because the resultant screening is sufficiently conservative to have a reasonable assurance of capturing all chemicals and chemical locations that pose a risk to the public and workers outside the facility.

G.3.4 Facility Radiological Accident Screening

G.3.4.1 *Methodology for Consequence Screening*

To facilitate radiological facility accident screening, integrated population exposure was established as an evaluation criterion. Consequences were calculated for the release of a unit of material and multiplied by the source term magnitude to obtain approximate consequences for screening. The calculations were performed with the MACCS 2 code (as described in section G.2.4) for both ground level releases and elevated releases (which varied from 18.3 to 100 meters, depending on the facility and the scenario of interest). The following distance intervals were used in each of the 16 compass directions: 0 to 1 kilometer, 1 to 2 kilometers, 2 to 3 kilometers, 3 to 4 kilometers, 4 to 8 kilometers, 8 to 12 kilometers, 12 to 20 kilometers, 20 to 30 kilometers, 30 to 40 kilometers, 40 to 60 kilometers, and 60 to 80 kilometers.

G.3.4.2 *Source Terms*

For radiological accidents, there are two source terms of interest: the initial source term and the suspension source term. The initial source term is the radioactive material driven airborne at the time of the accident. The suspension source term is the radioactive material that becomes airborne subsequent to the accident as a result of evaporation, winds, or other processes. For most DOE nonreactor facilities, the dose from inhalation exposure dominates the overall dose from accidents.

Source terms were estimated based on the accident progression for the scenario being considered. DOE Handbook 3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE 1994d), was used as the primary reference for calculation of source terms. DOE Standard 3014-96 (DOE 1996c), which covers aircraft crash accidents, has a separate source term methodology identified in Table II of the standard. Although it is stated to be based on DOE Handbook 3010-94, it is more conservative than the handbook. In order to maintain consistency across the accident analyses, and in accordance with the provision in Section 7.2.5 of the DOE standard, which provides that other methods can be used if justified, the DOE Handbook 3010-94 source term methodology has been applied to the aircraft crash accidents in this SWEIS.

MAR estimates were obtained from safety documentation and verified during the course of facility walkdowns. Two source term equations are used: one for the initial source term and one for the subsequent continuing suspension source term. The initial equation has the following general form:

Initial Source Term = (MAR) x (DR) x (ARF) x (RF) x (LPF)

where:

MAR = Material-at-risk (quantity of material available to be acted on by a given physical stress)

DR = Damage ratio (the fraction of the MAR actually impacted by the accident-generated conditions)

ARF = Airborne release fraction (the fraction of the material suspended in the air as an aerosol and, thus, available for transport due to the physical stresses from a specific accident or due to operation of HVAC systems)

RF = Respirable fraction (the fraction of the aerosols that can be transported through the air and inhaled into the human respiratory system, commonly assumed to include particles of 10 micrometers aerodynamic equivalent diameter or less)

LPF = Leak path factor (the fraction of the respirable aerosols transported through some confinement or filtration mechanism)

The suspension source term equation has the following general form:

Suspension Source Term = (MAR) x (DR) x (ARR/hr) x (24 hrs) x (RF) x (LPF)

where:

MAR = Material-at-risk

DR = Damage ratio

ARR/hr = Airborne release rate per hour

RF = Respirable fraction

24 hrs = Suspension calculational time period

LPF = Leak path factor

Note that the suspension source term includes all processes whereby material continues to become airborne. This includes evaporation of liquids, continuing leaks, and resuspension by air motions of material initially deposited. It is referred to as “suspension” to delineate it from resuspension, a term reserved for resuspension of deposited materials previously airborne.

G.3.4.3 *Identification of Accident Scenarios*

Two primary types of data sources were used for radiological accident analysis: (1) safety documentation, including SAs, hazard analyses (HAs), process hazard analyses (PrHAs), PRAs, and SARs; and (2) facility walkdown/interview data collection forms. Documentation relied upon for the radiological facility accident analysis included the following:

- The draft facility descriptions and hazard classification document for LANL, prepared by the LANL SWEIS Project Office (LANL 1995a)
- Descriptions of alternatives for key facilities prepared by the LANL SWEIS Project Office (LANL 1997c and LANL 1998a)
- The LANL seismic hazard evaluation (Wong et al. 1995)
- The LANL aircraft crash hazard evaluation (LANL 1996c)

- Various LANL memoranda and miscellaneous documentation
- Basis for Interim Operation, Operational Safety Requirements, and Technical Safety Requirements for various LANL facilities
- Environmental Assessments (EAs) and EISs
- Various DOE guidance documents
- DOE orders and standards
- Other nuclear industry data sources (e.g., Swain and Guttmann 1983 and Mahn et al. 1995)

Based on the results of the review of facility safety documentation and the facility walkdown/interview data collection process, a large suite of accident scenarios were identified and their consequences quantified by conservative screening methods. Table G.3.4.3–1 provides a consolidated listing of all of the various scenarios that were subjected to the conservative consequence screening analysis. Only those scenarios that were shown on a conservative screening basis to be potentially risk-dominant were then subjected to a more detailed analysis. (These are listed in Table G.4–1).

G.3.4.4 Addition of Site-Wide Wildfire to Screening Results

In the screening methodology, wildfire was not put into the list of natural phenomena hazards that might initiate accidents. Instead, the DOE initially treated wildfire as a subset of manmade fires (Table G.3.1–1). Manmade fires were considered at individual facilities, but were eliminated as the most frequent accident initiator, or the bounding or representative accident for the facility. Because of this, and because wildfires are not common in facility-specific hazard analysis documents, site-wide wildfires escaped consideration in the Draft SWEIS. At the same time, there was a general recognition of the threat to LANL, as evidenced by the multiple agency cooperation in an ongoing fuel reduction effort. This oversight was brought to the DOE's attention during the public hearings on the Draft SWEIS, and an analysis was immediately begun with input from the Española District of the Santa Fe National Forest, the Bandelier National Monument of the National Park Service, the Los Alamos Fire Department, and LANL departments and personnel. The final analysis appears as SITE–04.

G.3.5 Worker Accident Screening

Analysis of worker accidents was performed to provide estimates of potential health effects from chemical and radiological exposure for involved workers. (For purposes of this SWEIS, workers within the TA where the accident occurs are defined as "involved workers," and other on-site LANL employees are defined as "noninvolved workers.") Because worker health risk from industrial accidents (falls, electrical shock, crushing, etc.) dominates over worker health risk from exposure from radiological and chemical accidents, worker accident analysis is not as extensive or detailed as that for public impacts Also, there are far more low energy events whose impacts are highly dependent upon worker location and the details of the accident.

Worker accidents were reviewed qualitatively in order to arrive at a list of accidents that is representative of the accident potential at LANL under the four alternatives. The process used was similar to the analysis of accidents with public impact. The purpose of the separate worker accident screening was to identify whether there are accident scenarios that could have greater consequence to workers than the worker consequence associated with the public accident scenarios.

Data to support the accident analysis were obtained from a variety of sources, both facility- and site-specific as well as from industrial and

TABLE G.3.4.3–1.—*Consolidated List of Accidents Subjected to Radiological Consequence*

MATERIAL TYPE	HAZARD TYPE (PROCESS, MAN-MADE, NATURAL PHENOMENA)	FACILITY AND SCENARIO DESCRIPTION	ANNUAL FREQUENCY BIN
Highly Enriched Uranium, Depleted Uranium, Plutonium, Tritium, TRU	Natural Phenomena	Multiple facilities, site-wide earthquake resulting in structural damage or collapse	10^{-6} to 10^{-4}
Highly Enriched Uranium	Process	TA–3–29, fire/explosion in ULISSES solvent extraction line or HEU foundry	10^{-4} to 10^{-2}
	Process	TA–3–29, inadvertent criticality event due to multiple procedural violations and/or equipment failures	
	Man-Made	TA–3–29, aircraft crash and fire	10^{-6} to 10^{-4}
	Process	TA–18–116, power excursion leading to fuel melting	10^{-6} to 10^{-4}
	Process	TA–3–66, foundry fire	10^{-4} to 10^{-2}
Plutonium	Man-Made	TA–3–29, natural gas pipeline failure, ingestion of gas into building, explosion and fire	10^{-6} to 10^{-4}
	Process	TA–18–116, reactivity excursion, melting of Pu sample	10^{-6} to 10^{-4}
	Man-Made	TA–50–1, nonprocess-related boiler explosion, damage to clariflocculator	10^{-2} to 10^{-1}
	Process	TA–55–4, inadvertent criticality event due to multiple procedural violations and/or equipment failures	10^{-6} to 10^{-4}
	Process	TA–55–4, ion exchange column exothermic reaction and explosion, failure of HEPA filters	10^{-6} to 10^{-4}
	Process	TA–55–4, explosion and fire in hydride-dehydride glovebox, failure of HEPA filters	10^{-6} to 10^{-4}
	Process	TA–55–4, human error resulting in dropped plutonium oxide powder container, failure of HEPA filters	10^{-4} to 10^{-2}
	Process	TA–55–4, fire in heat source plutonium glovebox, fire suppression inoperable, HEPA filtration ineffective	10^{-6} to 10^{-4}
	Process	DARHT, inadvertent detonation	$< 10^{-6}$
	Process	DARHT, loss of containment	10^{-7} to 10^{-6}

TABLE G.3.4.3–1.—*Consolidated List of Accidents Subjected to Radiological Consequence*-Continued

MATERIAL TYPE	HAZARD TYPE (PROCESS, MAN-MADE, NATURAL PHENOMENA)	FACILITY AND SCENARIO DESCRIPTION	ANNUAL FREQUENCY BIN
Depleted Uranium	Process	TA–3–66, foundry fire	10^{-4} to 10^{-2}
Tritium	Process	TA–16–205, inadvertent opening of LP–50 container	10^{-2} to 10^{-1}
	Process	TA–16–205, high pressure gas handling system failure, ventilation isolation failure	10^{-4} to 10^{-2}
	Process	TA–16–205, tritium waste treatment system failure, ventilation isolation failure	10^{-4} to 10^{-2}
	Process	TA–21–155, release of tritium from nonsecondary contained system during maintenance, or release of tritium from glovebox due to leaking component	10^{-2} to 10^{-1}
	Process	TA–21–155, distillation column failure, vacuum jacket failure, fire	10^{-6} to 10^{-4}
	Process	TA–21–155, tritium leak, tritium waste treatment system failure	10^{-4} to 10^{-2}
	Man-Made	TA–21–155, aircraft crash and fire	10^{-6} to 10^{-4}
	Process	TA–21–209, molecular sieve regeneration error	10^{-4} to 10^{-2}
	Man-Made	TA–21–209, aircraft crash and fire	10^{-4} to 10^{-2}
	Man-Made	TA–54–1027, TA–54–1028, TA–54–1029, and TA–54–1041, unsuppressed wild fire, aircraft crash and fire, or truck fuel system leak and fire at tritium waste storage sheds	10^{-6} to 10^{-4}
	Process	TA–55–4, special recovery line de-inerting and fire	10^{-6} to 10^{-4}
TRU Waste	Man-Made	TA–50–37, aircraft crash and fire	10^{-4} to 10^{-2}
	Process	TA–50–69, TRU waste drum puncture by forklift outdoors	10^{-4} to 10^{-2}
	Man-Made	TA–50–69, truck fuel system leak and fire at outdoor container storage area	10^{-4} to 10^{-2}
	Man-Made	TA–54–38, truck fuel system leak and fire at outdoor container storage area	10^{-4} to 10^{-2}
	Man-Made	TA–54–229, TA–54–230, TA–54–231, and TA–54–232, aircraft crash and fire or unsuppressed wild fire at TWISP storage domes	10^{-6} to 10^{-4}

nuclear generic databases and compilations. Data sources included the following:

- Safety and hazard analysis documentation
- Data forms generated during the facility walkdowns
- LANL SWEIS alternatives documentation: generic data from industry and nuclear facilities including the following:
  - — *Component Failure Rate Data with Potential Applicability to a Nuclear Fuel Plant* (Dexter and Perkins 1982)
  - — *General Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs* (Eide et al. 1990)
  - — *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Application* (Swain and Guttman 1983)
  - — *Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites* (Coats and Murray 1984)
  - — Office of Nuclear and Facility Safety, Office of Environment, Safety and Health, U.S. Department of Energy, Washington, DC. Maintains and compiles a series of databases and reports on worker accidents in DOE facilities, including: (1) Occurrence Reporting and Processing System (ORPS) reports for LANL and other DOE facilities; (2) Office of Operating Experience Analysis and Feedback, Safety Notices; and (3) Office of Operating Experience Analysis and Feedback, Operating Experience Weekly Summary
  - — Occupational Safety and Health Administration Form 200 Injury/Illness Reports for LANL and other DOE facilities

The summary listing identified more than 600 potential worker accident scenarios. Potential worker accident scenarios were then sorted by material hazard and initiators and ranked according to relative risk. Risk was qualitatively assigned on the basis of the frequency and consequence ranking matrix for hazard evaluation described in DOE Standard 3009-94 (DOE 1994a) and shown in Figure G.1.1–1. The array of worker accidents was not dissimilar from the array of accidents with public impact, so that the worker accident component of the selected public accidents also provides a representative picture of the worker accident potential.

There are, however, some accidents that pose risk to workers but not to the public. An example is the medical research at TA–43–1, field work on small mammal capture and blood sampling, where the exposures to workers are localized and the exposure to the population from a release would be mitigated by environmental attenuation. Another exception is energetic hazards, where potential hazardous sources do not involve the public. Examples of energetic hazards are:

- High explosives
- Laser
- Pressurized gas
- Radiofrequency
- Liquid nitrogen/cryogen
- Neutron generator
- High pressure
- Hydrogen

Representative energetic hazard accidents include:

- Low pressure steam line failures (TA–16–205)
- Failure of cryogenic systems (TA–3–170, liquid nitrogen and liquid argon; TA–3–1698, liquid nitrogen; TA–16–205, liquid nitrogen; and TA–21–155, liquid nitrogen)
- Rupture of nontoxic gas bottles (TA–15–184, TA–50–1, TA–50–69, TA–54–39, and TA–59–1)

- Failure of noncombustible gas tube trailer (TA–3–29 and TA–50–69)
- Failure of pressurized gas lines (TA–16–205, TA–16–411)
- Electrical shock (all facilities)
- Laser accidents (TA–3–1698)
- Electromagnetic fields (TA–15–312 and TA–53)
- High explosive detonation (TA–15–184, TA–15–312, TA–16–260, TA–16–340, and TA–16–411)

The ranked worker accident scenarios were then compared to the public impact accidents with comparable risk rankings. From the review of the chemical and radiological accidents selected for detailed quantification of public risk, as well as a screen of these accidents against the worker accidents, the following worker accidents were selected for more detailed evaluation:

- Inadvertent high explosives detonation
- Biohazard contamination of a single worker
- Inadvertent criticality event
- Inadvertent exposure to electromagnetic radiation (x-rays, accelerator beam, laser, or RF source)

G.4 EVALUATION OF RISK-DOMINANT ACCIDENTS

The risk-dominant accidents that were selected for detailed evaluation and impact quantification are shown in Table G.4–1. These are five site-wide accidents (earthquakes of varying severity and a wildfire), six chemical accidents, sixteen radiological accidents, and four worker hazard accidents.

G.4.1 Accident Frequency Assessment

This section contains the methodology used to determine the frequency of the different accident scenarios. The resulting frequencies, summarized in Table G.4.1–1, cover a wide frequency range. To place these frequencies in perspective, Table G.1.5–1 (section G.1 of this chapter) gives the probability of some natural phenomena at LANL and the probability of large meteors impacting somewhere in the world.

G.4.1.1 *Earthquake Frequencies*

The frequency of accidents arising from earthquakes is predicated upon a methodology set forth in DOE Standard 1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* (DOE 1994e). Conceptually, the earthquake accident frequency assessment considers two parameters: (1) the frequency per year that earthquakes of different ground acceleration levels occur and (2) the conditional probability of component or structural failure, given those ground accelerations.

In practice, facilities are designed for earthquakes according to their hazard potential. The design for general industry is based on the Uniform Building Code (UBC), which has evolved considerably over the period of time during which currently active facilities at LANL have been constructed (early 1950's through the 1990's). DOE nuclear facilities have design basis earthquake standards (depending upon the hazard potential of the facility) and performance requirements for avoiding hazardous material releases.

The treatment of earthquakes in facility safety documentation varies from the simple (screening earthquakes based on meeting the design basis earthquake guidance) to the bounding (assuming complete structural collapse) to the detailed (seismic margin analysis). In order to try to place the assessment of system and structural response for all LANL facilities on a consistent basis, estimates were made of a parameter known as the high confidence in low probability of failure (HCLPF). This is the ground acceleration level at which the analyst is very confident that the probability of failure is very low. The HCLPF value can be mathematically related to the seismic hazard (annual frequency of ground acceleration) to produce a point estimate of frequency at which system or structural failure will occur.

The seismic hazard at LANL was the subject of a state-of-the-art probabilistic seismic hazard analysis (PSHA) prepared for the laboratory and DOE by Woodward-Clyde Federal Services. The methodology used in the study is similar to (but more advanced in some areas) that approved by the U.S. Nuclear Regulatory Commission (NRC) for commercial nuclear power plant sites located east of the Rocky Mountains. The PSHA produces a variety of results expressing the annual frequency of ground motion at the LANL site. Among the more important results and implications of the LANL PSHA are the following:

- Many important facilities at LANL were designed and constructed in the 1950's through the late 1970's and do not compare favorably with current DOE seismic design requirements.

TABLE G.4–1.—*Risk-Dominant Accidents at LANL*

PROCESS HAZARD ACCIDENTS	
CHEM–01	Single cylinder release of chlorine (150 pounds) from a potable water chlorinator (TA–00–1109, bounding) due to equipment failure or human error during chlorine cylinder replacement or maintenance activities
CHEM–03	Single cylinder release of chlorine (150 pounds) from toxic gas cylinder storage facility (TA–3–476) due to human error during cylinder handling or cylinder deterioration due to unintended long-term exposure to weather
CHEM–06	Chlorine gas release (150 pounds) from a process line at the Plutonium Facility (TA–55–4) due to mechanical damage to a supply manifold
RAD–03	Reactivity excursion accident at Pajarito Site Kiva #3 (TA–18–116) with Godiva-IV outside the kiva, vaporizing part of the highly enriched uranium fuel and melting the remainder
RAD–04	Inadvertent detonation of a plutonium-containing assembly at or near the DARHT Facility firing point, resulting in an elevated, explosive-driven release of plutonium (TA–15)
RAD–09	Transuranic waste drum failure or puncture at TA–54, Area G (bounding)
RAD–10	Plutonium release from a degraded storage container in the Plutonium Facility (TA–55–4) vault during container retrieval (Note: Determined by detailed analysis to be a worker accident only.)
RAD–11	Container breach after detonation of a plutonium-containing assembly at the DARHT firing point (TA–15), resulting in a ground-level release of plutonium
RAD–13	Plutonium melting and release accident at Pajarito Site Kiva #3 (TA–18–116)
RAD–14	Plutonium release from ion exchange column thermal excursion at TA–55–4 (Note: Determined by detailed analysis to be a worker accident only.)
RAD–15	Plutonium release from hydride-dehydride glovebox fire at TA–55–4 (Note: Determined by detailed analysis to be a worker accident only.)
WORK–01	Worker fatality due to inadvertent high explosive detonation
WORK–02	Worker illness or fatality due to inadvertent biohazard contamination
WORK–03	Multiple worker fatality due to inadvertent nuclear criticality event
WORK–04	Worker injury or fatality due to inadvertent electromagnetic radiation exposure (x-ray, accelerator beam, laser, or RF source exposure)
MAN-MADE HAZARD ACCIDENTS	
CHEM–02	Multiple-cylinder chlorine release (1,500 pounds) due to explosion or unsuppressed fire affecting a toxic gas storage facility (TA–3–476)
CHEM–04	Single cylinder release of toxic gas (selenium hexaflouride, historical bounding chemical) from the legacy toxic gas storage facility (TA–54–216) due to random cylinder failure or a forklift accident
CHEM–05	Cylinder release of toxic gas (sulfur dioxide, historical bounding chemical) from the legacy toxic gas storage facility (TA–54–216) due to a fire, a propane tank boiling-liquid expanding vapor explosion (BLEVE), or a propagating random failure
RAD–01	Plutonium release due to container storage area fire involving transuranic waste drums (TA–54–38)
RAD–02	Plutonium release due to natural gas pipeline failure near TA–3–29, with no immediate ignition, ingestion of gas into facility, followed by explosion and fire
RAD–05	Aircraft crash with explosion and/or fire at TA–21 resulting in a tritium oxide release

TABLE G.4–1.—*Risk-Dominant Accidents at LANL*-Continued

RAD–06	Aircraft crash with explosion and/or fire at TA–50–37, resulting in a plutonium release from transuranic waste drums (Note: Retained based on preliminary calculations; final calculations determined that this accident screened on frequency less than 1 x 10^{-7} per year.)
RAD–07	Plutonium release due to container storage area fire involving transuranic waste drums (TA–50–9)
RAD–08	Aircraft crash with explosion and/or fire at the transuranic waste dome area at TA–54 (TA–54–229, TA–54–230, TA–54–231, and TA–54–232)
RAD–16	Aircraft crash with explosion and/or fire at TA–3–29 resulting in a plutonium release
NATURAL PHENOMENA HAZARD ACCIDENTS	
SITE–01	Site-wide earthquake, resulting in damage to low capacity structure or internal components at multiple facilities
SITE–02	Site-wide earthquake, resulting in damage to moderate capacity structures or internal components at multiple facilities
SITE–03	Site-wide earthquake, resulting in structural damage or collapse to all facilities
SITE–03, Surface Rupture	Site-wide earthquake with accompanying surface rupture on subsidiary faults, resulting in structural damage or collapse to all facilities
SITE–04	Site-wide wildfire, consuming combustible structures and vegetation.
RAD–12	Plutonium release from a seismically initiated event

TABLE G.4.1–1.—*Accident Annual Frequency Results, by Alternative*

ACCIDENT SCENARIO	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
SITE–01	2.9×10^{-3}	same	same	same
SITE–02	4.4×10^{-4}	same	same	same
SITE–03	7.1×10^{-5}	same	same	same
SITE–03, Surface Rupture	1 to 3×10^{-5}	same	same	same
SITE–04	0.1	same	same	same
CHEM–01	1.2×10^{-3}	1.3×10^{-3}	1.1×10^{-3}	1.2×10^{-3}
CHEM–02	1.3×10^{-4}	1.5×10^{-4}	1.2×10^{-4}	1.3×10^{-4}
CHEM–03	1.2×10^{-4}	same	same	same
CHEM–04	4.1×10^{-3}	same	same	same
CHEM–05	5.1×10^{-4}	same	same	same
CHEM–06	6.3×10^{-2}	same	same	same
RAD–01	1.6×10^{-3}	same	same	same
RAD–02	$< 10^{-6}$ (Incredible)	same	same	same
RAD–03	3.4×10^{-6}	4.3×10^{-6}	3.4×10^{-6}	3.4×10^{-6}
RAD–04	$< 10^{-6}$ (Incredible)	same	same	same
RAD–05	3.8×10^{-6} (TSTA) 5.3×10^{-6} (TSFF)	same	same	same
RAD–06	$< 10^{-6}$ (Incredible)	same	same	same
RAD–07	1.5×10^{-4}	3.0×10^{-4}	1.1×10^{-4}	1.5×10^{-4}
RAD–08	4.3×10^{-6}	same	same	same
RAD–09	4.1×10^{-3} 0.4	4.9×10^{-3} 0.49	3.9×10^{-3} 0.38	4.1×10^{-3} 0.4
RAD–10	$< 10^{-6}$ (Incredible)	same	same	same
RAD–11	$< 10^{-6}$ (Incredible)	same	same	same
RAD–12	1.5×10^{-6}	same	same	same
RAD–13	1.6×10^{-5}	same	same	same
RAD–14	$< 10^{-6}$ (Incredible)	same	same	same
RAD–15	3.2×10^{-5}	same	same	same
RAD–16	3.5×10^{-6}	same	same	same
WORK–01	0.001 to 0.01	same	same	same
WORK–02	0.01 to 0.1	same	same	same

TABLE G.4.1–1.—*Accident Annual Frequency Results, by Alternative*-Continued

ACCIDENT SCENARIO	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
WORK–03	< 1.0×10^{-5}	same	same	same
WORK–04	0.01 to 0.1	same	same	same
WORK–05	0.23	same	same	same

- Earthquakes simultaneously affect all LANL facilities.
- All risk-significant facilities at LANL are located within 3.5 miles (5.6 kilometers) of the Pajarito Fault, which runs parallel to the western boundary of LANL and slopes down-to-the-east under the laboratory. The Pajarito Fault, along with the Embudo Fault (which runs to the north of LANL), is the principal source of large ground motions at LANL.
- The PSHA indicates that, for all eight LANL locations for which detailed calculations were performed, the frequency of a 1.0 g (where "g" is the acceleration due the Earth's gravity) peak horizontal ground acceleration is approximately 1 x 10^{-5} years (about once in one hundred thousand years), which is both well within the bounds of what is considered to be "credible" under NEPA (DOE 1993a) and large enough to heavily damage essentially all LANL facilities.

In order to evaluate earthquake damage to LANL facilities, HCLPF values were estimated based on a variety of sources of information, including detailed seismic margin studies[1] (e.g., TA–3–29 and TA–55–4) and safety documentation. Where no detailed information was available, HCLPF values were based on expert judgment and facility walkdowns. The HCLPF values were mathematically related to the PSHA results such that the HCLPF value is directly related to an annual frequency of occurrence. When this was done, the frequencies of failure of the facilities fell into three groupings for which the frequencies of occurrence differ by only a factor of 3 to 4 within the group. Considering the approximate method used to generate the results, this is considered to represent appropriate groupings for accident analysis purposes. The three earthquake scenarios, and their corresponding frequencies, are as follows:

- SITE–01, HCLPFs ranging from 0.04 g to 0.10 g, with a frequency of 3 x 10^{-3} per year, corresponding to failures of components and structures with relatively low seismic capacities.
- SITE–02, HCLPFs ranging from 0.10 g to 0.25 g, with a frequency of 4 x 10^{-4} per year, corresponding to failures of components and structures with moderate seismic capacities.
- SITE–03, HCLPFs ranging from 0.25 g to 0.44 g, with a frequency of 7 x 10^{-5} per year, corresponding to failure of components and structures with comparatively high seismic capacities.

Seismic studies recently completed and currently in progress have further evaluated the potential for ground faulting. These studies indicate the possibility of such events is low, but credible, at some locations on the LANL site. In addition, the potential of ground faulting at one facility of concern, the CMR Building, will be discussed as a subsection of the SITE–03 event. Section 4.2.2.2 (in volume I, chapter 4) and appendix I discuss further the recently completed studies and their implication for LANL and DOE.

In practice, with significant analytical resources assigned, it would be possible to derive robust HCLPF values and then convolve that information with the seismic hazard curve to identify failure frequencies for all important LANL facilities. However, even were this done, the uncertainties in the results would be substantial due to the uncertainty in the seismic hazard. For example, the range in ground acceleration from the 5^{th} to the 95^{th} percentile, result at a frequency of 1 x 10^{-5} per year, is from 0.55 g to more than 1.0 g. The representation of the earthquake risks by using the three site accidents identified above provides a reasonable level of resolution for the purposes of NEPA accident analysis.

1. A Seismic Margin Study is a study undertaken to quantify the ability of a structure, system, or component to withstand an earthquake greater than it was designed for and still achieve its function.

G.4.1.2 *Fire and Other Accident Frequencies and 1969 Rocky Flats Fire*

Accident frequency assessments were performed for accidents other than those caused by earthquakes and aircraft crash using PRA-based methods and available LANL and industry data sources. The accidents were examined in a step-by-step method that carefully examined the sequential progression of the accidents, beginning with an initiating event and continuing through the chain of equipment failures, human actions, and phenomenological events that constitute the accident scenario. General guidance for such calculations is provided in a Sandia National Laboratories (SNL) publication (Mahn et al. 1995), and this general guidance has been supplemented by numerous LANL-specific and other studies in order to provide a defensible basis for the accident frequency analysis.

It should be recognized that the DOE safety analysis guidance does not require PRA calculations to be performed in order to categorize the likelihood of accident scenarios (DOE 1994a). Rather, coarse binning efforts are undertaken to qualitatively rank the accident scenarios into frequency bins for the purposes of hazards analysis.

Fire other than from earthquake and aircraft crash was postulated to release MAR in several of the analyses (e.g., RAD–01 and RAD–07). A truck fire was considered more likely than other fire initiators (such as wildfire, lightning, and forklift fires) in outdoor areas and was used. However, a leaking fuel system on a truck that goes unnoticed long enough to pool a large amount of fuel, then followed with an ignition capable of igniting the nonvolatile diesel fuel, has a low frequency that is difficult to quantify. The same is true for wildfire in paved areas and for fires initiated by lightning. However, these accidents were retained for analysis because the combined frequency of fires from all causes is thought to pose a credible accident. (The explosive potential of diesel fuel tanks on trucks and other vehicles is very small and was screened out by more likely accident initiators at facilities where trucks might visit.)

In the Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management (SSM PEIS) (DOE 1996f) the reassignment of pit manufacturing to LANL was analyzed. In the resulting Record of Decision (ROD) (61 CFR 68014), DOE discussed the decision made, that is, to move pit manufacturing to LANL. Historically, pit manufacturing was conducted at the Rocky Flats Plant (now known as the Rocky Flats Environmental Technology Site [RFETS]). At RFETS, a major fire occurred in 1969, and minor fires occurred on other occasions in similar accidents. Plutonium was released in the 1969 fire-related accident.

To provide a better idea of the differences between the operations at Rocky Flats in 1969 and the operations in TA–55 today, a description of the 1969 Rocky Flats fire, as provided by the Atomic Energy Commission (AEC) at the time of the fire, is provided below (AEC 1969). This description includes the findings presented by the AEC. These findings have since been used to improve design characteristics and operating procedures in all DOE nuclear facilities. Thus, a similar sequence of events would not be possible either because of built in barriers that would restrict the initiation of such an event or would prevent the propagation of such a fire.

The LANL Plutonium processing facility, TA–55–4, was designed to correct the deficiencies that led to the 1969 Rocky Flats fire. In the following discussion, the AEC findings are crosswalked to design features and operating procedures that exist in TA–55 today. As demonstrated in this crosswalk, if the preventative measures that exist in TA–55 today were present at Rocky Flats in 1969, the major fire that resulted in release of plutonium would not have happened.

Fire is always a concern when working with any pyrophoric material such as plutonium. However, TA–55 was designed with specific engineering features to prevent fire and is where plutonium has been worked with, handled, and stored for many years. Its past and current research and development missions have been specifically focused on understanding plutonium and its material properties. Introducing pit production at Los Alamos, therefore, does not dramatically increase the potential for fire because TA–55–4 is where plutonium has been stored, handled, and processed since the facility's original inception.

In fact, the fire at Rocky Flats began in a process development area not a production area. The major differences in TA–55–4 that prevent a building-wide fire are specific operating procedures and design features (barriers) that were established based on lessons learned from fires such as that which happened at Rocky Flats. These barriers prevent the fire from starting, as well as prevent its spread should a fire start. As presented in the following discussion, the inference that TA–55–4 will have a building wide fire now that the facility is producing pits is misleading.

Description of the 1969 Fire at the Rocky Flats Plant

The available evidence indicates that the fire originated on the lower shelf of the storage cabinet in Glovebox 134-24 (see Figure G.4.1.2–1) in the North Line. Plutonium briquettes (discs 3 inches [8 centimeters] in diameter and 1 inch [3 centimeters] thick of either pressed scrap metal or lathe turnings) and some loose scrap metal were stored in uncovered cans in the storage cabinet. The exact cause of ignition is unknown; however, plutonium in the form of chips or lathe turnings is pyrophoric and caught fire. The heat from the burning plutonium metal evidently caused the storage cabinet, which was constructed mostly of cellulosic laminate material and plastic, to char and generate flammable gases that may have been ignited by burning plutonium. The heat of the burning gases may have ignited other briquettes and initiated a slow burning of the storage cabinet materials, particularly in the cracks between the joined sections of the cellulosic materials. Regardless of the process, the fire spread to the outer surfaces of the cabinet.

The smoke in the exhaust system of the North Line gradually clogged the filters. The flames on the outer surfaces of the cabinet spread to the combustible gloves and plastic windows on Glovebox 134-24. Up to this time, the fire was still undetected by the few people who were in the building that day because the smoke, flames, and heat were contained within the glovebox system. Because the heat detectors were located outside and under Glovebox 134-24 and were insulated by the floor of the storage cabinet, they were incapable of sensing the fire. (Similar detectors elsewhere in the glovebox system subsequently did function, and the alarm was sounded.)

Once the plastic windows of Glovebox 134-24 were breached, the air rushing in fanned the fire and caused it to spread into the North Conveyor Line and into the gloveboxes east of Glovebox 134-24.

The airflow in the North Conveyor Line normally flowed from east to west. However, because of the clogged filters, the airflow in the line reversed and followed the second ventilation system, which was part of the North-South Line and the Center Line. When the fire reached the North-South Line, it turned south because of two factors: a closed metal door in the North Line and the direction of the airflow. On reaching the Center Line, the fire again went east because of the airflow.

The first indication of a fire was an alarm received in the plant's fire station at 2:27 p.m.

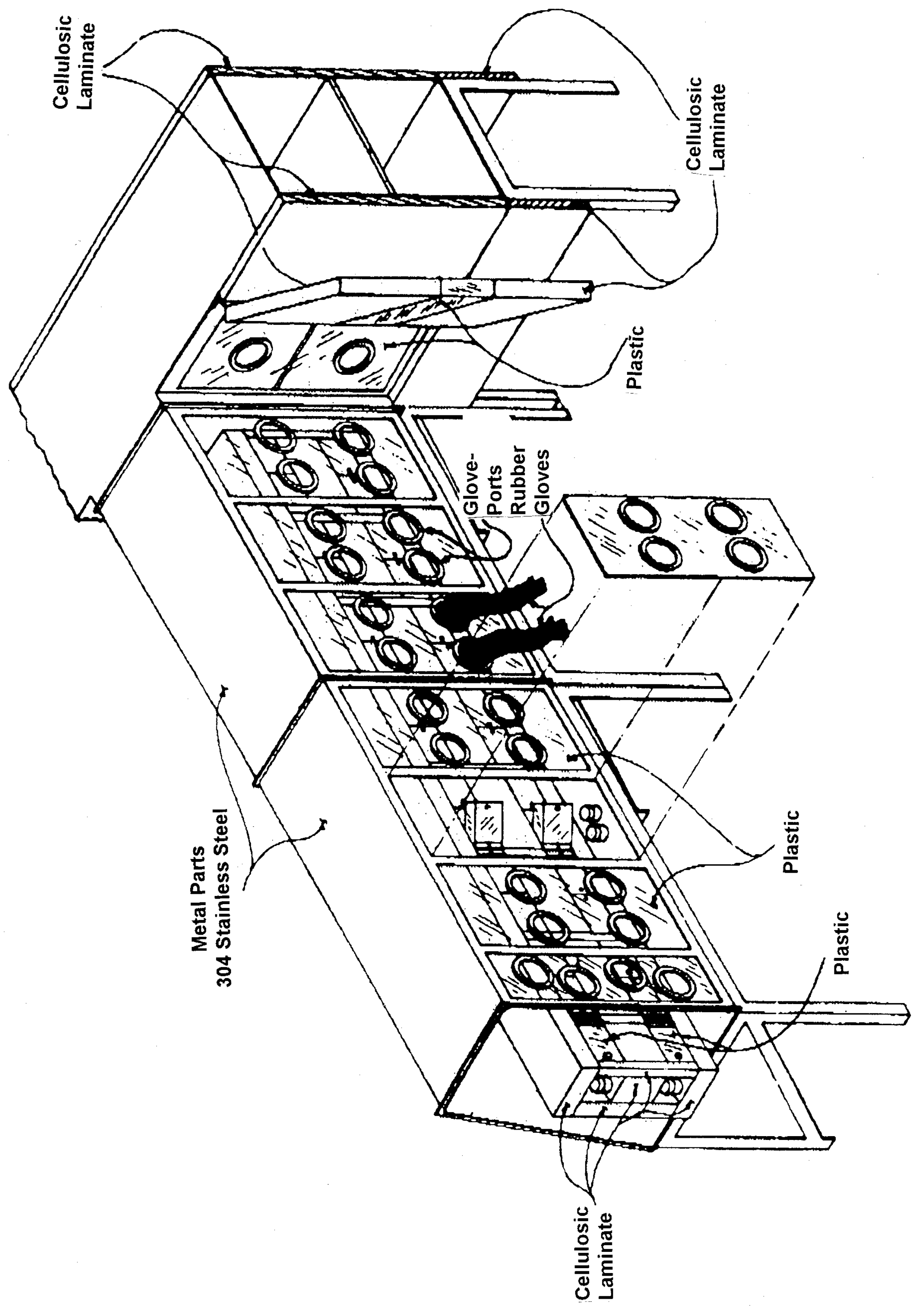


FIGURE G.4.1.2–1.—*Rocky Flats Site, Glovebox 123-24* on May 11, 1969, from the heat-sensing system that monitored temperatures at various locations in the glovebox systems in Building 776-777. Although the fire department responded promptly, the dense smoke, crowded conditions, and presence of large quantities of combustible shielding material made the fire very difficult to fight and extinguish. Because of the concern about the possibility of a nuclear criticality accident (a chain reaction), the standard firefighting procedures then in effect for Building 776-777 did not specify the use of water, except as a last resort. For this reason, there was no automatic sprinkler system in this area of the building. The first attack on the fire was made with carbon dioxide and was ineffective. Less than 10 minutes after the fire alarm was received, the fire captain initiated the use of water. Thereafter, water was used almost exclusively in the firefighting activities. No nuclear criticality occurred. The fire was brought under control about 6:40 p.m., but continued to burn or recur in isolated areas throughout the night.

The damage to Building 776-777 and its equipment was extensive. In addition to the actual fire and smoke damage, the building was heavily contaminated internally with plutonium. Substantial parts of the utility systems within the building were severely damaged. Some of the interconnected buildings sustained minor interior contamination. The fire did not breach the building roof, but slight exterior contamination was measured on the roof of Building 776 and an adjoining building, apparently due to a minor failure of a filter. Instrument readings indicated a level of 0.02 microcuries per 100 square centimeters with a few spots up to 0.2 microcuries per 100 square centimeters. Plutonium also was tracked out of Building 776 by the firefighters and was detectable on the ground around the building. Survey instrument readings in these areas indicated from 0.02 to 0.2 microcuries per 100 square centimeters.

AEC Findings on the May 1969 Rocky Flats Plant Fire

The AEC Report presented the following findings from the May 1969 fire at the Rocky Flats Plant (AEC 1969).

- With the available evidence, the AEC has no basis for concluding that the fire was set intentionally.
- The plastic windows contributed heavily to the spread of the fire and the extent of the loss. These windows, a major structural part of the containment system, provided a fuel surface on the inside of the glovebox-conveyor systems. Continued operation of the glovebox ventilation systems provided a supply of air to support the combustion. Under these conditions, burning of the windows and plutonium would have resulted essentially in the same loss as was experienced even if no other combustible materials had been present.
- Less than 1 percent of the total of almost 600 tons of combustible radiation shielding was consumed in the fire.
- The long interconnected conveyor system without physical barriers provided a path for the fire to spread. The closed metal door in the North Line demonstrated the effectiveness of even a simple firebreak in the line.
- The storage of plutonium briquettes in cans without lids provided potential ignition sources.
- Without the plastic and cellulosic laminate cabinet in Glovebox 134-24, it is unlikely that a plutonium briquette burning in an open metal container would have ignited the plastic windows.
- The addition of the storage cabinet, which nullified the heat-sensing system in Glovebox 134-24, prevented an earlier warning of fire.

Crosswalk of Design Barriers and Operating Procedures Between Rocky Flats in 1969 and TA–55–4 in 1998

The Rocky Flats fire started from the burning of plutonium metal scraps that were stored in metal containers without lids. In TA–55, plutonium is stabilized prior to storage. In this case, storage of scrap material is not permitted in open containers.

The storage containers at Rocky Flats were placed in storage cabinets that were made out of plastic and cellulosic laminate material, providing a fuel source for the burning plutonium. At TA–55, these types of storage cabinets are not used. Studies on combustible loadings are required for all operations that will be conducted within the gloveboxes, and restrictions are placed on the quantities of combustible materials to ensure that fires cannot be sustained and then propagated. Good housekeeping as well as other control measures such as conducting machining operations without oil has lead to a drastic reduction in incipient fires.

Once the fire at Rocky Flats was started, the fire detection systems did not sense the fire because the detectors were located on the outside of the gloveboxes, and the fire in its early stages was confined to the inside of the gloveboxes. Additionally, the glovebox acted to insulate the sensor from the heat of the fire—in effect preventing an early warning. In TA–55–4, the gloveboxes, have sensors both on the inside as well as on the outside of the gloveboxes, and additional sensors exist within the rooms. If the processes within the gloveboxes are modified, it is required to check the sensors to ensure that they have not been blocked.

Once the storage cabinets at Rocky Flats were set on fire, the fire propagated to the plastic gloves and plastic window on the glovebox, burned through, and created a breach in containment. Without the charring of the cabinets and the production of combustible gases, the fire would probably not have spread to the glovebox; however, in this case, the fire was sustained to the point that it could propagate to the glovebox. At TA–55–4 the gloveboxes themselves are required to provide a fire barrier between material in the glovebox and the room itself.

Once the fire at Rocky Flats breached the gloveboxes, there was radiation shielding that surrounded the gloveboxes and the conveyor lines. This material also was combustible, and a small percentage of it burned in the Rocky Flats fire. At TA–55–4 combustible loading within the separate laboratories is kept to a minimum. Also, due to the integration of safety management functions, the solution to one safety concern (such as the use of radiation shielding) is looked at for the potential to cause other safety concerns (such as the propagation of fires). Thus, radiation shielding used at TA–55–4 is not typically flammable.

At Rocky Flats there were no automatic sprinklers in this area of the building due to concerns about a criticality accident. At the time of the fire, the standard firefighting procedure was not to use water, except as a last resort. Within 10 minutes of the fire alarm, the firefighters used water and no criticality occurred. Automatic sprinkler systems are available in TA–55 to stop the spread of fires. In addition, fire water traps, that contain neutron absorbing material, are available to ensure that a criticality event does not occur.

The fire at Rocky Flats propagated east along the conveyor line, turning south following the airflow of the second ventilation system. Continuation of the fire through the North Line conveyor was stopped because of a closed metal door and the prevalent airflow conditions. The glovebox lines in TA–55–4 have automatic dampers that close in the event of a fire. These dampers are at the junction with each trunk line and between rooms. Also, the ventilation system is shutdown in the event of a fire to prevent airflow.

The degree of contamination in the buildings at Rocky Flats was due to regularly spaced plutonium material in the conveyor system and in the gloveboxes. Pit production at TA–55–4 will not come close to the capacity that was required at Rocky Flats. Thus, the amount of plutonium in the gloveboxes will be considerably less than was present at Rocky Flats. The processing lines will be configured in such a manner that a continuous source of exposed plutonium will not be present. Plutonium stored in the gloveboxes also must be in closed containers.

Additionally, Building 776-777 at Rocky Flats did not have an operations center that was staffed 24 hours a day providing full-time monitoring of systems. TA–55–4 has a fully staffed operations center to provide monitoring of systems and alarms on a 24-hours per day basis.

Summary of Differences Between Rocky Flats and TA–55–4

Substantial differences exist between the nuclear facility and operations being conducted in TA–55–4 today and those that were present at Rocky Flats in 1969. The above crosswalk illustrates the barriers that are in place at TA–55–4 that would have prevented the building wide fire at Rocky Flats. TA–55–4 was designed to correct the deficiencies detected in older facilities such as RFETS and is being upgraded to meet the even more stringent requirements of the 1990's, including enhanced seismic resistance and fire containment. Alarms are monitored, and the Operations Center is manned continually at TA–55. The amount of plutonium required for production at LANL is about half that required during RFETS operations. The manufacturing operations are substantively different than those at RFETS, significantly reducing risk. The concern that building wide fires will occur at TA–55–4 due to pit production operations being located at this facility is not plausible considering the controls that exist today.

Consideration of Fires at TA–55–4 in the SWEIS

The SWEIS, however, does consider the potential for fire in TA–55–4. A glovebox fire is analyzed in RAD–14, section G.5.6.14. A glovebox fire is considered credible; but the release of material to the public is not a credible event. A building-wide fire was screened based on the very low probability of propagating a glovebox fire to a laboratory, a laboratory fire to a wing, and a wing fire to the entire building. With the enhancement of pit production, the characterization of accidents at TA–55–4 and, therefore, the risk in operating the site does not change.

G.4.1.3 *Aircraft Crash Frequencies*

This section of the accident appendix presents an analysis of the frequency of an aircraft crash into structures located within the various TAs at LANL. In 1996, LANL issued a study performed by Selvage (LANL 1996c) that used the K. Solomon Model as a basis for aircraft crash frequency assessment. The LANL assessment has been overtaken by subsequent events.

In October 1996, DOE issued a final standard for *Accident Analysis for Aircraft Crash into Hazardous Facilities* that presents a standardized approach (DOE 1996c). The new standard was developed by an inter-agency working group with membership from DOE, the Defense Nuclear Agency, Westinghouse Savannah River Corporation, the Federal Aviation Administration (FAA), the EPA, and the NRC. The working group chairman and an expert panel (with technical experts from private industry, government, and the national laboratories) developed the standard. Technical support teams (data, modeling, structural, and exposure), which also included membership from private industry, government, and the national laboratories, provided technical input and data used in developing the standard. The standard was issued with a number of supporting technical documents for use in safety analysis.

In November 1996, the Final EIS on continued operation of the Pantex Plant and storage of nuclear weapon components was issued by DOE (DOE 1996a). Appendix E of the Pantex EIS included an aircraft crash frequency analysis prepared using the July 1996 draft of DOE Standard 3014. The final version of the DOE aircraft crash standard methodology was applied to LANL facilities to estimate the frequency of an aircraft crash into those facilities (DOE 1996c). Current and projected data describing air traffic are used in the analysis; aircraft traffic rates for Los Alamos Airport traffic reflect projected traffic for the year 2003, which is considered to be a reasonable approximation to the traffic in 2006 (the end of the SWEIS analytical period). The projected air traffic includes air taxi service to Los Alamos Municipal Airport (LAM), although no such service currently exists. This traffic component was retained because air taxi service has existed in the recent past and there is no way of knowing whether it will resume during the SWEIS analytical period extending to 2006.

An estimate of the frequency of an aircraft crash into any of the facilities of interest was generated and is shown in Table G.4.1.3–1. Table G.4.1.3–2 presents the projected number of aircraft operations at LAM.

Site Analysis of Crash Risk

Because there are no alternative sites included in the SWEIS, LANL is the only site that is analyzed with respect to the risk due to aircraft crash. LANL is located within 1 mile (1.6 kilometers) of LAM at its closest point. LAM consists of one runway, which runs from east to west. The primary purpose of LAM is to support the missions of the DOE and LANL (Greiner 1994) Due to local conditions, all takeoffs are to the east, and all landings are to the west. The west end of the runway is only used for runups and taxiing. There is prohibited airspace over LANL (Restricted Airspace R–5101) up to 14,000 feet (4,267 meters). The restricted airspace forces flights taking off from or landing at LAM to follow a path around LANL. During certain inclement weather flight conditions, LANL grants permission to overfly the Live Firing Range (TA–72). To perform this overflight, pilots must receive prior permission, and the firing range ceases operations during the overflight (LANL 1996c).

Note that the DOE standard (DOE 1996c) does not provide for a reduction in crash frequency to account for restricted airspace. Restricted airspace is an administrative control; no physical barriers exist. In the event of an aircraft accident, loss of control is presumed. Thus, the aircraft could, in principle, crash anywhere, including within a restricted airspace. Moreover, flights above 14,000 feet (4,267 meters) can overfly LANL in any event. Thus, while giving no credit to the restricted airspace in terms of reducing crash frequencies may be conservative, the degree of conservatism is not believed to be large enough to warrant a departure from the DOE Standard.

In addition to LAM, there are two airports in the vicinity of LANL. Santa Fe Municipal Airport is located approximately 18 miles (29 kilometers) southeast of LANL. Albuquerque International Airport is located approximately 56 miles (90 kilometers) southwest of LANL. These two airports are outside of the probability density function boundary for all categories of aircraft. Thus, only LAM airport activity and nonairport (in-flight) aircraft were included in the analysis as described in the DOE standard (DOE 1996c).

In this analysis, 1993 data obtained from the *Los Alamos Airport Master Plan* (Greiner 1994) indicate that there are approximately 12,431 operations per year at LAM. This number is split between Ross Aviation operations, permit

TABLE G.4.1.3–1.—*Aircraft Crash Rates*

AIRCRAFT CATEGORY	CRASH RATE	
	TAKEOFF (PER TAKEOFF)	LANDING (PER LANDING)
COMMERCIAL		
Air Carrier	1.9×10^{-7}	2.8×10^{-7}
Air Taxi	1.0×10^{-6}	2.3×10^{-6}
MILITARY		
Large[a]	5.7×10^{-7}	1.6×10^{-6}
Small[b]	1.8×10^{-6}	3.3×10^{-6}
GENERAL AVIATION		
Fixed-Wing, Single-Engine	1.1×10^{-5}	2.0×10^{-5}
Fixed-Wing, Multiple-Engine Piston	9.3×10^{-6}	2.3×10^{-5}
Fixed-Wing, Turboprop	3.5×10^{-6}	8.3×10^{-6}
Fixed-Wing, Turbojet	1.4×10^{-6}	4.7×10^{-6}

[a] Large military aircraft include bomber, cargo, and tanker aircraft.
[b] Small military aircraft include fighter, attack, and trainer aircraft.
Source: DOE 1996c

TABLE G.4.1.3–2.—*Projected LAM Yearly Flight Operations (Year 2003)*

AIRCRAFT CATEGORY	FLIGHT OPERATIONS	TAKEOFFS	LANDINGS
Air Carrier	0	0	0
Air Taxi	5,400	2,700	2,700
Large Military	0	0	0
Small Military	0	0	0
Single-Engine Piston	11,781	5,891	5,891
Multiple-Engine Piston	794	397	397
Turboprop	13	6	6
Turbojet	13	6	6
Total	18,000	9,000	9,000

Source: Greiner 1994

(based) aircraft operations, and transient aircraft operations.

The LAM Master Plan study forecasted future annual aircraft operations of 18,000 for the year 2003. This total includes 5,400 air taxi operations, 10,600 permit aircraft operations, and 2,000 transient aircraft operations. These projected numbers are used in the analysis, assuming half are takeoffs and half are landings.

According to the LAM Master Plan study, more than 99.9 percent of the aircraft forecasted to use LAM are Class A (12,500 pounds or less, single-engine) and B (12,500 pounds or less, multiple-engine) small aircraft. Less than 0.1 percent are Class C (12,500 to 300,000 pounds, multiple-engine), and no Class D (over 300,000 pounds, multiple-engine) aircraft can operate at LAM (Greiner 1994).

Based on the above percentages, the 13,800 general aviation operations were split between the four DOE standard (DOE 1996c) general aviation categories. The LAM Master Plan study indicates that the number of general aviation operations is dominated by "based" aircraft. Because based aircraft are predominately single-engine piston aircraft, the split between single-engine and multiple-engine aircraft was based on the percentage of based aircraft from these classes. Thus, 93.5 percent of the operations were assigned to single-engine aircraft, 6.3 percent to multiple-engine aircraft, and 0.1 percent each to turboprops and turbojets. One hundred percent of the air taxi operations were assumed to be accomplished using DHC–6 Twin Otter aircraft (Greiner 1994). This aircraft is considered an air taxi by the DOE standard technical support material (LLNL 1996). The actual wingspan of this aircraft is 65 feet (20 meters) (Jane's 1995). This wingspan was used in the calculation.

Because LANL TAs are within the aircraft category dependent exclusion distance from LAM, the aircraft operations of interest for this analysis are takeoff, landing, and in-flight modes. The length of the east-west runway at LAM is approximately 1.0 mile (1.61 kilometers). Due to the aircraft category dependent exclusion distance, all aircraft considered as in airport operation on the east-west runway were either in the takeoff or landing mode. For this runway, 50 percent of operations are takeoffs and 50 percent are landings. LANL resides within the aircraft category dependent exclusion distances, so a near-airport analysis was required, and probability density function values were used in this analysis.

The NPf (x,y) values provided in DOE Standard 3014-96 (DOE 1996c) for the various aircraft categories reflect the crashes per square mile, per year, centered at a given site for nonairport operations. In this analysis, the following NPf (x,y) values (in crashes per square mile per year, centered at the site) for LANL were used (DOE 1996c):

NPf (x,y) General Aviation = 2×10^{-4}

NPf (x,y) Air Carrier = 2×10^{-7}

NPf (x,y) Air Taxi = 3×10^{-6}

NPf (x,y) Large Military = 1×10^{-7}

NPf (x,y) Small Military = 5×10^{-6}

These values are specific to the LANL site, and are based on an analysis of the locations of past aircraft crashes within the continental U.S. The data are substantial for general aviation aircraft (over 1,000 crashes), while the available data for other aircraft categories (air carrier, large military, etc.) are very limited. Crash location frequencies for general aviation aircraft were based on the assumption that future levels of activity and flight patterns will be similar to the historical record.

Nonairport commercial and military crash frequencies are based on the assumption that the aircraft will fly point-to-point under the new

FAA regulations, rather than in specific airways. The model for these aircraft assumes that the traffic density within an Air Route Traffic Control Center (ARTCC) is uniform, and that given a crash within the ARTCC, the location of the crash is random. The crash rate is assumed to be uniform for the continental U.S. and proportional to the aircraft traffic volume handled at each ARTCC.

For small military aircraft, however, the number of crashes per year is estimated for each ARTCC based on the distribution of crash locations in the historical record. It is important to recognize that the in-flight analysis for military aviation applies only to normal in-flight operations outside military operations areas and low-level flight ranges.

Frequency of Releases as a Result of Aircraft Crash

It was recognized early in this SWEIS analysis that seismic events can cause simultaneous releases of hazardous materials from multiple facilities at frequencies in the range of 1 x 10^{-5} per year and higher. Accordingly, detailed aircraft crash consequence calculations were only performed if it appeared that the frequency and source term of the aircraft crash accident were risk-significant compared with the seismic event; that is, the products of the consequence and frequency were comparable. In this analysis, facilities that contain plutonium, tritium, and hazardous chemicals were considered.

The DOE Standard 3014-96 (DOE 1996c) provides methodologies for: (1) estimating the frequency of aircraft impact into a facility, based on a conservative, simplified equation; (2) determining the effect of the impact on the facility through structural response analysis; (3) determining the frequency of a release of hazardous materials from the facility, given an aircraft impact; and (4) evaluating the exposure resulting from such a release.

The DOE Standard 3014-96 approach to aircraft crash analysis is intended for use in safety analysis. The methodology provides an approximate level of risk, rather than a detailed risk assessment. As a result, the methodology adopts typical accident analysis practice by addressing uncertainty through the use of analytical margin instead of a formal uncertainty analysis. The focus is on analyzing the risk posed to the health and safety of the public and on-site workers. The standard does not consider the risk to the occupants of the aircraft, the risk to individuals inside a building affected by a crash, nor the risk to other individuals on the ground (either inside or outside a facility boundary) who might be directly impacted by the crash (DOE 1996c). The methodology also does not consider malicious acts (e.g., sabotage, terrorism, and war) (DOE 1996c).

Estimating the frequency of hazardous material releases as a result of aircraft involves a series of calculations of increasing analytical sophistication, to the level required to demonstrate that aircraft crash either does or does not cause a level of risk equivalent to that from other risk sources. The analysis considers the structural properties of the affected facility as well as its inventory of hazardous materials.

Local impacts to facilities include penetration, perforation, and scabbing. Penetration occurs when the missile (flying debris) striking a facility intrudes into the outer surface of the structure. Perforation occurs when the missile punctures a hole all the way through the concrete or steel surface. Scabbing occurs when the missile does not perforate, but does cause concrete to be ejected from inside face of the target into the facility.

Because heavy, high-speed aircraft have much greater potential to damage than do slow, light aircraft, the method requires that the population of aircraft in the skies around the site be resolved into subpopulations by weight and speed. A structural calculation is performed to determine if an aircraft that hits a facility will cause sufficient damage to warrant further analysis. Aircraft missiles (i.e., flying objects from the crash) for the structural calculations are selected by using representative engine weights and diameters. The structural analysis is performed by calculating the scabbing and perforation thickness for each aircraft category into the facility using an empirical model.

The first step in the process is to determine the representative type of aircraft for each category. Next, the effective area of a facility is determined based upon the length, width, and height of the facility and the aircraft's wingspan, flight path angle, heading relative to the heading of the facility, and the length of its skid. Using the calculated area of a facility, the number of operations near a facility, and crash rate density function, the frequency of hitting the facility for each aircraft category is calculated. The total frequency is the sum of all the aircraft category frequencies. If the total frequency of hitting a facility is greater than 1 x 10^{-6}, further analysis is conducted.

The calculations are refined to eliminate aircraft categories that cannot cause a release of hazardous materials, leaving only those that could, through impact and/or fire, release radionuclides or toxic chemicals. If the frequency of hitting a facility and causing either scabbing or perforation is greater than 1 x 10^{-6}, the DOE standard requires that a consequence analysis be performed (DOE 1996c).

Calculation of Facility Effective Area. The total effective area of a facility is the sum of the true area (the facility base area adjusted for aircraft dimension), the shadow area (defined by the facility height and the angle of postulated impact), and the skid area (the area covered by a skidding aircraft after impact with the ground).

The analysis was done on a building-by-building basis, treating each facility individually. The topographic features of the LANL site are such that the actual skid distances can be less than the skid distances given in the DOE standard. Subsequently, the skid distances were reduced based on actual site conditions. The majority of reduced skid distances affect only commercial and military aircraft. The angle of impact chosen was based on the values presented in the DOE standard (DOE 1996c). A total effective area for each facility was calculated using the reduced skid distance.

Table G.4.1.3–3 presents the various building dimensions. Table G.4.1.3–4 presents the aircraft operational data used, including the skid distances. Both the DOE standard and maximum wingspans for aircraft in the vicinity of LAM are given. Maximum wingspans were determined by selecting representative aircraft from *Jane's All the World's Aircraft* (Jane's 1995). The skid distances in the table correspond to the skid distances presented in DOE Standard 3014-96 (DOE 1996c).

Hit Frequency Calculation. Based on the center-line and perpendicular distances to the TA facilities of interest, all aircraft using LAM were analyzed using the near-airport model. The impact frequency was obtained for each facility by multiplying the number of flights, the impact area, the crash rate, and the crash density function for each category. Table G.4.1.3–5 contains the crash frequencies for landings, takeoffs, and the nonairport aircraft for each facility.

Structural Calculation. For this analysis, 70^{th} percentile velocities of aircraft were used (LLNL 1996). The velocities chosen were in either takeoff or landing operations, whichever was the largest. For facilities with overburden, these velocities were reduced according to the earth overburden velocity reduction equation.

The local response equations for rigid missiles impacting reinforced concrete structures were applied to applicable facilities, and the local response steel equations for rigid missiles were applied to applicable facilities. A reduction in penetration depth was taken because the

TABLE G.4.1.3–3.—*LANL Building Dimensions*

BUILDING	BUILDING LENGTH (ft)	BUILDING WIDTH (ft)	BUILDING HEIGHT (ft)	WALL THICKNESS (in.)	ROOF THICKNESS (in.)
TA–3–29 CMR	550	254	50	8	6
TA–3–476	18	12	9	0	0
TA–16–205 WETF	131	112	14	8	4
TA–16–411	87	24	20	8	6
TA–21–155 TSTA	70	15	26	1	3
TA–21–209 TSFF	40	35	20	1	2
TA–50–37 RAMROD	142	110	46	8	24
TA–50–69 Container Storage Area	90	24	6	0	0
TA–54 TWISP	414	286	38	0	0
TA–55–4	284	265	22	14	10
TA–18–26 Hs. Vault	18	12	10	18	12
TA–18–32 Kiva #2	59	58	25	15	4
TA–18–116 Kiva #3	81	64	36	18	8
TA–55–185	60	40	14	0	0
TA–8–22	42	39	21	8	8
TA–8–23	48	40	30	30	6
TA–15 DARHT	6	6	6	0	0
TA–18–23 Kiva #1	61	48	26	8	3
TA–18–168 SHEBA	20	20	18	0	0
TA–54–38 Container Storage Area	12	8	6	0	0

Source: Safety analysis documentation, site location maps, and miscellaneous sources
Note: TSTA and TSFF wall thicknesses are based on an approximate reinforced concrete equivalence for concrete block, based on the Pantex EIS analysis of similar construction (DOE 1996a).

TABLE G.4.1.3–4.—*Aircraft Operational Data: Takeoff, In Flight, and Landing*

	AIR CARRIER	AIR TAXI	LARGE MILITARY	SMALL MILITARY	GENERAL AVIATION			
					SINGLE ENGINE	MULTI-ENGINE	TURBOPROP	TURBOJET
DOE Standard Wingspan (ft)	98	59[b]	223	78	50	50	73	50
Maximum Wingspan (ft)	211	75	223	93	50	50	80	78
Takeoff Skid Length (ft)	1,440	1,440	780[a]	246	60	60	60	60
Landing Skid Length (ft)	1,440	1,440	368	447[a]	60	60	60	60

[a] Conservatively used for inflight.
[b] Actual wingspan is 65 feet. This wingspan is used in the calculation and does not change the overall hit frequency because hit frequency is dominated by general aviation.
Source: DOE 1996c, Jane's 1995, and calculated values

TABLE G.4.1.3–5.—*Aircraft Crash Frequencies*

CRASH FREQUENCIES (PER YEAR)				
BUILDING	**TAKEOFF**	**LANDING**	**NONAIRPORT**	**TOTAL**
TA–3–29 CMR	7.1×10^{-8}	5.0×10^{-6}	3.6×10^{-6}	8.6×10^{-6}
TA–3–476	1.6×10^{-9}	1.1×10^{-7}	8.5×10^{-8}	2.0×10^{-7}
TA–16–205 and TA–16–205A	0	1.7×10^{-7}	4.7×10^{-7}	6.4×10^{-7}
TA–16–411[a]	0	1.4×10^{-7}	2.8×10^{-7}	4.1×10^{-7}
TA–21–155 TSTA	1.3×10^{-5}	2.7×10^{-5}	2.7×10^{-7}	4.1×10^{-5}
TA–21–209 TSFF	1.0×10^{-5}	2.1×10^{-5}	2.1×10^{-7}	3.1×10^{-5}
TA–50–37 RAMROD	1.8×10^{-6}	2.8×10^{-6}	9.5×10^{-7}	5.5×10^{-6}
TA–50–69 Container Storage Area	2.9×10^{-7}	4.5×10^{-7}	1.6×10^{-7}	9.0×10^{-7}
TA–54 TWISP	8.9×10^{-7}	7.4×10^{-7}	2.6×10^{-6}	4.3×10^{-6}
TA–55–4	4.5×10^{-6}	4.5×10^{-6}	1.5×10^{-6}	1.1×10^{-5}
TA–18–26	3.2×10^{-9}	3.0×10^{-8}	5.5×10^{-8}	8.8×10^{-8}
TA–18–32	1.8×10^{-8}	1.8×10^{-7}	3.1×10^{-7}	5.1×10^{-7}
TA–18–116	3.2×10^{-8}	2.0×10^{-7}	4.8×10^{-7}	7.1×10^{-7}
TA–55–185	7.3×10^{-8}	6.0×10^{-7}	2.1×10^{-7}	8.9×10^{-7}
TA–8–22[b]	0	9.1×10^{-8}	2.3×10^{-7}	3.2×10^{-7}
TA–8–23[b]	0	1.2×10^{-7}	3.0×10^{-7}	4.3×10^{-7}
TA–15 DARHT[a]	0	1.0×10^{-8}	4.9×10^{-8}	5.9×10^{-8}
TA–18–23	1.8×10^{-8}	1.7×10^{-7}	3.1×10^{-7}	5.0×10^{-7}
TA–18–168	7.7×10^{-9}	7.4×10^{-8}	1.3×10^{-7}	2.2×10^{-7}
TA–54–38 Container Storage Area	3.2×10^{-9}	3.1×10^{-8}	5.5×10^{-8}	8.9×10^{-8}

Source: calculated values

[a] Note: This is the raw crash frequency for this facility. There is a conditional probability of MAR being present that must be multiplied times the crash frequency to obtain the frequency of a crash with MAR present. The conditional probability is classified for this facility.

[b] Note: This is the raw crash frequency for this facility. There is a conditional probability of MAR being present that must be multiplied times the crash frequency to obtain the frequency of a crash with MAR present. The conditional probability is less than 5 percent.

missiles were nonrigid. In cases where the structural equations presented in the DOE standard do not apply (e.g., due to the facility construction), it was assumed that significant building damage to these facilities was a certainty (i.e., probability of 1, given impact). In this analysis, the aircraft engine was investigated as the missile of concern. These engines were treated in the equations as nonrigid missiles. Table G.4.1.3–6 presents maximum engine weights and diameters for aircraft landing and taking off at LAM. Maximum engine weights and diameters were determined by selecting representative aircraft from *Jane's All the World's Aircraft* (Jane's 1995). Maximum engine weights and diameters were then used in the structural calculations.

Local response structural calculations were performed for the various overburden and building thicknesses. Table G.4.1.3–7 presents the results for perforation.

Perforation and Scabbing Frequency Calculation. For this analysis, it was assumed that for facilities such as the TRU waste domes in TA–54, which are constructed of a rigid arch frame covered by a tensioned membrane, the release frequency due to aircraft crash is the same as the hit frequency. For facilities with high explosives, the bounding accident is a perforation or scab leading to an explosion. For facilities without high explosives, the bounding accident is a perforation leading to a fire. Scabbing leading to an explosion in steel facilities is not possible because steel does not scab. The areas for the facilities were reduced using the structural analysis results. The reduced areas were then used to recalculate perforation and scabbing frequencies. Table G.4.1.3–8 presents the frequencies of perforation leading to an explosion, and Table G.4.1.3–9 presents the frequencies of perforation leading to a fire for landings, takeoffs, and the nonairport aircraft for each facility.

The true, shadow, and skid areas for the various facilities were reduced for perforation and scabbing (Table G.4.1.3–7). If the facility roof does not sustain damage, then the true area is reduced to zero. If the facility walls do not sustain damage, then the shadow and skid areas are reduced to the width of the building times the skid distance.

TABLE G.4.1.3–6.—*Aircraft Missile Characteristics*

AIRCRAFT CATEGORY	IMPACT VELOCITY (ft/sec)	ENGINE WEIGHT (lb)	ENGINE DIAMETER (in.)
Air Carrier	282	9,874	86
Air Taxi	282	861	31
Large Military	439	8,731	105
Small Military	513	4,201	51
Single-Engine Piston	152	500	30
Multiple-Engine Piston	152	596	25
Turboprop	152	465	19
Turbojet	152	2,574	37

Sources: LLNL 1996 and Jane's 1995. Impact velocities are based on 70th percentile values, corresponding to the skid distance values used in DOE Standard 3014-96 (DOE 1996c) and this analysis.

TABLE G.4.1.3–7.—*Structural Perforation Calculation Summary*

BUILDING	AIR CARRIER		AIR TAXI		LARGE MILITARY		SMALL MILITARY		GENERAL AVIATION							
									SINGLE ENGINE		MULTIPLE ENGINE		TURBO PROP		TURBO JET	
	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W
TA–3–29	X	X	X	X	X	X	X	X	X		X		X		X	X
TA–3–476	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TA–16–205	X	X	X	X	X	X	X	X	X		X		X		X	X
TA–16–411	X	X	X	X	X	X	X	X	X		X		X		X	X
TA–21–155	X	X	X	X	X	X	X	X	X		X		X		X	X
TA–21–209	X	X	X	X	X	X	X	X	X		X		X		X	X
TA–50–37	X	X		X	X	X	X	X								X
TA–50–69	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TWISP	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TA–55–4	X	X	X	X	X	X	X	X								X
TA–18–26	X	X			X											
TA–18–32	X	X	X	X	X	X	X	X	X		X		X		X	
TA–18–116	X	X	X	X	X	X	X	X							X	
TA–55–185	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TA–8–22	X	X	X	X	X	X	X	X							X	X
TA–8–23	X	X	X		X	X	X		X		X		X		X	
DARHT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TA–18–23	X	X	X	X	X	X	X	X	X		X		X		X	X
TA–18–168	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TA–54–38	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

R = Roof
W = Walls
X = Damage; perforation occurs.
Blank = No damage; perforation does not occur.
Source: Calculated values

TABLE G.4.1.3–8.—*Aircraft Crash Frequencies per Year for Perforation Leading to Explosion*

	FREQUENCY (PER YEAR)			
BUILDING	**TAKEOFF**	**LANDING**	**NONAIRPORT**	**TOTAL**
TA–3–29	0	0	0	0
TA–3–476	1.6×10^{-9}	1.1×10^{-7}	8.5×10^{-8}	2.0×10^{-7}
TA–16–205	0	0	0	0
TA–16–411	0	1.7×10^{-8}	5.0×10^{-8}	6.7×10^{-8}
TA–21–155	0	0	0	0
TA–21–209	0	0	0	0
TA–50–37	0	0	0	0
TA–50–69 Container Storage Area	0	0	0	0
TA–54 TWISP	0	0	0	0
TA–55–4	0	0	0	0
TA–18–26	0	0	0	0
TA–18–32	0	0	0	0
TA–18–116	0	0	0	0
TA–55–185	0	0	0	0
TA–8–22	0	$< 1.0 \times 10^{-9}$	1.6×10^{-8}	1.6×10^{-8}
TA–8–23	0	1.5×10^{-8}	4.7×10^{-8}	6.3×10^{-8}
DARHT	0	1.0×10^{-8}	4.9×10^{-8}	5.9×10^{-8}
TA–18–23	0	0	0	0
TA–18–168	0	0	0	0
TA–54–38 Container Storage Area	0	0	0	0

Source: Calculated values

TABLE G.4.1.3–9.—*Aircraft Crash Frequency per Year for Perforation Leading to Fire*

BUILDING	FREQUENCY (PER YEAR)			
	TAKEOFF	LANDING	NONAIRPORT	TOTAL
TA–3–29 CMR	2.7×10^{-8}	2.0×10^{-6}	1.5×10^{-6}	3.5×10^{-6}
TA–3–476	1.6×10^{-9}	1.1×10^{-7}	8.5×10^{-8}	2.0×10^{-7}
TA–16–205 and TA–1–205A WETF	$< 1.0 \times 10^{-9}$	6.3×10^{-8}	1.9×10^{-7}	2.6×10^{-7}
TA–16–411 Assembly Building	$< 1.0 \times 10^{-9}$	1.7×10^{-8}	5.0×10^{-8}	6.7×10^{-8}
TA–21–155 TSTA	1.0×10^{-6}	2.8×10^{-6}	3.5×10^{-8}	3.8×10^{-6}
TA–21–209 TSFF	1.6×10^{-6}	3.7×10^{-6}	4.2×10^{-8}	5.3×10^{-6}
TA–50–37 RAMROD	6.7×10^{-9}	1.4×10^{-8}	4.4×10^{-8}	6.5×10^{-8}
TA–50–69 Container Storage Area	2.9×10^{-7}	4.5×10^{-7}	1.7×10^{-7}	9.0×10^{-7}
TA–54 TWISP	8.9×10^{-7}	7.4×10^{-7}	2.6×10^{-6}	4.3×10^{-6}
TA–55–4 Plutonium Facility	$< 1.0 \times 10^{-9}$	3.3×10^{-9}	8.0×10^{-6}	8.4×10^{-8}
TA–18–26 Hillside Vault	$< 1.0 \times 10^{-9}$	$< 1.0 \times 10^{-9}$	$< 1.0 \times 10^{-9}$	$< 1.0 \times 10^{-9}$
TA–18–32 Kiva #2	4.3×10^{-9}	3.2×10^{-8}	7.3×10^{-8}	1.1×10^{-7}
TA–18–116 Kiva #3	$< 1.0 \times 10^{-9}$	$< 1.0 \times 10^{-9}$	1.6×10^{-8}	1.6×10^{-8}
TA–55–185 TRU Staging	7.3×10^{-8}	6.0×10^{-7}	2.1×10^{-7}	8.9×10^{-7}
TA–8–22 Radiography	$< 1.0 \times 10^{-9}$	$< 1.0 \times 10^{-9}$	1.6×10^{-8}	5.5×10^{-8}
TA–8–23 Radiography	$< 1.0 \times 10^{-9}$	1.5×10^{-8}	3.9×10^{-8}	5.9×10^{-8}
TA–15 DARHT	$< 1.0 \times 10^{-9}$	1.0×10^{-8}	4.9×10^{-8}	5.9×10^{-8}
TA–18–23 Kiva #1	3.9×10^{-9}	2.8×10^{-8}	6.7×10^{-8}	9.9×10^{-8}
TA–18–168 SHEBA	7.7×10^{-9}	7.4×10^{-8}	1.3×10^{-7}	2.2×10^{-7}
TA–54–38 Container Storage Area	3.2×10^{-9}	3.1×10^{-8}	5.5×10^{-8}	8.9×10^{-8}

Source: Calculated values

Note: In the cases of TA–8–22, TA–8–23, TA–15 DARHT, and TA–16–411, there is a conditional probability significantly less than one of MAR actually being present.

Discussion of Aircraft Crash and Release Frequencies

The aircraft crash frequencies in Table G.4.1.3–5 provide an indication of the frequency with which personnel injuries or fatalities could occur as a result of an aircraft crash at the facilities listed in the table. Note that a crash is not necessarily equivalent to a release of hazardous material; however, the conditional probability of a release given a crash is dependent on the design and construction of the facility and the nature of the aircraft impacting the facility.

Two types of release scenarios were considered: perforation leading to an explosion and perforation leading to a fire. The perforation-induced explosion results are presented in Table G.4.1.3–8. The results, particularly when the conditional probability of explosives being present is taken into account, indicate that perforation-induced explosion is a very minor contributor to risk. With the exception of the TA–3–476 facility, the other facilities potentially affected have perforation-induced explosion frequencies of less than 1 x 10^{-8} per year. This frequency is so low compared with the seismic structural damage/collapse scenarios (which can result in a large source term) that perforation-induced explosion is not considered further.

The perforation-induced fire results indicate that four facilities with hazardous materials have perforation-induced fire frequencies above 1 x 10^{-6} per year. The frequency of perforation-induced fire aircraft crash events at these facilities was examined in comparison with the seismic structural damage/collapse scenarios in order to evaluate whether aircraft crash accidents needed to be evaluated in detail.

It is important to recognize that the DOE aircraft crash standard (DOE 1996c) was intended for use as a safety analysis screening tool. For facilities that, after full analysis in accordance with the standard, still have aircraft crash frequencies in excess of the evaluation guidelines in the standard (crash frequency of greater than 1 x 10^{-6} per year), it was intended that a more detailed analysis be performed in order to determine whether aircraft crash should be considered to be an evaluation basis accident for safety analysis purposes. For NEPA purposes, the results indicate that the TA–3–29 (CMR), TA–21–155 (TSTA), TA–21–209 (TSFF), and TA–54 TWISP facilities dominate the aircraft crash-induced release frequency. The releases from TSTA and TSFF due to aircraft crash represent bounding tritium release scenarios for LANL because they occur at a relatively high frequency (compared with other large tritium release accidents) and, because of the accompanying fire, the tritium released would be in oxide form (which is more radiologically hazardous than elemental tritium gas).

Plutonium release from the CMR Building (RAD–16), plutonium release (from TRU waste) at TA–54 TWISP (RAD–08), and tritium oxide release from TSTA/TSFF (RAD–05) due to aircraft crash and fire were retained as risk-dominant accidents.

Having the crash frequency estimates, a consequence analysis was performed for each accident. (An analysis also was conducted for an "incredible" aircraft crash at RAMROD (RAD–06). The consequence analyses are similar to the consequence analyses for other accident scenarios, except that release fractions specified in the DOE aircraft crash standard (DOE 1996c) are used, rather than release fractions from DOE Standard 3010-94 (DOE 1994d).

The remaining perforation-induced fire scenarios identified in Table G.4.1.3–9 are considered to be bounded in risk by seismic release scenarios that occur at a much higher frequency. (Seismic releases occur in the frequency range of to 7.1 x 10^{-5} to 2.9 x 10^{-3} per year; whereas, the remaining aircraft crash with perforation-induced fire releases occur in the frequency range from to 1.3×10^{-10} to 8.9×10^{-7} per year.) For an aircraft crash accident to dominate over a seismic release for the remaining facilities, the source term for the aircraft crash accident would have to be orders of magnitude greater than for the seismic structural damage/collapse. No such release potential was identified.

G.4.2 Accident Source Term Assessment

The "source term" is a description of the physical and chemical characteristics of the materials released inside the facility or to the environment. The source term parameters include not only the MAR and the amount and rate of release, but also parameters that determine the subsequent transport, dispersion, and effects. These include whether the material is gas or particulate, in elemental or oxide form (e.g., for tritium and plutonium), and whether the release occurs at ground level or at some elevation above the ground. The plume source height is determined by the intensity of the fire or explosion, or, if the release is from a stack, the stack parameters (e.g., stack height diameter and velocity, heat content, etc.).

G.4.2.1 *Chemical Accident Source Terms*

Chemical accident source terms are estimated in a straightforward manner for the SWEIS. The screening analysis identified toxic gases and liquids that could easily disperse in the event of an accident. The source terms are based on the MAR quantities appropriate to the accident initiator. For example, in the case of a building structural collapse due to an earthquake, the entire gaseous/liquid chemical contents of the building are assumed to be released. For a process-related accident, such as the failure of a valve on a 150-pound capacity cylinder of chlorine, the source term is the maximum contents of the cylinder (even though it is recognized that the container may not be full when the valve failure occurs).

Where there are physical constraints on the release, these are recognized in the modeling. The 150-pound chlorine cylinder release is a good illustration of this sort of constraint. The chlorine inventory in the cylinder is partially gaseous and partially liquid. When the valve fails, the gaseous chlorine depressurizes very quickly, releasing a jet of liquid. However, this act results in a cooling of the cylinder below the boiling temperature of the liquid chlorine, halting the large release. As a result, not all 150 pounds of chlorine are released quickly. Simulation predicts the release of 68 pounds in the first 45 seconds at a flow rate of 91.5 pounds per minute. The flow rate then decreases sharply (Gephart and Moses 1989). The remaining chlorine would be released slowly as the container heats up to ambient temperature. Such a slow release rate would not pose significant hazards downwind of the release point. This type of release can be modeled with ALOHA™.

In some cases, conservative assumptions must be made in order to model the accident. A good example of this is the fire at TA–3–476, which results in chlorine release by melting fusible plugs in the chlorine cylinders (which melt at 165°F [74°C] and release the chlorine at a pre-defined rate in order to prevent sudden rupture of the cylinder). There are potentially ten affected cylinders in this accident. In reality, not all ten would release at exactly the same time. Due to modeling limitations, however, it was necessary to assume a simultaneous release. This is a conservative and bounding representation of the accident, but is not necessarily the most realistic portrayal of the accident. Table G.4.2.1–1 provides a summary of source terms for the chemical accidents.

TABLE G.4.2.1–1.—*Summary of Chemical Accident Source Term Calculations*

ACCIDENT SCENARIO DESIGNATOR	AFFECTED FACILITY	CHEMICAL RELEASED	SOURCE TERM INFORMATION
CHEM–01	TA–00–1109	chlorine	150 pounds
CHEM–02	TA–3–476	chlorine	1,500 pounds
CHEM–03	TA–3–476	chlorine	150 pounds
CHEM–04	TA–54–216	selenium hexafluoride	75 liters
CHEM–05	TA–54–216	sulfur dioxide	300 pounds
CHEM–06	TA–55–4	chlorine	150 pounds
SITE–01	TA–00–1109 TA–00–1110 TA–3–66 TA–3–476 TA–9–21 TA–43–1	chlorine chlorine hydrogen cyanide chlorine phosgene formaldehyde	300 pounds 300 pounds 7.6 liters 150 pounds 3 pounds 30 liters
SITE–02	TA–00–1109 TA–00–1110 TA–3–66 TA–3–476 TA–9–21 TA–43–1 TA–55–4 TA–55–4 TA–55–249	chlorine chlorine hydrogen cyanide chlorine phosgene formaldehyde chlorine nitric acid hydrochloric acid	300 pounds 300 pounds 7.6 liters 150 pounds 3 pounds 30 liters 150 pounds 6,100 gallons 5,200 gallons
SITE–03	TA–00–1109 TA–00–1110 TA–3–66 TA–3–476 TA–9–21 TA–43–1 TA–55–4 TA–55–4 TA–55–249	chlorine chlorine hydrogen cyanide chlorine phosgene formaldehyde chlorine nitric acid hydrochloric acid	300 pounds 300 pounds 7.6 liters 150 pounds 3 pounds 30 liters 150 pounds 6,100 gallons 5,200 gallons
SITE–04	TA–43–1	formaldehyde	30 liters

G.4.2.2 *Radiological Accident Source Terms*

DOE has issued standard guidance on estimating source terms for nonreactor nuclear facility accidents as DOE Handbook 3010-94 (DOE 1994d). (Note: aircraft crash source terms were not calculated using DOE Handbook 3010-94. Rather, DOE Standard 3014-96 specifies the source term methodology for aircraft crash accidents. Although DOE Standard 3014-96 cites DOE Handbook 3010-94 as a basis for its values, there are differences, and DOE Standard 3014-96 was used for aircraft crash accidents.)

DOE Handbook 3010-94 received extensive peer review within the DOE technical community and is the best available current information on the subject. Although the handbook presents both median and bounding values in many cases, this accident analysis employs the bounding values. (Accordingly, where SARs have used more realistic, less conservative source terms, the SARs have projected lesser consequences.) Although the availability of a median and bounding estimate might result in a temptation to generate a statistical distribution of values, the handbook specifically cautions against such an approach (DOE 1994d):

"The generation and suspension of particles is the result of the interaction of multiple physiochemical variables that have not been completely characterized as the majority of the experiments performed were designed in an attempt to reflect reasonably bounding conditions for specific industrial situations of concern. Accordingly, the data obtained are more accurately characterized as selected points from multiple distributions against multiple parameters than as different values from a common distribution. Even if this point is neglected, there are still practically intractable problems in attempting to generate statistical distributions. While the data are presumed to be bounding for the purpose intended, it is largely unknown whether the data values are truly 90^{th} percentile, 99^{th} percentile, 99.9^{th} percentile, etc. Further, in many cases it is considered likely that accident specific ARFs are actually distributed in a highly irregular manner (i.e., multi-modal or truncated distributions). Assuming a typical distribution (i.e., log-normal, Poisson) using standard deviations will produce seriously distorted values that may have little or nothing to do with reality."

The handbook also cautions against over reliance on the values contained therein (DOE 1994d). Table G.4.2.2–1 provides the details of source terms for radiological accidents.

TABLE G.4.2.2–1.—*Source Terms of Radiological Accidents at LANL*

ACCIDENT SCENARIO DESIGNATOR	AFFECTED FACILITY	MATERIAL RELEASED	SOURCE TERM INFORMATION
SITE–01	TA–3–29	Pu-239	96.9 g of Pu-239 initial; 9.4 g suspension
	TA–18–23	HEU	22.9 g of HEU initial; 0.22 g suspension
	TA–21–155	tritium oxide	200 g of tritium oxide
	TA–21–209	tritium oxide	200 g of tritium oxide
	TA–50–1	Pu-238, Pu-239, Am-241	5.8×10^{-5} g of Pu-238, 0.27 g of Pu-239 & 0.005 g of Am-241 initial; 1.3×10^{-4} g Pu-238, 5.85 g Pu-239 & 0.11g of Am-241 suspension
	TA–50–37	Pu-239	1.0 Pu-239 PE-Ci initial; 0.96 Pu-239 PE-Ci suspension
	TA–54–38	Pu-239	0.339 Pu-239 PE-Ci initial; 0.033 Pu-239 PE-Ci suspension
	TWISP	Pu-239	0.19 Pu-239 PE-Ci initial; 1.2 Pu-239 PE-Ci suspension
SITE–02	TA–3–29	Pu-239	102.8 g of Pu-239 initial; 9.4 g suspension
	TA–16–205	tritium oxide	100 g of tritium oxide
	TA–18–23	HEU	22.9 g of HEU initial; 0.22 g suspension
	TA–18–32	Pu-239, HEU	0.22 g Pu-239
	TA–18–116	Pu-239, HEU	0.028 g Pu-239
	TA–18–168	HEU	0.85 g HEU initial; 18.4 g suspension
	TA–21–155	tritium oxide	200 g of tritium oxide
	TA–21–209	tritium oxide	200 g of tritium oxide
	TA–50–1	Pu-238, Pu-239, Am-241	5.8×10^{-5} g of Pu-238, 0.27 g of Pu-239 & 0.005 g of Am-241 initial; 1.3×10^{-4} g Pu-238, 5.85 g Pu-239 & 0.11 g of Am-241 suspension
	TA–50–37	Pu-239	1.0 Pu-239 PE-Ci initial; 0.96 Pu-239 PE-Ci suspension
	TA–50–69	Pu-239	0.39 Pu-239 PE-Ci initial; 0.037 Pu-239 PE-Ci suspension
	TA–54–38	Pu-239	0.339 Pu-239 PE-Ci initial; 0.033 Pu-239 PE-Ci suspension
	TWISP	Pu-239	0.12 Pu-239 PE-Ci initial; 1.2 Pu-239 PE-Ci suspension
	TA–55–4	Pu-239, Pu-238, Pu-242, HEU	0.0174 g Pu-238, 5.31 g Pu-239, 0.201 g Pu-242 & 0.242 g HEU initial; 0.056 g Pu-238, 56.7 g Pu-239, 1.68 g Pu-242 & 0.025 g HEU suspension

TABLE G.4.2.2–1.—*Source Terms of Radiological Accidents at LANL*-Continued

ACCIDENT SCENARIO DESIGNATOR	AFFECTED FACILITY	MATERIAL RELEASED	SOURCE TERM INFORMATION
SITE–03	TA–3–29	Pu-239	140.8 g Pu-239 initial; 13.1 g suspension
	TA–16–205	tritium oxide, tritium gas	172 g of tritium oxide, 1,188 g tritium gas
	TA–18–23	HEU	22.9 g of HEU initial; 0.22 g suspension
	TA–18–32	Pu-239, HEU	0.22 g of Pu-239
	TA–18–116	Pu-239, HEU	0.028 g of Pu-239
	TA–18–168	HEU	0.85 g HEU initial; 18.4 g suspension
	TA–21–155	tritium oxide	200 g of tritium oxide
	TA–21–209	tritium oxide	200 g of tritium oxide
	TA–50–1	Pu-238, Pu-239, Am-241	5.8×10^{-5} g of Pu-238, 0.27 g of Pu-239 & 0.005 g of Am-241 initial; 1.3×10^{-4} g Pu-238, 5.85 g Pu-239 & 0.11 g of Am-241 suspension
	TA–50–37	Pu-239	1.0 Pu-239 PE-Ci initial; 0.96 Pu-239 PE-Ci suspension
	TA–50–69	Pu-239	0.39 Pu-239 PE-Ci initial; 0.037 Pu-239 PE-Ci suspension
	TA–54–38	Pu-239	0.339 Pu-239 PE-Ci initial; 0.033 Pu-239 PE-Ci suspension
	TWISP	Pu-239	0.25 Pu-239 PE-Ci initial; 2.4 Pu-239 PE-Ci suspension
	TA–55–4	Pu-239, Pu-238, Pu-242, HEU	2.04 g Pu-238, 69.2 g Pu-239, 0.062 g Pu-240, 3.36 g Pu-242 & 3.74 g HEU initial; 1.95 g Pu-238, 71.2 g Pu-239, 0.3 g Pu-240, 3.22 g Pu-242 & 3.6 g HEU suspension
	TA–55–185	Pu-239	0.006 Pu-239 PE-Ci initial; 0.06 Pu-239 PE-Ci suspension
SITE–03, Surface Rupture	TA–3–29	Pu-239	788.5 g Pu-239 initial; 27.6 g suspension
	TA–16–205	tritium oxide, tritium gas	172 g of tritium oxide, 1,188 g tritium gas
	TA–18–23	HEU	22.9 g of HEU initial; 0.22 g suspension
	TA–18–32	Pu-239, HEU	0.22 g of Pu-239
	TA–18–116	Pu-239, HEU	0.028 g of Pu-239
	TA–18–168	HEU	0.85 g HEU initial; 18.4 g suspension
	TA–21–155	tritium oxide	200 g of tritium oxide
	TA–21–209	tritium oxide	200 g of tritium oxide
	TA–50–1	Pu-238, Pu-239, Am-241	5.8×10^{-5} g of Pu-238, 0.27 g of Pu-239 & 0.005 g of Am-241 initial; 1.3×10^{-4} g Pu-238, 5.85 g Pu-239 & 0.11 g of Am-241 suspension
	TA–50–37	Pu-239	1.0 Pu-239 PE-Ci initial; 0.96 Pu-239 PE-Ci suspension
	TA–50–69	Pu-239	0.39 Pu-239 PE-Ci initial; 0.037 Pu-239 PE-Ci suspension
	TA–54–38	Pu-239	0.339 Pu-239 PE-Ci initial; 0.033 Pu-239 PE-Ci suspension
	TWISP	Pu-239	0.25 Pu-239 PE-Ci initial; 2.4 Pu-239 PE-Ci suspension
	TA–55–4	Pu-239, Pu-238, Pu-242, HEU	2.04 g Pu-238, 69.2 g Pu-239, 0.062 g Pu-240, 3.36 g Pu-242 & 3.74 g HEU initial; 1.95 g Pu-238, 71.2 g Pu-239, 0.3 g Pu-240, 3.22 g Pu-242 & 3.6 g HEU suspension
	TA–55–185	Pu-239	0.006 Pu-239 PE-Ci initial; 0.06 Pu-239 PE-Ci suspension
SITE–04	TA–16–205	tritium gas	1,360 g tritium gas
	TA–21–155	tritium oxide	200 g tritium oxide
	TA–21–209	tritium oxide	100 g tritium oxide
	TA–54	Pu-239	0.16 Pu-239 PE-Ci initial release (elevated); 0.74 Pu-239 PE-Ci suspension release (ground level)
RAD–01	TA–54–38	Pu-239	0.13 Pu-239 PE-Ci initial release (elevated); 0.60 Pu-239 PE-Ci suspension release (ground level)
RAD–02	TA–3–29	Pu-239	504 g Pu-239 released in 60 seconds (explosion), 6 g Pu-239 released in 2 hours (fire), 0.48 g Pu-239 suspension release (ground level)

TABLE G.4.2.2–1.—*Source Terms of Radiological Accidents at LANL*-Continued

ACCIDENT SCENARIO DESIGNATOR	AFFECTED FACILITY	MATERIAL RELEASED	SOURCE TERM INFORMATION
RAD–03	TA–18–116	HEU, Fission Products	7,194 g HEU and fission products initial release (ground level); 56.1 g HEU suspension release (ground level)
RAD–04	DARHT	Pu	Elevated release of Pu
RAD–05	TA–21–155 and/ or TA–21–209	tritium oxide	200 g tritium oxide, elevated release (fire), no suspension release
RAD–06	TA–50–37	Pu-239	0.63 Pu-29 PE-Ci released in 30 minutes (elevated release); 2.8 Pu-239 PE-Ci suspension release (ground level)
RAD–07	TA–50–69 Container Storage Area	Pu-239	0.28 Pu-239 PE-Ci released in 2.4 minutes (elevated); 0.52 Pu-239 PE-Ci suspension release (ground level)
RAD–08	TWISP	Pu-239	0.16 Pu-239 PE-Ci initial release (elevated); 0.74 Pu-239 PE-Ci suspension release (ground level)
RAD–09	TWISP	Pu-239	High activity container, 0.066 Pu-239 PE-Ci initial release (ground level; 0.63 Pu-239 PE-Ci suspension release (ground level); Average activity container, 0.0012 Pu-239 PE-Ci initial release, 0.012 Pu-239 PE-Ci suspension release
RAD–10	TA–55–4	Weapons-Grade Pu	2.7 g weapons-grade Pu initial release (stack); 4.3 g weapons-grade Pu suspension release (ground level)
RAD–11	DARHT	Pu	Ground-level release of Pu
RAD–12	TA–16–411	Pu	Elevated release of plutonium
RAD–13	TA–18–116	Weapons-Grade Pu, Fission Products	6 g weapons-grade Pu initial release, plus fission products (ground level); 0.6 g weapons-grade Pu suspension release (ground level)
RAD–14	TA–55–4	Weapons-Grade Pu	2.5 g weapons-grade Pu initial release (stack); 0.0983 g weapons-grade Pu suspension release (ground level)
RAD–15	TA–3–29	Weapons-Grade Pu	6.6 g weapons-grade Pu initial release; 4.34 g weapons-grade Pu suspension release (Expanded Operations Alternative only)
RAD–16	TA–3–29	Pu-239	0.69 g Pu-239 initial release (elevated); 0.21 g Pu-239 suspension release (ground level)

Note: As plutonium-239 (Pu-239) ages, there is an ingrowth of the daughter americium-241 (Am-241) that affects the gamma radiation levels. However, an analysis shows that health effects from the combined uptake are quite independent of the aging. Therefore, the MAR does not distinguish as to age of the material released.

G.5 ACCIDENT CONSEQUENCE ASSESSMENT

This section provides the detailed description and analysis results for each of the accident scenarios for which impact quantification is performed. Table G.5–1 provides a summary of the consequences to the public from risk-significant accidents at LANL. The annual frequency at which these consequences occur (that is, their probability of occurrence in any year), can be put into a common perspective by reference to Table G.1–2. When the term "societal risk" is encountered, recall that the product of consequence and probability is called societal risk in the SWEIS. It permits the ready comparison of accidents and alternatives without the burden of the details found in this section.

G.5.1 Note on Worker Consequences

Table G.5.1–1 provides a similar summary for consequences to workers in the facilities at which the accidents originate. The consequences are characterized rather than quantified. In most cases, it is possible to estimate the number or range in number of people that may be present as determined from experience, the size of the task, or administrative limits. However, it is not generally possible to quantify the number of injuries and fatalities this close to the source because: (1) the details of the contaminant distribution, fires, projectiles, and explosive forces close to the accident point are not known and are not predictable; (2) the numbers and locations of workers change frequently; and (3) worker response, which has a large effect in increasing or decreasing consequences, is not predictable.

G.5.2 Note on Soil Contamination

There is also soil contamination that results from deposition of plumes from radiological releases. When provided by the model, the predicted mean soil contamination levels are given in tables at the end of the descriptions of those radiological accidents that release more than a small amount of uranium or plutonium. (There is negligible deposition of tritium on soil.) The deposited material may subsequently become airborne by wind or other disturbances. The resulting potential for exposures through inhalation is small compared to the initial plume; nevertheless, the dose from such is calculated in the modeling and is included in the exposures in Table G.5–1.

Over the long term, the soil contamination has potential for further exposure through inhalation of air and ingestion of food products. The federal government, under the Federal Radiological Emergency Response Plan (61 Federal Register [FR] 20944), responds to a radiological emergency and provides resources to assist in the evaluation and mitigation of potential long-term exposure pathways to humans. Specifically, EPA will assume responsibility from DOE for long-term monitoring and remediation, assist in the preparation of area restoration plans, and recommend cleanup criteria. The U.S. Department of Agriculture (USDA) will inspect meat and meat products, poultry and poultry products, and egg products to ensure they are safe for human consumption. In addition, the USDA in conjunction with the U.S. Department of Health and Human Services (HHS) will assist in monitoring the production, processing, storage, and distribution of food through the wholesale level to eliminate or reduce contamination to a safe level. HHS will assist with the assessment, preservation, and protection of human health, and will assist state and local governments in making evacuation and relocation decisions.

TABLE G.5–1.—*Summary of Consequences from Risk-Significant Accidents at LANL*[a]

SCENARIO	DESCRIPTION	BASELINE LIKELIHOOD[b]	BASELINE CONSEQUENCE MEASURES[c]	EFFECT OF ALTERNATIVES[d]
SITE–01	Moderate earthquake. on the Pajarito Fault or a large earthquake in the Rio Grande Rift zone, resulting in structural damage and/or severe internal damage to comparatively low-capacity facilities.	Approximately 2.9 x 10^{-3} per year (i.e., one such event in approximately 350 years).	Mean population dose approximately 27,726 person-rem, resulting in approximately 16 excess LCFs; MEI dose 20 rem; several tens of people exposed at or above ERPG–2 or ERPG–3 levels at distances to a substantial fraction of 1 mile from multiple sources.	NOA—baseline. No difference among alternatives; the MAR and accident conditions are unaffected by the alternatives.
SITE–02	Large earthquake on the Pajarito Fault, resulting in structural damage and/or severe internal damage to low- and moderate-capacity facilities.	Approximately 4.4 x 10^{-4} per year (i.e., one such event in approximately 2,300 years).	Mean population dose approximately 41,340 person-rem, resulting in approximately 24 excess LCFs; MEI dose 34 rem; approximately 100 people exposed above ERPG–2 or ERPG–3 levels to a distance of about 1 mile from multiple sources.	NOA—baseline. No difference among alternatives: the MAR and accident conditions are unaffected by the alternatives.
SITE–03	Very large earthquake on the Pajarito Fault and perhaps the Embudo Fault, resulting in structural damage to essentially all facilities.	Approximately 7.1 x 10^{-5} per year (i.e., one such event in approximately 14,000 years).	Mean population dose approximately 210,758 person-rem, resulting in approximately 134 excess LCFs; MEI dose 247 rem; approximately 100 people exposed above ERPG–2 or ERPG–3 levels to a distance of about 1 mile from the sources.	NOA—baseline. No difference among alternatives; the MAR and accident conditions are unaffected by the alternatives.
SITE–03, Surface Rupture	Very large earthquake on the Pajarito Fault, resulting in structural damage to essentially all facilities with surface rupture possible on subsidiary faults.	Approximately 1 to 3 x 10^{-5} per year (i.e., one such event in 95,000 to 32,000 years).	Mean population dose approximately 344,581 person-rem, resulting in approximately 233 excess LCFs; MEI dose < 380 rem; approximately 100 people exposed above ERPG–2 or ERPG–3 levels to a distance of about 1 mile from multiple sources.	NOA—baseline. No difference among alternatives; the MAR and accident conditions are unaffected by the alternatives.
SITE–04	Site-wide wildfire consuming combustible structures and vegetation.	Approximately 0.1 per year (i.e., one every 10 years).	Mean population dose approximately 675 person-rem, resulting in approximately 0.34 excess LCFs; MEI dose < 25 rem; potential for limited exposure to chemicals.	NOA—baseline. No difference among alternatives; the MAR and accident conditions are unaffected by the alternatives.
CHEM–01	Large leak chlorine release (69 to 75 lb) from potable water treatment station due to human error during cylinder changeout or maintenance, or due to random hardware failures.	Approximately 1.2 x 10^{-3} per year (i.e., one such event in approximately 800 years).	For the risk-dominant large leak scenario, an average of approximately 43 people exposed above ERPG–2 levels, and approximately 12 people exposed above ERPG–3 levels to distances of up to a few tenths of 1 mile.	NOA—baseline. EXP—approximately 5% more likely. RED—approximately 5% less likely. GRN—same as baseline; no change in severity.

TABLE G.5–1.—*Summary of Consequences from Risk-Significant Accidents at LANL*[a]-Continued

SCENARIO	DESCRIPTION	BASELINE LIKELIHOOD[b]	BASELINE CONSEQUENCE MEASURES[c]	EFFECT OF ALTERNATIVES[d]
CHEM–02	Multiple cylinder release (1,500 lb) from toxic release gas storage shed at Gas Plant due to fire or aircraft crash.	Approximately 1.3×10^{-4} per year (i.e., one in approximately 8,000 years).	Average of 292 people within LANL (ranging from none to 1,000 depending upon wind direction) exposed at or above ERPG–2 or ERPG–3 levels; town protected by canyon from highest concentrations.	NOA—baseline. EXP—approximately 14% more likely. RED—approximately 5% less likely. GRN—same as baseline; no change in severity.
CHEM–03	Chlorine release (68 to 75 lb) from toxic gas storage shed at Gas Plant due to random failure or human errors during cylinder handling.	Approximately 1.2×10^{-4} per year (i.e., one in approximately 8,000 years).	An average of approximately 263 people exposed above ERPG–2 levels or 239 above ERPG–3 levels at distances to a fraction of 1 mile, all within LANL; town protected by canyon from highest concentrations.	NOA—baseline. No difference among alternatives; the MAR and accident conditions are unaffected by the alternatives.
CHEM–04	Bounding single container release of toxic gas (selenium hexafluoride) from waste cylinder storage.	Approximately 4.1×10^{-3} per year (i.e., one in approximately 250 years).	Average number of off-site people exposed above ERPG–2 level is zero; toxic effects generally limited to the source's technical area (TA–54).	NOA—baseline. No change in likelihood or severity among the alternatives.
CHEM–05	Bounding multiple cylinder release of toxic gas (sulfur dioxide) from waste cylinder storage.	Approximately 5.1×10^{-4} per year (i.e., one event in approximately 2,000 years).	Under conservative daytime conditions, no one outside the source area (TA–54) would see levels above ERPG–2. Under least favorable conditions, 13 people could be exposed above ERPG–3 levels and 59 above ERPG–2 levels.	NOA—baseline. No change in likelihood or severity among the alternatives.
CHEM–06	Chlorine gas release outside Plutonium Facility.	Approximately 6.3×10^{-2} per year (i.e., one event in approximately 16 years).	Average number of people exposed at or above ERPG–2 doses is approximately 102, and above ERPG–3, approximately 7 at ranges to a fraction of 1 mile.	NOA—baseline. No change in likelihood or severity among the alternatives.
RAD–01[e]	Plutonium release from RANT Facility transuranic waste container storage area fire.	Approximately 1.6×10^{-3} per year (i.e., one event in approximately 600 years).	Mean population dose approximately 72 person-rem, resulting in approximately 0.04 excess LCF; MEI dose at nearest public access (on Pajarito Road) approximately 46 rem; at most exposed residence approximately 4 rem.	NOA—baseline. No change in likelihood or severity among the alternatives.
RAD–02	Plutonium release from the CMR Building due to natural gas pipe-line break, gas ingestion into facility, and subsequent explosion and fire.	Negligible likelihood, $< 10^{-6}$ per year or > 1,000,000 years between occurrences.	Mean population dose approximately 120,000 person-rem, resulting in approximately 57 excess LCFs; MEI dose at nearest public access (Diamond Road) approximately 4000 rem; at nearest residence approximately 170 rem.	NOA—baseline. No change in likelihood or severity among the alternatives.

TABLE G.5–1.—*Summary of Consequences from Risk-Significant Accidents at LANL*[a]-Continued

SCENARIO	DESCRIPTION	BASELINE LIKELIHOOD[b]	BASELINE CONSEQUENCE MEASURES[c]	EFFECT OF ALTERNATIVES[d]
RAD–03	Highly enriched uranium release from power excursion accident with Godiva-IV outside Kiva #3.	Approximately 3.4 x 10^{-6} per year (i.e., one event in 300,000 years).	Mean population dose approximately 110 person-rem, resulting in approximately 0.06 excess LCF; MEI dose at nearest public access (Pajarito Road) approximately 150 rem; at nearest habitation approximately 0.5 rem.	NOA—baseline. EXP—approximately 25% more likely. RED and GRN—no change in likelihood. No change in severity among the alternatives.
RAD–04[f]	Inadvertent detonation of plutonium-containing assembly at DARHT firing point.	Negligible likelihood, < 10^{-6} per year or > 1,000,000 years between occurrences.	Mean population dose approximately 9,000 person-rem, resulting in approximately 5 excess LCFs; MEI dose for nearest public access (State Route 4) approximately 76 rem.	NOA—baseline. No change in likelihood or severity among the alternatives.
RAD–05	Tritium oxide release due to aircraft crash at TSFF.	5.3 x 10^{-6} per year (i.e., one accident in 190,000 years).	Mean population dose approximately 24 person-rem; 0.012 excess LCF or negligible chance of excess LCF. MEI approximately 0.01 rem.[g]	NOA—baseline. The same for all alternatives, except with RED, the tritium available for release is reduced by 25% in one but not both buildings.
RAD–06	Plutonium release due to aircraft crash at RAMROD.	Negligible likelihood, < 10^{-6} per year or > 1,000,000 years between occurrences.	Mean population dose approximately 7,900 person-rem, resulting in approximately 4 excess LCFs.	NOA—baseline. No change among alternatives.
RAD–07	Plutonium release from WCRRF transuranic waste container storage area fire.	1.5 x 10^{-4} per year (i.e., one in 7,000 years).	Mean population dose approximately 1,300 person-rem, resulting in approximately 0.7 excess LCF; MEI dose at closest public access (Pajarito Road) approximately 74 rem; at closest habitation approximately 4 rem.	NOA—baseline. EXP—likelihood doubles due to higher waste throughput. RED—likelihood reduced by 25%. GRN—same as baseline; no change in severity.
RAD–08	Plutonium release from TWISP transuranic waste storage domes due to aircraft crash and fire.	4.3 x 10^{-6} per year (i.e., one event in approximately 200,000 years).	Mean population dose approximately 400 person-rem, resulting in approximately 0.2 excess LCF; MEI dose at nearest public access (Pajarito Road and nearest border with White Rock) 22 rem.	NOA—baseline. No effect of alternatives on crash likelihood or maximum waste loading assumed in the analysis.

TABLE G.5–1.—*Summary of Consequences from Risk-Significant Accidents at LANL*[a]-Continued

SCENARIO	DESCRIPTION	BASELINE LIKELIHOOD[b]	BASELINE CONSEQUENCE MEASURES[c]	EFFECT OF ALTERNATIVES[d]
RAD–09	Plutonium release due to transuranic waste drum failure or puncture (for high and typical activity in drum).	4.1 x 10^{-3} per year (i.e., one in approximately 250 years for high-activity drum); 0.4 per year (i.e., 1 in 2.5 years for typical-activity drum).	Mean population dose (high-activity drum) approximately 230 person-rem, 0.12 excess LCF. Mean population dose (typical-activity drum) approximately 4.3 person-rem, with 0.0022 excess LCF or negligible risk. MEI dose of 0.41 rem.	NOA—baseline. Number of drum operations, and thus likelihood, up 20% for EXP; down 5% for RED. GRN—same as baseline.
RAD–10	Plutonium release from degraded storage container at plutonium facility.	< 10^{-6} per year; negligible likelihood of external release (i.e., < 10^{-6} per year).	For the incredible accident, mean population dose approximately 560 person-rem, with 0.28 excess LCF. MEI dose of approximately 44 rem at Pajarito Road boundary.	NOA—baseline. Alternatives do not alter the likelihood or severity of these accidents associated with the repackaging of stored plutonium.
RAD–11[f]	Container breach after detonation of plutonium-containing assembly at DARHT firing point.	Negligible likelihood, < 10^{-6} per year or > 1,000,000 years between occurrences.	Mean population dose approximately 210 person-rem, resulting in < 1 excess LCF; MEI dose (maximum dose point on State Route 4) approximately 14 rem.	NOA—baseline. Alternatives do not alter the likelihood or severity of such accidents.
RAD–12[f]	Explosively driven dispersal of plutonium at TA–16–411.	1.5 x 10^{-6} per year or about 1 in 670,000 years.	Mean population dose approximately 35,800 person-rem; 18 excess LCFs. MEI (maximum dose at closest site boundary) 138 rem.	NOA—baseline. Alternatives do not alter the likelihood or severity of such accidents.
RAD–13	Plutonium release from flux trap irradiation experiment at TA–18.	1.6 x 10^{-5} per year (i.e., one event in 62,000 years).	Mean population dose approximately 160 person-rem, resulting in 0.08 excess LCF; MEI dose at closest public access (Pajarito Road) is approximately 120 rem; at closest habitation is approximately 0.12 rem.	NOA—baseline. Alternatives do not alter the likelihood or severity of such accidents.
RAD–14	Plutonium release from ion exchange column thermal excursion at Plutonium Facility.	< 10^{-6} per year (i.e., < 1 in one million years).	Mean population dose approximately 130 person-rem (i.e., 0.063 excess LCF); MEI dose 0.45 rem at Pajarito Road and 0.32 rem at closest habitation.	NOA—baseline. Alternatives have no effect on likelihood or severity of such accidents.

TABLE G.5–1.—*Summary of Consequences from Risk-Significant Accidents at LANL*[a]-Continued

SCENARIO	DESCRIPTION	BASELINE LIKELIHOOD[b]	BASELINE CONSEQUENCE MEASURES[c]	EFFECT OF ALTERNATIVES[d]
RAD–15	Plutonium release from the ARIES process: (1) Hydride-dehydride glovebox fire. (2) Plutonium release from wing fire.	(1) 3.6 x 10^{-5} per year (2) 3.2 x 10^{-5} (i.e., 1 in about 30,000 years for both accident scenarios).	(1) Mean population dose 4.5 person-rem; approximately 0.0023 excess LCFs; MEI at closest public access: approximately 4.1 rem. (2) Mean population dose approximately 1,700 person-rem; approximately 0.85 excess LCFs, MEI at closest public access: approximately 91 rem.	NOA—baseline. EXP— (1) Increases the severity of the accident by approximately 4 times that of the NOA. (2) Increases the severity of the accident by approximately 100% over the NOA. RED and GRN—remain the same as the NOA. Frequencies remain the same across alternatives.
RAD–16[g]	Plutonium release due to aircraft crash at the CMR Building.	Approximately 3.5 x 10^{-6} per year (i.e., one event in approximately 300,000 years).	Mean population dose: approximately 56 person-rem; 0.03 excess LCFs expected; MEI dose at closest public access approximately 3 rem; at nearest habitation approximately 0.03 rem.	NOA—baseline. Alternatives do not alter the likelihood or severity of such accidents.
WORK–01	Inadvertent detonation of high explosives.	10^{-3} to 10^{-2} per year (i.e., one in approximately 100 to 1,000 years).	1 to 10 fatalities or injuries.	NOA—baseline. EXP—50% increase in likelihood. RED—20% reduction in likelihood. GRN—40% reduction in likelihood.
WORK–02	Biohazard contamination of a single worker.	10^{-2} to 10^{-1} per year (i.e., one in approximately 10 to 100 years).	One casualty.	NOA—baseline. No differences among alternatives apart from the addition of one more pathogen in EXP.
WORK–03	Inadvertent criticality event at the CMR Building, Critical Experiments Facility, or Plutonium Facility.	< 10^{-5} per year (i.e., one in more than 100,000 years).	Substantial doses to those few workers in the immediate vicinity, with possible fatalities from acute exposures.	NOA—baseline. Alternatives have little effect on likelihood and none on severity of such accidents.
WORK–04	Inadvertent exposure of workers to electromagnetic radiation.	10^{-2} to 10^{-1} per year (i.e., one in approximately 10 to 100 years).	Typically one, rarely several, casualties.	NOA—baseline. Alternatives have little effect on likelihood and none on severity of such accidents.

TABLE G.5–1.—*Summary of Consequences from Risk-Significant Accidents at LANL*[a]-Continued

SCENARIO	DESCRIPTION	BASELINE LIKELIHOOD[b]	BASELINE CONSEQUENCE MEASURES[c]	EFFECT OF ALTERNATIVES[d]
WORK–05	Plutonium release from degraded storage container at Plutonium Facility	0.23 per year (i.e., one in approximately 5 years).	Significant but nonlethal doses to one to two operators.	NOA—baseline. Alternative have little effect on likelihood and none on severity of such accidents.

[a] See the individual narratives for each accident in section G.5 for additional information.

[b] Accident likelihood estimates are conservative, given the information available. However, for the particularly unlikely accidents, it is possible that there are causal mechanisms that were missed; therefore, the possibility of a more probable scenario cannot be rigorously ruled out. The frequency per year is more correctly described as the probability of occurrence in any 12-month period. See detailed explanation under Meaning of Risk and Frequency in section G.1.

[c] Conservative assumptions have been employed in estimating the quantity and form of the hazardous materials available for release. Accident consequences are generally conservative (pessimistic) but do not bound the effects of accidents occurring under unusually unfavorable weather conditions. The results quoted for radiological accidents are weather-averaged. MEIs for each location are hypothetical individuals who do not leave and do not take protective actions to avoid exposure. Excess LCFs are cancers resulting from, and that develop well after, exposure to ionizing radiation. The excess LCF is the product of the dose and the risk factor of 5×10^{-4} excess LCF/person-rem. This is discussed in the primer on the effects of radiation in section D.1 of appendix D, Human Health.

[d] Explanations of the alternatives: No Action (NOA), Expanded Operations (EXP), Reduced Operations (RED), and Greener (GRN) appear in the introduction to this appendix and in chapter 3. The baseline risk is the risk from current operations, plus planned activities. Together, these constitute the NOA. There is frequently no difference among the alternatives in accident frequency and public consequence. The inventories used in the analyses are typically those of bounding permitted or administrative limits, rather than realistic values that would be more likely to change among the alternatives. The accident frequencies depend upon the accident initiators, many of which are independent of the operations and of inventory, and therefore, do not change among alternatives. Frequencies that depend upon operations, such as the number of drums being processed, do not necessarily translate into change in frequency of an environmental release, but may affect the frequency of worker accidents.

[e] As with other plutonium doses, these 4,000 rem are the total dose that accumulates over a 50-year lifetime as a result of the initial intake.

[f] These accidents are taken from the DARHT EIS (DOE 1995a) and utilize different modeling from the others shown in this table; therefore, the results may not be strictly comparable. For example, the integrated exposures for these accidents do not include exposures to on-site workers. The DARHT EIS treated the on-site workers as noninvolved workers. The doses were given as an individual dose and not included in the integrated population numbers. For this reason, integrated population doses in this EIS are higher than those in the DARHT EIS; however, both EISs assessed the consequences to noninvolved workers. See text under each accident for elaboration.

[g] This is at 360-meter distance. The closest public access would likely be involved in the crash.

TABLE G.5.1–1.—*Summary of Consequences to Workers at Accident Origination Facilities*

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
SITE–01	Moderate earthquake on the Pajarito Fault or a large earthquake in the Rio Grande Rift zone, resulting in structural damage and/or severe internal damage to comparatively low-capacity facilities.	Workers in buildings that are structurally damaged or that suffer partial or total collapse (unusual, but possible) could be injured or killed. Worldwide experience with very severe earthquakes indicates that *a priori* predictions of the numbers of injuries and fatalities are not possible. The experience clearly indicates that large numbers of fatalities (i.e., many hundreds to thousands of deaths) are not commonly experienced except under special conditions. These special conditions include severe earthquakes with large numbers of people in severely substandard structures that suffer complete collapse. Modern structures do not often experience such failures, even in very severe earthquakes. Other circumstances under which large numbers of fatalities can occur include seismically induced, widespread fires. Other impacts to workers can include delayed emergency response (including medical assistance) and indirect effects from releases of hazardous materials (both inside facilities and to the environment).
SITE–02	Large earthquake on the Pajarito Fault, resulting in structural damage and/or severe internal damage to comparatively moderate-capacity facilities.	See SITE–01.
SITE–03	Very large earthquake on the Pajarito Fault and perhaps the Embudo Fault, resulting in structural damage to essentially all facilities.	See SITE–01.
SITE–04	Site-wide wildfire consuming combustible structures and vegetation.	All threatened workers would be evacuated prior to arrival of the fire front. Aircraft crashes have occurred while dropping slurry on wildfires. Firefighters are at risk if they enter an area without an alternate escape route, and there have been historical fatalities from such events. However, because life safety is given first priority over protection of property at LANL, it is not likely that there will be worker fatalities. Some firefighters and other emergency personnel are likely to have significant but transient effects from smoke inhalation.
CHEM–01	Chlorine release (up to 150 pounds) from potable water treatment station due to human error during cylinder changeout or maintenance, or due to random hardware failures.	For the cylinder rupture event, it is unlikely that workers will be present because due to the nature of the event, it is assumed to occur at random rather than as a result of worker activity. Even with very prompt response by workers inside the building when the release occurs, severe injury or fatality is possible with large chlorine leak rates. The number of injuries and fatalities depends on the exact number and location of workers at the facility at the time of the event. For small leak rates, the likelihood of injury or death is low due to the self-annunciating nature of the event.

TABLE G.5.1–1.—*Summary of Consequences to Workers at Accident Origination Facilities*-Continued

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
CHEM–02	Multiple-cylinder release (1,500 pounds) from toxic gas storage shed at Gas Plant due to fire or aircraft crash.	Workers present at the Gas Plant (TA–3–170 and environs) can be injured or killed, depending upon wind direction and wind speed. However, the chlorine gas and fire causing the release will be readily visible, and escape from the plume, even on foot, is likely. Workers attempting to fight the fire without personal protective equipment can be overcome by chlorine gas.
CHEM–03	Chlorine release (150 pounds) from toxic gas storage shed at Gas Plant due to random cylinder failure or multiple human errors during cylinder handling.	Gas Plant workers who are directly involved in handling the cylinders of chlorine can be exposed to ERPG–2 or ERPG–3 concentrations from the human error contributor to this event. In the case of random failures, it is unlikely that workers will be in the immediate vicinity of the cylinder. Gas Plant workers can be exposed to high concentrations of chlorine if located outdoors; but these employees will be able to evacuate the area rapidly, which would tend to reduce exposure consequences.
CHEM–04	Bounding single-cylinder release of toxic gas (selenium hexafluoride) from waste cylinder storage.	There are typically four or five employees in the area during normal work hours. Injuries or fatalities can occur due to exposures as well as missiles from cylinder rupture. Workers are trained to leave the area in the event of a gas release. Consequences will depend on wind speed and direction.
CHEM–05	Bounding multiple-cylinder release of toxic gas (sulfur dioxide) from waste cylinder storage.	See CHEM–04.
CHEM–06	Chlorine release outside Plutonium Facility.	Air intakes at TA–55–4 are on the west end of the building, about 18 feet (5 meters) above the ground, and the chlorine release location is on the north side of the building at ground level. In addition, there is an isolation valve in the intake ductwork. Thus, it is unlikely that chlorine will be drawn into the building. Personnel located outdoors can be exposed to ERPG–2 and ERPG–3 concentrations of chlorine; but these employees will be able to evacuate the area rapidly, which would tend to reduce exposure consequences.
RAD–01	Plutonium release from RANT Facility transuranic waste container storage area fire.	There are about a dozen employees at the facility during day shift who can be at risk of plutonium inhalation as a result of this fire. However, the employees would be expected to take shelter or evacuate the area, which would reduce exposures. No lethal exposures would be expected.
RAD–02	Plutonium release from the CMR Building due to natural gas pipeline break, gas ingestion into facility, and subsequent explosion and fire.	Workers in the wing affected by the explosion can be severely injured or killed due to the dynamics of the explosion and the subsequent fire. Workers not directly affected by the explosion can inhale airborne plutonium that results from the explosion and subsequent fire. Contaminated air can be drawn into the building and dispersed to otherwise unaffected wings of the building.

TABLE G.5.1–1.—*Summary of Consequences to Workers at Accident Origination Facilities*-Continued

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
RAD–03	Highly enriched uranium release from power excursion accident with Godiva-IV outside Kiva #3.	Personnel will not be located outdoors during an experiment leading to this accident. The TA–18 control building provides 40% attenuation of gamma radiation; ventilation systems will be secured in the event of an accident, minimizing the air exchange rate with the outdoors. No acute fatalities are expected for this accident.
RAD–04	Inadvertent detonation of plutonium-containing assembly at DARHT firing point.	Up to15 fatalities can occur among workers directly affected by blast effects. Other workers farther away can be injured and/or exposed to airborne radioactivity (the latter depends on wind speed and direction and the location of the workers). Workers not directly affected by the blast could receive nonlethal exposures of up to 160 rem at 1,300 feet (400 meters) and up to 90 rem at 2,430 feet (750 meters).
RAD–05	Tritium oxide release due to aircraft crash at TSFF or TSTA.	An aircraft crash into the building can result in severe injuries or deaths to nearly all the occupants of the building. Nearby workers not within the facility can also be injured or killed as a result of the crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash can be exposed to tritium oxide, but the release plume will be elevated and may skip over the immediate crash site before returning to the ground at some distance.
RAD–06	Plutonium release due to aircraft crash at RAMROD.	An aircraft crash into the building can result in severe injuries or deaths to nearly all the occupants of the building. Nearby workers not within the facility can also be injured or killed as a result of the crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash could be exposed to plutonium, but the release plume will be elevated and may skip over the immediate crash site before returning to the ground at some distance. (Note that this scenario was found, after detailed analysis, to screen on a frequency less than 1×10^{-7} per year.)
RAD–07	Plutonium release from WCRRF transuranic waste container storage area fire.	There are typically five WCRRF workers present during normal operations. The postulated accident will not result in an immediate release, providing time for implementation of evacuation or other protective measures. No fatal exposures are expected.
RAD–08	Plutonium release from TWISP transuranic waste storage domes due to aircraft crash and fire.	A small number of workers may be present during normal operations and can be directly affected by crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash can be exposed to plutonium, but the release plume will be elevated and may skip over the immediate crash site before returning to the ground at some distance.

TABLE G.5.1–1.—*Summary of Consequences to Workers at Accident Origination Facilities*-Continued

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
RAD–09	Plutonium release due to transuranic waste drum failure or puncture.	The accident results in an immediate dispersal of plutonium to the area where the work is being performed. The dose to the worker will be dependent on ambient conditions and the speed with which protective actions can be taken (e.g., evacuation). No acute fatalities are expected for this accident.
RAD–10	Plutonium release from degraded storage container at Plutonium Facility.	The workers present when a container fails could be exposed to plutonium inhalation with substantial doses possible, depending upon the usage of PPE and the speed with which workers exit the immediate area.
RAD–11	Container breach after detonation of plutonium-containing assembly at DARHT firing point.	No fatalities are expected for the containment failure event because workers will be inside the facility and protected from material releases. Workers not directly involved with the experiment can receive nonlethal doses of up to 60 rem at 1,300 feet (400 meters) and up to 20 rem at 2,460 feet (1,750 meters).
RAD–12	Plutonium release from seismically initiated event at TA–16–411.	Workers within the facility would be killed by the explosion and building collapse.
RAD–13	Plutonium release from flux trap irradiation experiment at TA–18.	See RAD–03.
RAD–14	Plutonium release from ion exchange column thermal excursion at Plutonium Facility.	Workers in the room where the event occurs can be injured or killed due to the dynamics of the accident. Plutonium particulate inhalation is also possible. No fatalities have occurred in past resin thermal excursion events at other facilities.
RAD–15	Plutonium release from hydride-dehydride glovebox fire.	From one to three workers may be present attending the operations. These workers can be killed or injured due to the direct effects of a laboratory fire or can be exposed to plutonium particulates via inhalation. Other workers can be affected by smoke inhalation. Workers outside the facility will not be expected to be impacted due to redundant trains of HEPA filtration between the accident location and the outside environment.
RAD–16	Plutonium release due to aircraft crash at the CMR Building.	An aircraft crash into the CMR Building can result in severe injuries or deaths to nearly all the occupants of the building. Nearby workers not within the facility can also be injured or killed as a result of the crash dynamics, explosion, fire, missiles, etc. Workers not directly affected by the aircraft crash can be exposed to plutonium, but the release plume will be elevated and may skip over the immediate crash site before returning to the ground at some distance.
WORK–01	Inadvertent detonation of high explosives.	One to several workers can be killed due to explosion dynamics. The actual number of workers depends on the circumstances of the explosion (e.g., type of activity in progress, quantity of explosives involved, distances of workers from explosion site, etc.).

TABLE G.5.1–1.—*Summary of Consequences to Workers at Accident Origination Facilities*-Continued

SCENARIO	DESCRIPTION	FACILITY WORKER CONSEQUENCES
WORK–02	Biohazard contamination of a single worker.	One worker can be contaminated by this accident. The outcome of the contamination depends on the nature of the agent involved and the extent and efficacy of medical intervention. Fatality is possible but not likely, based on experience in the medical and research communities.
WORK–03	Inadvertent criticality event at the CMR Building, Critical Experiments Facility, or Plutonium Facility.	One or more workers can be killed due to acute radiation exposure, but the lethal zone is limited to tens of meters from the site of the criticality event. Other workers can receive sublethal exposures or can inhale fission products.
WORK–04	Inadvertent exposure of workers to electromagnetic radiation.	Severe injury or death is possible in the worst case. Sublethal effects (e.g., eye injuries) are also possible.
WORK–05	Plutonium release from degraded storage container at Plutonium Facility.	The workers handling the container can be exposed to plutonium particulates by inhalation. Significant but nonlethal doses are possible depending on the usage of personal protective equipment and the speed with which the workers exit the immediate area.

G.5.3 Note on the Consequences from Earthquakes

For the site-wide earthquakes, the earthquake frequency, the MAR (dominant contributors), and accident consequences across the alternatives are also projected to be comparable.

G.5.4 Site-Wide Earthquake and Wildfire Accidents

LANL is located within the Rio Grande Rift, a tectonically active province in the western U.S. Although only six historic earthquakes of Richter magnitude (ML) of 5.0 or greater have occurred in the LANL region, the period of historical observation is short (from about 1850 for events of ML 5.5) (Wong et al. 1995). Although no surface faulting has occurred in historic times, detailed paleoseismic investigations have found evidence of surface faulting in prehistoric times. Seismic studies currently in progress have further evaluated the potential for ground faulting. These studies indicate the possibility of such events is low, but credible, at some locations on the LANL site. Section 4.2.2.2 (in volume I, chapter 4) and appendix I further discuss the recently completed studies and their implication to DOE and LANL.

In order to evaluate the seismic hazards at LANL more fully, and in accordance with the guidance contained in DOE Standards 1020 and 1023 (DOE 1994e and DOE 1995b), LANL contracted with Woodward-Clyde Federal Services to perform a state-of-the-art PSHA. PSHA provides estimates of the frequency of various levels of ground movement (e.g., peak horizontal ground acceleration [PGA], represented in terms of the multiple of the force of gravity, represented by the letter "*g*"). The analysis evaluated the contribution of 25 faults to the seismic hazard at LANL, accounting for all known faults within 93 miles (150 kilometers) of the site that could produce ground accelerations of 0.05 *g* or greater (e.g., a PGA of 0.05 *g* is representative of the onset of strong ground shaking) (Wong et al. 1995). In addition, areal seismic sources were considered in an attempt to account for hidden faults that could produce earthquakes of up to magnitude 6.5 (larger faults would produce surface ruptures that would be represented already).

The Woodward-Clyde analysis found that most of the seismic hazard at LANL is due to projected seismic activity in the Rio Grande Rift and along the Pajarito, Rendija Canyon, Guaje, Sawyer Canyon, and Embudo faults. The surface expression of the Pajarito fault runs along the western boundary of LANL. The fault, which is a down-to-the-east fault, underlies the entire laboratory; all significant facilities at LANL are within 3.5 miles (5.6 kilometers) of the surface expression of the fault. The two facilities with the largest radiological hazard potential at LANL are the CMR Building and TA–55–4 facility, which are 0.4 and 1.9 miles (0.7 and 3.1 kilometers), respectively, from the surface expression of the Pajarito Fault. Therefore, the structures at LANL are considered to be near-field for the purposes of an earthquake along the Pajarito Fault. This near-field status means that large vertical displacements could occur in an earthquake along the Pajarito Fault, along with the horizontal displacements. Modeling performed by Woodward-Clyde indicates that vertical accelerations could exceed the horizontal acceleration at near-source distances of up to 6 miles (10 kilometers).

PSHA for Los Alamos indicates that the frequency of a very large peak horizontal ground acceleration (1.0 *g*) is approximately one in one hundred thousand per year, or 1.0×10^{-5} per year. Because the most structurally robust facility at LANL has a design basis earthquake of 0.31 *g*, it is clear that earthquakes have a potential to cause significant damage to LANL facilities.

The risks posed by earthquakes at LANL have been assessed on a site-wide basis, unlike existing safety documentation, which considers the facilities independently. The seismic analysis herein is based on PSHA, on available safety documentation (which in many cases provides information on the seismic capacity of important structures), on facility walkdowns conducted by the SWEIS accident analysts, and on engineering judgment. The approach taken in the analysis was to estimate conservative structural failure thresholds (referred to as HCLPF values), which correspond roughly to a high confidence that the conditional probability of structural failure is 5 percent or less at a given ground acceleration. By estimating conservative HCLPF values, the frequency of failure can be established with greater confidence than if the median or mean fragility values were estimated using limited resources. This approach places most of the uncertainty in failure frequency on the down side of the risk estimates; that is, it is much more likely that the actual failure frequency is lower than the estimated value than it is higher. Still, with a consistent approach to the analysis, the relative ranking of seismically initiated failures should be valid.

Once the HCLPF values are estimated (these values are tabulated in Table G.5.4–1), the seismic hazard information can be convolved with the HCLPF values to calculate the failure frequency. Because the seismic hazard is not very different among the eight LANL sites analyzed, the seismic hazard from TA–55 was used in quantification. The frequency of failure corresponding to HCLPF values for TA–55 is presented in Table G.5.4–2. Using the information in Tables G.5.4–1 and G.5.4–2, seismic failure events and their corresponding frequencies of occurrence were estimated as set forth in Table G.5.4–3.

In principle, if the assessment of seismically initiated accidents was being done as part of a full-scope PRA, the frequency of structural failure (or internal component/system damage) could be calculated uniquely for each structure and risks calculated separately for each resulting chemical or radiological release. However, the SWEIS accident analysis is not a seismic PRA. The goal of the analysis is to identify for the decision maker and stakeholders the risks associated with the SWEIS alternatives and to evaluate whether there are any significant differences in accident risks across the alternatives. Examining the results of the analysis in Table G.5.4–3, and considering the approximate method by which the HCLPF values were assigned, the uncertainties in the results are such that grouping the failure events by frequencies within a factor of three or four of one another is not unreasonable. Based on Table G.5.4–3, three site-wide earthquakes were identified, as listed in Table G.5.4–4. In addition, the potential impact of ground faulting at one facility of concern, the CMR Building, will be discussed as a subsection of the SITE–03 event.

Appendix I summarizes the ongoing and recently completed seismic hazard studies, as well as the implications of these studies for DOE and LANL. The uncertainties in the estimated seismic risk are large. The seismic hazard estimate alone has significant uncertainties. To illustrate, the uncertainties in the seismic hazard are such that the 5^{th} to 95^{th} percentile horizontal PGA values at a frequency of 1×10^{-5} per year range from about 0.55 *g* to much greater than 1.0 *g*. Similarly, the 5^{th} to 95^{th} percentile frequency values, for a horizontal PGA of 1.0 *g*, spans the range from 5×10^{-5} to much less than 1×10^{-6} per year.

G.5.4.1 *SITE–01, Site-Wide Earthquake Causing Damage to Low-Capacity Structures/Internals*

Consequences of SITE–01 for Facility Workers and the Public

The consequences of SITE–01 are presented separately for workers and the public. For

TABLE G.5.4–1.—*Estimated High Confidence in Low Probability of Failure Capacities of LANL Structures and Internals*

FACILITY DESIGNATION	FAILURE HCLPF[a]	NOTES
TA–00–1109	0.04	Unreinforced concrete block structure; large-diameter natural gas pipeline and pumping station located within 50 feet of this structure; a small-diameter natural gas pipe also enters the structure; HCLPF based on judgment and Campbell et al. 1988.
TA–00–1110	0.04	Unreinforced concrete block structure; two large water tanks located within 100 feet of this structure; HCLPF based on judgment and Campbell et al. 1988.
TA–3 Admin. Complex	0.04	0.15 *g* PGA calculated as having a high probability of failure (Miller et al. 1995); also consistent with LANL 1991a.
TA–3–29 (CMR)	0.08	The CMR Building expected to fail at 0.17 *g* median fragility (LANL 1995c), corresponding to a HCLPF of 0.08 *g*. The basement vault is expected to survive intact, but may suffer damage and leakage at earthquake magnitudes comparable to a HCLPF of 0.34 *g* (frequency of 7.1 x 10^{-5}/yr.).
TA–3–66 (Sigma)	0.05	Built in late 1950's; HCLPF based on LANL 1991a (original seismic design for 0.05 *g*) and PC 1996b (3 of 4 building sectors fail Federal Emergency Management Agency [FEMA] 178 life safety requirements corresponding to 0.14 *g* PGA).
TA–3–476	0.25	Judgmental estimate for overturning the shed in an earthquake.
TA–9–21	0.04	Judgmental estimate based on facility walkdown.
TA–15 DARHT	NA	No credible accident scenarios were identified wherein a seismic event could trigger a release from DARHT that would have any off-site impacts (DOE 1995a). If an earthquake were to occur with an assembly loaded and the containment sealed, not only would the container supports have to fail, but the explosives in the assembly would have to detonate and the containment would have to fail in order for a release to the environment to occur. The congruence of a sufficiently large earthquake, the conditional probability of an assembly being installed in the containment, the explosives detonating, and the containment structurally failing are considered to be incredible.
TA–16–205 (WETF)	0.14	Corresponds to 5 x 10^{-4}/yr frequency estimate in SAR based on Table G.5.1–2; this earthquake does not cause structural failure (LANL 1996e), but results in a tritium release due to failures internal to the facility coupled with failure of the ventilation isolation system (100 grams tritium oxide; 250 grams in the Expanded Operations Alternative).
	0.30	SAR estimates structural failure at 0.6 g (LANL 1996e); however, the frequency in the SAR (1.5 x 10^{-5}/yr) corresponds to an HCLPF of about 0.53 *g*, for which the median fragility would be much higher than 0.6 *g*. Indeed, that SAR frequency corresponds to approximately a 1.0 *g* PGA earthquake; the value shown here is a judgment pending further evaluation. In addition, during drafting of this SWEIS, DOE was informed that a seismically related unidentified safety question is in progress for WETF, which may lower the structural failure fragility to 0.3 *g*.
TA–16–411	0.05	Built in early 1950's; HCLPF based on judgment and PC 1996b (fails FEMA 178 life safety requirements corresponding to 0.14 *g* PGA).

TABLE G.5.4–1.—*Estimated High Confidence in Low Probability of Failure Capacities of LANL Structures and Internals*-Continued

FACILITY DESIGNATION	FAILURE HCLPF[a]	NOTES
TA–18–23 (Kiva #1)	0.05	Built in late 1940's to UBC criteria; HCLPF based on judgment and PC 1996b (fails FEMA 178 life safety requirements corresponding to 0.14 *g* PGA). Also calculated to be incapable of surviving the design basis earthquake of 0.22 *g* (LANL 1996f).
TA–18–32 (Kiva #2)	0.22	Analyzed in the SAR using finite element analysis against University of California Research Laboratory (UCRL–15910) seismic criteria and found to survive the design basis earthquake for a Hazard Category 2 facility. Assuming facility is DOE Standard 1020-94 Performance Category 2, HCLPF judgmentally assigned at 0.22 *g*, which corresponds to the Performance Category 2 earthquake at TA–18 (Wong et al.1995).
TA–18–116 (Kiva #3)	0.22	See notes for TA–18–32, above.
TA–18–168 (SHEBA)	0.22	See notes for TA–18–32, above.
TA–21–155 (TSTA)	0.10	Built in early 1950's; SAR indicates 0.33 *g* median fragility (LANL 1996g), but PC 1996b indicates that both sectors of building fail the FEMA 178 life safety requirements, corresponding to 0.14 *g* PGA. Building brought up to 1976 UBC requirements for seismic and wind; but the upgrade was not meant to conform to UCRL–15910 or DOE Standard 1020 (LANL 1996g).
TA–21–209 (TSFF)	0.10	Built in late 1960's; HCLPF based on SAR (LANL 1996h) and PC 1996b (all three sectors failed FEMA 178 life safety requirements, corresponding to 0.14 *g* PGA).
TA–43–1 (HRL)	0.08	HCLPF based on LANL 1991a (capable of 0.18 *g* resistance); 5 of 6 sectors failed FEMA 178 life safety requirements, corresponding to 0.14 *g* PGA (PC 1996b).
TA–50–1 Radioactive Liquid Waste Treatment Facility (RLWTF)	0.10	SAR states that the facility cannot withstand the 0.22 *g* design basis earthquake for a Performance Category 2 facility (LANL 1995d); HCLPF assigned by judgment based on SAR-reported frequency of 1.4 x 10^{-3}/yr (LANL 1995d).
TA–50–37 (RAMROD)	0.07	HCLPF assigned based on fragility of 0.15 *g* and corresponding frequency of 2 x 10^{-3}/yr (LANL 1996i).
TA–50–69 (WCCR Facility)	0.22	HCLPF assigned based on design basis earthquake of 0.22 *g* (LANL 1995e).
TA–54 TRU Domes	0.11	HCLPF assigned based on design basis earthquake of 0.22 *g* with a corresponding frequency of 1 x 10^{-3}/yr (LANL 1995f); corresponds to structural collapse of the tension dome structures of four domes and impact of 10% of the TRU waste drums on the top row of the stacks.
	0.31	HCLPF assigned based on beyond design basis earthquake of 0.57 *g* with a corresponding frequency of 1 x 10^{-4}/yr (LANL 1995f); corresponds to dome failure plus overturning of 10% of the TRU waste drums.
TA–54–38 (RANT)	0.11	HCLPF assigned based on the SAR, which states that the facility was designed to withstand seismic Zone 2 earthquake loads and design live loads per UBC 1985, corresponding to a 0.11 *g* design basis earthquake. However, additional bracing (tying together the roof and walls to resist the 100-year wind) brings the seismic resistance to greater than 0.11 *g* but less than the required 0.22 *g* for the facility (LANL 1996j).

TABLE G.5.4–1.—*Estimated High Confidence in Low Probability of Failure Capacities of LANL Structures and Internals*-Continued

FACILITY DESIGNATION	FAILURE HCLPF[a]	NOTES
TA–55–4	0.14	Design basis earthquake; facility structure remains intact, but some process enclosures collapse due to anchorage failure resulting in a free-fall spill of MAR and the rupture of process gas lines. Ventilation system fails due to loss of off-site power and failure of nonsafety-class ductwork within the building. LPF = 6% due to ventilation system failure and pressurized gas-driven release; frequency of this scenario is 4 x 10^{-4}/yr (LANL 1996k). The release for this scenario, calculated on a spreadsheet basis, is estimated at 1.16 x 10^{-2} grams of heat source plutonium, 5.17 grams of weapons-grade plutonium, 0.201 grams of plutonium-242, and 0.241 grams of highly enriched uranium (LANL 1996k).
	0.23	Beyond evaluation basis earthquake included in the SAR; similar to 0.30 *g* in that the structure remains intact with an LPF = 0.06, but more gloveboxes, etc., fail, increasing the source term. Release, calculated on a spreadsheet basis, is estimated at 1.74 x 10^{-2} grams of heat source plutonium, 5.31 grams of weapons-grade plutonium, 0.201 grams of plutonium-242, and 0.242 grams of highly enriched uranium (LANL 1996k).
	0.44	Beyond design basis earthquake not included in the TA–55 SAR; the structure has an HCLPF of 0.44 *g*, corresponding to an annual frequency of 3.16 x 10^{-5}/yr (LANL 1996k).
TA–55–185	0.31	TA–55–185 is a prefabricated metal building located on a concrete pad; it is a general use facility constructed in accordance with the 1988 UBC (DOE 1996g). HCLPF assigned based on judgment considering design and considering TA–54 Area G analysis for toppling of top row of TRU drums (LANL 1995f).
TA–55–249	0.23	Based on beyond evaluation basis earthquake for TA–55–4 (see above).

[a] Failure HCLPF is the ground acceleration where the probability of structural failure is 5% or less.

TABLE G.5.4–2.—*HCLPF Values Versus Annual Frequency of Failure*

HCLPF	FREQUENCY	HCLPF	FREQUENCY	HCLPF	FREQUENCY	HCLPF	FREQUENCY
0.01	9.93×10^{-3}	0.16	5.24×10^{-4}	0.31	1.01×10^{-4}	0.46	2.67×10^{-5}
0.02	8.59×10^{-3}	0.17	4.60×10^{-4}	0.32	9.18×10^{-5}	0.47	2.46×10^{-5}
0.03	6.38×10^{-3}	0.18	4.06×10^{-4}	0.33	8.36×10^{-5}	0.48	2.26×10^{-5}
0.04	4.67×10^{-3}	0.19	3.59×10^{-4}	0.34	7.62×10^{-5}	0.49	2.08×10^{-5}
0.05	3.54×10^{-3}	0.20	3.19×10^{-4}	0.35	6.95×10^{-5}	0.50	1.92×10^{-5}
0.06	2.78×10^{-3}	0.21	2.84×10^{-4}	0.36	6.35×10^{-5}	0.51	1.77×10^{-5}
0.07	2.24×10^{-3}	0.22	2.54×10^{-4}	0.37	5.80×10^{-5}	0.52	1.63×10^{-5}
0.08	1.84×10^{-3}	0.23	2.27×10^{-4}	0.38	5.31×10^{-5}	0.53	1.50×10^{-5}
0.09	1.53×10^{-3}	0.24	2.04×10^{-4}	0.39	4.86×10^{-5}	0.54	1.39×10^{-5}
0.10	1.29×10^{-3}	0.25	1.84×10^{-4}	0.40	4.45×10^{-5}	0.55	1.28×10^{-5}
0.11	1.09×10^{-3}	0.26	1.66×10^{-4}	0.41	4.08×10^{-5}	0.56	1.18×10^{-5}
0.12	9.29×10^{-4}	0.27	1.49×10^{-4}	0.42	3.74×10^{-5}	0.57	1.09×10^{-5}
0.13	7.99×10^{-4}	0.28	1.35×10^{-4}	0.43	3.44×10^{-5}	0.58	1.01×10^{-5}
0.14	6.90×10^{-4}	0.29	1.22×10^{-4}	0.44	3.16×10^{-5}	0.59	9.35×10^{-6}
0.15	6.00×10^{-4}	0.30	1.11×10^{-4}	0.45	2.90×10^{-5}	0.60	8.65×10^{-6}

TABLE G.5.4–3.—*Seismic Failures and Failure Frequencies Arrayed in Descending Order*

FREQUENCY	HCLPF	FACILITY AND FAILURE SCENARIO
4.7×10^{-3}	0.04	Administration Building structural failure
	0.04	TA–00–1109 structural failure
	0.04	TA–00–1110 structural failure
	0.04	TA–9–21 structural failure
3.5×10^{-3}	0.05	TA–3–66 (Sigma) structural failure
	0.05	TA–18–23 (Kiva #1) structural failure
	0.05	TA–16–411 structural failure
2.2×10^{-3}	0.07	TA–50–37 (RAMROD) structural failure
1.8×10^{-3}	0.08	TA–3–29 (CMR) structural failure
	0.08	TA–43–1 (HRL) structural failure
1.1×10^{-3}	0.10	TA–21–155 (TSTA) structural failure
	0.10	TA–21–209 (TSFF) structural failure
	0.10	TA–50–1 (RLWTF) structural failure
	0.11	TA–54 TRU domes structural failure, no drum overturning
	0.11	TA–54–38 (RANT) structural failure
6.9×10^{-4}	0.14	TA–16–205 internal failures, structure remains intact
	0.14	TA–55–4 (Plutonium Facility) internal failures, structure remains intact
2.5×10^{-4}	0.22	TA–18–32 (Kiva #2) structural failure
		TA–18–116 (Kiva #3) structural failure
		TA–18–168 (SHEBA) structural failure
		TA–50–69 (WCRR Facility) structural failure
2.3×10^{-4}	0.23	TA–55–4 (Plutonium Facility) internal failures, structure remains intact; nitric acid tank and berm structural failure
	0.23	TA–55–249 (hydrochloric acid tank and berm) structural failure
1.8×10^{-4}	0.25	TA–3–476 overturning
1.1×10^{-4}	0.30	TA–16–205 structural failure
1.0×10^{-4}	0.31	TA–54 TRU domes structural failure, drums overturning
	0.31	TA–55–185 structural failure
3.2×10^{-5}	0.44	TA–55–4 (Plutonium Facility) structural failure

TABLE G.5.4–4.—*Identified Site-Wide Earthquakes*[a]

FREQUENCY RANGE/YR	POINT ESTIMATE FREQUENCY	CHARACTERIZATION OF EARTHQUAKE
SITE–01 1.1 x 10^{-3} to 4.7 x 10^{-3}	2.9 x 10^{-3}	Low capacity structures or internals fail
SITE–02 1.8 x 10^{-4} to 6.9 x 10^{-4}	4.4 x 10^{-4}	Moderate capacity structures or internals fail
SITE–03 3.2 x 10^{-5} to 1.1 x 10^{-4}	7.1 x 10^{-5}	Comparatively high capacity structures fail

[a] Based on the information provided in Table G.5.1–3.

workers, the following consequences are identified:

- Any time a facility occupied by workers is subjected to structural damage or collapse in an earthquake, injuries will occur and the potential for fatalities is also present. Worldwide experience with very severe earthquakes indicates that *a priori* predictions of the numbers of injuries and fatalities are not possible. The experience clearly indicates that large numbers of fatalities (i.e., many hundreds to thousands of deaths) are not commonly experienced except under special conditions. These special conditions include severe earthquakes with large numbers of people in severely substandard structures that suffer complete collapse. Modern structures do not often experience such failures, even in very severe earthquakes. Other circumstances under which large numbers of fatalities occur include seismically induced dam failures and seismically induced, widespread fires.
- Workers trapped in nonhazardous buildings could be exposed to radioactivity and chemicals released into the atmosphere as a result of structural damage to other facilities and fires.
- Medical assistance to injured workers could be delayed due to limited availability of immediate medical response resources as well as by damage to transportation routes (e.g., due to landslides or collapsed bridges).
- These same considerations also apply to the off-site public.

Under the SITE–01 earthquake scenario, LANL nuclear facilities, except for the CMR Building, and most of LANL nonnuclear facilities would not collapse. The general effect is the potential to spill, create a small fire, or otherwise cause limited damage to material. Material that is "in process" is more likely to experience this type of effect. As a conservative value, the wing or building limits have been used as the MAR in these accidents with all of this material subject to spills, free-fall impacts, and a limited amount involved in fires. Bounding values were used in determining the amount of this material that had the potential for airborne transport. If internal systems could be damaged, the LPF for the facility was assumed to be 1.0. (That is, given the occurrence of the earthquake, it is assumed that the facilities that would experience structural or systems damage would always do so in a manner that creates an unconstrained path for material release outside of the structure.) This is a very conservative assumption because such damage could also occur in a manner that does not result in the release of material outside of the structure. (For example, walls might crack, but material storage containers could remain intact, or only spill material within the structure.) For buildings that would not sustain internal structural or systems damage, the LPF was assumed to be zero.

As a specific example, in evaluating the impact of hypothesized building damage from a SITE–01 earthquake affecting the CMR Building, it was assumed that the full amount of the MAR (the wing limits) were in powder form, uncontained and unprotected, subject to impacts and spills from the earthquake ground motion and falling objects. All of this material was assumed to be freely available for dispersal to the outside following the building damage. For comparison, generally only about 40 percent of the material in the CMR Building is in powder form, the remainder being in metal or solution, and most of the materials are in storage containers during routine operations (most is not “in process”). Such storage containers would have to be breached in the course of or following the earthquake to make that material available for release. Thus, while there is a variety of scenarios that could be developed for the events resulting from such an earthquake, this approach represents a conservative case for the purposes of NEPA.

LANL nuclear facilities do meet the requirements for design basis earthquakes. This includes engineered controls to minimize the damage to internal structures and systems. However, for the purposes of NEPA, the seismic hazard is treated very conservatively. This approach is taken in recognition that the frequency and magnitude of earthquakes are uncertain. The uncertainty will remain until much more is known and understood about the causes of earthquakes and their effects, including the predictability of earthquake magnitudes for a given area. Far less uncertain is the response of buildings to given forces; however, the process for determining the exact values for building responses is both expensive and time consuming. For the purposes of this SWEIS and consistent with the requirements of NEPA, the analyses considered conservative values for both the amount of material that could be affected in these scenarios and the ability for facilities and their systems to contain hazardous material.

Based on the foregoing discussion and analysis, low capacity structures/internals subject to damage and resulting in radiological releases for a 2.9 x 10^{-3} annual frequency earthquake include TA–3–29 (CMR Building structural collapse), TA–18–23 (Kiva #1 structural failure), TA–21–155 (TSTA Facility structural failure), TA–21–209 (Tritium Science and Fabrication Facility structural failure), TA–50–1 (RLWTF structural failure), TA–50–37 (Radioactive Materials Research, Operations, and Demonstration Facility structural failure), TA–54 Area G (TWISP Storage Dome failure), and TA–54–38 (Nondestructive Assay and Nondestructive Examination Facility structural failure). The dominant MAR and source terms are associated with TA–3–29, TA–50–1, TA–50–37, TA–54 Area G, and TA–54–38. Note that facilities that pose small additional risk were not included in the analyses. An example is TA–16–411, where the MAR is in a very strong part of the structure (vault) and is there only part of the time, so that a release from this facility as a result of an earthquake is believed to border on the incredible. The probability of such a release is discussed in detail under section G.5.6.12, RAD–12.

Note that these analyses (SITE–01, SITE–02, and SITE–03) do not attempt to evaluate the effect upon the population from the earthquake itself. Certainly, an earthquake in the Los Alamos area would have broader implications upon the local community than just the damage to LANL facilities. The population effects discussed here would only be incremental to the significant damage sustained from the earthquake itself.

The mean collective population dose from the dominant source term contributors is projected to total about 27,726 person-rem total effective dose equivalent (TEDE), resulting in approximately 16 excess LCFs. Some 97 percent of the exposure rises from the CMR Building (TA–3–29), RAMROD (TA–50–37), and the RLWTF (TA–50–1). No acute (immediate) fatalities from radiation are expected to result from the earthquake event.

Doses to the MEI member of the public from the subject facilities will generally not be additive because of the diverse locations of the facilities and the attendant requirement that different wind directions at each facility converging on the MEI would be necessary to obtain concurrent exposures (not physically possible). MEI doses for community residents and the corresponding release sources are summarized as follows: (1) 20.2 rem (TEDE), Los Alamos townsite resident (TA–3–29); (2) 20.1 rem (TEDE), Royal Crest Trailer Park resident (TA–3–29, TA–50–1, TA–50–37); and (3) 3.0 rem (TEDE), White Rock resident (TA–54 Area G).

Chemical release consequences also have been calculated. Chemical releases include 300 pounds of chlorine released from TA–00–1109 and TA–00–1110, 7.6 liters of hydrogen cyanide produced by collapse of the floor at the Sigma facility (TA–3–66), 3 pounds of phosgene released from collapse of TA–9–21 (a laboratory building), and 30 liters of formaldehyde released from the Health Research Laboratory (TA–43–1). The consequences of these releases are described below (note that no emergency response actions are assumed, with exposure assessed as though the people exposed are located outdoors; both assumptions are conservative).

- *TA–00–1109 and TA–00–1110, 300 pounds chlorine released at each.* In both cases, the most likely outcome would be that the higher concentrations of chlorine (being a heavy gas) would proceed down into nearby canyons, and exposures to the public would be reduced. Under typical meteorological conditions, and assuming flat terrain for the sake of conservatism, the ERPG–3 concentration of 20 parts per million could be exceeded to a distance of 361 yards (330 meters). Concentration profiles at 200 and 300 yards (183 and 275 meters) show that the ERPG–3 value is exceeded for a little over 10 minutes for a person located outdoors. At a 100-yard (92-meter) distance, the ERPG–3 value is exceeded significantly, with an exposure of about 200 parts per million lasting for about 10 minutes outdoors (see properties of chlorine gas under CHEM–02). Indoors, these values would be less, but the increment is not known due to damage to structures (with an intact single-story structure, the indoors concentration at 328 yards [100 meters] does not exceed ERPG–3, with a maximum concentration of 13.5 parts per million calculated). The circumstances of the release are such that the total release would be less than 300 pounds. The failure mode is evaluated to be shearing of the valves off the ends of the two tanks online. As discussed later under scenario CHEM–01, such a failure mode results in cooling the cylinder to a temperature less than the boiling point of chlorine, terminating the release before all the chlorine is released (actually, about half the total is released). The consequences of this would be no worse than those calculated for a single cylinder rupture, which releases 150 pounds from the building in 18.2 minutes. This results in 53 people being exposed to greater than ERPG–2 and 12 people exposed to greater than ERPG–3 concentrations under conservative daytime dispersion conditions.
- *TA–3–66, 7.6 liters of hydrogen cyanide released.* Hydrogen cyanide (HCN) would form in the basement of the Sigma Building. However, HCN is lighter than air and would be expected to evolve from solution in the basement and reach ground level, at which point it can be modeled as a ground level release. In order to place bounds on the consequences, several

scenarios were run. The most conservative release calculations assumed an instantaneous release of all 7.6 liters of HCN under adverse dispersion conditions, which is extremely conservative. The resulting maximum ERPG–2 and ERPG–3 distances were 0.60 and 0.43 miles (1 and 0.7 kilometers), respectively.

Another calculation was performed similar to those performed for EPA Risk Management Program (RMP) purposes, assuming a constant release rate with all the material released within 10 minutes under adverse dispersion conditions. The resulting maximum ERPG–2 and ERPG–3 distances were 0.45 and 0.28 miles (0.72 and 0.45 kilometers), respectively. A similar case, which assumed evaporation from a puddle under adverse dispersion conditions, produced maximum ERPG–2 and ERPG–3 distances of 0.27 and 0.17 miles (0.43 and 0.27 kilometers), respectively.

EPA RMP-type calculations under conservative daytime dispersion conditions produced maximum ERPG–2 and ERPG–3 distances of 119 yards (109 meters) and 75 yards (69 meters). Because ALOHA-calculated distances of the order of 100 yards or less are overestimates, this release scenario is of marginal consequence under conservative daytime dispersion. Even under adverse dispersion conditions, the ERPG–2 and ERPG–3 distances still did not extend to the Los Alamos townsite; any consequences would be limited to the LANL workforce population. The estimated numbers of people affected by concentrations greater than ERPG–2 and ERPG–3 are 15 and 15, respectively, for conservative daytime dispersion conditions and 44 and 29, respectively, for adverse dispersion conditions. Given collapse of the floor at Sigma, personnel in that facility would likely be severely injured or killed by the seismic event alone. Any survivors would have to rapidly evacuate the structure to avoid exposure to high concentrations of HCN.

- *TA–3–476, 150 pounds of chlorine released.* The consequences of this release are essentially identical to the consequences for accident scenario CHEM–03, as presented in Table G.5.6–1.
- *TA–9–21, 3 pounds of phosgene released.* TA–9–21 is a relatively isolated site at LANL (compared with, for example, TA–3 or TA–55) with a low workforce population in the immediate area. Nonetheless, phosgene is a very toxic gas (the ERPG–3 concentration for phosgene is 1 part per million; whereas, the ERPG–3 concentration or chlorine is 20 parts per million). Using EPA RMP-type release parameters of a constant 10-minute release under adverse dispersion conditions, the ERPG–2 and ERPG–3 distances are 0.76 and 0.0.32 miles (1.2 and 0.52 kilometers), respectively. Under conservative daytime dispersion conditions, the ERPG–2 and ERPG–3 distances decrease to 0.23 and 0.10 miles (0.37 and 0.16 kilometers), respectively. The estimated number of people affected by concentrations greater than ERPG–2 and ERPG–3 is 2 and 1, respectively, under either adverse or conservative daytime dispersion conditions.
- *TA–43–1, 30 liters of formaldehyde released.* This release was modeled because it is the largest inventory of easily dispersed (by air) carcinogens at LANL. The Los Alamos Medical Center is adjacent to the Health Research Laboratory, just across the bridge from LANL in the town area.

Similar to EPA RMP criteria, a 10-minute release was modeled under both adverse and conservative daytime dispersions. Under adverse dispersion, the ERPG–2 and ERPG–3 distances were calculated to be 0.68 and 0.41 miles (1.1 and 0.66 kilometers), respectively. Under conservative daytime conditions, the ERPG–2 and ERPG–3 distances were 0.17 and 0.10 miles (0.27 and 0.16 kilometers), respectively.

The number of people exposed to concentrations greater than ERPG–2 and ERPG–3 under adverse dispersion conditions are 60 and 23, respectively. Under conservative daytime dispersion, the number of people exposed to greater than ERPG–2 and ERPG–3 is 11 and 6, respectively.

The MAR (dominant contributors), earthquake frequencies, and accident conditions are the same for all four SWEIS alternatives; consequently, accident consequences across the alternatives are also projected to be comparable.

G.5.4.2 *SITE–02, Site-Wide Earthquake Causing Damage to Low- and Moderate-Capacity Structures/Internals*

As discussed in section G.5.4, the frequency of SITE–02 is 4.4 x 10^{-4} per year. The source term and consequences of this accident are also addressed in section G.5.4.

Consequences of SITE–02 for Facility Workers and the Public

In this earthquake scenario, the same conservative approach is used as was used in SITE–01. Facilities that sustain structural collapse would essentially consider all material in a facility as MAR. This includes stored material that could sustain damage from higher magnitude earthquakes. As with the SITE–01 scenario, for facilities that sustain internal damage only, the process material is considered to be at risk. Facilities that do not sustain damage do not contribute to MAR. Once the facility is considered to be damaged, the same conservative values (as were applied from SITE–01) for determining the source terms were used.

Moderate-capacity structures/internals subject to damage and resulting in radiological releases for a 4.4 x 10^{-4} annual frequency earthquake include TA–16–205 (Weapons Engineering Tritium Facility internals damage), TA–18–32 (Kiva #2 structural failure), TA–18–116 (Kiva #3 structural failure), TA–18–168 (SHEBA structural failure), TA–50–69 (WCRRF structural failure), and TA–55–4 (Plutonium Facility internals damage). The dominant MAR and source terms for moderate-capacity structures/internals are associated with TA–50–69 and TA–55–4.

For the 4.4 x 10^{-4} annual frequency earthquake, the dominant source term contributors include the identified moderate-capacity structures/ internals (TA–50–69 and TA–55–4) and the low-capacity structures/internals evaluated for Scenario SITE–01. The mean collective population dose is projected to total 41,340 person-rem (TEDE), resulting in approximately 24 excess LCFs. Most of the increase in exposure over the SITE–01 results comes from plutonium releases due to internal failures at the Plutonium Facility (TA–55–4); together, the TA–55–4 contribution and the contribution from the low-capacity facilities identified in SITE–01 account for 95 percent of the total integrated population dose. No acute fatalities are predicted to result from the earthquake event.

A member of the public residing at the Royal Crest Trailer Park has the potential of receiving concurrent exposures to releases from TA–3–29, TA–50–1, TA–50–69, and TA–55–4 for the postulated earthquake event. The MEI dose for this receptor location is conservatively projected to total 34.3 rem (TEDE) and primarily results from postulated releases associated with TA–55–4 (Plutonium Facility) TA–50–37 (RAMROD), and TA–3–29.

The MAR (dominant contributors), earthquake frequencies, and accident conditions are the same for all four SWEIS alternatives; consequently, accident consequences across the alternatives are also projected to be comparable.

Chemical release consequences also have been calculated. Chemical releases for SITE–02 include the same releases as for SITE–01, plus additional releases of 6,100 gallons of nitric acid and 5,200 gallons of hydrochloric acid from tanks at TA–55. These tanks are located within a few hundred feet of one another, and the consequences of the hydrochloric acid release are far greater than the nitric acid release. Accordingly, the hydrochloric acid release was modeled in detail (note that no emergency response actions are assumed, with exposure assessed as though the persons exposed are located outdoors; both assumptions are conservative). The hydrochloric acid tank is contained inside a berm; consequently, the release rate is limited by the surface area within the berm.

Consequence analyses were performed assuming a puddle of hydrochloric acid, which is the condition expected following seismic failure of the tank. The consequences of the release are provided in Table G.5.4.2–1

G.5.4.3 *SITE–03, Site-Wide Earthquake Causing Damage to All Structures/ Internals*

As discussed in section G.5.4, the frequency of SITE–03 is 7.1 x 10^{-5} per year. The source term and consequences of this accident are also addressed above in section G.5.4.

Consequences of SITE–03 for Facility Workers and the Public

In this case, high-capacity facility structures are subject to damage and collapse. Once these facilities are considered to be damaged by the earthquake, conservative values are used to estimate the source terms. These values are consistent with the conservative assumptions used in SITE–01 and SITE–02, but consider the larger magnitude of this earthquakes. The increase in impacts is associated with the greater inventories that are affected by the earthquake.

High-capacity facility structures subject to damage and resulting in radiological releases for a 7.1 x 10^{-5} annual frequency earthquake include TA–16–205 (Weapons Engineering Tritium Facility structural failure), TA–54 Area G (TRU drums overturn), TA–55–4 (Plutonium Facility structural failure), and TA–55–185 (TRU Waste Staging Facility structural failure). The dominant MAR and source terms for this scenario are associated with TA–3–29, TA–54 Area G, and TA–55–4.

For the 7.1 x 10^{-5} annual frequency earthquake, source term contributions include the identified dominant high-capacity structures (TA–54 Area G and TA–55–4), the other dominant moderate-capacity (TA–50–69), and low-capacity (TA–3–29, TA–50–1, TA–50–37, TA–54–38, and TA–54 Area G) structures/ internals. The mean collective population dose is projected to total 210,758 person-rem (TEDE), resulting in approximately 134 excess

TABLE G.5.4.2–1.—*Consequences of a Hydrochloric Acid Release*

POINT OF COMPARISON	ERPG–2	ERPG–3
Distance, Adverse Dispersion	2.0 miles	0.72 miles
Distance, Conservative Daytime Dispersion	1.0 miles	0.44 miles
Adverse Dispersion, Exposed Population	194	93
Conservative Daytime Dispersion, Exposed Population	124	36

LCFs. Projected doses and associated health effects primarily result from the postulated releases associated with TA–55–4 (accounting for almost 82 percent of the total) and TA–3–29 (accounting for an additional 14 percent of the total). No fatalities from acute radiation exposure are predicted to result from the earthquake event. The bounding dose at the MEI location in the Royal Crest Trailer Park is approximately 247 rem. The LANL seismic event exposures are almost exclusively from inhalation of plutonium, for which the exposures are more protracted and the acute effects are correspondingly reduced or absent.

The chemical release consequences for SITE–03 are the same as those for SITE–02 (section G.5.4.2).

The MAR (dominant contributors), earthquake frequencies, and accident conditions are the same for all four SWEIS alternatives; consequently, accident consequences across the alternatives are also projected to be comparable.

Recent and ongoing seismic studies have identified the potential for ground faulting at the CMR Building (TA–3–29). The assessment of ground faulting impacts on facility damage is difficult to quantify. For the CMR Building, the facility structure is assumed to collapse as part of the SITE–01 earthquake, with the CMR basement vault being intact until an earthquake magnitude comparable to a HCLPF of 0.34 *g* (frequency of 7.1 x 10^{-5} per year). The annual frequency associated with significant (greater than 50 centimeters) fault displacement is estimated to be 1 to 3 x 10^{-5} per year. Should fault displacement at the CMR Building occur in addition to other SITE–03 impacts, additional releases from the CMR Building could result. A conservative sensitivity assessment of this impact was completed. It should be reiterated that a detailed understanding of the additional damage and associated releases at the CMR Building has not been completed. The conservative sensitivity assessment results in an additional 133,823 person-rem collective population dose, resulting in about 99 additional excess LCFs. The MEI doses would increase by 133.9 rem at the Los Alamos townsite and 99.3 rem at the Royal Crest Trailer Park.

G.5.4.4 *SITE–04, Site-Wide Wildfire Consuming Combustible Structures and Vegetation*

General Scenario Description

The LANL site and surrounding vicinity are generally forested areas with high fuel loading. Wildfires are frequent occurrences on nearby U.S. Forest Service land, with obvious potential for encroaching on the LANL site, as demonstrated by recent events. For this site-wide accident, it is postulated that a wildfire is initiated to the southwest of LANL near the border of the Bandelier National Monument and the Dome Wilderness Area. While there is a potential for initiation of a wildfire at many locations within and near the LANL site, this location was considered as resulting in the most widespread impact to the site and surrounding area.

The fire begins mid day in the late April through June time frame, at a time of high or extreme fire danger, and is not extinguished in the first hour. The initial location is in an area populated with heavy ponderosa pine fuels that are found between roughly 6,500 and 8,200 feet (1,980 and 2,500 meters) elevation. As the fire grows, local jurisdictions respond to the fire, but are not effective due to remoteness, travel time, lack of road access, fire behavior, etc. Resources from more distant jurisdictions are alerted, but cannot arrive in a short time because of distance, limited roads, and opposing evacuation traffic. It proves impossible to put out the fire with the available resources and existing forest access before it enters the laboratory. Unlike the Water Canyon fire (greater than 3,000 acres [1,200 hectares] in June 1954), La Mesa fire (15,270 acres [6,180 hectares] in June 1977), Dome fire (16,500 acres [6,680 hectares]

April 25 to May 5, 1996), and Oso fire (greater than 5,000 acres [2,000 hectares] in June 1998), the weather does not change in time to prevent the fire from sweeping across the western part of LANL and into the townsite.

This specific analysis assumes a common meteorological situation that favors the fire. In this scenario, the fire begins about 10:00 a.m., reaches a size of 1,000 acres (400 hectares) in 3 hours, and becomes a well developed crown fire on a broad fire front containing 6,000 acres (2,400 hectares) in the second day. Like the La Mesa fire (Foxx 1981), at times it advances at a rate of 38 chains[1] per hour (0.44 miles [0.7 kilometers]). It starts spot fires 0.5 to 1.25 miles (0.8 to 0.2 kilometers) in advance, aided by prevailing southwest winds of 20 miles per hour and low daytime humidity. It easily jumps canyons and existing fuel break lines around LANL and the townsite.

The daytime convection column reaches to 20 or 25,000 feet (6 to 7,600 meters). In the Oso fire, the fire burned as actively at night as in the day, with flame heights on the order of 100 feet (30 meters). In this scenario, in order to have a conservative (low height) plume rise, at night the temperature drops and the relative humidity increases. The nighttime plume rise is then about 2,000 feet (600 meters). The fire regains its intensity at 10:00 a.m. each day. Following fire passage, the smoldering remains of vegetation and structures emit smoke and contaminants at the surface level.

The fire reaches State Road 4 and State Road 501, the southwest edge of LANL, at noon on the second day (see Figure G.5.4.4–1). Protective actions are already underway by LANL, such as relocating some radionuclides and barricading some windows, and releasing nonessential personnel following existing emergency plans. (Note that for this analysis, credit is given only for those protective measures that can be easily undertaken, such as ceasing operations or simple material transfers, are given credit.) The fuel break along these roads proves inadequate. At this point, the fire has progressed in areas where access is limited, hampering fire suppression activities due to concern for the safety of the firefighters. A control line is established at Pajarito Road and resources are concentrated there. Consequently, Pajarito Road is closed and not available for public evacuation. The fire burns forest to the west of and within LANL, but its eastern extent within LANL is constrained by pinyon-juniper woodlands and defined by fuel continuity and density.

From aerial photographs, it is estimated that these continuous fuel lines threaten TA–37, TA–15, TA–16, and TA–66, and those TAs to their west, as well as areas in and on the edge of the forested canyons. Following the continuous fuel lines and steered somewhat by southwesterly winds, the fire enters and crosses Pajarito Canyon and Two Mile Canyon, and by 1:00 a.m. of the third day burns up to the Pajarito Road control line just west of TA–66.

Although it would be expected that the control line will contain most fires, in this conservative accident scenario an adverse meteorological situation exists. At noon on the third day, aided by a modest daytime wind speed pickup and low relative humidity, the fire crosses the Pajarito Road control line between TA–3 and TA–55. It surrounds TA–3 and TA–48, and enters Los Alamos Canyon either directly or by spotting. The fire continues down Los Alamos Canyon on both sides of Omega Road where TA–41 and TA–2 are located. Because Omega Road continues down Los Alamos Canyon as a dirt road below the Omega site, it is unsafe for firefighters to enter Los Alamos Canyon, and the fire progresses essentially unabated.

From Los Alamos Canyon, the fire climbs onto the mesas where TA–53 and TA–21 are located. The fire also spots into Mortandad Canyon. The canyon fires are necessarily allowed to burn eastward, due to their inaccessibility, until they

1. 80 chains = 1 mile (1.6 kilometers).

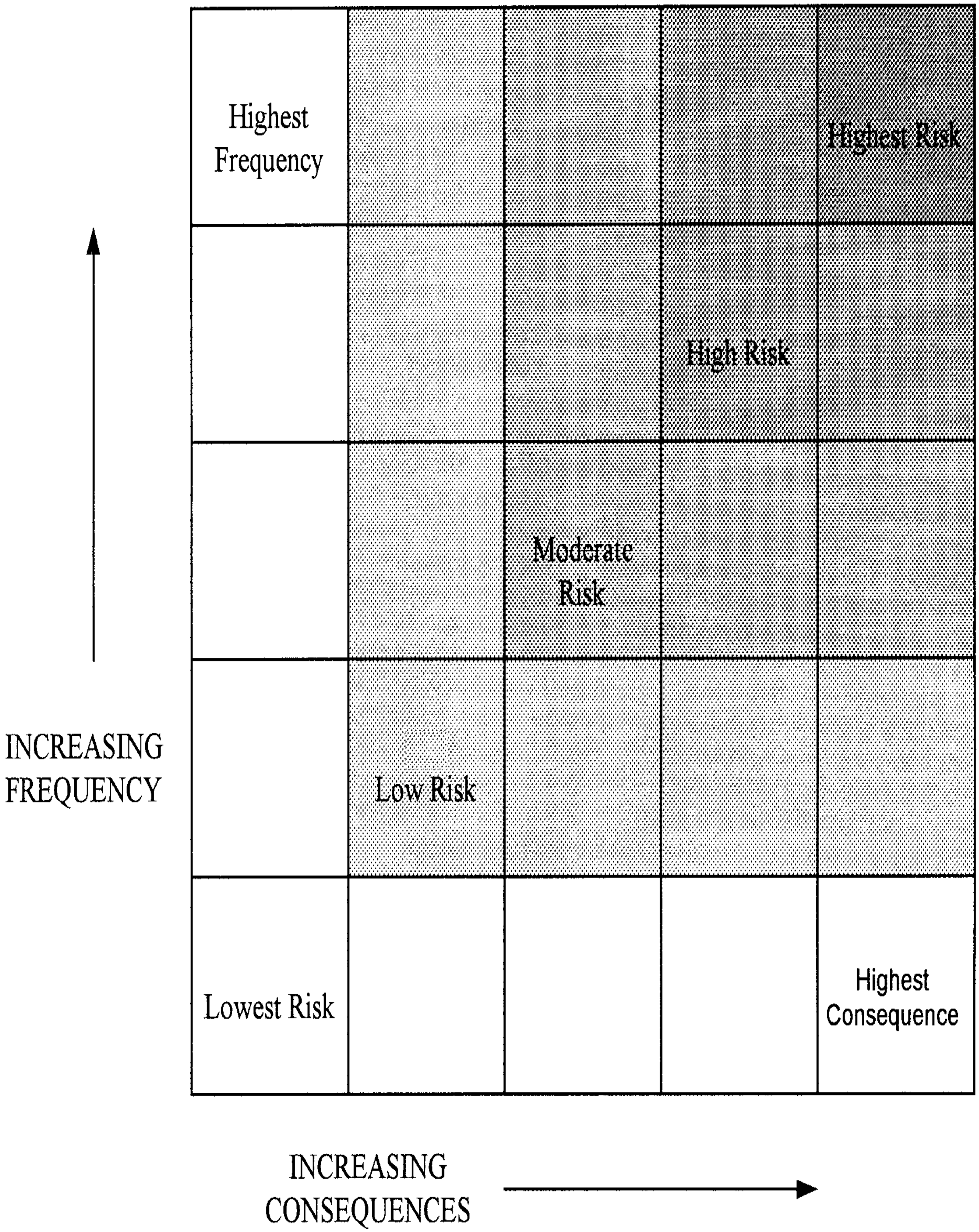


FIGURE G.5.4.4–1—*Location of the Los Alamos National Laboratory*.

reach the thinner stands of pinyon-juniper common to the lower parts of the canyons. There they come under control, by wind and weather changes, lack of fuel continuity, by human interference, or some combination of these. When there are sufficient trees on the canyon walls, fire climbs the walls and then ignites combustible structures and fuel at the canyon edges. It enters the townsite early on the fourth day after initiation.

An alternative fire scenario could have the fire initiate to the west of LANL and townsite in the Santa Fe National Forest of mixed conifer and ponderosa pine. This crown fire, similar to the Oso fire of 1998, travels downslope somewhat more slowly on a broad front. This fire spots only 1/4-mile or more in advance. The present, relatively narrow fuel break around the town and laboratory along State Road 501 would be overreached. This fire also would consume the ponderosa pine and combustible structures in continuous fuel areas over the same western part of LANL and townsite, and the fire would spread down the lengths of canyons until it encountered thin pinyon-juniper stands. It also could not be fought successfully because there is no access to the National Forest west and north of LANL and townsite, and because there is no north-south fuel break comparable to Pajarito Road where a control line can be established and defended. This alternative is not analyzed because the selected scenario is believed to maximize the exposure to the Los Alamos townsite from laboratory releases. The final acreage burned in both scenarios is on the order of 27,000 acres (10,900 hectares) of which about 8,000 acres (3,200 hectares) are within LANL boundaries.

On the LANL site, the fire is assumed to consume all combustible structures in its path that are evaluated as having moderate or higher risk from wildfire under the LANL Building Appraisal Program. The fire also exposes the surface of contaminated earth previously protected by vegetation in the firing sites and canyons. This text separately discusses the exposures from fire burning the soil cover and suspending the underlying soil, and the exposures from burning structures. Exposures from canyon fires are calculated individually, thus enabling the assessment of fires of lesser extent than the site-wide fire.

This accident analysis does not consider off-site damage directly caused by the flames and smoke from LANL fires, and does not address the direct effects of the fire on the townsite. It is recognized that there is continuous fuel joining the National Forest and the residential areas, and that fires in the canyons at LANL also could propagate into the townsite.

Wildfire Frequency

Conditions that Favor Wildfire. These scenarios are quite credible, in view of the present density and structure of fuel surrounding and within LANL and townsite, as well as the occurrence of three major fires in the past 21 years. Some protection is afforded LANL by the fire scars of the previous Dome and La Mesa fires, but there is ample fuel continuity remaining to bring an off-site wildfire to the southwest and western boundary of LANL.

The probability of high to extreme fire danger is determined by the frequency of meteorological conditions of low precipitation for 2 to 3 weeks preceding; low relative humidity for 3 consecutive days; and high temperatures. When the high to extreme fire danger exists in New Mexico in May through July, there are certain to be multiple ignition sources (from lightning, carelessness, and human causes). There is a high frequency of lightning and lightning-caused fires in the Jemez Mountains (Armstrong 1998). From 1975 to 1996, there were 372 fire starts (17.7 per year) in the 40,000 acres (16,000 hectares) of Santa Fe National Forest and Bandelier National Monument adjacent to LANL. Using as input the frequency of different sized fires, the PROBACRE model yielded a 30 percent probability of exceeding

5,000 acres (2,000 hectares) in a 5 year period (Armstrong 1998). Armstrong's calculation was made prior to the 1998 Oso fire, whose inclusion would increase the probability.

The frequency of a large fire encroaching on LANL is estimated as the joint probability of ignition in the adjacent forests, high to extreme fire danger, failure to promptly extinguish the fire, and a 3-day spell of southwesterly to westerly wind over 11 miles per hour (5 meters per second), low humidity, and no precipitation.

Determining the Joint Probability of Occurrence of Weather and Fire Danger Conditions. The probability of occurrence of the weather and fire conditions needed for this scenario were determined using wind data and fire danger data for April through June of 1980 through 1998. These months were chosen on the general knowledge that fire risk and frequency is greater in those months. Note that site-wide fires also are possible, but less probable, in other months besides April through June; thus, the annual frequency of fire-favorable weather is somewhat greater than quantified for April through June.

The fire danger was determined using Energy Release Component (ERC) data obtained from Bandelier National Monument (PC 1998b). The ERC is a component of the National Fire Danger Rating System, and the adjective ratings, such as "moderate" or "extreme," are determined from categories of the ERC, with higher values of the ERC representing conditions of higher fire danger. Above a threshold value of the ERC, the fire danger is "very high" and "extreme," and this threshold value was used to determine days of very high and extreme fire danger. Interpolation was performed to estimate for days when ERC data was missing.

In general, wind direction at any location varies and does not persist in a single direction for a few days. LANL is no exception. At LANL, persistent daytime winds are interrupted for a few hours when nighttime drainage winds occur. However, granting short interludes of drainage flow, there are many instances in which a dominant direction, such as southwesterly, westerly, northerly, etc., can exist for 3 days without precipitation.

For determining fire-favorable weather frequency, 15-minute average wind data from the 11.5-meter level of the TA–59 and TA–6 meteorological towers were used. For each day in April through June of 1980 through 1998, an average afternoon wind was calculated from the 15-minute data in order to eliminate local diurnal changes in wind speed and direction that are common to the area. Average afternoon wind speeds of greater than 10 miles (16 kilometers) per hour were chosen to represent strong winds. While this threshold may seem low for a strong wind, wind gusts of over 30 miles (48 kilometers) per hour and sometimes over 40 miles (64 kilometers) per hour were seen on most days when the afternoon average wind was above 10 miles (16 kilometers) per hour. The wind direction thresholds were set at 180° (southerly, meaning from the south) through 292.5° (west-northwesterly). Three-day periods from the same data set were then examined to determine if the ERC, wind speed, and wind direction fell above (or within) set thresholds. All 3-day periods falling within the set limits were then extracted.

The results show that it is not uncommon to see a 3-day period exhibiting the selected characteristics in a given year, and that when such a 3-day period appears, it is likely that more than one such period will occur within that year. Specifically, the resulting statistics show that of the 19 years examined, 5 of them displayed at least one 3-day period within the limits, or 1 every 4 years. Of these 5 years, 4 of them had an average of 3.6, 3-day periods. (An instance of 5 days in a row is counted as 3, 3-day periods.) This comes to 15.4 instances in 19 springs.

In summary, fire-favorable weather conditions occur on the order of once per year; the ignition sources are prevalent; and fire fighting is hampered by limited accessibility. Therefore, this analysis concludes that a major fire moving up to the edge of LANL is not only credible but likely, probably on the order of 0.1 per year. This frequency is the same for all alternatives.

Dispersion Meteorology

As noted, only certain meteorological conditions are compatible with such a fire. The meteorology of June 7 to 10, 1998, was selected for modeling the accident sequence because these dates were recognized as a recent time of serious fire danger to LANL. These conditions are regarded as conservative, in that in this period the wind is generally from LANL toward the nearby Los Alamos townsite and would result in higher total population doses. Santa Fe is much more distant, and concentrations would therefore be lower. Under northwesterly winds, exposures in Santa Fe (had the alternate scenario been used) would surely be less than exposures to the Los Alamos townsite from the southwesterly winds in this scenario.

Exposures at 100 meters distance from burning exposed soils are calculated using C stability and 6.6 feet (2 meters) per second wind speed. These exposures can be regarded as MEI exposures, although it is unlikely that anyone other than firefighters will be present at that distance. Exposures at 3,300 feet (1,000 meters) are also reported. In canyons, where elongated area sources exist, the calculation provides integrated exposure at 330 and 3,300 feet (100 and 1,000 meters) downwind of the long axis of the area, thus maximizing the exposure. This situation could occur with winds turning to follow the canyon profile, such as under drainage wind conditions. Thus, the calculation applies to plumes that are destined for any receptor within and beyond the contaminated sections of the canyons.

Soil Resuspension Following the Fire

Suspension by the wind of a fraction of the surface soil can occur following denuding of the vegetation. This has the potential of exposing workers returning to the area, as well as the transient public, until the situation has stabilized and vegetation has begun to recover. As proven by the continuing existence of soil and ash following a fire, the suspension of fire residue and of burned soil is very small compared to the bulk quantity that continues to remain. Only the loose material would be suspended, and, if the material is not mechanically disturbed, the rate of suspension would taper off. Even if precipitation halting the suspension did not occur, the wind direction would change many times so that the resuspended material would not be transported as effectively as that from the shorter term, initial release. Consequently, resuspension doses are only calculated for an individual standing directly on the contaminated area.

Large, brief suspensions for unweathered materials occur under mechanical disturbance, such as the passage of vehicles. This is highly dependent upon vehicle speed and wind speed (Figure 4-23, DOE 1994d). The highest, bounding resuspension rate is 1×10^{-2} per passage for a car driven directly through powder tracer material on an asphalt road (DOE 1994d). However, there are no asphalt roads and no fast vehicle traffic on the firing ranges, and most of the contamination is not near roads. Hence, suspension by vehicles will not be of this magnitude and is not included in this analysis. Rather, the direct suspension by the wind is analyzed.

A rate of resuspension is often expressed as the ratio of the airborne concentration and the areal surface contamination, usually with the units of meters^{-1}. This ratio is called the resuspension factor. Its magnitude depends upon the wind speed, particle size, and nature of the cover. The resuspension factor decreases with time due to weathering and downward migration of a portion of the contamination. Although most material remains in the surface soil, it becomes unavailable to the wind. Sehmel (1984) provides a substantive discussion of resuspension factors, their use, and limitations. Note, this concept strictly applies to the resuspension of material deposited from the atmosphere and applied to the soil as tracers in experiments and may not apply to material otherwise incorporated in the soil matrix. Most resuspension factors range from 10^{-5} to 10^{-11} per meter.

Note that the resuspension factor is not the fraction of the material that becomes airborne, and therefore cannot be treated as an airborne release fraction (ARF) or source term for dispersion models. Because of the way the resuspension factor is defined and measured, the concentrations apply only in the immediate vicinity (i.e., above) the contaminated soil. Concentrations beyond the area will be much lower, due to variations in the wind direction and atmospheric diffusion.

Although resuspension factors are highly irregular and poorly defined (Sehmel 1984), they were applied to evaluate residual concerns with reoccupying burned out contamination areas. A conservative resuspension factor of 1×10^{-5} meters^{-1} (sandy soil with charred debris) is selected for use in this analysis (from Section 4.4, Table 4-16, page 4-91, DOE 1994d). The fraction of the suspended contaminant that is respirable (less than 10 micrometers equivalent aerodynamic diameter) at the soil surface following the fire passage, is unknown. The particle size is likely to be large, as the contaminants will be attached to soil particles; but, because it is unknown, an RF of 1.0 is assumed. The appropriate time period for application of this conservative value is probably only a few days long, depending upon precipitation, because resuspension factors decrease by several orders of magnitude with time.

The resuspension factor of 1×10^{-5} meters^{-1} was applied to the mean areal soil concentration in the top layer of the contaminated sites, with the resultant radiological exposures shown in Table G.5.4.4.–1. These are the estimated exposures that could occur if all the contamination in the top soil layer were right at the surface, if there were no precipitation or soil cover, if there were wind, and if the receptor were standing above a spot that represented the average soil contamination for the contaminated portion of the site or canyon. These estimates are limited by the theoretical and experimental problems with resuspension factors.

In practice, before these known contamination areas would be reoccupied following a fire, the potential for exposure would be assessed and protective actions taken as appropriate to minimize exposure to the personnel.

Exposures from Burning Vegetation and Suspended Soil

Open Burn/Open Detonation Dispersion Model. During the burning of a vegetative cover, some fraction of the soil is entrained into the fire and transported and dispersed downwind. Such downwind concentrations of soil contaminants suspended by fire were calculated using the Open Burn/Open Detonation Dispersion (OBODM) model. The Open Burn/Open Detonation Dispersion Model (OBODM) is intended for use in evaluating the potential air quality impacts of the open-air burning and detonation of obsolete munitions and solid propellants at U.S. Department of Defense and DOE installations (DPG 1997). It can be used to calculate peak concentration, time-mean concentration, time-integrated concentration, and particulate deposition from multiple sources. It can consider instantaneous or quasi-continuous releases from point, volume, and/or line sources.

The model predicts buoyant rise of the plume from the burn and uses default mixing depths generally representative of noncoastal regions

TABLE G.5.4.4–1.—*Estimated Inhalation Doses from Resuspension Following Wildfire*

SITE	AREA (m^2)	TOTAL SOIL CONTAMINATION	MEAN SOIL SURFACE CONCENTRATION	AIR CONCENTRATION	INTAKE PER DAY[a]	EFFECTIVE DCF[b] (mrem/μCi)	RECEPTOR DOSE (mrem/day)
EF Site	11,690	675 kg DU	0.058 kg/m^2	5.8×10^{-7} kg/m^3	17.5 mg[c] 5.8×10^{-3} μCi	1.18×10^5	690
Phermex Site	11,690	568 kg DU	0.049 kg/m^2	4.9×10^{-7} kg/m^3	14.7 mg[c] 4.9×10^{-3} μCi	1.18×10^5	579
Potrillo Canyon	1,200	58 kg DU	0.048 kg/m^2	4.8×10^{-7} kg/m^3	14.6 mg[c] 4.9×10^{-3} μCi	1.18×10^5	575
Mortandad Canyon	13,600	4.7×10^9 pCi mixed	3.4×10^5 pCi/m^2	3.44 pCi/m^3	1.0×10^{-4} μCi	1.58×10^5	16.4
DP Canyon	3,600	1.6×10^7 pCi TRU	4,480 pCi/m^2	0.044 pCi/m^3	1.4×10^{-6} μCi	4.34×10^5	0.58
Los Alamos Canyon	18,900	1.2×10^8 pCi TRU	6,560 pCi/m^2	0.066 pCi/m^3	2.0×10^{-6} μCi	4.33×10^5	0.86
Acid Canyon	100	1.6×10^7 pCi TRU	1.6×10^5 pCi/m^2	1.64 pCi/m^3	5.0×10^{-5} μCi	4.35×10^5	21.6
Pueblo Canyon	28,500	2.5×10^8 pCi TRU	8,912 pCi/m^2	0.089 pCi/m^3	2.7×10^{-6} μCi	4.3×10^5	1.2

Notes:
[a] The breathing rate used is 30.24 m^3/day.
[b] The effective dose conversion factors are for the mixture of nuclides at each firing site and canyon.
[c] These intakes of uranium would exceed the OSHA PEL of 0.25 mg per 8 hours.

in the western United States. The minimum meteorological input consists of wind speed and direction at 10 miles elevation, air temperature, and the Pasquill stability category or the Net Radiation Index. For OBODM wildfire calculations, a conservative stability and wind speed (category C and 2 meters per second at 10 miles height) were selected to maximize the downwind exposures. A stable atmosphere would not represent the mixing conditions in the daytime meteorological situations favorable to a wildfire, and could not exist in the presence of the wildfire.

Vegetation Fire Plume Rise. The OBODM model calculates the plume rise given a fuel loading, rate of burn, and heat content of the fuel. It calculates the resulting concentration distribution at specified receptor points. The fuel model classes and associated rates of burn (defined pursuant to Anderson 1982) were determined by field survey (PC 1998c) and are given in Table G.5.4.4–2.

Caloric values of various terrestrial food plants and seeds are 4.5 to 5.2 cal/gm (Odum 1971). The heat content of dead cellulosic materials does not vary greatly (Simard et al. 1989). For this analysis, the heat content of both grass and of wood were assumed to be 4.95 cal/gm (20.7 J/gm) (Wilgen et al. 1990). The fuel models contain the sum the dead and live vegetation in various conditions of dryness and have an associated rate of fire spread. The range of uncertainty in the fuel load is large enough that the uncertainty in the moisture content, heat content, and rate of burn is not material. The total heat produced is used only to calculate the plume rise, which has only a modest effect on concentrations at moderate to large distances from the source.

Areas of Contaminated Soil Analyzed. The areas of contaminated soil were identified as PHERMEX Firing Site and EF Firing Site in TA–15, Potrillo Canyon (from runoff at the EF Firing Site), DP Canyon and Los Alamos Canyon below TA–21, and Mortandad Canyon below and east of TA–35. The radioactive waste lagoon at the end of TA–35 has cattails in it, but contains water. Acid Canyon received untreated waste water until 1953, then treated waste water until 1963. It has been cleaned up, but residual contamination still shows up in the Acid Weir sediment trap. The area of contamination in Acid Canyon is estimated as 3.3 feet wide by 330 feet long (1 meter wide by 100 meters long) (PC 1998d). Acid Canyon empties into Pueblo Canyon, which also is of low concentrations. Other, numerous contaminated areas that have been covered with clean soil are not at risk of suspension during and following wildfire and therefore were not evaluated. Ten Site Canyon below the Radioactive Liquid Waste Treatment Facility in TA–50 was not evaluated, as its contamination is primarily strontium-90, which has a lower dose conversion factor than plutonium and because it has such low concentrations that it is no longer sampled (PC 1998e).

The contamination levels were obtained from several publications, as identified at various places in this text and in the summary Table G.5.4.4–2. To be conservative, the total amount in the upper tier of sampled soil, usually 0 to 1 or 0 to 3 inches (2.5 or 7.6 centimeters) depth, were assumed to be entirely on the surface and exposed to the fire.

Airborne Release Fractions During Vegetation Fires. The model OBODM requires as input the fraction of contamination present in the fuels being burned. For these calculations, the ratio of this suspended contamination to the mass of fuel burned over the same area was presented to the model. To get this ratio, the mass of contamination suspended during the fire passage is the product of the contamination in the top layer of surface soil and the release fraction. For this assessment, all the contamination in the top layer of soil is assumed to be released with the release and respirable fraction (ARF x RF) appropriate to uranium metal under thermal stress.

For contamination in the soil, duff and litter, the burning temperature is going to be low and the burning time short, with the fire front progressing at 0.2 to 0.44 meter per second in timber and grass, respectively. The possibility of shrapnel in trees is recognized. However, there are few trees around the firing sites, and the release fraction from burning DU is small. Uranium is not capable of continued burning after the fire has departed, and so the burning release time would be short. The ARF x RF for uranium metal under thermal stress is taken from DOE 1994d, Section 4.2.1.2.1, page 4-42. The observed geometric mean ARF x RF is 1 x 10^{-4}, with a 95 percent confidence level ARF x RF of 4 x 10^{-4}. In this analysis, the value 4 x 10^{-4} also is used for beryllium and its compounds in the absence of experimental data dealing directly with beryllium. There are no release fractions available for radionuclides other than plutonium and uranium in the DOE-HDBK-3010-94 (DOE 1994d) or in the Nuclear Fuel Cycle Facility Accident Analysis Handbook NUREG/CR-6410 (NRC 1998). The bounding ARF x RF for powders subjected to thermal stress are 6 x 10^{-5} for nonreactive compounds and 1 x 10^{-5} for reactive compounds (DOE 1994d, Section 4.4.1, page 4-61). For consistency, the conservative ARF x RF of 4 x 10^{-4} also was used for other nuclides in contaminated soils.

Contamination in Plants and Animals. Small mammals have tissue/soil uranium ratios of 10^{-3} and 10^{-4} (Miera et al. 1980), and tissue/soil cesium and strontium ratios on the order of 1.0 (Whicker and Schultz 1982, Table 17). (It is unclear whether these ratios are wet or dry weights in the animals, plants, and soils.) For the reasons of their low concentration ratios, their escape ability, and their very small total mass compared to that of the vegetation, animals are ignored as a source of airborne nuclides in this analysis.

The NRC has published a list of plant/soil concentration ratios (NRC 1977). The ratios for stable strontium and cesium are 0.017 and 0.01, respectively, although there will be cases where observed values differ substantially (Whicker and Schultz 1982). Whicker and Schultz stated that the ratios for uranium range from 10^{-4} to over 10^{-1}, that ratios for plutonium are particularly dependent on chemical form, and that ratios for americium are perhaps 100-fold higher than plutonium. Plants growing where uranium concentrations in surface soils were 20 times to 3,500 times background, have exhibited uranium concentration factors of 0.05 (spring) to 0.08 (fall). Late fall standing dead vegetation at the EF site averaged 320 micrograms uranium per gram of dry vegetation (Miera et al. 1980). Applying this observation, the 1,987 kilograms of vegetation at the EF site would contain 0.64 kilogram of depleted uranium, all of which would presumably become airborne in the fire. Application of the ARF of 4 x 10^{-4} to the EF site soil would produce 0.27 kilogram of airborne depleted uranium. Thus, the dose from burning vegetation could contribute 2.37 times the dose from the suspended soil, and the doses could be 3.37 times the value given for soil alone in the final column of Table G.5.4.4–2.

Wenzel et al. (1987) studied radionuclide concentrations in soil, litter, and vegetation growing in a TRU waste area, and concluded that a higher resolution sampling is needed for cesium-137 and plutonium-239/plutonium-240 to interpret surveillance results and produce reliable risk assessments. Their observations, suggest that the concentrations of these nuclides, and of depleted uranium, in vegetation is always less than the concentrations in the top 0.8 inch (2 centimeters) of soil, and generally an order of magnitude less.

Thus, it is concluded that the doses in the final column of Table G.5.4.4–2 could be increased by a factor of three or four to account for the contamination in the vegetation above ground that becomes airborne.

Beryllium Exposures. The 8-hour time weighted average for worker exposure to

TABLE G.5.4.4–2.—*Summary Table for Contaminated Soil Areas*

SITE	PHYSICAL DIMENSIONS	MEAN SOIL CONTAMINATION	FUEL TYPE FUEL MODEL	BURN RATE	FUEL LOADING	RECEPTOR DOSE AT 100 m AND 1,000 m
EF Site[a]	200 ft/61 m radius 11,690 m^2	542 ppm area-weighted uranium[b]; 675 kg total	Grass Fuel Model 1	78 chain/hr (0.44 m/s)	1,987 kg; 0.74 ton/ acre (0.17 kg/m^2)	0.21 mrem (0.01 mrem)
PHERMEX Site[a]	200 ft/61 m radius 11,690 m^2	456 ppm area-weighted[b]; 568 kg total	Grass Fuel Model 1	78 chain/hr (0.44 m/s)	1,987 kg; 0.74 ton/ acre (0.17 kg/m^2)	0.18 mrem (0.008 mrem)
PHERMEX Site[c]	200 ft/61 m radius 11,690 m^2	Simple average 31.7 ppm Beryllium in 0 to 3 inch soil depth[d]	Grass Fuel Model 1	78 chain/hr (0.44 m/s)	1,987 kg; 0.74 ton/ acre (0.17 kg/m^2)	0.8 $\mu g/m^3$ (0.0005 $\mu g/m^3$)[i]
Potrillo Canyon[e]	4 m x 300 m 1200 m^2	58 kg uranium 0 to 15 cm depth	PIPO-Canyon Fuel Model 2	35 chain/hr (0.20 m/s)	566 kg; 2.1 ton/ acre (0.47 kg/m^2)	0.0016 mrem (3.5 x 10^{-4} mrem)
Mortandad Canyon[g]	4 m x 3,400 m 13,600 m^2	Surface inventory of 4.7 x 10^9 pCi of mixed nuclides	PIPO-Canyon Fuel Model 2	35 chain/hr (0.20 m/s)	6,415 kg; 2.1 ton/ acre 0.47 kg/m^2	4.7 x 10^{-4} mrem (3.6 x 10^{-5} mrem)
DP Canyon[f,g]	3 m x 1,200 m 3,600 m^2	1.6 x 10^7 pCi TRU surface inventory	PIPO-Canyon Fuel Model 2	35 chain/hr (0.20 m/s)	1,700 kg; 2.1 ton/ acre (0.47 kg/m^2)	2.8 x 10^{-4} mrem (1.6 x 10^{-4} mrem)
Los Alamos Canyon[g]	3 m x 6.3 km 18,900 m^2	1.2 x 10^7 pCi of TRU surface inventory	PIPO-Canyon Fuel Model 2	35 chain/hr (0.20 m/s)	8,920 kg; 2.1 ton/ acre (0.47 kg/m^2)	1.5 x 10^{-7} mrem (1.4 x 10^{-7} mrem)
Acid Canyon[g,h]	1 m x 100 m 100 m^2	16.4 x 10^6 pCi of TRU surface inventory	PIPO-Canyon Fuel Model 2	35 chain/hr (0.20 m/s)	47.2 kg; 2.1 ton/ acre (0.47 kg/m^2)	4.1 x 10^{-5} mrem (3.0 x 10^{-6} mrem)
Pueblo Canyon[g]	3 m x 9.5 km 28,500 m^2	2.5 x 10^8 pCi of TRU surface inventory	PIPO-Canyon Fuel Model 2	35 chain/hr (0.20 m/s)	13,450 kg; 2.1 ton/ acre (0.47 kg/m^2)	2.2 x 10^{-8} mrem (2.0 x 10^{-8} mrem)

[a] Data from DOE 1995a Appendix D.
[b] 456 ppm and 542 ppm area-weighted average depleted uranium in 0 to 3 inch depth of surface soil of density 1.4 g/cm^3 yield 568 kg and 675 kg depleted uranium.
[c] Data from Fresquez 1994, results of the soil sampling survey conducted over active RCRA firing site TA–15–184 (PHERMEX).
[d] Simple average concentration in surface soil of density 1.4 g/cm^3.
[e] Data from Miera et al. 1980.
[f] Width and length from PC 1998f.
[g] Data from Environmental Surveillance Reports (ESR) for 1992 (LANL 1994e), 1995 (LANL 1996r), and 1996 (LANL 1997c).
[h] Data from Acid Weir site, Table 5-14 of ESR 1996.
[i] For beryllium, rather than the TEDE or integrated concentration, the peak concentration is provided for comparison to standards. The acceptable maximum peak for a maximum of 30 minutes is 25 $\mu g/m^3$ (NIOSH 1997).
[j] Due to the very long line source oriented down the canyon and the wind blowing down the canyon, dose does not change much with distance down the canyon. In fact, at 10,000 m in Los Alamos Canyon, the dose is effectively the same as at 1,000 m.

beryllium and its compounds is 0.002 milligram per cubic meter. The acceptable maximum peak for a maximum duration of 30 minutes is 0.025 milligram per cubic meter (NIOSH 1997). These are not thresholds that will protect all people but are useful for comparison to the concentrations from burning over the PHERMEX site. The beryllium concentrations calculated by OBODM (Table G.5.4.4–2) were 0.0008 milligram per cubic meter, much less than these thresholds.

Conclusions as to Doses Downwind from Firing Sites and Canyon Fires. The doses at 330 feet and 3,300 feet (100 meters and 1,000 meters) downwind from fires over individual firing sites and canyons are provided in Table G.5.4.4–2. The doses assume that the receptor remains at those locations for the full time of the plume passage. This can be a long time, as the fire front advances at about 0.7 foot per second (0.2 meter per second) in the canyon timber. At this speed, the fire takes 13.5 hours to burn the contaminated area of Pueblo Canyon, 8.9 hours for Los Alamos Canyon, 4.8 hours for Mortandad Canyon, and 1.7 hours for DP Canyon, but only 0.42 hours for Potrillo Canyon and 20 minutes for the EF site.

The largest doses from the vegetation fires are at 330 feet (100 meters) downwind of the firing sites, EF (0.21 millirem), and PHERMEX (0.18 millirem). The 5×10^{-7} LCF per millirem risk factor can be applied to the doses in Table G.5.4.4–2, to receive assurance that there are no effects expected from the radiological exposures from burning vegetation and ground cover over soils. If the total area of contamination is small, such as for the firing sites and Acid Canyon, then the same values would apply for any wind direction. For the other canyons, however, the exposure is integrated for the entire length of the canyon fire, and so the exposure to the side of the canyon would be less than given in Table G.5.4.4–2.

Because the canyons are parallel, a receptor cannot be directly downwind from more than one canyon, and hence, the exposures from multiple canyons should not be added to obtain a new MEI dose. In order for a receptor to receive exposure from multiple canyons, the wind would have to be transverse to them, as it would be in this site-wide fire with the southwesterly winds. However, if the wind were transverse to multiple canyon fires, the orientation of the canyons would assure that the dose from each would be much less than those shown at 100 meters distance in Table G.5.4.4–2. One must conclude that, no matter the orientation of the wind, sources, and receptors, the MEI dose from site-wide vegetation fires must be less than 1 millirem.

Delayed Emissions Following Building Fire

The smoke or emissions from building remains following the fire passage were not modeled. The entrainment of surrounding air by strong fires will capture much of the delayed emissions that occur soon after passage of the fire front, converting them into an elevated release as part of the main fire. However, in the LANL landscape there may not be an intense, continuous fire front; hence, some of the contaminants in the surface emissions may travel and disperse at low elevations. The relative amount of the contaminant that is and is not entrained into the main fire plume cannot be evaluated.

Evaluation of Building Fires

This section analyzes potential individual and population radiological and chemical exposures from buildings burning as a result of wildfire initiation. Each building was first screened for its vulnerability to wildfire. Those that were evaluated as vulnerable were then screened for chemical and radiological inventories. For those with significant inventories, the doses from the fires were then obtained from previous fire analyses (such as in SARs or this SWEIS) or newly calculated using the MACCS code.

Criteria and Process for Determining Building Vulnerability to Wildfire. The evaluation of vulnerability to wildfire is on the basis of building construction, materials and exposure, slope, and the quantity and structure of external fuel as described below. The total wildland fire vulnerability was calculated for this SWEIS by the LANL Fire Protection Group. The vulnerability is the product of the structure hazard times the sum of the fuel hazard and slope hazard, as defined below.

The Structure Hazard Rating considers the combustibility of the exterior structure:

- Underground—0
- Noncombustible exterior (windowless)—1
- Noncombustible (window exposures)—2
- Combustible exterior—3

Fuel Hazard. This is the product of two components, fuel loading and distance factor. The fuel loading is taken as zero for short grass and asphalt, and for other conditions is determined by the fuel model type, as described in *Aids to Determining Fuel Models For Estimating Fire Behavior* (NWCGP 1982).

The distance factor, DF, expresses the distance of the fuel from the structure.

- DF—0, distance is greater than 4 times the height of the fuel.
- DF—1, distance is greater than 2 times the height of the fuel.
- DF—2, distance is the height of the fuel.
- DF—3, distance is less than 1/2 the height of the fuel.

Slope Hazard. Exposing slopes are rated as follows:

Slope Hazard	Slope
5	Mild (0 to 5%)
10	Moderate (6 to 20%)
15	Steep (21 to 40%)
20	Extreme (41% and greater)

The total vulnerability is then calculated as the product of the structure hazard times the sum of the fuel hazard and slope hazard. This number is converted to a word description as follows:

Numerical rating	Vulnerability
0 to 5	None
6 to 49	Very Low
50 to 79	Low
80 to 149	Moderate
150 to 259	High
260 and above	Extreme

Note that this LANL system does not provide a probability that a wildfire will approach the building, or that any particular building **will** burn in a fire. Rather, it sorts which buildings are more likely to be damaged or destroyed should a wildfire approach. Table G.5.4.4–3 lists the buildings that have a moderate or higher risk, have also been assigned a hazard category in the publication LANL 1998a, and were subsequently evaluated for public exposure from wildfire. Other buildings have no significant amounts of MAR and were not evaluated for this accident analysis.

For each building that has a moderate or higher vulnerability and appears in LANL 1998a, a determination was next made as to whether further analysis of public exposure was needed. Table G.5.4.4–4 provides the results. Some buildings were eliminated based on updated inventories, as having no significant inventories, or an inventory that was present only for brief periods. These determinations appear in the columns headed "Comments and EIS Assessment." The comments column

TABLE G.5.4.4–3—*Evaluation of Vulnerability of LANL Buildings to Wildfire*

TECHNICAL AREA	BUILDING	WILDLAND RISK	NUCLEAR FACILITY	HAZARDS	CONST. TYPE	COMMENTS, AND TENTATIVE INVENTORY PENDING VERIFICATION
TA–02	44	Moderate	No	Rad	1	
TA–02	49	Extreme	No	Rad	3	Cooling Tower
TA–03	130	Moderate	Yes	Rad	2	
TA–03	16/208	High	No	Rad	2	
TA–03	494	Moderate	No	Rad	2	
TA–03	66/451	High	Yes	Rad, Chem	2	Nitric acid, fuming (6,484 lbs.), hydrochloric acid (3,130 lbs.), hydrofluoric acid 48 to 51% (490 lbs.)
TA–08	65	Moderate	No	Rad	1	
TA–08	70	Moderate	Yes		2	
TA–15	183	Moderate	No	Rad	2	
TA–16	205	Moderate	Yes	Rad	2	
TA–16	248	Moderate	No		2	
TA–16	255	High	No		3	Exposes 16 to 205
TA–16	414	Moderate	No	Rad	2	
TA–16	459	High	No		3	Exposes 16 to 205
TA–18	32	Moderate	Yes	Rad	2	
TA–21	155	Moderate	Yes	Rad	2	
TA–21	209	Extreme	Yes	Rad, Chem	2	
TA–21	61	Moderate	No		2	
TA–35	110	High	No	Rad	3	
TA–35	213	High	No	Rad, Chem	2	Nitric acid (406 lbs.)
TA–41	2	Moderate	No		2	
TA–41	30	Moderate	No		2	Outside rad storage
TA–41	4	Moderate	No		2	
TA–43	1	Extreme	No	Rad, Chem	2	Hydrochloric acid (483 lbs.)
TA–46	208	Moderate	No	Rad	3	
TA–46	217/218	Moderate	No		3	Exposes 46 to 75
TA–48	1	Moderate	No	Rad, Chem	2	Sulfuric acid 14% (2,400 lbs.), hydrogen fluoride solution (663 lbs.), chlorine (223 lbs.)

TABLE G.5.4.4–3—*Evaluation of Vulnerability of LANL Buildings to Wildfire*-Continued

TECHNICAL AREA	BUILDING	WILDLAND RISK	NUCLEAR FACILITY	HAZARDS	CONST. TYPE	COMMENTS, AND TENTATIVE INVENTORY PENDING VERIFICATION
TA–48	45	Moderate	No	Rad, Chem	2	Nitric acid (1,812 lbs.), hydrochloric acid (545 lbs.), hydrofluoric acid (23 lbs.). Bldg. not in LANL 1998a
TA–51	11	Moderate	No	Rad	2	
TA–51	12	Moderate	No	Rad	2	
TA–53	1	Moderate	No	Rad	2	
TA–53	3	Moderate	No	Rad, Chem	2	
TA–53	Rad Waste Lagoon	Moderate	No	Rad	2	
TA–54	153	Moderate	No	Rad	3	
TA–54	215	Moderate	No	Rad	3	
TA–54	224	Moderate	No	Rad	3	
TA–54	226	Moderate	No	Rad	3	
TA–54	229	High	No	Rad	3	
TA–54	230	High	No	Rad	3	
TA–54	231	Moderate	No	Rad	3	
TA–54	232	Moderate	No	Rad	3	
TA–54	283	Moderate	No	Rad	3	
TA–54	33	High	No	Rad	3	
TA–54	48	Moderate	No	Rad	3	
TA–54	49	Moderate	No	Rad	3	
TA–54	Area G, Pad 2	Moderate	No	Rad	3	
TA–55	107	Moderate	No		3	
TA–59	118	High	No		3	
TA–59	119	High	No		3	
TA–59	32/33/34	Moderate	No		3	
TA–59	35/36/37	Moderate	No		3	

Notes: For construction type, 0 = Underground, 1 = Noncombustible/Windowless, 2 = Noncombustible, 3 = Combustible.

TABLE G.5.4.4–4—*Final Vulnerability and Consequence Assessment of Building Wildfires*

TECHNICAL AREA	BLDG. NO.	FACILITY NAME	COMMENTS	SWEIS ASSESSMENT
TA–02	4	Laboratory Storage Building, OWR	Former Facility Manager stated that no residual contamination exists in this building, and it would not add contaminants to the plume during a wildfire.	Eliminated based on no residual contamination or inventories.
TA–02	44	Laboratory Storage Building OWR	Former Facility Manager stated that two resin exchange columns exist in this building, and samples could be collected and analyzed to determine the amount of contamination that currently remains in the ion exchange columns. He indicated that the remaining contamination would be very small and may contain cobalt-60.	No data available and therefore could not be analyzed. Public exposures from the small inventory would be bounded by other building fires. Facility is scheduled for disposal.
TA–02	1	Omega West Reactor (OWR)	Former Facility Manager stated that reactor systems were flushed and analyzed as part of the decontamination and decommissioning process, the cooling systems are dry, the reactor vessel or housing is still radioactive, but is encased in a stainless steel vessel that should not burn.	Fuel has been removed; Reactor is in the process of completing any decontamination and decommissioning activities; eliminated based on no wildfire risk to inventory
TA–03	66/451	Sigma Building	130 kg of fines in oil, plus 100 electrodes each 1/4 inch thick by 8 inch by 4 ft. long. Remainder of 65,000 kg of DU is in fixed storage cabinets of 1/2 hour fire resistance. All material is in the basement. Information from facility walkdown conducted by GRAM, Inc. (Garvey 1998) nitric acid, fuming (6,484 lbs.), hydrochloric acid (3,130 lbs.), hydrofluoric acid 48 to 51% (490 lbs.).	The maximum dose from the inventory of 65,000 kg calculated for this scenario was 3.0×10^{-5} rem 50 yr. committed effective dose equivalent (EDE) at approximately 10 km from the release point (Young 1998). Chemicals below grade level and not likely to be affected by fire.
TA–08	24	Isotope Building	The facility is used only intermittently for storage of radioactive material; operations, in the event of a wildfire, would not be conducted or would be terminated and material would not be stored in this facility.	Eliminated based on the intermittent use of the facilities
TA–08	70	Nondestructive Test		Eliminated based on the intermittent use of the facilities

TABLE G.5.4.4–4—*Final Vulnerability and Consequence Assessment of Building Wildfires*-Continued

TECHNICAL AREA	BLDG. NO.	FACILITY NAME	COMMENTS	SWEIS ASSESSMENT
TA–15	203/213	PHERMEX Cavity Shelter	There is no known residual contamination or inventory of radioactive material in this building.	Eliminated based on no residual contamination or inventories
TA–15	313	Radiographic Support	Radiation is only present when machine is operating. Concrete blocks surround equipment; therefore, the equipment would not be at risk in a wildfire.	Eliminated based on no residual contamination or inventories of radioactive material
TA–16	205	Weapons Engineering Tritium Facility (WETF)	100 g, tritium in process; vault storage: 60 g in tubs, 1,200 g in Lp-50 Containers. Information from facility walkdown conducted by GRAM Inc. (Garvey 1998) March 2, 1998 FSAR available, No SER.	The maximum dose (MEI) was calculated as 0.25 rem at 4.85-km distance. Doses are less at shorter distances due to the plume rise. The population dose is 189 person-rem within the 80.5-kilometer (50-mile) radius. (Young 1998)
TA–18	32	Critical Assembly Building	All three kivas are concrete construction, and materials are contained in a concrete vault within the kivas.	Eliminated based on no wildfire risk to the inventories
TA–21	155	Tritium Science Test Assembly (TSTA)	200 g tritium. Information from facility walkdown conducted by GRAM Inc. (Garvey 1998).	The RAD–05 aircraft crash and fire accident consequences from a 200 g release of tritium oxide were 24 person-rem population exposure and mean MEI dose of 0.012 rem at State Road 5 (360 m). These consequences are 25% less under the Reduced Operations Alternative.
TA–21	209	Tritium Science and Fabrication Facility	100 g tritium Information from facility walkdown conducted by GRAM Inc. (Garvey 1998).	Scaling of the RAD–05 aircraft crash and fire accident consequences to a 100 g release of tritium in oxide form results in 12 person-rem population exposure and mean MEI dose of 0.006 rem at Route 502 (360 m).
TA–35	213	Target Fabrication	1 kg beryllium; 10 lbs. boron trichloride; 5 lbs. (solid), 8 kg (solutions) cyanide; 3 lbs. diborane, 3 l. formaldehyde, 4 lbs. metal carbonyls, 171 l nitric acid, 1 lb. phosphene, 20 Ci tritium, 10 kg U-235 Information from facility walkdown conducted by GRAM Inc. (Garvey 1998).	There would be only a very small dose, as 20 Ci is a 1/10 the inventory of the RAD–05 accident, and the TA–35 source is further from the townsite than is the TA–21 source. The chemical inventories are small and therefore not modeled.

TABLE G.5.4.4–4—*Final Vulnerability and Consequence Assessment of Building Wildfires*-Continued

TECHNICAL AREA	BLDG. NO.	FACILITY NAME	COMMENTS	SWEIS ASSESSMENT
TA–41	4	Experimental Science Laboratory Building	Approximately 0.02 g tritium (about 200 Ci) as residual contamination.	The RAD–05 aircraft crash and fire accident consequences from a 200 g release of tritium in oxide form at TA–21 were 24 person-rem population exposure and mean MEI dose of 0.012 rem at Route 502 (360 m).
TA–43	1	Health Research Laboratory	30 liters formaldehyde Information from facility walkdown conducted by GRAM, Inc. (Garvey 1998).	Evaluated in the SWEIS earthquakes. The ERPG–2 and ERPG–3 distances were 0.17 and 0.1 miles (0.27 and 0.16 km), respectively, under conservative daytime dispersion conditions. The number of people exposed to greater than ERPG–2 and ERPG–3 were 11 and 6, respectively.
TA–48	1	Radiochemistry Laboratory	See BIO for TA–48, approved 3/31/97.	Dissolving wing fire (Scenario 2) 0.3 mrem at 720 m, Alpha wing fire is 5.4 mrem at 720 m or at the Royal Crest Trailer Park. The whole facility fire is postulated to be 50 mrem. Chemical exposures at this location are less than ERPG-2.
TA–53	1	Laboratory Accelerator Building		Eliminated based on unavailability of the small inventory to wildfire, per walkdown provided by Chris Del Signore
TA–53	3	Linear Accelerator Building		Eliminated based on unavailability of the small inventory to wildfire, per walkdown provided by Chris Del Signore
TA–54	153, 224, 226, 229, 230, 231, 232, 283, 33, 48, 49, and Pad 2	Waste drum preparation, and domes	Evaluated in RAD–08.	The consequences of the aircraft-initiated fire in RAD–08 were 400 person-rem population exposure, and a mean MEI dose of 22 rem at both White Rock and Pajarito Road.

contains suspected inventories, pending verification.

Public Exposures from Burning Buildings. Those building fires with integrated population and MEI inhalation exposure from burning buildings are also presented in summary Table G.5.4.4–5. Analyses already existed for some buildings in SARs and elsewhere in this SWEIS, such as the case for the aircraft crashes and fires in TA–21 and TA–54, identified as RAD–05 and RAD–08. The exposures assume no sheltering inside buildings or vehicles and that no protective actions are taken by the individual at those locations. Although Area G is not in the direct path of the fire, it borders a canyon and could be victim to a canyon fire even in the absence of a site-wide fire. Therefore, it also has been included in the wildfire analysis. The reader may evaluate the consequences of a partial site-wide wildfire and/or canyon fires by selecting individual canyons from summary Table G.5.4.4–2 and individual facilities from Table G.5.4.4–4 for summation.

Vulnerable buildings and the outdoors in the fire path were screened for their chemical inventories. No new inventories were found that were not available for the analysis of the site-wide earthquake (sections G.5.4.1 and G.5.4.2). For fire-vulnerable facilities, the earthquake chemical results were accepted for the site-wide fire, and entered into Table G.5.4.4–4. Note that, whereas the chemical releases in the earthquake were at ground level, the chemicals in the plume from the fire would be at higher elevations, and the concentrations at ground level would be much less.

Note that the meteorology used for dispersion in the different SARs and for the radiological accidents RAD–05 and RAD–08 in this SWEIS are not the same as that posed for this wildfire. The SARs use more conservative dispersion with low wind speed and stable conditions and will have a higher dose than if they had used wildfire meteorology. The wildfire has significantly stronger wind and a neutral or unstable atmosphere, strongly affected by the fire itself. The SWEIS uses representative meteorology for an entire year and presents a mean MEI (section G.2.4). The representative meteorology includes winds blowing away from any receptor, and the full range of stabilities, weighted by frequency of occurrence. The wildfire meteorology would possibly result in the same dose to the MEI and population as does the mean meteorology because it may be close to the annually typical stability and wind speed. It was concluded that, due to the magnitude of the doses and the conservative assumptions in the wildfire scenario, and the uncertainty of the population distribution during the fire, new calculations were not warranted for RAD–05 and RAD–08.

There are no differences in wildfire frequency among the alternatives. The consequences do not vary with alternatives, except that the inventory and consequences are reduced by 25 percent in RAD–05 under the Reduced Operations Alternative.

Population Exposures

The following information on the exposed population is based upon the Los Alamos County Emergency Plan and the LANL Closure Plan (PC 1998f). In the event of a wildfire approaching from the south, LANL would begin evacuation of the southern area of LANL as soon as it was determined that the fire posed a threat, and proceed north with the evacuation. Personnel deemed essential to shutdown operations would remain until such actions were completed. Some emergency response personnel and security personnel would remain at all times in some areas. There are 10,200 LANL employees (including contractors), of which approximately 4,000 live outside of Los Alamos County and 6,200 within Los Alamos County. The main hill Road 502 will evacuate 800 cars per hour, and the combination of the

TABLE G.5.4.4-5—*Consequence Summary for Building Fires*

TECHNICAL AREA	BUILDING NUMBER	FACILITY NAME	SWEIS ASSESSMENT
TA–03	66/451	Sigma Building	The maximum dose calculated for this scenario was 3 x 10^{-5} rem 50 yr. committed effective dose equivalent (EDE) at approximately 10 km from the release point.
TA–16	205	Weapons Engineering Tritium Facility	The maximum dose (MEI) was calculated as 0.25 rem at 4.85-km distance. Doses are less at shorter distances due to the plume rise. The population dose is 189 person-rem within the 80.5-km (50-mile) radius.
TA–21	155	Tritium Science Test Assembly (TSTA)	Release of 200 grams of tritium oxide, resulting in population dose of 24 person-rem, and a mean MEI dose of 0.012 rem at State Road 502 (360 meters). These consequences are 25% less under the Reduced Operations Alternative.
TA–21	209	Tritium Science and Fabrication Facility	MEI dose of 0.006 rem at State Road 502 (360 meters) and 12 person-rem population dose.
TA–43	1	Health Research Laboratory	ERPG–2 and ERPG–3 distances are 0.17 and 0.1 miles (0.27 and 0.16 km) respectively. The number of people exposed to formaldehyde at greater than ERPG–2 and ERPG–3 are 11 and 6, respectively.
TA–48	1	Radiochemistry Laboratory	MEI dose from the entire building fire is 50 mrem at the Royal Crest Trailer Park. Chemical exposures at this location are less than ERPG–2.
TA–54	153, 224, 226, 229, 230, 231, 232, 283, 33, 48, 49, Pad 2	Waste Drum Preparation, and domes	Total population exposure 400 person-rem, and mean MEI of 22 rem at both White Rock and Pajarito Road.

East Jemez and Pajarito roads will evacuate another 800 cars per hour.

In a realistic scenario, evacuation of the town begins when the fire is well into the LANL site, but is impeded because of panic, accidents, and the very limited road system, including the closure of Pajarito Road. Some fraction of the population refuses to leave, and a significant number are relocated to the eastern edge of the town where there is less fuel load. Los Alamos has 11,500 residents, and White Rock has 8,000 residents. Los Alamos County estimates there are 2.4 people per family, and that 25 percent of the families will take two vehicles instead of one. It is accepted that the 6,200 LANL employees will all go home before evacuating the mesas. The 4,000 people living off the hill will take 1.25 hours to evacuate at two people per car in the absence of accidents. If all the employees go home first, the people living off of the hill may have cleared before the townsite begins. There would be 6,832 cars to leave the hill, which would take 4.3 hours. This is based on 2.4 people and the 25 percent extra vehicles. It should also be noted that up to 10 percent of the people might refuse to evacuate.

Because the differing population density as a function of time cannot be predicted, the results of the MACCS calculations must be presented as exposures to the same populations and receptors as used in the other accident analyses. Under the conservative assumptions applied in this analysis, the collective population dose from the wildfire consuming buildings is estimated to be about 625 person-rem. To this there may be added another 50 person-rem to capture the minor exposures from burning vegetation and from unidentified residual contamination in other buildings and vegetation. Most of this dose, about 75 percent, would come from the TA–54 Waste Management Complex. A population exposure of 675 person-rem would be expected to result in 0.34 excess LCFs.

Effects on Workers

All threatened workers would be evacuated prior to arrival of the fire front. Aircraft crashes with fatalities have occurred while dropping slurry on wildfires. Firefighters on the ground are at risk if they enter an area without an alternate escape route, and there have been historical fatalities from such events. However, because life safety is given first priority over protection of property at LANL, it is not likely that there will be worker fatalities. Some firefighters and other emergency personnel are likely to have significant but transient effects from smoke inhalation.

Ancillary Environmental Effects

Firewater. Firewater (water used in fighting building fires) at nonnuclear facilities is captured by outdoor containment and temporary dikes erected for fire fighting. Firewater at nuclear facilities is captured by the drain system and is sent to TA–50 for processing. Conceivably, some radioactively contaminated water could reach the outdoor environment, but would be of such small volume that it would not leave the building environs. Resultant contaminated soil would be eroded, pending the return of vegetative cover. As with other contaminated soils, the environmental and human health threat from the new contamination would be assessed and mitigated.

Loss of Protective Cover. The charred plant remains following a severe wildfire are the only immediate visual consequences. The consequences of a wildfire are diverse, continuing through time and space, and frequently having significant changes in geomorphology and biological communities and processes. LANL is perhaps unique in potential consequences, because in addition to a rich presence of biological communities and cultural remains and resources, there exists soil bearing legacy contaminants from historical operations.

Trees, grass and herbaceous cover, and forest litter are important features in stabilizing soils by: (1) reducing the velocity and impact of falling raindrops; (2) reducing the velocity of runoff, thereby encouraging infiltration and discouraging its transport by water and wind; and (3) reducing runoff quantities. Loss of vegetative cover will create a setting that can have pronounced effects on flow dynamics, soil erosion, and sediment deposition. These changes also can have significant ramifications for plant and animal communities and cultural resources.

Runoff, Soil Erosion, and Sedimentation. Without a protective ground cover, runoff quantities and velocities will be magnified, and soil erosion by water and wind will begin immediately. Contributing to this condition will be the likely formation of an ash layer that will inhibit the infiltration of runoff. Decreased infiltration will increase the quantity and velocity of surface runoff, promoting higher channel volumes and watershed discharges. These higher runoff quantities will be discharged into the Rio Grande where they will contribute to the overall floodwater storage of Cochiti Lake. Modified hydrologic conditions likely will cause some watercourses that have only rarely had sufficient flows to reach the Rio Grande to increase their frequency of discharge.

Commensurate with higher runoff quantities and velocities will be an increase in soil erosion. Sheetflow will begin transporting soil suspended by rainfall droplet impact. Both rill and gullying will begin on sloping ground surfaces with the first significant rainfall event. Higher channel volumes and velocities will promote both downward and lateral scouring of channels in the steeper portions of the watershed and sediment deposition in the lower portions. (These conditions depend on quantity of runoff discharges and resulting changes in channel hydraulics.) Headcutting will increase throughout the channel system. Delta formation will increase at the confluence of watercourses tributary to the Rio Grande, and added sediment will contribute to the depletion of the sediment reserve of Cochiti Lake.

The gradual establishment of ground cover will correspondingly retard soil erosion and a more stabilized hydrologic regime will return.

Effects on Legacy Contaminants. Active erosion processes have moved some contaminants bound to sediment from the watershed into the Rio Grande, mainly as suspended sediment and bedload sediment. Conversely, many of the remaining legacy contaminants at LANL are present in situ or have not been transported far from their origin or remain on site. Water transport is a major mechanism for the transport of contaminants both in the dissolved and suspended sediment phases. Because vegetation acts to hold soil and reduce erosion, its loss (however short term) may significantly increase the potential for erosion and the transportation of contaminants. Some water courses have only rarely had sufficient flow to reach the Rio Grande, and because of this they have become “discharge sinks” for some contaminants. Increases in runoff amounts and frequency will increase the potential to remove and transport contaminants from the ground surface and subsurface and stream channels on LANL into the Rio Grande and downstream to Cochiti Lake.

Effects on Biological Systems. Although fire is a natural part of biological systems, anthropogenic influences such as grazing, logging, and fire suppression have produced conditions that have pronounced adverse effects on forest ecosystems. Natural high-frequency, low intensity fire regimes have been replaced with low-frequency, high-intensity fires that consume a higher percentage of vegetation. As reflected in other nearby areas that have experienced severe wildfires in the past (e.g., Water Canyon, La Mesa, Dome, and Oso Complex fires), a wildfire at LANL will result in a period of disequilibrium with a reversion to early seral development and a corresponding change in animal use (Allen 1996). Fire debris, fallen trees, and needle cast will gradually begin to check erosion and develop soil conditions that will promote the establishment of grasses and herbaceous vegetation that will in turn further reduce erosion. This gradual re-establishment of ground cover will begin the dynamic process of seral progression toward a wooded or forested plant community.

A loss of forest or woodland habitat will result in a temporary loss of habitat for a broad spectrum of animals. As vegetation is re-established an altered community of animal species will follow, its composition changing with the evolution of the plant community. The pattern of burned vegetation will play a significant role in renewed wildlife use. Early plant communities of grasses and herbaceous growth can have a high biomass and species diversity as exhibited by nearby areas affected by recent wildfires. This expansion of grass and herbaceous growth could provide additional forage for the large elk population in and around LANL and contribute to existing management concerns.

Impacts on threatened and endangered species (e.g., the Mexican spotted owl) will depend on several factors such as the burn pattern, the time of day that the burn occurs, the type of fire, topography, and if nesting is occurring. Threatened and endangered species have remained or returned to nearby areas that have experienced recent burns. Some species, such as the peregrine falcon, could benefit through improved foraging habitat. Individual response to fire also will vary. Perhaps the most significant impact to threatened and endangered species precipitated by a wildfire could be the general disturbance caused by the fire fighting effort itself (e.g., fire fighting crews, aircraft, and vehicular traffic).

As discussed previously, increased runoff discharges will result in a commensurate increase in channel scouring, enlargement, and headcutting. This process and any accompanying sedimentation will have the potential to degrade or remove the limited riparian vegetation on LANL. Wetlands associated with water courses also would be affected, and perhaps several would be removed for a period of time because of changes in channel morphology. With the degradation of riparian vegetation and wetlands would be an associated reduction or loss of habitat for a variety of invertebrates, small and large mammals, amphibians, reptiles, and a diversity of birds.

Any impacts of contaminants transported to downstream riverine and lacustrine ecosystems is unknown, but there could potentially be an increase in ecological risk.

Effects on Cultural Resources. LANL is located in a region of abundant and culturally significant prehistoric and historic resources, including traditional cultural properties. As stated, fire is a normal feature of the landscape and has played and continues to play a natural role in the culture of regional communities. Because of anthropogenic influences, the character of recent fires will be different from historic fires and will affect resources differently. Also, the need to protect property and life from wildfire will necessitate measures that can affect cultural resources.

As discussed, high intensity fires can burn an appreciable amount of ground cover and accelerate erosion. Surface erosion can physically disturb surface features and confuse and distort the contextual integrity of the site. More pronounced erosion in the form of gully formation and lateral bank cutting can permanently remove site features. Also, a high intensity fire can scorch organic remains located near the ground surface, decreasing their interpretive value. Historical structures can suffer through direct incineration. Damage to these resources also can occur as a consequence of vehicular traffic and mechanical disturbance (e.g., bulldozers and fire trucks) and other soil disturbing activities connected with the firefighting effort.

Traditional cultural properties present on and adjacent to LANL include ceremonial and archaeological sites, natural features, ethno-botanical sites, artisan material sites, and subsistence features. These resources are an integral part of the landscape and almost certainly are and have been affected by natural fires. Because of the altered character of fires, these resources may be affected to a greater extent. Depending on the characteristics of these properties, they could either be permanently or temporarily affected by a wildfire and its subsequent ancillary effects (e.g., erosion).

Mitigation

The next fire season begins in April 1999. As a result of the process of this accident analysis, actions were initiated to reduce the wildfire risk to major facilities with significant radiological inventories. Specifically, considerations were given to reducing the risk to low or very low for the following facilities:

- TA–3 Building 66/451, Sigma
- TA–54 (Area G) Pads
- TA–21 Building 209, Tritium Science and Fabrication Facility (TSFF)
- TA–21 Building 155, Tritium Storage and Test Assembly (TSTA)
- TA–16 Building 205/205A, Weapons Engineering Tritium Facility (WETF).

Nevertheless, the public exposure from these specific facilities has been included in this wildfire analysis. With the completion of these actions, the population dose from site-wide wildfire would be reduced from an estimated 675 person-rem to 50 person-rem, with associated 0.25 excess LCF. In addition, although no credit is taken for it in this analysis, the long-term environmental restoration of contaminated sites will reduce airborne nuclides suspended by vegetation fires over those sites.

There also is an ongoing, interagency, collaborative program to reduce the threat of catastrophic wildfire from occurring at LANL and the townsite by thinning and removing vegetation at the perimeter and in the surrounding Santa Fe National Forest and Bandelier National Monument. This will reduce the frequency and intensity of wildfires that could impinge on LANL.

Uncertainties

The frequency of wildfire impinging on LANL was estimated as 0.1 per year under the current fuel conditions in the surrounding forest and perimeter. This frequency includes wildfires approaching from the north through west and south. When fire enters LANL or originates from within LANL, there are numerous credible scenarios, most of which consume less of the LANL area than is covered in this analysis. Specifically, this analysis presumes that the fire jumps the Pajarito Road or any other established control line, spots or otherwise burns into all contaminated canyons, and successfully climbs canyon walls to ignite combustible buildings with moderate and higher wildfire vulnerability. The frequency of such a site-wide fire is surely less than 0.1 per year. The consequences of a complete burning of the western portion of LANL are presented in accord with the conservative nature of this SWEIS as a whole.

The plume rise calculated by OBODM in the canyon fires is likely to be much less than that which would actually occur resulting in lower doses at a distance of 330 and 3,300 feet (100 and 1,000 meters). This analysis used only the heat content of the fuel over the contaminated area; whereas, there is much fuel to the sides of the fire, and the combined heat would loft the plume thousands of feet. The observed convection columns in the past major forest fires would carry most contaminants far above the breathing zone of downwind individuals.

The wind speed used for dispersion of airborne material from the contaminated site fires was only 2 meters per second, which is probably less than would occur during a wildfire. The doses are inversely proportional to the wind speed, such that if the observed wind were 6 meters per second, the dose would be 1/3 that calculated.

The fraction of the suspended contaminant that is respirable (less than 10 micrometers equivalent aerodynamic diameter) is unknown. According to Section D.5 of the DARHT EIS, the uranium in the soil is not all respirable. The particle size of the airborne soil contamination is likely to be large because the contaminants will be attached to soil particles preceeding the fire and to soil and smoke particles in the plume. Because the airborne contaminant particle size is unknown, an RF of 1.0 is assumed. This is very conservative.

The White Rock and Santa Fe population is included in the MACCS calculations. The additional MACCS calculations for WETF and Sigma made for this wildfire analysis used the winds observed June 7 to 10, 1998, which are toward the Los Alamos townsite; whereas, the previous calculations for the other facilities used representative annual meteorology from 1995 (as described in section G.2.4). Because population is not evenly distributed about these sources, there would be a difference in the integrated population dose (i.e., in the person-rem) depending upon the meteorology used. Because the source inventories at the buildings vulnerable to wildfire do not vary significantly among alternatives, this does not affect the decision. (The inventory at TSTA is reduced by 25 percent under the Reduced Operations Alternative.)

The model calculations for dispersion of the plumes, for canyon sources several and more kilometers long, are most uncertain. The source was input as a volume having the dimensions of the width and length of the contaminated area, oriented along the axis of the wind direction. Differences in concentrations downwind are noted if the source is entered as a volume source versus a line source. The model also objects to a burning time longer than 60 minutes, and was manipulated into accepting these extensively long volumes and longer burn times. The 60-minute limitation in the model is likely intended to prevent the user from exceeding the bounds of experimental data, most of which is for 10 to 30 minute releases. There are no field experiment data to which the canyon results can be compared. However uncertain, the radiological exposures predicted for the canyon fires are orders of magnitude less than the 100 mrem annual limit for public exposure from routine releases.

It has been estimated that there would be 50 person-rem from burning of buildings with residual contamination and from identified and unidentified contaminated soil/vegetation areas. This is a number not supported or disputed by hard data, and is believed to be very conservative.

There are no release fractions available for radionuclides other than plutonium and uranium. For consistency only, the ARF x RF of 4×10^{-4} for uranium was also used for plutonium, americium, and cesium in contaminated soils, which is conservative for plutonium by a factor of 7, and therefore, overestimates the bounding doses for mixed nuclides and TRU in Table G.5.4.4–2 by this factor.

There is no ready evidence that burning of the vegetation over the firing sites would produce detectable airborne DU. The U.S. Army tested DU projectiles at the Jefferson Proving Ground, releasing 50 metric tonnes of uranium in a 4 year period, of which 45.5 metric tonnes were not recovered from the area. Special samples showed that most of the DU was on or near the surface. The vegetative undergrowth was regularly controlled through burning, at which time high volume particulate air samples were collected. Analyses of the air samples did not detect any DU (Abbott 1988). For DU munitions in an intense wood-fuel oil fire burning for 2 hours, no airborne DU was collected in the air samplers at various distances out to 328 yards (100 meters), and 0.01 of residual oxides was in the respirable size range (DOE 1994d).

The MEI and population doses do not take credit for sheltering in vehicles or buildings, which will easily reduce doses to 1/2 to 1/20 of that outdoors (Engelmann 1990, Engelmann et al. 1991). It should be noted that airborne contamination will be in the smoke, which people are inclined to avoid.

About 400 person-rem, or 75 percent of the total population exposure of 675 person-rem, results from a wildfire at TA–54. The results from RAD–08, an aircraft crash-initiated fire at TA–54, were used for the wildfire. The two fires would be quire different, one entailing aircraft fuel that will challenge waste containers. At present, the combustible loading within the dome structures is small, so that RAD–08 results very conservatively bound the consequences of a wildfire at TA–54.

Another 189 person-rem results from total release of the tritium inventory at WETF, including 1,260 grams in storage, which is assumed to bound an increased administrative limit that may be established. The storage containers are resistant to fire, but have been assumed to release their entire content in tritiated water form, in accord with the highly conservative nature of this analysis.

G.5.5 Chemical Accidents

G.5.5.1 *CHEM–01, Single Cylinder Release of Chlorine from Potable Water Chlorinator*

General Scenario Description

Accident scenario CHEM–01 postulates a chlorine gas leak from a single cylinder at a potable water chlorination station. The accident is initiated by equipment failure or human error during chlorine cylinder replacement or maintenance activities at the chlorinator station. Two, 150-pound chlorine cylinders are connected to the injector system, which adds a small amount of chlorine to the potable water system for purification purposes.

The scenario is modeled as occurring at TA–00–1109, which is a site in the town of Los Alamos north of the high school. This location is one of nine chlorinator sites located around LANL and the town; the other locations are TA–00–1110, TA–00–1113, TA–00–1114, TA–16–560, TA–33–200, TA–54–1008, TA–72–3, and TA–73–9. TA–00–1109 was selected as the modeling location based on its proximity to residential housing and special populations, and provides an upper bound estimate of the potential impacts to the public. (It should be noted that a study is being conducted by LANL to evaluate the conversion of the chlorinator systems from a gaseous chlorine system to a less hazardous MIOX system that hydrolyzes brine to produce chlorine on site. In addition, negotiations are in progress that could lead to the chlorinator system being turned over to Los Alamos County.)

CHEM–01 Release Mechanisms

Chlorine usage has been estimated for the four SWEIS alternatives, with an average of seven to nine cylinders used per year at each of the potable water chlorinator stations. The chlorinator system at TA–00–1109 is a sweetener station that actually uses only two to three cylinders per year. Hence, it is conservative to model the station use rate at seven to nine cylinders per year, depending on the alternative.

Three leakage rates were defined for this event. The smallest leak is essentially a pin-hole leak that would result from random equipment failures or human errors. The next leak considered as a valve failure, which would open a 0.25-inch (0.64-centimeter) diameter hole in the cylinder pressure boundary. Finally, a random cylinder rupture was defined that would instantaneously depressurize the cylinder.

No Action Alternative Frequency Analysis

The frequency of these endpoints was calculated separately for hardware and human error initiating events. Random cylinder failure (leak or rupture), as well as failures of the packing, the pressure gage, or the vacuum regulator can result in a chlorine release. The equipment failure contribution to this scenario is quantified as follows:

$$F_{EQP} = (F_{RAND\text{-}LEAK}) + (F_{RAND\text{-}RUPT})$$

where:

F_{EQP} = Annual frequency of the scenario due to equipment failure

$F_{RAND\text{-}LEAK}$ = Frequency of random failure resulting in cylinder leakage

$F_{RAND\text{-}RUPT}$ = Frequency of random failure resulting in cylinder rupture

These terms are all random events with a general equation as follows:

F = (rate/hr) x (8,760 hr/yr) x (number of items)

These values are as follows:

$F_{RAN\text{-}LEAK}$ = (2 x 10^{-8}/hr) x (8,760 hr/yr) x (4) = 7 x 10^{-4}/yr (LARGE LEAK); for factor of 20 difference from rupture (Mahn et al. 1995 and LANL 1995c)

$F_{RAND\text{-}RUPT}$ = (1 x 10^{-9}/hr) x (8,760 hr/yr) x (4) = 3.5 x 10^{-5}/yr (RUPTURE) (Mahn et al. 1995)

The total equipment failure contribution to CHEM–01 can be evaluated as follows:

$$F_{EQP} = F_{RAND\text{-}LEAK} + F_{RAND\text{-}RUPT}$$

$$F_{EQP} = (7 \times 10^{-4}) + (3.5 \times 10^{-5})$$

$$F_{EQP} = 7 \times 10^{-4}\text{/yr (LARGE LEAK)}$$

$$F_{EQP} = 3.5 \times 10^{-5}\text{/yr (RUPTURE)}$$

The human error contribution to this scenario is quantified as follows:

$$F_{HEP} = H_{VALVE} + H_{LEAK}$$

where:

F_{HEP} = Annual frequency of human error-induced chlorine release

H_{VALVE} = Human error leading to chlorine tank valve failure (LARGE LEAK)

H_{LEAK} = Human error leading to chlorine leak (SMALL LEAK)

A large leak due to valve failure would require human error in cylinder handling such that a chlorine cylinder with the valve cap removed is dropped, striking the valve and causing the valve to shear off. Small leaks could be due to a variety of causes, such as failure to follow cylinder changeout procedures resulting in a leak at the cylinder valve packing, the injector connection, tubing, or the V-notch assembly.

H_{VALVE} is related to the number of times per year that a full chlorine cylinder is removed from storage, has its valve cap removed, and then is placed into operation or into standby. Estimates of chlorine consumption in 150-pound cylinders have been made for all four alternatives (Barr 1997).

It is assumed that chlorine cylinder usage is averaged out over the nine potable water chlorinators. The number of chlorine cylinders changed out annually is eight for the No Action and Greener Alternatives, nine for the Expanded Operations Alternative, and seven for the Reduced Operations Alternative.

The basic human error rate is estimated as 0.003 per demand (Swain and Guttmann 1983). Considering that personnel performing chlorine cylinder operations are aware of the hazards involved, that the hazard is very direct, and it is therefore reasonable to assume that extra caution is employed in the operation, and that the changeout process is governed by a written procedure that is required to be used, this value was reduced by a factor of 50 to 6 x 10^{-5} per demand. (The derivation of the factor of 50 is based on the human error probability for checking the status of equipment under normal conditions and the probability for checking the status of equipment when the status affects one's safety [Swain and Guttmann 1983].) No recovery probability is assessed because once the cylinder is dropped there is no opportunity to recover the situation. For the No Action Alternative, the frequency of human error leading to a large leak as a result of valve failure is 8 x (6 x 10^{-5}), or 4.8 x 10^{-4} per year.

The human error leading to a leak is assessed based on recent experience with cylinder changeout. One leak has occurred in the past 5 years. With nine chlorinators changing out an average of eight cylinders per year, this is one leak in the change out of 9 x 8 x 5, or 360 cylinders, or a conditional probability of a leak of once per 360 changeouts, or 2.8 x 10^{-3} per changeout. With eight changeouts per year, this is a frequency of 2.2 x 10^{-2} per year.

Based on the above evaluation, the following frequencies are identified for the No Action Alternative:

- Rupture (large leak rate, complete release in less than 60 seconds; to be calculated) 3.5 x 10^{-5} per year (random rupture)
- Large Leak (1/4-inch hole corresponding to valve size) 1.2 x 10^{-3} per year = 4.8 x 10^{-4} per year (human error, dropped cylinder) + 7 x 10^{-4} per year (random leak)
- Small Leak (pin-hole type leak, rate to be calculated) 2.2 x 10^{-2} per year (human error, cylinder changeout/maintenance)

Expanded Operations Alternative Frequency Analysis

The Expanded Operations Alternative does not alter the configuration of the chlorinator system. The rupture frequency and the small leak frequencies will remain the same. The large leak frequency increases somewhat because the number of cylinders changed out annually increases from eight to nine. This results in a human error contribution of 9 x (6 x 10^{-5}) = 5.4 x 10^{-4}, plus the random leak rate of 7 x 10^{-4} per year, yielding a large leak rate of (5.4 x 10^{-4}) + (7 x 10^{-4}) = 1.2 x 10^{-3} per year.

Reduced Operations Alternative Frequency Analysis

The Reduced Operations Alternative does not alter the configuration of the chlorinator system. The rupture frequency and the small leak frequencies will remain the same. The large leak frequency decreases somewhat because the number of cylinders changed out annually decreases from eight to seven. This results in a human error contribution of 7 x (6 x 10^{-5}) = 4.2 x 10^{-4}, plus the random leak rate of 7 x 10^{-4} per year, yielding a large leak rate of (4.2 x 10^{-4}) + (7 x 10^{-4}) = 1.1 x 10^{-3} per year.

Greener Alternative Frequency Analysis

The Greener Alternative does not alter the configuration of the chlorinator system; all release frequencies are the same because the cylinder changeout rate is the same. The frequencies of occurrence for CHEM–01 are considered to be bounding and conservatively take no credit for the frequency of time that some of the chlorine cylinders stored in the building may be empty.

Source Term Calculations

The initial source term for the postulated accident equals the contents of one filled chlorine cylinder (150 pounds). Due to the physical form of the hazardous material (gas), there is no suspension source term contribution to the release. Because the cylinder size and system configuration do not vary across the alternatives, the source terms are the same across the alternatives. In all three cases (rupture, large leak, and small leak), the release is modeled as a ground level release. This is conservative because the release, especially in the case of smaller leak rates, could be released via the building exhaust system, which would result in an elevated release.

The smallest size hole with which the ALOHA™ code can perform release calculations is 0.0394 inch (0.1 centimeter) in diameter. Because this release occurs from a building, in accordance with EPA guidance the release rates are multiplied by 0.55 to correct for mixing within the building. For winter and summer conditions, this results in release rates from the building of 0.122 pound per minute and 0.181 pound per minute, respectively. Total releases within an hour total only 4 and 6 pounds of chlorine for winter and summer conditions, respectively.

For the large leak scenario, a release rate was estimated by conservatively assuming a direct release of the cylinder contents, and the same 0.55 in-building factor was applied, yielding a release rate of 8.25 pounds per minute for18.2 minutes.

Uncertainties and Sensitivities Affecting the Source Term for CHEM–01

Not all chlorine cylinders that are dropped and result in valve failure would release 150 pounds of chlorine (some would be empty or nearly so). Random failure (rupture) of a chlorine cylinder could potentially cause failure of one or more adjacent cylinders. The source term estimates above do not consider such factors. To bound the possible consequences of a process-related chlorine release from the potable water chlorination system, the assumption is made that the cylinder is full and that the release cannot be terminated once it starts. Although this is a conservative assumption, it is consistent with the approach taken in the TA–55–4 SAR (LANL 1996k) for a process-related release from a chlorine system that also uses 150-pound cylinders.

Consequences of CHEM–01 for Facility Workers and the Public

The consequences of CHEM–01 are presented separately for workers and the public. For workers, the following consequences are identified.

For the cylinder rupture accident, the likelihood of a worker being present is very low (the failure happens at random, rather than as a result of worker activity). Accordingly, no worker consequences would be expected under most conditions for cylinder rupture because workers would be present at the facility for a limited number of hours per month. Any workers present in the building would likely be killed due to the very high concentrations of chlorine that would result from cylinder rupture, as well as from the lack of time to escape from the immediate area before potentially lethal exposures would occur. Death to workers inside the building could also occur as a consequence of missiles (flying debris) generated when the cylinder ruptures.

For the large leak scenario, the workers present in the building (for the nonrandom failure part of the term) could be killed due to the high chlorine concentration in the building and/or the possibility of being struck by a missile (either the cylinder or the valve).

For the small leak scenario, injury seems to be a more likely outcome than fatality for facility workers. This is borne out by operating experience.

The public consequences for the small leak scenario are negligible (no ERPG–2 or ERPG–3 concentrations beyond 100 yards [92 meters]) regardless of the time of day, time of year, and even considering very adverse dispersion leading to a very stable, nonmeandering plume.

If the direction of the plume were to remain constant for the small leak scenario, nearby residents might detect the chlorine release by odor; however, even the ERPG–1 value of 1 parts per million would not be reached outside 100 yards (92 meters) from the facility under a conservative daytime dispersion condition (2.8 meters per second wind, Stability Class C). Under adverse (stable atmosphere) dispersion, the ERPG–1 distance could extend as far as 236 yards (216 meters). Given these results, no detailed quantification of the small leak scenario is carried forward.

For the large leak rupture scenarios, the release rate is of course much greater. For the large leak scenario, equivalent to a ruptured cylinder valve, the release rate is 2.2 to 3.8 pounds per minute (variable depending on time of year). Under adverse (stable atmosphere) dispersion, the ERPG–2 distance is 0.6 mile (1 kilometer), while the ERPG–3 distance is 0.2 mile (0.3 kilometer). Under conservative daytime dispersion, the ERPG–2 distance varies from 0.16 to 0.26 mile (0.26 to 0.42 kilometer), while the ERPG–3 distance varies from 0.06 to 0.09 mile (0.1 to 0.14 kilometer). The average number of people exposed at concentrations greater than ERPG–2 and ERPG–3 under adverse dispersion is 81 and 30, respectively, and for ERPG–2 and ERPG–3 under conservative daytime dispersion about 43 and 12, respectively.

For the rupture scenario, ERPG–2 concentrations reach a distance of about 1,600 yards (1,464 meters) under adverse dispersion (stable atmosphere) and a distance of about 500 to 700 yards (458 to 641 meters) under conservative daytime dispersion. ERPG–3 distances are about 450 yards (412 meters) under adverse dispersion and about 200 to 250 yards (183 to 229 meters) under conservative daytime dispersion. The average number of exposed people exposed to concentrations greater than ERPG–2 and ERPG–3 under adverse dispersion is 226 and 180, respectively, and about 53 and 12, respectively, under conservative daytime dispersion. A summary of CHEM–01 results is presented in Table G.5.5.1–1.

G.5.5.2 *CHEM–02, Multiple Cylinder Release of Chlorine from Gas Plant*

General Scenario Description

Scenario CHEM–02 involves a multiple-cylinder release of chlorine from TA–3–476. This building is an all-weather, prefabricated, "Apache" all-metal storage shed that is used to store chlorine cylinders (and other hazardous gas cylinders) prior to distribution to end users at LANL. TA–3–476 is located at the northwest corner of the Gas Plant (the main facility at the Gas Plant is TA–3–170), which is located along Eniwetok Road near the Sigma Facility (TA–3–66). The storage shed, which has an open metal grate at the bottom, rests on asphalt.

In addition to chlorine, other extremely toxic gases that have in the past been temporarily stored at TA–3–476 include phosgene, arsine, phosphine, and fluorine. Such gases are typically present 1 day or less per year per gas. Some quantity of chlorine is present essentially all the time. The release of the largest single container of these gases has been modeled in the Safety Assessment under adverse dispersion conditions (Class F stability, wind speed of 3.3 feet [1 meter] per second) and compared with a 150-pound chlorine cylinder release. The distances to which ERPG–2 and ERPG–3 exposures could be experienced were the largest for the chlorine cylinder release.

The frequency of release of gases other than chlorine would be directly proportional to the conditional probability of their presence at the facility. Accordingly, it has been determined that the risk of a release of chlorine from TA–3–476 bounds the risks of release of other toxic gases both in frequency of occurrence and in the consequences of the release.

The CHEM–02 accident scenario involves a release of chlorine gas, which is conservatively assumed (with respect to exposure at short distances) to occur at ground level, followed by dispersal of the gas downwind. The release is also conservatively modeled as involving simultaneous release from multiple cylinders. In fact, the cylinders may not all release at the same time, in which case the downwind concentrations would be less, and there would be less chance of exceeding the thresholds for health effects.

Properties of Chlorine Gas

Chlorine is a greenish-yellow gas or liquid. Chlorine is extremely irritating to the mucous membranes of the eyes and respiratory tract at a concentration of 3 parts per million. A concentration of 3.5 parts per million is detectable by odor. A concentration of 15 parts per million causes immediate irritation of the throat. Concentrations of 50 parts per million are dangerous for even short exposures, and concentrations of 1,000 parts per million may be fatal even when the exposure is brief (Lewis 1993). The ERPG–1, –2, and –3 concentrations are 1, 3, and 20 parts per million, respectively (Craig 1996). The pressure in a 150-pound chlorine cylinder is 0.588 MPa (85.3 psig) at a temperature of 70°F (21°C) (MGP 1997). Cylinders containing chlorine are equipped with a fusible metal plug with a melting temperature of 165°F (73.9°C) (Braker and Mossman 1980). In the event of a fire that exceeds this temperature, the fusible plug will melt, permitting the chlorine to escape but preventing the cylinder from catastrophically failing due to overpressure. Chemical reactions of chlorine of potential interest to this scenario include the reaction with carbon monoxide to form phosgene (carbonyl chloride, CCl2O, a colorless poison gas) (Braker and Mossman 1980), and the reaction with ammonia causing an explosion (Lewis 1993).

Properties of a Heavy Gas

The release of chlorine from a pressurized cylinder will consist of a combination of droplets and vapor constituting a heavy, cold cloud full of small droplets that remain airborne and travel significant distances. The continuing evaporation of these droplets along the plume path virtually renews the strength of the cloud as it travels and keeps it cool and heavier than the ambient air. This has significant effects on the dispersion, and the standard Gaussian plume models are inappropriate; "heavy gas" models such as DEGADIS and SLAB must be used instead. The cloud can persist for substantially longer times than the spill duration, and plume travel time can be substantially longer than would be expected from the wind speed. When the concentration of the chlorine falls to a value such that the cloud density is similar to that of the air, it no longer acts independently of the air as a heavy gas, but behaves as a passive tracer. The concentration at which this occurs depends upon the wind speed and height of the cloud (which in turn depends upon the size of the release). When the wind is 3.3 feet per second (1 meter per second) and the chlorine cloud is 33 feet (10 meters) high, the change from heavy gas to passive behavior occurs at about 280 parts per million. This is substantially greater than the ERPG–3 of 20 parts per million and produces serious health effects. For this reason, protection from a chlorine release is not assured by intervening canyons.

CHEM–02 Release Mechanisms

Three potential release mechanisms were identified and subjected to detailed analysis. Release by direct impact of a vehicle on the stored cylinders was screened out based on the presence of vehicle barriers in front of and to the sides of the storage shed, the inability of a vehicle to approach the shed from behind (an arroyo is located behind the shed), and the administrative controls on speed limits at the Gas Plant (along with the DOT training and LANL-specific training of truck drivers at the plant). Two other release mechanisms were considered for their contribution to the frequency of CHEM–02: (1) a truck fuel fire, resulting in failure of the chlorine cylinders; and (2) the impact of an aircraft on nearby hydrogen tube trailers, resulting in failure of multiple chlorine cylinders due to overpressure, impact by missiles (shrapnel created by the detonation of hydrogen tubes upon impact by the aircraft), or fire.

This accident was not analyzed in the Gas Plant Safety Assessment (LANL 1994b). The safety assessment (SA) screened all multiple cylinder release scenarios as being incredible (i.e., having frequencies less than 10^{-6} per year). The most severe scenario analyzed in the SA was a single cylinder release of chlorine (see CHEM–03, section G.5.1.6). The SA concluded that the installation of the vehicle barrier around TA–3–476 eliminated the possibility of a multiple cylinder release. While this appears to be a valid conclusion insofar as direct vehicular impact with the chlorine cylinders is concerned, it is not clear that the SA considered a fuel fire for which the vehicle barriers would be ineffective.

No Action Alternative Frequency Analysis

The fuel fire and aircraft crash contributors are analyzed separately. In the case of a fuel fire, a truck accident near TA–3–476, or one impacting the vehicle barrier around TA–3–476, could result in a failure of the truck fuel system or the fuel tank(s), resulting in a spill of diesel fuel. Second, a truck parked near TA–3–476 could experience a fuel system leak or fuel tank leak due to causes unrelated to a vehicle accident. In either case, once a fuel leak occurs, ignition of the spilled fuel would lead to a fire that, if it is close enough to TA–3–476 and it is not suppressed, would result in damage to the chlorine cylinders and a release of chlorine to the environment.

There are no automatic means of fire detection or fire suppression installed at TA–3–476, although there is a fire hydrant located within 164 feet (50 meters) of TA–3–476 where fire hoses could obtain water for fighting the fire. Manual fire fighting equipment (extinguishers) is provided at TA–3–170. The response time of a fire brigade to TA–3–476 is estimated at 2 to 3 minutes; the fire station at TA–3–41 is within a kilometer of TA–3–476.

There are no physical barriers present that are capable of precluding a fire from reaching TA–3–476. There are concrete-filled metal tubes installed at the front of TA–3–476 to prevent the impact of a vehicle on the storage shed. While the barriers will essentially preclude direct vehicular impact with the cylinders, the barriers will have no affect on the propagation of a fuel fire (which could result from a ruptured fuel line/fuel tank as a consequence of impact of a vehicle with the vehicle barriers).

The frequency of the fuel leak and fire contributor accident can be estimated using the following equation:

$$F_{FIRE} = N_{SHIPMENTS} \text{ x } L \text{ x } F$$

where:

F_{FIRE} = Frequency of a fire at TA–3–476

$N_{SHIPMENTS}$ = Number of shipments to or from TA–3–476 per year

L = Fuel leak rate per shipment

F = Conditional probability of fire given a fuel leak and subsequent release of chlorine

The frequency of a fuel system leak or fuel tank leak and a resulting fire is assessed for TA–3–476 based on methods and data contained in the TA–54, Area G Hazard Analysis (LANL 1995g) and the evaluation of TRU waste transportation by H&R Technical Associates (Rhyne 1994). The annual frequency of a fuel leak was assessed at 0.1 per year in the TA–54 hazard analysis

(LANL 1995g). Embedded in this estimate is 78 trips per year of trucks to the facility. Thus, on a per trip basis, the likelihood of a fuel leak is 0.1/78, or 1.3 x 10^{-3} per trip.

The TA–54 hazard analysis (LANL 1995 through 1997) cites data from Rhyne 1994 to the effect that the conditional probability of a fire given a fuel leak is 4.7 x 10^{-3} per fuel leak. Although the direct applicability of this value is open to interpretation, the value is used in CHEM–02, RAD–01, and RAD–07 because no other comparable value could be identified and because DOE believes the value to be conservative.

The TA–54 hazard analysis recommended an additional frequency reduction by a factor of ten compared with the H&R evaluation due to the fuel being diesel (LANL 1995g). However, the H&R evaluation already takes into account the fact that the transport vehicle is a flatbed truck, which is a diesel fuel vehicle (Rhyne 1994). Accordingly, this additional factor of ten reduction in conditional probability was not employed here.

Site-wide usage of chlorine has been estimated across the alternatives in Table G.5.5.2–1. The number of shipments to or from TA–3–476 per year for the No Action Alternative is estimated based on the sum of shipments from the chlorine supplier to TA–3–476 and shipments from TA–3–476 to the potable water chlorination stations in and around LANL. During the walkdown of TA–3–476, it was stated that there were two shipments per year from the chlorine supplier. However, this information is inconsistent with the number of 150-pound chlorine cylinders estimated to be used annually.

The data in Table G.5.5.2–1 was interpreted by dividing the 150-pound cylinder usage by 150 pounds to obtain the approximate number of cylinders used annually. This value is shown in the last row of Table G.5.5.2–1. Because only ten full chlorine cylinders are permitted to be in TA–3–476 at any one time (LANL 1997b), the number of trips was approximated by dividing the number of cylinders used annually by ten (the number of cylinders allowed to be at TA–3–476). The number of supplier shipments is thus seven per year for all alternatives except Expanded Operations, where the number of supplier shipments is eight.

The number of shipments from TA–3–476 to potable water chlorinators is 14 per year (based on shipments of no more than 5 cylinders at a time and a total of 70 cylinders needed per year). The total number of shipments is therefore 7 plus 14, or 21.

The frequency equation can be solved as follows for the No Action Alternative:

$$F_{FIRE} = N_{SHIPMENTS} \text{ x L x F}$$

$$F_{FIRE} = 21 \text{ x } (1.3 \text{ x } 10^{-3}) \text{ x } (4.7 \text{ x } 10^{-3})$$

$$F_{FIRE} = 1.3 \text{ x } 10^{-4}\text{/yr}$$

As noted above, fuel fires also can occur as a result of a truck accident near TA–3–476 or as a result of an impact of a vehicle with the vehicle barrier immediately in front of TA–3–476. The general accident rate for highway traffic is 1 x 10^{-6} per mile (Fenner 1996). Data on which the RADTRAN transportation accident code is based show that only 29 percent of all accidents occur at speeds of 20 miles per hour or less (Clarke 1976), which is what would be expected at the Gas Plant because the speed limit is 15 miles per hour (allowing for some margin over this value, 20 miles per hour was selected as a quantification basis). Thus, the accident rate should be (1 x 10^{-6}) x 0.29 = 2.9 x 10^{-7} per mile. Even if the distance from the Gas Plant security gate to TA–3–476 is used for quantification, this is a distance of approximately 220 feet (67 meters) or 0.042 miles. The accident rate per trip is thus 21 trips/yr x 0.042 miles/trip x (2.9 x 10^{-7} accidents/mile) = 2.6 x 10^{-7} accidents per year. Even allowing that there are trips near

TA–3–476 not involving chlorine shipments, there would have to be thousands of such shipments before this contributor would begin to compete probabilistically with the fuel leak/ fire scenario quantified above. Moreover, each shipment would have to pass sufficiently near TA–3–476 such that the fire, if it occurred, actually reached the chlorine cylinders stored in that building. Accordingly, this potential accident contributor was screened out.

Evaluation of Hydrogen Tube Trailer Failure

During the physical inspection (walkdown) of the Gas Plant and during subsequent visual spot checks, there have been four or five hydrogen tube trailers parked within 164 feet (50 meters) of TA–3–476. Gas Plant management states that typically half of the trailers are empty and half are full (Lovato and Nielsen 1997). The trailers are typically located within less than 164 feet (50 meters) of TA–3–476.

In the event of a catastrophic tube trailer failure (rupture of tube or tubes, detonation of hydrogen), there are no physical barriers that could preclude overpressure or missile impact from reaching TA–3–476. The outer shell of TA–3–476 is simply sheet metal, which would offer very little resistance.

A tube on a hydrogen tube trailer failed catastrophically at TA–3–170 in June 1981. There was no effect on TA–3–476 as a result of that accident, and the tube failure did not propagate to the entire tube trailer. While the specific scenario that occurred in June 1981 is no longer considered to be credible (the process that caused the accident is no longer performed at the facility), the hydrogen tubes could fail due to other causes.

The tube trailers are DOT Type 3AA trailers with 38 tubes per trailer. The trailers are 22 feet (6.7 meters) long. Each tube trailer holds 50,000 standard cubic feet of hydrogen gas (261.37 pounds of hydrogen). In order to evaluate the consequences of the catastrophic failure of an entire tube trailer, a simple TNT equivalent calculation was performed. In accordance with standard practice involving calculations of explosive yield for design purposes, a 20 percent safety factor was applied to the calculation. Assuming 100 percent explosive yield is grossly conservative. In accordance with recommendations by the American Institute of Chemical Engineers, a 15 percent conversion factor was used (AICE 1994). The estimated explosive yield (in TNT equivalent) was calculated to be about 965 pounds. This amount of TNT was found to be insufficient for a 10-psi overpressure to reach TA–3–476, and it was concluded that random failure of a single tube trailer could not cause a chlorine release.

Calculations of aircraft crash frequency have been performed according to the methodology in DOE Standard 3014-96 (DOE 1996c). The width of the “target” was increased to account for the chlorine storage shed itself (TA–3–476) as well as the hydrogen tube trailers. This was done to account for the possibility that the aircraft would impact the tube trailers, causing a detonation of one or more tube trailers. The resulting crash frequency was calculated to be 2.0×10^{-7} per year.

The frequency of occurrence for CHEM–02 is the sum of the frequency of the contributing means of occurrence:

$$F_{TOTAL} = F_{FIRE} + F_{AIR}$$

where:

F_{TOTAL} = Total scenario frequency

F_{FIRE} = Frequency from vehicle fires

F_{AIR} = Frequency from aircraft crash

This equation can be evaluated as follows:

$$F_{TOTAL} = F_{FIRE} + F_{AIR}$$

$$= (1.3 \times 10^{-4}) + (2.0 \times 10^{-7})$$

$$= 1.3 \times 10^{-4} \text{ per year}$$

Expanded Operations Alternative Frequency Estimate

The only change in circumstances affecting the frequency of CHEM–02 compared with the No Action Alternative is the frequency of shipments to or from TA–3–476 for the vehicle fuel fire scenario. For the Expanded Operations Alternative, the number of shipments increases from 14 to 16 per year due to a higher rate of chlorine consumption for potable water use. In addition, the number of shipments from the chlorine supplier increases from seven to eight per year. The total number of shipments is thus 24, and the frequency of the vehicle fuel fire contributor can be estimated as follows:

$$F_{FIRE} = N_{SHIPMENTS} \times L \times F$$

$$F_{FIRE} = 24 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$F_{FIRE} = 1.5 \times 10^{-4}$$

The summed frequency for all contributors becomes:

$$F_{TOTAL} = F_{FIRE} + F_{AIR}$$

$$F_{TOTAL} = (1.5 \times 10^{-4}) + (1.3 \times 10^{-6})$$

$$F_{TOTAL} = 1.5 \times 10^{-4} \text{ per year}$$

Reduced Operations Alternative Frequency Calculation

The only change in circumstances affecting the frequency of CHEM–02 compared with the No Action Alternative is the frequency of shipments to or from TA–3–476 for the vehicle fuel fire scenario. For the Reduced Operations Alternative, the number of shipments decreases from 16 to 13 per year due to a higher rate of chlorine consumption or potable water use. The number of shipments inbound from the chlorine supplier remains at seven. Thus, the frequency of the vehicle fuel fire contributor can be estimated as follows:

$$F_{FIRE} = N_{SHIPMENTS} \times L \times F$$

$$= 20 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$= 1.2 \times 10^{-4}$$

The summed frequency for all contributors becomes:

$$F_{TOTAL} = F_{FIRE} + F_{AIR}$$

$$= (1.2 \times 10^{-4}) + (2.0 \times 10^{-7})$$

$$= 1.2 \times 10^{-4} \text{ per year}$$

Greener Alternative Frequency Calculation

The frequency of shipments to or from TA–3–476 is the same for the Greener Alternative as it is for the No Action Alternative. Thus, the summed frequency of all contributors of 1.3×10^{-4} per year applies to the Greener Alternative as well.

Uncertainties and Sensitivities Affecting the Frequency of CHEM–02

The accident frequency calculations reported above do not account for the possible suppression of the fire by Gas Plant personnel or the fire department (TA–3–41) prior to the failure of the chlorine cylinders. Thus, the frequencies calculated above for the fuel fire contributor to the accident frequency represent overestimates, but given the reporting time for the fire brigade (2 to 3 minutes) and the low melting temperature of the fusible plugs on the chlorine cylinders (165°F [73.9°C]), this conservatism is not considered to be substantial.

The frequency calculations for the fuel fire contributor are sensitive to the inferred rate of fuel failures per shipment (to or from the facility) and to the conditional probability of a fire given a fuel leak. The likelihood of a fire given a fuel leak is based on vehicle accident data that include vehicle speeds of up to highway speeds. In contrast, the speed of vehicles around the Gas Plant is limited to much lower speeds. Because it would seem reasonable to assume that the likelihood of a fuel leak given an accident bears some relationship to the speed of impact (or overturning), the conditional probability of a fire given a fuel leak may be unduly pessimistic. Because an alternative value could not be identified, this admittedly pessimistic value was used in the calculations.

Source Term Calculations

The administrative limit on the number of full chlorine cylinders that can be located at TA–3–476 is eight cylinders. This limit can be exceeded for a maximum of three days by procedure on a temporary basis (LANL 1997b and Lovato and Nielsen 1997). Note that a number of cylinders in excess of ten would bring the total chlorine inventory in TA–3–476 to over 1,500 pounds. Under OSHA Standard 1910.119, Appendix A, 1,500 pounds or more of chlorine are considered to present a potential for a catastrophic event. Therefore, consequence estimates have been prepared using 1,500 pounds of chlorine. This quantity will be conservative by at least 300 pounds under most conditions. This source term is used across all alternatives.

The release was modeled as a direct release, with a constant release rate for 10 minutes based on sensitivity calculations and discussions with the code authors. The release is modeled as originating with a single cylinder that numerically represents the effective release rate of ten, 150-pound cylinders. The release is assumed to occur as a result of the melting of fusible plugs on the cylinder, which melt at 165°F (73.9°C).

Uncertainties and Sensitivities Affecting the Source Term for CHEM–02

The assumption of a ground level release is conservative with respect to chlorine gas concentrations close to TA–3–476 (such as at the TA–3 administrative complex). Indeed, the assumption of a ground level release is not realistic because the release is caused by a fire, whose heat would elevate the plume above ground level. A ground level release will produce higher concentrations at breathing level than the expected elevated release.

Consequences of CHEM–02 for Facility Workers and the Public

Workers at TA–3–170 could be exposed to concentrations greater than ERPG–2 and ERPG–3 if they are downwind. Because Gas Plant workers will be closest to the accident site, the plume will be dense and will probably be visible during the period of the greatest release. The workers could escape from the plume on foot provided they do not become immersed in the plume (in which case they would encounter very high chlorine concentrations). Workers attempting to fight the fire without an air supply could be overcome by chlorine gas. (Workers are directed not to fight fires but instead to call the fire department and evacuate the area.)

Under adverse dispersion conditions (light wind, stable plume), ERPG–2 concentrations are exceeded out to distances ranging from 2.6 to 2.7 miles (4.2 to 4.3 kilometers), while ERPG–3 concentrations are exceeded out to distances of 1.1 to 1.2 miles (1.8 to 1.9 kilometers). Under conservative daytime dispersion, ERPG–2 concentrations are exceeded out to distances ranging from 1.2 to 1.4 miles (1.9 to 2.3 kilometers), while ERPG–3 concentrations are exceeded to distances ranging from 0.57 to 0.66 mile (0.92 to 1.1 kilometer). Average numbers of people affected by these concentrations are shown in Table G.5.5.2–2, which summarizes the modeling results for CHEM–02. Note that this release occurs within the LANL boundary. The town of Los Alamos is separated from the release point by wide, deep canyons that would trap and steer the highest concentrations of the plume away from the town site. The average number of people exposed is governed by numerous directions of release where no or few members of the public are located. If, however, the plume blows toward the most heavily populated area of TA–3 (which occurs less than 10 percent of the time), the number of people exposed to concentrations greater than ERPG–2 and ERPG–3 could number in the many hundreds to low thousands.

G.5.5.3 *CHEM–03, Single Cylinder Chlorine Release from Gas Plant*

General Scenario Description

Like CHEM–02, CHEM–03 occurs at TA–3–476. However, CHEM–03 involves the release of chlorine from a single 150-pound cylinder. This scenario was evaluated in the Gas Plant Safety Assessment (LANL 1994b). Three contributors were identified: (1) release without fire due to an on-site transportation accident at the toxic gas storage shed (Scenario 5), frequency from 10^{-4} to 10^{-3} per year; (2) release due to drop of toxic gas cylinder (Scenario 11), frequency from 10^{-4} to 10^{-3} per year; and (3) release due to deterioration of cylinders from weather (Scenario 23), frequency from 10^{-4} to 10^{-3} per year. The properties of chlorine gas and heavy gases were addressed in section G.5.1.5.

CHEM–03 Release Mechanisms

As noted above, three release mechanisms were postulated in the Gas Plant SA (LANL 1994b). Release due to impact of a cylinder by a truck is discounted here because of the installation of bumpers in front of the toxic gas storage shed, which was accomplished as a corrective action after the SA was performed. Chlorine releases from a single cylinder due to a dropped cylinder and due to long-term exposure to weather are addressed separately below.

No Action Frequency Analysis

Because all cylinders are stored with their valve covers installed (Lovato and Nielsen 1997), the scenario would have to involve a second human error in failing to install the valve cover correctly at the supplier facility. A third error would also be required because receipt inspections are performed and the status of the valve cover would normally be checked at this time.

On the basis of these considerations, the frequency of this contributor can be calculated using the following equation:

$$F_{DROP} = N_{HANDLED} \text{ x } H_{DROP} \text{ x } H_{COVER} \text{ x } H_{CHK} \text{ x } C_{FAIL}$$

where:

F_{DROP} = Frequency of dropped cylinder resulting in chlorine release

$N_{HANDLED}$ = Number of cylinders handled per year

H_{DROP} = Human error, dropping cylinder during handling

H_{COVER} = Human error, failure to install valve cover properly

H_{CHK} = Human error, failing to check valve cover installation during receipt inspection

C_{FAIL} = Conditional probability of valve failure when cylinder is dropped

The number of cylinders handled annually under the No Action Alternative is 70 based on the information presented above in section G.5.5.1. Each cylinder is handled twice (once during placement into TA–3–476 for storage and again during retrieval from storage). Thus, the total number of handling events is 140.

We estimate the basic human error rate as 0.003 per demand. Although perhaps not directly applicable to DOE facilities, a study of human reliability with emphasis on nuclear power plant applications supports this number (Swain and Guttmann 1983). Considering that the personnel handling the cylinder expect the valve cover to be installed, no additional credit is taken here for extra precautions that might be observed if the workers believed that their life would be endangered by mistakes. No recovery probability is assessed because once the cylinder is dropped there is no opportunity to recover the situation. The human error probability (HEP) for failing to install the valve cover properly is 0.003 (failure to properly mate a connector; Swain and Guttmann 1983). Failure to check the valve cover installation during receipt inspection is 0.1 (Swain and Guttmann 1983). The conditional probability of valve failure given that the cylinder is dropped with an improperly installed valve cover is judged to be no more than 0.25 because the cylinder can be dropped on the top, the bottom, or either side, and only dropping the cylinder on the top is judged to be associated with valve failure.

On the basis of these considerations, the above equation can be quantified as follows:

$$F_{DROP} = N_{HANDLED} \text{ x } H_{DROP} \text{ x } H_{COVER} \text{ x } H_{CHK} \text{ x } C_{FAIL}$$

$$= 140 \text{ x } 0.003 \text{ x } 0.003 \text{ x } 0.1 \text{ x } 0.25$$

$$= 3.2 \text{ x } 10^{-5} \text{ per year}$$

The Gas Plant SA identified failure of a cylinder due to deterioration from weather. This failure mode is essentially a random cylinder failure, especially considering that the cylinders are designed to be exposed to weather but are stored inside the toxic gas storage shed until they are picked up for shipment to the potable water chlorinator stations.

The frequency of random cylinder failure can be assessed as follows:

$$F_{RANDOM} = R_{HOUR} \text{ x (8,760 hr/yr) x } N_{CYL}$$

where:

F_{RANDOM} = Frequency of random cylinder failure

R_{HOUR} = Random failure rate per hour of a pressurized cylinder

8,760 hr/yr = The number of hours in a year

N_{CYL} = The number of cylinders in storage

The random failure rate for a pressurized cylinder is 1 x 10^{-9} per hour (Mahn et al. 1995). The number of cylinders in storage is ten full cylinders at any one time (Lovato and Nielsen 1997). Thus, the above equation can be quantified as follows:

$$F_{RANDOM} = R_{HOUR} \text{ x (8,760 hr/yr) x } N_{CYL}$$

$$= (1 \text{ x } 10^{-9}\text{/hr) x (8,760 hr/yr) x } 10$$

$$= 8.8 \text{ x } 10^{-5} \text{ per year}$$

The combined frequency of occurrence of a single cylinder toxic gas release is obtained from the following equation:

$$F_{TOTAL} = F_{DROP} + F_{RANDOM}$$

$$= (3.2 \text{ x } 10^{-5}) + (8.8 \text{ x } 10^{-5})$$

$$= 1.2 \text{ x } 10^{-4} \text{ per year}$$

Expanded Operations Alternative Frequency Analysis

There is only one difference for the Expanded Operations Alternative that affects sequence frequency. In the Expanded Operations Alternative there are 79 cylinders handled per year, with a total of 158 handling events. The equation above for the cylinder drop scenario can be reevaluated for the Expanded Operations Alternative as follows:

$$F_{DROP} = N_{HANDLED} \times H_{DROP} \times H_{COVER} \times H_{CHK} \times C_{FAIL}$$

$$= 158 \times 0.003 \times 0.003 \times 0.1 \times 0.25$$

$$= 3.6 \times 10^{-5} \text{ per year}$$

Because the frequency of random failure does not change, the combined frequency of occurrence of a single cylinder toxic gas release for the Expanded Operations Alternative is obtained as follows:

$$F_{TOTAL} = F_{DROP} + F_{RANDOM}$$

$$= (3.6 \times 10^{-5}) + (8.8 \times 10^{-5})$$

$$= 1.2 \times 10^{-4} \text{ per year}$$

Reduced Operations Alternative Frequency Analysis

There is only one difference for the Reduced Operations Alternative that affects sequence frequency. Based on the analysis of scenario CHEM–02 (Rev. 0, 04/08/97), there are 66 cylinders handled per year, with a total of 132 handling events. The equation for cylinder drop can be reevaluated as follows:

$$F_{DROP} = N_{HANDLED} \times H_{DROP} \times H_{COVER} \times H_{CHK} \times C_{FAIL}$$

$$F_{DROP} = 132 \times 0.003 \times 0.003 \times 0.1 \times 0.25$$

$$F_{DROP} = 3.0 \times 10^{-5} \text{ per year}$$

Because the frequency of random failure does not change, the combined frequency of occurrence of a single cylinder toxic gas release for the Expanded Operations Alternative is obtained as follows:

$$F_{TOTAL} = F_{DROP} + F_{RANDOM}$$

$$= (3 \times 10^{-5}) + (8.8 \times 10^{-5})$$

$$= 1.2 \times 10^{-4} \text{ per year}$$

Greener Alternative Frequency Analysis

The number of cylinders handled per year under the Greener Alternative is the same as the No Action Alternative. Thus, the frequency of a release of a single cylinder of chlorine gas is the same, or a frequency of 1.2×10^{-4} per year.

Uncertainties and Sensitivities Affecting the Frequency of CHEM–03

Because the number of cylinders handled per year and the number of trips per year are relatively well known, the principal uncertainties in the frequency of a single cylinder release of chlorine relate to the error factors for the human errors modeled. These error factors range from three to five (Swain and Guttman 1983). Even if an error factor of five were considered, the contribution to frequency of CHEM–03 would be about evenly split between the low-frequency human error leading to valve failure and the random failure of a cylinder.

Source Term Calculations

The available material for release in the CHEM–03 source term is limited to the complete contents of one chlorine cylinder, or 150 pounds. However, the release through the valve orifice is such that 68 to 75 pounds of chlorine release quickly; but, in the process the cylinder is cooled below the boiling point of the chlorine liquid remaining in the cylinder and the release is essentially terminated. If no recovery actions are taken, the cylinder would ultimately heat up above the boiling temperature of chlorine and a release would resume, but at a very low rate, which is unlikely to result in any health consequences downwind of the cylinder.

Uncertainties and Sensitivities Affecting the Source Term for CHEM–03

EPA Risk Management Program off-site consequence analysis guidance issued in 1996 indicates that when a toxic gas is released inside a building that has direct contact with the outside environment (such as a shed), the release rate is ameliorated somewhat due to mixing within the shed. The guidance suggests multiplying the release rate by 0.55 (EPA 1996). The same quantity of gas is released, but the release duration is extended beyond what would be predicted by the ALOHA™ code. This reduction factor is not applied here because the release could also occur outdoors (human error dropping a cylinder).

Consequences of CHEM–03 for Facility Workers and the Public

Consequences of the CHEM–03 accident are reported separately for facility workers and the public. Gas Plant personnel who are directly involved in handling the cylinders of chlorine could quickly be exposed to high concentrations for the human error (cylinder dropping) contributor to the scenario frequency. In the case of the random cylinder failure contributor, however, it is more likely that no one will be near the toxic gas storage shed when the leakage begins. Other Gas Plant personnel located outdoors at the time of the accident could be exposed to concentrations greater than ERPG–2 and ERPG–3. However, these personnel would be in a position to evacuate the affected area very quickly (due to being outdoors), which would reduce the potential for serious health effects.

Under adverse dispersion conditions (stable atmosphere), the ERPG–2 distance ranges from 0.76 to 0.79 mile (1.2 to 1.3 kilometer), and the ERPG–3 distance ranges from 0.32 to 0.33 mile (0.52 to 0.53 kilometer). Under conservative daytime dispersion conditions, the ERPG–2 distance ranges from 0.62 to 0.71 miles, and the ERPG–3 distance ranges from 0.27 to 0.31 mile. The average number of people exposed under conservative daytime dispersion conditions is shown in Table G.5.5.3–1.

G.5.5.4 *CHEM–04, Single Container Release of Toxic Gas from Waste Gas Cylinder Storage*

General Scenario Description

TA–54–216 is located at TA–54 Area L, which provides permitted storage for hazardous waste and liquid- or volatile-organic-containing waste that is contaminated with both hazardous and radioactive components. The TA–54–216 storage canopy is used to store waste gas cylinders pending final determination of disposal options. The storage canopy is a fabric dome structure that is open on three sides (east, north, and west) to provide ventilation.

From 1983 to November 1996, TA–54–216 has received a total of 4,144 waste cylinders. Currently, approximately 200 cylinders are stored at the facility and are representative of what TA–54–216 is anticipated to have in inventory in the future. Occasionally, a large influx of gas cylinders may occur due to decontamination and decommissioning activities at LANL.

Activities at TA–54–216 are generally limited to the receipt, storage, staging, and shipment of gas cylinders. Gas cylinders are stored and moved in gas cylinder racks by forklift (gasoline or electric). At some time in the future, it will be necessary to repackage some of the gases into DOT-qualified packages so that they may be shipped off site for disposal. Facility activities generally do not involve the removal of cylinder valve covers (some do not have covers but the cylinder design protects the valve). The exception to this is when the valve covers are briefly removed for verification that the valves are secure and leak-tight prior to off-site shipment for disposal.

Based on the type of activities conducted at TA–54–216, potential accident initiators leading to an individual cylinder release include random failure of a cylinder, failure of a cylinder due to a forklift accident, or human error during cylinder handling.

This accident was not evaluated in LANL safety analysis documentation reviewed in the preparation of the SWEIS.

Properties of Selenium Hexafluoride Gas

Selenium hexafluoride is a colorless toxic gas (TWA is 0.05 parts per million) that irritates the skin and eyes; may cause severe pulmonary irritation with coughing, choking, and shortness of breath; and also may cause pulmonary edema. It is stable at normal temperatures but has hazardous decomposition products. There is no evidence of carcinogenicity.

No Action Alternative Frequency Analysis

The frequency of a single cylinder release of any gas was calculated at TA–54–216 using the inventory of gas cylinders at the facility and associated movements. This provides a bounding estimate of risk associated with a single cylinder release and gives a broader representation of risk for site-wide activities potentially leading to a single container release of a toxic gas (postulated chlorine releases are evaluated separately).

Human error contributions (dropping a cylinder during handling with valve cover removed or improperly installed) are considered negligible for off-site shipments. This is based on verification of valve leak tightness while the cylinder is in the cylinder rack (precluding a drop accident), the low probability of the valve cover being improperly reinstalled (this would be self evident), and the hazards training and awareness of involved personnel. The combined frequency (F_{TOTAL}) of a single cylinder release may be quantified as:

$$F_{TOTAL} = F_{RANDOM} + F_{FORKLIFT}$$

where:

F_{RANDOM} = Frequency of a toxic gas release due to a random cylinder failure

$F_{FORKLIFT}$ = Frequency of a toxic gas release due to a forklift accident

Random cylinder failure can occur due to a variety of causes (including cylinder defects, weathering, corrosive attack, damage to valving). For random failure, the frequency can be estimated as follows:

$$F_{RANDOM} = 8{,}760 \times R_{HOUR} \times N_{CYL}$$

where:

F_{RANDOM} = Frequency of a toxic gas release due to a random cylinder failure

8,760 = Number of hours in a year (24 hours x 365 days)

R_{HOUR} = Random failure rate of pressurized cylinder (10^{-9} per hour; Mahn et al.1995)

N_{CYL} = Number of toxic gas cylinders at risk (200 representative inventory)

Thus, the above equation can be quantified as follows:

$$F_{RANDOM} = 8{,}760 \times R_{HOUR} \times N_{CYL}$$

$$= 8{,}760 \text{ hr} \times (1 \times 10^{-9}/\text{hr}) \times 200$$

$$= 1.8 \times 10^{-3} \text{ per year}$$

The frequency of a forklift accident leading to a release of a toxic gas from a single cylinder may be analyzed using the following equation:

$$F_{FORKLIFT} = N_{FMOVE} \times C_{PFACC} \times C_{PCFAIL}$$

where:

$F_{FORKLIFT}$ = Frequency of a toxic gas release due to a forklift accident

N_{FMOVE} = Number of forklift movements per year

C_{PFACC} = Conditional probability of a forklift accident per movement

C_{PCFAIL} = Conditional probability of toxic gas cylinder failure per forklift accident

Between 1983 and November 1996, TA–54–216 received 4,144 toxic waste cylinders. Thus, annual throughput is approximated as 300 (4,144/14) toxic gas cylinders per year. Forklift movements at TA–54–216 occur at the time of receipt and for off-site shipment. Additionally, it is assumed that at least one forklift movement is made for inventory control/staging while stored at TA–54–216. Multiple cylinders are stored in racks. It is conservatively assumed that only two cylinders are stored per rack, resulting in an estimated 450 (3 x 300/2) forklift movements per year. The conditional probability of a forklift accident is estimated as 1 x 10^{-5} per forklift movement (LANL 1995g). Not all forklift accidents will be of sufficient severity to result in damage to a cylinder and a release of its contents. The conditional probability depends on the nature of the accident and how the individual cylinder is mechanically impacted by drop, puncture, and crush forces. There is a potential that any forklift accident at TA–54–216 would be aggravated by the uneven grade at the facility. There is an elevation grade transition of approximately 3.3 feet (1 meter) that runs through the center length of the canopy. To account for the foregoing, and because some of the cylinders are not U.S. Department of Transportation (DOT) certified, it is conservatively assumed that the conditional probability of a single cylinder failure per forklift accident is 0.5. Forklift accidents also may also involve multiple cylinder failures, such as a forklift fuel tank fire. This component of risk is quantified in accident Scenario CHEM–05.

Thus, the above equation can be quantified as follows:

$$F_{FORKLIFT} = N_{FMOVE} \times C_{PFACC} \times C_{PCFAIL}$$

$$= 450 \text{ moves} \times (1 \times 10^{-5} \text{ per move}) \times 0.5$$

$$= 2.3 \times 10^{-3} \text{ per year}$$

From the above analyses, the combined frequency of occurrence for a single cylinder release of toxic gas is estimated as:

$$F_{TOTAL} = F_{RANDOM} + F_{FORKLIFT}$$

$$= (1.8 \times 10^{-3}) + (2.3 \times 10^{-3})$$

$$= 4.1 \times 10^{-3} \text{ per year}$$

Expanded Operations Alternative, Reduced Operations Alternative, and Greener Alternative Frequency Analysis

There are no differences in operations or throughput across the alternatives for this scenario. Accordingly, the No Action Alternative frequency value represents all alternatives.

Uncertainties and Sensitivities Affecting the Frequency of CHEM–04

Several uncertainties are associated with the selected accident scenario frequency and conditional probability parameters. In all cases, realistically conservative values have been used based on identified accident conditions and facility-specific conditions.

Source Term Calculations

Accident screening of the historical chemical inventory data identified selenium hexafluoride as the dominant chemical-of-concern for a single toxic gas cylinder (75 liters) release. This chemical had the greatest ERPG–2 and ERPG–3 distances for a single cylinder out of the historical inventory, which should be broadly representative of future activities. In fact, it should be generally the case that future gas cylinders passing through TA–54–216 would be less hazardous than in the past, due to effort by LANL to reduce its inventory of hazardous chemicals.

The release is modeled as a direct release of 7.5 liters of gas per minute for 10 minutes. The release is modeled in this manner because there is insufficient information available regarding cylinder size and pressure to perform a more precise calculation. There is no variation in the MAR or postulated accident conditions from the No Action Alternative across the remaining alternatives.

Uncertainties and Sensitivities Affecting the Source Term for CHEM–04

The source term calculation is based on the single cylinder's size and chemical producing the largest ERPG–2 and ERPG–3 distances for the toxic gas cylinders processed through TA–54–216 in the historical database. Given this, unless circumstances change significantly (i.e., a much more toxic chemical is handled in significant quantity), this release should be bounding. It should be noted that it is conservative to assume that the cylinder is full; it is likely that the inventory may have been partially or largely depleted during use.

Consequences of CHEM–04 for Facility Workers and the Public

Typically four to five people actively work in the Area L yard in which TA–54–216 is located. An additional ten people may be present in the yard in support of construction activities. Depending on the nature of activity at TA–54–216, zero to three people would be expected to be present at the facility itself.

Traumatic injuries or fatalities could occur from missiles for any individuals present at the time of cylinder rupture or involved in the forklift accident. Health consequences from the toxic nature of the released gas also may occur. Depending on exposure levels and durations, four possible adverse health outcomes may result: (1) mild, transient adverse health effects; (2) reversible, but more serious adverse health effects; (3) irreversible, adverse health effects; and (4) life-threatening health effects.

For outdoor incidents, facility workers are trained (Emergency Action Plan) to stop all activity and to leave the immediate area for any release of an unknown substance or known hazardous substance. Personnel are trained to alert others and to activate applicable alarms on the way out and to proceed upwind (based on direction of visible windsock, wind vane, or other indicators) to the nearest muster station. If not at immediate risk, the worker is trained to shutdown equipment. Emergency response planning also includes provisions for evacuation. These actions will serve to mitigate impacts to workers.

Under adverse dispersion conditions, the ERPG–2 distance is about 230 yards (210 meters). Under conservative daytime dispersion conditions, the ERPG–3 and ERPG–2 exposure distances are less than 100 yards. The average number of people exposed to greater than ERPG–3 and ERPG–2 concentrations for conservative daytime dispersion is provided in Table G.5.5.4–1.

G.5.5.5 *CHEM–05, Multiple Cylinder Release of Toxic Gas from Waste Gas Cylinder Storage at TA–54–216*

General Scenario Description

This scenario occurs at the same facility as CHEM–04; however, it differs in that the consequence results from the bounding historical inventory of chemicals present in multiple cylinders. Accident screening of the historical chemical inventory data identified sulfur dioxide as the dominant chemical-of-concern for a multiple toxic gas cylinder release.

Properties of Sulfur Dioxide Gas

Sulfur dioxide is a colorless, nonflammable gas (or liquid under pressure). Sulfur dioxide (SO_2) is listed on EPA's Extremely Hazardous Substances List. It is a poisonous gas chiefly affecting the upper respiratory tract and the bronchi, and it is also a corrosive irritant to the eyes, skin, and mucous membranes (Lewis 1993).

CHEM–05 Release Mechanisms

Based on the type of activities conducted at TA–54–216, potential accident initiators leading to a multiple cylinder release include propagation of a random failure of a cylinder (rupture) from missiles, a forklift fire or a delivery/shipment truck fire incident, or rupture and subsequent BLEVE (boiling liquid expanding vapor explosion) of the adjacent propane tank. The resulting fireball and thermal radiation would be the primary concern associated with potential to impact multiple cylinders. Propane tank leak explosion hazards include the potential for significant overpressure and missiles.

No Action Alternative Frequency Analysis

While sulfur dioxide is the dominant chemical-of-concern for a multiple cylinder release, the frequency of a multiple cylinder release of any gas was calculated at TA–54–216 using the typical inventory of gas cylinders at the facility and associated movements. This provides a bounding estimate of risk associated with a multiple cylinder release of sulfur dioxide and gives a broader representation of risk for site-wide activities potentially leading to a multiple cylinder release of a toxic gas (postulated chlorine releases are evaluated separately).

Potential accident initiators leading to a multiple cylinder release include propagation of a random failure of a cylinder (rupture) from missiles, a forklift fire or a delivery/shipment truck fire incident, or rupture and subsequent BLEVE/explosion of the adjacent propane tank. Thus, the combined frequency (F_{TOTAL}) of a multiple cylinder release may be quantified as:

$$F_{TOTAL} = F_{RANDOM} + F_{FLFTFIRE} + F_{TRKFIRE} + F_{PROTANK}$$

where:

F_{RANDOM} = Frequency of a toxic gas release due to a random cylinder failure

$F_{FLFTFIRE}$ = Frequency of a toxic gas release due to a forklift fire

$F_{TRKFIRE}$ = Frequency of a toxic gas release due to a truck fire

$F_{PROTANK}$ = Frequency of a toxic gas release due to detonation of the propane tank

Random failure can occur due to a variety of causes (including cylinder defects, weathering, corrosive attack, damage to valving). For propagation of a random failure resulting in a multiple cylinder release, the frequency (F_{RANDOM}) can be estimated as follows:

$$F_{RANDOM} = 8{,}760 \times R_{HOUR} \times N_{CYL} \times C_{PROP}$$

where:

8,760 = Number of hours in a year (24 hours x 365 days)

R_{HOUR} = Random failure rate of pressurized cylinder (1 x 10^{-9}/hr) (Mahn et al.1995)

N_{CYL} = Number of toxic gas cylinders at risk (200 representative inventory)

C_{PROP} = Conditional probability of propagating failure given one cylinder ruptures

The CMR Building SAR (LANL 1995c) indicates based on historical experience that a leak is 20 times more likely to occur than a rupture. Leaks will not propagate unless the leaked gas is flammable or pyrophoric; sulfur dioxide is neither. Consequently, conservatively assuming that propagation occurs given a rupture, the conditional probability of propagation is 0.05 (1/20). This value is considered to be very conservative, especially considering the separation of several of the cylinder racks to accommodate forklift movements. The above equation can be quantified as follows:

$$F_{RANDOM} = 8{,}760 \times R_{HOUR} \times N_{CYL} \times C_{PROP}$$

$$= 8{,}760 \times (1 \times 10^{-9}) \times 200 \times 0.05$$

$$= 8.8 \times 10^{-5} \text{ per year}$$

The frequency of a forklift fire ($F_{FLFTFIRE}$) leading to a release of toxic gas from multiple cylinders may be analyzed using the following equation:

$$F_{FLFTFIRE} = N_{FMOVE} \times N_{HOUR} \times F_{FUEL} \times C_{PING}$$

where:

N_{FMOVE} = Number of forklift movements per year

N_{HOUR} = Number of hours per forklift movement

F_{FUEL} = Frequency of a fuel tank rupture per hour

C_{PING} = Conditional probability of ignition given a fuel tank rupture and subsequent propagation of failure

From 1983 to November 1996, TA–54–216 received 4,144 waste cylinders. Thus, annual throughput has been approximately 300 (4,144/14) cylinders per year. Forklift movements at TA–54–216 occur at the time of receipt and for off-site shipment. Additionally, it is assumed that at least one forklift movement is made for inventory control/staging while stored at TA–54–216. Multiple cylinders are stored in racks. It is conservatively assumed that only two cylinders are stored per rack, resulting in an estimated 450 (3 x 300/2) forklift movements per year. It is conservatively assumed that each forklift movement has a duration of 0.5 hour.

The frequency of a forklift fuel tank rupture and a resulting fire is assessed for TA–54–214 based on methods and data contained in the TA–54, Area G hazard analysis (LANL 1995g) and the evaluation of ignition probabilities given a tank rupture by the Reliability Analysis Center in Rome, New York (RAC 1991). The frequency of a fuel tank rupture was assessed as 2.3×10^{-5} per hour in the TA–54 hazard analysis (LANL 1995g). For a nondiesel fuel (propane), the conditional probability of ignition given a rupture is assigned a value of 1×10^{-2}.

Thus, the above equation can be quantified as follows:

$$F_{FLFTFIRE} = N_{FMOVE} \times N_{HOUR} \times F_{FUEL} \times C_{PING}$$

$$= 450 \times 0.5 \times (2.3 \times 10^{-5}) \times 0.01$$

$$= 5.2 \times 10^{-5} \text{ per year}$$

The frequency of a truck fuel leak and fire contributor accident can be estimated using the following equation:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

where:

F_{FIRE} = Frequency of a fire at TA–54–216

$N_{SHIPMENTS}$ = Number of shipments to or from TA–54–216 per year

C_{LEAK} = Conditional probability of fuel leak per shipment

C_{PFIRE} = Conditional probability of a fire given a fuel leak and subsequent propagation of failure

The frequency of a fuel system leak or fuel tank leak and a resulting fire is assessed for TA–54–216 based on methods and data contained in the TA–54, Area G Hazard Analysis (LANL 1995g) and the evaluation of TRU waste transportation by H&R Technical Associates, discussed in section G.5.5.1. On a per trip basis, the likelihood of a fuel leak is 0.1/78, or 1.3 x 10^{-3} per trip. The conditional probability of a fire given a fuel leak is 4.7 x 10^{-3} per fuel leak. The number of shipments is estimated at 60 shipments per year (300 cylinder throughput per year x 2 shipments per cylinder/ 10 cylinders per shipment). Thus, the above equation can be quantified as follows:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

$$= 60 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$= 3.7 \times 10^{-4} \text{ per year}$$

For a random tank failure and subsequent BLEVE/explosion (F_{RANDOM}), the frequency can be estimated as follows:

$$F_{RANDOM} = 8{,}760 \times R_{HOUR} \times C_{PEXP}$$

where:

8,760 = Number of hours in a year (24 hours x 365 days)

R_{HOUR} = Random tank failure rate per hour

C_{PEXP} = Conditional probability of a BLEVE/ explosion and subsequent propagation of failure

The random failure rate of a pressurized tank, accounting for in-service inspections is 10^{-10} per hour (Mahn et al. 1995). The conditional probability of a BLEVE/explosion versus no ignition or jet flaming is conservatively estimated to be 0.25 on the basis that propane has a very narrow explosive range (lower explosive limit of 2.1 and an upper explosive limit of 9.5) (MGP 1997).

Thus, the above equation can be quantified as follows:

$$F_{RANDOM} = 8{,}760 \times R_{HOUR} \times C_{PEXP}$$

$$= 8{,}760 \times (1 \times 10^{-10}) \times 0.25$$

$$= 2.2 \times 10^{-7} \text{ per year}$$

From the above analyses, the combined frequency of occurrence for a multiple cylinder release of toxic gas is estimated as:

$$F_{TOTAL} = F_{RANDOM} + F_{FLFTFIRE} + F_{TRKFIRE} + F_{PROTANK}$$

$$F_{TOTAL} = (8.8 \times 10^{-5}) + (5.2 \times 10^{-5}) + (3.7 \times 10^{-4}) + (2.2 \times 10^{-7})$$

$$F_{TOTAL} = 5.1 \times 10^{-4} \text{ per year}$$

Expanded Operations Alternative, Reduced Operations Alternative, and Greener Alternative Frequency Analysis

No differences in operations across the alternatives have been identified for this accident scenario. Accordingly, the above frequency calculations represent all alternatives.

Uncertainties and Sensitivities Affecting the Frequency of CHEM–05

Several uncertainties are associated with the selected accident scenario frequency and conditional probability parameters. In all cases, realistically conservative values have been used based on identified accident conditions and facility specifics.

Source Term Calculations

The source term for this accident scenario is based on a release of the contents of multiple toxic gas cylinders. Accident screening of the current chemical inventory data identified sulfur dioxide as the dominant chemical-of-concern for a multiple toxic gas cylinder (136 liters) release. The release is modeled as two, 150-pound cylinders releasing 30 pounds per minute for 10 minutes. The release is modeled as a continuous release because insufficient information is available concerning the cylinder size and pressure.

Uncertainties and Sensitivities Affecting the Source Term for CHEM–05

Sulfur dioxide is the dominant chemical-of-concern from a toxic standpoint. Source term uncertainties include the total number of cylinders that may be affected by a specific accident initiator, the release rate from the cylinders, and the possible influences of building wakes and buoyancy considerations for fire events.

Consequences of CHEM–05 for Facility Workers and the Public

Typically four to five operations personnel actively work in the Area L yard where TA–54–216 is located. An additional ten people may be present in the yard in support of construction activities. Depending on the nature of activity at TA–54–216, zero to three people would be expected to be present at the facility itself.

Traumatic injuries or fatalities could occur from missiles for any individuals present at the time of the postulated cylinder ruptures or involved in the forklift/truck fire incidents. Health consequences from the toxic nature of the released gas also may occur. Depending on the exposure levels and durations, four possible adverse health outcomes may result: (1) mild, transient adverse health effects; (2) reversible but more serious adverse health effects; (3) irreversible, adverse health effects; and (4) life-threatening health effects.

For outdoor incidents, facility workers are trained (Emergency Action Plan) to stop all activity and to leave the immediate area for any release of an unknown substance or known hazardous substance. Personnel are trained to alert others and to actuate applicable alarms on the way out and to proceed upwind (based on direction of visible windsock, wind vane, or other indicators) to the nearest muster station. If not at immediate risk, the worker is trained to shutdown equipment. Emergency response planning also includes provisions for evacuation. These actions will serve to mitigate impacts to the workers.

Under adverse dispersion conditions (stable atmosphere), the ERPG–2 distance is 1.7 miles (2.7 kilometers), while the ERPG–3 distance is 0.75 mile (1.2 kilometer). Under conservative daytime dispersion conditions, the ERPG–2 distance ranges from 0.62 to 0.81 mile (1.0 to 1.3 kilometers), while the ERPG–3 distance ranges from 0.28 to 0.34 mile (0.45 to 0.55 kilometer). The average affected population at higher than ERPG–2 and ERPG–3 concentrations under conservative daytime dispersion conditions is shown in Table G.5.5.5–1. There are only two directions (west and northwest) where the off-site population can be exposed, due to the remoteness of the site.

G.5.5.6 *CHEM–06, Chlorine Gas Release from Outside the Plutonium Facility*

General Scenario Description

TA–55–4 is the LANL Plutonium Facility. At TA–55–4, gaseous chlorine is used for various processes. The chlorine is supplied by piping from a 150-pound cylinder that is kept in a storage room for corrosive and toxic gases, outside TA–55–4. When the chlorine is not in use, the piping is shut off at the chlorine tank valve, and the line is purged and then pressurized with argon to prevent leaks during off-duty hours (LANL 1996k).

In this scenario, a chlorine release occurs due to a failure of piping associated with a chlorine gas cylinder. The piping failure is assumed to occur outside TA–55–4, leading to a release directly to the atmosphere (LANL 1996k). Chlorine is a heavy gas, which will affect the downwind dispersion of the gas following release. The properties of chlorine gas and heavy gases are discussed in section G.5.5.1.

Accident Scenario CHEM–06 was analyzed in detail in the TA–55–4 SAR. The SAR analysis considered significant inventories of hazardous chemicals with potential for release affecting workers and the off-site population. The hazard analysis that underlies the SAR identified a spill of nitric acid, a spill of hydrochloric acid, a release of gaseous fluorine or hydrogen fluoride, and a release of gaseous chlorine as possible scenarios (LANL 1996k).

The SAR evaluated the tests through which DOT-approved storage cylinders are placed, and concluded that catastrophic failures of gas bottles are not expected. Rather, the SAR found that chronic releases from improper or failed connectors at piping manifolds are the most likely cause of a release. Using a Gaussian dispersion model, the SAR analyzed the consequences of the bounding toxic gas releases at a 2,952-foot (900-meter) distance where public exposure is possible. Chlorine was found to produce the bounding consequence (LANL 1996k).

The SAR analysis assumed a release of 150 pounds of chlorine gas over a 15-minute period at a release height of 16 feet (5 meters). The downwind concentration of chlorine was calculated using the CHEM-MIDAS heavy gas dispersion model, and evaluated for adverse dispersion conditions (in this case, stability Class F and 1.9 meters per second wind speed). The code calculated a concentration at the Royal Crest Trailer Court of 8 parts per million (LANL 1996k). The ERPG–3 concentration for chlorine is 20 parts per million, while the ERPG–2 level is 3 parts per million.

CHEM–06 Release Mechanisms

The TA–55 SAR assumed the chlorine release was due to a break in the line outside TA–55–4.

No Action Alternative Frequency Analysis

During the facility walkdown, it was learned that the TA–55 SAR frequency bin assignment of 10^{-2} to 10^{-1} per year for this scenario was based on one event in 16 years (1978 to1996) in which a cylinder of chlorine was partially released as a result of mechanical damage to the gas line. Because this was a partial failure, the calculation of frequency based on one event in 16 years (6.3×10^{-2} per year) is conservative.

Expanded Operations Alternative, Reduced Operations Alternative, and Greener Alternative Frequency Analysis

There are no differences in operations across the alternatives affecting the chlorine system. The frequency estimated above for the No Action Alternative is considered to be applicable to the remaining alternatives.

Uncertainties and Sensitivities Affecting the Frequency of CHEM–06

The TA–55 hazard analysis places the rupture of the gas manifold due to impact by heavy equipment in the frequency bin from 10^{-4} to 10^{-2} per year (LANL 1996l). The hazard analysis also identifies a gas leak in Room 116 in the same frequency bin, citing Unusual Occurrence Report 89832 (LANL 1996l). Figure 2A–3 of the TA–55 SAR identifies Room 116 of TA–55–4 as a corridor between the 100 Area and 200 Area rooms on the first floor of the building. This release would affect TA–55–4 workers in the first instance, but would ultimately be released to the environment.

Other failure modes for chlorine release are possible, such as random cylinder or manifold failure, or human error during cylinder changeout (see section G.5.5.1). Given the much lower level of activity at TA–55–4 for chlorine cylinder changeout, the experience-based frequency cited above is selected.

Source Term Calculations

The release is assumed to be a ground level release of a full, 150-pound cylinder. There are no differences in source term across the SWEIS alternatives. The release is modeled as a 15-pound per minute release into the building for 10 minutes, in accordance with the description of the release in the TA–55 SAR.

The EPA RMP off-site consequence analysis guidance issued in 1996 indicates that when a toxic gas is released inside a building that has direct contact with the outside environment (such as a shed), the release rate is ameliorated somewhat due to mixing within the shed. The guidance suggests multiplying the release rate by 0.55 (EPA 1996). In order to obtain the release duration, it is then necessary to divide the total quantity released by the effective release rate. When this method is applied to the TA–55 chlorine gas leak, the release duration is increased to 18.2 minutes and the outdoor concentrations proportionately reduced.

Uncertainties and Sensitivities Affecting the Source Term for CHEM–06

The release rate from the cylinder itself is modeled as a continuous rate; whereas, releases from cylinders vary with time. The 10-minute period is regarded as conservative. The factor of 0.55 accounting for the retention time prior to release to the outdoors is uncertain for this storage shed.

Consequences of CHEM–06 for Facility Workers and the Public

Facility worker and public consequences are addressed separately. Because the air intakes for TA–55–4 are on the west end of the building at a point centered 18 feet (5.5 meters) above the ground, and the chlorine release point is on the north side of the building (LANL 1996k), it is unlikely that chlorine released into the air would be drawn into the building by the ventilation system. Moreover, there is a 30-inch (76-centimeter) diameter butterfly valve in the intake ductwork that can be closed manually to act as a shut-off valve (LANL 1996k). TA–55 personnel located outdoors at the time of the accident could be exposed to high concentrations of chlorine. However, these personnel would be in a position to evacuate from the affected area very quickly (being outdoors), which should reduce the potential for health effects.

Under adverse dispersion conditions (stable atmosphere), the ERPG–2 distance ranges from 0.58 to 0.66 mile (0.93 to 1.1 kilometer), while the ERPG–3 distance is 0.2 mile (0.32 kilometer). Under conservative daytime dispersion conditions, the ERPG–2 distance is about 0.27 mile (0.43 kilometer), while the ERPG–3 distance is about 0.10 mile (0.16 kilometer). The average number of members of the public exposed above ERPG–2 and ERPG–3 concentrations under conservative daytime dispersion conditions is shown in Table G.5.5.6–1.

TABLE G.5.5.6–1.—*Summary Results for Scenario CHEM–06*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	6.3×10^{-2}	150 pounds of chlorine released in 18.2 minutes; average number of people exposed above ERPG–2 and ERPG–3 concentrations is 102 and 7, under conservative daytime dispersion conditions.
Expanded Operations	6.3×10^{-2}	Same as No Action Alternative.
Reduced Operations	6.3×10^{-2}	Same as No Action Alternative.
Greener	6.3×10^{-2}	Same as No Action Alternative.

G.5.6 Radiological Accidents

G.5.6.1 *RAD–01, TRU Waste Container Storage Area Fire at NDA/NDE Facility (TA–54–38)*

General Scenario Description

The Nondestructive Assay/Nondestructive Examination (NDA/NDE) Facility conducts verification assay and radiographic examination of unopened waste containers to confirm compliance with waste acceptance criteria (WAC). An outdoor container storage area (40 feet by 40 feet [12 meters by 12 meters]) is designated to stage waste processed through the facility. The outdoor Container Storage Area has a RCRA Part B permitted capacity of 7,920 gallons of mixed waste, which is equivalent to 144, 55-gallon drums. However, the capacity of the Container Storage Area is administratively controlled to 23 DOT Type A drums (of the type used for TRU waste). Scenario RAD–01 involves an airborne release of radioactive material due to a fire that develops at the outdoor Container Storage Area.

Properties of TRU Waste. Transuranic waste contains at least 100 nanocuries per gram of transuranium isotopes (primarily plutonium and americium). It is present in a wide variety of forms at LANL, some of which are combustible (e.g., paper, plastic, etc.) and some of which are not combustible (e.g., concrete).

RAD–01 Release Mechanisms. Potential accident initiators include: (1) truck fires, (2) forklift fires, (3) external fires (wild fires), (4) lightning strikes, and (5) aircraft accidents. Aircraft crash was evaluated in section G.4 and is not considered further here. Lightning may strike the Container Storage Area or pose an indirect hazard by initiating a wildfire. The Container Storage Area does not have lightning protection; however, a lightning strike would, at most, pose a localized hazard due to ignition of combustible waste. It would have a very limited opportunity to propagate with waste contained in metal drums and the low combustible loading of the storage array. Wild fires, initiated by lightning strikes or otherwise, do not pose a significant hazard considering the developed nature of the area (e.g., pavement) and the time available to take mitigative actions. A forklift fire would be credible but would be significantly bounded by the MAR for a truck fire accident.

Two truck fire scenarios could occur. The first is an accident involving a truck that causes a fuel leak and subsequent fire involving the Container Storage Area. This is judged not to be credible considering the low truck speeds involved in the confined yard area and the limited vehicle traffic, with the exception of forklift activity. The second involves a truck parked near the Container Storage Area that could experience a fuel system leak or fuel tank leak due to causes unrelated to a vehicle accident. Once a fuel leak occurs, ignition of the spilled fuel would lead to a fire that, if it is close enough to the Container Storage Area and if it is not suppressed, would envelop multiple waste containers. This scenario is retained for analysis. The TA–54–38 safety assessment did not evaluate the potential for a Container Storage Area fire (LANL 1996j).

No Action Alternative Frequency Analysis

The frequency of a truck fuel leak and subsequent fire accident can be estimated using the following equation:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

where:

F_{FIRE} = Frequency of truck fuel leak and fire

$N_{SHIPMENTS}$ = Number of shipments to or from the outdoor Container Storage Area at TA–54–38 per year

C_{LEAK} = Conditional probability of fuel leak per shipment

C_{PFIRE} = Conditional probability of a fire given a fuel leak

The frequency of a fuel system leak or fuel tank leak and a resulting fire is assessed for the outdoor Container Storage Area based on methods and data contained in the TA–54, Area G Hazard Analysis (LANL 1995g) and the evaluation of TRU waste transportation by H&R Technical Associates (Rhyne 1994). As described in section G.5.5, on a per trip basis, the likelihood of a fuel leak is 0.1/78, or 1.3 x 10^{-3} per trip. Similarly, as described in section G.5.5, the conditional probability of a fire given a fuel leak is 4.7 x 10^{-3} per fuel leak.

Facility truck movements may be associated with the loading dock, the truck bay (primarily in support of Waste Isolation Pilot Plant [WIPP] shipments), and the outdoor Container Storage Area. LANL intra-site shipments of TRU waste average approximately 16 drums per shipment, with a maximum of 40 drums. Because the Container Storage Area capacity is administratively controlled to a limit of 23 drums, it will be assumed that all shipments are 23-drum shipments. It is assumed that shipments associated with the outdoor Container Storage Area would primarily be conducted to receive waste from TA–54 Area G for staging just prior to shipment to WIPP and are insensitive to the facility throughput for assay verification. Each WIPP shipment consists of three Transuranic Packaging Transporter (TRUPACT)-IIs, each with a cargo capacity of 14 drums, for a total of 42 drums per WIPP shipment. Under the proposed action for WIPP, a total of 5,009 shipments to WIPP are projected over 35 years (DOE 1996d). This gives an average WIPP shipment rate of 143 per year. Thus, it is estimated that there are 261 (143 x 42/23) shipments per year from TA–54 Area G to the outdoor Container Storage Area.

Thus, the above equation can be quantified as follows:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

$$F_{FIRE} = 261 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$F_{FIRE} = 1.6 \times 10^{-3} \text{ per year}$$

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

Because the above frequency analysis is based on an average WIPP shipment schedule that is unaffected by the SWEIS alternatives, the frequency calculated above is considered to be applicable to all alternatives.

Uncertainties and Sensitivities Affecting the Frequency of RAD–01

Uncertainties in the frequency point estimates include the frequency of a fuel leak per shipment, the conditional probability of a fuel fire given a fuel leak, and the number of shipments per year.

Source Term Calculations

The MAR for the postulated accident is limited by the fraction of waste inventory immediately involved in the truck fuel pool fire. The MAR is estimated based on a 100-gallon (379-liter) fuel spill, yielding a burn area of 500 square feet (46 square meters). This is based on a burn area relationship of 250 square feet (23 square meters) for 50 gallons of fuel (RFETS 1994). Even allowing for aisle spacing as required by the *Resource Conservation and Recovery Act* (RCRA), the entire Container Storage Area inventory of 23 drums could be consumed in a fire of 500 square feet (46 square meters).

Potential waste forms present include solidified liquids (aggregate); surface contaminated, packaged combustible solids; and surface contaminated, noncombustible solids. The bounding ARF and RF products for these three waste forms in a thermal stress environment (fire) are 6 x 10^{-5}, 5 x 10^{-4}, and 6 x 10^{-5}, respectively (DOE 1994a). (Recall, ARF = airborne release fraction [the fraction of the material suspended in the air as an aerosol and thus available for transport due to the physical stresses from a specific accident of due to operation of HVAC systems], and RF = respirable fraction [the fraction of the aerosols that can be transported through the air and inhaled into the human respiratory system, commonly assumed to include particles of 10 microns aerodynamic equivalent diameter or less].)

Consequently, it can be concluded that releases will be dominated by combustible waste and the analysis will be limited to this waste form. It is conservatively assumed that 35 percent of the radiological inventory is present in combustible waste forms (combustible waste comprises approximately 10.3 percent of TRU waste by volume) (LANL 1996o, estimated from Table 4–1); however, the higher value is meant to account for the presence of decontamination trash, HEPA filters, and the relatively high surface contamination area to volume ratio for combustible materials. Separate calculations are performed for combustible and noncombustible forms. Thus, for the MAR (23 drums), the damage ratio is set equal to 0.35 for combustible material and at 0.65 for noncombustible forms. The Container Storage Area is located outdoors; consequently, the LPF is 1.0.

Currently, the average TRU radioactive material content per waste container is 8.9 plutonium-239 equivalent curies (PE-Ci) (LANL 1995f). Less than 1 percent of all TRU waste containers in the existing Area G inventory exceed 75 PE-Ci in radioactive material content (LANL 1995c). The predominant TRU waste generated at LANL is weapons-grade plutonium. The LANL fissile gram equivalent limit for this material type is 25 PE-Ci per drum (LANL 1995c). Revision 5 of the WIPP WAC limits the maximum plutonium-239 equivalent activity for untreated contact-handled TRU waste to be received by the facility to 80 PE-Ci per drum (if not overpacked). Considering that the postulated accident scenario involves multiple drums (23); that the drums represent a small fraction of the total TRU waste inventory managed at LANL, and their radioactive content could be skewed to the high end (depending on the waste generator source); and the above TRU limits; it is conservatively assumed that one drum contains the WIPP WAC limit for untreated waste of 80 PE-Ci (if not overpacked) and the other 22 drums involved in the fire have an average TRU content of 25 PE-Ci.

With the above information, the initial source term equation can be quantified as follows:

Initial Combustible Source Term = MAR x DR x ARF x RF x LPF

= [(22 x 25 PE-Ci) + (80 PE-Ci)] x 0.35 x (5 x 10^{-4}) x 1 x 1

= 0.11 PE-Ci

Initial Noncombustible Source Term = MAR x DR x ARF x RF x LPF

= [(22 x 25 PE-Ci) + (80 PE-Ci)] x 0.65 x (6 x 10^{-5}) x 1 x 1

= 0.02 PE-Ci

Total Initial Source Term = Initial Combustible + Initial Noncombustible

= 0.11 PE-Ci + 0.02 PE-Ci

= 0.13 PE-Ci

The MAR equals the initial MAR, minus the initial source term. The DR and LPF are set to 1. The ARR and RF are assigned values of 4 x 10^{-5} and 1.0, respectively, based on bounding resuspension factors for surface contaminated combustible solids exposed to ambient conditions (DOE 1994a). Thus, the suspension source term can be quantified as:

Suspension Source Term = MAR x DR x ARR x 24 hrs x RF x LPF

= (630 - 0.13 PE-Ci) x 1 x (4 x 10^{-5}) x 24 hrs x 1 x 1

= 0.60 PE-Ci

The suspension source term is conservative, considering that fire protection actions (e.g., foam, water spray) and contamination control measures would likely limit airborne releases significantly. This would reduce the suspension period from the 24 hours assumed above to a much smaller number, which could in principle be zero. The 24-hour calculation is retained as a conservative measure for impact estimation. There are no variations in source terms across the alternatives.

Uncertainties and Sensitivities Affecting the Source Term for RAD–01

A significant uncertainty for this postulated accident is quantification of the MAR in terms of the number of drums involved in the fire and their associated radioactive material content. Accepted methodologies and reasonably conservative radiological estimates have been made to provide an upper estimate of the source term.

It could be postulated that the truck fire would lead to an explosion of the truck's fuel. This accident would have a lower frequency, perhaps being incredible, but would not involve more than the 23 drums. The explosion could disperse the drums, perhaps beyond the range of the fire, but the release and airborne fraction would likely not increase. Section 5.1 of DOE Handbook 3010 (DOE 1994d) gives a median ARF of 8 x 10^{-5} and a bounding ARF of 5 x 10^{-4} for thermal stress on packaged combustible solids. The ARF used in this analysis was also 5 x 10^{-4}.

Consequences of RAD–01 for Facility Workers and the Public

Consequences for facility workers and the public are considered separately. On a day shift, a total of 12 facility workers (including truck bay activities) would typically be involved with facility operations and would be at risk for exposure to airborne radioactive material.

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 72 person-rem (TEDE), resulting in 0.036 excess LCFs. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.1–2 and G.5.6.1–3, respectively. Table G.5.6.1–1 summarizes the modeling results for RAD–01.

G.5.6.2 *RAD–02, Natural Gas Pipeline Failure, Ingestion, and Explosion/Fire at CMR*

General Scenario Description

This accident scenario involves the rupture of a 3-inch (8-centimeter) natural gas pipeline near the CMR Building (TA–3–29), no immediate ignition of the gas, transport of the gas to the CMR intake structure, and subsequent explosion and fire in Wing 7 of the CMR Building. Rupture of the natural gas pipeline is assumed to be due to construction work in the vicinity of the pipeline (the pipeline also could fail randomly, but this is a lower frequency failure mode).

Although the CMR Building itself is not served by natural gas, a buried natural gas pipeline runs along its eastern boundary. At this location, the pipeline is a 3-inch (8-centimeter) diameter, 100 psia natural gas pipeline. The specific scenario identified in the CMR SAR involves a failure of the section immediately in front of the CMR Building, which is located about

TABLE G.5.6.1–1.—*Summary Results for Scenario RAD–01*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	1.6 x 10^{-3} per year	Initial source term: 0.13 PE-Ci, elevated thermal release; suspension source term: 0.60 PE-Ci, ground-level release; mean population dose of 72 person-rem excess LCF of 0.036.
Expanded Operations	1.6 x 10^{-3} per year	Same as No Action Alternative.
Reduced Operations	1.6 x 10^{-3} per year	Same as No Action Alternative.
Greener	1.6 x 10^{-3} per year	Same as No Action Alternative.

TABLE G.5.6.1–2.—*Predicted Mean Doses to MEIs for Scenario RAD–01*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	**DOSE**
Closest public access (SA): Pajarito Road (100 m)	4.6 x 10^{1}
Special population distance: San Ildefonso Pueblo boundary (400 m)	3.5 x 10^{0}
Special population distance: Mortandad Cave (2,400 m)	1.4 x 10^{-1}
Closest residence: Royal Crest Trailer Park (4,300 m)	5.1 x 10^{-2}
Special population distance: San Ildefonso Pueblo (11,600 m)	1.3 x 10^{-2}

TABLE G.5.6.1–3.—*Predicted Mean Ground Contamination Levels for Scenario RAD–01*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	1.1 x 10^{4}
1.0 to 2.0 km	1.2 x 10^{3}
2.0 to 3.0 km	4.7 x 10^{2}
3.0 to 4.0 km	2.6 x 10^{2}
4.0 to 8.0 km	1.3 x 10^{2}
8.0 to 12.0 km	7.6 x 10^{1}
12.0 to 20.0 km	3.5 x 10^{1}
20.0 to 30.0 km	1.7 x 10^{1}
30.0 to 40.0 km	8.4 x 10^{0}
40.0 to 60.0 km	4.2 x 10^{0}
60.0 to 80.0 km	2.4 x 10^{0}

BQ/m^2 = Becquerel per square meter

120 meters from the CMR ventilation intakes located near the spinal corridor of the facility.

This accident scenario is analyzed in the CMR SAR (LANL 1995c). The SAR states that construction potentially leading to this event occurs about every 3 years, and that the conditional probability of damaging the line with construction equipment is 1 x 10^{-3} per construction event (LANL 1995c). This results in an initiating event frequency of 3.3 x 10^{-4} per year.

The SAR includes an event tree for evaluating the frequency of the accident scenario. The event tree accounts for the conditional probability of no external explosion, whether the gas drifts toward or away from the CMR Building, whether the concentration at the intake is above the lower explosive limit (LEL) for natural gas, whether an explosion occurs at the intake, and whether an explosion and/or a fire occur interior to the CMR Building (LANL 1995c). The event tree identifies five separate outcomes leading to an accident:

- External explosion, 1.7 x 10^{-4} per year
- Internal explosion without a fire, 1.6 x 10^{-7} per year
- Explosion at the CMR HVAC intake structure, 1.6 x 10^{-6} per year
- Explosion and fire at the CMR HVAC intake structure, 1.8 x 10^{-7} per year
- Internal explosion with a fire, 1.5 x 10^{-6} per year

Because the internal explosion with a fire is the most likely event having radiological consequences, this is the outcome that is modeled in the SAR and in the SWEIS. The SAR states that an internal explosion is likely to involve only one half of the laboratories in a wing because ventilation in each half of each wing is supplied by a separate supply fan. However, the remainder of the wing could be damaged by fires ignited by the explosion. The explosion also may damage the fire suppression sprinkler system, so no credit is given for containing any fires subsequent to an explosion in a wing. Finally, if the explosion involves a significant portion of a wing, damage to the building structure may occur (such as blowing out the glass block windows and doors), creating an open leak path to the environment (LANL 1995c).

The most vulnerable sections of the CMR Building for this accident are Wings 2, 3, and 7 (and the Administrative Wing) because these wings are located on the east side of the CMR Building nearest the natural gas pipeline. The source term analysis is based on Wing 7 because that wing has the highest administrative limit on dispersible MAR of these three wings (LANL 1995c).

Wing 7 has an administrative limit of 6 kilograms of plutonium-239 equivalent in dispersible form.[1] Of this amount, one kilogram was assumed to be located outside of gloveboxes or sealed metal containers and unprotected from direct blast effects. The release is assumed to be a ground level release (LANL 1995c).

RAD–02 Release Mechanisms

This accident involves consideration of explosion and fire effects on the MAR in the CMR Building. There is a wide variety of radioactive material stored and used in the CMR Building. In the SAR and safety limits documentation, the MAR at the CMR Building is converted to equivalent grams of pure plutonium-239. Although this is an abstraction of what is actually present in the facility, it captures the radiological effects of the diverse MAR. Plutonium-239 in both powder and solution form is considered in this accident.

1. The CMR SAR expresses most radiological releases as equivalent releases of pure plutonium-239. The CMR Building has a variety of different types of MAR, including various plutonium mixtures. Wing limits are expressed in terms of plutonium-249 equivalents, and the SAR accident analysis is largely in the same units.

No Action Alternative Frequency Analysis

The annual frequency for this scenario is quantified as follows:

$$F = F_{PIPE} \times P_{EXTEXP} \times P_{DRIFT} \times P_{LEL} \times P_{INTAKE} \times P_{INTEXP} \times P_{INTFIRE}$$

where:

F = Annual frequency of the scenario

F_{PIPE} = Annual frequency of pipe rupture due to construction

P_{EXTEXP} = Conditional probability of no external explosion at pipe rupture

P_{DRIFT} = Conditional probability of natural gas drifting to HVAC intake

P_{LEL} = Conditional probability of concentration above the LEL at HVAC intake

P_{INTAKE} = Conditional probability of natural gas not exploding at HVAC intake

P_{INTEXP} = Conditional probability of internal explosion of natural gas

$P_{INTFIRE}$ = Conditional probability of internal fire subsequent to explosion

The above equation is evaluated in accordance with the analysis in the SAR. As noted, the frequency of pipe rupture due to construction is 3.3×10^{-4} per year. (This value is consistent with generic industry data, which indicate a pipeline rupture rate of 1.25 per 1,000 miles of pipeline per year [AICE 1994]. Applied to the CMR Building, and taking into account 660 feet [201 meters] of piping in front of CMR [this is the overall width of CMR], this data yields a value of 1.6×10^{-4} per year.) The conditional probability of no external explosion was set at 0.5 (i.e., as likely as not). The conditional probability that the gas drifts toward the CMR Building is based on historical meteorological data for LANL, and is set at 0.285 (a conservative value). The conditional probability that the gas concentration is above the LEL at the intake is evaluated at 0.0769 (based on a calculation from a Gaussian plume dispersion model). The conditional probability of no explosion at the intake is set at 0.5 (i.e., as likely as not). The conditional probability of an internal explosion and the conditional probability of a fire given an explosion, are both set at 0.9 (i.e., very likely).

The frequency equation above is evaluated as follows:

$$F = F_{PIPE} \times P_{EXTEXP} \times P_{DRIFT} \times P_{LEL} \times P_{INTAKE} \times P_{INTEXP} \times P_{INTFIRE}$$

$$= (3.3 \times 10^{-4}) \times 0.5 \times 0.285 \times 0.0769 \times 0.5 \times 0.9 \times 0.9$$

$$= 1.5 \times 10^{-6}$$

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

There is no difference in construction frequency across the alternatives. No other factor potentially affecting the conditional probability of any of the other terms of the No Action Alternative frequency equation has been identified. Accordingly, the frequency of 1.5×10^{-6} per year is applicable to the Expanded Operations, Reduced Operations, and Greener Alternatives.

Uncertainties and Sensitivities Affecting the Frequency of RAD–02

The SAR accident scenario progression incorporates several inherent uncertainties that are resolved with the assignment of conservative or representative conditional probabilities using engineering/expert opinion, historical meteorological data, and supporting calculations. The terms of the frequency equation that seem to be the most subject to uncertainty are the two conditional probabilities of explosion: P_{EXTEXP} and P_{INTAKE}.

The conditional probability of no external explosion at the time of the pipeline rupture (P_{EXTEXP}) is probably conservative because the rupture occurs as a result of mechanical damage to the pipeline, which damage (or the engine on the equipment performing the excavation) would be likely to result in ignition of the escaping gas. To illustrate, if this term has a value of 0.1 instead of 0.5, the frequency of the accident would drop to 3 x 10^{-7} per year.

Embedded in the analysis details of this scenario are a number of other assumptions that, if relaxed from their current conservative values, could render the scenario less likely or result in conditions under which the scenario could not progress due to insufficient gas reaching the wing to support an explosion and fire. Among these assumptions are: (1) it is assumed that the supply system can maintain a 100-psia pressure through the 3-inch pipe for the required period of time, even though the system is depressurizing through the break; (2) it is assumed that the flow rate from the broken pipe is equal to the critical flow at the initial system pressure (no credit is taken for pipe segments depressurizing as a result of the break); and (3) the fire suppression sprinkler system within the CMR Building fails 100 percent of the time given an explosion and fire (this is a conservative assumption) (LANL 1995c).

More significantly, however, DOE authorized funding for installation of a flow restriction orifice in the natural gas pipeline, which is the source of the above-described accident. This orifice will limit gas flow in the event of a pipeline break to a value that will preclude the accident from taking place. Thus, upon completion of orifice installation this accident will no longer be credible. The installation was scheduled for Fall 1997 at the time the calculations were made for this accident appendix.

Other Potential Gas Pipeline Accidents at LANL

As a result of the identification of this pipeline failure accident in the CMR SAR, consideration was given to other possible natural gas pipeline accidents at LANL. Four examples have been identified. The TA–18 SAR identified a natural gas explosion for the Hillside Vault (TA–18–26). During the walkdown of this facility, this contributor was screened on the basis of physical implausibility (e.g., the natural gas pipeline is shielded from the Hillside Vault, and there is no active ventilation system nor natural flow process that would result in ingestion of the gas into the Hillside Vault). Similarly, natural gas pipelines are located near TA–55–4. In this case, the construction of TA–55–4 is much more robust than the CMR Building (TA–55–4 has 14-inch-thick reinforced concrete walls), and the ventilation system would remain intact in the event of an explosion (the HVAC system filters are located remotely from the possible site of any explosion inside TA–55–4). In the case of both TSTA and WETF, the natural gas lines are too far from the facilities to present a credible threat. Accordingly, the CMR scenario is considered to be the bounding accident of this type.

Source Term Calculations

The initial source term equation is evaluated four times for four separate source term contributors identified in discussions with CMR facility representatives, and is based on the draft 1996 SAR update for the CMR facility. The four sources of release are MAR in containers and enclosures affected by the explosion, MAR in solution outside an enclosure affected by the explosion, MAR in powder form affected by the fire, and MAR in solution affected by the fire. The initial source term equation is evaluated as follows for these sources:

$$ST_{POWEXP} = MAR \times DR \times ARF \times RF \times LPF$$

$$ST_{POWEXP} = 2{,}500 \times 1 \times 0.005 \times 0.3 \times 1 = 3.8 \text{ grams}$$

$$ST_{SOLEXP} = MAR \times DR \times ARF \times RF \times LPF$$

$$ST_{SOLEXP} = 500 \times 1 \times 1 \times 1 \times 1 = 500 \text{ grams}$$

$$ST_{POWFIRE} = MAR \times DR \times ARF \times RF \times LPF$$

$$ST_{POWFIRE} = 2{,}487 \times 1 \times 0.006 \times 0.01 \times 1 = 0.1 \text{ grams}$$

$$ST_{SOLFIRE} = MAR \times DR \times ARF \times RF \times LPF$$

$$ST_{SOLFIRE} = 3{,}000 \times 1 \times 0.002 \times 1 \times 1 = 6.0 \text{ grams}$$

$$\text{Total Initial Source Term} = ST_{POWEXP} + ST_{SOLEXP} + ST_{POWFIRE} + ST_{SOLFIRE}$$

$$= 3.8 + 500 + 0.1 + 6.0 = 510 \text{ grams}$$

where:

ST = Source Term

ST_{POWEXP} = Source term from powder in containers affected by the explosion

ST_{SOLEXP} = Source term for solution affected by the explosion

$ST_{POWFIRE}$ = Source term for powder affected by the fire

$ST_{SOLFIRE}$ = Source term for the solution affected by the fire

The CMR SAR did not account for source term contribution from suspension subsequent to the explosion and fire. The suspension source term calculation would come from three sources (the fourth possible source, the solution affected by the explosion, has no suspension source term contribution because it was 100 percent released in the initial source term): (1) MAR in containers and enclosures affected by the explosion, (2) MAR in powder form affected by the fire, and (3) MAR in solution affected by the fire. The suspension source term equation is evaluated three times for these sources:

$$RST_{POWEXP} = MAR \times DR \times ARR \times 24 \text{ hrs} \times RF \times LPF$$

$$RST_{POWEXP} = 2{,}496 \times 1 \times (4 \times 10^{-6}/\text{hr}) \times 24 \text{ hrs} \times 1 \times 1$$

$$RST_{POWEXP} = 0.24 \text{ grams}$$

$$RST_{POWFIRE} = MAR \times DR \times ARR \times 24 \text{ hrs} \times RF \times LPF$$

$$RST_{POWFIRE} = 2{,}487 \times 1 \times (4 \times 10^{-6}/\text{hr}) \times 24 \text{ hrs} \times 1 \times 1$$

$$RST_{POWFIRE} = 0.24 \text{ grams}$$

$$RST_{SOLFIRE} = MAR \times DR \times ARR \times 24 \text{ hrs} \times RF \times LPF$$

$$RST_{SOLFIRE} = 2{,}994 \times 1 \times (4 \times 10^{-8}/\text{hr}) \times 24 \text{ hrs} \times 1 \times 1$$

$$RST_{SOLFIRE} = 0.003 \text{ grams}$$

The total suspension source term is the sum of the above contributors, or 0.48 grams.

Suspension source term parameters were selected as follows: (1) based on a homogeneous bed of powder buried under structural debris exposed to ambient conditions or under static conditions within a structure (DOE 1994d); (2) based on the same considerations as (1); and (3) based on a solution indoors, on heterogeneous surfaces, covered with debris or under static conditions (DOE 1994d).

No variations are identified in the progression of the accident or the MAR; thus, the calculated source terms above are considered to represent the accident for all alternatives.

Uncertainties and Sensitivities Affecting the Source Term for RAD–02

The source term for this postulated accident scenario is dominated by the very conservative SAR assumption of an ARF of 1.0 for the solution affected by the explosion. The explosive yield of the explosion inside the wing is not identified in the CMR SAR. DOE Handbook 3010-94 recommends that for detonations in or immediately contiguous to a pool of liquid, a bounding release is assessed to be the mass of inert material equal to the calculated TNT equivalent (DOE 1994d). However, it is not evident that the explosion necessarily occurs in or contiguous to the solution in the case of the CMR event. If the explosion occurs at some distance from the solution and merely spills the solution or shatters the container holding the solution, the source term would be reduced by at least two orders of magnitude, resulting in a release of 5 grams or less, instead of 500 grams.

Because the source term for this accident is completely driven by the assumption of a 100 percent release of the 500 grams of plutonium-239 equivalent in the solution, it is clear that any reduction in this term will directly reduce the overall source term.

Uncertainties in the source term calculation include the extent that the entire wing may be affected by the initial explosion (the SAR assumes only half of wing is involved); the fraction of material that is outside the gloveboxes/enclosures; the fraction of material in powder, solution, or less dispersible forms; and the integrity of the building confinement (e.g., glass block windows). (Building integrity affects the LPF.)

Consequences of RAD–02 for Facility Workers and the Public

The consequences of RAD–02 for facility workers and the public are discussed separately. All workers in Wing 7 at the time of the accident could be severely injured or killed as a result of the dynamics of the explosion, the dynamics and combustion products of the fire, and exposure to plutonium-239 oxide via inhalation. Supply air for the remainder of the building is unfiltered outside air (LANL 1995c). Depending on the dynamics of the explosion release and the direction of the wind at the time of release, it is possible that air contaminated with material released from Wing 7 could be drawn into the remainder of the CMR Building and distributed to the workers in other areas of the building. This would result in inhalation exposures to those workers and contamination of other areas of the CMR Building. Due to the complications of evaluating the impact of the explosion and the resulting emergency response activities, an estimation of the worker doses is not possible with any reliability.

No acute fatalities from radiation exposure to the public are predicted to result from the postulated accident. The mean collective population dose is projected to total 120,000 person-rem (TEDE), resulting in 57 excess LCFs. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.2–2 and G.5.6.2–3, respectively. Table G.5.6.2–1 summarizes the modeling results for RAD–02.

Based on re-evaluation of the meteorological conditions and the frequency of catastrophic brakes, DOE estimates the frequency for this accident now to be less than 10^{-6} (i.e., not credible) (CMR BIO, Appendix J).

G.5.6.3 *RAD–03, Power Excursion Accident with Fast Burst Assembly Outside Kiva #3*

General Scenario Description

The Godiva-IV fast-burst reactor, housed at Kiva #3 at Pajarito Site (TA–18–116), is used in a variety of experiments. This type of reactor is

TABLE G.5.6.2–1.—*Summary of Results for Scenario RAD–02*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	1.5×10^{-6}	504 grams plutonium-239 explosion release (60-second), 6 grams plutonium-239 fire release (2-hour), 0.48 gram plutonium-239 suspension release (24-hour); 120,000 person-rem collective exposure, resulting in 57 excess LCFs.
Expanded Operations	1.5×10^{-6}	Same as No Action Alternative.
Reduced Operations	1.5×10^{-6}	Same as No Action Alternative.
Greener	1.5×10^{-6}	Same as No Action Alternative.

[a]Note: Based on re-evaluation of the meteorological conditions and the frequency of catastrophic brakes, DOE estimates the frequency for this accident now to be $<10^{-6}$ (i.e., not credible) (CMR BIO, Appendix J).

TABLE G.5.6.2–2.—*Predicted Mean Doses to MEIs for Scenario RAD–02*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	DOSE
Closest public access (SA): Diamond Road (40 m)[a]	4.0×10^{3}
Nearest residence (CMR SAR): Los Alamos Townsite (1,000 m)	1.7×10^{2}
Nearest special population distance: Los Alamos Medical Center (1,100 m)	1.5×10^{2}
Other nearest residences (CMR SAR): Royal Crest Trailer Park (1,200 m)	1.3×10^{2}
Special population distance: San Ildefonso Pueblo (4,500 m)	1.3×10^{1}
Special population distance: San Ildefonso Pueblo (18,600 m)	8.4×10^{-1}

[a] Approximated as 50 m.

TABLE G.5.6.2–3.—*Predicted Mean Ground Contamination Levels for Scenario RAD–02*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	1.3×10^6
1.0 to 2.0 km	2.5×10^5
2.0 to 3.0 km	1.0×10^5
3.0 to 4.0 km	5.7×10^4
4.0 to 8.0 km	2.1×10^4
8.0 to 12.0 km	7.6×10^3
12.0 to 20.0 km	3.0×10^3
20.0 to 30.0 km	1.4×10^3
30.0 to 40.0 km	7.4×10^2
40.0 to 60.0 km	4.0×10^2
60.0 to 80.0 km	2.2×10^2

BQ/m^2 = Becquerel per square meter

a research tool designed to provide a pulse (or burst) of neutrons for experimental purposes. Accident scenario RAD–03 involves a reactivity excursion that vaporizes a portion of the core and melts the remainder.

Godiva-IV has three 93 percent HEU control rods. One of the rods is used to adjust the burst yield, one is used for achieving a critical state, and the third is rapidly inserted in order to initiate the pulse. A fourth control element, called the safety block, provides a large reactivity shutdown for the assembly.

The assembly is operated by inserting the safety block and adjusting two of the control rods to bring the assembly to a low power steady-state condition called delayed critical. Following the achievement of delayed criticality, the control rod used for yield adjustment is set to an appropriate position for the desired pulse size. The safety block is then partially withdrawn in order to let delayed neutrons decay away for about 15 minutes. The safety block is reinserted, and the pulse rod is rapidly inserted. The control system is designed with interlocks so that each step cannot be taken unless a precise sequence of events occurs (LANL 1996f).

Three principal potential sources of error can be identified in this process: (1) a miscalculation of the desired control-element position and the subsequent element insertion to the wrong position, (2) an incorrect position insertion based on a correct adjustment calculation, and (3) an error due to a faulty position indicator. In the first two cases, two errors are necessary. In the first case, two operators perform the calculation independently, making it unlikely that the same incorrect position could be calculated. (In addition, the operators have a logbook available to consult for past control element settings to produce the required pulse.) In the second case, the senior operator checks the final adjustment (LANL 1996f).

The effect of an operator error in the control-element adjustment could be either a larger- or smaller-than-planned superprompt critical pulse. The magnitude of the pulse is dependent on the magnitude of the error. A conditional probability factor is applied to recognize that only a small fraction of the wide range of potential pulse sizes would actually lead to reactor damage.

Another potential scenario for initiating an over-sized pulse is based upon inadvertent movement of an experiment near the reactor during the pulse operations. All equipment installed in the immediate vicinity of Godiva-IV is required to be structurally stable without support by guy wires, unattached props, or other means. However, the possibility of movement cannot be completely eliminated because the cause of movement is as varied as the experiments themselves. Because movable and remotely controllable experiments are carefully controlled and executed to avoid such movement, the most likely cause of movement is a gravity fall of the experiment (LANL 1996f). Experiment movement during the pre-pulse waiting period is not apparent through observable system parameters (LANL 1996f).

The inadvertent movement of an experiment during the waiting period could change the reactivity of the system, which establishes the rate at which the chain reaction would occur. Depending on the magnitude of the change in the experimental setup, the additional reactivity could produce a substantial increase in the energy released during the pulse. The additional energy could be sufficient to vaporize material in the reactor. The amount of energy introduced to the system is estimated at 40.3 megajoules, which is large enough to cause fracturing, melting, or boiling of the fissile material. The vaporized material has an estimated energy of 10 percent of the total energy, or 4.0 megajoules. Thus, the vaporized material has the potential to damage the core and release an abnormal amount of fission products to the kiva building.

This accident scenario was analyzed in the TA–18 SAR. No accident sequence frequency was estimated or calculated in the SAR, nor was a frequency bin assignment made. Rather, the SAR stated that all of the accidents analyzed were incredible, implying a frequency of less than 10^{-6} per year.

The SAR source term was estimated based on the assumption that 10 percent of the 66 kilograms of uranium metal is volatilized into transportable aerosol. The release of fission products due to the pulse operation also was taken into consideration (LANL 1996f). The release fractions for fission products are specified as 100 percent for noble gases, 25 percent for halogens (e.g., iodine), and 1 percent for “semi-volatiles” (LANL 1996f). (The SAR does not describe what happens to the 90 percent of the core that does not vaporize. Analysis of a similar scenario involving the SPR-III fast-burst reactor at SNL suggests that the remainder of the core melts. Whether this assessment is fully applicable to Godiva-IV is unclear; however, the analysis below errs on the side of conservatism, and the source term reflects the melting of the remainder of the fuel.)

No Action Alternative Frequency Analysis

This accident requires an unanticipated reactivity insertion being introduced during the time between the shutdown of the delayed-critical setup operation and the insertion of the burst reactivity. This could occur in one of two ways: (1) by operator error or a malfunction of the control systems in adding the burst reactivity increment or (2) by addition of reactivity from movement or reconfiguration of the experiment between shutdown of the delayed-critical setup operation and the insertion of the burst reactivity (LANL 1996f).

Operator error or malfunction of the control systems leading to addition to the planned burst increment can happen in three ways: (1) a miscalculation of the desired control-element position and the subsequent element insertion to the wrong position, (2) an incorrect position insertion based on a correct adjustment calculation, and (3) an error due to a faulty position indicator.

Miscalculation of Control-Element Position. Miscalculation of the control element position requires two independent errors. In addition, the errors have to be sufficiently severe to result in an extreme power excursion. The frequency of this contributor to RAD–03 can be calculated as follows:

$$F_{HEPCALC} = F_{EXP} \times H_{MISCALC} \times H_{MISCALC} \times C_{EXTREME}$$

where:

$F_{HEPCALC}$ = Frequency of the human error in calculation contribution to RAD–03

F_{EXP} = Annual number of Godiva-IV experiments performed

$H_{MISCALC}$ = Human error probability for calculational error

$C_{EXTREME}$ = Conditional probability of a large calculational error

The annual number of Godiva-IV runs for the No Action Alternative is reported to be a maximum of 80 (PC 1997).

The HEP for a miscalculation is generally in the range of 10^{-4} to 10^{-2} (Mahn et al. 1995 and Swain and Guttmann 1983). A value in the middle of that range is judged to be appropriate, considering that the most likely cause of the calculational error is entering an incorrect datum into a calculator/computer.

In addition, it should be noted that not all calculational errors are of equal severity in terms of their ability to result in scenario RAD–03. The conditional probability of such a severe calculational error, especially considering that the results can be checked with the logbook of previous burst calculations, is judged to be less than 0.01 (1 percent). (Considering the conduct of experiments under specially prepared test plans and experiment plans, an even lower value could be appropriate.)

The above equation can be solved as follows:

$$F_{HEPCALC} = F_{EXP} \text{ x } H_{MISCALC} \text{ x } H_{MISCALC} \text{ x } C_{EXTREME}$$

$$= 80 \text{ x } 0.001 \text{ x } 0.001 \text{ x } 0.01$$

$$= 8 \text{ x } 10^{-7} \text{ per year}$$

Incorrect Position Insertion. This contributor to power excursions requires two human errors: the incorrect positioning action, as well as the failure of the crew chief to detect this incorrect positioning. In addition, the error must be sufficiently extreme such that the large power excursion for RAD–03 occurs.

The frequency of this contributor to RAD–03 can be calculated using the following equation:

$$F_{HEPPOS} = F_{EXP} \text{ x } H_{POS} \text{ x } H_{CHK} \text{ x } C_{EXTREME}$$

where:

F_{HEPPOS} = Frequency of the human error in mispositioning the controller

F_{EXP} = Annual number of Godiva-IV experiments performed

H_{POS} = HEP for calculational error

H_{CHK1} = HEP, check of position by supervisor

H_{CHK2} = HEP, check of position against log of previous experiments

$C_{EXTREME}$ = Conditional probability of a large calculational error

As indicated above, the annual number of Godiva-IV runs for the No Action Alternative is a maximum of 80. The mean HEP for setting a rotary control to the wrong position is 0.001 per demand (Swain and Guttmann 1983). The HEP for the crew chief failing to detect the incorrect position indication is 0.05 per demand, based on checking that involves active participation in special measurements (Swain and Guttmann 1983). Finally, the position indication would be checked against previous experiments, providing one last opportunity to correct the error. The likelihood that this check will fail to correct the error is taken as 0.05 as well. Once the position is incorrectly set and verified, there is no additional opportunity to correct the error.

The most likely incorrect position insertion is a small deviation from normal. Such a small deviation would not yield a large enough reactivity insertion to result in accident RAD–03. Only a very large deviation would produce this accident. It is judged that the conditional probability of the error being large enough to produce the accident scenario is likely to be in the range of 0.01 per error (that is, given an error is made, there is a 1 percent chance that the error will be of a sufficiently large magnitude to result in the accident).

The above equation can be solved as follows:

$$F_{HEPPOS} = F_{EXP} \times H_{POS} \times H_{CHK1} \times H_{CHK2} \times C_{EXTREME}$$

$$= 80 \times 0.001 \times 0.05 \times 0.05 \times 0.01$$

$$= 2 \times 10^{-6} \text{ per year}$$

Faulty Position Indication. The frequency of this contributor to RAD–03 can be calculated by the following equation:

$$F_{IND} = F_{EXP} \times F_{RATE} \times D_{EXP} \times H_{DETECT}$$

where:

F_{IND} = Annual frequency of faulty indicator contributor to RAD–03

F_{EXP} = Annual number of Godiva-IV experiments performed

F_{RATE} = Failure rate of the indicator per hour

D_{EXP} = Duration of experiment in hours (time in which indicator must function)

H_{DETECT} = HEP for failure of operations staff to detect the failed indicator

The annual number of Godiva-IV runs for the No Action Alternative is a maximum of 80. The type of position indicator used for the Godiva-IV machine is not specified in the SAR. Typical nuclear industry failure rates for indicator devices are in the range of 2×10^{-7} to 2×10^{-6} per hour (INEL 1990); a value in the middle of this range is assumed (7×10^{-7} per hour). It is assumed that the position indicator must read accurately for 1 hour.

The HEP for failure of the operations staff to detect the failed indicator is estimated at 0.01 per demand (based on an analogy to detecting a failed valve that has neither position indication nor a rising stem to identify the failed state) (Swain and Guttmann1983).

The above equation can now be solved as follows:

$$F_{IND} = F_{EXP} \times F_{RATE} \times D_{EXP} \times H_{DETECT}$$

$$F_{IND} = 80 \times (7 \times 10^{-7}) \times 1 \times 0.01$$

$$F_{IND} = 6 \times 10^{-7} \text{ per year}$$

Sum Total Frequency for RAD–03

The sum total frequency of RAD–03 is obtained by adding the frequency of the three contributing events as follows:

$$F_{TOTAL} = F_{HEPCALC} + F_{HEPPOS} + F_{IND}$$

$$= (8 \times 10^{-7}) + (2 \times 10^{-6}) + (6 \times 10^{-7})$$

$$= 3.4 \times 10^{-6} \text{ per year}$$

Expanded Operations Alternative Frequency Analysis

The total number of pulse operations at Godiva-IV and Skua will increase for the Expanded Operations Alternative to 120 to 150 per year. We have assumed that the relative proportion of Godiva-IV versus Skua bursts will remain constant, and accordingly, have increased the frequency of RAD–03 by a factor of 1.25, to 4.3×10^{-6} per year.

Reduced Operations and Greener Alternatives Frequency Analysis

The frequency of Godiva-IV runs for the Reduced Operations and Greener Alternatives is the same as for the No Action Alternative. Thus, the frequency of accidents is the same for the Reduced Operations and Greener Alternatives as it is for the No Action Alternative.

Uncertainties and Sensitivities Affecting the Frequency of RAD–03

The frequency of RAD–03 is sensitive to the assumptions made above regarding the likelihood of various types of human errors and equipment failures.

Source Term Calculations

The accident being considered here assumes that the Godiva-IV assembly is being operated outside the confines of Kiva #3, which is occasionally done for direct radiation dose measurements to remove the effects of reflected and backscattered radiation (LANL 1996f). The SAR assumes that 10 percent of the core (6.6 kilograms of highly enriched uranium [HEU]) is vaporized, and also models the fission product release as a result of core damage and vaporization. The release fractions assumed are consistent with melting of the nonvaporized portion of the core.

The general initial source term equation will be used to evaluate the additional contribution to the source term arising from melting of the remaining 59.4 kilograms of the core (66 kilograms less 6.6 kilograms vaporized). The MAR is 66 kilograms. The damage ratio is 0.9 (the fraction of the core not vaporized). The ARF and RF values are selected based on free-fall of molten metal drops, with ARF = 0.01 and RF = 1.0 (DOE 1994d). The LPF is 1 because the release occurs outdoors. This results in an additional airborne release of HEU of:

Initial Source Term = MAR x DR x ARF x RF x LPF

= 66,000 x 0.9 x 0.01 x 1 x 1

= 594 grams

The total initial source term for HEU is thus 6,600 grams + 594 grams, or a total of 7,194 grams.

The suspension source term was not calculated in the TA–18 SAR. Most of the HEU not participating in the initial release would be expected to “freeze” and not be available for release. However, this is not addressed in DOE Handbook 3010-94 (DOE 1994d). Accordingly, a conservative suspension release will be calculated by assuming that the HEU not initially released is deposited on the ground as a powder.

The suspension source term is calculated as follows:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= (66,000 - 7,194) x 1 x 0.00004 x 24 hrs x 1 x 1

= 56 grams

The release of fission products also occurs in this accident. A screening analysis was conducted of the released fission products identified by the SAR. For a release of this nature, occurring during a short fission pulse, the large majority of fission products have very short half-lives (on the order of 0.21 seconds to 3.15 minutes), and decay primarily by beta and gamma emission. The SAR analysis assigned an average dose-rate conversion factor for air immersion (cloudshine) of 4,000 millirem-cubic meters per microcurie-year. Based on the SAR radionuclide release quantities and the dose-rate conversion factor values, the dominant radionuclides were identified. Decay of the risk-dominant radionuclides to more stable progeny was evaluated. Comparison of the decay product quantities and dose conversion factors with the highly enriched uranium source term values indicated that the fission products provide a negligible contribution to the total dose from internal exposure pathways. Consequently, doses resulting from internal exposure pathways for fission products were not modeled. Doses resulting from the external exposure pathway (air immersion) for fission products (4.68 x 10^5 curies) were estimated using the SAR determined average dose-rate conversion factor of 4,000 millirem-cubic meters per microcurie-year. There are no differences in source terms across the alternatives.

Uncertainties and Sensitivities Affecting the Source Term for RAD–03

The major uncertainties in the source term calculation are the 10 percent assumed vaporization of HEU as a result of the power excursion and the conservative modeling of suspension based on HEU as a powder.

Consequences of RAD–03 for Facility Workers and the Public

The consequences for facility workers and the public are discussed separately. Operations with Godiva-IV located outside Kiva #3 would be conducted during off hours with road closure controls in effect. Staffing at TA–18 would be expected to be less than during normal workday operations. The Kiva #3 control room is located 669 feet (204 meters) from the kiva (LANL 1996f). The walls of the control room are such that 40 percent attenuation of gamma doses from the outside is accomplished (LANL 1996f). In the event of an accident, ventilation systems for the control building (TA–18–30) would be secured. Air exchange with the outside would be a function of wind loading and diffusion in and around wall and ceiling penetrations (LANL 1996f). However, the ventilation system for the control building is not protected by HEPA filters (LANL 1996f).

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 110 person-rem (TEDE), resulting in 0.06 excess fatal cancers. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.3–2 and G.5.6.3–3, respectively. Table G.5.6.3–1 summarizes the modeling results for RAD–03.

G.5.6.4 *RAD–04, Inadvertent Detonation of Plutonium-Containing Assembly at DARHT*

General Scenario Description

The DARHT Facility is under construction at R site in TA–15. When completed, the facility will provide dual-axis radiographic images at the highest penetration and resolution available for the study of materials and devices under hydrodynamic conditions. DARHT was the subject of a DOE Environmental Impact Statement (DOE 1995a) and subsequent Record of Decision. The DARHT EIS included analysis of potential accidents, including bounding accidents that were selected and evaluated on a what-if basis (DOE 1995a) based on potential consequences, with little or no consideration of the frequency of occurrence, though the likelihood of occurrence would be small; in related safety analyses these accidents have been evaluated to be not credible (probability less than 10^{-6} per year) and they have been similarly identified in this SWEIS. Scenario RAD–04 represents the inadvertent uncontained detonation of plutonium-containing assembly that was evaluated as the bounding accident for all alternatives in the DARHT EIS, and is included on a similar what-if basis. Scenario RAD–11 represents the other such plutonium accident evaluated in the DARHT EIS on a what-if basis, the breach of a double-walled containment vessel.

As explained in greater detail in the DARHT EIS, the accident scenario RAD–04 involves the inadvertent detonation of high explosives and subsequent dispersal of plutonium from a plutonium-containing assembly intended for a dynamic experiment to be radiographed at DARHT (or its existing predecessor facility located a short distance away, Pulsed High-Energy Radiation Machine Emitting X-Rays

TABLE G.5.6.3–1.—*Summary Results for Scenario RAD–03*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	3.4×10^{-6}	7,194 grams of HEU initially, along with 4.68×10^{5} Ci fission products; three, 8-hour suspension releases of 18.7 grams each; all ground level releases; results in 110 person-rem integrated population exposure and 0.06 excess LCFs.
Expanded Operations	4.3×10^{-6}	Same as No Action Alternative.
Reduced Operations	3.4×10^{-6}	Same as No Action Alternative.
Greener	3.4×10^{-6}	Same as No Action Alternative.

TABLE G.5.6.3–2.—*Predicted Mean Doses to MEIs for Scenario RAD–03*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	DOSE
Closest public access: Pajarito Road (30 m)[a]	1.5×10^{2}
Operations boundary (TA–18 SAR): (200 m)	1.4×10^{1}
Site Boundary (TA–18 SAR): San Ildefonso Pueblo boundary (1,000 m)	1.6×10^{0}
Special population distance: Mortandad Cave (2,900 m)	4.6×10^{-1}
Receptor distance (TA–18 SAR): Population center (4,400 m)	2.7×10^{-1}
Special population distance: San Ildefonso Pueblo (14,600 m)	5.0×10^{-2}

[a] This MEI dose is provided even though for outdoor operations Pajarito Road would be closed to the public. Distance approximated as 50 m.

TABLE G.5.6.3–3.—*Predicted Mean Ground Contamination Levels for Scenario RAD–03*

RADIAL DISTANCE	HEU GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	1.5×10^4
1.0 to 2.0 km	1.5×10^3
2.0 to 3.0 km	5.7×10^2
3.0 to 4.0 km	3.0×10^2
4.0 to 8.0 km	1.0×10^2
8.0 to 12.0 km	3.8×10^1
12.0 to 20.0 km	1.6×10^1
20.0 to 30.0 km	7.1×10^0
30.0 to 40.0 km	3.2×10^0
40.0 to 60.0 km	1.5×10^0
60.0 to 80.0 km	8.1×10^{-1}

BQ/m^2 = Becquerel per square meter

(PHERMEX); continued operation of PHERMEX was considered under the No Action Alternative in the DARHT EIS). PHERMEX has performed, and when completed DARHT will perform, radiography of both hydrodynamic tests and dynamic experiments (DOE 1995a).

A hydrodynamic test is a dynamic, integrated systems test of a mockup nuclear package, in which simulant materials are used to replace the fissile materials. Dynamic experiments provide information on the basic physics of materials or characterize the physical changes or motions of materials under the influence of high explosive detonations. Some dynamic experiments contain plutonium in order to obtain needed information and understanding associated with nuclear weapons aging and continued assurance of weapon safety and performance (DOE 1995a). As a matter of policy, these experiments will always be conducted inside a double-walled steel containment system consisting of an inner confinement vessel and an outer safety vessel to prevent plutonium release; furthermore, the experiments will always be arranged and conducted in such a manner that a nuclear explosion could not result (DOE 1995a). Though some hundreds of dynamic experiments may be conducted per year, only a small number will contain plutonium (LANL 1996m).

For the RAD–04 scenario, in addition to immediate worker deaths due to the high explosive blast, human health impacts to the public are dominated by the explosive aerosolization and atmospheric dispersal of plutonium and the subsequent public exposure. Impact analysis for this SWEIS is taken directly from the DARHT EIS analysis, upon which DOE has received comment from the public; other agencies; and state, local, and tribal governments. Up to tens of excess LCFs based on a 50-year committed dose could result from this hypothetical scenario, depending on the population sector assumed to be exposed due to extant winds. For the convenience of the public and the decision maker, some of that information is also directly reproduced here and referenced to the DARHT EIS. The methodology and all impacts associated with this hypothetical, uncontained detonation scenario are principally contained in Chapter 5 and Appendixes H, I, and J of that EIS; additional information is contained in a classified appendix.

No Action Alternative Frequency Analysis

As discussed above, this accident analysis was presented in the DARHT EIS on a “what-if” basis. What-if means that regardless of the actual ability for an initiating event or accident progression to occur, the consequences of an assumed event shall be considered. For this case, the event is an uncontained detonation of a plutonium-containing assembly at the DARHT facility.

The accident was estimated to be incredible, but several related safety studies were underway when the DARHT EIS was being completed. These studies have since been completed. The studies also support the initial estimation that the accident would be incredible (probability less than 10^{-6} per year). RAD–11 is the mitigated accident where the container is breached, and its probability is also less than 10^{-6} per year. These probabilities mean that, for these accidents, neither is expected to occur.

Nevertheless, this scenario is presented along with several other incredible accidents. These scenarios tend to demonstrate the importance and effectiveness of controls and engineering standards. The what-if scenario generally corresponds to the case where controls are assumed to have failed, and an initiating event that could cause such a consequence is assumed to be possible. When estimates are made about the probability of an initiating event occurring or the failure of multiple control barriers, then the frequencies of an inadvertent detonation become very small. The expected outcome for these experiments is a contained detonation, with a very limited probability that an inadvertent detonation will occur.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

Because the activities at DARHT do not charge across alternatives, the frequency of this scenario remains less than 10^{-6} per year.

Source Term Calculations

Detonation of an experimental assembly results in the aerosolization and potential atmospheric dispersion of a portion of the materials contained within the assembly. As described in the DARHT EIS (DOE 1995a), analysis of this hypothetical accident is documented in a classified appendix to that EIS. While the resulting impacts, as well as unclassified calculations, assumption, and modeling methods are contained in the unclassified sections of the EIS, some details of such experiments, including some associated with the source terms for this accident scenario, are classified.

Consequences of RAD–04 for Facility Workers and the Public

Impacts to workers, noninvolved workers, public populations, and MEIs were described in the DARHT EIS. For involved workers at and around the firing site, the number of workers (and observers) when explosives are present is limited to 15; under an inadvertent detonation scenario, all of these individuals could be killed (DOE 1995a).

Predominant human health impacts to noninvolved workers or the public would stem from exposure to aerosolized and dispersed material. Impacts to noninvolved workers at distances of 2,500 and 1,300 feet (750 and 400 meters) were evaluated (DOE 1995a). Doses to noninvolved workers were estimated to be 90 rem and 160 rem for a worker at 2,500 and 1,300 feet (750 and 400 meters), respectively; corresponding probability of an excess LCF would be 0.06 and 0.04, respectively, for those individuals. LANL administratively controls access to explosives areas by noninvolved individuals and has a set of established hazard radii for protection of personnel from fragment injury from explosives experiments, based on DOE principles. It was estimated that a noninvolved worker would likely be no closer than 2,500 feet (750 meters). The public MEI located at State Road 4 was calculated to receive 76 rem, with a resulting probability of an excess LCF of 0.04 (DOE 1995a). The impacts to workers and the public MEI were summarized in Table G–10 of the DARHT EIS, which is reproduced here as Table G.5.6.4–1 for the convenience of the public. This table also includes information pertinent to the containment breach scenario RAD–11.

TABLE G.5.6.4–1.—*DARHT EIS Hypothetical Impacts to Workers and the Public from Postulated Accidents Involving Plutonium*

AFFECTED CATEGORY	INADVERTENT DETONATION		CONTAINMENT BREACH	
	DOSE (REM)	MAXIMUM PROBABILITY OF EXCESS LCFS	DOSE (REM)	MAXIMUM PROBABILITY OF EXCESS LCFS
Workers —	___[a]	NA	no impact	no impact
Noninvolved Workers				
750 m	90	0.04	20	0.009
400 m	160	0.06	60	0.02
Public MEI	76	0.04	14	0.007

[a] No radiological impact estimated; up to 15 fatalities could result from explosion blast effects.
[b] NA = Not applicable

The population exposure for the most populated sector (which includes White Rock and Santa Fe) was estimated to be between 9,000 and 24,000 person-rem for 50th and 95th percentile meteorological conditions, respectively, resulting in 5 to 12 excess LCFs (DOE 1995a). While diffusion of material across an entire directional sector was taken into account, it was assumed that all of the community populations were located at or near to the plume center line, a conservative assumption that results in an overestimate of exposures (DOE 1995a).

Population dose and impacts to other communities also were calculated using the conservative assumption that the plume passed directly over and through each hypothetically affected community (though they are generally in different directions). Because of its closeness to LANL, Los Alamos could be one of the most affected communities if the plume passed its way, calculated to receive up to 45,100 person-rem resulting in up to 22 excess LCFs (for 95th percentile meteorology). (This value could be overestimated because the airborne plume would be relatively narrow at this distance and may miss much of the population.) Other communities, including Española and the Jemez and Santa Clara Pueblos, could receive sufficient population doses under the specific exposure conditions assumed that some excess LCFs could occur. The impacts to public populations were summarized in tables G-11 and G-12 of the DARHT EIS, which are reproduced here as Tables G.5.6.4–2 and G.5.6.4–3 for the convenience of the public. (Table G.5.6.4–2 also includes information pertinent to the containment breach scenario RAD–11.) In addition, Figure 5–1 from the DARHT EIS, which shows the most populated sector and the distribution of minority population, also is reproduced here (as Figure G.5.6.4–1).

The DARHT analysis (DOE 1995a) evaluated all significant impacts from this accident, including dispersal and human health impacts from other materials in the dynamic experiment assembly; it evaluated impacts to the public MEI, to the population, noninvolved workers, and involved workers. It used a conservative 95th percentile meteorology to various geographic population sectors, based on recent historical wind data, in calculating impacts. For atmospheric dispersion and resulting dose consequences, the DARHT EIS employed the GENII code, while other analyses in this SWEIS uses the MACCS 2 code; both codes are established for such use. The DARHT EIS also considered some different approaches to

TABLE G.5.6.4–2.—*DARHT EIS Hypothetical Impacts to the Most Populated Sector from Postulated Accidents Involving Plutonium*

ATMOSPHERIC DISPERSION ASSUMPTION	INADVERTENT DETONATION		CONTAINMENT BREACH	
	POPULATION DOSE (PERSON-REM)	NUMBER OF EXCESS LCFS	POPULATION DOSE (PERSON-REM)	NUMBER OF EXCESS LCFS
50th percentile	9,000	5	210	0 (0.1)
95th percentile	24,000	12	560	0 (0.3)

Note: The communities of Santa Fe and White Rock are included within the population of this sector.

TABLE G.5.6.4–3.—*DARHT EIS Hypothetical Impacts to Nearby Communities from a Postulated Inadvertent Detonation Accident Involving Plutonium*

COMMUNITY	50TH PERCENTILE METEOROLOGY[a]		95TH PERCENTILE METEOROLOGY[b]	
	POPULATION DOSE (PERSON-REM)	NUMBER OF EXCESS LCFS	POPULATION DOSE (PERSON-REM)	NUMBER OF EXCESS LCFS
Cochiti Pueblo	300	0	800	0
Santa Clara Pueblo	1,000	0	2,900	1
San Ildefonso Pueblo	400	0	900	0
Jemez Pueblo	600	0	4,400	2
Española	4,400	2	12,100	6
Pojoaque Pueblo	50	0	100	0
Los Alamos	5,900	3	45,100	22
White Rock	500	0	2,400	1
Santa Fe	7,500	3	18,700	9

[a] 50th percentile of atmospheric dispersion conditions.
[b] 95th percentile of atmospheric dispersion conditions.
Note: Values for communities in different compass directions are not additive (see Table G–6).

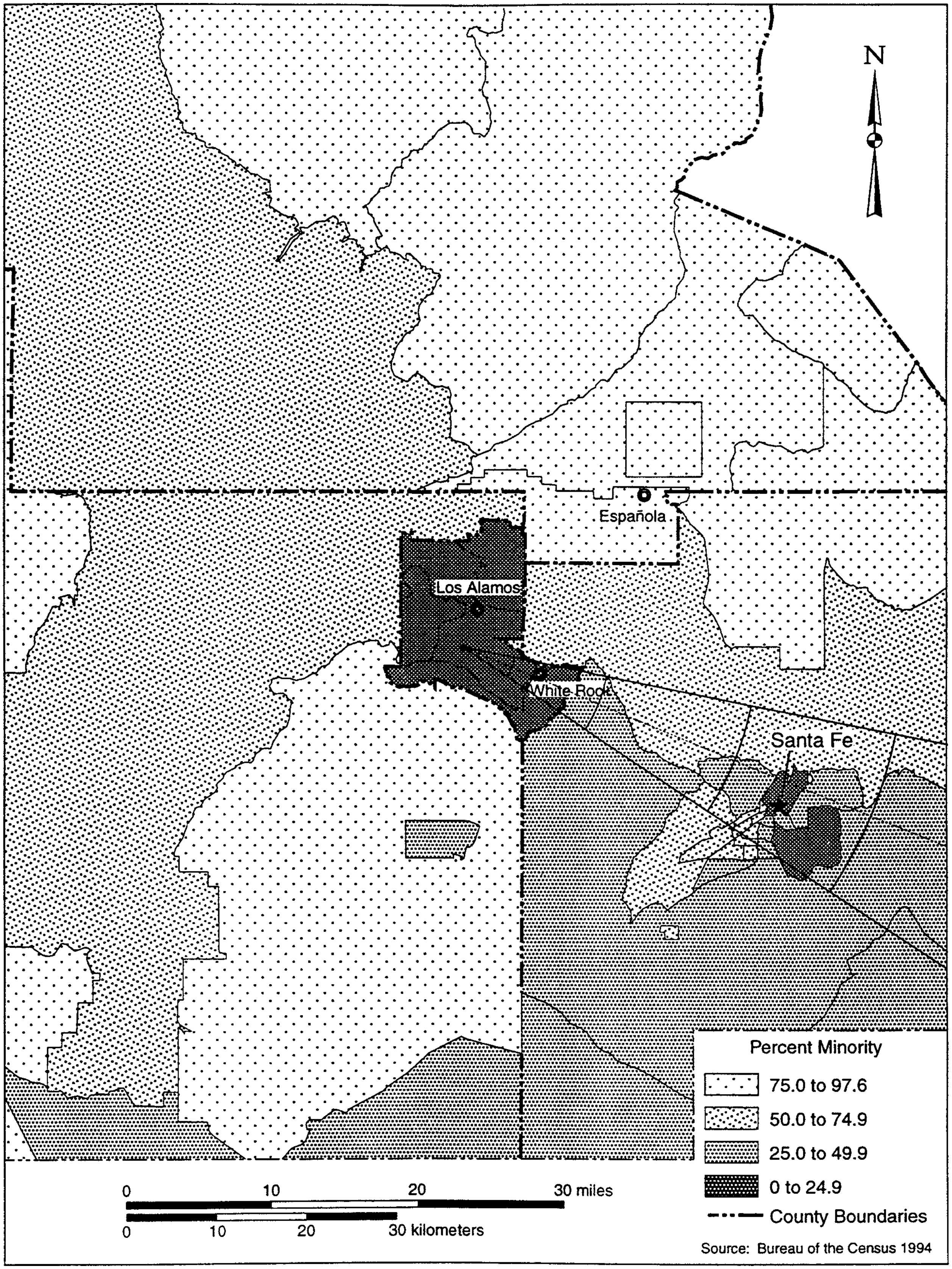


FIGURE G.5.6.4–1.—*DARHT EIS Most Populated Sector and the Distribution of Minority Populations.*

dispersion modeling, the results of which varied by less than a factor of 10 uncertainty in atmospheric dispersion model results that the EIS acknowledged to be ordinarily assumed for such models (DOE 1995a). As does this SWEIS, the DARHT EIS incorporated various factors and approximations to assure impact analyses are conservative, though not unduly so. Therefore, differences in models and methodology from the DARHT EIS do not affect the evaluation of the alternatives in this SWEIS.

G.5.6.5 *RAD–05, Aircraft Crash and Tritium Release at TSTA/ TSFF*

General Scenario Description

The Tritium Science and Fabrication Facility (TSFF, TA–21–209) and the Tritium Systems Test Assembly (TSTA, TA–21–155) are two DOE Hazard Category 2 nonreactor nuclear facilities that handle tritium. The buildings are located in TA–21, 0.4 mile (0.6 kilometer) from and parallel to the runway of Los Alamos Airport. The buildings are about 75 feet (23 meters) apart with an intervening building (TA–21–152) separating the two facilities.

The accident scenario for RAD–05 involves an aircraft crash into TSFF and/or TSTA. Initially, it was thought that these two facilities could be modeled as a single target. However, refinement of the modeling indicated that tritium was actually likely to be present only in a small fraction of the total floor area of these two facilities. Accordingly, and in conformance with DOE Standard 3014-96 (DOE 1996c), the targets were modeled separately. Perforation/ explosion was not considered to be possible at these facilities due to the lack of explosive materials. Accordingly, the scenario was limited to perforation/fire considerations. Further refinement of the crash scenarios is possible to take into account shielding of the two buildings with respect to one another, which would reduce the crash frequencies. However, even conservatively assuming the entire facility inventory is released in oxide form, the dose consequences are somewhat modest (24 person-rem integrated population exposure and 0.0093 excess LCFs) compared with other accident scenarios evaluated in the LANL SWEIS, and further refinement was deemed to be unnecessary.

No Action Alternative Frequency Analysis

The air space above LANL is restricted up to 14,000 feet (4,270 meters), designated as Restricted Airspace R-5101 (LANL 1996c). However, DOE Standard 3014-96 states that once an in-flight mishap does occur, with eventual loss of control, there is nothing to prevent a disabled aircraft from crashing into any location, even within a restricted airspace area (DOE 1996c). The estimated frequency for perforation/fire for TSTA and TSFF is estimated at 3.8 x 10^{-6} and 5.3 x 10^{-6} per year, respectively.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

Aircraft crash rates in the vicinity of LANL are not significantly associated with the level of activity at LANL. Accordingly, the frequency of aircraft crash does not vary by alternative.

Uncertainties and Sensitivities Affecting the Frequency of RAD–05

There is a large number of data required in order to perform the DOE Standard 3014-96 calculations. In addition, the standard itself requires the use of numerous equations that are recognized to be approximations (DOE 1996c).

Perhaps the most important uncertainty is the assumption (embedded in the standard) that a skidding aircraft will impact a facility with the same velocity it had when it began the skid. This results in a conservative impact velocity because no credit is taken for drag, friction, impact with objects between the impact point and the facility, and so on. Other conservatisms include the assumption that the entire aircraft engine is the penetrating missile of concern. This is conservative because most of the fan shroud would tear away when striking the facility, leaving the engine shaft as the secondary penetrator.

Source Term Calculations

It was conservatively assumed that the entire inventory of the facility of interest (either TSTA or TSFF) would be released in oxide form in the event of an aircraft crash, due to fire. The MAR value for TSFF is 100 grams of tritium in process and 100 grams of tritium in storage in containers in vaults (Valentine and Pendergrass 1997). The MAR for TSTA is 200 grams (except for the Reduced Operations Alternative, for which the MAR is 150 grams). Only one building is assumed to be destroyed in a crash due to the presence of the intervening structure (TA–21–152) between TSFF and TSTA. It is assumed that in all cases the inventory of the building that is destroyed is 200 grams of tritium, released in oxide form. With the exception of TSTA in the Reduced Operations Alternative, the inventory of the destroyed building will be 200 grams. Because in the Reduced Operations Alternative there is as good a chance of hitting a 200 gram inventory building as there is hitting a 150 gram inventory building, modeling the release as 200 grams is reasonable. The standard DOE Handbook 3010-94 source term equation was employed in the source term calculation. The DR is 1 (building destruction due to explosion and fire). The ARF and RF are 1 for tritium. The LPF is also 1 due to the breach of the building by the aircraft penetration and explosion. As a result, the source term equation reduces to the MAR.

Uncertainties and Sensitivities Affecting the Source Term for RAD–05

It is assumed that there is 100 percent conversion of tritium gas to tritium oxide. This is conservative but feasible.

Consequences of RAD–05 for Facility Workers and the Public

Worker consequences and public consequences are discussed separately. A detailed worker consequence analysis was not performed; however, the following observations are made regarding the aircraft crash scenario:

- An aircraft crash that destroys the facility is assumed to result in the death of all workers in the building.
- Workers in adjacent facilities (such as the noninvolved tritium building and the intervening structure) may be injured due to flying debris from the explosion or aircraft crash, and could also be exposed to tritium oxide.

No radiation-related acute fatalities are predicted to result from the accident. The mean collective population dose is projected to total 24 person-rem (TEDE), resulting in 0.012 excess LCFs. Mean projected doses for MEIs (and their associated locations) are presented in Table G.5.6.5–2. The tritium oxide source term does not result in ground contamination. Table G.5.6.5–1 summarizes the modeling results for RAD–05.

G.5.6.6 *RAD–06, Aircraft Crash and Plutonium Release from RAMROD*

General Scenario Description

The Radioactive Materials Research, Operations, and Demonstration (RAMROD) Facility is located at TA–50–37, the site of the former treatment demonstration incineration facility. Although the RAMROD Facility has

TABLE G.5.6.5–1.—*Summary Results for Scenario RAD–05*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	3.8×10^{-6} (TSTA) 5.3×10^{-6} (TSFF)	200 grams of tritium as oxide; integrated population exposure of 24 person-rem, 0.012 excess LCFs.
Expanded Operations	3.8×10^{-6} (TSTA) 5.3×10^{-6} (TSFF)	Same as No Action Alternative.
Reduced Operations	3.8×10^{-6} (TSTA) 5.3×10^{-6} (TSFF)	Same as No Action Alternative.[a]
Greener	3.8×10^{-6} (TSTA) 5.3×10^{-6} (TSFF)	Same as No Action Alternative.

[a]For the Reduced Operations Alternative, the inventory at TSTA is reduced by 25 percent. The bounding consequence of 24 person-rem from a 200 gram release at TSFF is assumed.

TABLE G.5.6.5–2.—*Predicted Mean Doses to MEIs for Scenario RAD–05*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	**DOSE**
Closest public access: Access road to facility (10 m)	(see note)
Closest routine public access: Route 502 (360 m)	1.2×10^{-2}
Closest special population: Los Alamos Airport (780 m)	2.0×10^{-2}
Closest residence (TSFF SAR MEI location): Los Alamos (970 m)	1.8×10^{-2}
Special population distance: San Ildefonso Pueblo boundary (2,300 m)	3.3×10^{-2}
Special population distance: San Ildefonso Pueblo (14,000 m)	1.2×10^{-2}

Note: For the given modeling conditions, the postulated elevated release would pass over this location before touching the ground. However, in reality this location would probably be directly impacted by the aircraft crash, and an estimation of dose would be impractical and of limited usefulness.

several uses, the most significant from the standpoint of health and safety consequences in the event of an accident is the visual characterization of TRU waste. SWEIS accident scenario RAD–06 involves an aircraft crash at RAMROD, resulting in a fire that causes the release of plutonium from TRU waste. Most of the release results from the combustible portion of the waste, which is stored in DOT Type A 55-gallon drum containers when it is not being visually examined in glovebox lines in RAMROD.

This accident is presented to provide comparisons of the aircraft crash results across LANL. The accident would have screened out based on the frequency of occurrence for such events.

Source Term Calculations

The source term calculation assumed a fire following the aircraft crash. Two aircraft types account for about 98.5 percent of the total aircraft crash frequency at RAMROD: multiple-engine piston aircraft and small military aircraft. In order to evaluate the fire potential of these aircraft, the bounding fuel load (LLNL 1996) was based on a review of the characteristics of the aircraft in these classes as identified in the supporting documentation for DOE Standard 3014-96. The aircraft selected for these classes are: (1) the Cessna Titan line, with a fuel load of 413 gallons (1,564 liters), for the multiple-engine piston aircraft; and (2) the F-16C, with a fuel load of 1,801 gallons (6,819 liters) for the small military aircraft (LLNL 1996).

In order to quantify the burn area resulting from a spill of aircraft fuel and its subsequent combustion, guidance from the Rocky Flats Risk Assessment Guide was followed that provides an estimate of a 250 square-foot (23 square-meter) burn area per 50 gallons of fuel burned (RFETS 1994). Burn areas were calculated as follows for the three significant classes of aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

where:

A_{BURN} = Burn area in square feet

F_{LOAD} = Aircraft fuel load in gallons

The estimated burn area for each of the significant aircraft types can now be calculated:

Multiple-Engine Piston Aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = (413/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = 2{,}065 \text{ ft}^2$$

Small Military Aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = (1{,}801/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = 9{,}005 \text{ ft}^2$$

For RAMROD, the overall area of the facility (first floor) is 15,690 square feet (1,458 square meters). The burn areas identified above represent the following percentages of the RAMROD building:

- Multiple-engine piston aircraft = 13.2 percent
- Small military aircraft = 57.4 percent

The MAR for RAMROD consists of 479 containers. These consist of 48 containers containing 75 PE-Ci each (according to the TA–54 SAR, 1 percent of LANL TRU waste containers have an inventory of 75 PE-Ci) (LANL 1995i), and 431 containers containing an average of 12 PE-Ci each (LANL 1996n). Thus, the total inventory is (48 x 75) + (431 x 12) = 3,600 + 5,172 = 8,772 PE-Ci. Given the units used in the RAMROD SAR, releases to the environment will be expressed in grams of pure plutonium-239, rather than in grams of weapons-grade or heat-source plutonium. (The low-level mixed waste inventory is not included because the contribution to the PE-Ci inventory is trivial.)

The initial source term equation must be quantified separately for each type of aircraft contributing significantly to the crash frequency due to the difference in the impacted area of the facility. Due to the random nature of aircraft crashes, no specific directionality is associated with the crashes. The damage ratio will be expressed as the product of the percentage of the facility floor area burned in a fire (which will be assumed to equate to the fraction of the inventory affected by fire) and the fraction of the TRU waste inventory that is typically present in combustible form (0.35). This approach is equivalent to "smearing" the inventory evenly across the floor area of the building.

It is recognized that some crashes could result in a fire without affecting MAR; whereas, other crashes could burn a quantity of waste that is in excess of the fraction the floor area affected by the burn. However, the approach adopted above is believed to yield a reasonable result that is considered to be representative of the average that would result from a large number of crashes.

The ARF and RF values are selected from DOE Handbook 3010-94 and are based on the bounding values for packaged mixed combustible waste. The recommended ARF and RF values are 0.0005 and 1.0 (DOE 1994d). For the noncombustible waste, the ARF and RF values are 0.006 and 0.01 (DOE 1994d). Due to the penetration of the building by the aircraft-related missiles and/or due to external or internal explosion of fuel, the LPF is taken to be 1.0.

The general initial source term equation is quantified below for the two aircraft types that contribute to the crash frequency, as well as for both combustible and noncombustible waste forms:

Multiple-Engine Piston Aircraft:

Initial Combustible Source Term = MAR x DR x ARF x RF x LPF

= 8,772 x (0.132 x 0.35) x 0.0005 x 1 x 1

= 0.2 PE-Ci

Initial Noncombustible Source Term = MAR x DR x ARF x RF x LPF

= 8,772 x (0.132 x 0.65) x 0.006 x 0.01 x 1

= 0.05 PE-Ci

Multiple-Engine Piston Initial Source Term Total = Initial Combustible + Initial Noncombustible

= 0.2 + 0.05

= 0.25 PE-Ci

Small Military Aircraft:

Initial Combustible Source Term = MAR x DR x ARF x RF x LPF

= 8,772 x (0.574 x 0.35) x 0.0005 x 1 x 1

= 0.88 PE-Ci

Initial Noncombustible Source Term = MAR x DR x ARF x RF x LPF

= 8,772 x (0.574 x 0.65) x 0.006 x 0.01 x 1

= 0.20 PE-Ci

Air Taxi Aircraft Initial Source Term Total = Initial Combustible + Initial Noncombustible

= 0.88 + 0.20

= 1.08 PE-Ci

Following the initial source term release, resuspension releases are possible due to dispersal of material by the wind. For an aircraft crash, a 24-hour suspension release is reasonable due to the significant damage resulting from the aircraft crash and subsequent explosion and fire.

The general suspension source term equation is used. The DR is simply the fraction of the area burned because the ARR/hr and RF values are the same for both combustible and noncombustible waste. The ARF and RF values are selected from DOE Handbook 3010-94 and are based on the bounding values for packaged mixed waste. The recommended ARR and RF values are 4 x 10^{-5} per hour and 1.0 (DOE 1994d). Due to the penetration of the building by the aircraft-related missiles and/or due to external or internal explosion of fuel, the LPF is taken to be 1.0. It is assumed that temporary confinement cannot be erected or otherwise established for 24 hours to control suspension releases.

The suspension source term equation also must be quantified individually for each of the two crash frequency contributors:

Multiple-Engine Piston Aircraft:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= 8,772 x 0.132 x 0.00004 x 24 x 1 x 1

= 1.1 PE-Ci

Small Military Aircraft:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= 8,772 x 0.574 x 0.00004 x 24 x 1 x 1

= 4.8 PE-Ci

In order to specify a single source term for the RAMROD aircraft crash accident, the initial source terms and suspension source terms are frequency-weighted according to their contributions to the overall risk, as shown in Tables G.5.6.6–1 and G.5.6.6–2.

Based on these calculations, the source term for RAD–06 for the No Action Alternative is represented with an initial source term of 0.63 PE-Ci released in 30 minutes, and a suspension source term of 2.8 PE-Ci released over 24 hours.

There are no differences in source term across the alternatives because the No Action Alternative source terms are based on the RCRA-permitted capacity of the building.

Uncertainties and Sensitivities Affecting the Source Term for RAD–06

The source terms (initial and suspension) are maximum values, based on the RCRA-permitted capacity of the building. At any given time, there may be less TRU waste in the building than the permitted capacity. The average amount of TRU waste in combustible form may vary (an average value was used).

The suspension source term calculation extends for 24 hours. This may be very conservative in that it is likely that fire fighting and hazardous material (HAZMAT) response to the crash scene would be accompanied by extensive use of water and foam-based suppression systems. This application of suppressants would likely continue for some time to preclude flareup of the fire once it is extinguished, as well as to limit further spread of airborne plutonium contamination. Thus, the suspension source term may be very conservatively estimated for this scenario.

Consequences of RAD–06 for Facility Workers and the Public

Consequences for facility workers and the public are reported separately. An aircraft crash into the facility that destroys part of the facility is assumed to result in the death of all workers

TABLE G.5.6.6–1.—*Frequency Weighted Source Term Calculation for Initial Source Term*

AIRCRAFT TYPE	PERCENTAGE CONTRIBUTION TO AIRCRAFT CRASH FREQUENCY	INITIAL SOURCE TERM (PLUTONIUM-239 PE-Ci)	WEIGHTED INITIAL SOURCE TERM (PLUTONIUM-239 PE-Ci)
Multiple-Engine Piston	52.3%	0.25	0.13
Small Military	46.2%	1.08	0.50
TOTAL	98.5%		0.63

TABLE G.5.6.6–2.—*Frequency Weighted Source Term Calculation for Suspension Source Term*

AIRCRAFT TYPE	PERCENTAGE CONTRIBUTION TO AIRCRAFT CRASH FREQUENCY	SUSPENSION SOURCE TERM (PLUTONIUM-239 PE-Ci)	WEIGHTED SUSPENSION SOURCE TERM (PLUTONIUM-239 PE-Ci)
Multiple-Engine Piston	52.3%	1.1	0.58
Small Military	46.2%	4.8	2.22
TOTAL	98.5%		2.80

in the part destroyed. Workers elsewhere in the structure may be injured or killed due to flying debris or secondary effects from the fire (e.g., smoke inhalation). Workers in the building who are not directly affected by the crash and explosion or fire may be exposed to radiation as a result of plutonium inhalation. If the building collapses as a result of the impact of the aircraft, additional injuries or fatalities could result.

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total approximately 7,900 person-rem (TEDE), resulting in 4.2 excess LCFs. No ground contamination results or MEI doses are presented because the accident is incredible. Table G.5.6.6–3 summarizes the modeling results for RAD–06.

G.5.6.7 *RAD–07, TRU Waste Container Storage Area Fire at WCRR Facility*

General Scenario Description

The Waste Characterization, Reduction, and Repackaging (WCRR) Facility performs a variety of activities related to characterization, volume reduction, and repackaging, primarily for TRU waste. In order to support these activities, an outdoor Container Storage Area is provided just to the south of the WCRR Facility main building. Accident scenario RAD–07 involves a fire at the Container Storage Area, resulting in the release of plutonium from the TRU waste (which is contained in DOT Type A 55-gallon drums). The Container Storage Area has a RCRA Part B permitted capacity of 30,000 gallons of mixed waste, which is equivalent to 545, 55-gallon drums. WCRR Facility also has a RCRA Part B permitted capacity of 1,500 gallons of mixed waste (equivalent to 27, 55-gallon drums).

TABLE G.5.6.6–3.—*Summary Results for RAD–06*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	6.5×10^{-8}	Initial release of 0.63 PE-Ci, released in 30 minutes; Suspension source term of 2.8 PE-Ci, released over 24 hours; integrated population exposure of 7,900 person-rem and 4.2 excess LCFs.
Expanded Operations	6.5×10^{-8}	Same as No Action Alternative.
Reduced Operations	6.5×10^{-8}	Same as No Action Alternative.
Greener	6.5×10^{-8}	Same as No Action Alternative.

RAD–07 Release Mechanisms

The postulated RAD–07 accident scenario involves an airborne release of radioactive material due to a fire that develops at the outdoor container storage area. Potential accident initiators include: (1) truck fires, (2) forklift fires, (3) external fires (wild fires), (4) lightning strikes, and (5) aircraft accidents. Lightning may strike the Container Storage Area or pose an indirect hazard by initiating a wildfire. The Container Storage Area does not have lightning protection; however, a lightning strike would, at most, pose a localized hazard due to ignition of combustible waste. It would have a very limited opportunity to propagate with waste contained in metal drums and the low combustible loading of the storage array. Wild fires, initiated by lightning strikes or otherwise, do not pose a significant hazard considering the developed nature of the area (e.g., pavement), the low vegetation loading of the immediate surrounding area, and the time available to take mitigative actions. A forklift fire would be credible, but would be significantly bounded by the MAR for a truck fire accident.

Two truck fire scenarios could occur. The first is an accident involving a truck that causes a fuel leak and subsequent fire involving the Container Storage Area. This is judged not to be credible considering the low truck speeds involved in the confined yard area and the limited vehicle traffic, with the exception of forklift activity. The second involves a truck parked near the Container Storage Area that could experience a fuel system leak or fuel tank leak due to causes unrelated to a vehicle accident. Once a fuel leak occurs, ignition of the spilled fuel would lead to a fire that, if it is close enough to the Container Storage Area and if it is not suppressed, would envelope multiple waste containers. This scenario is retained for analysis.

While not required by the RCRA Part B permit, waste drums are currently stored in transportables for weather protection. The analysis takes no credit for the separation provided by the transportables because the RCRA Part B permit does not require their use. This accident was not evaluated in the WCRR Facility SAR (LANL 1995e).

No Action Alternative Frequency Analysis

The frequency (F_{FIRE}) of a truck fuel leak and subsequent fire accident can be estimated using the following equation:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

where:

$N_{SHIPMENTS}$ = Number of shipments to or from the Container Storage Area at TA–50–69 per year

C_{LEAK} = Conditional probability of fuel leak per shipment

C_{PFIRE} = Conditional probability of a fire given a fuel leak

The frequency of a fuel system leak or fuel tank leak and a resulting fire is assessed for the Container Storage Area at TA–50–69 based on methods and data described in section G.5.10, RAD–01. The per trip fuel leak rate is 1.3×10^{-3} per trip, with 24 shipments per year assumed for the purposes of analysis (2 shipments per month). Thus, the above equation can be quantified as follows:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

$$F_{FIRE} = 24 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$F_{FIRE} = 1.5 \times 10^{-4} \text{ per year}$$

In order to assure that the frequency of a fire due to forklift activity was dominated by the truck fire scenario, the frequency of a forklift fire was estimated. The frequency of a forklift fire ($F_{FLFTFIRE}$) leading to a release of TRU material at the Container Storage Area may be analyzed using the following equation:

$$F_{FLFTFIRE} = N_{FMOVE} \times N_{HOUR} \times F_{FUEL} \times C_{PING}$$

where:

N_{FMOVE} = Number of forklift movements per year

N_{HOUR} = Number of hours per forklift movement adjacent to Container Storage Area

F_{FUEL} = Frequency of a fuel tank rupture per hour

C_{PING} = Conditional probability of ignition given a fuel tank rupture

Forklift movements at TA–50–69 occur on an individual drum basis and on a palletized basis at the time of receipt and shipment. The WCRR Facility SAR (LANL 1995e) estimates 200 movements of palletized drums per year. Individual drum movements are not evaluated in the SAR. However, based on four drums per pallet, two palletized movements per set of four drums (for unloading and loading), and that individual drum movements would occur when waste drums are brought to and returned from the WCRR Facility, it is estimated that there are 800 ([200/2] x 2 x 4) individual drum movements per year.

The frequency of a forklift fuel tank rupture and a resulting fire is assessed based on methods and data contained in the TA–54, Area G Hazard Analysis (LANL 1995g), which references the evaluation of ignition probabilities given a tank rupture by the Reliability Analysis Center (RAC 1991). The frequency of a fuel tank rupture was assessed as 2.3×10^{-5} per hour in the TA–54 hazard analysis (LANL 1995g). For a nondiesel fuel (propane), the conditional probability of ignition given a rupture is assigned a value of 1×10^{-2}. It is conservatively assumed that each forklift movement lasts 0.5 hour. For individual drum movements, it is assumed the forklift movement time is equally divided at the Container Storage Area, in transit to the facility, and at the facility. For the palletized movements, it is assumed that the forklift time is equally spent immediately near the Container Storage Area and at the truck. Because of the small fuel capacity of the forklift as compared with the truck, it is assumed that any forklift incidents at the truck would not involve the Container Storage Area. Additionally, it is noted that forklift activities would be in the vicinity of the truck bed and, thus, would not involve the truck/tractor fuel tanks.

Thus, the above equation for forklift movements near the Container Storage Area can be quantified as follows:

$$F_{FLFTFIRE} = N_{FMOVE} \times N_{HOUR} \times F_{FUEL} \times C_{PING}$$

$$= [800 \text{ moves} \times (0.5/3 \text{ hr/move}) + 200 \text{ moves} \times (0.5/2 \text{ hr/move})] \times (2.3 \times 10^{-5} \text{ /hr}) \times (1 \times 10^{-2})$$

$$= 4.2 \times 10^{-5} \text{ per year}$$

The calculated frequency for a forklift fire involving the Container Storage Area is less than that for a truck fire. Additionally, the MAR for a postulated forklift fire would be much less than that for a truck fire. Consequently, truck fires dominate potential risks and forklift fire contributions are not considered further.

Expanded Operations Alternative Frequency Analysis

The Expanded Operations Alternative waste management practices and the low-level radioactive mixed waste (LLMW) generation rate will be comparable to the No Action Alternative. However, TRU waste volumes are expected to double (5,100 versus 2,500 cubic meters) from those in the No Action Alternative (LANL 1997c). On this basis, it is expected that waste throughput at WCRR Facility and the associated frequency of a potential truck fire at the Container Storage Area will be greater than in the No Action Alternative. Historically, WCRR Facility activities have primarily involved TRU waste characterization and volume reduction. Consequently, it is assumed that the change in throughput at WCRR Facility will be directly proportional to the change in TRU waste volume, resulting in 49 shipments per year (24 x 5,100/2,500).

With a revised number of truck shipments for the Expanded Operations Alternative, the frequency (F_{FIRE}) of a truck fuel leak and subsequent fire accident can be estimated as:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

$$F_{FIRE} = 49 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$F_{FIRE} = 3.0 \times 10^{-4} \text{ per year}$$

Reduced Operations Alternative Frequency Analysis

For the Reduced Operations Alternative, waste management practices and the LLMW waste generation rate will be comparable to the No Action Alternative. However, TRU waste volumes are expected to be almost 25 percent less (1,900 versus 2,500 cubic meters) than those for the No Action Alternative (LANL 1997c). On this basis, it is expected that waste throughput at WCRR Facility and the associated frequency of a potential truck fire at the Container Storage Area will be less than in the No Action Alternative. Historically, WCRR Facility activities have primarily involved TRU waste characterization and volume reduction. Consequently, it is assumed that the change in throughput at WCRR Facility will be directly proportional to the change in TRU waste volume, resulting in 18 shipments per year (24 x 1,900/2,500).

With a revised number of truck shipments for the Reduced Operations Alternative, the frequency (F_{FIRE}) of a truck fuel leak and subsequent fire accident can be estimated as:

$$F_{FIRE} = N_{SHIPMENTS} \times C_{LEAK} \times C_{PFIRE}$$

$$F_{FIRE} = 18 \times (1.3 \times 10^{-3}) \times (4.7 \times 10^{-3})$$

$$F_{FIRE} = 1.1 \times 10^{-4} \text{ per year}$$

Greener Alternative Frequency Analysis

For the Greener Alternative, waste management practices and waste generation rates for LLMW and TRU waste will be comparable to those for the No Action Alternative. On this basis, it is expected that waste throughput at WCRR Facility and the associated frequency of a potential truck fire at the Container Storage Area will be the same as in the No Action Alternative.

Uncertainties and Sensitivities Affecting the Frequency of RAD–07

Insofar as the fire modeling is concerned, the uncertainties affecting the frequency of RAD–07 are identical to those affecting CHEM–02. The frequency results are also sensitive to the assumed number of shipments per year for the Container Storage Area.

Source Term Calculations

The initial source term equation is used for this case. The MAR for the postulated accident is limited to the Container Storage Area waste inventory immediately involved in the truck fuel pool fire. Propagation of the fire to the entire inventory is not expected, as discussed in section G.5.16.1. The MAR is estimated for a 100-gallon (379-liter) fuel spill, yielding a burn area of 500 square feet (46 square meters). This is based on a burn area relationship of 250 square feet for 50 gallons of fuel (23 square meters for 189 liters of fuel) (RFETS 1994). Assuming that half the burn area is off center from the Container Storage Area and that half the remaining area involves waste (allows for aisle/access space), approximately 62 drums (stacked two high) would be involved (125 square feet x 2 drums/4 square feet).

Potential waste forms present include solidified liquids (aggregate); surface contaminated, packaged combustible solids; and surface contaminated, noncombustible solids. The bounding ARF and RF products for these three waste forms in a thermal stress environment (fire) are 6×10^{-5}, 5×10^{-4}, and 6×10^{-5}, respectively (DOE 1994d). Consequently, it can be concluded that releases will be dominated by combustible waste and the analysis will be limited to this waste form. It is conservatively assumed that the combustible waste fraction at the Container Storage Area is the same as that for the TRU waste inventory at Area G. The Container Storage Area combustible waste fraction is likely to be much lower due to the facility's primary mission of size reduction of metal objects, such as gloveboxes; however, combustible waste forms would be expected to be present due to characterization activities. Additionally, it is conservatively assumed that 35 percent of the radiological inventory is present in combustible waste forms. Thus, for the MAR (62 drums), the DR is set equal to the fraction of combustible material (0.35). The Container Storage Area is located outdoors; consequently, any postulated accident involving a release to the environment would have an LPF of 1.0.

Proposed administrative limits for the radionuclide content of each individual waste container are presented in Table 9-2 of the WCRR Facility SAR (LANL 1995e) and are based on DOE Standard 1027-92 (DOE 1992) Hazard Category 3 threshold limits or a fissile gram equivalent limit based on the WIPP WAC. Currently, the average TRU radioactive material content per waste container is 8.9 PE-Ci (LANL 1995f). Less than 1 percent of all TRU waste containers in the existing Area G inventory exceed 75 PE-Ci in radioactive material content (LANL 1995f). The predominant TRU waste generated at LANL is weapons-grade plutonium (MT52). The LANL fissile gram equivalent limit for this material type is 25 PE-Ci per drum (LANL 1995f). Revision 5 of the WIPP WAC limits the maximum plutonium-239 equivalent activity for untreated, contact-handled TRU waste to be received by the facility to 80 PE-Ci per drum. Considering that the postulated accident scenario involves multiple drums (62); that the drums represent a small fraction of the total TRU waste inventory managed at LANL, and their radioactive content could be skewed to the high end (depending on the waste generator source); and the TRU limits described above; it is conservatively assumed that one drum contains the WIPP WAC limit for untreated waste of 80 PE-Ci and the other 61 drums involved in the fire have an average TRU content of 25 PE-Ci.

With the above information, the initial source term equation can be quantified as follows:

$$\text{Initial Source Term} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF}$$

$$= ([61 \times 25 \text{ PE-Ci}] + 80 \text{ PE-Ci}) \times 0.35 \times (5 \times 10^{-4}) \times 1 \times 1$$

$$= 0.28 \text{ PE-Ci}$$

The suspension source term calculation is performed using the general equation. The suspension MAR equals the initial MAR, minus the initial source term. The suspension DR and LPF have the same values (1.0) as in the initial source term calculation. The ARR and RF are assigned values of 4×10^{-5} and 1.0, respectively, based on bounding resuspension factors for a homogeneous bed of powder exposed to ambient conditions (DOE 1994d). Thus, the suspension source term can be quantified as:

$$\text{Suspension Source Term} = \text{MAR} \times \text{DR} \times \text{ARR} \times 24 \text{ hrs} \times \text{RF} \times \text{LPF}$$

$$= (1{,}550 - 0.28 \text{ PE-Ci}) \times 0.35 \times (4 \times 10^{-5}) \times 24 \text{ hrs} \times 1 \times 1$$

$$= 0.52 \text{ PE-Ci}$$

The suspension source term is highly conservative, considering that fire protection actions (e.g., foam, water spray) and contamination control measures would likely limit airborne releases significantly.

No variation by alternative is projected because waste management practices are expected to be comparable (LANL 1997c), with the MAR and postulated accident conditions the same.

Uncertainties and Sensitivities Affecting the Source Term for RAD–07

A significant uncertainty for this postulated accident is quantification of the MAR in terms of the number of drums involved in the fire and their associated radioactive material content. Accepted methodologies and reasonably conservative radiological estimates have been made to provide an upper estimate of the source term.

Consequences of RAD–07 for Facility Workers and the Public

Typically, five facility workers are associated with TA–50–69 operations and would be at risk for exposure to airborne radioactive material. The postulated accident would not result in an immediate release, providing time for personnel to vacate the immediate area. Personnel in the facility may not have time to vacate before a release occurs; however, CAM alarms and the availability of personal protective equipment could serve to mitigate potential exposures.

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 1,300 person-rem (TEDE), resulting in 0.69 excess LCFs. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.7–2 and G.5.6.7–3, respectively. Table G.5.6.7–1 summarizes the modeling results for RAD–07.

G.5.6.8 *RAD–08, Aircraft Crash and Plutonium Release from TA–54 TWISP Storage Domes*

General Scenario Description

Accident Scenario RAD–08 involves the crash of an aircraft, accompanied by explosion and/or fire, at the TRU waste management area of TA–54, Area G. The largest target, which dominates the aircraft crash frequency results and also has a very large potential MAR, consists of the storage domes for the Transuranic Waste Inspectable Storage Project (TWISP).

TABLE G.5.6.7–1.—*Summary Results for Scenario RAD–07*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	1.5×10^{-4}	Initial release of 0.28 PE-Ci; Suspension release of 0.52 PE-Ci; integrated population exposure of 1,300 person-rem, 0.69 excess LCFs.
Expanded Operations	3.0×10^{-4}	Same as No Action Alternative.
Reduced Operations	1.1×10^{-4}	Same as No Action Alternative.
Greener	1.5×10^{-4}	Same as No Action Alternative.

TABLE G.5.6.7–2.—*Predicted Mean Doses to MEIs for Scenario RAD–07*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	DOSE
Closest public access: Pajarito Road (100 m)	7.4×10^{1}
Special population distance: San Ildefonso Pueblo boundary (500 m)	3.5×10^{0}
Closest public residence: Royal Crest Trailer Park (1,200 m)	7.4×10^{-1}
Closest special population distance: Ashley Pond (2,100 m)	2.6×10^{-1}
Special population distance: San Ildefonso Pueblo (13,600 m)	1.4×10^{-2}

TABLE G.5.6.7–3.—*Predicted Mean Ground Contamination Levels for Scenario RAD–07*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	1.7×10^{4}
1.0 to 2.0 km	1.7×10^{3}
2.0 to 3.0 km	6.7×10^{2}
3.0 to 4.0 km	3.8×10^{2}
4.0 to 8.0 km	1.8×10^{2}
8.0 to 12.0 km	9.3×10^{1}
12.0 to 20.0 km	5.5×10^{1}
20.0 to 30.0 km	2.9×10^{1}
30.0 to 40.0 km	1.6×10^{0}
40.0 to 60.0 km	9.3×10^{0}
60.0 to 80.0 km	4.9×10^{0}

BQ/m^2 = Becquerel per square meter

TRU waste is stored in aluminum arch-frame supported, membrane-covered domes that rest on asphalt pads. Four domes are in use as storage for TRU waste generated since the early part of 1991, designated as TA–54–48, TA–54–153, TA–54–224, and TA–54–283. The storage capacity is 11,000 drums, and there were 3,600 drums in storage as of the end of 1995.

Previously, from 1979 to 1991, TRU waste was stored in retrievable arrays under several feet of earth on three pads (Pads 1, 2, and 4). This retrievable TRU waste is being removed from this configuration and temporarily placed into storage dome structures. The retrieved waste is characterized, repackaged, and certified to WIPP WAC. (All of the retrievable TRU waste is planned to be shipped to WIPP after 1998.) Once the retrieved waste is characterized, repackaged, and WIPP WAC-certified, it will be stored in one of six dome structures, designated as TA–54–229, TA–54–230, TA–54–231, and TA–54–232 (plus two domes yet to be constructed). The four domes are located adjacent to one another at the far eastern extent of the TA–54 operating area; the other two domes will be located at a distance from the four TWISP domes so as to constitute a separate target area, the contribution to risk of which will be bounded by the four existing TWISP storage domes.

The characteristics of the TRU waste to be retrieved from Pads 1, 2, and 4 are generally known as detailed in Table G.5.6.8–1 (LANL 1996n). There are a total of 16,641 drums: 5,487 drums of combustible waste containing an average of 4.34 PE-Ci of plutonium-239 each, and 11,154 drums of noncombustible waste containing an average of 4.11 PE-Ci of plutonium-239 each. There are also 187 fiberglass-reinforced plastic-coated plywood (FRP) crates: 33 FRP crates of combustible waste containing an average of 12.5 PE-Ci of plutonium-239 each, and 154 FRP crates of noncombustible waste containing an average of 8.6 PE-Ci of plutonium-239 each. The total inventories of the three pads are: 7,812 PE-Ci of plutonium-239 for Pad 1; 24,052 PE-Ci of plutonium-239 for Pad 2; and 39,502 PE-Ci of plutonium-239 for Pad 4. In total, the FRP crates represent 1,736 PE-Ci of plutonium-239, or about 2.4 percent of the total TRU waste inventory.

TABLE G.5.6.8–1.—*Characterization of TRU Waste in Pads 1, 2, and 4 at TA–54 Area G*

TRU PAD #1, USED FROM 5/29/79 TO 12/29/81
4,816 Drums
1,276 drums of combustible waste containing 2,240 PE-Ci of plutonium-239
3,540 drums of noncombustible waste containing 4,400 PE-Ci of plutonium-239
88 FRP Crates
8 FRP crates of combustible waste containing 2.03 PE-Ci of plutonium-239
80 FRP crates of noncombustible waste containing 1,170 PE-Ci of plutonium-239
TRU PAD #2, USED FROM 12/8/81 TO 8/20/85
7,280 Drums
2,475 drums of combustible waste containing 6,890 PE-Ci of plutonium-239
4,805 drums of noncombustible waste containing 17,100 PE-Ci of plutonium-239
48 FRP Crates
22 crates of combustible waste containing 1.47 PE-Ci of plutonium-239
26 crates of noncombustible waste containing 60.3 PE-Ci of plutonium-239
TRU PAD #4, USED FROM 3/18/85 TO 1/3/91
4,545 Drums
1,736 drums of combustible waste containing 14,700 PE-Ci of plutonium-239
2,809 drums of noncombustible waste containing 24,300 PE-Ci of plutonium-239
51 FRP Crates
3 FRP crates of combustible waste containing 410 PE-Ci of plutonium-239
48 FRP crates of noncombustible waste containing 91.9 PE-Ci of plutonium-239

No detailed apportionment of the TRU waste recovered from Pads 1, 2, and 4 among the four domes (TA–54–229, TA–54–230, TA–54–231, and TA–54–232) have been identified. For the purposes of this analysis, it is assumed that the TWISP TRU inventory, in terms of PE-Ci, is split evenly among the six domes. Thus, each dome is assumed to contain 4,041 PE-Ci of Plutonium-239 as combustible TRU waste and 7,854 PE-Ci of noncombustible TRU waste.

At the average content values identified above, this would represent about 931 drums of combustible TRU waste and 1,911 drums of noncombustible TRU waste. (This is a slight over-estimate, but considered to be reasonable considering possible repackaging.)

In the storage domes, TRU waste drums are palletized (four drums to a pallet) and stored in inspectable arrays. The arrays consist of palletized drums stacked three high, separated by a minimum aisle space of 26 inches (66 centimeters). FRP crates and standard waste boxes (SWBs) are also stored in these structures. FRP crates and SWBs are stored in rows and stacked one to three boxes high (LANL 1995f). LANL is in the process of exchanging plywood pallets for metal pallets to reduce fire hazards in the TRU waste domes.

Fire-fighting water for Area G is provided by a 10-inch main from a water distribution system supplied by two water tanks near TA–54. The primary tank is a gravity feed with a 1.5 million gallon domestic booster pump (booster station 2). The secondary tank is a pressure feed with a 1.5 million gallon domestic booster pump (booster station 1). Water mains are designed to provide 1,170 gallons per minute at the fire hydrants with a residual pressure of 20 psi (LANL 1996n). Fire-fighting equipment can arrive at TWISP operations in 8 to 12 minutes. The initial response is two pumpers capable of dispensing 1,250 gallons per minute with a 500-gallon onboard storage capacity each, one light rescue vehicle, and one staff vehicle. An additional pumper is available on the second alarm (LANL 1996n).

In addition to fire-fighting response, LANL ESH-10 maintains a HAZMAT team at TA–64. The HAZMAT team would respond to an accident such as an aircraft crash at TA–54 Area G.

The TA–54 Area G SAR did not evaluate aircraft crash accidents. Aircraft crash at a TRU waste dome was identified in the TA–54 Area G Hazard Analysis with a frequency assigned as below 1 x 10^{-6} per year based on expert judgment (LANL 1995g).

A separate LANL study evaluated aircraft crash frequency at TA–54 by calculating the crash frequency for the largest building at the site, which is one of the TWISP fabric domes at 320 feet (98 meters) long, 246 feet (75 meters) wide, and 38 feet (12 meters) high. The study calculated the aircraft crash at 1.02 x 10^{-8} per year (LANL 1996c).

No Action Alternative Frequency Analysis

The air space above LANL is restricted up to 14,000 feet, designated as Restricted Airspace R-5101 (LANL 1996c). However, DOE Standard 3014-96 states that once an in-flight mishap does occur, with eventual loss of control, there is nothing to prevent a disabled aircraft from crashing into any location, even within a restricted airspace area (DOE 1996c).

The TRU waste storage domes at TA–54 Area G were reviewed. As a result of their locations, TA–54–153 and TA–54–283 are essentially a single target (they are separated by less than 100 feet [31 meters]); TA–54–283 is a temporary structure.

TA–54–224 represents another target (separated from TA–54–283 and TA–54–153 by over 100 feet (31 meters). TA–54–48 is still another stand-alone target, being more than 100 feet (31 meters) from the TA–54–229 through

TA–54–232 group of domes. TA–54–229 through TA–54–232 represent a single target as they are adjacent to one another separated by less than 50 feet (15 meters) between the domes.

The TWISP retrieval dome, as well as the two temporary domes used to house TWISP waste after retrieval but before repackaging (TA–54–224 and TA–54–283), are all temporary structures. The only permanent structures will be the two existing domes used to store TRU waste from ongoing operations (TA–54–48 and TA–54–153), as well as the four TWISP storage domes (TA–54–229 through TA–54–232). Because TA–54–283 is a temporary structure, essentially there are two single dome targets (TA–54–48 and TA–54–153) and the four-dome target (TA–54–229 through TA–54–232). The single dome targets will represent a small fraction of the total effective aircraft target area for TA–54. Accordingly, aircraft crash analytical efforts were focused on the four-dome TWISP storage dome target.

Based on the TWISP SAR, the four TWISP domes were analyzed as one target with dimensions of 414 feet (126 meters) long, 286 feet (87 meters) wide, and 38 feet (12 meters) high. Skid distance is limited due to the Finger Mesa location, but has been established at 50 feet (15 meters) for conservatism. Based on physical inspection, this is reasonable for all directions except north, for which a longer skid distance can be justified. Considering the configuration of the mesa, a 50-foot (15 meter) skid distance is judged to adequately represent the site.

The estimated perforation/fire frequency for the TWISP domes is 4.3×10^{-6} per year. The crash frequency is dominated by single-engine piston aircraft, multiple-engine piston aircraft, and small military aircraft (the air taxi frequency contribution is conservatively binned with small military in this case), representing 98.2 percent of the total perforation/fire frequency.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

Aircraft crash rates in the vicinity of LANL are not significantly associated with the level of activity at LANL. Accordingly, the frequency of aircraft crash does not vary by alternative.

Uncertainties and Sensitivities Affecting the Frequency of RAD–08

There is a large amount of data required to perform the DOE Standard 3014-96 calculations. In addition, the standard itself requires the use of numerous equations that are recognized to be approximations. Perhaps the most important uncertainty is the assumption (embedded in the standard) that a skidding aircraft will impact a facility with the same velocity it had when it began the skid. This results in a conservative impact velocity because no credit is taken for drag, friction, impact with objects between the impact point and the facility, and so on.

Another conservatism for the TA–54 Area G analysis is the assumption of a 38-foot (12-meter) height for the target. This is the actual height of the membrane domes, but these structures would not offer much resistance to aircraft. Aircraft could in principle strike the dome itself and pass through without impacting the TRU waste stored inside (at least this would be possible with aircraft approaching from the east or west).

As a sensitivity calculation, the height was lowered to 12 feet (4 meters), representing two drum heights. The resulting frequency of perforation/fire crashes was 2.8×10^{-6} per year. The overall reduction in impact frequency for modeling the domes as 12 feet (4 meters) high instead of 38 feet (12 meters) high is less than a factor of two. It is concluded that the impact frequency results are not strongly sensitive to this parameter.

Source Term Calculations

Fires were evaluated for their source term contribution. Three aircraft types account for about 98.2 percent of the total aircraft crash frequency at the TWISP storage domes: (1) single-engine piston aircraft; (2) multiple-engine piston aircraft; and (3) small military aircraft. In order to evaluate the fire and explosion potential of these aircraft, the characteristics of the aircraft in these classes as identified in the supporting documentation for DOE Standard 3014-96 were used to select the bounding fuel load (LLNL 1996). The aircraft selected for these classes are: (1) the Piper Turbo line, with a fuel load of 128 gallons (486 liters), for the single-engine piston aircraft; (2) the Cessna Titan line, with a fuel load of 413 gallons (1,564 liters), for the multiple-engine piston aircraft; and (3) the F-16C, with a fuel load of 1,801 gallons (6,819 liters) for the small military aircraft (LLNL 1996). (The F-16 is typical of local military operations out of Kirtland Air Force Base in Albuquerque, for example.)

In order to quantify the burn area resulting from a spill of aircraft fuel and its subsequent combustion, guidance from the Rocky Flats Risk Assessment Guide was followed that provides an estimate of a 250 square-foot (23 square-meter) burn area per 50 gallons (189 liters) of fuel burned (RFETS 1994). Burn areas were calculated as follows for the three significant classes of aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

where:

A_{BURN} = Burn area in square feet

F_{LOAD} = Aircraft fuel load in gallons

The estimated burn area for each of the three significant aircraft types can now be calculated:

Single-Engine Piston Aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = (128/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = 640 \text{ ft}^2$$

Multiple-Engine Piston Aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = (413/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = 2{,}065 \text{ ft}^2$$

Small Military Aircraft:

$$A_{BURN} = (F_{LOAD}/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = (1801/50) \times 250 \text{ ft}^2$$

$$A_{BURN} = 9{,}005 \text{ ft}^2$$

The area of one of the TWISP storage domes is 16,000 square feet (1,486 square meters). The burn areas identified above represent the following percentages of a single storage dome:

- Single-Engine Piston Aircraft = 4.0 percent
- Multiple-Engine Piston Aircraft = 12.9 percent
- Small Military Aircraft = 56.3 percent

As discussed above, each of the four TWISP storage domes is assumed to contain 4,041 PE-Ci of plutonium-239 as combustible TRU waste and 7,854 PE-Ci of noncombustible TRU waste. The source term contribution will be assumed to be "smeared" evenly across the floor area of the dome (16,000 square feet [1,486 square meters]); calculations will have to be performed separately for combustible and noncombustible fractions because the ARF and RF values are very different.

The DOE Handbook 3010-94 initial source term equation is used, and must be quantified separately for each type of aircraft contributing significantly to the crash frequency due to the difference in the impacted area of the facility; it is also quantified separately for combustible and noncombustible waste forms. Due to the random nature of aircraft crashes, no specific directionality is associated with the crashes. The damage ratio will be expressed as the percentage of the facility floor area burned in a fire (which will be assumed to equate to the fraction of the inventory affected by fire).

It is recognized that some crashes could result in a fire without affecting MAR; whereas, other crashes could burn a quantity of waste that is in excess of the fraction the floor area affected by the burn. However, the approach adopted above is believed to yield a reasonable result that is considered to be representative of the average that would result from a large number of crashes.

The ARF and RF values are selected from DOE Handbook 3010-94 and are based on the bounding values for packaged mixed waste. The recommended ARF and RF values for combustible waste are 0.0005 and 1.0 (DOE 1994d). The recommended ARF and RF values for noncombustible waste are 0.006 and 0.01 (DOE 1994d). The LPF is taken to be 1 because the TRU waste fabric domes do not represent a confinement structure and because the fabric membranes are assumed to be penetrated by aircraft or aircraft missiles, or breached due to extreme fire conditions.

The general initial source term equation is quantified below for the three aircraft types that contribute to the crash frequency:

Single-Engine Piston Aircraft:

Initial Combustible Source Term = MAR x DR x ARF x RF x LPF

= 4,041 x 0.04 x 0.0005 x 1 x 1

= 0.08E-Ci

Initial Noncombustible Source Term = MAR x DR x ARF x RF x LPF

= 7,854 x 0.04 x 0.006 x 0.01 x 1

= 0.02 PE-Ci

Total Initial Source Term = 0.08 + 0.02 = 0.10 PE-Ci

Multiple-Engine Piston Aircraft:

Initial Combustible Source Term = MAR x DR x ARF x RF x LPF

= 4,041 x 0.129 x 0.0005 x 1 x 1

= 0.26 PE-Ci

Initial Noncombustible Source Term = MAR x DR x ARF x RF x LPF

= 7,854 x 0.129 x 0.006 x 0.01 x 1

= 0.06 PE-Ci

Total Initial Source Term = 0.26 + 0.06 = 0.32 PE-Ci

Small Military Aircraft:

Initial Combustible Source Term = MAR x DR x ARF x RF x LPF

= 4,041 x 0.563 x 0.0005 x 1 x 1

= 1.14 PE-Ci

Initial Noncombustible Source Term = MAR x DR x ARF x RF x LPF

= 7,854 x 0.563 x 0.006 x 0.01 x 1

= 0.27 PE-Ci

Total Initial Source Term = 1.14 + 0.27 = 1.41 PE-Ci

Following the initial source term release, resuspension releases are possible due to dispersal of material by the wind. For an aircraft crash, a 24-hour suspension release is considered to be reasonable due to the significant damage resulting from the aircraft crash and subsequent explosion and fire. The general suspension source term equation is used to calculate the suspension source term. The DR is defined in the same manner as with the initial source term. The ARF and RF values are selected from DOE Handbook 3010-94 and are based on the bounding values for packaged mixed waste. The recommended ARR and RF values are 4 x 10^{-5} per hour and 1.0 (DOE 1994d). Due to the penetration of the building by the aircraft-related missiles and/or due to external or internal explosion of fuel, the LPF is taken to be 1.0. This is assumed to be applicable because it is considered unlikely that a temporary structure would be erected as soon as 24 hours to mitigate releases.

The suspension source term equation also must be quantified individually for each of the three crash frequency contributors (quantification is based on the total PE-Ci content because the ARR and RF values are the same regardless of whether the source MAR is combustible or not):

Single-Engine Piston Aircraft:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= 11,895 x 0.04 x 0.00004 x 24 x 1 x 1

= 0.46 PE-Ci

Multiple-Engine Piston Aircraft:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= 11,895 x 0.129 x 0.00004 x 24 x 1 x 1

= 1.47 PE-Ci

Small Military Aircraft:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= 11,895 x 0.563 x 0.00004 x 24 x 1 x 1

= 6.43 PE-Ci

In order to specify a single source term for the TA–54 Area G aircraft crash accident, the initial source terms and suspension source terms are frequency-weighted below according to their contributions to the overall risk, as shown in Tables G.5.6.8–2 and G.5.6.8–3.

TABLE G.5.6.8–2.—*Frequency Weighted Source Term Calculation for Initial Source Term*

AIRCRAFT TYPE	PERCENTAGE CONTRIBUTION TO AIRCRAFT CRASH FREQUENCY	INITIAL SOURCE TERM (PLUTONIUM-239 PE-Ci)	WEIGHTED INITIAL SOURCE TERM (PLUTONIUM-239 PE-Ci)
Single-Engine Piston	0.884	0.10	0.088
Multiple-Engine Piston	0.060	0.32	0.019
Small Military	0.037	1.41	0.052
TOTAL	0.981		0.16

TABLE G.5.6.8–3.—*Frequency Weighted Source Term Calculation for Suspension Source Term*

AIRCRAFT TYPE	PERCENTAGE CONTRIBUTION TO AIRCRAFT CRASH FREQUENCY	SUSPENSION SOURCE TERM (PLUTONIUM-239 PE-Ci)	WEIGHTED SUSPENSION SOURCE TERM (PLUTONIUM-239 PE-Ci)
Single-Engine Piston	0.884	0.46	0.41
Multiple-Engine Piston	0.060	1.47	0.09
Small Military	0.037	6.43	0.24
TOTAL	0.981		0.74

Based on these calculations the source term for RAD–08 for the No Action Alternative will be represented with an initial source term of 0.16 PE-Ci released in 30 minutes, and a suspension source term of 0.74 PE-Ci released over 24 hours. There are no differences in source term across the alternatives (because the No Action Alternative source terms are based on the average maximum quantity of TRU waste in the four TWISP storage domes). The TWISP source term is identical across the alternatives.

Uncertainties and Sensitivities Affecting the Source Term for RAD–08

The source terms (initial and suspension) are the average maximum values expected for the TWISP storage domes once they are fully loaded. Of course, it is possible that an aircraft crash would occur in a dome that is not fully loaded (or even empty, depending on timing). Clearly, the values calculated above are bounding, assuming the average maximum quantities are correct.

The number of TWISP storage domes occupied with TRU waste will depend on the processing rate during TWISP recovery and repackaging and also on the WIPP shipment rate. Neither of these rates is known with precision, particularly the latter. Thus, a bounding calculation was performed.

The suspension source term calculation extends for 24 hours. This may be very conservative in that it is likely that fire fighting and HAZMAT response to the crash scene would be accompanied by extensive use of water and foam-based suppression systems. This application of suppressants would likely continue for some time to preclude flareup of the fire once it is extinguished, as well as to limit further spread of plutonium contamination.

Consequences of RAD–08 for Facility Workers and the Public

The consequences of RAD–08 for facility workers and the public are discussed separately. Typically, only a small number of facility workers would be expected to be present at the TWISP domes, and would be at risk for possible exposure to airborne radioactive material as well as exposure to the dynamics of the aircraft crash. An aircraft crash into the dome that destroys part of the facility is assumed to result in the death of all workers in the part that is destroyed. Workers elsewhere in the structure may be injured or killed due to flying debris or secondary effects from the fire (e.g., smoke inhalation). Workers in the dome who are not directly affected by the crash and explosion or fire may be exposed to radiation as a result of plutonium inhalation. If the dome collapses as a result of the impact of the aircraft (which is to be expected), additional injuries or fatalities could result.

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 400 person-rem (TEDE), resulting in 0.2 excess LCFs. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.8–5 and G.5.6.8–6, respectively. Table G.5.6.8–4 summarizes the modeling results for RAD–08.

G.5.6.9 *RAD–09, Plutonium Release from TRU Waste Drum Failure or Puncture*

General Scenario Description

A contact-handled TRU waste drum failure/ puncture is postulated to occur during drum handling operations (all subsequent discussions refer to the waste as TRU waste). Either a complete or a partial drum spill may occur. A complete spill of drum contents is more likely to occur during retrieval of TRU waste from Pads 1, 2, and 4 at TA–54, Area G (considering the potential for degraded drums and the number of drums to be retrieved, 16,641). A partial spill of drum contents would result from drum puncture accidents or from the majority of drop related accidents. This scenario assumes a complete spill occurs to represent failure of a degraded drum and to conservatively bound an individual or multiple drum puncture accident. A large majority of drum handling operations occur outdoors or within structures that do not have HEPA filtration. Consequently, the accident scenario postulates that the incident occurs outdoors. The drum failure/puncture scenario could occur at multiple facilities at TA–3, TA–16, TA–50, TA–54, or TA–55. The accident is postulated to occur at TA–54, Area G because the large majority of TRU waste drum handlings occur there.

Drum handling operations are primarily conducted with forklifts/lift trucks. Exceptions include the use of drum dollies for movements within facilities or dock areas, drum lift fixtures for glovebox entry/egress, manual methods (such as individual drum retrieval activities at Pads 1, 2, and 4), and crane/hoist activities (such as WCRR Facility enclosure movements or RANT transportation bay loading activities). Drum handling may be conducted on an individual drum basis, on a palletized basis (four drums banded together), or on a 7-pack basis (seven drums banded together by metal banding or plastic stretch wrap for shipment to WIPP in a TRUPACT-II container). Drum drop tests at Hanford (WHC 1995) have demonstrated that dropping a pallet of four banded drums results in damage to a single drum. Consequently, the MAR (one drum) for this postulated accident scenario would be representative of an accident involving the handling of multiple drums.

Because waste management activities involve the movement of a large number of TRU waste containers, with the large majority having a low radioactive material content, risks associated with a drum failure/puncture will be evaluated for both an average and a high radioactive content drum.

Note that this accident scenario does not include TRU waste drum handling operations associated with possible retrieval of buried TRU waste located on Pads 9 and 29 and in Trenches A, B, C, and D. Possible retrieval of this waste was mentioned briefly as being conducted during the 10-year period covered by the SWEIS in the draft November 1996 Waste Management Strategies document issued by LANL (LANL 1996o), but insufficient specific information was available upon which to base a quantification of possible impacts.

A similar accident scenario is analyzed in the Safety Analysis Report for TA–54, Area G (LANL 1995f), with the exception that it assumes that intact drums are involved in the accident. The postulated accident scenario evaluated for the SWEIS is intended to cover potential accidents involving retrieval of degraded drums from earthen-covered storage

TABLE G.5.6.8–4.—*Summary of Results for Scenario RAD–08*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	4.3×10^{-6}	Initial source term of 0.16 PE-Ci released in 30 minutes; suspension source term of 0.74 PE-Ci, released over 24 hours; integrated population exposure of 400 person-rem, 0.2 excess LCFs.
Expanded Operations	4.3×10^{-6}	Same as No Action Alternative.
Reduced Operations	4.3×10^{-6}	Same as No Action Alternative.
Greener	4.3×10^{-6}	Same as No Action Alternative.

TABLE G.5.6.8–5.—*Predicted Mean Doses to MEIs for Scenario RAD–08*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	**DOSE**
Closest public access from TA–54–229: Pajarito Road (210 m)[a]	2.2×10^{1}
Closest site boundary from Pads 1, 2 and 3 White Rock (245 m) (see note) (TWISP SAR; TA–54 Area G SAR)	2.2×10^{1}
Special population distance from TA–54–229: San Ildefonso boundary (500 m)	7.2×10^{0}
Closest White Rock residence from TA–54–229 (1,500 m)	1.1×10^{0}
Closest population center from Pads 1, 2 and 3: White Rock (1,680 m) (TWISP SAR; TA–54 Area G SAR)	9.6×10^{-1}
Special population distance from TA–54–229: Piñon Elementary School/Park (2100 m)	6.6×10^{-1}
Special population distance from TA–54–229: San Ildefonso Pueblo (14,300 m)	2.5×10^{-2}

[a] Estimated using radial distance of 230 m.

TABLE G.5.6.8–6.—*Predicted Mean Ground Contamination Levels for Scenario RAD–08*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	3.9×10^4
1.0 to 2.0 km	5.1×10^3
2.0 to 3.0 km	2.1×10^3
3.0 to 4.0 km	1.2×10^3
4.0 to 8.0 km	4.8×10^2
8.0 to 12.0 km	1.9×10^2
12.0 to 20.0 km	6.6×10^1
20.0 to 30.0 km	2.8×10^1
30.0 to 40.0 km	1.5×10^1
40.0 to 60.0 km	7.2×10^0
60.0 to 80.0 km	3.5×10^0

BQ/m^2 = Becquerel per square meter

at Pads 1, 2, and 4. The SAR accident scenario results from forklift handling of a waste container. The accident frequency in the SAR is based on 5,000 waste container handling events per year at Area G, a waste handling accident frequency of 1×10^{-5} per container handling event, and a conditional probability of 1×10^{-2} of involving a maximum drum (1,000 PE-Ci). (The WIPP WAC previously allowed up to 1,000 PE-Ci per waste container.)

Selected parameter values that were used for this source term analysis were: (1) MAR—bounding value of 1,000 PE-Ci (previous WIPP WAC limit); (2) damage ratio—0.1, based on engineering judgement and cited drum drop test results for DOT Type A containers; (3) airborne release fraction—0.0001, bounding value for solid contaminated material from an early draft of DOE Handbook 3010-94; (4) respirable fraction—0.05, based on a draft of DOE Handbook 3010-94; and (5) leakpath factor—1.0 (bounding).

The Final Safety Analysis Report (FSAR) for the Retrieval for Transuranic Waste from Pads 1, 2, and 4 at TA–54, Area G evaluates a degraded TRU waste container failure during retrieval (LANL 1996n) in support of the TWISP. While all waste containers are examined for signs of degradation and are stabilized as necessary before retrieval, it is assumed that the bottom of a degraded waste drum could fail. The FSAR retrieval accident scenario frequency is based on 20,000 waste handling events per year, a waste handling accident frequency of 1×10^{-5} per container handling event, and a conditional probability of 1×10^{-2} of involving a drum with greater than 100 PE-Ci. For this analysis the source term was based on: (1) the current maximum TRU waste container of 658 PE-Ci (LANL 1996n); (2) a damage ratio of 0.5, based on engineering judgement for a degraded drum and cited drum drop tests; (3) an airborne release fraction of 0.001; (4) a respirable fraction of 0.1; and (5) a leakpath factor of 1.0.

The SAR for the WCRR Facility analyzes a postulated waste drum puncture accident in the outdoor staging area (LANL 1995e). It is assumed that a forklift tine punctures a waste drum being loaded on or off the bed of a truck. Because a drum grapple will be used to handle drums at all times when the drums are not palletized, the SAR concludes a scenario of this type is not credible for other drum handling operations. The SAR puncture accident scenario frequency is based on 200 movements of palletized drums per year and a waste handling accident frequency of 1×10^{-5} per container handling event. The source term was based on: (1) the proposed WCRR Facility limits for plutonium mixes or individual radionuclides (DOE Standard 1027-92 Hazard Category 3 threshold limits, WIPP WAC fissile gram equivalent limit of 325 grams), (2) a damage ratio of 0.05 (puncture of a nondegraded drum), (3) an airborne release fraction of 0.001, (4) a respirable fraction of 0.05, and (5) a leakpath factor of 1.0.

The SAR for the Radioactive Materials Research, Operations, and Demonstration Facility evaluates a postulated accident involving a forklift dropping a single TRU waste container (outside) from greater than four feet (which is the qualification limit for DOT Type A containers) (LANL 1996i). The SAR drum drop accident scenario frequency is based on 5,000 waste movements per year, a waste handling accident frequency of 1 x 10^{-5} per movement, and a conditional probability of 1 x 10^{-1} of involving a maximally loaded drum (1,000 PE-Ci). The source term was based on: (1) the previous WIPP WAC container limit of 1,000 PE-Ci, (2) a damage ratio of 0.1 (drop of a nondegraded drum), (3) an airborne release fraction of 0.001, (4) a respirable fraction of 0.05, and (5) a leakpath factor of 1.0.

The SA for the NDA/NDE Facility analyzes a design basis accident involving the puncture of a TRU waste drum by a forklift tine (LANL 1996j). A supplemental analysis is presented in the SA appendix for a smaller breach due to a drum grappler accident. The postulated accident frequency is based on a throughput of 5,000 drums per year (interim operation limit) and a forklift tine or grappler puncture conditional frequency of 1 x 10^{-5} or 1 x 10^{-6} per movement, respectively. The source term was based on the maximum radionuclide inventory for a drum (200 grams of plutonium-239, or 40 grams of plutonium-238, or 19 grams of americium-241).

No Action Alternative Frequency Analysis

Legacy waste (current dome storage) requiring characterization is estimated to involve six forklift handling operations: (1) loading onto a truck for transfer to an on-site location for assay verification, (2) unloading of the transfer truck for assay verification, (3) waste drum loading onto a transfer truck for movement to interim storage (Area G), (4) unloading of the transfer truck for interim storage, (5) waste drum movement to a staging area for shipment to WIPP, and (6) waste drum movement for loading a TRUPACT-II for shipment to WIPP.

Legacy waste (earthen-covered storage) requiring characterization/treatment is estimated to involve seven forklift handling operations: (1) retrieval of drum to laydown area, (2) drum movement for gas venting, (3) loading onto a truck for transfer to an on-site treatment location (such as the drum preparation facility), (4) unloading of the transfer truck for waste treatment, (5) waste drum movement for final NDA/NDE, (6) waste drum loading and unloading for interim storage (dome), and (7) waste drum loading and unloading of a transfer truck and subsequent movement for loading a TRUPACT-II for shipment to WIPP.

Legacy waste (earthen-covered storage) requiring overpacking/repackaging is estimated to require the same number of forklift handling operations as legacy waste that requires characterization.

The pre-decisional draft of the SWEIS Alternatives Document, Waste Management Key Facility (LANL 1997c), indicates that the newly generated waste volume for the No Action Alternative over the ten-year SWEIS time frame will total an estimated 6.61 x 10^{5} gallons (2,500 cubic meters). This is equivalent to 12,018, 55-gallon drums. The entire legacy waste (dome and earthen covered) volume of approximately 2.38 x 10^{6} gallons (9,000 cubic meters) is assumed shipped to WIPP during the SWEIS period. The legacy waste volume is equivalent to 43,273, 55-gallon drums, of which 21,136, 55-gallon drums (4,400 cubic meters) are in earthen covered storage (LANL 1997c).

It is estimated that there will be approximately 8,413 (12,018 x 7/10) waste drum handlings per year for newly generated TRU waste. Similarly, for dome legacy waste, it is estimated that there will be approximately 11,069 ([43,273 - 21,136] x 5/10) waste drum handlings per year. Earthen-covered legacy waste movements are estimated to total 21,137 (21,137 x 10/10) per year. Thus, the No Action Alternative is estimated to total 40,619 TRU waste handling (forklift) events per year. This is consistent with the 30,000-plus waste handling events identified in the cited LANL safety documentation.

Based on DOE system operating experience, the waste handling accident frequency is estimated as 1 x 10^{-5} per container handling event. This conditional accident frequency is cited in multiple LANL safety documents, including the TA–54 TWISP FSAR (LANL 1996n), the TA–54 Area G SAR (LANL 1995f), and the WCRR Facility FSAR (LANL 1995e). Additionally, the TA–54 Area G SAR indicates that less than 1 percent of all TRU waste containers in the existing Area G inventory exceed 75 PE-Ci in radioactive material content (LANL 1995f). Thus, it can be concluded that the conditional probability of a handling accident involving a high radioactive content drum is less than 1 percent. With the foregoing information, the frequency of a drum failure/ puncture due to a forklift accident can be calculated as:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

where:

$N_{FEVENTS}$ = Number of forklift handling events per year

C_{PFACC} = Conditional probability of a forklift accident resulting in a container failure

$C_{PHI/AVG}$ = Conditional probability of accident involving an average or high radioactive content container

Substituting the above values, the annual frequency for a drum failure/puncture at LANL is:

High Radioactive Content Container:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

$$F_{FAILURE} = 40{,}619 \times (1 \times 10^{-5}) \times 0.01$$

$$F_{FAILURE} = 0.0041 \text{ per year}$$

Average Radioactive Content Container:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

$$F_{FAILURE} = 40{,}619 \times (1 \times 10^{-5}) \times 0.99$$

$$F_{FAILURE} = 0.4 \text{ per year}$$

Expanded Operations Alternative Frequency Analysis

The pre-decisional draft of the SWEIS Alternatives Document, Waste Management Key Facility (LANL 1997c), indicates that Expanded Operations Alternative waste management practices and the mixed LLW waste generation rate will be comparable to the No Action Alternative. However, newly generated TRU waste volumes are expected to double to 1.35 x 10^{6} gallons (5,100 cubic meters) from those in the No Action Alternative. This is equivalent to 24,545, 55-gallon drums.

It is estimated that there will be approximately 17,182 (24,545 x 7/10) waste drum handlings per year for newly generated TRU waste. TRU waste drum handlings for legacy TRU waste will be the same as the No Action Alternative because waste management practices will be the same for both alternatives. Thus, the Expanded Operations Alternative is projected to total 49,388 (17,182 + 11,069 + 21,137) TRU waste handling (forklift) events per year.

With a revised number of TRU waste handling events for the Expanded Operations Alternative, the frequency ($F_{FAILURE}$) of a postulated drum failure/puncture can be estimated as:

High Radioactive Content Container:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

$$F_{FAILURE} = 49{,}388 \times (1 \times 10^{-5}) \times 0.01$$

$$F_{FAILURE} = 0.0049 \text{ per year}$$

Average Radioactive Content Container:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

$$F_{FAILURE} = 49{,}388 \times (1 \times 10^{-5}) \times 0.99$$

$$F_{FAILURE} = 0.49 \text{ per year}$$

Reduced Operations Alternative Frequency Analysis

The pre-decisional draft of the SWEIS Alternatives Document, Waste Management Key Facility (LANL 1997c), indicates that Reduced Operations Alternative waste management practices and the mixed LLW waste generation rate will be comparable to the No Action Alternative. However, TRU waste volumes are expected to total 5.02×10^5 gallons (1,900 cubic meters), almost 25 percent less than those for the No Action Alternative. This is equivalent to 9,127, 55-gallon drums.

It is estimated that there will be approximately 6,389 (9,127 x 7/10) waste drum handlings per year for newly generated TRU waste. TRU waste drum handlings for legacy TRU waste will be the same as the No Action Alternative because waste management practices will be the same for both alternatives. Thus, the Reduced Operations Alternative is projected to total 38,595 (6,389 + 11,069 + 21,137) TRU waste handling (forklift) events per year.

With a revised number of TRU waste handling events for the Expanded Operations Alternative, the frequency ($F_{FAILURE}$) of a postulated drum failure/puncture can be estimated as:

High Radioactive Content Container:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

$$F_{FAILURE} = 38{,}595 \times (1 \times 10^{-5}) \times 0.01$$

$$F_{FAILURE} = 0.0039 \text{ per year}$$

Average Radioactive Content Container:

$$F_{FAILURE} = N_{FEVENTS} \times C_{PFACC} \times C_{PHI/AVG}$$

$$F_{FAILURE} = 38{,}595 \times (1 \times 10^{-5}) \times 0.99$$

$$F_{FAILURE} = 0.38 \text{ per year}$$

Greener Alternative Frequency Analysis

The pre-decisional draft of the SWEIS Alternatives Document, Waste Management Key Facility (LANL 1997c), indicates that the Greener Alternative waste management practices and waste generation rates for mixed LLW and TRU waste will be comparable to those for the No Action Alternative. On this basis, it is expected that TRU waste handling and the associated frequency of a potential container failure will be the same as in the No Action Alternative.

Uncertainties and Sensitivities Affecting the Frequency of RAD–09

Uncertainties include broad characterization of drum handling events by waste category type, the extent that particular drum movements involve multiple drums (thus reducing the number of drum handlings), and the likelihood that all legacy TRU waste is shipped to WIPP (and the associated handlings at LANL) during the LANL SWEIS time frame. Drum movement characterization assumptions were chosen to provide an upper estimate of the frequency of occurrence for the postulated accident and are reasonably conservative when compared with the number of drum movements identified in LANL safety documentation.

Source Term Calculations

Currently, the average TRU radioactive material content per waste container is 8.9 PE-Ci (LANL 1995f). Revision 5 of the WIPP WAC limits the maximum plutonium-239 equivalent activity for untreated CH-TRU waste to be received by the facility to 80 PE-Ci per drum, if not overpacked. The WIPP WAC previously allowed up to 1,000 PE-Ci per waste container. Based on the existing inventory, the maximum container of TRU waste has 658 PE-Ci of radioactive material (LANL 1996n).

Source Term for High Radioactive Content Container. The source term for a postulated accident involving a high radioactive content TRU container is based on the identified maximum drum of TRU waste (658 PE-Ci) to be managed at LANL. From the above discussion, it is clear that this will provide a bounding source term value. As noted in section 3, the frequency of occurrence calculation accounts for the likelihood (or lack thereof) that the postulated accident would involve a drum with a high radioactive material content. (Note that RAD–07 was a fire involving 62 drums, with their expected PE-Ci content; whereas, this accident involves a single drum of the maximum PE-Ci content.)

A damage ratio of 1.0 is conservatively assumed for the postulated accident to account for a degraded drum failure during retrieval handling activities. The TWISP SAR (LANL 1996n) accounted for the potential of a degraded drum, but interpreted drum drop tests for nondegraded drums on an unyielding surface to justify a somewhat less conservative value for the damage ratio (0.5). Bounding values for the airborne release fraction and respirable release fraction of 0.001 and 0.1, respectively, are assigned and are representative of the situation where surface contaminated material is packaged in a robust container (e.g., drum) that fails due to impact with the floor. The accident is assumed to occur outdoors such that the leakpath factor has a value of 1.0. With the above information, the initial source term equation can be quantified as follows:

Initial Source Term = MAR x DR x ARF x RF x LPF

= 658 PE-Ci x 1.0 x 0.001 x 0.1 x 1.0

= 0.066 PE-Ci

The suspension MAR equals the initial MAR, minus the initial source term (0.066), which for this case effectively equals the initial MAR. The suspension DR and LPF have the same values (1.0) as in the initial source term calculation. The ARR and RF are assigned values of 4×10^{-5} and 1.0, respectively, based on bounding resuspension factors for surface contaminated material exposed to ambient conditions (DOE 1994d). Thus, the suspension source term can be quantified as:

Suspension Source Term = MAR x DR x ARR x 24 hrs x RF x LPF

= 658 PE-Ci x 1.0 x (4×10^{-5}) x 24 hrs x 1.0 x 1.0

= 0.63 PE-Ci

It can be seen that the suspension source term is an order of magnitude greater than the initial source term. The calculated suspension source term is highly conservative considering that DOE Handbook 3010-94 assigns the same suspension value for surface contaminated materials as for powders and the assumption that the spill is not controlled for 24 hours. This is conservative since the HAZMAT team would be expected to clean up the spill much sooner than 24 hours.

Source Term Analysis for Average Radioactive Content Container. The source term for this postulated accident is based on a conservative estimate of the average radioactive content (12 PE-Ci) of a TRU waste container, as noted above. Other initial source term parameters for the high radioactive content container would be applicable and are retained for the analysis of an average radioactive content container. Thus, the initial source term is quantified as:

Initial Source Term = MAR x DR x ARF x RF x LPF

= 12 PE-Ci x 1.0 x 0.001 x 0.1 x 1.0

= 0.0012 PE-Ci

The suspension MAR equals the initial MAR, minus the initial source term (0.0012), which for this case effectively equals the initial MAR. The suspension DR and LPF have the same values (1.0) as in the initial source term calculation. The ARR and RF are assigned values of 4×10^{-5} and 1.0, respectively, based on bounding resuspension factors for surface contaminated material exposed to ambient conditions (DOE 1994d). Thus, the suspension source term can be quantified as:

Suspension Source Term = MAR x DR x ARR x 24 hrs x RF x LPF

= 12 PE-Ci x 1.0 x (4×10^{-5}) x 24 hrs x 1.0 x 1.0

= 0.0115 PE-Ci

As with the high radioactive content container analysis, it can be seen that the suspension source term is an order of magnitude greater than the initial source term and is conservative.

Because the source terms are based on average and maximum content containers, there are no variations across the alternatives.

Uncertainties and Sensitivities for RAD–09

This accident assumes that all of the material in a drum is spilled. This assumption is very conservative because a drum puncture due to a drop or a puncture with a forklift is not likely to spill the entire contents of a TRU waste container. The conservative assumption, however, would bound this instance or the consequences of an event where more than one drum would be punctured. The ARF, ARR, and RF values also bound the type of material that could be involved in the accident. Thus, the accident represents a bound on the variations that could occur with a drum puncture and is still considered conservative.

The suspension term is the dominate contributor to the doses for this event. Because of the nature of the drum puncture event, the cleanup can be easily controlled and evaluated. If cleanup is assumed to take 1-hour as opposed to 24 hours, the suspension terms would then change as shown in Table G.5.6.9–1.

If the results are scaled by the source and suspension terms consistent with a 1-hour cleanup period, the consequences would be as given in Table G.5.6.9–2.

The results for the 24-hour cleanup are very conservative. Because of the limited nature of the accident, the expectation is for cleanup to

TABLE G.5.6.9–1.—*Suspension Terms for RAD–09*

SCENARIO	SUSPENSION TERM 1-HOUR CLEANUP	SUSPENSION TERM 24-HOUR CLEANUP
Average Activity Container	0.00048 PE-Ci	0.012 PE-Ci
High Activity Container	0.026 PE-Ci	0.63 PE-Ci

TABLE G.5.6.9–2.—*Consequences for RAD–09, 1-Hour Cleanup*

SCENARIO	INTEGRATED POPULATION DOSE (PERSON-REM, TEDE)	EXCESS LCFS
Average Activity Container	0.55	2.7×10^{-4}
High Activity Container	30	0.015

begin immediately after the accident and to be completed within 1 hour.

Consequences of RAD–09 for Facility Workers and the Public

The consequences for facility workers and the public are discussed separately. All facility operations personnel receive emergency preparedness training specific to the facility and for procedures applicable to all of LANL. The Emergency Action Plan directs personnel to move as quickly as possible in an upwind direction away from any hazardous situation and to make appropriate notifications to the Emergency Management and Response (EM&R) Group Office as soon as they are safely away from the hazard. Once notified, the EM&R Office assumes all elements of emergency response and coordination.

The postulated accident would result in an immediate release to the surrounding area. The primary hazard would be airborne suspension of respirable radioactive material. The dose to the involved worker would be dependent on the ambient conditions of the accident and how they affect dilution of the radioactive material in the air (e.g., outdoors, wind speed, confined area, indoors or outdoors), the time for the worker to identify a release and to vacate the immediate area, and any impediments (accident related) to the worker's movement away from the release. The number of workers potentially exposed would depend on the location of the accident and the nature of the activity being conducted at the time of the accident (e.g., retrieval versus waste staging versus truck loading/unloading).

No acute fatalities are predicted to result from a postulated accident involving an average or a high radioactive content drum. The mean collective population dose is projected to total 4.4 person-rem (TEDE) for an accident involving an average radioactive content drum, resulting in 0.0022 excess LCF. For a high radioactive content drum, accident impacts are projected to total 230 person-rem (TEDE), resulting in 0.12 excess LCF. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.9–4 and G.5.6.9–5, respectively. Table G.5.6.9–3 summarizes the modeling results for RAD–09.

TABLE G.5.6.9–3.—*Summary Results for Scenario RAD–09*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	0.0041 per year (High Activity)	High Activity Container: Initial source term is 0.066 plutonium-239 PE-Ci, ground-level release; suspension source term is 0.63 plutonium-239 PE-Ci, ground-level release; integrated population exposure of 230 person-rem (TEDE), 0.12 excess LCF.
	0.4 per year (Avg. Activity)	Average Activity Container: Initial source term is 0.0012 plutonium-239 PE-Ci, ground-level release; suspension source term is 0.012 plutonium-239 PE-Ci, ground-level release; integrated population exposure of 4.4 person-rem, 0.0022 excess LCF.
Expanded Operations	0.0049 per year (High Activity) 0.49 per year (Avg. Activity)	Same as No Action Alternative.
Reduced Operations	0.0039 per year (High Activity) 0.38 per year (Avg. Activity)	Same as No Action Alternative.
Greener	0.0041 per year (High Activity) 0.4 per year (Avg. Activity)	Same as No Action Alternative.

TABLE G.5.6.9–4.—*Predicted Mean Doses to MEIs for Scenario RAD–09*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)		
MEI LOCATION	**AVERAGE RAD CONTENT DRUM**	**HIGH RAD CONTENT DRUM**
Closest public access from TA–54–229: Pajarito Road (210 m)[a]	4.1×10^{-1}	2.3×10^{1}
Closest site boundary from Pads 1, 2 and 3: White Rock (245 m)[a] (TWISP SAR; TA–54 Area G SAR)	4.1×10^{-1}	2.3×10^{1}
Special population distance from TA–54–229: San Ildefonso boundary (500 m)	1.1×10^{-1}	6.1×10^{0}
Closest White Rock residence from TA–54–229 (1500 m)	1.6×10^{-2}	8.6×10^{-1}
Closest population center from Pads 1, 2 and 3: White Rock (1,680 m) (TWISP SAR; TA–54 Area G SAR)	1.3×10^{-2}	7.0×10^{-1}
Special population distance from TA–54–229: Piñon Elementary School/Park (2,100 m)	8.4×10^{-3}	4.6×10^{-1}
Special population distance from TA–54–229: San Ildefonso Pueblo (14,300 m)	2.2×10^{-4}	1.2×10^{-2}

[a] Estimated using radial distance of 230 m.

TABLE G.5.6.9–5.—*Predicted Mean Ground Contamination Levels for Scenario RAD–09*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)	
	AVERAGE CONTENT	**HIGH CONTENT**
0.0 to 1.0 km	6.2×10^{2}	3.4×10^{4}
1.0 to 2.0 km	6.1×10^{1}	3.4×10^{3}
2.0 to 3.0 km	2.4×10^{1}	1.3×10^{3}
3.0 to 4.0 km	1.3×10^{1}	6.9×10^{2}
4.0 to 8.0 km	4.7×10^{0}	2.6×10^{2}
8.0 to 12.0 km	1.9×10^{0}	1.0×10^{2}
12.0 to 20.0 km	7.1×10^{-1}	3.9×10^{1}
20.0 to 30.0 km	2.8×10^{-1}	1.6×10^{1}
30.0 to 40.0 km	1.5×10^{-1}	8.3×10^{0}
40.0 to 60.0 km	7.4×10^{-2}	4.1×10^{0}
60.0 to 80.0 km	4.4×10^{-2}	2.4×10^{0}

BQ/m^2 = Becquerel per square meter

G.5.6.10 *RAD–10, Plutonium Release from Degraded Vault Storage Container at TA–55–4*

General Scenario Description

TA–55–4 is the Plutonium Facility at LANL. Among the activities at TA–55–4 is the storage of a large quantity of plutonium in vault rooms in the basement of the building. Accident scenario RAD–10 involves dropping a plutonium container during retrieval from the vault. The container is a degraded container that fails and disperses plutonium into the atmosphere of the vault. If this sequence of events occurs during normal operations with both the HVAC and HEPA systems in operation, the release will be filtered by several stages of HEPA filters, and the release to the environment will be less than 10^{-8} grams. Under the SWEIS screening criteria, this scenario would screen. In order to have a release to the environment, the HEPA filters would have to be failed or the facility would have to lose power, placing the facility into a breathing mode. The breathing mode results in an LPF of 0.011 (LANL 1996k), while the LPF with the HEPA filters failed and the HVAC system in operation is assumed to be 1.0 (LANL 1996k). The LPF under normal conditions with both HVAC and HEPA filters in operation is 8×10^{-13} for a multi-stage HEPA filter system (LANL 1996k).

As a result of implementation of the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 94-01 by DOE, LANL will be retrieving from storage, stabilizing, and repackaging a large amount of plutonium (DNFSB 1994). LANL began its program with 8,670 containers of plutonium, and had completed about 17 percent of the program as of early 1996. There are approximately 7,200 remaining containers to be retrieved and repackaged by the year 2002. This represents a rate of about 1,200 per year over the 6-year period from 1996 to 2002.

LANL has already completed a 100 percent visual inventory inspection of the packages so far retrieved, and found 361 containers with some defect. Of these, 82 appeared to have lost outer containment.

LANL has approached the degraded container issue from a systems reliability standpoint. There is a total of 7,200 plutonium containers remaining in the vault. Of these, 5.5 percent are projected to have a failed outer container (i.e., a total of 396). Of these, an estimated 2 percent also have failed inner containers (i.e., a total of 8) (LANL 1996p). DOE Standard 3013-96 (DOE 1996e) addresses the requirements for containers for long-term (at least 50 years) storage of plutonium. To meet the standard, plutonium-bearing materials must be in stable forms and packaged in containers designed to maintain their integrity under both normal storage conditions and anticipated handling accidents for at least 50 years (DOE 1996e). The standard applies to metal, oxide, and alloys containing at least 50 percent plutonium by mass, and containing less than 3 percent plutonium-238 by mass (DOE 1996e). The quantity of metal per container should be as close as practical to, but not exceed, 9.68 pounds (4.40 kilograms). Stored metal pieces are required to have thicknesses greater than 0.04 inch (1.0 millimeter) and have specific surface areas less than 71 square inches per pound (1.0 square centimeters per gram) to reduce potential pyrophoric tendencies (DOE 1996e). The quantity of oxide by container should be as close as practical to, but not exceed, 10.97 pounds (5.00 kilograms), representing the plutonium dioxide equivalent of 9.68 pounds (4.40 kilograms) of plutonium metal. The oxides are required to be thermally stabilized with less than 0.5 percent mass loss-on-ignition (DOE 1996e). The containers are required to include a minimum of two nested sealed containers and have at least one container that remains leak-tight after a free drop from a

30-foot (9-meter) height into a flat, essentially unyielding, horizontal surface (DOE 1996e). The containers are required to have a cylindrical geometry not exceeding 4.9 inches (12.5 centimeters) outside diameter or 10 inches (25.4 centimeters) external height (DOE 1996e). Once the plutonium is repackaged in DOE Standard 3013-96-compliant containers, the likelihood of RAD–10 will be significantly reduced.

The TA–55 SAR (LANL 1996k) analyzes this scenario in detail. The SAR places the unmitigated scenario (i.e., with HVAC operating and HEPA filters failed) into the frequency bin from 10^{-4} to 10^{-2} per year. The SAR quantified the source term as follows (LANL 1996k):

Initial Source Term
= MAR x DR x ARF x RF x LPF

= 4,500 x 1 x 0.002 x 0.3 x 1

= 2.7 grams of plutonium

The SAR evaluated the dose to the off-site MEI, located at the Royal Crest Trailer Court, 2,952 feet (900 meters) from TA–55–4, using 95th percentile meteorology. The calculated exposure was 8.1 rem TEDE (LANL 1996k).

No Action Alternative Frequency Analysis

There are two types of containers for which analyses must be made. Most containers in the vault are closed such that some pre-existing failure would be necessary in order to get a release from dropping the container. This applies to 7,200 total containers, less those that do not meet this criterion (1,370), or a total of 5,830 containers. The frequency of this scenario can be evaluated using the following equation:

$$F_{DROP} = N_{CONT} \times H_{DROP} \times C_{INNER} \times C_{OUTER} \times C_{HEPA} \times H_{HVAC}$$

where:

F_{DROP} = Frequency of dropped container resulting in unfiltered release of plutonium

N_{CONT} = Number of containers handled per year

H_{DROP} = Human error probability (HEP), dropping a container

C_{INNER} = Conditional probability of a degraded inner container

C_{OUTER} = Conditional probability of a degraded outer container

C_{HEPA} = Conditional probability of HEPA failure

H_{HVAC} = Human error probability, failure to terminate HVAC system with HEPA filters failed and stack monitor alarming

The number of containers handled per year, based on the DNFSB 94-1 program being completed in the year 2002, is 1,200 containers per year. Of these, 5,830 have seals that would require a pre-existing failure, or a rate of 972 per year. It is assumed that containers are handled only once before being placed into DOE Standard 3013-96 containers.

The HEP in dropping a plutonium container is estimated at 0.001 per demand. This value is applicable to a checker failing to check the status of equipment if the status of the equipment affects one's safety when performing the task (Swain and Guttmann 1983). This error rate is judged to most closely represent the circumstances involved in retrieving a container of plutonium from the vault at TA–55–4.

The conditional probabilities of failed outer and inner containers are estimated at 0.055 and 0.02, respectively, based on LANL-specific data (LANL 1996p). The conditional probability of the HEPA system being failed is evaluated based on LANL-specific data from 1990 to1994 (LANL 1990b, LANL 1991b, LANL 1994c, LANL 1994d, and LANL 1995h), and considered a two-stage HEPA filter system (LANL 1996k). The 1990 to 1994 data indicate a 5 percent failure rate for HEPA filters. However, there is differential pressure measuring instrumentation installed between the HEPA filters in series, which alarms when it detects failure of a filter. In order for HEPA filters in series to fail, both the HEPA filters and the differential pressure instrumentation indicating failure of filters must fail. Considering two filters in series, this yields a HEPA failure rate of 0.05 x 0.05, or 2.5×10^{-3} for the HEPA filters, and an additional conditional probability of 5×10^{-3} for failure of a single instrument channel covered by a preventive maintenance program and related administrative procedures (Mahn et al. 1995). Thus, the overall HEPA filter failure probability is $(2.5 \times 10^{-3}) \times (5 \times 10^{-3})$, or 1.3×10^{-5} per demand.

H_{HVAC} is a proceduralized action. The Human Reliability Handbook identifies a basic HEP for these circumstances of 0.025 per demand (Swain and Guttmann 1983). A shift supervisory function also would be staffed and would be expected to respond if the operator does not. The HEP for this function is 0.1 (Swain and Guttmann 1983). The total HEP for H_{HVAC} is 0.025 x 0.1, or 2.5×10^{-3} per demand.

Based on these considerations, the above equation can be quantified as follows:

$$F_{DROP} = N_{CONT} \times H_{DROP} \times C_{INNER} \times C_{OUTER} \times C_{HEPA} \times H_{HVAC}$$

$$= 972 \times 0.001 \times 0.055 \times 0.02 \times (1.3 \times 10^{-5}) \times (2.5 \times 10^{-3})$$

$$= 3.5 \times 10^{-11} \text{ per year}$$

The frequency of such a scenario affecting only facility workers is much higher because the C_{HEPA} and H_{HVAC} terms disappear from the frequency equation (it is not necessary to have HEPA or HVAC failures to affect workers inside the facility). Quantified for workers, the frequency becomes 1.1×10^{-3} per year.

The remaining 1,370 containers are food pack cans, dressing jars, or other similar containers. These containers were used to pack plutonium metal (LANL 1996k). In addition, these containers lack a hermetic seal, which can lead to oxidation of the metal and failure of the inner containers. Corrosion of the metal by organic compounds caused by alpha-particle-induced decomposition of the plastic also can occur. Finally, degradation of taped seals on containers and plastic bags around the inner containers makes the containers susceptible to rupture during handling or if dropped (LANL 1996k). For these reasons, the conditional probability of a degraded container is taken as 1.0.

The following equation applies:

$$F_{DROP} = N_{CONT} \times H_{DROP} \times C_{HEPA} \times H_{HVAC}$$

where:

F_{DROP} = Frequency of dropped container resulting in release of plutonium

N_{CONT} = Number of containers handled per year

H_{DROP} = Human error probability, dropping a container

C_{HEPA} = Conditional probability of HEPA failure

H_{HVAC} = Human error probability, failure to terminate HVAC system with HEPA filters failed and stack monitor alarming

The number of containers is 1,370, divided by the 6-year period of the 94-1 program, or a rate of 228 per year.

Based on the information presented above, the equation can be quantified as follows:

$F_{DROP} = N_{CONT} \times H_{DROP} \times C_{HEPA} \times H_{HVAC}$

$= 228 \times 0.001 \times (1.3 \times 10^{-5}) \times (2.5 \times 10^{-3})$

$= 7.5 \times 10^{-9}$ per year

Clearly, these containers dominate the overall frequency. However, the overall frequency is extremely low. Based on detailed frequency quantification, it was determined that the qualitative binning of this sequence into the 10^{-6} to 10^{-4} per year frequency bin in the TA–55 SAR is excessively conservative, and that this scenario screens on low frequency. On a deterministic basis, so many failures and/or human errors are required for a release to the environment to occur from this scenario that the scenario is not credible.

The frequency of such a scenario affecting a worker is different because the C_{HEPA} and H_{HVAC} terms disappear from the frequency equation (it is not necessary to have HEPA or HVAC failures to affect workers inside the facility). Quantified for workers, the frequency becomes 0.228 per year, or about one every 5 years. This would place this scenario into an expected occurrence. The quantification is conservative in that it assumes every time a container is dropped a spill results. This scenario has been included as a strictly worker accident in section G.5.7.5.

Uncertainties and Sensitivities Affecting the Frequency of RAD–10

Regardless of the sensitivities and uncertainties in the frequency of this scenario, the absolute frequency is extremely small and would not result in a credible scenario frequency even if more conservative values were used in quantification. The scenario is screened from further analysis.

Source Term Calculations

Source term calculations followed the general DOE Handbook 3010-94 process, with the ARF and RF selected therefrom (DOE 1994d, page 4-9) and are also those used for this spill. The DR is 1 (the entire contents of the container are spilled), and the LPF = 1 with the HEPA filters failed (this is very conservative). Thus, the source term equation can be quantified as follows:

Initial Source Term = MAR x DR x ARF x RF x LPF

= 4,500 x 1 x 0.002 x 0.3 x 1

= 2.7 grams weapons-grade plutonium

The suspension source term calculation also is performed according to DOE Handbook 3010-94. The ARR and RF values for a powder spill are 0.00004 and 1.0, respectively, for a homogeneous bed of powder exposed to normal process ventilation flow (it is conservative to assume that the ventilation system is not turned off). Quantification is for 24 hours (this is potentially very conservative for a spill inside the facility). The suspension source term equation is quantified as follows:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= (4,500 - 2.7) x 1 x 0.00004 x 24 x 1 x 1

= 4.3 grams of weapons-grade plutonium

There are no differences in source term across the alternatives.

Uncertainties and Sensitivities Affecting the Source Term for RAD–10

The assumption of an LPF of 1 with the ventilation on and the HEPA filters failed is extremely conservative. It would be expected that, by procedure in response to stack radiation alarms, the ventilation system would be shut down as soon as the HEPA filter failure was discovered, which would take the LPF from 1 to 0.011. The assumption of a 24-hour suspension period for this process-oriented event is also potentially very conservative because the spill would be expected to be cleaned up well before 24 hours.

Another significant uncertainty is the quantity of plutonium in the container. The analysis assumes the maximum allowed (4,500 grams). In reality, the amount could be smaller, resulting in a smaller source term.

Consequences of RAD–10 for Facility Workers and the Public

Consequences are discussed separately for facility workers and the public. The workers retrieving the container that is dropped and fails could be exposed to plutonium inhalation, with substantial doses possible depending upon the usage of PPE and the speed with which the worker(s) is able to exit the immediate area.

The public consequences are summarized in Table G.5.6.10–1. It must be understood that the worker consequences occur at a much higher frequency. As indicated above, the likelihood of public consequences from this scenario is extremely small and considered to be incredible under NEPA practice. The likelihood of worker consequences is much higher, ranging from 1.1×10^{-3} to 0.22 per year for the two contributing scenarios.

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 560 person-rem (TEDE), resulting in 0.28 excess LCFs. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.10–2 and G.5.6.10–3, respectively.

G.5.6.11 *RAD–11, Container Breach After Detonation of Plutonium-Containing Assembly at DARHT*

General Scenario Description

General information on the DARHT Facility and its function and mission is provided in RAD–04. As stated in RAD–04, the DARHT EIS included analysis of potential accidents, including bounding accidents that were selected and evaluated on a “what-if” basis (DOE 1995a) based on potential consequences, with little or no consideration of the frequency of occurrence, though the likelihood of occurrence would be small. Scenario RAD–11 represents the failure of a double-walled steel containment system following the detonation of a plutonium-containing assembly. As noted earlier in the DARHT EIS, in related safety analyses these accidents have been evaluated to be not credible (probability less than 10^{-6} per year). Although some hundreds of dynamic experiments may be conducted per year, only a small number will contain plutonium (LANL 1996m), and these experiments would not reasonably be expected to result in any release of plutonium to the environment (DOE 1995a).

As explained in greater detail in the DARHT EIS, the accident scenario RAD–11 involves the failure (breach) of a double-walled steel containment system following the planned detonation of a plutonium-containing assembly to be radiographed at DARHT or at the existing PHERMEX Facility located a short distance away. Some dynamic experiments involve plutonium in order to obtain needed information and understanding associated with nuclear weapons aging and continued assurance of weapon safety and performance (DOE 1995a). As a matter of policy, these experiments will always be conducted inside a double-walled steel containment system consisting of an inner confinement vessel and an outer safety vessel to prevent plutonium release; furthermore, the

TABLE G.5.6.10–1.—*Summary Results for Scenario RAD–10*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	Incredible	2.7 grams of weapons-grade plutonium released initially from the stack, 4.3 grams subsequently released in 24 hours due to suspension; integrated population exposure of 560 person-rem, 0.28 excess LCFs.
Expanded Operations	Incredible	Same as No Action Alternative.
Reduced Operations	Incredible	Same as No Action Alternative.
Greener	Incredible	Same as No Action Alternative.

TABLE G.5.6.10–2.—*Predicted Mean Doses to MEIs for Scenario RAD–10*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	DOSE
Closest Public Access: Pajarito Road (50 m)	44
Closest Residence: Royal Crest Trailer Park (900 m)	1.1×10^{0}
Special Population Distance: Los Alamos Hospital (1,200 m)	3.2×10^{-1}
Special Population Distance: San Ildefonso Pueblo boundary (3,900 m)	1.5×10^{-1}
Special Population Distance: San Ildefonso Pueblo (17,000 m)	1.1×10^{-2}

TABLE G.5.6.10–3.—*Predicted Mean Ground Contamination Levels for Scenario RAD–10*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	5.7×10^{3}
1.0 to 2.0 km	2.3×10^{3}
2.0 to 3.0 km	1.2×10^{3}
3.0 to 4.0 km	7.1×10^{2}
4.0 to 8.0 km	3.1×10^{2}
8.0 to 12.0 km	1.2×10^{2}
12.0 to 20.0 km	5.0×10^{1}
20.0 to 30.0 km	2.0×10^{1}
30.0 to 40.0 km	1.1×10^{1}
40.0 to 60.0 km	5.4×10^{0}
60.0 to 80.0 km	2.9×10^{0}

experiments will always be arranged and conducted in such a manner that a nuclear explosion could not result (DOE 1995a).

The impacts of the hypothetical RAD–11 containment breach scenario are similar to but less than those for the hypothetical uncontained detonation scenario of RAD–04. For the RAD–11 scenario, no immediate worker deaths would be anticipated due to the high-explosives blast causing the containment breach because involved workers would be sheltered at the time of test execution. The human health impacts to the public and to noninvolved workers are dominated by the explosive aerosolization of plutonium, which is then released through a breach in the double-walled containment and atmospherically dispersed. In the DARHT EIS, DOE examined the environmental consequences that could occur if the outer vessel were breached with a 1-inch hole (DOE 1995a). Up to tens of excess LCFs based on a 50-year committed dose would result from this hypothetical scenario, depending on the population sector assumed to be exposed due to extant winds. Impact analysis for this SWEIS is taken directly from the analysis DOE has already performed and received comment on from the public; other agencies; and state, local, and Tribal governments in the DARHT EIS. For the convenience of the public and the decision maker, some of that information also is directly reproduced in this SWEIS (section G.5.6.4). The methodology and all impacts associated with this hypothetical containment failure are principally contained in Chapter 5 and Appendixes H, I, and J of that EIS; additional information is contained in a classified appendix.

No Action Alternative Frequency Analysis. The frequency of this scenario is evaluated as incredible (i.e., less than 10^{-6} per year), as was indicated the DARHT EIS (DOE 1995a). This frequency is corroborated by DOE safety analyses.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis. No differences in frequency across the SWEIS alternatives have been identified that would alter the designation of this scenario as having a frequency of less than 10^{-6} per year, as discussed in the DARHT EIS. The frequency categorization for the No Action Alternative is assumed to be applicable across the SWEIS alternatives.

Source Term Calculations. As described in the DARHT EIS (DOE 1995a), analysis of this hypothetical accident is documented in a classified appendix to that EIS. While the resulting impacts, as well as unclassified calculations, assumptions, and modeling methods, are contained in the unclassified sections of the EIS, some details of such experiments, including some associated with the source terms for this accident scenario, are classified.

Consequences of RAD–11 for Facility Workers and the Public. Impacts to involved workers, noninvolved workers, public populations and MEIs, were described in the DARHT EIS. Under this scenario, there would be no impact to workers, who would be sheltered during the detonation and subsequent breach of the vessel system.

Predominant human health impacts to noninvolved workers or the public would stem from exposure to aerosolized and dispersed material. Impacts to noninvolved workers at distances of 2,500 and 1,300 feet (750 meters and 400 meters) were evaluated (DOE 1995a). Doses to noninvolved workers were estimated to be 60 rem and 20 rem for a worker at 1,300 feet and 2,500 feet (400 meters and 750 meters), respectively; corresponding probabilities of excess LCFs would be 0.02 and 0.009, respectively, for such individuals. LANL administratively controls access to explosives areas by noninvolved individuals and has a set of established hazard radii for protection of personnel from fragment injury from explosives experiments, based on DOE principles. It was estimated that a noninvolved worker would likely be no closer than 2,500 feet (750 meters). The public MEI located at State Road 4 was calculated to receive 14 rem, with a resulting probability of an excess LCF of 0.007 (DOE 1995a).

The population exposure for the most populated sector (which includes White Rock and Santa Fe) was estimated to be between 210 and 560 person-rem for 50th and 95th percentile meteorological conditions, respectively, resulting in negligible excess LCFs (DOE 1995a). While diffusion of material across an entire directional sector was taken into account, it was assumed that all of the community populations were located at or near to the plume center line, a conservative assumption that results in an overestimate of impacts (DOE 1995a). Impacts for both workers and the public also can be found in tabular form in Table I-10 and Table I-11 in the DARHT EIS, which is reprinted for convenience in this SWEIS in section G.5.6.4. These tables show impacts from both the uncontained detonation and containment breach scenarios on a what-if basis. Population dose and impacts to other communities also were calculated for the inadvertent detonation accident, which is the bounding case, and can be seen in RAD–04 (section G.5.6.4). Table G.5.6.11–1 summarizes these results.

G.5.6.12 *RAD–12, Plutonium Release from a Seismically Initiated Event*

General Scenario Description

The accident scenario discussed here is an explosively driven release of plutonium from building TA–16–411. This scenario is similar to that of RAD–04, but would be specific to the TA–16–411 facility because it supports existing high explosives operations. The explosive dispersal would be initiated by the collapse of appropriate parts of this structure during an earthquake, during one of the short periods when an explosive assembly including plutonium would reside in this facility. In this scenario, the seismic collapse is postulated to cause high explosives to detonate and, in the process, aerosolize a portion of the plutonium as respirable particles. Although it could be expected from the collapse of the building that a portion of the material (including respirable particles) would be trapped by the debris and unavailable for atmospheric transport. For this case it was conservatively assumed that there was no trapping of material relative to an uncontained, open-air explosives release.

The scenario is considered marginally credible based on recent safety analyses, and may fall at or below the screening criteria cutoffs (to "incredible") as more detailed analysis is developed. New studies have demonstrated that the frequency of such an accident would

TABLE G.5.6.11–1.—*Summary Results for Scenario RAD–11*

ALTERNATIVE	ACCIDENT FREQUENCY	INTEGRATED POPULATION DOSE (PERSON-REM, TEDE)	EXCESS LCFS
No Action	$< 10^{-6}$	210	.01
Expanded Operations	$< 10^{-6}$	210	01
Reduced Operations	$< 10^{-6}$	210	01
Greener	$< 10^{-6}$	210	01

decrease based on more detailed and thorough (yet still conservative) evaluation of the structural robustness of the vault of building TA–16–411 (the only part of the structure where these materials would reside) to withstand earthquakes. These studies are currently under review by LANL and DOE. Similarly, other factors of conservatism are included in the current assessment of probability of this scenario.

No Action Alternative Frequency Analysis

Because this accident scenario is a seismically initiated event, the capacity of the building to withstand an earthquake is a key factor in determining the frequency of the accident. TA–16–411 includes a vault structure attached to an older main building. Because high explosives and plutonium material would only be present within the vault structure, it is the capacity of the vault to withstand earthquakes, not that of the less-robust older part of the structure, that relate to the probability or frequency of this scenario.

The vault and its major components in TA–16–411 are known to have a significantly greater capacity to resist damage from an earthquake than the older main structure. Highly conservative analyses based on simple statistical modeling of the vault structure showed the vault would withstand earthquakes in the SITE–01 grouping of earthquake magnitudes (0.04 to 0.1 *g*), but were consistent with a low probability of failure from earthquakes of about 0.3 *g*, in the SITE–03 range. This means that we have a great deal of confidence that the vault will not fail for higher frequency earthquakes, and are therefore very conservative in estimating a failure of the vault at these stated values.

Note that in the SITE–01 estimates of the HCLPF values, the building as a whole corresponds to 0.05 *g*, which lies in the range designated as the SITE–01 grouping of earthquake magnitudes (0.04 to 0.10 *g*). The HCLPF value related to the structure as a whole is limited by the older main structure; this magnitude earthquake would correspond to a frequency of 3.5 x 10^{-3}.

The overall accident frequency is lower than the estimated earthquake occurrence frequency because of further conditional probabilities of an earthquake occurring when the high explosives components are in the vault because they are not housed in the vault on a continuous basis. Finally, these explosives are not highly susceptible to detonation from low impact mechanical shocks, such as falling debris.

Because the vault is the only relevant component of the building, the overall frequency based on this seismic analysis would be on the order of magnitude of 4 x 10^{-6}, near the screening threshold for credible accidents in this SWEIS.

More recently, a more thorough dynamic modal analysis of this structure (still based on conservative principles) performed under contract to LANL has indicated that the structure would have a high confidence of withstanding at least 0.31 *g* earthquakes. This would reduce the frequency associated with this accident scenario to about 1.5 x 10^{-6} or lower. More precise estimates of this frequency may be available by the time the Final SWEIS is prepared. At this frequency, the accident is marginally credible when conservatively analyzed. More realistic, but still conservative, assumptions could reduce this frequency to below 10^{-6}; however, to be conservative, this scenario is included in the Draft SWEIS as marginally credible.

Expanded Operations, Reduced Operations, and Greener Alternatives

Because this building will be used under all alternatives, the frequency values would remain the same.

No Action Source Term Calculations

Some details associated with the source terms for this accident scenario are classified. No credit is taken for entrapment of the material by building debris, so all of the respirable particles are considered available for atmospheric transport.

Consequences for Facility Workers

The workers in the facility would be killed by the explosion or falling debris. No doses were evaluated because it would be highly unlikely that anyone would survive such an event.

Consequences for the Public

As noted earlier, different methodologies may be used to evaluate atmospheric dispersal and human health impacts; it is understood in this analysis that there is a range of uncertainty associated such models. Conservatism is included through a variety of approximations and assumptions. For this accident scenario, the equations used to define the initial plume dimensions and plume centerline height are those recommended in *Plutonium Explosive Dispersal Modeling Using the MACCS 2 Computer Code* (Steele et al. 1997). The Julick System (Vogt 1997) derived for 164-foot (50-meter) plumes is used for determining the downwind expansion of the Σ_y and Σ_z terms. The plume meander option was not activated.

The duration of the emergency phase was defined as 1 day. It was assumed that no emergency phase mitigative actions (evacuation or sheltering) were implemented to reduce emergency phase exposures. For doses from the inhalation of resuspended particles, chronic population exposures were to be mitigated by decontamination, temporary interdiction, or condemnation of contaminated property, if doses exceeded 2 rem in the first year following the accident. This criterion is a generalization of EPA guidance that recommends dose mitigative actions if it is projected that individuals will receive 2 rem in the first year following the accident (EPA 1991).

The integrated population numbers are given for both the public within a 50-mile (80-kilometer) radius and, separately, the LANL workforce populations. Note that adding these numbers represents a conservative number. LANL employees who work at the site and live within the area are counted twice for the integrated population doses.

Table G.5.6.12–1 is a summary of the consequences for this scenario. Table G.5.6.12–2 is a summary of the overall risks for this scenario. The MEI locations calculated for this scenario are given in Table G.5.6.12–3.

G.5.6.13 *RAD–13, Plutonium Release from Flux Trap Irradiation Experiment*

General Scenario Description

The Skua fast-burst reactor, housed at Kiva #3 at Pajarito Site (TA–18–116) can be used for irradiation of experiments within a cavity in the reactor core, called a flux trap. These experiments would be carried out inside Kiva #3 (LANL 1996f). The bounding experiment modeled here is a shock rod experiment; other experiments, involving less severe conditions and far less MAR, may also be carried out in the Skua flux trap. The intent of a shock rod experiment is to measure the stress generated in a sample of fissile material by the rapid heating caused by fissions induced by the neutron pulse. The accident scenario involves a shock rod experiment in which the maximum design pulse of power is delivered to the experiment, rather than the lower intended power. The oversized pulse results in a very high energy deposition in the shock rod, resulting in melting (but not vaporization) of 6,000 grams of plutonium.

TABLE G.5.6.12–1.—*Consequences for Accident Scenario RAD–12*

LANL WORKFORCE POPULATION DOSES (TEDE, PERSON-REM)	EXCESS LATENT CANCER FATALITIES	OFF-SITE POPULATION DOSES (TEDE, PERSON-REM)	EXCESS LATENT CANCER FATALITIES
7,800	3.9	28,000	14

TABLE G.5.6.12–2.—*Overall Risks for Accident Scenario RAD–12*

ALTERNATIVE	ACCIDENT FREQUENCY (EVENT/YR)	INTEGRATED POPULATION DOSE (TEDE, PERSON-REM)	EXCESS LATENT CANCER FATALITIES
No Action	1.5×10^{-6}	35,800	18
Expanded Operations[a]	No change	No change	No change
Reduced Operations[a]	No change	No change	No change
Greener[a]	No change	No change	No change

[a] No change is noted with regard to the No Action Alternative.

TABLE G.5.6.12–3.—*Predicted MEI Doses for Scenario RAD–12*

MEI LOCATION	DOSE
100 m	87
Closest Site Boundary: 550 m	138
Closest Residential Population: 5.2 km	18

Note that no such experiments have been conducted to date at TA–18. Thus, the TA–18 SAR analysis concerns a capability to perform such experiments, rather than an intention to do so. (Shock rod experiments have been performed at SNL using the SPR-II fast-burst reactor, and are discussed in the SARs of both SPR-II and SPR-III.)

Shock rod experiments can be carried out using highly enriched uranium (largely, uranium-235) or plutonium (largely, plutonium-239) (LANL 1996f). However, because the expected fuel failure and resultant hazards of uranium experiments are much lower than for plutonium rods, the TA–18 SAR analysis focused on the plutonium shock-rod experiments (LANL 1996f). The SWEIS accident analysis also concerns plutonium shock rod experiments for the same reasons.

Plutonium experiments with the Skua fast-burst assembly are required to incorporate two levels of containment; but, the TA–18 SAR analysis assumes no containment (LANL 1996f and Paternoster et al. 1995). However, even if containment is used, the SAR calculations indicate that a final liquid temperature of about 3,600°F (2,000°C) is achieved. Because the melting temperature of a range of stainless steels used as glory-hole liners is 2,552 to 2,732°F (1,400 to 1,500°C), rupturing of the steel liner in the containment device would be expected, which would allow the molten plutonium to contact air. Because the ignition temperature of plutonium in air is about 930 to 1,100°F (500 to 600°C) (depending on the surface area of the plutonium), a plutonium fire would occur (LANL 1996f).

This accident scenario was analyzed in the TA–18 SAR. No accident sequence frequency was estimated or calculated in the SAR, nor was a frequency bin assignment made. Rather, the SAR stated that all of the accidents analyzed were incredible, implying a frequency of less than 10^{-6} per year. The source term was calculated assuming a release fraction of 0.001 from the melt (i.e., 6 grams of plutonium). Release into the environment was modeled based on exfiltration through the confinement structure and dispersal downwind. The source term also took into consideration the fission products generated during the burst of neutrons to the target material (LANL 1996f).

No Action Alternative Frequency Analysis

No shock rod experiments have been performed at TA–18, nor are any such experiments planned under any of the SWEIS alternatives. The TA–18 SAR analysis is more by way of providing SAR assessment space so that if the need arises, the capability to conduct shock rod experiments can be realized without a lengthy administrative delay that could otherwise be needed in order to amend the SAR. Accordingly, any frequency assignment for this accident scenario will necessarily be speculative.

Nevertheless, some perspective on the likelihood of the accident scenario can be gained by considering what sorts of failures would be necessary in order for the accident to take place. Both the TA–18 SAR and the SAR for the SPR-III facility at SNL characterize the accident as probable because it can occur at the design power level of the fast-burst reactor used to conduct the experiment (LANL 1996f). Based on DOE Standard 3009-94 (DOE 1994d), this is interpreted to mean that the accident is credible, but very unlikely, representing a design basis accident. This would place the accident scenario into the 10^{-6} to 10^{-4} per year frequency bin.

The most likely cause of the accident would be a chain of human errors leading to an excessive power level (but still within Skua design levels) being used for the experiment, although it is feasible that an undetected design or fabrication error could also lead to the accident. Typical human error rates for tasks generally are in the range of 10^{-4} to 10^{-2} (Mahn et al. 1995 and Swain and Guttmann 1983). Considering the fact that tests at TA–18 are performed under a testing plan and an experiment plan, these additional levels of administrative control suggest that the lower end of this range of human error rates is more reasonable as a basis for quantification. The probability of errors for a checker of someone else's work is expected to be higher than the probability of the original error because the checker does not normally completely redo the calculations when evaluating someone else's work. This represents a special case of dependence in human reliability analysis (Swain and Guttmann 1983). The basic recommended error rate for a checker is 0.1 when using written procedures; for a one-of-a-kind check (nonroutine), the recommended value is 0.05 because the checker would be expected to approach this task with a higher level of alertness for possible errors (Swain and Guttmann 1983).

Also important for the particular accident under evaluation here is that the opportunities for recovery from the error during the pulse operation are extremely limited once the calculation checks have been completed. This is due to the nature of the event. That is, once the experiment has been set up and the operation initiated, the neutron pulse happens in a tiny fraction of a second, and there is no chance to recover from the error or mitigate the consequences of the event (apart from emergency response).

Considering the above, the human error rate in experiment operation might be of the order of 5×10^{-7} per experiment (0.0001 x 0.05 x 0.1), assuming one initial error and two failed checks. Even this estimate implicitly assumes that all errors lead to the fuel melting outcome; this is clearly incorrect because not all operational errors are catastrophic. Clearly, a plutonium melting accident arising from a shock rod experiment is not very likely.

It is also possible that an error in maintenance or calibration could lead to a higher than intended power level being delivered to a shock rod experiment. This would also require at least two errors (the initial error and the failure of the checker to detect the error). If independence between these errors is assumed, a typical HEP for test, maintenance, and calibration activities that leaves a component or system with an unrevealed fault is 10^{-3} per demand, with a range from 3×10^{-4} to 3×10^{-3} per demand (Mahn et al. 1995), with the lower end of the range being more reasonable, given the administrative controls mentioned above. Given the unique nature of a shock rod experiment for LANL, the appropriate checker failure rate would be 0.05. This would yield a value of about 1.5×10^{-5} ($0.0003 \times 0.05 = 1.5 \times 10^{-5}$). However, not all errors are equally serious or would necessarily lead to a power level resulting in shock rod melting (e.g., some errors would lead to the inability to conduct the pulse, with an investigation into the cause being very likely to identify the error and lead to its correction.) Again, a plutonium melting accident arising from a shock rod experiment is not very likely.

Consistent with the sliding-scale approach in DOE NEPA guidance (DOE 1993b), the frequency of this accident is set to 1.6×10^{-5} per experiment for all alternatives (the sum of the conditional frequencies of the two contributing error modes). (This frequency is carried forward as one experiment per year.)

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

This accident is independent of the alternatives. The activity that could give rise to this accident has not yet been performed at LANL and is not scheduled to be performed. The accident models a capability to perform the activity. Therefore, there is no reason to assess a variation in frequency across the alternatives.

Uncertainties and Sensitivities Affecting the Frequency of RAD–13

The accident frequency calculation documented above is speculative. However, given that the experiment has not been performed at LANL and that there are no current plans to perform the experiment, the frequency estimate is considered to be representative of what might be expected for circumstances under which the experiment is conducted infrequently (once per year or less).

Source Term Calculations

The TA–18 SAR employed a respirable release fraction (ARF x RF) of 0.001. This assessment was based on assuming 6,000 grams of plutonium melted and that this entire amount is distributed for optimum dispersal (LANL 1996f). The SAR analysis does not make reference to DOE Handbook 3010-94. The SNL SPR-III SAR analysis predates the LANL analysis, and mirrors it in most respects. One notable difference, however, is that the LANL release fraction is five times lower than the SNL release fraction (0.001 versus 0.005).

The source term was quantified for the SWEIS according to DOE Handbook 3010-94 guidance. The MAR is 6,000 grams of weapons-grade plutonium in molten (liquid) form (LANL 1996f). The DR is assessed as 1.0 (all 6,000 grams are molten).

The LPF is not directly calculated or estimated in the TA–18 SAR. Because the SAR assessed no driving force associated with the accident, the release from the kiva was modeled as wind-driven exfiltration. Over a 2-hour period, the release fraction (which is dependent on wind speed) ranges from 0.05 to 0.25 for wind speeds in the range from 1 to 10 miles per second (2.2 to 22.3 miles per hour) (LANL 1996f). Because typical upslope and downslope winds at Los Alamos are in the range of 2.5 to 3 miles (4.0 to 4.8 kilometers) per second (LANL 1990a), DOE has selected an LPF of 0.1 (which is between the values for 2 and 3 miles [3.2 to 4.8 kilometers] per second).

Selection of appropriate ARF and RF values is complicated by the limited description of the accident scenario in the LACEF SAR. The SAR acknowledges the possibility that rupturing the containment vessel could allow molten plutonium to slump to the assembly stand and adjacent areas. For airborne release of particulates from disturbed molten metal surfaces (i.e., flowing metal, actions resulting in continuous surface renewal), DOE Handbook 3010-94 recommends the bounding ARF and RF values of 0.01 and 1.0, respectively (DOE 1994d). The handbook clarifies that the bounding value applies to situations where ignited, molten plutonium is disturbed by direct impact of high air velocities such as during free fall (DOE 1994d).

The handbook also addresses a circumstance involving the airborne release of particulates formed by self-sustained oxidation (molten metal with oxide coat), self-induced convection. The handbook clarifies that this applies to self-sustained oxidation in air of metal pieces (DOE 1994d). The ARF and RF values for this circumstance are 0.0005 and 0.5, respectively.

ARF and RF bounding values for these two sets of circumstances yield initial source terms as follows:

Self-Sustained Oxidation

Source Term = MAR x DR x ARF x RF x LPF

= 6,000 x 1 x 0.0005 x 0.5 x 0.1

= 0.15 grams

Disturbed Molten Metal Surfaces

Source Term = MAR x DR x ARF x RF x LPF

= 6,000 x 1 x 0.01 x 1 x 0.1

= 6.0 grams

The suspension source-term calculation was also performed according to DOE Handbook 3010-94 guidance:

Suspension Source Term = MAR x DR x ARR/hr x 24 hrs x RF x LPF

= 6,000 x 1 x 0.00004 x 24 hrs x 1 x 0.1

= 0.6 grams

The ARR and RF values are based on powder located inside a building with ambient conditions (DOE 1994d). This was considered to be appropriate because the melted plutonium released from the containment device will burn on contact with air and change the physical state of the plutonium.

In addition to the plutonium source term from the melting event, a radiological release will occur as a result of the generation of fission products due to the neutron pulse. The large majority of fission products have very short half-lives (on the order of 0.21 seconds to 3.15 minutes) and their mode of decay is primarily by beta and gamma emission. The SAR analysis assigned an average dose-rate conversion factor for air immersion (cloudshine) of 4,000 millirem-cubic meter per microcurie per year to those beta-gamma emitting radionuclides not having documented values. Comparison of the decay product quantities and dose conversion factors with the plutonium source term values indicated that the fission products provide a negligible contribution to the total dose from internal exposure pathways. Consequently, doses resulting from internal exposure pathways for fission products were not modeled. Doses resulting from the external exposure pathway (air immersion) for fission products (6.02×10^3 curies) were estimated using the SAR-determined average dose-rate conversion factor of 4,000 millirem-cubic meter per microcurie per year.

The accident does not change across the alternatives. The No Action Alternative source term applies to all of the SWEIS alternatives.

Uncertainties and Sensitivities Affecting the Source Term for RAD–13

The source term for RAD–13 is very sensitive to the accident progression, which has unfortunately not been evaluated in detail past the point where the plutonium melts. If the accident progression is relatively benign (involving low pressure melting of the container and candling of the molten liquid down the sides of the Skua device), then the SAR source term is probably conservative. If, however, a more energetic surface reaction occurs in the molten material, then the SAR estimate of the source term is possibly too low.

One uncertainty in this case would be how much of the plutonium would actually be ejected, versus the amount that would cool and freeze to the interior surface of the container. Finely divided liquid plutonium metal at high temperature would be expected to be energetically pyrophoric with the air inside the kiva. The rate of oxidation of plutonium is dependent on: (1) temperature, (2) the surface area of the reacting metal, (3) the oxygen concentration, (4) the concentration of moisture and other vapors in the air, (5) the type and extent of alloying, and (6) the presence of a protective oxide layer on the metal surface (DOE 1994d). Factors 1 and 2 are maximized under the conditions hypothesized; indeed, the plutonium would initially be far above the ignition temperature (i.e., 2,000°F [1,093°C] at release versus the ignition temperature of 914°F to 932°F [490 to 500°C]). Factor 3 is essentially unlimited because oxygen in the air would be replenished from outside the kiva. Factor 6 is not applicable because the plutonium is in a liquid form. The source term from this configuration could be significantly higher than calculated above.

Consequences of RAD–13 for Facility Workers and the Public

Consequences for facility workers and the public are discussed separately. The Kiva #3 control room is located 669 feet (204 meters) from the kiva (LANL 1996f). The walls of the control room are such that 40 percent attenuation of gamma doses from the outside is accomplished (LANL 1996f). In the event of an accident, ventilation systems for the control building (TA–18–30) would be secured. Air exchange with the outside would be a function of wind loading and diffusion in and around wall and ceiling penetrations (LANL 1996f). However, the ventilation system for the control building is not protected by HEPA filters (LANL 1996f).

No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 160 person-rem (TEDE), resulting in 0.082 excess LCFs. The public consequences for RAD–13 are provided in Table G.5.6.13–1, which summarizes the modeling results for RAD–13. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.13–2 and G.5.6.13–3, respectively.

G.5.6.14 *RAD–14, Plutonium Release Due to Ion-Exchange Column Thermal Excursion*

General Scenario Description

This accident scenario involves the release of plutonium through the building ventilation systems during a process event. In TA–55, ion exchange columns, inside of gloveboxes, are used to separate out different plutonium compounds. As plutonium nitrate solutions are introduced into these columns, an abnormal increase in temperature is possible. This temperature rise could be due to degraded resin, greater reactivity of the solution with the column resin, or even a limited glovebox fire.

For the accident to proceed, the column must rupture due to a pressure build up caused by the temperature rise. Aerosolized plutonium nitrate could then enter the glovebox and be drawn into the glovebox ventilation system. For any release of material into the building ventilation systems, the glovebox HEPA filter system would have to fail. For the material to reach the environment, the building HEPA filters would also have to fail. This scenario has a probability that is extremely low. The probability is low enough to be deemed incredible even though an initiating event is considered possible.

The accident would have to start from some initiating event such as: (1) inadvertent introduction of a high temperature solution causing the resins to decompose; (2) inadvertent introduction of impurities in the feed stock, such as strong oxidants; and (3) inadvertent introduction of high concentrations of nitric acid. Each of these situations, could set up a reaction in the column that quickly heats the material in the column, possibly leading to an ion-exchange column overpressurization.

Because such situations have occurred, LANL uses resins that are resistive to degradation. The vinyl pyridine polymers used in the ion exchange columns are significantly more resistant than resins incorporating a polymer of polystyrene and divinyl benzene. These resins have a marked improvement in stability for conditions of high temperature, concentrated nitric acid exposure and for conditions of high radiation. Progressive resin deterioration can be detected by decreased resin exchange capacity and the appearance of bead fragments in the effluent. The resins generally are replaced before they become seriously degraded. Even with these precautions, however, problems with resins are known to occur.

TABLE G.5.6.13–1.—*Summary Results for Scenario RAD–13*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	1.6×10^{-5}	Bounding, 6 grams of weapons-grade plutonium initial release, 0.6 grams of weapons-grade plutonium in suspension release over 24 hours; integrated population exposure of 160 person-rem, 0.08 excess LCFs.
Expanded Operations	1.6×10^{-5}	Same as No Action Alternative.
Reduced Operations	1.6×10^{-5}	Same as No Action Alternative.
Greener	1.6×10^{-5}	Same as No Action Alternative.

TABLE G.5.6.13–2.—*Predicted Mean Doses to MEIs for Scenario RAD–13*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	DOSE
Closest Public Access: Pajarito Road (30 m)[a]	1.2×10^{2}
Operations Boundary (TA–18 SAR): (200 m)	2.3×10^{1}
Site Boundary (TA–18 SAR): San Ildefonso Pueblo boundary (1,000 m)	1.8×10^{0}
Special Population Distance: Mortandad Cave (2,900 m)	2.7×10^{-1}
Receptor Distance (T–18 SAR): Population center (4,400 m)	1.2×10^{-1}
Special Population Distance: San Ildefonso Pueblo (14,600 m)	1.2×10^{-2}

[a] Approximated at 50 m.

TABLE G.5.6.13–3.—*Predicted Mean Ground Contamination Levels for Scenario RAD–13*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	2.6×10^{4}
1.0 to 2.0 km	3.5×10^{3}
2.0 to 3.0 km	1.4×10^{3}
3.0 to 4.0 km	7.1×10^{2}
4.0 to 8.0 km	2.5×10^{2}
8.0 to 12.0 km	9.4×10^{1}
12.0 to 20.0 km	3.7×10^{1}
20.0 to 30.0 km	1.5×10^{1}
30.0 to 40.0 km	8.3×10^{0}
40.0 to 60.0 km	4.4×10^{0}
60.0 to 80.0 km	2.7×10^{0}

BQ/m^2 = Becquerel per square meter

For the accident to proceed, the pressure must buildup and cause a column rupture. Because the pressure can be relieved by either the pressure relief valve or through the output line on the column, both of these components have to fail. In other words, the pressure relief valve does not actuate and the output line on the column is blocked.

At this point in the progression, an accident has occurred; but the material is still contained in the glovebox. For the material to escape the glovebox, the HEPA filter system would have to fail, allowing material into the building ventilation system. For this accident sequence, the HEPA filter is assumed to be damaged by the rupture of the ion-exchange column. Material is then transported by the ventilation system to the building HEPA filters. Again, for this material to escape the building, the multi-staged HEPA filters on the building would have to fail. The material would now be available for atmospheric transport from the south exhaust stack.

This accident progression is used to estimate the frequency of the event. Because there are a number of barriers that must fail, the calculated accident frequency is below the screening criteria cutoffs for credible accidents. The accident has been retained, however, to illustrate the nature of defense-in-depth and how it is used to reduce the frequency and consequences of possible plutonium releases at TA–55.

Comparison of Accident Analysis in the Pit Disassembly and Conversion Demonstration Environmental Assessment and This SWEIS

DOE is preparing an EA (DOE 1998) to examine the environmental impacts of the proposed development and demonstration of an integrated pit disassembly and conversion process for fissile material disposition. The hazard analysis, used for this EA first considered a baseline of public impacts given the hypothetical case where no controls exist for the operation. This evaluation determined that without controls the impacts to the MEI are below the DOE evaluation guidelines. The hazard analysis further quantified the expected consequences to the public, given that the building is designed to provide containment of hazardous material in the event of an accident. Given these controls, the dose to the MEI was reduced to 3 x 10^{-8} rem and the frequency of occurrence was reduced from 10^{-3} to 10^{-5}.

Although the consequence and frequency numbers in the EA are slightly higher than those given for this accident, i.e., in the ion-exchange column thermal excursion, the risks from the pit disassembly and conversion process are considered to fall within the envelop as established by this SWEIS. Additional control barriers, other than those outlined in the EA, exist to further reduce the frequency of an initiating event and to reduce the frequency of an event with public impacts to below the 10^{-6} screening criteria. The consequences for an unconfined release of plutonium are similar and, when taking credit for HEPA filtration, the doses become very low. Doses in this range (considering filtration) could not be distinguished from background doses. Overall, for process events, the risks from this operation would be dominated by the risks of a fire for the CMR Building.

The characterization of risk at LANL, as presented by the set of accidents in this appendix is appropriate, given consideration of the EA analysis. When considering the accident risk associated with the pit disassembly and conversion process for fissile material disposition, the risk profile for LANL (as presented for each alternative) would not change. The SWEIS risk characterization is more realistic because it includes other processes implemented through adherence to DOE safety programs, including the defense-in-depth policy.

No Action Alternative Frequency Analysis

Table G.5.6.14–1 associates the accident progression, as discussed above, with either a frequency of occurrence or a rate of failure. The terms in the table are explained in subsequent sections.

Initiator

There are several types of events that could cause a column overpressurization or rupture. Unfortunately, it is difficult to quantify the initiating event likelihood and therefore the likelihood of the overall accident. A search was done for recorded cases of column overpressurizations or ruptures. This search did not find any cited incidents. To put a bound on this initiator frequency, the ORPS database, where such incidents are systematically cataloged, was used. The last 5 years of data was considered representative of the likely initiators at LANL. No ion-exchange column overpressurization or rupture were reported in the last 5 years. Given that LANL is operated for approximately 260 days per year, the frequency of occurrence is less than 1 event in 1,300 days, or a rate of less than 8×10^{-4} per day. Because there are essentially 260 operating days per year, the annual frequency for a column rupture is 0.2 per year (260 operating days per year x 8×10^{-4} per day). This number, although very conservative, was used as the likelihood that precursors exist for these process type accidents. Precursors would include having contaminants in the solutions, degraded resins, etc.

Human Error Probability

Missed Procedural Step. Procedures are used to ensure that the setups are correct and materials introduced into the process meet the specified criteria, such as concentrations for solutions, etc. If one of these steps is omitted, then the initiating event can progress into an accident (e.g., overpressurization of an ion-exchange column). Generally, it takes more than one step to be missed or improperly done in order for an accident to progress; but, in this case it is assumed that the omission of one step, such as a quality control step for measuring the concentration of feed material, occurs and can contribute to the overpressurization event occurring. The probability for omitting a step in a procedure is generally from 3×10^{-4} to 3×10^{-3} per demand (Mahn et al. 1995). Therefore, the midpoint of 1.7×10^{-3} per demand is used in this analysis.

Missed Procedural Check. Because the setups and the processes are governed by procedures, checks are also made by operations staff to ensure that each step has been followed. The failure of an operations staff member to detect such an omission is 0.1 per demand (Swain and Guttmann 1983).

Process Controls

Blocked Output Line. Pressure can bleed out of the ion-exchange column through the output line. However, it has been assumed that this output line, under this condition, can easily become blocked. Therefore, the probability of this line failing to relieve overpressurization is assumed to be 1.0, a very conservative assumption.

Relief Valve Failure. Based on industry experience, the failure rate for relief valves is from 1.4×10^{-5} to 3.6×10^{-5} per demand (NRC 1998, Table III 2-3). Again, the midpoint value of 2.5×10^{-5} was selected for this analysis.

HEPA Filter (Glovebox). The glovebox has a HEPA filter to contain any material that could become aerosolized in the glovebox. Although, the overpressurization and subsequent rupture of a column is not expected to damage the glovebox. This analysis conservatively assumes that the HEPA filter fails, and the probability is set to 1.0

TABLE G.5.6.14–1.—*Accident Progression Associated with Either Occurrence Frequency or Failure Rate*

SCENARIO PROCESS EVENT AT TA–55	INITIATOR FREQUENCY	HUMAN ERROR PROBABILITY		PROCESS CONTROL FAILURE		BUILDING CONTROL FAILURES	FREQUENCY OF ION-EXCHANGE COLUMN OVER-PRESSURIZATION AND PLUTONIUM RELEASE
		MISSED PROCEDURAL STEP	MISSED PROCEDURAL CHECK	PROBABILITY OF BLOCKED LINE	PROBABILITY OF RELIEF VALVE FAILURE		
Ion-Exchange Column Rupture	0.2/yr	0.0017	0.1	1.0	2.5×10^{-5}	1.0 (glovebox HEPA filter failure)	8.5×10^{-10}/yr (worker hazard only)
Ion-Exchange Column Rupture and Loss of HEPA Filters	0.2/yr	0.0017	0.1	1.0	2.5×10^{-5}	6.3×10^{-7} (HEPA failure/HVAC operating)	5.6×10^{-16}/yr
Ion-Exchange Column Rupture and Loss of Ventilation System	0.2/yr	0.0017	0.1	1.0	2.5×10^{-5}	4.5×10^{-7} (HEPAs operating/HVAC fails)	3.8×10^{-16}/yr

Building Controls

HEPA System. For TA–55, filtration consists of a three-stage HEPA filter system located on the outside of the facility. Any incident inside of the facility, such as an ion-exchange column rupture, would not damage the HEPA filters or the ventilation system. Therefore, for the HEPA filters to fail, at the same time this accident occurs, is an independent event.

LANL data from 1990 to 1994 (LANL 1990b, LANL 1991b, LANL 1994c, LANL 1994d, and LANL 1995h) looked at the failure rates of HEPA filters. When the failure rate of a two-stage HEPA filter system was considered (LANL 1996k), the failure probability for a single HEPA stage was 5 percent. For three stages of filters to fail, the failure probability is 1.3×10^{-4}.

HEPA System Summary

- *1st stage HEPA filter failure: 0.05 per demand*
- *2nd stage HEPA filter failure: 0.05 per demand*
- *3rd stage HEPA filter failure: 0.05 per demand*
- *Monitoring instrumentation failure: 5×10^{-3} per demand*
- *Failure of three-stage HEPA filter system: 6.3×10^{-7} per demand*

However, the HEPA filters on TA–55 are monitored to make sure they are functioning properly. The difference in pressure across the filter banks is monitored. An alarm sounds if the proper pressure drops are not being maintained. Also, the sensor is covered by a preventive maintenance program and administrative procedures. Given these conditions, the probability of the sensor failing is 5×10^{-3} (Mahn et al. 1995).

HEPA System Human Error Probability. Given that the HEPA systems are monitored and action is required to make sure the HEPA filters are operating properly, it is always possible for operators to fail to respond. The Human Reliability Handbook identifies a basic HEP for these circumstances as 0.025 per demand (Swain and Guttmann 1983). A shift supervisory function would also be staffed and would be expected to respond if the operator does not. The HEP for this function is 0.1 (Swain and Guttmann 1983). The total HEP for H_{HVAC} is 0.025 x 0.1, or 2.5×10^{-3} per demand. If this probability is coupled with the probability that the HEPA filters could fail, the probability that the building would be operating without containment is 1.6×10^{-10}.

Facility Containment. If the ventilation system fails (i.e., the fans fail), during the rupture of the ion-exchange column, the negative pressure is not maintained between the room and the glovebox and between the laboratory and the environment. Under these conditions, the building is said to go into a breathing mode and unfiltered air can be exchanged between the building and the outside air. However, because there is nothing keeping the material airborne or drawing it outdoors, very little material can escape.

Facility Containment

- *Probability of loss of power: 1.5×10^{-4}*
- *Probability of diesel generator failure: 0.03*
- *Common mode beta factor: 0.1*
- *Probability of ventilation system failure: 4.5×10^{-7}*

For the building to go into a breathing mode, the power to the fans would have to fail and the back-up diesel generator would have to fail also. The annual rate for loss of power is 0.04 per year according to the Western Systems Coordination Council (Oswald et al. 1982). A typical beta factor for common mode failures is 0.1 (Fleming et al. 1985).

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

This accident covers the generic operation of TA–55 for process type events. No increase or decrease in the level of activity associated with the accident frequency is anticipated for any of the other alternatives.

No Action Alternative Source and Suspension Term Calculations

Source Term with Operational HEPA and HVAC Systems. Table G.5.6.14–2 summarizes the results of the source term calculations. The derivation of these numbers is described in the following sections.

When the accident occurs, plutonium is either in the form of plutonium nitrate in solution or it has adhered to the column resin. When the column ruptures, the plutonium can be aerosolized either by the flashing of the solution or by the burning of the resin bed. Because these represent two different mechanisms for plutonium release from the ion-column rupture, the two source terms are tracked separately.

Material-at-Risk. For the solution, MAR equals 246 grams in the form of plutonium nitrate. The maximum concentration of the solution is 100 grams per liter. The volume of the column is 2.46 liters; therefore, the MAR is 246 grams of weapons-grade plutonium in solution as plutonium nitrate.

Material-at-Risk

- *Material Source: Plutonium Nitrate*
- *MAR = 246 g*
- *Material Source: Plutonium Oxide*
- *MAR = 1,000 g*

For the column, the maximum capacity of the resin is 1,000 grams of weapons-grade plutonium (LANL 1996k). Although the plutonium on the resin is not in oxide form, the plutonium released during the accident is assumed to be oxidized due to the high temperatures associated with the burning of the column resins. The oxide designation is used here for tracking purposes only.

Damage Ratio. For flashing of the solution, DR is assumed to be 1.0. All the material in the solution is considered to be involved in the accident.

Damage Ratio

- *Material Source: Plutonium Nitrate*
- *DR = 1.0*
- *Material Source: Plutonium Oxide*
- *DR = 0.1*

Although the resins have remained stable under high temperature and exposure to radiation, 10 percent of the resin in the column is assumed to burn or degrade due to the high temperatures. This assumption is a conservative estimate of the material on the column that can be released during the accident.

TABLE G.5.6.14–2.—*Source Term with Operational HEPA and HVAC Systems*

MATERIAL SOURCE	MAR	DR	ARF	RF	LPF	SOURCE TERM
Plutonium Nitrate	246 g	1.0	0.01	0.6	8×10^{-9}	1.2×10^{-8} g
Plutonium Oxide	1,000 g	0.1	0.01	1.0	8×10^{-9}	7.2×10^{-9} g

Airborne Release Fraction and Respirable Fraction. For the solution, the bounding values were for a flashing spray from relatively low energy liquids. The liquids had temperatures greater than the boiling point but less than 122°F (50°C) superheat. Therefore, the values for the ARF and RF are 0.01 and 0.6, respectively (DOE 1994d).

Airborne Release Fraction (ARF) and Respirable Fraction (RF)

- *Material Source: Plutonium Nitrate*
  - *ARF = 0.01*
  - *RF = 0.6*
- *Material Source: Plutonium Oxide*
  - *ARF = 0.01*
  - *RF = 0.9*

In the TA–55 SAR (LANL 1996k), the product of the ARF x RF is given as 0.009. This product is consistent with the highest measured ARF of 0.0078, with an RF of 0.9, for the burning of contaminated polystyrene and ion-exchange resin (DOE 1994d). Therefore, an ARF x RF of 0.009 was used in this analysis.

Leak Path Factor. For this case, the material escapes into the ventilation system and is filtered through a three-stage HEPA filter. The filteration factor is 8 x 10^{-9} (LANL1996k).

Leak Path Factor (LPF)

- *Material Source: Plutonium Nitrate*
  - *LPF = 8 x 10^{-9}*
- *Material Source: Plutonium Oxide*
  - *LPF = 8 x 10^{-9}*

Suspension Term with Operational HEPA and HVAC Systems. Table G.5.6.14–3 summarizes the results of the suspension term calculations. The amount of suspended material is based on the type of accident and resulting dispersal mechanisms after the accident. For this case, the HEPA filters and ventilation systems are assumed to be operational. Each of the terms is explained in the following sections.

Material-at-Risk. Because very little material escapes to the environment, the amount of material assumed to remain at the site for further dispersal is the same as the original MAR.

Material-at-Risk

- *Material Source: Plutonium Nitrate*
  - *MAR = 246 g*
- *Material Source: Plutonium Oxide*
  - *MAR = 1,000 g*

Damage Ratio. In both instances, the same fraction of material is considered available for further dispersal as was available for the original accident. All the material in solution is considered available. Plutonium that was not released from the resin bed initially is still not considered available; therefore, the DR is 10 percent, or 0.1.

Airborne Release Rate, Release Period, and Respirable Fraction. For the solution, the suspended material is assumed to come from a liquid on a heterogeneous surface (stainless steel, concrete) exposed to low air speeds up to

TABLE G.5.6.14–3.—*Suspension Term with Operational HEPA and HVAC Systems*

MATERIAL SOURCE	MAR	DR	ARR	RELEASE PERIOD	RF	LPF	SUSPENSION TERM
Plutonium Nitrate	246 g	1.0	4 x 10^{-7}/hr	24 hrs	1.0	4 x 10^{-9}	1.9 x 10^{-11} g
Plutonium Oxide	1,000 g	0.1	4 x 10^{-5}/hr	24 hrs	1.0	4 x 10^{-9}	7.7 x 10^{-10} g

Damage Ratio

- *Material Source: Plutonium Nitrate*
  - *DR = 1.0*
- *Material Source: Plutonium Oxide*
  - *DR = 0.1*

normal facility ventilation flow (DOE 1994d). These values are bounding values for the type of suspension that could have been considered. Thus, the ARR and RF selected were 4 x 10^{-7} and 1.0, respectively. Although, the release period is assumed to be 24 hours, this is considered a very conservative value given the limited extent of the accident.

Airborne Release Rate, Release Period, and Respirable Fraction

- *Material Source: Plutonium Nitrate*
  - *ARR = 4 x 10^{-7} per hour*
  - *Release Period = 24 hours*
  - *RF = 1.0*
- *Material Source: Plutonium Oxide*
  - *ARR = 4 x 10^{-5} per hour*
  - *Release Period = 24 hours*
  - *RF = 1.0*

For the plutonium released from the resin bed, it is assumed that the material was deposited out on material in the glovebox. The values selected for the ARR and RF, 4 x 10^{-5} and 1.0, were for surface contamination from combustible solids under ambient conditions (DOE 1994d). Again these values along with the release period of 24 hours were bounding given this type of accident.

Leak Path Factor. The HEPA filters and the ventilation system is assumed to be operating after the accident for this scenario. Thus, the filteration efficiency for the three-stage HEPA filters is used in this case, and very little of the material can escape.

Leak Path Factor

- *Material Source: Plutonium Nitrate*
  - *LPF = 8 x 10^{-9}*
- *Material Source: Plutonium Oxide*
  - *LPF = 8 x 10^{-9}*

Source Term with Failed HEPA Filters and Operational HVAC Systems. Table G.5.6.14–4 summarizes the results of the source term calculations. The values are the same for the accident with operational HEPA and HVAC systems, except for LPF. Therefore, only LPF is discussed below.

Leak Path Factor. For this case the HEPA filters are assumed to fail, but the ventilation system is operating. Material is drawn into the ventilation system and released out the south stack of the building. No credit is assumed either for settling or deposition in the ductwork, etc.; therefore, the LPF is 1.0.

Leak Path Factor

- *Material Source: Plutonium Nitrate*
  - *LPF = 1.0*
- *Material Source: Plutonium Oxide*
  - *LPF = 1.0*

Suspension Term with Failed HEPA Filters and Operational HVAC System. Table G.5.6.14–5 summarizes the results of the suspension term calculations. The material suspended is based on the type of accident and resulting dispersal mechanisms after the accident. For this case, the HEPA filters have failed but the fans are assumed to be operational. These terms are identical to the case where the HEPA filters have not failed, except for MAR and LPF. Therefore, only MAR and LPF are discussed below.

Material-at-Risk. The amount of material remaining at the site is assumed to be the initial

TABLE G.5.6.14–4.—*Source Term with Failed HEPA Filters and Operational HVAC Systems*

MATERIAL SOURCE	MAR	DR	ARF	RF	LPF	SOURCE TERM
Plutonium Nitrate	246 g	1.0	0.01	0.6	1.0	1.5 g
Plutonium Oxide	1,000 g	0.1	0.01	0.9	1.0	1.0 g

TABLE G.5.6.14–5.—*Suspension Term with Failed HEPA Filters and Operational HVAC Systems*

MATERIAL SOURCE	MAR	DR	ARR	RELEASE PERIOD	RF	LPF	SUSPENSION TERM
Plutonium Nitrate	244.5 g	1.0	4×10^{-7}/hr	24 hrs	1.0	1.0	0.0023 g
Plutonium Oxide	999.2 g	0.1	4×10^{-5}/hr	24 hrs	0.9	1.0	0.096 g

MAR, minus the amount that was released for atmospheric transport.

> ***Material-at-Risk***
>
> - *Material Source: Plutonium Nitrate*
>   - *— MAR = 246 g*
>   - *— Dispersed MAR = 1.5 g*
>   - *— Suspension MAR = 244.5 g*
> - *Material Source: Plutonium Oxide*
>   - *— MAR = 1,000 g*
>   - *— Dispersed MAR = 0.81 g*
>   - *— Suspension MAR = 999.2 g*

Leak Path Factor. For this case, the HEPA filters are assumed to fail but the ventilation system is operating. Material is drawn into the ventilation system and released out the south stack of the building. No credit is assumed either for settling or deposition in the ductwork, etc. The LPF is taken as 1.0.

> ***Leak Path Factor***
>
> - *Material Source: Plutonium Nitrate*
>   - *— LPF = 1.0*
> - *Material Source: Plutonium Oxide*
>   - *— LPF = 1.0*

Source Term with Failed HVAC Fans and Operational HEPA Filters. Table G.5.6.14–6 summarizes the results of the source term calculations. The accident progression is the same except that, in this case, the HEPA filters remain in tact but the fans, drawing material through the ventilation systems, fail. The only way to get material out of the building is through exchange of air with the atmosphere, such as entering or exiting the building. Thus, the only term that is discussed below is LPF.

Leak Path Factor. This LPF is for a building in a breathing mode, but with a strong temperature difference between the facility and the environment. This value is generally associated with a fire. Although a fire is not part of this accident progression, the value will be used here as a conservative number.

> ***Leak Path Factor***
>
> - *Material Source: Plutonium Nitrate*
>   - *— LPF = 0.011*
> - *Material Source: Plutonium Oxide*
>   - *— LPF = 0.011*

Suspension Term with Failed HVAC Fans and Operational HEPA Filters. Table G.5.6.14–7 summarizes the results of the suspension term calculations. The material suspended is based on the type of accident and resulting dispersal mechanisms after the accident. For this case, the HVAC fans have failed but the HEPA filters remain intact. These terms are identical to the case where the HEPA filters failed, except for LPF. Because so little material is released during the accident, MAR is considered the same as the source term MAR. Therefore, only LPF is discussed below.

Leak Path Factor. The value will be used as a conservative number and is the same LPF used in the determination of the source term.

> ***Leak Path Factor***
>
> - *Material Source: Plutonium Nitrate*
>   - *— LPF = 0.011*
> - *Material Source: Plutonium Oxide*
>   - *— LPF = 0.011*

Summary of Source and Suspension Terms. Table G.5.6.14–8 summarizes the amount of material that is available for atmospheric transport. Each case represents a different failure mechanism for the building HEPA filtration systems.

Consequences for Facility Workers. All facility operations personnel receive emergency preparedness training specific to the facility and for procedures applicable to the entire LANL.

TABLE G.5.6.14–6.—*Source Term with Failed HVAC Fans and Operational HEPA Filters*

MATERIAL SOURCE	MAR	DR	ARF	RF	LPF	SOURCE TERM
Plutonium Nitrate	246 g	1.0	.01	0.6	0.011	0.016
Plutonium Oxide	1,000 g	0.1	0.9	1.0	0.011	0.01

TABLE G.5.6.14–7.—*Suspension Term with Failed HVAC Fans and Operational HEPA Filters*

MATERIAL SOURCE	MAR	DR	ARR	RELEASE PERIOD	RF	LPF	SUSPENSION TERM
Plutonium Nitrate	246 g	1.0	4×10^{-7}/hr	24 hrs	1.0	0.011	2.6×10^{-5}
Plutonium Oxide	1,000 g	0.1	4×10^{-5}/hr	24 hrs	1.0	0.011	1.1×10^{-3}

TABLE G.5.6.14–8.—*Summary of Material Available for Atmospheric Transport*

SCENARIO	MATERIAL TYPE	SOURCE TERM	SUSPENSION TERM	TOTAL
Filtration Systems Operating	Plutonium Nitrate	1.2×10^{-8} g	1.9×10^{-11} g	1.2×10^{-8} g
	Plutonium Oxide	7.2×10^{-9} g	7.7×10^{-10} g	8.0×10^{-9} g
Total				2.0×10^{-8} g
HEPAs Failed	Plutonium Nitrate	1.5 g	0.0023 g	1.5 g
	Plutonium Oxide	0.81 g	0.096 g	0.9 g
Total				2.4 g
HVAC Failed	Plutonium Nitrate	0.016 g	2.6×10^{-5} g	0.016 g
	Plutonium Oxide	0.011 g	0.0011 g	0.12 g
Total				0.14 g

The Emergency Action Plan directs personnel to move as quickly as possible away from any hazardous situation and to make appropriate notifications to the EM&R Office as soon as they are safely away from the hazard. Once notified, the EM&R Office assumes all elements of emergency response and coordination.

Breach of the ion-exchange column may include breach of adjacent vessels, breach of the glovebox exhaust filter, and damage to one or more gloves and/or loss of a window in the proximity of the affected column. The dissipation of the pressure surge through the glovebox line and the glovebox ventilation exhaust is such that no damage to the glovebox exhaust filter plenums would occur. If an operations technician is involved in glovebox work at the time of the postulated accident, severe injury is possible. The worker would be exposed to some glass shrapnel (protected, for the most part, by the shielding screen on the column) and to the forcibly ejected nitric acid/ plutonium nitrate solution (LANL 1996k).

No fatalities have been associated with ion-exchange resin explosions in nuclear applications. One medical disability resulted from the Hanford cation exchange column incident.

The airborne plutonium concentration in the room will be a function of the volume of gas generated by the column rupture, the degree of mixing in the glovebox, the level of damage to the glovebox, and the resultant volume of gas released to the room. Worker exposure is dependent on worker proximity to a potential glovebox breach and the residence time in the aerosol cloud. If glovebox confinement is breached, the room's continuous air monitor would detect the release of radioactive material to the room and provide both local and TA–55 Operation Center alarm of the incident.

Consequences for the Public. MACCS was used to determine the doses for the integrated populations. There is only one scenario where the HEPA filters failed and the fans continued to draw material through the ventilation system. Therefore, the atmospheric transport was modeled as an elevated release for both the initial release and the suspension release. Further discussions of atmospheric modeling can be found in section G.2.4.

As a point of comparison, the results of the MACCS runs were ratioed by the amount of material released in the other cases. Thus, the dose of each scenario can be compared (Table G.5.6.14–9).

From these results, no additional excess fatal cancers are anticipated from this event. Any of these results are well within the variations of measuring cancer fatalities within a population group.

The results of the analysis are summarized in Table G.5.6.14–10. No acute fatalities are predicted to result from the postulated accident. The mean collective population dose is projected to total 130 person-rem (TEDE), resulting in 0.063 excess fatal cancers. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.14–11 and G.5.6.14–12. Note that the MEIs are given only for the highest consequence result, but the resultant doses would be lower than those presented.

Deposition Profile. This result is given only for the scenario with the highest consequences. For the other cases the result is expected to be less.

G.5.6.15 *RAD–15, Plutonium Release from Laboratory and Wing Fires at CMR*

General Scenario Description

The accident scenario discussed in RAD–15 is for a general process-initiated fire at the CMR

TABLE G.5.6.14–9.—*A Result Comparison of the MACCS Runs*

	TOTAL MATERIAL RELEASED	INTEGRATED POPULATION DOSE (PERSON-REM)	EXCESS FATAL CANCERS
Release with Filtration System Operating	2.0×10^{-8} g	1.0×10^{-6}	5×10^{-10}
Release with HEPA Failed	2.4 g	130	0.06
Release with HVAC Failed	0.14 g	7.0	0.0035

TABLE G.5.6.14–10.—*Summary Results for RAD–14*

ALTERNATIVE	SCENARIO	ACCIDENT FREQUENCY (EVENT/YR)	INTEGRATED POPULATION EXPOSURE (PERSON-REM)	EXCESS FATAL CANCERS
No Action	Release with Operational Filtration System	8.5×10^{-10}	1.0×10^{-6}	5×10^{-10}
	Release with HEPAs Failed	5.6×10^{-16}	130	0.06
	Release with HVAC Failed	3.8×10^{-16}	7.0	0.0035
Expanded Operations	No Change	No Change	No Change	No Change
Reduced Operations	No Change	No Change	No Change	No Change
Greener	No Change	No Change	No Change	No Change

TABLE G.5.6.14–11.—*Predicted Mean Doses to MEIs for Scenario RAD–14*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)			
MEI LOCATION	OPERATIONAL HEPAs DOSE	DOSE FAILED HEPA	DOSE FAILED HVAC
Closest Public Access: Pajarito Road (50 m)	3.4×10^{-9}	4.1×10^{-1}	0.024
Closest Residence: Royal Crest Trailer Park (900 m)	2.4×10^{-9}	2.9×10^{-1}	0.017
Special Population Distance: Los Alamos Hospital (1,200 m)	1.6×10^{-9}	2.0×10^{-1}	0.012
Special Population Distance: San Ildefonso Pueblo boundary (3,900 m)	2.2×10^{-10}	2.7×10^{-2}	0.0015
Special Population Distance: San Ildefonso Pueblo (17,000 m)	1.4×10^{-11}	1.7×10^{-3}	1.2×10^{-6}

TABLE G.5.6.14–12.—*Predicted Mean Ground Contamination Levels for Scenario RAD–14*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	2.1×10^{3}
1.0 to 2.0 km	5.8×10^{2}
2.0 to 3.0 km	2.5×10^{2}
3.0 to 4.0 km	1.4×10^{2}
4.0 to 8.0 km	5.7×10^{1}
8.0 to 12.0 km	2.1×10^{1}
12.0 to 20.0 km	8.4×10^{0}
20.0 to 30.0 km	2.9×10^{0}
30.0 to 40.0 km	1.4×10^{0}
40.0 to 60.0 km	7.1×10^{-1}
60.0 to 80.0 km	3.8×10^{-1}

BQ/m^2 = Becquerel per square meter

Building. The fire is postulated to start in a laboratory that in the future may house a plutonium hydride-dehydride process. A variation of the scenario in which the fire develops into a wing-wide fire is also analyzed.

The plutonium hydride-dehydride process was developed from a small-scale experimental setup located at TA–55–4. This experiment was used to determine the rates of reaction and other physical parameters that were necessary for a feasibility study as well as the design of the hydride-dehydride process. In the future, the process may involve up to 4.5 kilograms of plutonium, and so was selected for analysis.

The fire is assumed to start from any one of a number of possible initiators. The fire is not put out either by personnel in the laboratory with manual fire extinguishers or by the laboratory automatic fire suppression systems. Furthermore, doors to the laboratory are left open allowing aerosolized plutonium to get into the corridor of the wing. Finally, emergency doors are used by personnel to exit the CMR Building, creating a pathway for aerosolized plutonium to escape the building.

In the future, this hydride-dehydride process may be located at both TA–55–4 and at the CMR Building. This scenario at TA–55–4 is not considered because the dehydride-hydride process itself is not considered a potential fire initiator due to current design features, which are listed in the preconceptual design report (LANL 1996q). Secondly, the fire history at TA–55–4 does not support a general fire scenario, given the defense-in-depth building features (such as fire barriers and HEPA filters), and the process designs (such as process monitoring and limited combustible material).

No Action Alternative Frequency Analysis

The frequencies above are derived in the subsequent subsections.

No Action Alternative Frequency Analysis

- *CMR Scenario: Laboratory Fire*
  - — *Fire Frequency = 4.0×10^{-3}*
  - — *Plutonium Release Frequency = 3.6×10^{-5}*
- *CMR Scenario: Wing-Wide Fire*
  - — *Fire Frequency = 3.5×10^{-5}*
  - — *Plutonium Release Frequency = 3.2×10^{-5}*

Fire Initiators

No specific initiator is used for this accident sequence. Instead, fires are taken to occur at a rate of approximately one per year. This frequency is based on a review of the number of CMR incident reports found in the ORPS database. There were three reported fire incidents in the 5 years.

Fire Frequency

Damage to the plutonium is possible only if fire suppression fails. Fire suppression includes actions by personnel in the laboratory as well as automatic fire suppression systems. Therefore, the frequency of a laboratory fire is the product of the frequency of fire incidents and the probability that successive fire suppression systems will fail. If either of these barriers succeed, the result is a fire that does not release radioactive material.

Fire Frequency

- *Frequency of fire incidents at CMR 1 per year*
- *Probability of manual suppression failure: 0.1 per event*
- *Probability of automatic suppression failure: 0.04 per event*
- *Frequency of laboratory fires at CMR 4×10^{-3} per year*

Operating history for industry indicates that about 90 percent of fires are manually extinguished. The same probability for the manual suppression of fires is used for accident analysis at the CMR Building (LANL 1997a). Thus, the second term is given as 0.1. The third term is taken from the probability of failure of the fire suppression system at TA–55 (SNL 1990).

For a wing-wide fire, there must first be a laboratory fire, and then a failure of the laboratory fire barriers. The fire barriers are the walls and doors of the laboratory. The frequency of a wing-wide fire is therefore estimated to be 3.5×10^{-5} per year. If the walls and doors contain the fire, no wing-wide fire occurs.

The fire door is a Type 1 barrier with a failure rate of 0.0074 per demand. The walls are a Type 3 barrier with a failure rate of 0.0012. Because either the door or walls could fail and therefore permit the fire to propagate into the wing, the sum of these terms, 0.0086, is the probability a fire barrier will fail.

Fire Frequency (Wing Wide)

- *Frequency of fire incidents at CMR 1 per year*
- *Probability of manual suppression failure: 0.1 per event*
- *Probability of laboratory automatic suppression failure: 0.04 per event*
- *Probability of laboratory fire barrier failure: 0.0086 per demand*
- *Estimated frequency of wing fires at CMR: 3.5×10^{-5} per year*

Failure of Containment and Release of Plutonium

Laboratory Fire. For the laboratory fire, in order for a substantial quantity of material to be released to the environment, the material must have a direct exit to the environment. If the material escape path is through the HEPA filters that filter exhaust air from the laboratory, or through those HEPA filters that separately process exhaust air from the wing, the material will be essentially contained on the filters. The failure rate of HEPA filters is approximately 1.3×10^{-5}. Thus, the combination of a fire and HEPA filter failure (3.5×10^{-5} per year x 1.3×10^{-5}) is not a reasonably foreseeable event.

Other means of allowing material to escape to the environment include creating openings into the laboratory that allow material to escape. For the laboratory fire, this includes leaving doors open or allowing material to escape through openings in the doors. In addition, because the laboratories are contained within the wing, a second opening from the wing to the outside must be created, such as by leaving an emergency exit open. That is, the material must escape a laboratory into the wing, and then escape the wing into the outdoors. The joint probability of a release is illustrated as follows:

> ***Laboratory Fire***
>
> - *Frequency of laboratory fires at CMR: 0.0004 per year*
> - *Probability of laboratory containment failure: 0.9 per event*
> - *Probability of wing containment failure: 0.1 per event*
> - *Frequency of plutonium release: 3.6 x 10^{-5} per year*

During a laboratory fire, it is considered quite probable that doors would be left open to accommodate personnel exiting the laboratory, or be opened for fire fighting equipment. Thus, the second term is conservatively estimated to be 0.9.

During a laboratory fire, personnel also may use wing emergency exits. The probability that these doors will not close is only 0.01 (LANL 1997a).

Wing Fire. For the wing fire, the frequency of releasing material is the joint frequency of a wing fire and the loss of confinement of material by the wing. This is illustrated as follows:

> ***Wing Fire***
>
> - *Frequency of wing fires at CMR: 3.5 x 10^{-5} per year*
> - *Probability of wing containment failure 0.9 per event*
> - *Frequency of plutonium release: 3.2 x 10^{-5} per year*

During a wing-wide fire it is considered quite probable that the confinement for the wing will be lost. Thus, the second term is determined to be 0.9.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis. The fire frequencies at the CMR Building remain the same across the alternatives. Due to process design features, the introduction of the hydride-dehydride process does not change the fire frequency at the CMR Building.

Uncertainties and Sensitivities Affecting the Frequency of RAD–15

The initiating fire frequency selected was that of all fires. The fact that these fires require a significant combustible loading to enable small fires to spread to the point of involving an entire laboratory and then a wing is not addressed. It is a recognized policy, enforced in practice and procedures, and addressed in worker training, to keep unnecessary combustibles out of areas where there is plutonium.

No Action Alternative—Initial Source and Suspension Term. Table G.5.6.15–1 summarizes the source term calculations. The derivation of these numbers is described in the following subsections.

The source terms are derived from consideration of the total amount of material that can be involved in a fire. Although fires can involve lesser amounts of material, the risk-dominant scenarios are those that damage

TABLE G.5.6.15–1.—*Summary of the Source Term Calculations (No Action Alternative)*

SCENARIO	MAR	DR	ARF	RF	LPF	SOURCE TERM
Laboratory Fire	1.0 kg	1.0	0.006	0.01	0.23	0.014 g
Wing Fire	6.0 kg	1.0	0.006	0.01	1.0	0.36 g

the entire laboratory or wing, with its the entire material inventory.

Material-at-Risk. MAR is the administrative limit for material in a laboratory (i.e., 1.0 kilogram of plutonium-239 equivalent). For the wing, the administrative limit is 6.0 kilogram plutonium-239 equivalent.

Material-at-Risk

- *Scenario: Laboratory Fire*
  — *MAR = 1.0 kg*
- *Scenario: Wing Fire*
  — *MAR = 6.0 kg*

Damage Ratio. The fire is assumed to damage the entire inventory. Therefore, the DR is assumed to be 1.0.

Damage Ratio

- *Scenario: Laboratory Fire*
  — *DR = 1.0*
- *Scenario: Wing Fire*
  — *DR = 1.0*

Airborne Release Fraction and Respirable Fraction. The ARF and RF values are taken from DOE Handbook 3010-94 and are based on material type, its form, and the nature of the challenge. The inventory is considered to be in a dispersible form. The ARF and RF values are selected for powder, even though not all of the material in the CMR Building is in the form of a powder. Other material forms and release mechanisms could be postulated, and some combinations could lead to higher values of ARF and RF. However, there are no controls in place at the facility that would control the inventories of various forms and packaging to be present. Also, evaluations of the plutonium facility fires at the Rocky Flats Plant demonstrated that the major contributor to environmental releases during those events was the tracking of contamination out of the facility by the firefighters and other responders. Assuming the material to be in powder form results in the maximum amount of material being made available for this release mechanism. For a fire, the recommended ARF and RF values are 0.006 and 0.01, respectively (DOE 1994d).

Airborne Release Fraction and Respirable Fraction

- *Scenario: Laboratory Fire*
  — *ARF = 0.006*
  — *RF = 0.01*
- *Scenario: Wing Fire*
  — *ARF = 0.006*
  — *RF = 0.01*

Leak Path Factor. The laboratory fire does not establish a direct path to the environment. Rather, a laboratory fire that does not propagate to involve the wing has an LPF of 0.23. This is the highest LPF found from complex modeling studies for this facility (LANL 1998a). For the wing-wide fire, loss of containment for the building equates to an LPF of 1.0.

Leak Path Factor

- *Scenario: Laboratory Fire*
  — *LPF = 0.23*
- *Scenario: Wing Fire*
  — *LPF = 1.0*

No Action Alternative—Suspension Term. The suspension term is the amount of material subsequently dispersed from the location of the accident by wind or other disturbances. The amount of material available for suspension is highly dependent on accident response and clean-up activities.

Table G.5.6.15–2 summarizes the suspension term results. It should be noted that if the

TABLE G.5.6.15–2.—*Summary of the Suspension Term Calculations (No Action Alternative)*

SCENARIO	MAR	DR	ARR	RELEASE PERIOD	RF	LPF	SUSPENSION TERM
Laboratory Fire	1.0 kg	1	0.00004	24	1	4×10^{-9}	3.84×10^{-9} g
Wing Fire	6.0 kg	1	0.00004	24	1	1	5.76 g

building remains intact after a wing fire, or if prompt clean-up activities are implemented, this term will be much smaller and could be near zero.

Material-at-Risk. The material remaining at the site is the initial source terms, minus the amount that was initially dispersed in respirable form. Because so little of the initial MAR is transported away from the site by the fire, the amount that is subject to suspension is the same as the initial MAR.

Material-at-Risk

- *Scenario: Laboratory Fire*
  - *— Initial MAR = 1.0 kg*
  - *— Initial Source Term = 0.014 g PE-Ci*
  - *— Suspension MAR = 1.0 kg*
- *Scenario: Wing Fire*
  - *— Initial MAR = 6.0 kg*
  - *— Initial Source Term = 0.36 g PE-Ci*
  - *— Suspension MAR = 6.0 kg*

Damage Ratio. For suspension, the amount of material damaged was considered to be the same as the fraction that was damaged in the fire.

Damage Ratio

- *Scenario: Laboratory Fire*
  - *— DR = 1.0*
- *Scenario: Wing Fire*
  - *— DR = 1.0*

Airborne Release Rate, Release Period, and Respirable Fractions. The ARR and RF selected correspond to a bed of powder exposed to nominal atmospheric conditions, even though this material may remain indoors away from the wind (DOE 1994d). The release period is conservatively assumed to be 24 hours, but could be shorter depending on when clean-up is begun.

Airborne Release Rate, Release Period, and Respirable Fractions

- *Scenario: Laboratory Fire*
  - *— ARR = 0.00004*
  - *— Release Period = 24*
  - *— RF = 1*
- *Scenario: Wing Fire*
  - *— ARR = 0.00004*
  - *— Release Period = 24*
  - *— RF =1*

Leak Path Factor. For a laboratory fire, the ventilation and HEPA filters are considered to be functional. The LPF for HEPA filtration, 4×10^{-9}, is therefore used for the laboratory fire. For a wing fire, the large damage assumed for this event is assumed to produce an LPF of 1.0.

Leak Path Factor

- *Scenario: Laboratory Fire*
  - *— LPF = 4×10^{-9}*
- *Scenario: Wing Fire*
  - *— LPF = 1*

Expanded Operations Alternative—Source and Suspension Term Calculations. For the Expanded Operations Alternative, the hydride-dehydride process could be located at either the

CMR Building or TA–55. As noted earlier, the general fire scenario is not reasonably foreseeable for TA–55. Therefore, the laboratory fire is assumed to be located in the CMR Building. The material for the hydride-dehydride process is considered to be in addition to the material already present in a CMR laboratory and wing.

Table G.5.6.15–3 summarizes the results of the source term determination. Each of the terms is derived in the following sections.

Material-at-Risk (Table G.5.6.15–4). The hydride-dehydride process is the continuous processing of plutonium from a solid to a plutonium hydride and then into a plutonium powder. The maximum amount of plutonium hydride estimated to be in the process is 250 grams. This material is represented separately because of its pyrophoric nature. The remainder of the material in the laboratory is the feedstock for the hydride-dehydride process, 4.25 kilograms of plutonium metal (LANL 1997d). Although the CMR Building has an administrative wing limit of 6 kilograms of plutonium-239 equivalent, for the Expanded Operations Alternative, the amount of material associated with the hydride-dehydride process has been added to the amount currently in a CMR wing.

Damage Ratio (Table G.5.6.15–5). Because the fire is assumed to involve the entire laboratory, the damage ratio is 1.0. Because the wing fire is assumed to damage the entire wing, the damage ratio for the material is again assumed to be 1.0.

Airborne Release Fraction and Respirable Fraction (Table G.5.6.15–6). The ARF and RF values from DOE Handbook 3010-94 are 0.01 and 1.0, respectively, for finely divided plutonium hydride (DOE 1994d).

Leak Path Factor (Table G.5.6.15–7). LPF is taken as 0.23 for the laboratory fire and 1.0 for the wing fire (LANL 1998b).

Expanded Operations Alternative—Suspension Term. Table G.5.6.15–8 summarizes the results for the suspension term.

Material-at-Risk (Table G.5.6.15–9). The material available for suspension after the fire is considered the initial MAR, minus the respirable quantity transported off site. In most instances, except for the plutonium hydride, so little is considered to have be transported away that the initial MAR was used for the suspension MAR.

Damage Ratio (Table G.5.6.15–10). Because of the fire scenario, all material was considered to be vulnerable to further dispersal. The damage ratio is therefore 1.0.

Airborne Release Rate, Release Period, and Respirable Fraction (Table G.5.6.15–11). The ARF and RF values are 4 x 10^{-5} per hour and 1.0 (DOE 1994d). The release period is considered to be 24 hours. Prompt clean-up can reduce this amount considerably.

Leak Path Factor (Table G.5.6.15–12). For a laboratory fire, the ventilation and HEPA filters are considered to be functional. The LPF for HEPA filtration is therefore used for the laboratory fire. For a wing fire, the large damage assumed for this event corresponds to an LPF of 1.0.

Uncertainties and Sensitivities affecting the Source Term for RAD–15. The values calculated above are bounding. The largest uncertainty in the source term is considered to be the assumption of an LPF of 1.0. Such a large LPF may be applicable when the structure has completely failed (i.e., collapsed) or when the structure is intact but the HVAC fans are continuing to run with failed HEPA filters. A running ventilation system will pull air into the building through opened doors. In this conservative analysis, it is assumed that the HVAC system is failed or bypassed, but the structure remains intact.

TABLE G.5.6.15–3.—*Summary of the Source Term Calculations (Expanded Operations Alterative)*

SCENARIO	MATERIAL TYPE	MAR	DR	ARF	RF	LPF	INITIAL SOURCE TERM
Laboratory Fire	Plutonium Hydride	250 g	1.0	0.01	1.0	0.23	0.575 g
	Plutonium (metal)	4.25 kg	1.0	0.0005	0.5	0.23	0.25 g
Wing Fire	Plutonium Hydride	250 g	1.0	0.01	1.0	1.0	2.5 g
	Plutonium (metal)	4.25 kg	1.0	0.0005	0.5	1.0	1.06 g
	Plutonium-239 equivalent powders, solutions, solids	6.0 kg	1.0	0.006	0.01	1.0	0.36 g

TABLE G.5.6.15–4.—*Material-at-Risk (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	MAR
Laboratory Fire	Plutonium Hydride	250 g
	Plutonium (metal)	4.25 kg
Wing Fire	Plutonium Hydride	250 g
	Plutonium (metal)	4.25 kg
	Plutonium-239 equivalent powders, solutions, solids	6.0 kg

TABLE G.5.6.15–5.—*Damage Ratio (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	DR
Laboratory Fire	Plutonium Hydride	1.0
	Plutonium (metal)	1.0
Wing Fire	Plutonium Hydride	1.0
	Plutonium (metal)	1.0
	Plutonium-239 equivalent powders, solutions, solids	1.0

TABLE G.5.6.15–6.—*Airborne Release and Respirable Fraction (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	ARF	RF
Laboratory Fire	Plutonium Hydride	0.01	1.0
	Plutonium (metal)	0.0005	0.5
Wing Fire	Plutonium Hydride	0.01	1.0
	Plutonium (metal)	0.0005	0.5
	Plutonium-239 equivalent powders, solutions, solids	0.006	0.01

TABLE G.5.6.15–7.—*Leak Path Factor (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	LPF
Laboratory Fire	Plutonium Hydride	0.23
	Plutonium (metal)	0.23
Wing Fire	Plutonium Hydride	1.0
	Plutonium (metal)	1.0
	Plutonium-239 equivalent powders, solutions, solids	1.0

TABLE G.5.6.15–8.—*Summary of Suspension Term Calculations (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	MAR	DR	ARR	RELEASE PERIOD	RF	LPF	SUSPENSION SOURCE TERM
Laboratory Fire	Plutonium Hydride	249g	1.0	0.00004	24 hrs	1.0	4×10^{-9}	9.5616e-10 g
	Plutonium (metal)	4.25 kg	1.0	0.00004	24	1.0	4×10^{-9}	1.632e-8 g
Wing Fire	Plutonium Hydride	248 g	1.0	0.00004	24	1.0	1.0	0.24 g
	Plutonium (metal)	4.25 kg	1.0	0.00004	24	1.0	1.0	4.1 g
	Plutonium-239 equivalent powders, solutions, solids	6.0 kg	1.0	0.00004	24	1.0	1.0	5.76 g

TABLE G.5.6.15–9.—*Material-at-Risk (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	LPF
Laboratory Fire	Plutonium Hydride	249 g
	Plutonium (metal)	4.25 kg
Wing Fire	Plutonium Hydride	248 g
	Plutonium (metal)	4.25 kg
	Plutonium-239 equivalent powders, solutions, solids	6.0 g

TABLE G.5.6.15–10.—*Damage Ratio (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	DR
Laboratory Fire	Plutonium Hydride	1.0
	Plutonium (metal)	1.0
Wing Fire	Plutonium Hydride	1.0
	Plutonium (metal)	1.0
	Plutonium-239 equivalent powders, solutions, solids	1.0

TABLE G.5.6.15–11.—*Airborne Release Rate, Release Period, and Respirable Fraction (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	ARR	RELEASE PERIOD	RF
Laboratory Fire	Plutonium Hydride	0.00004	24 hrs	1.0
	Plutonium (metal)	0.00004	24 hrs.	1.0
Wing Fire	Plutonium Hydride	0.00004	24 hrs.	1.0
	Plutonium (metal)	0.00004	24 hrs.	1.0
	Plutonium-239 equivalent powders, solutions, solids	0.00004	24 hrs.	1.0

TABLE G.5.6.15–12.—*Leak Path Factor (Expanded Operations Alternative)*

SCENARIO	MATERIAL TYPE	LPF
Laboratory Fire	Plutonium Hydride	4×10^{-9}
	Plutonium (metal)	4×10^{-9}
Wing Fire	Plutonium Hydride	1.0
	Plutonium (metal)	1.0
	Plutonium-239 equivalent powders, solutions, solids	1.0

The assumption also was made that one or a few doors would permit aerosolized material to escape. The area of the doors is small relative to the volume of the building, and so there will be a delay during which airborne material will be depositing within the building during its transit between the fire and the release points. This deposition is not accounted for in this analysis. The amount of material available for release also will be reduced by the foam and water used by fire fighting crews who are supposedly leaving doors open. To assume that fire fighters will have open doors requires the sensible assumption that they also will be laying down suppressants that reduce the initial release and will stop all subsequent suspension.

No Action, Expanded Operations, Reduced Operations, and Greener Alternatives Consequences for Facility Workers

Consequences to Workers. From one to three workers may be present in the glovebox operations. These workers could be injured or killed due to direct fire effects in a laboratory fire, or they could be exposed to plutonium oxide particulates by inhalation.

In the case of a wing fire, there may be several dozen workers present in the wing. These workers could be injured or killed due to direct fire effects, or could be exposed to plutonium oxide particulates by inhalation. Workers elsewhere in the building could be exposed to plutonium inhalation and skin contamination.

Because of the long time (decades) for any effects of plutonium inhalation to appear, there would be no deaths from acute doses.

Consequences to the Public. MACCS was used to determine the doses for the integrated populations. The source term was modeled as a 30-minute elevated release. The suspension term was modeled as three, 8-hour, ground level releases. For a discussion of the MACCS code and modeling results, please refer to section G.2.4.

The results of this analysis for a laboratory fire are summarized in Table G.5.6.15–13. No acute fatalities are predicted due to exposure to plutonium. If the fire remains within the laboratory, no excess LCFs are expected from this accident.

The results of this analysis for the wing fire are summarized in Table G.5.6.15–14. The consequences and risk are greater than with the laboratory fire because of the greater inventory of material when the entire wing is considered. If the total wing material is held to 13 pounds (6.0 kilograms), the doses increase slightly when the hydride-dehydride process is introduced because of the pyrophoric nature of the plutonium hydride.

The MEI doses for the Expanded Operations case are given in Table G.5.6.15–15. The MEI doses for the No Action Alternative would be less because the amount of material involved is less.

TABLE G.5.6.15–13.—*Summary Results for CMR Laboratory Fire, RAD–15*

ALTERNATIVE	ACCIDENT FREQUENCY (EVENT/YR)	INTEGRATED POPULATION DOSE (PERSON-REM)	EXCESS LATENT FATAL CANCERS
No Action	3.6×10^{-5}	4.5	0.0023
Expanded Operations	No Change[a]	175	0.088
Reduced Operations	No Change[a]	No Change[a]	No Change[a]
Greener	No Change[a]	No Change[a]	No Change[a]

[a] No change is expected with regard to the No Action Alternative.

TABLE G.5.6.15–14.—*Summary Results for the CMR Wing Fire, RAD–15*

ALTERNATIVE	ACCIDENT FREQUENCY (EVENT/YR)	INTEGRATED POPULATION DOSE (PERSON-REM)	EXCESS LATENT FATAL CANCERS
No Action	3.2×10^{-5}	1,700	0.85
Expanded Operations	No Change[a]	3,400	1.7
Reduced Operations	No Change[a]	No Change[a]	No Change[a]
Greener	No Change[a]	No Change[a]	No Change[a]

[a] No change is expected with regard to the No Action Alternative.

TABLE G.5.6.15–15.—*Predicted Mean Doses to MEIs for Scenario RAD–15 (Expanded Operations Alternative)*

MAXIMUM EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)		
MEI LOCATION	LABORATORY FIRE	WING FIRE
Closest Public Access (SA): Diamond Road (40 m)	0.41	9.1×10^{1}
Nearest Residence (CMR SAR): Los Alamos Townsite (1,000 m)	0.48	9.2×10^{0}
Nearest Special Population Distance: Los Alamos Medical Center (1,100 m)	0.18	3.4×10^{0}
Other Nearest Residences (CMR SAR): Royal Crest Trailer Park (1,200 m)	0.16	3.0×10^{0}
Special Population Distance: San Ildefonso Pueblo (4,500 m)	0.02	3.5×10^{-1}
Special Population Distance: San Ildefonso Pueblo (18,600 m)	0.001	2.6×10^{-2}

Note: Approximated as 50 m.

Deposition Profile. The ground contamination levels for the Expanded Operations Alternative are given in Table G.5.6.15–16. The levels for the No Action Alternative would decrease correspondingly to the amount of material released for the No Action Alternative.

After publication of the Draft LANL SWEIS, DOE approved the CMR Basis for Interim Operations (BIO) (LANL 1998b) on August 31, 1998. That document includes a detailed analysis of a similar wing-wide fire. The CMR BIO takes a different approach to the accident, due to its stated need to identify the facility systems, processes, and controls necessary to prevent or mitigate the postulated accidents. The CMR BIO analysis results in a similar frequency, and MEI doses ranging from 10.8 rem to 42.8 rem, depending on the release mechanisms. The CMR BIO also assumes 95 percent meteorological conditions; whereas, the SWEIS uniformly assumed mean conditions. Given the differing assumptions in the scenarios, the large underlying uncertainties in such analyses, and the difference in meteorological modeling, these results demonstrate good agreement. Therefore, both analyses provide similar results to allow for the appropriate decision making.

G.5.6.16 *RAD–16, Plutonium Release Due to Aircraft Crash and Fire at CMR*

General Scenario Description

Accident Scenario RAD–16 involves the crash of an aircraft, accompanied by a fire, at the CMR Building, TA–3–29.

From the analysis of the aircraft operating in the vicinity of the CMR Building (section G.4.1.3), single- and multiple-engine general aviation aircraft and small military aircraft are capable of penetrating into a wing at the CMR Building. A fire then starts due to ignition of the planes fuel load and damage to a portion of the plutonium inventory in a wing. Because a range of outcomes is possible, the damage to the inventory is assumed to be proportional to the size of the burn area created by the fuel spill.

No Action Alternative Frequency Analysis

The analysis for the frequency of aircraft hitting the CMR Building and causing a release of hazardous material is presented in section G.4.1.3. The frequency for an aircraft penetration and resulting fire for the CMR Building is 3.5 x 10^{-6}. The aircraft that operate in the vicinity of LANL are predominantly general aviation, either single- or multiple-engine aircraft, with additional small military aircraft that make overflights in the area. These aircraft make up approximately 96 percent of the aircraft that have a greater than 10^{-6} chance per year of hitting and releasing material from the CMR Building.

It should be noted that the area of the CMR Building was reduced from the total building square footage to the combined areas of Wings 3, 5, 7, and 9. Because most of the hazardous materials are located in these areas, the reduction in area was deemed reasonable to account for the frequency of actually involving hazardous material in an aircraft crash induced fire. If the entire building is used for the calculations, the results change modestly (by about a factor of 2).

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

The frequency of an aircraft crash does not vary across the alternatives. Because no major changes in the location of hazardous material or their amounts are planned across alternatives, the probability of releasing these materials from an aircraft crash does not change.

TABLE G.5.6.15–16.—*Ground Contamination Levels (Expanded Operations Alternative)*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)	
	LABORATORY FIRE	WING FIRE
0.0 to 1.0 km	2.0×10^{3}	4.0×10^{4}
1.0 to 2.0 km	3.8×10^{2}	7.5×10^{3}
2.0 to 3.0 km	1.9×10^{2}	3.7×10^{3}
3.0 to 4.0 km	1.2×10^{2}	2.2×10^{3}
4.0 to 8.0 km	4.7×10^{1}	9.2×10^{2}
8.0 to 12.0 km	1.9×10^{1}	3.7×10^{2}
12.0 to 20.0 km	7.5	1.5×10^{2}
20.0 to 30.0 km	3.0	5.8×10^{1}
30.0 to 40.0 km	1.7	3.3×10^{1}
40.0 to 60.0 km	8.2×10^{-1}	1.6×10^{1}
60.0 to 80.0 km	4.3×10^{-1}	8.5×10^{0}

BQ/m^2 = Becquerel per square meter

Uncertainties and Sensitivities Affecting the Frequency of RAD–16

There is a large number of data required in order to perform the DOE Standard 3014-96 calculations. In addition, the standard itself requires the use of numerous equations that are recognized to be approximations.

No Action Alternative Source and Suspension Term Calculations

Source Term. The source term is derived from consideration of the amount of material that can be involved in a fire and the subsequent amount that, through the dynamics of the accident and a fire, can be made available for atmospheric transport. Because there are several types of aircraft that contribute to the frequency term for an aircraft crash event, the source terms for the three most likely aircraft to impact the CMR Building, are listed in Table G.5.6.16–1.

Determination of the source term follows the standard format, as illustrated in Table G.5.6.16–1. The source term summary presented in this table is explained in subsequent sections.

The source terms are calculated by multiplying together each of the factors in the standard equation. These results represent the magnitude of the releases possible from different categories of aircraft that operate in the vicinity of LANL.

Material-at-Risk. Each wing in the CMR Building is limited to a maximum of 6.0 kilograms of equivalent plutonium-239 (LANL 1997a). The aircraft are assumed to penetrate only one wing. This scenario is based on the ability of aircraft to penetrate structures. This is assessed by determining whether or not dense components (such as an engine shaft, etc.) can penetrate the building. The fuel is conservatively assumed to enter the building through these penetrations. Thus, this scenario is not likely to involve more material than is in one wing of the CMR Building. MAR, regardless of the aircraft category, is considered to be the maximum inventory in a wing.

Material-at-Risk

Aircraft Category:

- *Single-Engine*
  - — *MAR = 6.0 kg Pu-239 (equivalent)*
- *Multiple-Engine*
  - — *MAR = 6.0 kg Pu-239 (equivalent)*
- *Small Military*
  - — *MAR = 6.0 kg Pu-239 (equivalent)*

Damage Ratio. DR will be determined by assessing how much of the inventory could be affected by the fire. To do this, a fire is assumed to start from a fuel spill that spreads across a portion of the CMR Building, and subsequently involves the inventory of plutonium in this portion. The Rocky Flats Risk Assessment Guide (RFETS 1994) was used to determine the burn area for the amount of fuel spilled. In this case, the entire fuel load of the appropriate aircraft is assumed to burn. Because the inventories are being used in various

TABLE G.5.6.16–1.—*Source Term for Aircraft Crash*

AIRCRAFT CATEGORY	MAR[a]	DR	ARF	RF	LPF	SOURCE TERM[a]
Single-Engine	6.0 kg Pu-239	.021	0.006	0.01	1.0	0.008 g Pu-239
Multiple-Engine	6.0 kg Pu-239	.068	0.006	0.01	1.0	0.024 g Pu-239
Small Military	6.0 kg Pu-239	.298	0.006	0.01	1.0	0.11 g Pu-239

[a] Pu-239 refers to equivalent plutonium-239.

gloveboxes and laboratories throughout a wing, the inventory is also assumed to be evenly distributed throughout the CMR wing. Thus, the damage ratio for a given aircraft category was determined to be the ratio of the burn area to the total square footage of one wing in the CMR Building.

Damage Ratio

Aircraft Category:

- *Single-Engine*
  - — *DR = 0.021*
- *Multiple-Engine*
  - — *DR = 0.068*
- *Small Military*
  - — *DR = 0.298*

The characteristics of these aircraft categories, as identified in the supporting documentation for DOE Standard 3014-96, were reviewed and the bounding fuel load was selected. The aircraft selected for these categories are: (1) the Piper Turbo line, with a fuel load of 128 gallons (486 liters) for the single-engine piston aircraft; (2) the Cessna Titan line, with a fuel load of 413 gallons (1,564 liters) for the multiple-engine piston aircraft; and (3) the F-16C, with a fuel load of 1,801 gallons (6,819 liters) for the small military aircraft (LLNL 1996). (The F-16C is typical of local military operations out of Kirtland Air Force Base in Albuquerque, New Mexico.)

According to the Rocky Flats Risk Assessment Guide (RFETS 1994), the estimate for burn area is a 250-square-foot (23-square-meter) burn area per 50 gallons (189 liters) of fuel.

The area of a wing, A_{WING}, at the CMR Building is approximately 30,250 square feet (275 feet by 110 feet). The burn areas identified below represent the following percentages of the total square footage for a wing at the CMR Building and therefore represent an equivalent DR for the plutonium inventory in a wing.

Burn Areas

Aircraft Category:

- *Single-Engine*
  - — F_{LOAD} = 128 gal.
  - — A_{BURN} = 640 ft^2
- *Multiple-Engine*
  - — F_{LOAD} = 413 gal.
  - — A_{BURN} = 2,065 ft^2
- *Small Military*
  - — F_{LOAD} = 2,802 gal.
  - — A_{BURN} = 9,005 ft^2

A_{BURN} = Burn area in square feet
F_{LOAD} = Aircraft fuel load in gallons

Burn Area Square Footage

Aircraft Category:

- *Single-Engine*
  - — *% Total Footage* (A_{BURN}/A_{WING} = *2.1%)*
  - — *DR = 0.021*
- *Multiple-Engine*
  - — *% Total Footage* (A_{BURN}/A_{WING} = *6.8%)*
  - — *DR = 0.068*
- *Small Military*
  - — *% Total Footage* (A_{BURN}/A_{WING} = *29.8%)*
  - — *DR = 0.298*

Airborne Release Fraction and Respirable Fraction. The DOE Handbook on airborne release fractions and respirable fractions, DOE Handbook 3010-94, presents values for ARF and RF based on the type of material, its form, and the nature of the event (e.g., fire, explosions, etc.). The ARF and RF values are selected for plutonium in powder form. These values represent the highest numbers for ARF and RF of the material in the CMR Building even though not all of the material in the CMR Building is in the form of a powder. For a fire, the recommended ARF and RF values are 0.006 and 0.01 (DOE 1994d).

Airborne Release Fraction and Respirable Fraction

Aircraft Category:

- *Single-Engine*
  - *ARF = 0.006*
  - *RF = 0.01*
- *Multiple-Engine*
  - *ARF = 0.006*
  - *RF = 0.01*
- *Small Military*
  - *ARF = 0.006*
  - *RF = 0.01*

Leak Path Factor. Due to the nature of an aircraft crash into a building and subsequent fire, no credit is taken for confinement of the material by either the structure or potential accident debris. The material that is in a respirable form can then be transported through the atmosphere. LPF is therefore assumed to be 1.0.

Leak Path Factor

Aircraft Category:

- *Single-Engine*
  - *LPF = 1.0*
- *Multiple-Engine*
  - *LPF = 1.0*
- *Small Military*
  - *LPF = 1.0*

Suspension Term. The suspension term is derived from consideration of the amount of material that can be further dispersed from the site of the accident by the wind or other disturbances. The amount of material available for suspension is highly dependent on accident response and clean-up activities. However, due to the nature of an aircraft accident, it is assumed that the material at the site can be released into the atmosphere for the next 24 hours.

Determination of the suspension term follows the standard format, as illustrated in Table G.5.6.16–2. The summary of the suspension term, as presented in this table, is explained in subsequent sections.

The suspension terms are calculated by multiplying each of the factors in the standard equation together. These results represent the magnitude of the suspension releases possible from different categories of airplanes that operate in the vicinity of LANL.

Material-at-Risk. Because so little of the material is released due to the fire, most of the material remains at the site. Therefore, 6.0 kilograms equivalent plutonium-239 is considered the MAR for suspension from the release point.

Material-at-Risk

Aircraft Category:

- *Single-Engine*
  - *MAR = 6.0 kg Pu-239 (equivalent)*
- *Multiple-Engine*
  - *MAR = 6.0 kg Pu-239 (equivalent)*
- *Small Military*
  - *MAR = 6.0 kg Pu-239 (equivalent)*

TABLE G.5.6.16–2.—*Suspension Term Calculations (No Action Alternative)*

AIRCRAFT CATEGORY	MAR[a]	DR	ARR	RELEASE PERIOD	RF	LPF	SUSPENSION TERM[a]
Single-Engine	6.0 kg Pu-239	0.021	4×10^{-6}/hr	24 hrs	1.0	1.0	0.008 g Pu-239
Multiple-Engine	6.0 kg Pu-239	0.068	4×10^{-6}/hr	24 hrs	1.0	1.0	0.024 g Pu-239
Small Military	6.0 kg Pu-239	0.298	4×10^{-6}/hr	24 hrs	1.0	1.0	0.11 g Pu-239

[a] Pu-239 refers to equivalent plutonium-239.

Damage Ratio. The DR is the same as the source term release. Material that was not damaged by the initial event is not considered available for suspension releases.

> ***Damage Ratio***
>
> *Aircraft Category:*
> - *Single-Engine*
>   - *DR = 0.021*
> - *Multiple-Engine*
>   - *DR = 0.068*
> - *Small Military*
>   - *DR = 0.298*

Airborne Release Rate, Release Period, and Respirable Fractions. For the fire release, the appropriate ARR and RF values are 4.0 x 10^{-6} per hour and 1.0, respectively, because it is assumed that the source powder would be buried under some structural debris (DOE 1994d). The suspension is assumed to occur for 24 hours after the initial accident.

> ***Airborne Release Rate, Release Period, and Respirable Fraction***
>
> *Aircraft Category:*
> - *Single-Engine*
>   - *ARR = 4 x 10^{-6} per hour*
>   - *Release Period = 24 hours*
>   - *RF = 1.0*
> - *Multiple-Engine*
>   - *ARR = 4 x 10^{-6} per hour*
>   - *Release Period = 24 hours*
>   - *RF = 1.0*
> - *Small Military*
>   - *ARR = 4 x 10^{-6} per hour*
>   - *Release Period = 24 hours*
>   - *RF = 1.0*

Leak Path Factor. Because the material is exposed to ambient conditions, LPF was considered to be 1.0. ARR accounts for any protection of the material by the debris at the site.

> ***Leak Path Factor***
>
> *Aircraft Category:*
> - *Single-Engine*
>   - *LPF = 1.0*
> - *Multiple-Engine*
>   - *LPF = 1.0*
> - *Small Military*
>   - *LPF = 1.0*

Uncertainties and Sensitivities Affecting the Source Term for RAD–16

The suspension source term calculation extends for 24 hours. This is very conservative in that it is likely that fire fighting and HAZMAT response to the crash scene would be accompanied by extensive use of water and foam-based suppression systems. This application of suppressants would likely continue for some time to preclude flareup of the fire once it is extinguished, as well as precisely to limit further spread of plutonium contamination.

Expanded Operations, Reduced Operations, and Greener Alternatives Source and Suspension Term Analysis

The source and suspension terms do not vary across the alternatives. Because no major changes in the location of hazardous material or their amounts are planned across alternatives, the source and suspension terms do not change. The amount of material that could be involved in the accident varies and has been conservatively estimated based on the wing limits for the facility. These wing limits do not change across alternatives.

Consequences for Facility Workers

An aircraft crash is capable of killing or injuring a large fraction of the worker population in the impacted wing due to generation of missiles, structural damage, fire, etc. Workers in the CMR Building who are not directly affected by the crash and explosion or fire may be exposed to radiation as a result of plutonium inhalation.

Consequences for the Public

To determine the consequences, or dose, to the public, an average value was used, based on frequency weighting the source and suspension terms for each aircraft category. The total source term used for dose and excess LCF calculations is 0.69 equivalent plutonium-239 (Table G.5.6.16–3). The total suspension term is 0.21 PE-Ci (Table G.5.6.16–4).

MACCS was used to determine the doses for the integrated populations. The source term was modeled as a 30-minute elevated release. The suspension term was modeled as three, 8-hour, ground level releases. For a discussion of the MACCS code and modeling results, please refer to section G.2.4.

The results for this accident are summarized in Table G.5.6.16–5. The accident may result in fatalities to occupant(s) of the aircraft and to people on the ground. However, no acute fatalities from the release of plutonium are predicted to result from the postulated accident. The mean collective population dose is projected to total 56 person-rem (TEDE), resulting in 0.03 excess LCFs. Mean projected doses for MEIs (and their associated locations) and ground contamination levels are presented in Tables G.5.6.16–6 and G.5.6.16–7, respectively.

G.5.7 Facility Hazard Accidents

G.5.7.1 *WORK–01, Inadvertent High Explosives Detonation*

General Description of High Explosives Operations

High explosives (HE) processing facilities are located at LANL TA–8, TA–9, TA–11, TA–16, TA–28, and TA–37. HE processing activities include storage, synthesis, formulation, pressing, machining, assembly, quality assurance processes, shipping and receiving of HE and HE devices, and disposal. Los Alamos HE facilities were designed in accordance with U.S. Department of Defense (DoD) Ammunition and Explosives Safety Standards, DoD 6055.9 (now referenced in the DOE Explosives Safety Manual [DOE 1994g]). Processing equipment has been continually upgraded and modernized.

HE processing facilities are generally separated from other operations and are all within restricted areas that require DOE badges for access through security check stations. Access to all buildings is further controlled by locks on building entrances that require specially controlled keys. Additionally, all HE areas are patrolled by protective force guards.

Operational controls and the associated level of protection are based on the explosive hazard class. There are four hazard classes. Hazard Class I processes involve activities that are considered to have a high accident potential and are designed to be conducted remotely so that an accidental detonation vents the high pressure and fragments via a frangible wall away from inhabited areas. Examples of Class I activities include screening, blending, pressing, dry machining, and new explosives development. Hazard Class II activities involve a moderate accident potential; examples include weighing, some wet machining, assembly and disassembly, and environmental testing. Hazard Class III activities are designated as having a low accident potential and include storage activities and operations incidental to storage. Hazard Class IV consists of activities involving insensitive HE. This explosive type is so insensitive that a negligible probability exists for accidental initiation or transition from burning to detonation. Selected activities using insensitive HE, such as machining and pressing, are conservatively designated as Class I. Explosives and personnel limits and controls are used to minimize the quantity of explosives and

TABLE G.5.6.16–3.—*Frequency Weighted Source Term Calculation for Fire Source Term*

AIRCRAFT TYPE	FRACTIONAL CONTRIBUTION TO PERFORATION/FIRE FREQUENCY	INITIAL SOURCE TERM (GRAMS EQUIVALENT PLUTONIUM-239)	WEIGHTED INITIAL SOURCE TERM GRAMS EQUIVALENT PLUTONIUM-239
Single-Engine Piston	0.77	0.008	0.0616
Multiple-Engine Piston	0.16	0.024	0.0038
Small Military	0.031	0.11	0.0034
TOTAL	0.961		0.69

TABLE G.5.6.16–4.—*Frequency Weighted Source Term Calculation for Fire Suspension Term*

AIRCRAFT TYPE	FRACTIONAL CONTRIBUTION TO PERFORATION/FIRE FREQUENCY	INITIAL SOURCE TERM (GRAMS EQUIVALENT PLUTONIUM-Ci)	WEIGHTED INITIAL SOURCE TERM GRAMS EQUIVALENT PLUTONIUM-239
Single-Engine Piston	0.77	0.012	0.00924
Multiple-Engine Piston	0.16	0.039	0.00624
Small Military	0.031	0.17	0.00527
TOTAL	0.961		0.21

TABLE G.5.6.16–5.—*Summary Results for Scenario RAD–16*

ALTERNATIVE	ACCIDENT FREQUENCY (EVENT/YR)	INTEGRATED POPULATION EXPOSURE (PERSON-REM)	EXCESS FATAL CANCERS
No Action	3.5×10^{-6}	56	0.03
Expanded Operations	3.5×10^{-6}	No Change	No Change
Reduced Operations	3.5×10^{-6}	No Change	No Change
Greener	3.5×10^{-6}	No Change	No Change

Note: No change is expected with regard to the No Action Alternative.

TABLE G.5.6.16–6.—*Predicted Mean Doses to MEIs for Scenario RAD–16*

MAXIMALLY EXPOSED INDIVIDUAL (MEI) DOSE (REM, TEDE)	
MEI LOCATION	**DOSE**
Closest Public Access (SA): Diamond Road (40 m)	3.0
Nearest Residence (CMR SAR): Los Alamos Townsite (1,000 m)	3.4×10^{-2}
Nearest Special Population Distance: Los Alamos Medical Center (1,100 m)	2.8×10^{-2}
Other Nearest Residences (CMR SAR): Royal Crest Trailer Park (1,200 m)	2.4×10^{-2}
Special Population Distance: San Ildefonso Pueblo (4,500 m)	4.1×10^{-3}
Special Population Distance: San Ildefonso Pueblo (18,600 m)	8.4×10^{-4}

TABLE G.5.6.16–7.—*Predicted Mean Ground Contamination Levels*

RADIAL DISTANCE	PLUTONIUM-239 GROUND CONCENTRATION (BQ/m^2)
0.0 to 1.0 km	5.0×10^{2}
1.0 to 2.0 km	5.8×10^{1}
2.0 to 3.0 km	2.6×10^{1}
3.0 to 4.0 km	1.9×10^{1}
4.0 to 8.0 km	1.5×10^{1}
8.0 to 12.0 km	1.1×10^{1}
12.0 to 20.0 km	6.1×10^{0}
20.0 to 30.0 km	2.6×10^{0}
30.0 to 40.0 km	1.3×10^{0}
40.0 to 60.0 km	7.3×10^{-1}
60.0 to 80.0 km	4.1×10^{-1}

BQ/m^2 = Becquerel per square meter

the number of personnel to carry out an operation in a safe and efficient manner. Personnel may not work alone performing explosives activities that have a high risk of serious injury. Additionally, quantity-separation distance criteria are used to minimize collateral damage in the event of an accident.

General Scenario Description

Accident scenario WORK–01 involves the inadvertent detonation of HE material. Potential accidents involving hazardous or radioactive material are not considered, as their impacts are bounded by the chemical and radiological specific accidents, which have been already analyzed. Based on the foregoing operations/controls discussion, it is very unlikely that an accident would impact workers other than those directly involved in the explosives activity, and it would be extremely unlikely that any credible postulated event would involve the public. The number of individuals that may be injured or fatally harmed for a postulated event will vary depending on the quantity of explosives involved and the number of workers present. As discussed above, operational controls limit both parameters. Laboratory testing of small samples may involve only one worker, while assembly operations (e.g., TA–16–411) may vary from three to ten workers. Blast effects to individuals are summarized in Table G.5.7.1–1 and are taken from the tri-service manual on *Structures to Resist the Effects of Accidental Explosions* (U.S. Army et al. 1990). Generally, human tolerance to the blast output of an explosion is relatively high, with specific impacts dependent on the orientation of the individual to the blast front and the shape of the pressure front (fast or slow rise, stepped loading). The lungs are considered the critical target organ in blast pressure injuries. Considering the high level of human tolerance to blasts and fragment operational/design controls, it is more likely that a postulated explosive accident will result in worker injuries rather than fatalities.

No Action Alternative Frequency Analysis

Walkdowns of selected HE processing facilities and discussions with knowledgeable facility personnel did not identify the occurrence of any explosive blast accidents at LANL resulting in injuries or fatalities. Additionally, a search of 5 years of LANL occurrence report data (1990 through 1994 Type F Reports) did not identify any explosive blast accidents. Site-specific experience at Pantex results in an explosive accident frequency of 10^{-2} per year (DOE 1996a). Based on this DOE system experience and scaling for the level of worker activities (2,000 weapons operations annually at Pantex), an accident frequency range of 10^{-3} to 10^{-2} is estimated for the LANL No Action Alternative.

Expanded Operations Alternative Frequency Analysis

The level of HE operations activity compared to the No Action Alternative is projected to increase: (1) by 40 to 100 percent for fabrication activities, depending on the specific program supported; (2) by 50 percent for HE

TABLE G.5.7.1–1.—*Blast Effects to Humans Due to Fast-Rising Air Blasts (3 to 5 Minutes Duration)*

CRITICAL ORGAN OR EVENT	MAXIMUM EFFECTIVE PRESSURE (PSI)
Eardrum Rupture:	
Threshold	5
50 percent	15
Lung Damage:	
Threshold	30 to 40
50 percent	80 and above
Lethality:	
Threshold	100 to 120
50 percent	130 to 180
Near 100 percent	200 to 250

Note: Maximum effective pressure is the highest of incident pressure, incident pressure plus dynamic pressure, or reflected pressure.

waste treatment, QA efforts, and receiving, transportation, and storage; (3) by 40 percent for facility support functions; (4) by 25 percent for safety and mechanical testing; and (5) by undefined increases in the remaining capability areas (LANL 1996b). As a first order estimate, it is assumed that the overall increase in the level of HE operations corresponds to the projected increase in HE receiving, transportation, and storage activities. This is based on the observation that receiving, transportation, and storage operations would be expected to reflect the site-wide level of activities in support of HE operations. Consequently, HE handling and processing activities are projected to increase by 50 percent over the No Action Alternative level of effort. This level of change in operations is within the range of past operational activity levels. Consequently, it is concluded that past operational experience and the projected accident frequency for the No Action Alternative would be applicable.

Reduced Operations Alternative Frequency Analysis

The level of HE operations activity is projected to be decreased: (1) to 80 percent of the No Action Alternative level of effort for the safety/mechanical testing and quality assurance efforts; (2) to 75 percent of the No Action Alternative level of effort for test device assembly, stockpile surveillance, and above ground testing; (3) to 60 percent of the No Action Alternative level of effort for HE synthesis and production, HE and plastics development and characterization, HE receiving, transportation and storage, and facility support; (4) to 40 percent of the No Action Alternative level of effort for HE waste treatment; and (5) to a much reduced level of effort for fabrication in support of refurbishment and weapons research and development (LANL 1996b). As a first order estimate, it is assumed that the overall decrease in the level of HE operations corresponds to the projected decrease in HE receiving, transportation, and storage activities. This is based on the observation that receiving, transportation, and storage operations would be expected to reflect the site-wide level of activities in support of HE operations. Consequently, HE handling and processing activities are projected to decrease to 60 percent of the No Action Alternative level of effort. This level of variation is within the range of past operational activity levels. Consequently, it is concluded that past operational experience would be applicable and that the projected accident frequency would be at the low end of the range for the No Action Alternative.

Greener Alternative Frequency Analysis

The level of HE operations activity for each of the capability categories is projected to be comparable to the Reduced Operations Alternative (LANL 1996b). Consequently, as with the Reduced Operations Alternative, HE handling and processing activities are projected to decrease to 60 percent of the No Action Alternative level of effort, with a projected accident frequency at the low end of the range for the No Action Alternative.

Source Term Calculations

The postulated accident does not release hazardous or radiological material to the environment. Potential HE incidents involving either hazardous or radiological materials are bounded by accident scenarios CHEM–01 through CHEM–06 and RAD–01 through RAD–16.

Uncertainties and Sensitivities Affecting the Source Term for WORK–01

The potential for blast impacts beyond laboratory and operations personnel are extremely low, based on both LANL and DOE system-wide experience and controls.

Consequences of WORK–01 for Facility Workers and the Public

This accident is limited to facility workers. Access controls and operational boundaries preclude any significant impacts to members of the public. Table G.5.7.1–2 summarizes the analysis results for WORK–01.

G.5.7.2 *WORK–02, Biohazard Contamination of a Single Worker*

General Scenario Description

There are three scenarios in which a LANL worker could be exposed to a biohazard: (1) accidental exposure to a passive or active bacterium, fungus, virus, etc, being used in the HRL (TA–43) for research purposes; (2) contact with fecal material or other infected avian or mammalian bodily fluids during field research or monitoring and surveillance activities; or (3) exposure of health workers to infectious agents carried by workers visiting the clinic. Of these three potential exposures, the one with the highest probability is the accidental exposure during research and development activities involving biohazards in HRL.

The accident scenario WORK–02 involves the inadvertent biohazard contamination of a single worker during activities at TA–43–1 (HRL). Biohazards are present or will be present at TA–43 in passive or active states in some research and development activities. Biohazards may include facultative pathogens or obligate pathogens such as Clostridium, Pseudomonas, E. coli, saccharomyces, Bacillus, and (in the Expanded Operations Alternative) Hepatitis B.

Activities involving biohazards are conducted, monitored, and regulated by the LANL Institutional Biosafety Committee using guidelines from the National Institutes of Health (NIH) and the Centers for Disease Control and Prevention (CDC). This work is done according to Biohazard Level 2 controls; all waste materials from culture operations are treated to kill the infectious agents prior to disposal, using autoclave heating or viricides/bactericides. Biohazard Level 2 equipment and engineering controls include limited access to work areas, protective laboratory coats and gloves, and safety cabinets or isolation enclosures for any operations that have a high potential for creating aerosols containing microorganisms (LANL 1996b).

Due to the proximity of HRL to the Los Alamos County Medical Center, stringent administrative controls are used to control organisms and potentially contaminated biohazardous waste and research materials. Specific bacteria, such as spore formers, which can live in encysted state for periods of time without nourishment or water or air, can only be used after LANL senior management review, and special protocols are required. Work with live viral agents is prohibited except for engineered viral agents used as vectors for transferring genetic material which present

TABLE G.5.7.1–2.—*Summary Results for Scenario WORK–01*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM
No Action	0.001 to 0.01	Accidental injury or fatality from 1 to 15 operations personnel
Expanded Operations	0.001 to 0.01	Accidental injury or fatality from 1 to 15 operations personnel
Reduced Operations	0.001 to 0.01	Accidental injury or fatality from 1 to 15 operations personnel
Greener	0.001 to 0.01	Accidental injury or fatality from 1 to 15 operations personnel

negligible risk of infection. Research on HIV and other human pathogens is limited to genome mapping and other operations that do not involve the original or active biological material (LANL 1996b).

No Action Alternative Frequency Analysis

In contrast to the documented occurrence of laboratory-acquired infections in laboratory personnel, laboratories working with infectious agents have not been shown to represent a threat to the community (CDC 1993). The primary risks from microbiology laboratories are to laboratory workers, and are specific to the agent, for example (CDC 1993):

- *Hepatitis B*—accidental inoculation, exposure of broken skin or the mucous membranes of the eyes, nose, or mouth
- *Clostridium botulinum*—accidental inoculation; toxin may be absorbed after ingestion or following contact with the skin, eyes, or mucous membranes
- *Pseudomonas*—aerosol and skin exposure

The frequency of accidental infections from biohazards is judged by DOE to be no greater than 0.01 to 0.1 per year given the level of research and development activities. The potential for nonworker exposure is at least hundreds of times less than worker exposure probability and is not credible within the scope of this analysis at a probability of 10^{-6} per year.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

No significant differences in activity levels are identified that would result in a greater risk of accidental infection compared with the No Action Alternative.

Uncertainties and Sensitivities Affecting the Frequency of WORK–02

Hepatitis B is a new potential source of infection in the Expanded Operations Alternative. However, no cases of infection to laboratory workers from any agent were reported in the review of laboratory accidents and incidents in the 1990's or in during several discussions with LANL personnel at TA–43 and the institutional biosafety committee. Accordingly, given the period of time in which TA–43–1 has operated and during which field operations have been conducted, the frequency estimate of 0.01 to 0.1 per year is considered to bound the actual frequency. This frequency is very conservative based on National Cancer Institute (NCI) and NIH statistics of research and development accidental biohazard infection and resulting infection during the 1990's, which would estimate the frequency not to exceed 0.001 (NIH 1996).

Source Term Calculations

This accident does not release hazardous material to the environment. The potential for infection of persons other than laboratory personnel is very low. Because any such infections would have to be first observed in laboratory personnel, the risks are dominated by these original infections. Infection of one laboratory worker is the most likely outcome, multiple worker infections are less likely, and the spread of an infection beyond laboratory or field operations personnel is incredible (less than 10^{-6}).

Uncertainties and Sensitivities Affecting the Source Term for WORK–02

The potential for exposures beyond laboratory personnel are very low, based on both LANL and industry-wide experience.

Consequences of WORK–02 for Facility Workers and the Public

This accident affects only laboratory research and development workers. The potential for public impact is judged to be nil. Table G.5.7.2–1 summarizes the analysis results for WORK–02.

G.5.7.3 *WORK–03, Inadvertent Nuclear Criticality Event*

General Scenario Description

WORK–03 involves an inadvertent criticality event, the most significant impacts of which are on workers in the immediate vicinity of the event (due to neutron and gamma exposure). Critical assemblies and experiments are routinely performed at Pajarito Site (TA–18), and were considered in RAD–03. Outside of TA–18, a criticality event, although unlikely in the absolute sense, is most likely to occur at TA–55–4 (Plutonium Facility). At this facility, the consideration would mainly be due to operations with fissile material in liquid solutions. While fissile material is handled in the solid form, it is considered to be much less likely to be involved in a criticality event than a solution (LANL 1996k).

Criticality events are capable of producing potentially lethal amounts of neutron and gamma radiation in a localized area. Depending upon the physical form of the system, such as a solution, the event may be accompanied by the release of plutonium through the aerosolization of the solution and also may produce fission products that might be released to the environment.

Historical Criticality Events

There have been several inadvertent criticality events with solutions since the 1940's. Some of these events are summarized in Table G.5.7.3–1. As demonstrated by the table, these events occur infrequently, and each tends to be unique in nature, making a quantitative frequency estimation difficult. Most recently, there were two criticality events reported in Russia. The first was reported to be an excursion in a uranium solution in May 1997. Later, in June of the same year, a fatality was reported from a criticality event; however, this one apparently involved a solid fueled critical assembly. Details on these two accidents are not sufficient at this time to provide further discussion of them and their potential implications here.

LANL SAR Evaluations of Inadvertent Criticality Event

The TA–55 SAR identifies a nuclear criticality event in the uranium/plutonium separations process as a bounding event. The evaluation is essentially generic, applying to all deep-well,

TABLE G.5.7.2–1.—*Summary Results for Scenario WORK–02*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM
No Action	0.01 to 0.1	Accidental exposure of one laboratory worker resulting in diagnosed infection. No public impact.
Expanded Operations	0.01 to 0.1	Accidental exposure of one laboratory worker resulting in diagnosed infection. No public impact.
Reduced Operations	0.01 to 0.1	Accidental exposure of one laboratory worker resulting in diagnosed infection. No public impact.
Greener	0.01 to 0.1	Accidental exposure of one laboratory worker resulting in diagnosed infection. No public impact.

TABLE G.5.7.3–1.—*Summary of Inadvertent Solution Criticality Events (1945 to the Present)*

DATE	LOCATION	FISSIONABLE MATERIAL	PHYSICAL ARRANGEMENT	TOTAL FISSION YIELD	DESCRIPTION AND CONSEQUENCES
53/03/15	Mayak, Urals (Russia)	Plutonium solution (31 l)	Steel vessel	2.5×10^{17}	Human error (chief operator transferred solutions from two vessels into a single vessel); chief received 1,000 rad and another operator received 100 rad
54/05/26	Oak Ridge	Uranium solution (18.3 kg Uranium-235, 55.4 l of solution)	Cylindrical annulus, unreflected	1×10^{17}	Shift of poison; no physical damage
56/02/01	Oak Ridge	Uranium solution (27.7 kg Uranium-235, 58.9 l of solution)	Cylinder, unreflected	1.6×10^{17}	Geometry change; warping of bottom of cylinder
57/04/12	Mayak, Urals (Russia)	Uranium solution	Cylinder	2×10^{17}	Human error (leading to oxalate precipitation); lethal to operator, five others developed symptoms of radiation sickness
58/01/02	Mayak, Urals (Russia)	Uranium solution	Tank with control rod	2.3×10^{17}	Human error (staff decided to tip tank to speed up draining of solution, in violation of procedures), bodies acted as reflector; 3 deaths, fourth operator developed radiation sickness and lost sight
58/06/16	Oak Ridge	Uranium solution (2.5 kg Uranium-235, 56 l of solution)	Cylinder, concrete reflected below	1×10^{16}	Valve leaked or left open; no physical damage; $1,000 loss
58/12/30	Los Alamos	Plutonium solution (3.27 kg Plutonium, 168 l of solution)	Cylinder, water reflected below	1.5×10^{17}	Human error (failure to follow procedure); lethal to operator; no physical damage
59/10/16	Idaho Falls	Uranium solution (34.5 kg Uranium-235, 800 l of solution)	Cylinder, concrete reflected below	1×10^{17}	Sparge gage plugged; no physical damage; $62,000 loss

TABLE G.5.7.3–1.—*Summary of Inadvertent Solution Criticality Events (1945 to the Present)*-Continued

DATE	LOCATION	FISSIONABLE MATERIAL	PHYSICAL ARRANGEMENT	TOTAL FISSION YIELD	DESCRIPTION AND CONSEQUENCES
60/12/05	Mayak, Urals (Russia)	Plutonium solution	Cylinder, unfavorable geometry	1×10^{17}	Human error (failure to check results after mass discrepancy discovered; transfer of solution to unfavorable geometry); several people exposed to up to 5 rad
61/01/25	Idaho Falls	Uranium solution (8 kg Uranium-235, 40 l of solution)	Cylinder	6×10^{17}	Human error (instruction misinterpreted); no physical damage; $1,000 loss
61/08/14	Siberian Chemical Combine (Russia)	Uranium hexafluoride accumulated in oil	Cylinder	1×10^{16}	Human error (assumed first criticality alarm was false, restarted facility); operator received 200 rad
62/09/07	Mayak, Urals (Russia)	Plutonium solution, dissolution of Plutonium scrap in nitric acid; 1.2 kg Plutonium	Cylinder	2×10^{17}	Settling of solution after stirrer turned off; doses low due to no one near dissolver and lead shielding on dissolver
63/01/30	Siberian Chemical Combine (Russia)	Uranium solution	Cylinder	7.9×10^{17}	Human error (poor record keeping, mislabeling of uranium concentration); four persons received 6 to 17 rad at a distance of 10 meters
63/12/13	Siberian Chemical Combine (Russia)	Uranium solution	Cylinder, hemispherical bottom	2×10^{17}	Accumulation of uranium solution in trap; no injuries
64/07/24	Wood River Junction	Uranium solution (2.64 kg Uranium-235)	Cylinder, unreflected	1.1×10^{17}	Human error (failure to follow procedure); lethal to operator; no physical damage
65/12/16	Mayak, Urals (Russia)	Uranium solution	Cylinder	7×10^{17}	Human error (excess loading of uranium into solution, cessation of stirring); several staff exposed up to 30 mR
70/08/24	Windscale (U.K.)	Plutonium complex (2.5 kg Plutonium, 100 l of solution)	Cylinder	1×10^{15}	Plutonium accumulated in organic; no physical damage

Source: DOE 1994b unless otherwise noted.

wet chemistry operations. The accident assumes that as a result of multiple overbatching errors, the fissile material inventory for a glovebox substantially exceeds the allowable limit. A vessel overpressure or some other mechanism results in the rupture of adjacent vessels containing rich solution. The solution collects in a deep well, followed by a separate influx of water (failure of a water line), resulting in a single-pulse solution criticality event yielding 5 x 10^{17} fissions. The resulting fission products and plutonium aerosol are processed through the ventilation system and released from the south exhaust stack (LANL 1996k). Based on a PRA, the TA–55 SAR estimates the frequency of a solution criticality event at 6 x 10^{-7} per year per operation (LANL 1996k). Because there are hundreds of operations, the cumulative frequency of a criticality accident in TA–55–4 is estimated to be in the range from 10^{-6} to 10^{-4} per year (LANL 1996k).

The TA–55–4 SAR includes exposure analyses for the maximum off-site individual (MOI) at Royal Crest Trailer Park, 2,952 feet (900 meters) away, for an unmitigated scenario (no HEPA filtration, LPF = 1) and for a realistic scenario (with HEPA filtration). The unmitigated MOI dose is 1.6 rem; whereas, the realistic MOI dose is 35 millirem. Regarding consequences to workers, the SAR states that anyone within 16 feet (4.9 meters) of the criticality location would receive more than 500 rem. The dose at 33 feet (10 meters) drops to 80 rem. The number of people in the room varies with the work being done, but is most likely to be two or three people (LANL 1996k).

No Action Alternative Frequency Analysis

Consistent with the TA–55 SAR analyses, which account for LANL-specific design and operational practices, the frequency of an accidental critical excursion is estimated to be no greater than 10^{-6} per operation; but, considering that there are hundreds of operations per year, the frequency of accidental criticality is likely to be in the range of 10^{-6} to 10^{-4} per year.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

Although there is an increase in activities involving fissile materials in the Expanded Operations Alternative (as a result of pit production), most of these activities involve solid systems that do not contribute significantly to criticality accident frequency. Other alternatives do not vary significantly in the level of activities that are most likely to give rise to inadvertent criticality events. Accordingly, no difference in frequency is identified across the alternatives.

Uncertainties and Sensitivities Affecting the Frequency of WORK–03

Historical experience has demonstrated that criticality accidents are unpredictable, unique events that do not lend themselves to a straightforward frequency determination. Accordingly, this analysis only attempts to establish a range, rather than an individual value, for the frequency.

Source Term Calculations

Given the low MOI exposure estimates in the TA–55–4 SAR (doses to the MOI of less than 50 millirem), no public exposure estimates will be performed for this accident because it would screen as insignificant based on the SWEIS accident analysis screening methods (off-site exposure of less than 500 millirem).

Consequences of WORK–03 for Facility Workers and the Public

The consequences to the public from WORK–03 are insignificant. Workers located close to the site of the criticality event (i.e., within 30 feet [9.2 meters]) can receive doses of neutron and gamma radiation on the order of

500 rem or higher. Acute radiation injuries and deaths are possible within this radius. Workers located elsewhere in the facility could be exposed to volatile fission products (noble gases, radioiodines, etc.) that evolve from the solution criticality accidents. This is the same for all options. Table G.5.7.3–2 summarizes the analysis results for WORK–03.

G.5.7.4 *WORK–04, Inadvertent Worker Exposure to Electromagnetic Radiation*

General Scenario Description

Accident scenario WORK–04 involves the inadvertent exposure of one or more workers to electromagnetic radiation. Used in this context, electromagnetic radiation refers to exposure to x-rays, accelerator beams, lasers, or radio frequency (RF) sources. Such radiation sources are used widely in various facilities at LANL, especially lasers.

No Action Alternative Frequency Analysis

The WORK–04 accident scenario is meant to represent a class of accidents involving inadvertent exposure of workers to the types of sources described above. Accordingly, there is no unique sequence of events that can be analyzed for frequency and conditional probability. However, these accidents typically involve a failure of an interlock device and/or the failure of the workers to follow procedures and/or observe precautions that could have prevented the exposure.

Events involving electromagnetic radiation sources that occur more often than once in 10 years (and that have a frequency above 0.1 per year) are accounted for and discussed under the subject of nonionizing radiation elsewhere in the SWEIS. Due to the large number of sources of electromagnetic radiation in use at a broad range of facilities at LANL, it is concluded that, in sum, the frequency of accidents resulting in worker injury or fatality is unlikely to be less than 1 in 100 per year (i.e., a frequency of less than 0.01 per year). This places bounds of 0.01 to 0.1 per year for the WORK–04 accident.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analysis

No significant differences in activity levels are identified that would result in a greater risk of accidental exposure of workers to electromagnetic radiation compared with the No Action Alternative. Thus, no difference in frequency is identified across the alternatives.

Uncertainties and Sensitivities Affecting the Frequency of WORK–04

Uncertainties are not considered to substantially influence the estimated frequency range for this accident due to the large number of potential sources to which workers could be exposed.

TABLE G.5.7.3–2.—*Summary Results for Scenario WORK–03*

ALTERNATIVE	ACCIDENT FREQUENCY	SOURCE TERM AND CONSEQUENCES
No Action	10^{-6} to 10^{-4}/year	Fatalities to nearby workers. No consequences to the public.
Expanded Operations	10^{-6} to 10^{-4}/year	Fatalities to nearby workers. No consequences to the public.
Reduced Operations	10^{-6} to 10^{-4}/year	Fatalities to nearby workers. No consequences to the public.
Greener	10^{-6} to 10^{-4}/year	Fatalities to nearby workers. No consequences to the public.

Administrative controls enforced by LANL management are similar across LANL and should not be associated with significant variation in risk from facility to facility.

Source Term Calculations

This accident does not release hazardous material to the environment; hence, no source term calculations are required.

Uncertainties and Sensitivities Affecting the Source Term for WORK–04

This issue is not applicable to WORK–04 because no source terms are calculated.

Consequences of WORK–04 for Facility Workers and the Public

Due to the nature of facility designs and the nature of the hazards involved, no public impact is expected. Worker consequences could range from minor injuries to major eye injuries, and could include fatalities under some circumstances. The number of workers injured or killed by any given accident would be expected to be small (typically one) because it is unlikely that a group of workers would all violate administrative controls and have this violation result in injury or fatality. This is not to say that this never happens, because it does; but by far and away the most likely outcome is a single worker being affected by any one event. Table G.5.7.4–1 summarizes the analysis results for WORK–04.

G.5.7.5 *Work–05, Plutonium Release from Degraded Vault Storage Container at TA–55–4*

General Scenario Description

TA–55, the Plutonium Facility at LANL, handles containers of plutonium as part of day-to-day operations. Among the current activities at TA–55 is the repackaging of material stored in vault rooms in the facility's basement. The plutonium in these containers is being repackaged due to the degraded nature of some of the containers. The repackaging activity is part of a program to implement the DNFSB Recommendation 90-4.

In order to repackage the plutonium, the containers must be retrieved, the plutonium taken out, and the material repackaged. While handling the container, there is the possibility of the container being dropped and some portion of the contents being spilled. If this accident occurs while the building HEPA filters and HVAC systems are operating, very little of the plutonium can escape the facility. Thus, this accident presents the frequency for dropping a degraded container and qualitatively evaluates the exposure of facility workers to this plutonium spill.

The impacts to the public from this type of accident was presented in section G.5.6.10. This discussion presents the frequency for the drop of the container and the exposure of

TABLE G.5.7.4–1.—*Summary Results for Scenario WORK–04*

ALTERNATIVE	ACCIDENT FREQUENCY	CONSEQUENCES
No Action	0.01 to 0.1/year	Typically one worker injury or fatality; small likelihood of two or more workers being simultaneously affected.
Expanded Operations	0.01 to 0.1/year	Same as No Action Alternative.
Reduced Operations	0.01 to 0.1/year	Same as No Action Alternative.
Greener	0.01 to 0.1/year	Same as No Action Alternative.

workers within the facility only. The public impacts were discussed previously.

For the contents of a container to be spilled, the containers must be corroded or have some other physical damage. LANL has currently retrieved about 1,450 containers and found, through visual inspection, 361 containers to have some defect. Of these 361 containers, 82 have lost outer containment, or approximately 5.5 percent have outer containment failure. The rate of inner containment failure is estimated to be 2 percent. To have a release of material, a container would have to have both its outer and inner container fail during a drop. The contents would then have to be spilled. For this accident, the frequency is therefore dependent on dropping a container that has sufficient damage, such as loss of containment, in order to spill the material.

Once the containers are repackaged, risk will be reduced because of upgrades to the containers and the required stability of the material inside.

For further information, DOE Standard 3013-96 (DOE 1996e) addresses the requirements for containers for long-term (at least 50 years) storage of plutonium. To meet the standard, plutonium-bearing materials must be in stable forms and packaged in containers designed to maintain their integrity under both normal storage conditions and anticipated handling accidents for at least 50 years (DOE 1996e). The standard applies to metal, oxide, and alloys containing at least 50 percent plutonium by mass, and containing less than 3 percent plutonium-238 by mass (DOE 1996e). The quantity of metal per container should be as close as practical to, but not exceed, 9.68 pounds (4.40 kilograms). Stored metal pieces are required to have thicknesses greater than 0.04 inches (1.0 millimeters) and have specific surface areas less than 71 inches/2 pounds (1 centimeter/2 grams) to reduce potential pyrophoric tendencies (DOE 1996e). The quantity of oxide by container should be as close as practical to, but not exceed, 10.97 pounds (5.00 kilograms), representing the plutonium dioxide equivalent of 9.68 pounds (4.40 kilograms) of plutonium metal. The oxides are required to be thermally stabilized with less than 0.5 percent mass loss-on-ignition (DOE 1996e). The containers are required to include a minimum of two nested, sealed containers, and have at least one container that remains leak tight after a free drop from a 30-foot (9-meter) height into a flat, essentially unyielding, horizontal surface (DOE 1996e). The containers are required to have a cylindrical geometry not exceeding 4.9 inches (12.5 centimeters) outside diameter or 10 inches (25.4 centimeters) external height (DOE 1996e). Although the risk will be reduced once the plutonium is repackaged, new risk numbers are not calculated. These numbers are considered representative of the type of worker risk that exists when handling plutonium in LANL nuclear facilities.

No Action Alternative Frequency Analysis

Table G.5.7.5–1 summarizes the frequency analysis for a container drop in TA–55. Because there are two types of containers, the frequency for dropping each container is presented. The terms for the equation are explained in subsequent sections. Table G.5.7.5–2 presents the number of container handling operations.

For the purposes of this analysis, the containers are being tracked as two types of containers. Most containers are doubly contained drums, (i.e., drums that have an inner and outer container, and are hermetically sealed). The other type has various names such as food pack cans, or dressing jars. These names were derived from their general appearance to distinguish one container over another. However, these cans would sustain similar damage when dropped. The drums would have a different failure rate than the metal cans when dropped, so the containers are being tracked as two separate types.

TABLE G.5.7.5–1.—*Frequency Analysis for a Container Drop in TA–55*

SCENARIO	NUMBER OF CONTAINERS HANDLED PER YEAR	HEP FOR CONTAINER DROP	PROBABILITY OF DEGRADED INNER CONTAINER	PROBABILITY OF DEGRADED OUTER CONTAINER	FREQUENCY OF CONTAINER DROP AND SPILL (SPILL PER YEAR)
Drums	972	0.001	0.055	0.02	0.0011
Nonhermetically Sealed Containers	228	0.001	1.0	1.0	0.23

TABLE G.5.7.5–2.—*Number of Container Handling Operations*

CONTAINER TYPE	TOTAL NUMBER OF CONTAINERS	PERCENTAGE OF CONTAINERS REPACKAGED PER YEAR	NUMBER OF HANDLING OPERATIONS TO REPACKAGE	HANDLING OPERATIONS PER YEAR
Drums	5,830	17	1	972
Metal Cans	1,370	17	1	228

Because the repackaging effort will take approximately 6 years, the repackaging rate was estimated to be 17 percent of the total containers each year.

Each container will be handled once before being placed into a DOE Standard 3013-96 container. Although the entire repackaging process may have additional steps, this is the activity where the material is most likely to be spilled and have worker exposure. Thus, the number of degraded container handling operations is 972 drum operations and 228 metal can operations for a total of 1,200 handling operations of degraded containers per year.

Generally, dropping a container does not involve equipment failure, but rather, errors in setting up the equipment properly. This failure is similar to that of checking the status of equipment, if the status of the equipment affects one's safety when performing the task (Swain and Guttmann 1983). As shown in Table G.5.7.5–3, the probability of dropping a container, for either type, is therefore estimated to be 0.001.

In order for a container drop to result in a material spill and exposure to workers, a degraded container must be dropped. For drums, the probability of this occurring is assumed to be directly proportional to the number of drums that have both the inner and outer containers damaged. From existing inspections of containers, about 5.5 percent have outer containment failure, and about 2 percent have inner containment failures. Given that the inner containment failure is not linked to outer containment failure, the probability of both of these conditions existing

TABLE G.5.7.5–3.—*Human Error Probability (HEP), Container Drop*

SCENARIO	HEP, CONTAINER DROP
Drums	0.001
Metal Cans	0.001

is about 0.11 percent (as shown in Table G.5.7.5–4).

For the metal cans, the probability of these containers failing is assumed to be 1.0. These containers were used to pack plutonium metal (LANL 1996k). Although some of these containers had inner and outer containers, they lacked a hermetic seal. Without the hermetic seal, the metal could be oxidized. Also, the inner container was often placed in a plastic bag and then placed inside the outer container. Normally, degradation of the plastic bags was not a problem because the plutonium metal was not stored in them for long periods of time. However, because the plastic bags decompose into various organic compounds through alpha-particle-induced decomposition and can cause the metal and containers to corrode, the plutonium metal must be repackaged. For these reasons, the conservative assumption was made that if a container is dropped then the material is spilled, therefore, by definition, the container is a degraded container.

For workers, the rate of plutonium exposure from these types of accidents is about 1 in 5 years.

Expanded Operations, Reduced Operations, and Greener Alternatives Frequency Analyses

The same type of activities will be conducted for each of the alternatives. Because no appreciable changes in these activity levels are anticipated for the various alternatives, the results of the frequency analysis for the No Action Alternative remains the same for these alternatives.

Uncertainties and Sensitivities Affecting the Frequency of WORK–05

The assumption that the "metal can" containers will spill material if dropped is considered a conservative assumption for this analysis.

Source Term Calculations

If the entire contents of the package was spilled, the amount of material that could be inhaled is 2.7 grams of plutonium (see section G.5.6.10, Source Term). It is not likely that a worker would inhale this much plutonium. The worker has personnel protective equipment that would be used in response to the accident. Alarms would also sound if plutonium became airborne as part of the accident and limit the exposure of other workers in the area.

Expanded Operations, Reduced Operations, and Greener Alternatives Source Term Analyses

Because the MAR is associated with an individual container-handling operation and LANL will continue to perform these types of activities in order to carry out any assigned mission, the source term would not change.

Worker Consequences

Significant but nonlethal doses are possible to the workers handling the plutonium. Any adverse impacts would be mitigated by prompt use of protective equipment and/or prompt

TABLE G.5.7.5–4.—*Probability of Dropping a Degraded Container*

SCENARIO	PROBABILITY OF INNER CONTAINMENT FAILURE	PROBABILITY OF OUTER CONTAINMENT FAILURE	PROBABILITY OF HANDLING A DEGRADED CONTAINER
Drums	0.02	0.55	0.0011
Metal Cans	1.0	1.0	1.0

exiting of the immediate vicinity for those not involved in clean-up activities. Table G.5.7.5–5 summarizes the analysis results for WORK–05.

G.6 UNCERTAINTIES AND SENSITIVITIES

In principle, one could estimate the uncertainty associated with each step of the analysis for each accident scenario, and predict the uncertainty in the results (frequency, source term, consequences, risk, etc.). However, conducting such a full-scale quantitative uncertainty analysis is neither practical nor a standard practice for a study of this type. Instead, the analysis is intended to ensure, through judicious selection of release scenarios, models, and parameters that the results represent and bound the actual risks.

This is accomplished by making assumptions at each step of the calculations. The models, model parameters, and release scenarios are selected in such a way that most intermediate results and the final estimate of impacts are greater than what would be expected should the events actually occur. As a result, even though the range of uncertainty in a quantity might be large, the values selected for quantification are conservative, so the chance that the actual quantity will be greater than the calculated value is low.

The approach taken for quantification of accident risks is such that most of the uncertainty in the results lies on the downside of the values presented. That is, there is a small chance that the actual value lies above those presented, but a very large chance that the actual value lies below those presented in this appendix and in chapter 5 of volume I.

TABLE G.5.7.5–5.—*Summary Results for Scenario WORK–05*

ALTERNATIVE	ACCIDENT FREQUENCY	WORKER CONSEQUENCES
No Action	0.23	Plutonium exposure to one or two workers. Adverse exposure limited by use of personnel protective equipment.
Expanded Operations	No Change	No Change
Reduced Operations	No Change	No Change
Greener	No Change	No Change

REFERENCES

Abbott 1988 — *A Review of the Radiological Environmental Monitoring Data at U.S. Army Jefferson Proving Ground, Madison, Indiana*. David T. Abbott. Available in draft form from U.S. Army TECOM, AMSTE-SM-S. Aberdeen Proving Ground, Maryland. Undated, but believed to be about 1988.

ACGIH 1992 — *Industrial Ventilation: A Manual of Recommended Practice*, 21st Edition. American Conference of Governmental Industrial Hygienists. Cincinnati, Ohio. 1992.

AEC 1969 — Press release on Rocky Flats Fire. W. B. McCool, Secretary, Atomic Energy Commission. November 13, 1969.

AICE 1994 — *DOW's Fire & Explosion Hazard Classification Guide*, 7th Edition. American Institute of Chemical Engineers. New York, New York. 1994.

AIHA 1991 — *Emergency Response Planning Guidelines.* American Industrial Hygiene Association. November 1991.

Allen 1996 — Allen, Craig D. 1996 Fire Effects in Southwestern Forests, Proceedings of the Second La Mesa Fire Symposium, Los Alamos, New Mexico, March 29-31, 1994. Craig D. Allen, Technical Editor. General Technical Report RM-GTR-286. USDA Forest Service, Fort Collins, CO. September 1996.

Anderson 1982 — Anderson, Hal E. 1982 Aids to determining fuel models for estimating fire behavior. USDA For. Serv. Gen. Tech Rep. INT-122, 22p. Intermt. For. and Range Exp. Stn, Ogden Utah 84401.

Armstrong 1998 — Armstrong, Bill. 1998 Analysis of the Risk of Crown Fire Initiation and Spread in the Valle Ecosystem Management Area on the Española District of the Santa Fe National Forest, Northern New Mexico: A Final Project Submitted for Technical Fire Management. USFS, Española Ranger District Office, Santa Fe National Forest, Española, New Mexico. April 13, 1998.

Barr 1997 — M. Barr, GRAM Team, Memorandum to Bill Rhyne, H&R Technical Associates. Subject: LANL SWEIS. Los Alamos, New Mexico. February 17, 1997.

Braker and Mossman 1980 — *Matheson Gas Data Book,* 6th Edition. W. Braker and A. L. Mossman. Matheson Company, Division of Searle Medical Products USA Inc. Lyndhurst, New Jersey. 1980.

Campbell et al. 1988	*Compilation of Fragility Information from Available Probabilistic Risk Assessments,* Rev. 1. R. D. Campbell, M. K. Ravindra, and R. C. Murray. Lawrence Livermore National Laboratory, prepared for the U.S. Nuclear Regulatory Commission. UCID-20571. Livermore, California. September 1988.
CDC 1993	*Biosafety in Microbiological and Biomedical Laboratories,* 3rd Edition. Centers for Disease Control and Prevention, Public Health Service, and National Institutes of Health. HHS Publication No. CDC 93-8395. March 1993.
Clarke 1976	*Severities of Transportation Accidents*. R. K. Clarke et al. Sandia National Laboratories. SLA-74-0001. Albuquerque, New Mexico. July 1976.
Coats and Murray 1984	*Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites.* D. W. Coats and R. C. Murray. Lawrence Livermore National Laboratory. UCRL-53582. Livermore, California. 1984.
Craig et al. 1995	"Alternative Guideline Limits for Chemicals without Environmental Response Planning Guidelines." D. K. Craig, J. S. Davis, R. DeVore, D. J. Hansen, A. J. Petrocchi, and T. J. Powell. *American Industrial Hygiene Association Journal*. Vol. 56, pp. 919-925. 1995.
Craig 1996	*ERPGs and TEELs for Chemicals of Concern at SRS:* Rev. 11. D. K. Craig. Savannah River Site, prepared for the DOE Subcommittee on Consequence Assessment and Protective Actions (SCAPA). ECS-CAT-96-0095. October 31, 1996.
Dexter and Perkins 1982	*Component Failure Rate Data with Potential Applicability to a Nuclear Fuel Plant.* A. H. Dexter and W. C. Perkins. DuPont de Nemours, Savannah River Laboratory. DP-1633, E.1 Aiken, South Carolina. 1982.
DNFSB 1994	*Improved Schedule for Remediation in the defense Nuclear Complex*, DNFSB Recommendation 94-01. Defense Nuclear Facility Safety Board. 1994.
DOE 1992	*Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.* U.S. Department of Energy. DOE Standard 1027-92. December 1992.
DOE 1993a	*Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*. U.S. Department of Energy, Office of NEPA Oversight. May 1993.

DOE 1993b *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*. U.S. Department of Energy. DOE Standard 3007-93. November 1993.

DOE 1994a *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports.* U.S. Department of Energy. DOE Standard 3009-94. July 1994.

DOE 1994b *Hazard Baseline Documentation*. U.S. Department of Energy. DOE EM Standard 5502-94. August 1994.

DOE 1994c *Atmospheric Dispersion Modeling Resources,* Second Edition. U.S. Department of Energy, Subcommittee on Consequence Assessment and Protective Actions. 1994.

DOE 1994d *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* Vols. I & II. U.S. Department of Energy. DOE Handbook 3010-94. December 1994.

DOE 1994e *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, Change Notice #1, January 1996. U.S. Department of Energy. DOE Standard 1020-94. April 1994.

DOE 1994g *DOE Explosives Safety Manual,* Revision 7. U.S. Department of Energy. DOE/EV/06194. August 1994.

DOE 1995a *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement*. U.S. Department of Energy, Albuquerque Operations Office and Los Alamos Area Office. DOE/EIS-0228. Albuquerque, New Mexico. August 1995.

DOE 1995b *Natural Phenomena Hazards Assessment Criteria.* U.S. Department of Energy. DOE Standard 1023-95. 1995.

DOE 1996a *Final Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components.* U.S. Department of Energy, Albuquerque Operations Office. DOE/EIS-0225. November 1996.

DOE 1996b *Chemical Process Hazard Analysis.* U.S. Department of Energy. DOE Handbook 1100-96. February 1996.

DOE 1996c *Accident Analysis for Aircraft Crash into Hazardous Facilities*. U.S. Department of Energy. DOE Standard 3014-96. October 1996.

DOE 1996d — *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement*, Supplement 2, Draft. U.S. Department of Energy, Carlsbad Area Office. DOE/EIS-0026. November 1996.

DOE 1996e — *Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage*. U.S. Department of Energy, Office of Defense Programs. DOE Standard 3013-96. September 1996.

DOE 1996f — *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*. U.S. Department of Energy. DOE/EIS-0236. Washington, D.C. September 1996.

DOE 1996g — *Final Environmental Assessment, TRU Waste Drum Staging Building, Technical Area 55, Los Alamos National Laboratory*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-0823. Los Alamos, New Mexico. February 9, 1996.

DOE 1997 — *Environmental Assessment for the Proposed CMR Building Upgrades at the Los Alamos National Laboratory*. U.S. Department of Energy, Los Alamos Area Office. DOE/EA-1101. Los Alamos, New Mexico. February 4, 1997.

DOE 1998 — *Pit Disassembly and Conversion Demonstration Environmental Assessment and Research and Development Activities.* U.S. Department of Energy, Office of Fissile Materials Disposition. DOE/EA-1207. Washington, D.C. August 1998.

DPG 1997 — Bjorklund, Jay R., James F. Bowers, Gregory C. Dodd, and John M. White 1997. Open Burn/Open Detonation Dispersion Model Users Guide. (Two volumes) DPG-TR-96-008a and DPG-TR-96-008b. West Desert Test Center, U.S. Army Dugway Proving Ground, Dugway, Utah 84022. July 1997.

Dukes 1995 — *MULTUS Database*. L. L. Dukes. INSITE Analysis, Inc. Albuquerque, New Mexico. 1995.

Eide et al. 1990 — *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs.* S. A. Eide, S. V. Chmielewski, and T. D. Swantz. EGG-SSRE-8875. Idaho National Engineering Laboratory. Idaho Falls, Idaho. 1990.

Engelmann 1990 — *Effectiveness of Sheltering in Buildings and Vehicles for Plutonium*. Rudolf Engelmann. U.S. Department of Energy. DOE/EH-0159T. Washington, D.C. 1990.

Engelmann et al. 1991	*Sheltering Effectiveness Against Plutonium Provided by Stationary Automobiles*. R. J. Engelmann, W. R. Pendergrass, J. R. White, and M. E. Hall. ATDD©91/25. Final Report to NASA. National Oceanic and Atmospheric Administration. Oak Ridge, Tennessee. 1991.
EPA 1987	*Technical Guidance for Hazards Analysis.* U.S. Environmental Protection Agency, with the Federal Emergency Management Agency and the U.S. Department of Transportation. 1987.
EPA 1991	Manual of Protective Action Guides and Protective Actions for Nuclear Incidents. U.S. Environmental Protection Agency. EPA 400-R-92-001. Washington, D.C. October 1991.
EPA 1996	*Risk Management Plan, Off-Site Consequence Analysis Guidance.* U.S. Environmental Protection Agency. Washington, D.C. 1996.
Fenner 1996	Letter from H. Allen Fenner, Transportation Planning Division, New Mexico State Highway Department, to W. R. Rhyne. Santa Fe, New Mexico. January 17, 1996
Fleming et al. 1985	*Classification and Analysis of Reactor Operating Experience Involving Dependent Events*. K. N. Fleming, et al. Pickard, Lowe and Garrick, Inc., prepared for the Electric Power Research Institute. EPRI-NP-3967. Palo Alto, California. June 1985.
Foxx et al. 1981	Foxx, Teralene S. La Mesa Fire Symposium. LA-9236-NERP Southwest Fire Council, National Park Service, and Los Alamos National Laboratory, October 6 and 7, 1981.
Fresquez 1994	Memorandum from Fresquez to Greiggs. Subject: "Results of the soil sampling survey conducted over active RCRA firing site TA–15–184 (PHERMEX)." May 26, 1994.
Garvey 1998	Data obtained from facility walkdowns conducted by GRAM, Inc. and SWEIS Project Office files. August 28, 1998.
Gephart and Moses 1989	*An Approach to Evaluate the Acute Impacts from Simulated Accidental Releases of Chlorine and Ammonia.* L. Gephart and S. Moses. Plant/ Operations Progress, 8:1, Eastman Kodak Company. Rochester, New York. January 1989.
Greiner 1994	*Los Alamos Airport Master Plan, 1994-2013.* Greiner, Inc. Prepared for Los Alamos National Laboratory. Albuquerque, New Mexico. September 1994.

INEL 1990 *Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), Data Manual, Part 3: Hardware Component Failure Data (HCFD)*, Vol. 5, Rev. 3. Idaho National Engineering Laboratory. Prepared for the U.S. Nuclear Regulatory Commission. NUREG/CR-4639, EGG-2458. Washington, D.C. December 1990.

Jane's 1995 *All the World's Aircraft*, 85th Edition. Jane's Information Group, Inc. Alexandria, Virginia. 1994–1995.

LANL 1990a *Los Alamos Climatology*. Los Alamos National Laboratory. LA-11735-MS. Los Alamos, New Mexico. May 1990.

LANL 1990b *In-Place Testing Summary (1990)*. Los Alamos National Laboratory. LA-UR-91-3101. Los Alamos, New Mexico. May 1990.

LANL 1991a *Seismic Hazards Investigation, Los Alamos National Laboratory*, unpublished paper. Los Alamos National Laboratory. Los Alamos, New Mexico. August 29, 1991.

LANL 1991b *In-Place Filter Testing Summary (1991)*. Los Alamos National Laboratory. LA-UR-93-1586. Los Alamos, New Mexico. January 1991.

LANL 1994a *Specific Activities and DOE-STD-1027-92 Hazard Category 2 Thresholds*. Los Alamos National Laboratory. LA-12846-MS. Los Alamos, New Mexico. November 1994.

LANL 1994b *Safety Assessment for Compressed Gas Processing Facility, TA-3-170*, Revised. Los Alamos National Laboratory. Los Alamos, New Mexico. April 1994.

LANL 1994c *In-Place HEPA Filter Testing Summary (1994)*. Los Alamos National Laboratory. Los Alamos, New Mexico. 1994.

LANL 1994d *In-Place Testing Summary (1992)*. Los Alamos National Laboratory. LA-12792-PR. Los Alamos, New Mexico. September 1994.

LANL 1994e *Environmental Surveillance at Los Alamos During 1992*. Los Alamos National Laboratory. LA-12764-MS. UC-902. Los Alamos, New Mexico. July 1994.

LANL 1995a *Technical Areas of Los Alamos National Laboratory, Facility Descriptions and Hazard Classifications*. Los Alamos National Laboratory, Site-Wide Environmental Impact Statement Project Office (EIS-ESH). Los Alamos, New Mexico. December 8, 1995.

LANL 1995b *Table of DOE-STD-1027-92 Hazard Category 3 Threshold Quantities for the ICRP-30 List of 757 Radionuclides.* Los Alamos National Laboratory. LA-12981-MS. Los Alamos, New Mexico. August 1995.

LANL 1995c *Final Safety Analysis Report for the Chemistry and Metallurgical Research (CMR) Facility*. Los Alamos National Laboratory. CMR-FAC-95-291. Los Alamos, New Mexico. October 1995.

LANL 1995d *Final Safety Analysis Report for Radioactive Liquid Waste Treatment Facility at TA-50-1.* Los Alamos National Laboratory. LW-CST-13-AP13, R0. Los Alamos, New Mexico. October 1995.

LANL 1995e *Final Safety Analysis Report for Waste Characterization Reduction and Repackaging Facility at TA-50-69.* Los Alamos National Laboratory, CST7WCRRF-REPORT-0002, R.1. Los Alamos, New Mexico. October 1995.

LANL 1995f *Final Safety Analysis Report and Technical Safety Requirements for TA-54, Area G, CST-14.* Los Alamos National Laboratory. CST14G-REPORT-003, R.0. Los Alamos, New Mexico. August 1995.

LANL 1995g *Hazards Analysis of the Los Alamos National Laboratory Area G, Low-Level Waste and Transuranic Waste Storage Facility*. Los Alamos National Laboratory. LA-UR-95-888. Los Alamos, New Mexico. August 30, 1995.

LANL 1995h *In-Place HEPA Filter Testing Summary (1993).* Los Alamos National Laboratory. LA-12928-MS. Los Alamos, New Mexico. April 1995.

LANL 1995i *Final SAR and TSR for the Low-Level Radioactive Waste Disposal and Transuranic Waste Storage Site*. Los Alamos National Laboratory. CST-14G, Report 003, R. 0. Los Alamos, New Mexico. August 1995.

LANL 1996c *Evaluation of Aircraft Crash Hazard at Los Alamos National Laboratory Facilities.* Los Alamos National Laboratory. LA-13105. Los Alamos, New Mexico. July 1996.

LANL 1996e *Weapons Engineering Tritium Facility (WETF) Final Safety Analysis Report (FSAR).* Los Alamos National Laboratory. WETF-FSAR, R.0. Los Alamos, New Mexico. March 3, 1996.

LANL 1996f *Safety Analysis Report for the Los Alamos Critical Experiments Facility (LACEF) and Hillside Vault (PL-26).* Los Alamos National Laboratory. LA-CP-92-235, Rev. 2.0. Los Alamos, New Mexico. February 1, 1996.

LANL 1996g *Final Safety Analysis Report for Tritium Systems Test Assembly (TSTA), TA-21-155, ESA-TSE*. Los Alamos National Laboratory. TSTA-SAR, R1. Los Alamos, New Mexico. April 1996.

LANL 1996h *Final Safety Analysis Report for The Tritium Science and Fabrication Facility (TSFF) at TA-21-209*. Los Alamos National Laboratory. TSFF SAR, R0. Los Alamos, New Mexico. May 1996.

LANL 1996i *Safety Analysis Report for the Radioactive Materials Research, Operations, and Demonstration Facility, TA-50-37*. Los Alamos National Laboratory. RAMROD-REPORT-001, R.0. Los Alamos, New Mexico. April 1, 1996.

LANL 1996j *Safety Assessment for the Los Alamos National Laboratory Nondestructive Assay/Nondestructive Examination Facility, TA-54 West, Building MD-38*. Los Alamos National Laboratory. CST7RANT-REPORT-002, R.3. Los Alamos, New Mexico. July 1996.

LANL 1996k *TA-55 Final Safety Analysis Report, TA-55-PRD-108-01.1*. Los Alamos National Laboratory. LA-CP-95-169, Rev. 1. Los Alamos, New Mexico. July 1996.

LANL 1996l *TA-55 Hazard Analysis*. Los Alamos National Laboratory. LA-CP-94-0076, Revised. Los Alamos, New Mexico. July 1996.

LANL 1996m *Firing Sites*, DOE Review Draft II, Alternatives Description Document. Prepared by the Los Alamos National Laboratory Site-Wide EIS Project Office. Los Alamos, New Mexico. October 23, 1996.

LANL 1996n *Final Safety Analysis Report and Technical Safety Requirements for the Retrieval of Transuranic Waste from Pads 1, 2, and 4 at TA-54, Area G.* Prepared for Los Alamos National Laboratory by Benchmark Environmental Corporation. REPORT-54G-11, R.0 and REPORT-54G-12, R.0. Albuquerque, New Mexico. August 21, 1996.

LANL 1996o *LANL SWEIS Waste Management Strategies*, Predecisional Working Draft. Los Alamos National Laboratory, Waste Management Program Office. Los Alamos, New Mexico. November 1996.

LANL 1996p *Systems Analysis Results for Los Alamos 94-1 Program.* Presentation at the LANL Stockpile Management Program Review. Los Alamos National Laboratory. Los Alamos, New Mexico. February 6, 1996.

LANL 1996q *Advanced Recovery and Integrated Extraction System (ARIES) Preconceptual Design Report.* Los Alamos National Laboratory. LA-13178. Los Alamos, New Mexico. September 1996.

LANL 1996r *Environmental Surveillance at Los Alamos During 1995*. Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.

LANL 1997a *Chemical and Metallurgy Research (CMR) Facility Final Safety Analysis Report*, Revised Draft. Los Alamos National Laboratory. CMR-FAC-95-291. Los Alamos, New Mexico. April 1, 1997.

LANL 1997b *BUS-4 Procedure No. GF-0-19, How to Perform an Inventory of Toxic and Flammable Gases*. Los Alamos National Laboratory. Los Alamos, New Mexico. January 7, 1997.

LANL 1997c *SWEIS Alternatives Document, Waste Management Key Facility (TA-50, TA-54)*, Predecisional Draft. Los Alamos National Laboratory, SWEIS Project Office (ESH-EIS). Los Alamos, New Mexico. January 30, 1997.

LANL 1997d *Capability Maintenance & Improvements Project (CMIP) Preliminary Hazard Analysis*, Working Draft. Los Alamos National Laboratory. Los Alamos, New Mexico. March 14-1997.

LANL 1997e *Environmental Surveillance and Compliance at Los Alamos during 1996.* Los Alamos National Laboratory, Environmental Assessments and Resource Evaluations Group. LA-13343-ENV. Los Alamos, New Mexico. 1997.

LANL 1998a *Description of Technical Areas and Facilities at LANL.* Los Alamos National Laboratory. LA-UR-97-4275. Los Alamos, New Mexico. March 1998.

LANL 1998b "CMR Basis for Interim Operations." Los Alamos National Laboratory. July 21, 1998.

Lewis 1993 *Hazardous Chemicals Desk Reference*, 3rd Edition. R. J. Lewis, Sr. Van Nostrand Reinhold. New York, New York. 1993.

LLNL 1985 *Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites*, Rev.1. Lawrence Livermore National Laboratory, prepared for the U.S. Department of Energy. UCRL-53526. Livermore, California. 1985.

LLNL 1996 *Data Development Technical Support Document for the Aircraft Crash Risk Assessment Methodology (ACRAM) Standard*. Lawrence Livermore National Laboratory, prepared for the U.S. Department of Energy. UCRL-ID-124837. Livermore, California. 1996.

Lovato and Nielsen 1997	*Response to the GRAM Team Facility Walkdown/Interview Data Collection Document for LANL SWEIS Accident Analysis, TA-3-476, Gas Plant Toxic Gas Storage Shed*. J. Lovato and R. Gonzales-Nielsen. Attachment to February 19, 1997 LANL letter (ESH-EIS:97-038) from Doris Garvey (LANL/ESH-EIS) to Tom Anderson (GRAM, Inc.). Los Alamos National Laboratory. Los Alamos, New Mexico. 1997.
Mahn et al. 1995	*Qualitative Methods for Assessing Risk*. J. A. Mahn, G. W. Hannaman, and P. M. Krysta. Sandia National Laboratories, prepared for the U.S. Department of Energy. SAND95-0320. Albuquerque, New Mexico. April 1995.
MGP 1997	*Matheson Gases and Equipment.* Matheson Gas Products. Montgomeryville, Pennsylvania. 1997.
Miera et al. 1980	F. R. Miera, Jr., W. C. Hanson, E. S. Gladney, and P. Jose. "Mobility of Elevated Levels of Uranium in the Environment." *Natural Environment III*. T. F. Gesell and W. M. Lowder, eds. U. S. Department of Energy CONF-780422 (Vol. 1) pp. 681-699. Washington, D.C. 1980.
Miller et al. 1995	*A Report on the Seismic Capacity of the General Laboratory and Administration Building at Los Alamos National Laboratory*. C. A. Miller, et al. BNL-61500. Brookhaven National Laboratory. Prepared for Los Alamos National Laboratory. Brookhaven, New York.
NIOSH 1997	Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.
NRC 1977	*Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I*. Regulatory Guide 1.109. U.S. Nuclear Regulatory Commission. Washington, D.C. October 1997.
NRC 1998	*Nuclear Fuel Cycle Facility Accident Analysis Handbook.* NUREG/CR-6410. U.S. Nuclear Regulatory Commission. Washington, D.C. March 1998.
NSC 1995	*ALOHA^{TM}, Areal Locations of Hazardous Atmospheres User's Manual.* U.S. Environmental Protection Agency, National Safety Council, Chemical Emergency Preparedness and Prevention Office, and National Oceanic and Atmospheric Administration Hazardous Materials Response and Assessment Division. June 1995.
NWCG 1982	National Wildfire Coordinating Group. General Technical Report INT-122. April 1982.
Odum 1971	Odum, E. P. Fundamentals of Ecology. W. B. Saunders, Philadelphia. 1971.

Oswald et al. 1982 — *Generic Data Base for Data and Models Chapter of the National Reliability Evaluation Program (NREP) Guide*. A. J. Oswald, et al. Idaho National Engineering Laboratory, prepared for the U.S. Nuclear Regulatory Commission. EGG-EA-5887. June 1982.

Paternoster et al. 1995 — *Safety Analysis Report for the Los Alamos Critical Experiments Facility and the Hillside Vault*. R. R. Paternoster, R. E. Anderson, and E. M. Mullen. Los Alamos National Laboratory. Los Alamos, New Mexico. September 1995.

PC 1996b — Internal LANL e-mail from D. E. Volkman to D. Seide, regarding Summary of Seismic Capability of Key LANL Buildings. Los Alamos National Laboratory. April 7, 1996.

PC 1997 — Telecon between Stephanie Cohen, Los Alamos National Laboratory ESH-1, and Dr. Mohammed Abu-Shehadeh. April 4, 1997.

PC 1998 — Personal communication between Jack Hill and Nannette Founds, regarding meteor strikes. January 1998.

PC 1998b — Baars, J. Personal Communication from Bandelier National Monument. Los Alamos National Laboratory. Los Alamos, New Mexico. 1998.

PC 1998c — Balice, Randy. Personal Communication, Summary of Fuels by Forest-topography class. Los Alamos National Laboratory. August 12, 1998.

PC 1998d — Katzman, Dan. Environmental Restoration Program, LANL. Personal Communication via Wayne C. Hanson. Concentrations in DP Canyon. August 19, 1998

PC 1998e — Pratt, Allyn. Personal Communication to Rudolf Engelmann, SAIC. Los Alamos National Laboratory. September 11, 1998.

PC 1998f — Darling, Gene. Personal Communication to Rudolf Engelmann, Population Information for Los Alamos. August 25, 1998.

RAC 1991 — *Non-Electric Parts Reliability Data*. Reliability Analysis Center. Report NPRD-91. Rome, New York. May 1991.

RFETS 1994 — *Rocky Flats Risk Assessment Guide*, Revision 3. Rocky Flats Environmental Technology Site. Golden, Colorado. September 30, 1994.

Rhyne 1994 — *Risk Management of the Transport of Drums Containing Transuranic Waste from TA-55 to TA-54*. W. R. Rhyne. Prepared for Los Alamos National Laboratory by H&R Technical Associates, Inc. H&R 503-1. Oak Ridge, Tennessee. July 1994.

Sehmel 1984 — Sehmel, George. 1984 Deposition and Resuspension. In Atmospheric Science and Power Production, DOE/TIC-27601. U.S. Department of Energy, 1984. pp. 533-583.

Simard et al. 1989 — Simard, Albert J., Richard W. Blank, and Sharon L. Hobrla. Measuring and Interpreting Flame Height in Wildland Fires. Fire Technology, May 1989. p. 114-133.

SNL 1990 — *Procedures for the External Event Core Damage Frequency Analyses for NUREG-1150.* Sandia National Laboratories, prepared for the U.S. Nuclear Regulatory Commission. NUREG/CR-4840 and SAND88-3102. November 1990.

Steele et al. 1997 — *Plutonium Explosive Dispersal Modeling Using the MACCS 2 Computer Code.* C. M. Steele, T. L. Wald, and D. I. Chanin. U.S. Department of Energy, Los Alamos Area Office. September 1997.

Swain and Guttmann 1983 — *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications, Final Report.* A. D. Swain and H. E. Guttmann. Sandia National Laboratories, prepared for the U.S. Nuclear Regulatory Commission. NUREG/CR-1278 and SAND80-0200. Albuquerque, New Mexico. August 1983.

U.S. Army et al. 1990 — *Structures to Resist the Effects of Accidental Explosions.* U.S. Departments of the Army, the Navy, and the Air Force. TM 5-1300/NAVFAC P-397/ARF 88-22. Washington, D.C. November 19, 1990.

Valentine and Pendergrass 1997 — *TSFF TA-21-209 Accident MAR*. Informal LANL memorandum from Allen Valentine and Ann Pendergrass (ESH-EIS) to Doris Garvey (ESH-EIS). Los Alamos, New Mexico. April 7, 1997.

Vogt 1997 — "Empirical Investigations of the Diffusion of Waste Air Plumes in the Atmosphere." K. J. Vogt. *Nuclear Technology,* Vol. 34, pp. 43-57. 1977.

Wenzel et al. 1987 — Wenzel, W. J., T. S. Foxx, A. F. Gallegos, G. Tierney, and J. C. Rodgers. Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B. 1987.

WHC 1995 — *Drum Drop Test Report*. Westinghouse Hanford Corporation. WHC-SD-WM-TRP-231, Rev. 0. Richland, Washington. 1995.

Whicker and Schultz 1982 — *Radioecology: Nuclear Energy and the Environment*. F. Ward Whicker and Vincent Schultz. Vol. 2 of 2 volumes. CRC Press. Boca Ratan, Florida. 1982.

Wilgen et al. 1990 Wilgen, B. W. Van, K. B. Higgins, and D. U. Bellstedt. The Role of Vegetation Structure and Fuel Chemistry in Excluding Fire from Forest Patches in the Fire-Prone Fynbos Shrublands of South Africa. Journal of Ecology, 78:210-222. 1990.

Wong et al. 1995 *Seismic Hazards Evaluation of the Los Alamos National Laboratory*, Final Report, Vol. III. I. Wong, et al. Woodward-Clyde Federal Services. Oakland, California. February 24, 1995.

Young 1998 "LANL Wildfire Analyses." M. L. Young. Los Alamos National Laboratory. October 1998.

APPENDIX H
SUPPLEMENTAL ANALYSIS FOR THE ENHANCEMENT OF PIT MANUFACTURING AT LOS ALAMOS NATIONAL LABORATORY, STOCKPILE STEWARDSHIP AND MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Department of Energy
Washington, DC 20585

March 13, 1998

MEMORANDUM FOR GENE IVES
DEPUTY ASSISTANT SECRETARY FOR MILITARY APPLICATIONS AND STOCKPILE MANAGEMENT

ROBIN STAFFIN
DEPUTY ASSISTANT SECRETARY FOR RESEARCH AND DEVELOPMENT

FROM: Victor H. Reis
Assistant Secretary for Defense Programs

SUBJECT: Determination re: Supplement Analyses for the National Ignition Facility (NIF) and Pit Production at Los Alamos National Laboratory (LANL)

I have reviewed the attached Supplement Analyses on (1) the Use of Hazardous Materials in NIF Experiments at LLNL and (2) Enhancement of Pit Manufacturing at LANL in accordance with applicable Departmental regulations as well as your March 11, 1998, memorandum. I have approved the Supplement Analyses and have concluded that: (1) there are no substantial changes in the proposed actions that are relevant to environmental concerns; and (2) there are not significant new circumstances or information relevant to environmental concerns and bearing on the proposed actions or their impacts. Therefore, I have determined, that in accordance with 40 CFR 1502.9(c) and 10 CFR 1021.314(c), that neither a new Stockpile Stewardship and Management (SSM) Programmatic Environmental Impact Statement (PEIS) nor a supplement to the existing SSM PEIS is required.

Attachment

cc: B. Twining, AL
J. Turner, OAK

Concurrence: 3/12/98
GC-51
for William J. Dennison
Assistant General Counsel for Environment

Printed on recycled paper

**SUPPLEMENT ANALYSIS:
ENHANCEMENT OF PIT MANUFACTURING
AT LOS ALAMOS NATIONAL LABORATORY,
STOCKPILE STEWARDSHIP AND MANAGEMENT
PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT**

March 1998

SUMMARY

Recently, several issues have been raised regarding whether or not the 1996 Department of Energy (DOE) Stockpile Stewardship and Management (SSM) Programmatic Environmental Impact Statement (PEIS) analysis of locating a enhanced pit manufacturing capability at Los Alamos National Laboratory (LANL) should be supplemented due to new or overlooked information. Broadly, these issues have to do with: whether or not connected facilities were considered in the SSM PEIS; whether or not the upgrades to deteriorating facilities at LANL should have been considered in the SSM PEIS; and whether or not more recent information should be considered.

DOE has analyzed these issues in this Supplement Analysis and has concluded that there is no need to prepare a supplemental SSM PEIS to address reestablishing pit fabrication capability. The issues raised were either covered in the SSM PEIS and so were available to the decisionmaker; were project-specific issues related to the implementation of SSM decisions at LANL and so would be subject to subsequent tiered environmental review and decisionmaking; or were preliminary information and so would be subject to future review at such time as they are ripe for decision. Through this Supplement Analysis DOE recommends that neither a Supplemental PEIS, a new EIS, nor an amended ROD be prepared.

INTRODUCTION

Purpose of this Document

This document is a Supplement Analysis prepared to assist the Department of Energy (DOE) to determine whether or not to prepare a Supplemental Programmatic Environmental Impact Statement (PEIS) for its Stockpile Stewardship and Management (SSM) Program. This Supplement Analysis specifically addresses the issue of those aspects of DOE's nuclear weapons pit manufacturing capability and capacity (a "pit" is a central component of a nuclear weapon) that were assigned to Los Alamos National Laboratory (LANL) in the SSM Record of Decision (ROD).

Background - SSM PEIS

Before addressing whether or not the SSM PEIS should be supplemented, consideration of some background information regarding the PEIS, its intent, the decisions reached, and the formulation of issues, is presented. This information assists in arriving at conclusions and recommendations regarding supplementing the SSM PEIS, preparing a new EIS to address pit manufacturing, or changing the SSM ROD. The SSM PEIS was prepared in accordance with the National Environmental Policy Act (NEPA) [42 USC 4321 et seq.], the Council on

Environmental Quality (CEQ) NEPA implementing regulations [40 CFR 1500], and the DOE NEPA implementing regulations [10 CFR 1021].

In March 1996 DOE published a Draft PEIS on its nuclear weapons SSM Program [A.R. No. I-1385]; DOE published the Final SSM PEIS in September 1996 [DOE/EIS-0236, A.R. No. I-1561]. The SSM PEIS analyzed how DOE might carry out its nuclear weapons mission assignments, at a programmatic level, including alternative locations where DOE might assign various SSM missions. A ROD, based in part on the environmental analyses in the SSM PEIS, was issued on December 19, 1996 [61 FR 68014, A.R. No. I-1606, A.R. No. VII.B-26]. The SSM PEIS and ROD were intended to address the programmatic decisions facing DOE regarding implementation of its SSM Program. A two-tiered NEPA strategy was adopted, wherein implementing the programmatic decisions at a site-specific level in many cases would be accomplished through subsequent tiered project-specific NEPA reviews [SSM PEIS Vol. I, Sec. 1.5, p. 1-8; see also SSM ROD, Sec. 3.A.4].

The SSM PEIS and the SSM ROD covered those proposed actions which were the salient decision factors for determining how DOE would implement the SSM program for the foreseeable future. One of the proposals involved "Reestablishing Manufacturing Capability and Capacity for Pit Components" [SSM PEIS, Vol. I, Sec. 2.5.3, p. 2-11]. Capability is the practical ability to perform a basic function, and SSM capabilities are needed independent of future nuclear weapons stockpile sizes. Capacity is the size of the capability; in other words, the number of components that could be fabricated at a specific facility or a specific time. The SSM PEIS analyzed the potential capacity at different sites to support a potential nuclear weapons stockpile of various sizes (numbers of weapons) in order to examine the sensitivity of programmatic decisions to transfer weapons manufacturing activities to sites such as LANL. [SSM PEIS Vol. I, Sec. 1.1, p. 1-2.]

DOE needed to reestablish the capability to produce stockpile-ready pits that was lost when in 1992 DOE ceased plutonium pit manufacturing operations at its Rocky Flats Plant (RFP) (now known as the Rocky Flats Environmental Technology Site) in Colorado [SSM PEIS Vol. I, Sec. 2.5.3, p. 2-11]. The programmatic question addressed in the SSM PEIS and ROD related to pit fabrication was which DOE site should receive this mission assignment. Programmatic alternatives for locating pit fabrication alternatives were limited to sites which had some level of technical or facility infrastructure [SSM PEIS Vol. I, Sec. 2.5.3, p. 2-11; SSM PEIS Vol. I, Sec. 3.4.3, p. 3-57]. SSM PEIS alternatives included reestablishing pit capability and capacity at the DOE's LANL; reestablishing the capability and capacity at the DOE's Savannah River Site (SRS); or to continue to rely on the existing capability and capacity at LANL and the DOE's Lawrence Livermore National Laboratory (LLNL). LANL's facility infrastructure is located in several buildings at different Technical Areas (TAs). The three siting alternatives discussed and analyzed in the SSM PEIS were:

1. No Action (continue to use existing limited capabilities at LANL and continue to use the limited capability at LLNL to support material and technology development);
2. Reestablish pit fabrication at LANL (use existing facilities at TA-55, -3, -8, -50 and -54, and construct some upgrades);
3. Reestablish pit fabrication at SRS (use space in existing "hardened" nuclear facilities with extensive equipment and construction upgrades).

The SSM PEIS provided a comparative analysis of the programmatic impacts that would be expected to occur if the pit fabrication capability were to be reestablished at either LANL or SRS, compared against the No Action baseline [SSM PEIS, Vol. I, Section 4.6.3, p. 4-276]. Because construction of new buildings was not anticipated to be needed in order to assign the pit fabrication mission to LANL, notable environmental impacts were primarily limited to those from operations, such as radiological impacts, and socioeconomics. If the pit fabrication mission had been relocated to SRS, some new construction would have been needed [SSM PEIS, Vol. I, Section 4.3.3, p. 4-107]. Appendix A [SSM PEIS, Vol. II, Sec. A.1.5, p. A-28] *provided greater detail of the Defense Programs* Facilities in use at LANL, including the Chemical and Metallurgical Research (CMR) Building and Sigma Complex at TA-3, and the plutonium (Pu) facilities at TA-55 [Table A.1.5-1]. Similar, but less detailed information, for SRS was also presented [SSM PEIS, Vol. II, Sec. A.1.2, p. A-10]. Appendix A also discussed the specific facilities anticipated to be used for pit fabrication at LANL [SSM PEIS, Vol. II, Sec. A.3.3.1, p. A-117]; a list of specific facilities (including CMR and Sigma at TA-3, and the Plutonium Facility (PF) 4 and Nuclear Materials Storage Facility (NMSF) at TA-55) and type of construction was provided [SSM PEIS, Vol. II, Table A.3.3.1-1]. The text pointed out that if LANL were selected as the pit fabrication site, the then-current stockpile pit rebuild program at LANL would be absorbed within the pit fabrication effort since the activity would be the same -- only the number of pits would be different (greater) [SSM PEIS Vol. II, p. A-120]. Similar information was provided for SRS [SSM PEIS Vol. II, Sec. A.3.3.2, p. A-124].

In December 1996 DOE issued its programmatic decisions regarding how it would implement the SSM Program. The SSM ROD was based on more than just the environmental analysis of the SSM PEIS. DOE considered "other factors such as DOE statutory mission requirements, national security policy, cost, schedule, and technical risks. Additional technical descriptions and assessments of cost, schedule and technical risk are found in the Analysis of Stockpile Management Alternatives (DOE/AL, July 1996), the Stockpile Management Preferred Alternatives Report (DOE/AL, July 1996) ..." [SSM ROD, Supplementary Information - Background]. The technical and cost analyses for production capability and capacity alternatives analyzed in the SSM PEIS were covered in the draft "Stockpile Management Preferred Alternatives Report" [A.R. No. I-1381] and the "Analysis of Stockpile Management Alternatives" [A.R. No. I-1381], both dated February 1996, mentioned in the Final SSM PEIS [see, for example, SSM PEIS Vol. IV, comment response 40.18, p. 3-107]. The analyses in these reports showed that compared to SRS, locating the pit fabrication mission at LANL would be lower in cost and have less technical risk because LANL had recent experience in providing pits for nuclear explosive testing [SSM PEIS Vol. IV, comment response 32.03, p. 3-81; 32.06, p. 3-81]. These draft reports mentioned in the SSM PEIS were released in final form in July 1996 [A.R. No. I-1506] following the SSM PEIS and were used by the decisionmaker in determining SSM Program implementation decisions.

The DOE SSM decision regarding reestablishing pit fabrication was:

> ...to reestablish the pit fabrication capability, at a small capacity, at LANL. ... This decision limits the plutonium fabrication facility plans to a facility sized to meet expected programmatic requirements over the next ten or more years. It is not sized to have sufficient capacity to remanufacture new plutonium pits at the same production rate as that of their original manufacture. DOE will perform development and demonstration work at its operating plutonium facilities over the next several years to study alternative facility concepts for larger capacity. Environmental analysis of this larger capacity has not been performed at this time because of the uncertainty in the need for such capacity and the uncertainty in the facility technology that would be utilized. Should a larger pit fabrication capacity be required in the future, appropriate environmental and siting analysis would be performed at that time.
>
> Mitigation. Specific mitigation measures are not addressed for the stockpile management decisions of the ROD, although many potential mitigation measures are identified in the PEIS. In accordance with the Stockpile Stewardship and Management Program's two-tiered NEPA Strategy, these specific mitigation measures will be addressed, as necessary, on a site-by-site basis, in any site-specific NEPA analyses needed to implement the stockpile management decisions of this ROD.
>
> [ROD, Sec. 3.A.4]

In May 1997, a coalition of 39 organizations headed by the Natural Resources Defense Council (NRDC) brought action against DOE for alleged failure, among other things, "to adequately analyze the environmental effects of, and reasonable alternatives to" the SSM Program [NRDC v. Peña, Complaint for Declaratory and Injunctive Relief, May 2, 1997, p. 7]. In an amended complaint plaintiffs brought action against DOE for alleged failure, among other things, "to prepare a Supplemental [PEIS] based upon significant new information regarding the potential environmental impacts arising from ... the fabrication of nuclear weapon cores, or pits, at [LANL]"

[NRDC v. Peña, Amended Complaint for Declaratory and Injunctive Relief, January 30, 1998, p. 6 - 7]. The amended complaint included an affidavit from NRDC researcher Christopher Paine (Paine Affidavit) dated January 30, 1998, which among other things gave five reasons why plaintiffs believe a supplemental SSM PEIS was needed to further address pit production at LANL.

RECENT ISSUES RELATED TO PIT PRODUCTION

Overview

This Supplement Analysis has been prepared to determine whether to supplement that portion of the SSM PEIS which deals with the proposed action to reestablish a manufacturing capability and capacity for pits. It specifically looks at the five points raised by the Paine Affidavit, which are alleged to warrant preparation of a supplemental SSM PEIS. It also examines four issues which were raised by DOE because they may have some bearing on addressing points raised by Paine. The following section describes the issues raised by plaintiffs and by DOE.

Issues Raised by Plaintiff NRDC et al.

The Amended Complaint of January 30, 1998, among other things, asks that a supplemental SSM PEIS be prepared to address pit production at LANL. Reference is made to PF-4, TA-55, which is the main plutonium processing facility at LANL, the CMR Building at TA-3, and NMSF at TA-55. The following five issues and claims of alleged new information regarding DOE's pit production mission at LANL were identified by plaintiffs NRDC, et al., in their amended complaint and accompanying memorandum and supporting documents.

1. **Impacts at TA-55, PF-4.** That all proposed activities analyzed in the SSM PEIS for the LANL pit production mission were assumed to take place at TA-55, PF-4, and that impacts from connected actions were omitted. (Plaintiffs' Memorandum of Points and Authorities, Ex. 1, Affidavit of Christopher Paine, paragraph 19.)

2. **Connected actions.** That the Final PEIS did not identify and assess the connected and cumulative environmental impacts of six projects related to pit production, costing on the order of $1 billion. Those six projects are:
   (a) Modernize facilities and infrastructure at TA-55, particularly PF-4, to allow the continuing safe nuclear materials processing operations needed for pit fabrication through FY 2020.
   (b) Modernize the facilities and infrastructure of the TA-3 Sigma Complex for fabricating nonnuclear (e.g. beryllium, vanadium, uranium) pit components.
   (c) Relocate selected environmentally sensitive nuclear materials missions from TA-55 to CMR to provide sufficient space for expanded pit manufacturing operations at TA-55, a decision that is now under active reconsideration and may be abandoned.
   (d) Add sufficient analytical chemistry to the CMR facility to support increased pit production rates.
   (e) Establish a Special Nuclear Material Transportation Corridor between TA-55 and the CMR facility.
   (f) Renovate NMSF to accommodate increased plutonium inventory resulting from a planned increase in pit surveillance and pit fabrication operations.

   (Plaintiffs' Memorandum of Points and Authorities, Ex. 1, Affidavit of Christopher Paine, paragraph 20.)

3. **Surge planning scenario.** That the PEIS analysis is outdated because it did not analyze the reasonable foreseeable environmental impacts from DOE's approved surge planning scenario for fabricating up to 500 pits per year at multiple sites. (Plaintiffs' Memorandum of Points and Authorities, Ex. 1, Affidavit of Christopher Paine, paragraph 21.)

4. **DNFSB safety consideration.** That the PEIS inadequately considered safety consideration associated with the CMR Building, identified in part in a December 1997 DNFSB report to DOE. (Plaintiffs' Memorandum of Points and Authorities, Ex. 1, Affidavit of Christopher Paine, paragraphs 22 and 23.)

5. **Accidents involving Pu-238.** That the PEIS omitted any analysis of accident consequences involving release of Pu-238, where information indicates that two-thirds of the PF-4 space at TA-55 slated for processing Pu-238 would be located in the same building as pit fabrication activities. (Plaintiffs' Memorandum of Points and Authorities, Ex. 1, Affidavit of Christopher Paine, paragraph 24.)

Issues Raised by DOE

The SSM ROD assigned the mission to reestablish its pit fabrication capability, at a small capacity, at LANL. DOE's plans for implementing the pit production mission at LANL have evolved, organizational changes have been accomplished, and new studies have been initiated regarding regional environmental features. The pertinent issues that have been raised by DOE over the past several months, which bear on the issues raised by plaintiffs, are as follows.

1. **Pit production strategy.** That DOE approved a modified strategy for pit fabrication in December 1997 and in January 1998 directed LANL to pursue the modified strategy. The strategy in general addressed engineering project management, scheduling, and logistics issues. The three objectives of the new strategy are:

   (a) Decouple the specific DOE project for pit fabrication, which is included in the Capability Maintenance and Improvements Project (CMIP), from other projects and focus development of pit production capability at TA-55 without disrupting ongoing mission.
   (b) Maintain pit production as a continuous process, and achieve an intermediate capacity of 20 pits per year by FY 2007 without prejudice to the eventual 50 pit per year capacity.
   (c) Delay CMIP while performing urgent maintenance and equipment replacement beginning in FY 1999.

2. **CMR project management considerations.** That in early 1997 DOE and LANL decided to temporarily suspend construction activities for the CMR upgrades project pending a thorough budget and project management review.

3. **CMR safety reviews and organizational changes.** That on September 2, 1997, in response to safety considerations, LANL temporarily suspended operations within the CMR building pending an in-depth review of all operations and procedures being implemented within the building to support on-going LANL missions. Operations were resumed over time in a phased manner as work control and work authorization procedures were verified for each on-going project within the building.

4. **New earthquake faulting studies at LANL.** That new studies initiated in 1997 indicate an increased likelihood of geologic rupture should certain seismic events occur.

ANALYSIS OF ENVIRONMENTAL ISSUES RAISED

Analysis

For each of the issues outlined above, this Supplement Analysis examines the following factors:

(a) Is the issue germane to a NEPA analysis?
(b) Does the issue represent a substantial change to the proposal analyzed in the SSM PEIS?

(c) Does the issue present significant new circumstances or information relevant to environmental concerns that was not available to the decisionmaker at the time the SSM ROD was issued?
(d) Would the issue, if known at the time, have affected the outcome of the programmatic decisions in the SSM ROD?

If the Supplement Analysis leads to the conclusion that the decisions in the SSM ROD were based on an obsolete analysis, and if new information could have led to a different programmatic decision regarding where to locate the reestablished pit fabrication capability, then the SSM PEIS should be supplemented. If the Supplement Analysis leads to the conclusion that the information raised in the issue was incorporated in the SSM PEIS or otherwise known to the decisionmaker at the time the SSM ROD was issued; that the information pertains to site-specific implementation of programmatic decisions; or that the information is irrelevant to a NEPA review; then the SSM PEIS need not be supplemented.

Analysis of Issues Raised by Plaintiffs

1. Impacts at TA-55, PF-4. That all proposed activities analyzed in the SSM PEIS for the LANL pit production mission were assumed to take place at TA-55, PF-4, and that impacts from connected actions were omitted.

The alternative to reestablish pit fabrication at LANL is discussed in the SSM PEIS in Chapter 3 [SSM PEIS Vol. I, Sec. 3.4.3.2, p. 3-58] which in turn refers to a more detailed discussion in Appendix A [SSM PEIS Vol. II, Appendix A, Sec. A.3.3.1, p. A-117]. Appendix A, Table A.3.3.1-1, lists six separate buildings projected to be used for pit fabrication if the mission were located at LANL. Therefore it was understood that more than one facility would be used for pit fabrication activities at LANL. [See also the *Declaration of Paul T. Cunningham*, June 6, 1997, paragraph 5.]

The SSM PEIS provided an analysis of those factors that allowed the decisionmaker to discriminate between locating the pit fabrication capability at LANL or SRS. The SSM PEIS focused on major facilities and omitted minor facilities [SSM PEIS, Vol. II, Sec. A.1.5, p. A-28]. The programmatic analysis was based on bounding scenarios for potential impacts at the two sites considered, and the level of detail that appeared in the SSM PEIS was sufficient for the decision to be made -- that of placement of mission.

Environmental impacts from reestablishing pit fabrication at LANL were analyzed in Chapter 4 [SSM PEIS, Vol. I, Sec. 4.6.3, p. 4-276]; impacts to the several facets of the environment were projected based on the description of the alternatives in Appendix A. The discussions under many of the facets made reference to the multiple TAs involved in the proposal; see, for example, the discussion for cultural resources [SSM PEIS, Vol. I, Sec. 4.6.3.7, p. 4-291] which specifically addressed the potential for impacts at each of six TAs. The Paine Affidavit issue specifically addressed impacts for waste management, air quality, and surface water. The PEIS impact analysis for waste management referenced LANL "facilities" in the plural [SSM PEIS, Vol. I, Sec. 3.4.3.2, p. 3-61]; that for air quality was based on either actual stacks or a hypothetical centrally located stack [SSM PEIS, Vol. II, Sec. B.3.6, p. B-14]; that for surface water resources referenced "TAs" in the plural [SSM PEIS, Vol. I, Sec. 4.6.3.4, p. 4-283]. Therefore, where appropriate impacts were analyzed for more than just TA-55.

The SSM PEIS provided a comparative analysis of the action alternatives against the No Action alternative, which served as a reference base [SSM PEIS, Vol. II, Sec. A.1, p. A-1]. Each of the two sites analyzed in the SSM PEIS, LANL and SRS, have an existing infrastructure associated with nuclear operations; hence the impacts associated *with locating the pit fabrication mission were additive to the No Action impacts from missions already* at each site. The No Action alternative assumed that the sites would continue to operate until at least 2005 with existing facilities that could comply with environment, safety and health requirements, and that facilities would be subject to routine maintenance and repairs. Therefore, the impacts of reasonably foreseeable facility repairs and workloads were included in the No Action baseline.

Consideration of whether actions are connected in the sense of NEPA is useful to determine whether they should be analyzed together, as in a programmatic review such as the SSM PEIS, rather than separately [40 CFR 1508.25(a)(1)]; it is appropriate to consider in one programmatic analysis the impacts from establishing connected pit fabrication activities in several facilities. The SSM PEIS did this. In keeping with the two-tiered NEPA strategy outlined in the SSM PEIS [SSM PEIS, Vol. I, Sec. 1.5, p.1-8], DOE decided that the impacts of implementing programmatic decisions at a site-specific level would be addressed in subsequent tiered project-specific NEPA reviews [SSM ROD Sec. 3.A.4].

The LANL Site Wide EIS (SWEIS), currently in preparation in accordance with 10 CFR 1021.330(c), will provide a site-specific look at the cumulative impacts of operating LANL; it will also analyze four alternative ways to continue to operate the entire site for the next ten years [Advance Notice of Intent (ANOI) to prepare the SWEIS [59 FR 40889, August 10, 1994], A.R. No. VII.B-14; Notice of Intent to prepare the SWEIS [60 FR 25697, May 12, 1995], A.R. No. VII.B-18; LANL SWEIS Implementation Plan [DOE/EIS-0238], November 1995, A.R. No. VII.B-20]. The four planned draft alternatives are:

(a) No Action - continue LANL operations at their current planned level.
(b) Expanded Operations - implement all current DOE mission element assignments to LANL at the highest foreseeable level of activity and fully implement recent mission assignments.
(c) Reduced Operations - conduct the minimal level of activity necessary to maintain capabilities necessary to support DOE missions.
(d) Greener Operations - use LANL capabilities to minimize support to DOE defense and nuclear weapons missions, and maximize support to other DOE mission elements.

The LANL SWEIS will consider the impacts of implementing the SSM programmatic decisions at LANL. It will consider enhancement of the existing pit manufacturing capability at LANL, and is expected to provide a project-specific NEPA review for certain aspects of the SSM ROD pit fabrication mission assignment, including CMIP. The SSM PEIS looked at pit fabrication needs over the next 10 or more years, essentially the same timeframe as the LANL SWEIS analysis. Under the No Action Alternative (the base case in the SWEIS analysis), LANL could continue to fabricate pits at the existing capability level (approximately a pit per month); under the Expanded Operations alternative, LANL could fabricate 50 pits per year (using a single labor shift) or achieve 80 pits per year (the surge level indicated in the SSM PEIS) within the 10-year timeframe; and under the other two alternatives LANL could maintain a pit manufacturing capability but produce pits at a lesser number.

The Draft LANL SWEIS is currently scheduled for release to the public for review and comment in May 1998. The Final SWEIS is scheduled for November 1998, and the ROD for late 1998.

The issue is in error regarding the allegation that only TA-55 was considered in the SSM PEIS; the SSM PEIS analysis was based on the projection that several major and minor facilities at LANL would be involved in pit fabrication. The issue provides no new information that was not available to the SSM decisionmaker. Therefore, no change to the SSM PEIS is warranted.

2. Connected actions. That the Final PEIS did not identify and assess the connected and cumulative environmental impacts of six projects related to pit production, costing on the order of $1 billion. Those six projects are:

(a) modernize facilities and infrastructure at TA-55, particularly plutonium Facility 4, to allow the continuing safe nuclear materials processing operations needed for pit fabrication through FY 2020;

The SSM PEIS limited its review of alternative locations for reestablishing pit fabrication to those sites that already had some measure of the appropriate technical or facility infrastructure [SSM PEIS Vol. I, Sec. 2.5.3, p. 2-11];

only two sites, LANL and SRS, qualified. At LANL the preexisting plutonium capability existed largely at TA-55, which contributed to LANL qualifying as an alternative site. Facilities at LANL such as TA-55 are used to support a variety of mission needs for a variety of sponsors [SSM PEIS Vol. I, Sec. 3.2.6, p. 3-18; Table 3.2.6-1, p. 3-19]. TA-55 is one of the newer facilities at LANL (first occupied in the late 1970s); like all buildings it requires periodic maintenance in order to continue to operate. The SSM PEIS indicated that no facilities at LANL would be phased out regardless of decisions on pit fabrication stemming from the SSM PEIS [SSM PEIS Vol. I, Sec. 4.6.1, p. 4-246]. It is essential to maintain the nuclear infrastructure at LANL in safe operating condition and perform upgrades when necessary to achieve environment, safety and health goals. Therefore, the SSM PEIS decisionmaker was aware that DOE would be obligated to repair and maintain its facilities at LANL, including TA-55, in a safe operating condition independent of the mission assignment for pit fabrication. LANL has existing capabilities that are essential to support other ongoing missions in addition to pit fabrication, such as the TA-55 capability for residue processing and for storing and handling plutonium. Although TA-55 facilities are being used to support LANL's pit fabrication mission, facility maintenance requirements exist independent of this mission assignment.

DOE included requirements and plans for refurbishing nuclear facilities at LANL as part of the No Action alternative in the SSM PEIS. In addition, this issue was addressed in the Final PEIS Comment Response Document [SSM PEIS, Vol. IV]. In response to a question of why DOE is investing in new facilities at LANL, DOE stated that "The TA-55 plutonium facility is approaching 20 years of service and many components of the facility need replacement or upgrading in order to sustain the R&D mission of the laboratory." [SSM PEIS Vol. IV, comment response 32.16, p. 3-84.] DOE further stated: "It is true that DOE has determined that, under the existing stockpile stewardship and management activities that have been ongoing for many years, facilities at LANL will have to be maintained and in some cases repaired or upgraded to allow LANL to continue to fulfill its existing mission. Far from being a 'stunning admission' that future assignments are already being implemented, DOE believes that is simply good management practice to keep its considerable real property -- its buildings and other infrastructure -- in safe, sound, and operating order." [SSM PEIS, Vol. II, comment response 40.90, p. 3-144.] DOE and LANL need to continue to operate TA-55 and PF-4 in a way that will allow the safe operation of the buildings to support nuclear materials processing operations for the indefinite, foreseeable future; one such use, but not the only such use, will be pit fabrication activities. In addition to the repairs and maintenance that would take place under the No Action baseline, the SSM PEIS acknowledged that upgrades to PF-4, TA-55 would be needed to implement the pit fabrication mission [SSM PEIS, Vol. I, Sec. 3.4.3.2, p. 3-58].

The SSM PEIS provided a programmatic review of the factors needed for the decisionmaker to discriminate between locating the pit fabrication activities at LANL or SRS. Under the two-phase NEPA strategy outlined in the SSM PEIS, project-specific decisions related to exactly how the programmatic decisions would be implemented at LANL would be covered in subsequent tiered NEPA reviews. Although the SSM PEIS indicated it assumed, as a No Action base case, that operating facilities at LANL and SRS would be kept in safe, environmentally compliant operating condition [SSM PEIS, Vol. II, Sec. A.1, p. A-1], it did not analyze at the site-specific level exactly how that would be accomplished. That level of detail would have been unnecessary, hence inappropriate, for a programmatic siting decision. Any future proposals to upgrade equipment or structures at TA-55 would be looked at to determine if they would be subject to NEPA review; any such review pertaining to pit fabrication would be considered a tiered review flowing from the SSM PEIS and ROD. This issue was also addressed in November 1997 as part of the court-ordered disclosure of information regarding pit production activities at LANL.

The Paine Affidavit makes reference to a newspaper article about the pit fabrication project (Paragraph 20, Attachment G), "LANL Plutonium Pit Project Plagued by Cost Overruns" [*Santa Fe New Mexican*, December 5, 1997, p. A-1, A.R. VII.B-44]. This article was based on a wide-ranging interview with the LANL pit fabrication program manager, and discussed the then-current status of the pit fabrication project. The article discussed cost overruns in the CMR Upgrades project. The situation regarding cost overruns in the CMR Upgrades project is addressed under DOE Issue 2, below. The article also referenced five upgrade alternatives; these are discussed below under Plaintiffs' Issue 5, Paine Affidavit Attachment J. The information referenced in the newspaper article does not constitute a substantial change to the programmatic proposal analyzed in the SSM PEIS.

This issue is not germane to a programmatic decision as to whether to site pit fabrication capabilities at LANL or SRS. Because it was understood in the SSM PEIS that facilities such as TA-55 needed to be kept in safe operating condition regardless of whether or not LANL received the pit fabrication mission, this issue does not present new information that was not available to the SSM decisionmaker. Even if a NEPA review would be required, it would be a tiered, project-specific review. Therefore, no change to the SSM PEIS is warranted.

(b) modernize the facilities and infrastructure of the TA-3 Sigma Complex for fabricating nonnuclear (e.g. beryllium, vanadium, uranium) pit components;

Nonnuclear weapons components such as those made from beryllium are an integral part of a pit; fabricating beryllium and other components was reassigned to LANL in 1993 prior to and independently of the pit fabrication mission assignment [SSM PEIS Vol. IV, comment response 32.08, p. 3-83]. In 1992 DOE decided to prepare an Environmental Assessment (EA) on its proposal to consolidate certain nonnuclear facilities within the nuclear weapons complex [57 FR 3046, January 27, 1992, A.R. No. VII.B-5], and completed the EA in June 1993 [DOE/EA-0792, A.R. No. III-85]. In this context, nonnuclear facilities are those which manufacture or test the nonnuclear parts of nuclear weapons. These parts include such things as electronics, batteries, detonators, and specifically include beryllium technology and pit support [Nonnuclear Consolidation EA Executive Summary, p. ES-1, DOE/EA-0792(ES), A.R. No. VII.B-9]. On September 14, 1993, DOE issued a Finding of No Significant Impact (FONSI) on the Nonnuclear Consolidation EA [58 FR 48043, A.R. No. VII.B-12] after considering public comments on a proposed FONSI [A.R. No. VII.B-11]. The then-proposed action included a proposal to enhance existing beryllium technology at LANL: "Beryllium Technology and Pit Support -- The existing technology base and prototyping capability at LANL would be enhanced to provide limited manufacturing capability for beryllium technology and pit support now done at RFP." [58 FR 48045.]

As soon as the FONSI was issued, DOE began to implement the proposed action [Letter from Howard Canter, Deputy Assistant Secretary for Weapons Complex Reconfiguration, to Interested Parties, September 24, 1993, A.R. No. VII.B-13]. The beryllium technology work from RFP was subsequently moved to the Sigma Complex at TA-3, LANL, to complement and enhance the prior existing capability.

The DOE's proposal to enhance the capability at the TA-3 Sigma Complex for beryllium technology and pit support functions was analyzed at length in the Nonnuclear Consolidation EA, June 1993, and discussed in its FONSI, September 1993. Implementation of this proposal began shortly after the FONSI was issued and included upgrades to Sigma Complex. Therefore, this decision did not have to be revisited in the SSM PEIS; since no decisions were needed on this aspect, no additional NEPA analysis was needed in the SSM PEIS.

This issue does not present new information that was not available to the SSM decisionmaker. Therefore, no change to the SSM PEIS is warranted.

(c) relocate selected environmentally sensitive nuclear materials missions from TA-55 to the aging CMR building to provide sufficient space for expanded pit manufacturing operations at TA-55, a decision that is now under active reconsideration and may be abandoned;

The SSM PEIS addressed the programmatic issues related to whether to site pit fabrication activities at LANL or SRS. The SSM PEIS stated that site-specific implementation of the programmatic decision would be addressed in subsequent tiered NEPA reviews [SSM PEIS, Vol. I, Sec. 1.5, p. 1-8]. The CMR Building is needed to support ongoing LANL work regardless of the assignment of the pit fabrication mission to LANL, and space allocations for assignment of work relating to nuclear materials may or may not be relevant to the pit fabrication mission. For pit fabrication, the specifics of exactly what processes would go in which building would be a site-specific detail of implementation beyond the intent of the SSM PEIS. A planning decision has not yet been made regarding whether to propose the use of the CMR building for missions relocated from TA-55, if, in fact, any activities are moved from TA-55. Potential environmental impacts for this scenario, if proposed, would be analyzed in project-specific NEPA reviews when appropriate. Alternatives to moving activities from TA-55 to CMR are anticipated to be addressed in the LANL SWEIS, including the potential for expanding TA-55. In the event that a decision that is made through a NEPA review is subsequently abandoned, additional NEPA review is not needed to address the agency's failure to take the action.

This issue does not present new information that is germane to a programmatic SSM decision. Therefore, no change to the SSM PEIS is warranted.

(d) add sufficient analytical chemistry capacity to the CMR facility to support increased pit production rates;

LANL has existing capabilities that are essential to support other ongoing missions in addition to pit fabrication including the capability for analytical chemistry in CMR. In 1997 DOE completed its EA on the proposed upgrades to the CMR Building [DOE/EA-1101, A.R. No. VII.B-27]. DOE found that no significant impacts would be expected to occur, therefore an EIS on that proposal was not needed [FONSI, February 11, 1997, A.R. No. VII.B-28]. The EA analyzed upgrades needed to make the building continue to be useable for the foreseeable future for continuing ongoing mission assignments. It specifically did not analyze upgrades needed to implement potential future new mission assignments. The CMR FONSI covered two potential upgrade designs for the CMR upgrades. Under the first, DOE would upgrade the chemistry space in three wings with collocated office space. Under the second, DOE would upgrade the chemistry space in two wings, relocate office space, and put the third wing in safe standby condition. The FONSI stated that if DOE selected the second design, and subsequently considered the space in the third wing for other programmatic needs, DOE would perform a separate NEPA analysis regarding any proposed new mission use.

DOE must maintain the nuclear infrastructure at LANL regardless of the pit fabrication mission in order to perform nuclear operations safely and reliably. Analytical chemistry is needed to support pit fabrication [SSM PEIS, Vol. I, Sec. 3.4.3.2, p. 3-58; Sec. 3.4.3.3, p. 3-64]. The SSM PEIS analyzed analytical chemistry as part of the infrastructure capability for each site (LANL and SRS) sufficient to support the pit capacities analyzed. The CMR building, built in the early 1950s, requires maintenance, repairs and upgrades to sustain the effectiveness and safety of the facility. These upgrades were addressed in the No Action Alternative in the SSM PEIS [SSM PEIS, Vol. IV, comment response 41.18, p. 3-158] and in the CMR EA and FONSI of February 1997. [See also the Declaration of Paul T. Cunningham, paragraphs 9 and 10, and the Second Declaration of Albert E. Whiteman, paragraph 5.d.1.]

There are no proposals to increase pit production rates over those analyzed in the SSM PEIS. Although at the request of Congress DOE and LANL have done some preliminary contingency planning as to how higher production rates might be achieved, if ever necessary, these considerations have not reached the state of an agency proposal, hence are not ripe for decision or NEPA review (see Plaintiffs' Issue 3, below).

This issue is based on incorrect information regarding rates of pit fabrication. The issue does not indicate that the analytical capability analyzed in the PEIS was incorrect. Therefore, no change to the SSM PEIS is warranted.

(e) establish a Special Nuclear Material Transportation Corridor between TA-55 and the CMR facility;

Although the idea of paving an existing, essentially abandoned, gravel road between TA-55 and the CMR Building at TA-3 has been discussed over the years, and may have some advantages for the safe, secure transport of nuclear materials between those two facilities, DOE has not yet formally proposed to undertake this action; however, it is anticipated that this may be included in the SWEIS as part of the consideration of a possible new transportation corridor between the two buildings.

This issue is not germane to a programmatic NEPA review since it is at the level of a minor site-specific infrastructure feature. While it may be a convenience in operating LANL facilities, it is not a necessary action for pit fabrication and does not bear on the programmatic decision to locate the pit fabrication mission at LANL. Therefore, no change to the SSM PEIS is warranted.

(f) renovate and make major modifications to the Nuclear Materials Storage Facility (NMSF) at TA-55 to accommodate increased plutonium inventory resulting from planned increase in pit surveillance and pit fabrication operations.

In 1986 DOE completed an EA and FONSI on the construction and operation of the then-new proposal for NMSF. [Memorandum, DOE/HQ, EH-1, Assistant Secretary Walker, to DOE/HQ, DP-1, Assistant Secretary Foley, August 28, 1986, A.R. VII.B-2; NMSF EA, A.R. No. VII.B-1, and FONSI, August, 1986, A.R. No. VII.B-2.] The operation of NMSF for its intended purpose was considered in the SSM PEIS as part of the No Action baseline and as a facility that could be used to support pit fabrication at LANL.

The NMSF was conceived in the early 1980's as a centralized facility at LANL for receipt and intermediate to long-term storage of special nuclear materials. Upon completion of construction of NMSF in 1987, DOE and LANL identified design and construction deficiencies in this facility which precluded the acceptance of the structure for occupancy; the introduction of nuclear materials into the NMSF was therefore not possible because it could not be used for its intended function and because health and safety operating parameters could not be met. In the early 1990's a series of studies was conducted to determine what needed to be done to bring the structure to an operable state. The repairs came to be known as the "NMSF Renovation Project." The NMSF renovations would allow the building to operate at its original design capacity (6.6 metric tons of plutonium) to support ongoing mission assignments at LANL, and were determined to be covered by the 1986 NMSF EA [Memorandum, Webb, DOE/LAAO, to Foxx, LANL, December 21, 1994, A.R. VII.B-17; covering memorandum, Reis, DOE/HQ/DP-1, to Manager, DOE/AL, November 9, 1994, A.R. No. VII.B-15; see also Ellard, LANL, May 14, 1993, A.R. No. VII.B-6, and Tingley et al., LANL, May 25, 1993, A.R. No. VII.B-7].

DOE is now renovating the facility to correct design and construction deficiencies in the structure, and damage and deterioration resulting from these deficiencies. Conceptual design for the NMSF renovations began in 1997, preliminary design began in 1998, final design is expected to start in the spring of 1999, construction is scheduled to begin in the summer of 2000, and the renovations are scheduled to be completed in 2004. The renovations will allow the facility to store up to 6.6 metric tons of plutonium, as was covered in the 1986 EA and FONSI. The facility will be used to support many on-going LANL mission requirements, including the SSM Program.

DOE plans to renovate the NMSF, as has been discussed since 1992, to correct design and construction deficiencies in the structure and damage and deterioration resulting from these deficiencies. However, the renovations would serve only to make the building functional in order to perform the activities discussed and analyzed in the 1986 NMSF EA and FONSI. The baseline used in the SSM PEIS for determining the impacts of reestablishing pit fabrication capability at LANL included making use of NMSF when functional (NMSF cannot be used to store nuclear materials until it becomes functional which would not be possible until renovation activities have taken place). The plans to renovate the NMSF were known to the SSM decisionmaker and do not constitute new information. There are no plans to store additional material in the NMSF over the amount considered at the time the SSM PEIS was prepared -- the NMSF will be renovated to accommodate storing 6.6 metric tons of plutonium, the same amount of material used as the basis of the analysis in the 1986 NMSF EA.

There are no proposals to increase pit production rates over those analyzed in the SSM PEIS. Although at the request of Congress DOE and LANL have done some preliminary contingency planning as to how higher production rates might be achieved, if ever necessary, these considerations have not reached the state of an agency proposal, hence are not ripe for decision or NEPA review (see Plaintiffs' Issue 3, below). There are no plans to increase pit surveillance over current projections (known to SSM decisionmakers) or to increase pit fabrication operations over the levels analyzed in the SSM PEIS.

This issue was earlier addressed in this litigation in the First Declaration of Albert E. Whiteman. He states that the NMSF renovation was considered in the baseline No Action alternative of the SSM PEIS, and that these "activities are necessary for ongoing stockpile stewardship and management independent of the determination made in the SSM-PEIS." [First Declaration of Albert E. Whiteman, p. 2. See also Declaration of Paul T. Cunningham, paragraph 11.]

This issue does not present new information that was not available to the SSM decisionmaker. The issue regarding increase in pit fabrication operations over that analyzed in the SSM PEIS is erroneous. Therefore, no change to the SSM PEIS is warranted.

3. Surge planning scenario. That the PEIS analysis is outdated because it did not analyze the reasonable foreseeable environmental impacts from DOE's approved surge planning scenario for fabricating up to 500 pits per year at multiple sites.

The SSM PEIS analysis of fabricating 20 to 50 pits per year, with 80 pits per year on a surge basis, was predicated on the need for new pits over the next 10 or more years. For comparison, the capacity of RFP when operating was about 2,000 pits per year [SSM PEIS Vol. IV, comment response 32.01, p. 3-80]; the SSM PEIS addressed reestablishing the former RFP capability but not its former capacity. DOE was aware at the time the PEIS was prepared that future requirements for capacity for pit fabrication were uncertain [*SSM PEIS Vol. I, Sec. 3.6, p.* 3-93]. In the SSM PEIS Comment Response Document, DOE stated: "Because of the small demand for the fabrication of replacement plutonium pits over the next 10 or more years, DOE did not propose a new pit fabrication facility with a capacity equivalent to the capacities required for other portions for the nuclear weapons complex. However, limited fabrication of new replacement pits would be required to maintain capability and to replace pits lost during weapons surveillance. Section 3.6 discusses DOE's future plans should a life-limited phenomenon be found in stockpile pits and a larger pit fabrication capacity be required." [SSM PEIS Vol. IV, comment response 40.19, p. 3-107.] The SSM ROD indicated that if a greater capacity for pit fabrication were to be needed in the future, appropriate environmental and siting analyses would be performed at that time [SSM ROD Supplementary Information; Sec. 3.A.4]. To date, the nation has not determined future stockpile rates to be greater than anticipated in the SSM PEIS, and DOE has no proposals at this time to establish a greater pit fabrication capacity within its planned capability.

Part of the assignment given to LANL by the SSM ROD was to assist DOE in developing equipment and technologies to expand the limited capability assigned in 1996 to LANL into a larger capability that might be needed by DOE at some site at some point in the future. This did not imply that such an expanded capacity, if ever needed, would be located at LANL; instead, the SSM ROD stated that in this event, environmental and siting studies would be performed [SSM ROD 3.A.4].

The Paine Affidavit makes reference to LANL's Institutional Plan for FY 1998 - 2003 (Paragraph 21, Attachment H). The "Institutional Plan FY 1998 - FY 2003" [LALP-97-130, October 1997, A.R. No. VII.B-40], in turn, makes reference to a multi-site study and the consideration of a modular production capability that could be deployed rapidly if there was a change from the requirements considered in the SSM PEIS and ROD [LALP-97-*130, p. 28]. In February 1996 DOE formed an inter-site team which was asked to develop a plan which would* provide a strategy to establish a project in FY00 which would be responsible for developing a means to achieve a higher pit production capacity within five years of an identified need [Memorandum, February 21, 1996, Whiteman to Veldman, et al., A.R. No. VII.B-22; Attachment, "Rapid Reconstitution of Pit Production Capacity," February 20, 1996, Khalil, DOE AL, A.R. No. VII.B-21]. The memorandum stated that the project needed to provide a scaleable capacity, and would require development and technology demonstration; the *SSM ROD* subsequently recognized this: "DOE will perform development and demonstration work at its operating plutonium facilities over the next several years to study alternative facility concepts for a larger capacity." [SSM ROD, Sec. 3.A.4.] This memorandum predated the SSM PEIS and was known to the SSM decisionmaker. In August 1997 the inter-site team completed its report, "Rapid Reconstitution of Pit Production Capacity: Systems Studies Assessment and Recommendations" [LLNL UCRL-ID-128655, Jardine, LLNL, Reardon, LANL, and Grimley and Branstetter, Sandia National Laboratories, August 1997, A.R. No. VII.B-36]. This document is subject to controlled distribution because it contains Unclassified Controlled Nuclear Information (UCNI) material. The strategy responds to the 1996 memorandum charge to be able to establish a greater capacity within five years of an identified need. The SSM ROD stated that in the event a larger capacity were ever needed, appropriate siting and environmental reviews would be performed at that time [SSM ROD, Sec. 3.A.4]. While the August 1997 report was completed after the SSM ROD was issued, it addressed a topic that the SSM ROD specifically excluded as a reasonably foreseeable action requiring a programmatic decision at that time. Therefore neither the LANL Institutional Plan nor the 1997 rapid reconstitution plan present new information that would bear on the SSM ROD decisions to site pit manufacturing capacity at LANL.

As part of prudent planning to support and maintain the directed stockpile levels in the event of an unforeseen future issue that could affect national security, at the request of Congress in FY96 DOE began work on a preliminary contingency plan that could put into place a production capability of up to 500 pits per year. In the National Defense Authorization Act for Fiscal Year 1997, P.L. 104-201, Section 3151, Congress required the Secretary of Energy to submit to Congress a report on DOE's plans for achieving the capability to produce and remanufacture plutonium pits. In response to that requirement, DOE prepared the "Department of Energy Report on Plutonium Pit Production and Remanufacturing Plans" [Letter, Secretary Peña to Congressman Floyd Spence, Chairman, Committee on National Security, U.S. House of Representatives, August 18, 1997, covering "Department of Energy Report on Plutonium Pit Production and Remanufacturing Plans, Secretary of Energy, July 1997." A.R. No. VII.B-37]. The report provided Congress with DOE's initial baseline plan to restore the capability to produce pits for the nuclear weapons stockpile (war-reserve pits). The baseline consisted of three parts: (a) demonstrate that the capability to produce war-reserve pits can be reestablished at LANL; (b) install a limited capacity at LANL to produce up to 50 war-reserve pits; and (c) develop a contingency plan to establish capacity to produce up to 500 war-reserve pits, using LANL technology as a model, at existing DOE buildings at SRS, DOE's Oak Ridge Reservation, DOE's Pantex Plant, and DOE's Nevada Test Site [Report, p. 2]. The number 500 was used for planning purposes because it represented a rate which could reproduce a large quantity "lot" within a reasonable timeframe, and because it was felt to be achievable by replicating multiple setups of the type that are being put into place at LANL. [See also A.R. No. VII.B-42.] No specific requirements for an upper capacity number have yet been developed. This preliminary plan, which has never progressed beyond its very early stages, is currently on hold pending development and evaluation of the design, processes, equipment, and feasibility of the current ongoing pit rebuild program at LANL. As stated in the SSM ROD, any decisions to pursue an expanded capacity in the future, including siting decisions, would be subject to further NEPA review [SSM PEIS, Vol. I, Sec. 1.5, p. 1-8].

The SSM PEIS and ROD acknowledged that future needs for pit fabrication capacity are unknown, and that future plans for future capacities will be subject to future NEPA review. The contingency plan requested by Congress, which has had some preliminary work, is not fully developed and is not expected to be fully developed for quite some time. Therefore it does not represent a proposal within the meaning of NEPA, and is not ripe for analysis or decision.

This issue does not present new information that is germane to the programmatic decisions in the SSM ROD. It raises an issue that is not yet ripe for NEPA review. Therefore, no change to the SSM PEIS is warranted.

4. DNFSB safety consideration. That the PEIS inadequately considered safety consideration associated with the CMR Building, identified in part in a December 1997 DNFSB report to DOE.

The DNFSB, established in 1988, has certain oversight responsibilities for nuclear facilities at LANL, such as TA-55 or CMR. Under its enabling statute [42 USC 2286] DNFSB is responsible for independent, external oversight of all activities in DOE's nuclear weapons complex affecting health and safety. The DNFSB reviews operations, practices, and occurrences at DOE's defense nuclear facilities and recommends actions to the Secretary of Energy to protect public health and safety. As such, the DNFSB assists DOE in its continuous efforts to control risks associated with its operations and to continually improve its performance. This aspect of site management is an integral component of continuing operations at all DOE sites, including LANL.

In July 1997 LANL provided DOE and the DNFSB with a copy of the draft "Enhanced Conceptual Design Report (ECDR) for the Capability Maintenance and Improvement Project (CMIP)" referenced in Paragraph 23 of the Paine Affidavit. The DNFSB conducted an on-site review of the draft ECDR in September 1997. The DNFSB letter of December 5, 1997, referenced in Paragraph 23 of the Paine Affidavit as Attachment I [A.R. No. VII.B-45], provided input to DOE and LANL on the draft ECDR. Completion of the draft ECDR is currently on hold due to project changes and funding considerations. DOE recently approved a modified approach to implementing CMIP [Memorandum, January 12, 1998, Whiteman to Cunningham, A.R. No. VII.B-50] (see DOE Issue 1), and the draft ECDR will be revised to accommodate the modified strategy. Given current funding and schedule considerations, LANL does not expect to resume work on the draft ECDR until FY99, with FY00 as the earliest completion date.

The issues raised by the DNFSB in its December 1997 letter are management and process issues consistent with the charter of that Board. While it is possible that future DOE initiatives associated with correcting the problems noted by the DNFSB could be subject to future NEPA reviews, no such proposals have yet been made. Furthermore, the management and process issues raised by the DNFSB do not affect the programmatic question of assignment of the pit production mission to either LANL or SRS addressed in the SSM ROD. Any proposals resulting from these issues will be appropriately addressed by further, facility-specific NEPA reviews.

CMR project management and operational considerations are discussed under DOE Issues 2 and 3. Construction of the CMR Upgrades project was temporarily suspended in the spring of 1997 pending review and implementation of better project management controls. That work was completed and construction restarted in the summer of 1997. Project management considerations of the Upgrades Project, CMR operations safety reviews and organizational changes are unrelated to NEPA reviews. In the fall of 1997 in response to safety considerations, LANL temporarily suspended operations within the CMR building pending an in-depth review of all CMR operations. Operations were resumed over time in a phased manner as work control and work authorization procedures were verified for each on-going project within the building; most operations have resumed. In November 1997, LANL received a new Director; in January 1998 the Director reorganized the management structure for operating the CMR Building and its ongoing operations. Budgeting, establishing project management controls, temporary suspension of work to review operational safety, and establishing management organizations would not be subject to NEPA. While it is possible that certain activities taken to improve operational safety may be subject to NEPA, any such action pertaining to implementing pit fabrication activities at LANL would be of a facility-specific nature; in other words, would be tiered from programmatic decisions established in the SSM ROD.

The DNFSB letter of December 5, 1997 also mentioned earthquake faults in the vicinity of TA-3 and the CMR Building; this is discussed under DOE Issue 4. In 1997, LANL geologists initiated a study of the interrelationship of three known geologic faults (Pajarito, Guaje Mountain, and Rendija Canyon faults) in the vicinity of LANL. The preliminary results of that draft study were presented to DOE management [Memorandum, October 28, 1997, Ives, DOE/HQ, to Manager, DOE AL, A.R. No. VII.B-41; Memorandum, Senazi to Trapp, November 13, 1997, A.R. No. VII.B-43; Attachment 1: memorandum, Ives to Manager, October 28, 1997, A.R. No. VII.B-41]. The results to date indicate a possible connection between the three faults, which would increase the likelihood of geologic rupture should a seismic event occur. This could indicate that some buildings in TA-3 might be vulnerable to damage if certain seismic events occurred. DOE requires its sites to review seismic information at about ten year intervals to determine if there is any new information that would result in revising site management actions [DOE Order 420.1, Facility Safety, Sec. 4.4, Natural Phenomena Hazards Mitigation]; LANL has been performing site studies for several years in response to this requirement. Additionally, DOE is conducting an agency-wide review of seismic safety at all of its facilities in response to EO 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings" [59 FR 62545, A.R. No. VII.B-16], and a related DOE implementing guidance memorandum of October 18, 1996 from the Assistant Secretary for Environment, Safety and Health. This report is due to the Federal Emergency Management Administration by December 1, 1998, and has not yet been issued.

The preliminary studies and draft reports indicate the need to consider revising building engineering standards at LANL [Memorandum, Ives to Manager, October 28, 1997, A.R. No. VII.B-41]. The LANL seismic studies do not indicate that the probability of an earthquake event is any more likely than previously thought; the SSM PEIS discussed the known moderate seismic risk at LANL and the possibility of a seismic event as an accident initiator [SSM PEIS, Vol. I, Sec. 4.6.3.5, p. 4-288; Vol. II, Appendix F, Sec. F.2.3.1, p. F-21, F-22; see also SSM PEIS Vol. I, Glossary, definition of "capable fault," p. 9-3]. These studies indicate, however, that DOE, LANL and safety agencies must come to agreement on the amount of seismic protection needed for new and retrofitted buildings at LANL.

Construction of structural modifications such as installing additional seismic bracing would be subject to a NEPA review; this type of facility-specific review if pertaining to implementing pit fabrication decisions would be tiered from programmatic decisions established in the SSM ROD.

While the incidents and studies pointed out in this issue postdate issuance of the SSM PEIS and SSM ROD, actions pertaining solely to budgeting, project management, personnel reorganizations, and developing design standards would not be subject to NEPA. Implementing specific actions pertaining to operational safety or seismic upgrades may be subject to NEPA; however, these would be project-specific NEPA reviews tiered from the SSM analysis, if applicable, and are not germane to programmatic decisions regarding locating the pit fabrication mission.

5. Accidents involving Pu-238. That the PEIS omitted any analysis of accident consequences involving release of Pu-238, where information indicates that two-thirds of the PF-4 space at TA-55 slated for processing Pu-238 would be located in the same building as pit fabrication activities.

The Paine Affidavit, Paragraph 24, refers to alleged new information, Attachment J, that is claimed to shed new light on the accident consequences of processing Pu-238 at TA-55, PF-4. Following completion of the SSM PEIS and assignment of pit fabrication to LANL in the SSM ROD, as part of its site-specific studies to develop an approach to implementing the pit fabrication mission, LANL considered various alternative ways to allocate office and laboratory space at TA-55 and CMR among the various ongoing and newly-assigned missions. The results of that feasibility study were documented in "Alternative for Increasing the Nuclear Materials Processing Space at Los Alamos for Future Missions" [LA-UR-97-1000, April 25, 1997, A.R. No. VII.B-30], which was included as Attachment J to the Paine Affidavit. The feasibility study included, as introductory material in the section cited by Plaintiffs, a summary of the different then-current missions and then-existing space allocations in TA-55. This summary information on mission assignments was not new, and, as explained below, was available to the SSM decisionmaker at the time the SSM ROD was prepared. The feasibility study was included as an attachment to the draft ECDR sent in July 1997 to DOE and DNFSB; the ECDR has not yet been finalized.

LANL carries out Pu-238 operations in TA-55, PF-4, including the manufacture of Pu-238 heat sources for the National Aeronautics and Space Administration (NASA) deep space missions, and has done so for many years under projects such as the Cassini Project ["Environmental Assessment for Radioisotopic Heat Source Fuel Processing and Fabrication," DOE Offices of Special Applications, Assistant Secretary for Space and Defense Energy Systems, DOE/EA-0534, A.R. No. VII.B-3; FONSI 56 FR 34057, July 25, 1991, A.R. No. VII.B-4; "EIS for the Cassini Mission," Solar System Exploration Division, Office of Space Science, NASA, June 1995, A.R. No. VII.B-19; see also Final Supplemental EIS for the Cassini Mission, NASA, June 1997, A.R. No. VII.B-32]. The use of plutonium laboratory floor space at TA-55, PF-4 for Pu-238 work associated with the Cassini mission, including the consequences of release of radiological materials under normal or accident conditions, was specifically assessed in the 1991 EA [DOE/EA-0534, Sec. 4.2.1, p. 4-3; Sec. 6.2.1.2, p. 6-3; Sec. 6.2.2, p. 6-4; FONSI 56 FR 34059]; DOE subsequently implemented this work essentially as described in the EA except that the period of operations for the Cassini project extended until 1996 instead of 1994 as projected in the 1991 EA due to overall project delays. The information regarding collocation of Pu-238 work with other Pu work at TA-55, PF-4, has been in the public venue since mid-1991 and does not represent "new information."

The cumulative radiological impacts of collocating Cassini work and pit processing was mentioned in the SSM PEIS [SSM PEIS, Vol. IV, comment response 11.07]. LANL has always had a limited capacity to manufacture pits [see, for example, SSM PEIS, Vol. IV, response to comment summary 32.12, p. 3-84; and reply to Question 15a from the NRDC questions "Pit Production at Los Alamos: Questions Concerning Environment, Safety and Health Issues," November 1997]. The ongoing mix of plutonium operations at TA-55, which include among other things the current pit fabrication work, Pu-238 operations, and plutonium research and development to support LANL's national security and environmental management missions, was included in the No Action Alternative in the SSM PEIS; the pit production mission is not expected to result in any changes to the PF-4 areas involved in Pu-238 work. DOE continues to conduct these ongoing activities and has in place procedures to assure that new activities will be subject to rigorous safety reviews (which among other things assess the risk of collocating new activities with ongoing operations) before any new activities would be allowed to begin. Therefore, information regarding the collocation of ongoing Pu-238 activities and proposed pit fabrication activities was available to the SSM decisionmaker at the time the SSM ROD was issued. The SSM PEIS provided a programmatic analysis to compare impacts of pit fabrication that would be expected if located at LANL or SRS; it was intended that site-specific impacts of implementing programmatic mission assignments (including the cumulative effects of collocated missions at TA-55) would be analyzed in subsequent tiered NEPA documentation [SSM PEIS, Vol. I, Sec. 1.5, p. 1-8].

The accident analyses of the SSM PEIS were explained in detail in Appendix F, which stated that the issues regarding health risks were twofold: to determine whether accidents at specific facilities would pose unacceptable risks; and which alternative locations would provide an advantage of lesser risk [SSM PEIS, Vol. II, Sec. F.1.1, p. F-1]. The SSM PEIS also acknowledged that specifics regarding measures to reduce risk would be contained in subsequent tiered NEPA reviews, project-specific design reviews, and facility-specific safety analysis reports [SSM PEIS, Sec. F.1.1, p F-2]. The source documents reviewed [SSM PEIS, Vol. II, Table F.1.1-1] made reference to the presence of Pu-238 at TA-55. The SSM PEIS provides a bounding accident analysis and compares the potential health effects from different accident scenarios at LANL and SRS [SSM PEIS, Vol. II, Sec. F.2.3, p. F-16]. [See also SSM PEIS Vol. IV, response to comment 11.08, p. 3-107; and 11.42, p. 3-54.]

The decisionmaker had relevant information available regarding the comparative risk of placing pit fabrication activities at LANL or SRS (including that of collocating pit fabrications activities in the same building as Pu-238 activities), and whether or not the accident risk at any given facility was unacceptable. DOE is obligated to operate TA-55 at LANL in a safe operating configuration (including ongoing activities with Pu-238) regardless of the incremental effect of placing pit fabrication activities at that facility. The decisionmaker knew that Pu-238 activities take place at TA-55, and the decisionmaker weighed whether or not the incremental addition of adding pit fabrication operations to TA-55 posed an unacceptable risk.

This issue was addressed previously in this litigation in the Second Declaration of Albert E. Whiteman. He stated that it has always been acknowledged that Pu-238 operations are carried out in TA-55 PF-4, and are addressed in the TA-55 Safety Analysis Report, A.R. No. I-1124, I-1125 [Second Declaration of Albert E. Whiteman, p. 28]. He stated Pu-238 processes are housed in the north half of PF-4 while pit manufacturing processes are housed in the south half, and discusses safety and accident considerations [Second Declaration, p. 28, 29].

This issue does not present new information that was not available to the SSM decisionmaker. Therefore, no change to the SSM PEIS is warranted.

Analysis of Issues Raised by DOE

1. Pit production strategy.

In September 1997 DOE initiated an evaluation of the potential for fabricating pits in the near-term without displacing other ongoing activities in TA-55. A modified strategy was approved by DOE HQ in December 1997 and transmitted from DOE AL to LANL in January 1998. The strategy in general addressed engineering project management, scheduling, and logistics issues. CMR and Sigma facilities would continue to support pit production. [Memorandum, Whitteman to Cunningham, January 12, 1998, A.R. No. VII.B-50; Attachment 1: memorandum, Ives to Twining, December 16, 1997, A.R. No. VII.B-46; Attachment 2: "Pit Production -- Baseline Program and Project Requirements and Assumptions."]

The three objectives of the modified strategy are:

(a) Decouple the CMIP project for pit fabrication from other projects and focus development of pit production capability at TA-55 without disrupting ongoing mission.
(b) Maintain pit production as a continuous process, and achieve an intermediate capacity of 20 pits per year by FY 2007 without prejudice to the eventual 50 pit per year capacity.
(c) Delay CMIP while performing urgent maintenance and equipment replacement beginning in FY 1999.

The modified strategy in general addresses engineering project management, scheduling, and logistics issues. These types of issues do not result in environmental impacts other than those from implementing the proposed actions, and are generally irrelevant to a NEPA review. The site-specific implementation of CMIP would be subject to project-specific NEPA review. DOE anticipates that the site-specific environmental impacts of implementing the CMIP project will be contained in the LANL SWEIS now under preparation.

The SSM PEIS acknowledged DOE's intent to further refine its plans to implement its programmatic decisions; the SSM PEIS and ROD discussed the two-tiered NEPA strategy and indicated that project-specific decisions on how to implement programmatic decisions would be analyzed in subsequent, tiered, NEPA reviews. DOE is now in the process of refining its plans for implementing the new pit fabrication mission at LANL, and at the same time continuing to carry out its prior pit fabrication missions.

Under the modified strategy, CMR and Sigma facilities would continue to support pit production. The use of these two facilities to support pit production was discussed in the SSM PEIS. As discussed above, the use of Sigma to manufacture nonnuclear pit components was analyzed by DOE in the Nonnuclear Consolidation EA, June 1993, and its related FONSI, September 1993. Implementation of that proposed action began in 1993.

Decoupling the CMIP project from other ongoing construction projects at LANL facilities is a project management (paperwork) activity that would not in itself result in additional environmental impacts. In any case, the CMIP project represents site-specific implementation of programmatic SSM decisions; in accordance with the SSM PEIS and ROD, site-specific implementation would be subject to subsequent, tiered NEPA review.

Maintaining pit production as a continuous process is a project management aspect of implementing this proposal. The comparison of environmental impacts, if any, from differential schedules for implementing pit production would be captured in the project-specific NEPA review for CMIP or its follow-on activities.

Supplement Analysis: Enhancement of Pit Manufacturing at LANL, SSM PEIS

At the same time that they were considering implementation needs for CMIP, DOE and LANL considered the need to expedite certain planned activities at TA-55 so that they would occur prior to CMIP. These are maintenance actions and equipment upgrades that would be needed to conduct LANL's defense mission at TA-55 independent of the pit fabrication mission. Maintenance actions and upgrades to existing equipment at TA-55 would be subject to project-specific NEPA review; the LANL SWEIS is anticipated to consider the cumulative impacts of operating TA-55 under different scenarios, and additional project-specific NEPA review may be needed for any proposed equipment upgrades at the time they are ripe for decision.

The modified strategy for implementing the pit fabrication mission at LANL, as captured in the CMIP project modifications, would be details of site-specific implementation that would not be germane to a programmatic decision to locate this mission. Because it was understood in the SSM PEIS that facilities such as TA-55 needed to be kept in safe operating condition regardless of whether or not LANL received the pit fabrication mission, this issue does not present new information that would bear on the programmatic pit fabrication siting decision. Tiered, project-specific NEPA reviews are planned to cover the CMIP project and improvements to related facilities. Therefore, no change to the SSM PEIS is warranted.

2. CMR project management considerations.

In the SSM PEIS, DOE acknowledged that it could not eliminate any of its weapons manufacturing and component surveillance capabilities [SSM PEIS, Vol. I, Sec. 2.4.2, p. 2-8], and would continue to need all the basic capabilities of its industrial and laboratory base regardless of its decisions to reestablish pit manufacturing capability [SSM PEIS, Vol. I, Sec 2.5, p. 2-10]. The need for analytical chemistry as part of the pit fabrication mission was described in Appendix A [SSM PEIS, Vol. II, Sec. A.3.3, p. A-117, and Figure A.3.3-1, p. A-118]. DOE also acknowledged that its SSM Program would continue to evolve as better information became available and technological advancements occur, and that these future advancements would be subject to future NEPA reviews [SSM PEIS, Vol. I, Sec. 2.5.1, p. 2-10]. One of the ongoing capabilities DOE continues to need in support of its nuclear weapons mission, and independently of any decision to site pit fabrication capabilities, is its analytical chemistry capability at CMR.

Over the past several years, and independent of the need to reestablish pit fabrication, DOE has planned to upgrade the CMR building to extend its useful life to meet ongoing LANL mission requirements. DOE prepared the CMR Upgrades EA [DOE/EA-1101, A.R. No. VII.B-27] and reached a FONSI for the proposed upgrades on February 11, 1997 [A.R. No. VII-B.28]. DOE and LANL immediately began to implement those proposed actions in a sequential manner. LANL was tasked with carrying out certain project management assignments to facilitate design and construction of the upgrades project. In early 1997 it became apparent that costs of the ongoing CMR upgrades project would, unless checked, overrun the FY97 budget. After considering budget, schedules and project management issues, DOE and LANL decided to temporarily suspend construction activities for the CMR upgrades project pending a thorough budget and project management review. [Memorandum, Cunningham to Whiteman, April 24, 1997, A.R. No. VII.B-29; memorandum, Whiteman to Cunningham, May 5, 1997, A.R. No. VII.B-31; letter, Reis to Senator Thurmond, June 19, 1997, A.R. No. VII.B-33; letter, Reis to Senator Domenici, June 19, 1997, A.R. No. VII.B-34. See also Second Declaration of Albert E. Whiteman, June 6, 1997, paragraph 4.g. (p. 8).] Following that review, the upgrades project resumed and upgrade construction activities are underway.

NEPA is a forecasting tool that projects the anticipated environmental impacts that would occur if proposed actions were implemented. The SSM PEIS projected the expected impacts if the pit fabrication mission were to be located at LANL, including use of the CMR Building to support that assignment. The CMR EA analyzed the impacts from constructing the CMR upgrades and the impacts of operating the upgraded CMR Building. The projection and analysis of potential environmental impacts is not dependent on project management considerations such as design and engineering costs, schedules, and skill. These are irrelevant to a NEPA analysis, although they are of interest for other reasons.

This issue raises new information, but not information that is germane to a NEPA review. Therefore, there is no need to supplement the existing NEPA reviews on the CMR upgrades project. The need for the CMR upgrades project is independent of the decision to reestablish pit fabrication at LANL. Therefore, the consideration of the adequacy of the site-specific review of the CMR upgrades project is irrelevant to the programmatic decisions in the SSM PEIS, and does not represent a substantial change to the proposal analyzed in the SSM PEIS. Accordingly, no change to the SSM PEIS is warranted.

3. CMR safety reviews and organizational changes.

On September 2, 1997, in response to safety considerations, LANL temporarily suspended operations within the CMR building pending an in-depth review of all operations and procedures being implemented within the building to support on-going LANL missions. Operations were resumed over time in a phased manner as work control and work authorization procedures were verified for each on-going project within the building. [Memorandum, Gancartz to All CMR Occupants, September 2, 1997, A.R. No. VII.B-38; memorandum, Jackson to Todd, September 5, 1997, A.R. No. VII.B-39.] To further improve operation of the CMR facility within a safe operating envelope for nuclear facilities, LANL Director Browne announced a new integrated management organization for CMR in which the technical, operations, and facility management of CMR would be integrated with that of TA-55. This reorganization became effective in January 1998. [E-mail memorandum, Browne to managers, December 17, 1997, A.R. No. VII.B-47; memorandum, Reis to All CMR and TA-55 Employees, December 19, 1997, A.R. No. VII.B-48; electronic LANL Newsbulletin, "News from John Browne, CMR and TA-55 Integration," January 7, 1998, A.R. No. VII.B-49.]

DOE needs to continue to operate CMR and its other nuclear facilities in a safe, secure manner in order to be able to perform its mission assignments. Operation and management of the CMR Facility is, to some extent, delegated to LANL under its management and operating contract with the DOE. Therefore, it is incumbent upon LANL managers to take actions they deem necessary to ensure that LANL facilities are operated safely and in compliance with operating authorizations.

Management actions such as facility organizational arrangements do not generally, in and of themselves, result in environmental impacts other than those of carrying out the work of the facility. The management actions taken to improve operations at the CMR Building present new information, but not information that is germane to a NEPA review. Consideration of improvements to the management structure at CMR would be a site-specific detail of implementing programmatic mission assignments from the SSM ROD. Therefore, no change to the SSM PEIS is warranted.

4. New earthquake faulting studies at LANL.

As discussed in Plaintiffs' Issue 4 above (consideration of the DNFSB safety concerns), in 1997, LANL geologists initiated a study of the interrelationship of three known geologic faults (Pajarito, Guaje Mountain, and Rendija Canyon faults) in the vicinity of LANL. The preliminary results of that draft study were presented to DOE management [Memorandum, October 28, 1997, Ives, DOE/HQ, to Manager, DOE AL, A.R. No. VII.B-41; Memorandum, Senazi to Trapp, November 13, 1997, A.R. No. VII.B-43; Attachment 1: memorandum, Ives to Manager, October 28, 1997, A.R. No. VII.B-41]. The results to date indicate a possible connection between the three faults, which would increase the likelihood of geologic rupture should a seismic event occur. This could indicate that many buildings in TA-3 would be vulnerable to damage if a seismic event occurred. DOE requires its sites to review seismic information at about ten year intervals to determine if there is any new information that would result in revising site management actions [DOE Order 420.1, Facility Safety, Sec. 4.4, Natural Phenomena Hazards Mitigation]; LANL has been performing site studies for several years in response to this requirement. Additionally, DOE is conducting an agency-wide review of seismic safety at all of its facilities in response to EO 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings" [59 FR 62545, A.R. No. VII.B-16], and a related DOE implementing guidance memorandum of October 18, 1996 from the Assistant Secretary for

Environment, Safety and Health. This report is due to the Federal Emergency Management Administration by December 1, 1998, and has not yet been issued.

The results of the preliminary studies and draft reports suggest that some LANL buildings could be vulnerable to damage in the event of certain seismic events. These studies indicate the need to consider revising building engineering standards at LANL. Promulgating design standards would not be subject to NEPA review, although implementation of any such standards may be. The LANL seismic studies do not indicate that the probability of an earthquake event is any more likely than previously thought; the SSM PEIS discussed the known moderate seismic risk at LANL [SSM PEIS, Vol. I, Sec. 4.6.3.5, p. 4-288; Vol. II, Appendix F, Sec. F.2.3.1, p. F-21, F-22; see also SSM PEIS Vol. I, Glossary, definition of "capable fault," p. 9-3]. These studies indicate, however, that DOE, LANL and safety agencies must come to agreement on the amount of seismic protection needed for new and retrofitted buildings at LANL.

The SSM PEIS considered release of radioactive materials in a seismic accident event and this information was considered by the decisionmaker when deciding to site the pit fabrication mission at LANL. While new seismic studies now underway appear to indicate that there is a need to invest in greater seismic retrofitting to protect building infrastructure, these new studies do not indicate that there would be a greater frequency of seismic events. If new standards are promulgated, buildings at LANL would need to be retrofitted to ensure continuation of safe secure operations to perform ongoing mission requirements regardless of the decision to site the pit fabrication mission at LANL.

The SSM PEIS analyzed the safety and health impacts if a seismic event occurred (regardless of the projected likelihood of this event occurring) and massive structural damage resulted in a release of radioactive materials. The new studies ongoing at LANL do not indicate any preliminary information that would result in a change to the accident analysis presented in the SSM PEIS. Construction activities related to structural modifications would be site-specific actions irrelevant to the programmatic questions considered in the SSM PEIS. Therefore no change to the SSM PEIS is warranted.

CONCLUSIONS

These Issues Do Not Change the SSM PEIS Analysis

The nine issues considered in this Supplement Analysis were either covered in the SSM PEIS and so were available to the decisionmaker; were project-specific issues related to the implementation of SSM decisions at LANL and so would be subject to subsequent tiered NEPA review and decisionmaking; or were preliminary information and so would be subject to future review at such time as they are ripe for decision. Therefore, none of these issues would result in a need to change the SSM PEIS analysis of pit fabrication.

These Issues Do Not Change the SSM ROD

The SSM ROD was based in part on the environmental analysis in the SSM PEIS and in part on other factors. None of the issues raised in the Paine Affidavit, or in the related information considered by DOE, bring forth salient new information bearing on programmatic decisions for siting the reestablished pit fabrication mission of which the decisionmaker was unaware at the time the SSM ROD was issued. Therefore, none of these issues would result in a need to change or amend the programmatic SSM ROD.

RECOMMENDATIONS

Based on the analysis of the issues raised by plaintiff in the Paine Affidavit, DOE does not see any need to supplement the SSM PEIS analysis of reestablishing the former RFP pit fabrication mission at LANL to provide an enhanced pit manufacturing capability. DOE does not believe that any new proposals have emerged which would require preparation of a new EIS at this time. DOE recommends that the SSM PEIS analysis of reestablishing pit fabrication at LANL be left standing and that no additional NEPA reviews, apart from those already planned in the LANL SWEIS or elsewhere, be initiated at this time.

Date: 3/13/98

X Approved

__________ Disapproved

[signature]

Victor H. Reis, Assistant Secretary for Defense Programs

APPENDIX I
REPORT ON THE STATUS AND IMPLICATIONS OF SEISMIC HAZARD STUDIES AT LANL

United States Government **Department of Energy**

Albuquerque Operations Office

memorandum

DATE: JAN 08 1999

REPLY TO: NPD

SUBJECT: Status and Implications of Seismic Hazard Studies at LANL

TO: W. Scott Gibbs, Program Director, MMP, LANL, MS A102

We have reviewed the subject LANL report (dated December 17, 1998), and concur with the conclusions reached regarding the implications of this series of seismic studies. The information summarized in this report and discussed in more detail in the five seismic studies that have been completed, to date, are and will continue to be considered in the execution of mission work at LANL. A specific example of this is the recently approved Interim Technical Safety Requirements for operations at the Chemistry and Metallurgy Research (CMR) Building, which includes reductions in material at risk in that facility and plans for containerization of material in glovebox lines which is not actively being used; these actions are taken to reduce the potential consequences of seismically-initiated accidents in the CMR Building. DOE will continue to examine the mission work at LANL in consideration of seismic and other risks to ensure that such work can be accomplished within acceptable levels of risk.

Should you have any questions on this matter, please contact me (845-6038) or Mr. Corey Cruz (845-6736) of my staff.

A. E. Whiteman
Assistant Manager for
Technology and Site Programs

cc:
E. Ives, DP-20, FORS, HQ
J. Ordaz, DP-13, GTN, HQ
J. Kimball, DP-45, GTN, HQ
L. Goen, LANL, MS P946

Los Alamos National Laboratory

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Date: December 22, 1998
Refer to: NW/M&M:98-20

Mr. Edwin E. Ives
Technical Director
DP-20, FORS
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Mr. A. Earl Whiteman
Assistant Manager
Technology and Site Programs
U.S. Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185-5400

Dear Mr. Ives and Mr. Whiteman:

Subject: Transmittal of Los Alamos Report, "Status and Implications of Seismic Hazard Studies at LANL"

Attached for your use is the report "Status and Implications of Seismic Hazard Studies at LANL," December 17, 1998, prepared by Larry Goen, ESA-EA, Los Alamos National Laboratory. The report summarizes the results of five recent seismic studies for various areas at Los Alamos National Laboratory, and makes note of two additional studies that are still in progress. It has been reviewed by staff at both DOE Headquarters and the DOE Albuquerque Operations Office. This final version incorporates comments made by Jeffrey Kimball, seismologist, DOE/HQ DP-45.

The stratigraphic survey for Technical Area (TA) 55 indicates that the area is not susceptible to surface rupture from earthquakes. The stratigraphic survey for TA-3 is in progress and a full report is not expected until March 1999. It appears that surface rupture from earthquakes is not a concern for those facilities at TA-3 that are not nuclear facilities. However, the discovery of a fault under the Chemistry and Metallurgy Research (CMR) Building, which is a nuclear facility, may have implications for decisions concerning the future use of CMR. The seismic studies also address ground motion from earthquakes, and indicate that this hazard is within the parameters assumed in the 1995 probabilistic seismic hazard analysis. The studies conclude that Laboratory structural standards remain valid in regards to ground motion.

Mr. Edwin E. Ives, DOE/HDQS -2- December 22, 1998
Mr. A. Earl Whiteman, DOE/AL
NW/M&M:98-20

I appreciate your interest in this subject. Your office has copies of the completed studies, and we will transmit the remaining studies as soon as they are completed.

Sincerely,

W. Scott Gibbs
Program Director
Materials and Manufacturing Programs

WSG:MDW:bjc

Att: a/s

Cy: John Ordaz, Program Manager, SWEIS, DOE/HQ DP-13
Corey Cruz, Project Manager, SWEIS, DOE/AL/EISPO
Jeffrey Kimball, DOE/HQ DP-45
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Status and Implications of Seismic Hazard Studies at LANL

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Los Alamos, New Mexico 87545

December 17, 1998

Status & Implications of Seismic Hazard Studies at LANL

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Status & Implications of Seismic Hazard Studies at LANL

TABLES

FIGURES

Status & Implications of Seismic Hazard Studies at LANL

1.0 Summary

A number of studies (Table 1) have been initiated in the last two years to address seismic issues at LANL. These studies have focused on the potential for surface rupture at TA-55 and TA-3 and the seismic hazard in general. For surface rupture, studies have centered around the mapping of faults in and around specific technical areas. In addition, a probabilistic surface rupture assessment has been completed for TA-3. For the seismic hazard, studies have focused on the earthquake history on the Pajarito fault.

Table 1 – Seismic Hazard Studies

Task	Status	Ref.
1) Stratigraphic Survey for TA-55	Complete	1
2) FY97 Pajarito Trench Study	Complete	3
3) Probabilistic Surface Rupture Assessment for TA-3	Complete	6
4a) Core Hole Study at SCC/NISC Site	Complete	5
4b) Core Hole Study at CMR Site	Complete	4
5) Stratigraphic Survey for TA-3	In Progress	N/A
6) FY98 Pajarito Trench Study	In Progress	N/A

Surface Rupture

The stratigraphic survey (Ref. 1) for TA-55 is complete and found no evidence for existing faults. Thus the area is not susceptible to surface rupture from earthquakes.

The stratigraphic survey for TA-3 is in progress and a full report is not expected until the end of March 1999. However, it is evident that TA-3 does have faults with vertical displacements in the range of 1-10 feet in 1.2 million year old Bandelier tuff. The heaviest concentration of these faults is in the southeast corner of TA-3. This concentration is believed to be defining the southern end of the Rendija Canyon fault. The faults found include one under the CMR Building (Ref. 4) with a vertical offset of approximately 8 feet.

While surface rupture can cause significant structural damage, surface rupturing earthquakes are low probability events. From the probabilistic assessment of surface rupture (Ref. 6), earthquakes that might result in permanent ground displacements of about four inches are estimated to be 10,000 to 20,000 year events. Four inches was taken as the threshold for a displacement causing severe cracking in a concrete or masonry structure. Earthquakes with would result in permanent ground displacements capable of causing structures to collapse are estimated to be 33,000 to 100,000 year events. The displacement threshold for collapse was taken as about 20 inches.

Based on the probabilistic study (Ref. 6), for non-nuclear structures, surface rupture is not a concern. The performance goal (annual probability of seismic induced damage) for such facilities

Status & Implications of Seismic Hazard Studies at LANL

per DOE guidance is 5 x 10^{-4} (2000 year recurrence interval). Designing to resist the ground motion caused by an earthquake is the primary concern when considering the seismic hazard. While surface rupture not a concern for non-nuclear structures, siting new facilities over known faults should not be done.

For the CMR Building, a nuclear facility, the probability of damaging ground displacement is at or beyond the performance goal for the facility, $1x10^{-4}$ (10,000 year recurrence interval). In its current condition, the probability of damaging ground motion is at least 20 times greater than the probability of damage caused by surface rupture. Therefore, the discovery of the fault under the building does not increase the seismic risk at CMR.

The discovery of a fault under the CMR Building has an impact on decisions concerning upgrades and future uses for the facility. From the seismic perspective, the question which needs to be assessed is whether or not it is prudent to upgrade the structure to resist ground motion loads when the probability of damaging surface rupture is near the performance goal level for the facility. While it is possible to upgrade to resist the forces/displacements caused by permanent ground deformation, the upgrade costs would increase substantially. It should be noted that this site would not be considered adequate for a new nuclear facility.

Ground Motion

In the last two years, a number of trenches have been excavated to study the earthquake history on the Pajarito fault. The purpose of the studies has been to determine when the most recent ground rupturing event occurred on the fault, to get a better understanding of recurrence intervals for earthquakes (slip rate), and to help determine if the three main faults in the Los Alamos area are connected.

For the seven trenches excavated in June 1998, data analysis is in progress and preliminary results are not available. For the seven trenches excavated in July 1997, the results (Ref. 3) show that the most recent event occurred 1500-2000 years ago with no other events in the last 10,000 years. The slip rates determined from this study indicate that they are within the parameters assumed in a 1995 probabilistic seismic hazard analysis. The 1995 study is the basis for the LANL design basis ground motion.

The significance of this information is that there is no direct evidence that the three local faults (Pajarito, Rendija Canyon and Guaje Mountain faults) are connected and the assumptions made in the probabilistic seismic hazard assessment completed in 1995 are still valid. Therefore, the design basis ground motion defined in the LANL structural standards is still valid.

Status & Implications of Seismic Hazard Studies at LANL

2.0 Introduction

In FY 1997, the first two tasks shown in Table 1 were undertaken to better understand the seismic hazard at the Los Alamos National Laboratory (LANL) site. One study was to investigate the possibility of the Rendija Canyon fault extending through Technical Area 55 (TA-55). The other was to investigate seismic history on the Pajarito fault, the main contributor to the seismic hazard for return periods of greater than 1,000 years. From preliminary results of these two studies, questions were raised concerning the possible connection of the Pajarito, Rendija Canyon and Guaje Mountain faults, shown in Figure 1, and surface rupture at TA-3. Both of the studies were finalized in FY98.

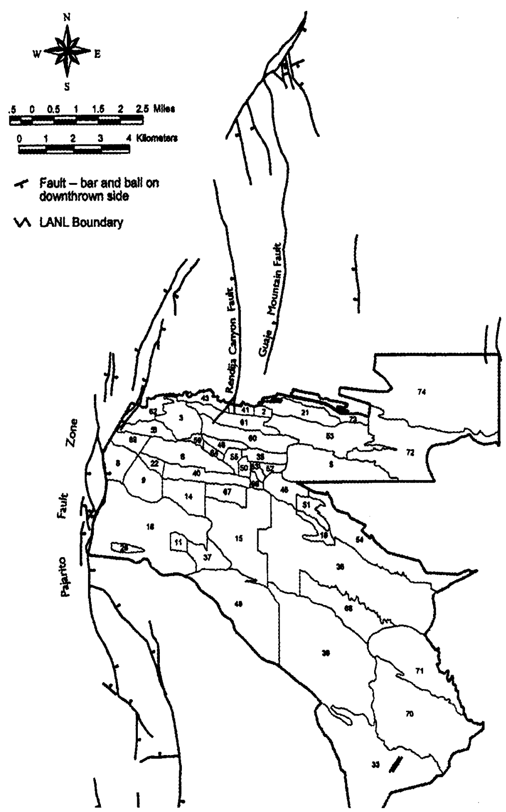

Figure 1 – Major Surface Faults at LANL

At TA-55, the study (Ref. 1) found that the Rendija Canyon fault does not project through TA-55 and that the site is free of any observable faulting. The study did find evidence for faulting further to the west, in the vicinity of TA-3. Data collection for the mapping of the faulting in the TA-3 area, the sixth task shown in Table 1, began in October, 1997 and continued through September 1998. Although the data have only been partially analyzed, it is evident that faulting is present in TA-3.

On the Pajarito fault, trench studies were conducted to try to estimate the last event on the fault, to try to estimate recurrence intervals on events, and to estimate slip rates. All of these factors were assumed in the seismic hazard evaluation (Ref. 2) completed in 1995 and physical data is needed to confirm that the assumptions made were conservative. The investigation (Ref. 3) initiated in FY97 has resulted in finding the most recent event on the Pajarito approximately 1500 - 2000 years ago and that slip rates were consistent with those assumed in Reference 2. In addition, a similar study, the sixth task in Table 1, began in FY98. For the FY98 study, the fieldwork is complete and data analysis is in progress.

In this report, the results of these studies plus those either completed or in progress are discussed as well as what the implications are for new and existing construction in TA-3. Findings for individual studies are first presented followed by a summary of DOE seismic requirements. Finally, the impacts on the understanding of the seismic hazard on facilities at LANL, in particular those in TA-3 such as CMR are presented.

Status & Implications of Seismic Hazard Studies at LANL

3.0 Findings to Date

The emphasis for work over the last two fiscal years falls in two categories: the potential for surface rupture at TA-55 and TA-3, and, investigation of the seismic history on the Pajarito fault.

3.1 Surface Rupture Investigations

Work in this area can be divided into three areas, fault mapping at TA-55 (1st task in Table 1), fault mapping at TA-3 (4th and 5th tasks in Table 1), and probabilistic surface rupture assessment of TA-3 (3rd task in Table 1).

3.1.1 Fault Mapping and Surface Rupture Investigation at TA-55

In Reference 1, results are presented of high-precision geologic mapping in the vicinity of TA-55 that has been done to identify parts of the southern portion of the Rendija Canyon fault, or any other faults, with the potential for seismic surface rupture. To assess the potential for surface rupture at TA-55, an area of approximately 3 square miles that includes the Los Alamos County Landfill and Twomile, Mortandad, and Sandia Canyons has been mapped in detail.

This mapping indicates that there is no faulting in the near surface directly below TA-55, and that the closest fault is about 1500 feet west of the Plutonium Facility. Faulting is more abundant on the western edge of the map area, west of TA-48, near TA-3, in uppermost Mortandad Canyon, upper Sandia Canyon, and at the County Landfill. With the exception of the County Landfill, measured vertical offsets ranged from 1 to 8 feet. At the County Landfill, faulting exposed has a distributed zone of faulting over 1000 feet wide with a net down to the west vertical displacement of 15 feet. Individual faults within this zone have vertical offsets ranging from 1 to greater than 15 feet. The area mapped is shown in Figure 2 (Ref. 1).

3.1.2 Fault Mapping and Surface Rupture Investigation at TA-3

The surface rupture investigation at TA-3 includes locating and mapping of existing faults using two different methods. One of methods used is high precision location of stratigraphic contacts using total station surveying techniques in the canyons to the north and south of TA-3. The other method is the drilling of core holes to locate stratigraphic contacts at specific sites, namely the CMR site (Ref. 4) and the proposed site for the Strategic Computing Center (SCC) and Nonproliferation and International Security Center (NISC) projects (Ref. 5), within TA-3.

High Precision Mapping at TA-3:

High precision mapping at TA-3, similar to that accomplished in the TA-55 area, is an in-progress study. Data collection for this study was completed in September, 1998. Data analysis and report writing is ongoing. The final report is expected to be completed in March, 1999.

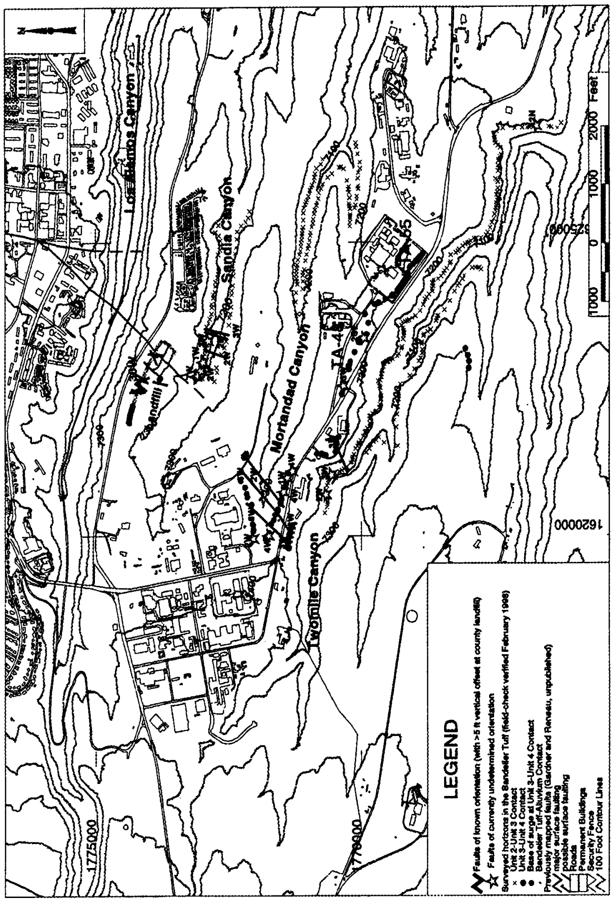

Figure 2 – Map of Faulting in TA-55 Area (Ref. 1)
Numbers and leeters adjacent ot faults indicate the amount of displacement (in feet) and sense of displacement (e.g., 4W = 4 feet of displacement down to the west).

The areas surveyed in the data collection portion of this study are indicated in Figure 3. Along with the survey locations, Figure 3 also depicts the location of linear features found in the examination of air photos dating to the 1940's. The linear features could indicate the location of faults, but could also indicate other linear features such as fences trails and roads. These linear features are being used as guides in the data analysis currently underway. As the data analysis progresses, it is expected that some of the air photo lineaments will be designated faults while others will be removed from the map.

Status & Implications of Seismic Hazard Studies at LANL

Although data analysis is in progress, preliminary findings indicate faulting is present in the TA-3 area. The majority of the faults is in the southeastern area of TA-3. These faults have vertical offsets in the range of 1 to 10 feet.

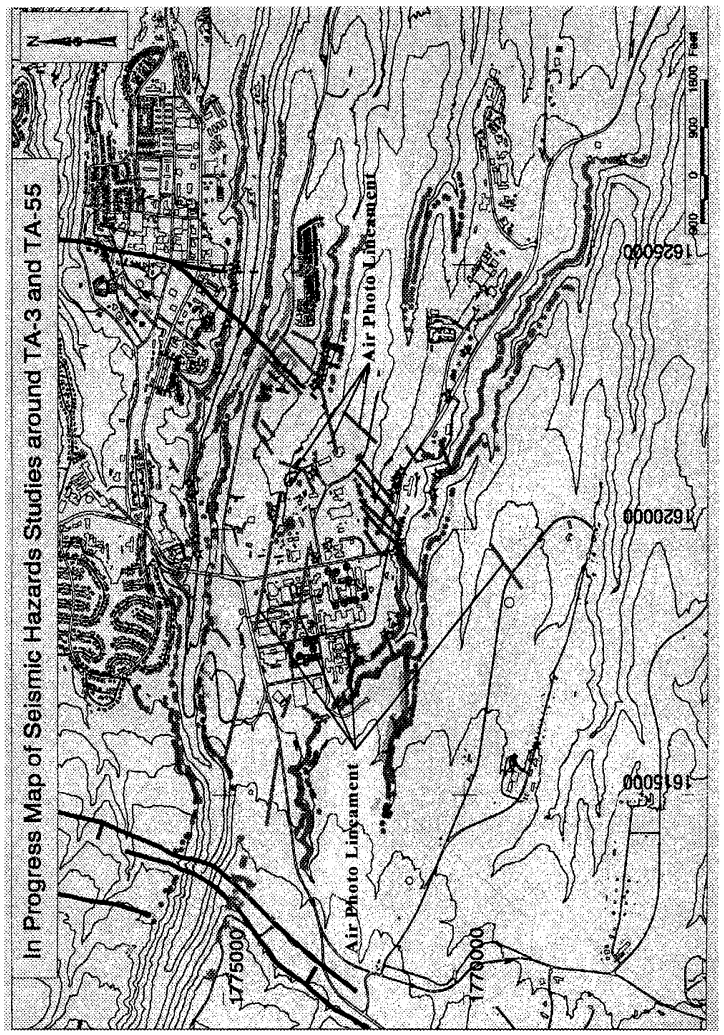

Figure 3 – In Progress Map of Fault Location in TA-3
Unless indicated as "Air Photo Lineament" (purple lines), lines indicate faults of known orientation. Stars represent faults of unknown orientation. Dots indicate surveyed points of stratigraphic contacts.

Status & Implications of Seismic Hazard Studies at LANL

CMR Core Hole Investigation:

At the site of the existing Chemistry and Metallurgical Research (CMR) Building, nine closely spaced, shallow holes were drilled. The purpose of the holes was to obtain the cores and to establish the elevation at which contacts between particular layers of the Bandelier Tuff are located. These elevations were then used to develop a contour map at a particular contact. Abrupt changes in the contours would indicate the presence of faulting. The goal of the investigation was to identify faults that may have the potential for earthquake-induced surface ruptures at the site.

Analysis (Ref. 4) of the data obtained indicates that a fault is present at the CMR Building. Its location and inferred orientation are shown in Figure 4. The fault is contained within the core obtained from the CMR-6 and can be inferred to occur between the CMR-2 and CMR-3 locations. This orientation is consistent with one of the air photo lineaments shown in Figure 3. The total displacement of Unit 3 in the CMR-6 core is approximately 8 feet.

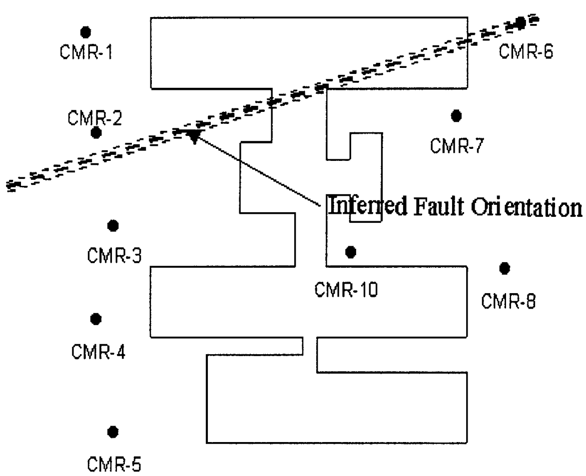

Figure 4 – Plan View of CMR Building With Inferred Location of Fault

Based on this investigation, it can be concluded that the CMR Building site has, in the past, been impacted by fault rupture. However, as discussed later in this report, the probability of an earthquake causing significant surface displacement at this site in the future is small.

SCC/NISC Core Hole Investigation:

At the site proposed for the new Strategic Computing Center (SCC) and the new Nonproliferation and International Security Center (NISC) projects, ten closely spaced, shallow holes were drilled. The purpose of the holes is the same as the holes drilled at the CMR Building.

Status & Implications of Seismic Hazard Studies at LANL

From analysis (Ref. 5) of the data gathered, there is no evidence for faults under the building sites. Because no significant or cumulative faulting events have disturbed the site in the last 1.22 million years, the age of the Bandelier Tuff, it is unlikely that surface rupture will occur at the site in future large earthquakes.

3.1.3 Probabilistic Surface Rupture Analysis

A probabilistic seismic hazard analysis for potential surface fault displacement at TA-3 has been performed and is described and summarized in Reference 6. The objective of the analysis was to estimate the potential surface rupture hazard posed by the Pajarito fault system, in particular, a possible splay of the Rendija Canyon fault that may transect TA-3. The principal products of this study are probabilistic surface rupture hazard curves for the CMR and SCC/NISC sites. The study focused on these two sites at TA-3 and provides bounding case assessments of the surface rupture potential at each site.

Three different cases were considered in the hazard analysis: (1) distributed faulting only; (2) principal faulting at the CMR site; and, (3) principal faulting at the SCC/NISC site. Principal faulting is faulting occurring along the main plane(s) of crustal weakness responsible for the release of seismic energy during an earthquake. Distributed faulting is defined as rupture that occurs on other faults, shears, or fractures in the vicinity of the principal rupture in response to the principal displacement. The three cases correspond to three different possible scenarios for the southern end of the Rendija Canyon fault. For Case 1, three different hypothetical conditions were assumed: (a) a distributed fault with 9m of cumulative displacement in the Bandelier Tuff, (b) a distributed fault with 1m of cumulative displacement, and (c) a fracture with no observable displacement in the tuff. A total of 15m of cumulative displacement is assumed in cases 2 and 3.

The results, summarized in Table 2, show that for annual frequencies of 10^{-4} or larger, surface rupture is minimal or nonexistent. The hazard curves developed for the two sites are shown in Figures 5 and 6. Hazard curves that investigate the sensitivity of the three main faults being connected or not are shown in Figure 7.

Table 2 – Probabilistic Surface Rupture Results

Annual Frequency	Case 1a	Case 1b	Case 1c	Case 2&3
10^{-4}	<1 mm	<1 mm	<1 mm	2 cm
10^{-5}	50 cm	20 cm	10 cm	70cm

Status & Implications of Seismic Hazard Studies at LANL

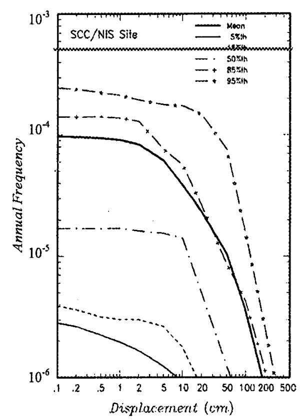

Figure 5a – Case 1a:
Distributed Faulting w/ 9m
Cumulative Displacement

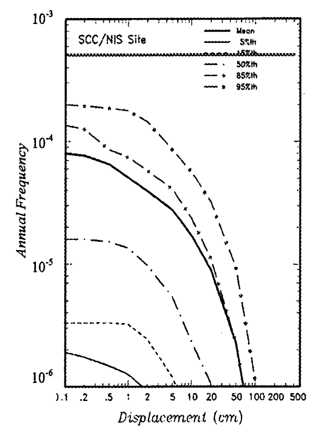

Figure 5b – Case 1b:
Distributed Faulting w/ 1m
Cumulative Displacement

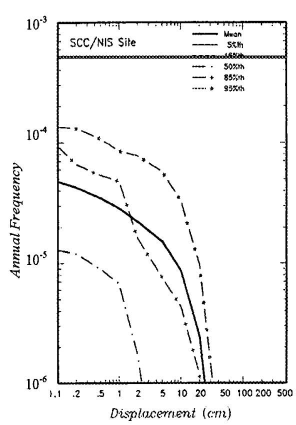

Figure 5c – Case 1c:
Distributed Faulting w/ no
Cumulative Displacement

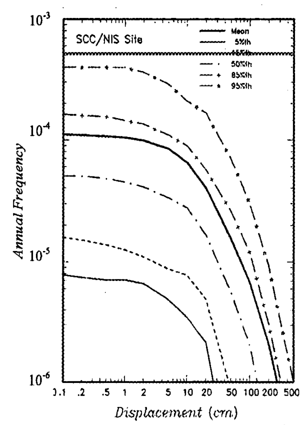

Figure 5d – Case 2:
Principal Faulting w/ 15m
Cumulative Displacement

Figure 5 – Surface Rupture Hazard Curves for the SCC/NISC Site (Performance Goal for PC 2 Facilities is 5x10^{-4})

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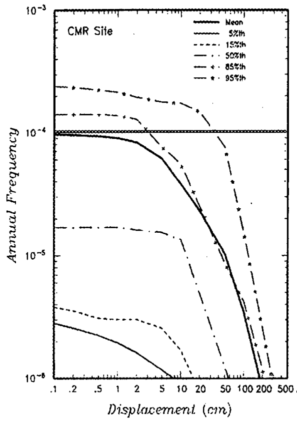

Figure 6a - Case 1a:
Distributed Faulting
9m Cum. Displacement

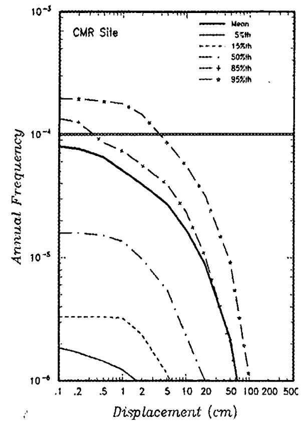

Figure 6b - Case 1b:
Distributed Faulting
1m Cum. Displacement

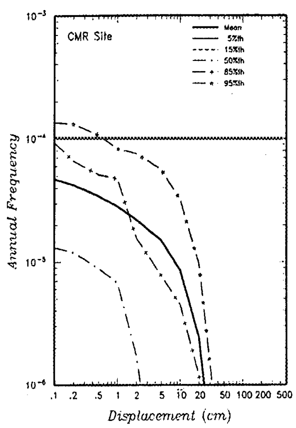

Figure 6c - Case 1c:
Distributed Faulting
No Observable Displacement

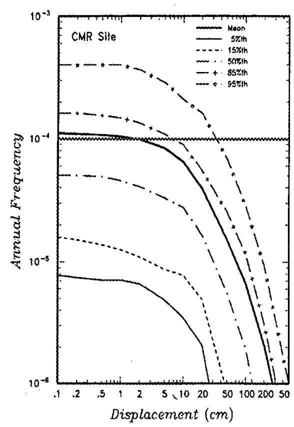

Figure 6d - Case 3:
Principal Faulting
15m Cum. Displacement

Figure 6 – Surface Rupture Hazard Curves for the CMR Building Site (Performance Goal for PC 3 Facilities is $1x10^{-4}$)

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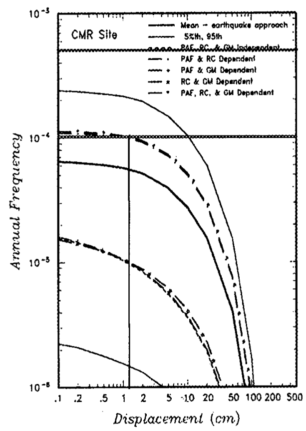

Figure 7a – Case 1b
Distributed Faulting w/ 1m
Cumulative Displacement

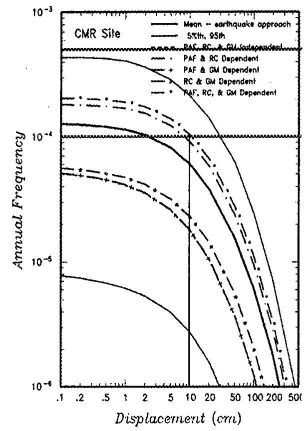

Figure 7b – Case 3:
Principal Faulting w/ 15m
Cumulative Displacement

Figure 7 – Surface Rupture Hazard Curve Sensitivity Results (Illustrates the effects of assuming fault dependency on hazard curves.)

3.2 Paleoseismic Investigations

Recent paleoseismic investigations have focussed on the Pajarito Fault. Two separate but related studies were initiated in Fiscal Year 1997 and Fiscal Year 1998. Locations of the studies are shown in Figure 8. Fieldwork for the paleoseismic studies is completed in a fairly short time frame but the analysis of samples required to develop date constraints is a time consuming process. Thus, work initiated in one fiscal year typically carries over to the following fiscal year to obtain dating information.

3.2.1 FY97 Paleoseismic Investigation on the Pajarito Fault

In July 1997, seven trenches were excavated across strands of the Pajarito fault zone to characterize the most recent faulting event (MRE), and to refine characterization of previous faulting events. The strategy for capturing the MRE was to excavate a series of seven trenches along an east-west transect across the fault zone south of Los Alamos Canyon, where parallel faults span a zone nearly 2 km wide. Two of the seven trenches were located on the main 50 m high scarp of the Pajarito fault, with the remainder on smaller east- and west-facing scarps. This study is presented in Reference 3.

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The best paleoseismic records were preserved on scarps that faced west, or upslope. Each of these trenches displayed evidence of mid- to late-Holocene MRE. The MRE appears to fall in a relatively narrow age range between about 1300 to 2300 years ago with a likely age of about 1500 years.

The MRE dated at about 1500 years does not appear to be contemporaneous with the MRE on the Guaje Mountain fault, dated at 4000-6000 years or the MRE on the Rendija Canyon fault, dated at either 8 or 23 thousand years. The trenches on the Pajarito do not show evidence for either a second (or third) earthquake at either 4000-6000 years or 8000 years. Thus, it appears that the MREs on each of the three faults in the Pajarito fault system are separate earthquakes.

3.2.2 FY98 Paleoseismic Investigation on the Pajarito Fault

In June, 1998, seven additional trenches were excavated across the Pajarito fault zone further south than the FY97 study. Again, the purpose of the excavations was to characterize the most recent faulting event (MRE), and to refine characterization of previous faulting events. While the fieldwork is complete, analysis of the data obtained is ongoing. The final report is to be complete in March, 1999.

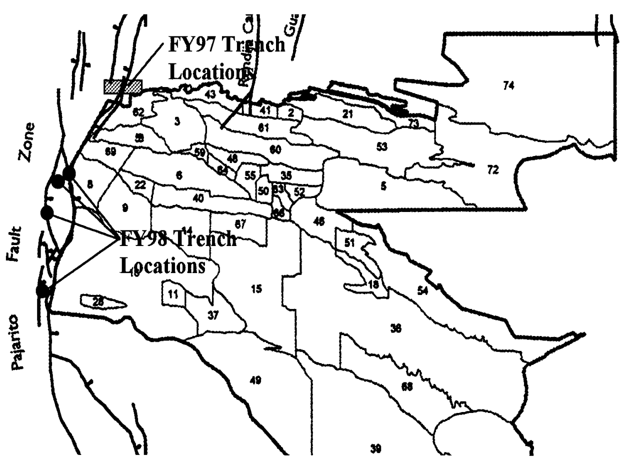

Figure 8 – Locations of Paleoseismic Studies

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4.0 DOE Requirements

The DOE, through orders and standards, provides guidance for facility siting and design with respect to earthquakes. The guidance is probabilistically based.

The Implementation Guide to DOE Order 420.1 "Natural Phenomena Hazards for DOE Nuclear Facilities and Non-Nuclear Facilities" (Ref. 7) requires that structures systems and components be designed and constructed to withstand the effects of natural phenomena hazards (NPH) using a graded approach. The target safety levels for structures systems and components (SSCs) subject to NPH are given in the guide in terms of performance goals. These performance goals are defined as the acceptable annual probability of failure. The performance goals are shown in Table 3 and are a function of performance categorization. Performance categorization is determined in accordance with DOE STD 1021 (Ref. 8). The guide also states that siting of structures over active geologic faults should be avoided.

Table 3 - Performance Goals and Categories for SSCs

Performance Category	Description of Performance Required	Seismic Performance Goal
PC0	No consideration.	N/A
PC1	Prevent major structural damage or collapse which would endanger personnel (life-safety).	$1x10^{-3}$
PC2	Maintain operation of essential facilities allowing relatively minor structural damage.	$5x10^{-4}$
PC3	Confinement of hazardous materials.	$1x10^{-4}$
PC4	Confinement of hazardous materials	$1x10^{-5}$

DOE STD 1020 (Ref. 9) specifies seismic loading in probabilistic terms. The annual exceedance probability for the ground motion associated with the various performance categories is shown in Table 4. The peak ground accelerations for LANL are based on the information in Reference 2.

Table 4
Peak Ground Accelerations at LANL

Performance Category	Annual Probability of Exceedance (Return Period)	Horizontal Peak Ground Acceleration (g)	Vertical Peak Ground Acceleration (g)
PC1	$2x10^{-3}$ (500 yr.)	0.15	0.11
PC2	$1x10^{-3}$ (1,000 yr.)	0.22	0.19
PC3	$5x10^{-4}$ (2,000 yr)	0.31	0.27
PC4	$1x10^{-4}$ (10,000 yr)	0.57	0.58

For seismic design, the standard recommends using deterministic design rules that are familiar to design engineers and which have a controlled level of conservatism. This level of conservatism combined with the specification of probabilistic seismic loading leads to performance goal achievement.

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DOE STD 1022 (Ref. 10) provides guidance for NPH Characterization Criteria including the necessity for establishing the potential for surface rupture and points to EPA guidance for offsetting hazardous waste facilities from active faults. Active faults are characterized "by the presence of surface or near surface deformation of geologic deposits of a recurring nature within the last approximately 500,000 years or at least one in the last approximately 50,000 years."

DOE STD 1023 (Ref. 11) provides criteria for NPH assessment. In this document, some guidance is provided for ground failure (surface rupture). If surface rupture may occur near a facility, a probabilistic evaluation may be necessary. If the annual probability of ground failure is greater than the necessary performance goal either the site should be avoided, mitigation measures taken, or an evaluation performed of the effects of fault offset.

15 December 17, 1998

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5.0 Implications of Findings

This section discusses the implication of the findings on projects at TA-3 and for the Laboratory in general. These studies have implications for LANL in two areas: (1) surface rupture potential at TA-3 with respect to both non-nuclear facilities and the CMR Building, and (2) design ground motion for all facilities.

5.1 Surface Rupture at TA-3

The studies to date indicate that there are faults in some locations at TA-3 including under the CMR Building. These faults will be addressed in a manner consistent with DOE guidance. For new facilities, building sites will be selected such that "active" faults are avoided. For existing facilities that are located over faults, assume they meet "active" criteria and a probabilistic approach will be followed.

Non-Nuclear Facilities (PC 1 and PC 2):

For the SCC and NISC projects, a site specific study (Ref. 5) was performed to determine if faulting was present at the proposed site. The results of this study indicate the site is clear of faulting and is therefore acceptable for new construction.

For existing facilities, hazard curves developed in the probabilistic surface rupture study (Ref. 6) for TA-3 are used. At the performance goals for PC 1 and PC 2, $1x10^{-3}$ and $5x10^{-4}$, respectively, the estimated displacement for any of the cases as shown in Figures 4 and 5 and summarized in Table 2 is less than 1 millimeter. This is true even for the case where all faults are assumed to be connected. This small amount of displacement has a negligible effect on structures. Therefore, for existing PC 1 and PC 2 facilities, surface rupture is not a credible hazard and the only aspect of the seismic hazard at TA-3 that should be considered is ground motion.

The CMR Building (PC 3)

As previously indicated, it has been determined that there is an existing fault under the CMR. The vertical offset in this fault is approximately 8 feet. The identification, location and orientation of the fault under the CMR shown in Figure 4 is based on air photo interpretation, high precision mapping of faults in canyons to the south of TA-3, and examination of cores taken from the nine holes drilled around the CMR Building. The air photos indicate a linear feature running through the CMR site from the northeast corner of the facility and through the site to the west-southwest. The high precision mapping effort located a fault with about 5 feet of vertical offset in Twomile Canyon to the southwest which coincides with the southwest end of the air photo feature running through the CMR site. The examination of the cores showed that the core taken at the northeast corner (CMR-6) of the facility cut through a fault with a total vertical offset of about 8 feet and that it is likely that the same fault lies between cores CMR-2 and CMR-3. This information also coincides with the air photo feature. The location and orientation of the fault shown in Figure 4 are consistent with the information known to date.

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If this site were to be considered for a new nuclear facility, it would not be used and an alternate site, clear of faulting concerns, would be chosen. However, since this is an existing facility, the impact on the safe operation of the facility must be assessed. For this assessment a probabilistic approach is used.

The CMR Building is a PC 3 facility that contains special nuclear materials. The performance goal for design basis earthquakes is $1x10^{-4}$. The vertical offset of the fault under the facility lies between the existing conditions evaluated in cases 1a (9m offset) and 1b (1m offset) in Reference 6. As shown in Table 2, the probable offset for these cases at the performance goal is less than 1 mm. This small amount of displacement has a negligible effect on structures and it could be concluded that the discovery of this fault is not a credible hazard for the design basis event.

However, if the worse case assumption is made that this is a principal fault and that all three faults are connected, the estimated offset from Figure 6 for the PC 3 performance goal is approximately 10 centimeters (4 inches). A displacement of this magnitude can cause significant cracking in a concrete shear wall structure such as those used in the construction of the CMR Building. This cracking could result in a loss of confinement.

It can be shown (Ref. 12) that the annual probability of seismic induced failure, based on ground motion associated with an earthquake, is about $2x10^{-3}$ for most areas of the CMR Building. The exceptions to this is the vault that has an annual probability of seismic induced failure, again, based on ground motion, of about $7x10^{-5}$, and the floor wells which have yet a lower probability of failure. The significance of this information is that ground motion could cause a loss of confinement for most areas of the CMR Building at frequency that is at least 20 times greater than surface rupture.

In the safety analysis for the CMR Building, the consequences of the seismic accident are assessed assuming that the CMR building, with the exception of the vault and floor wells, collapses at the frequency indicated above. With the vault and floor wells located such that they would not be directly effected by a surface displacement, the assumptions used in the safety analysis for the seismic accident are still valid even with new knowledge of a fault beneath the facility.

Based on current available information, the fault under the CMR site is a subsidiary fault. As a result, any movement on the fault is likely to be small and would be a result of a large (Magnitude 6 to 7) earthquake on the Rendija Canyon or the Pajarito fault. Such earthquakes are low probability events. In Figure 9 the estimated annual frequency of damage caused by ground motion is compared to the annual frequency of damage caused by surface rupture. This figure illustrates that damaging surface rupture is far less likely to occur than damaging ground motion.

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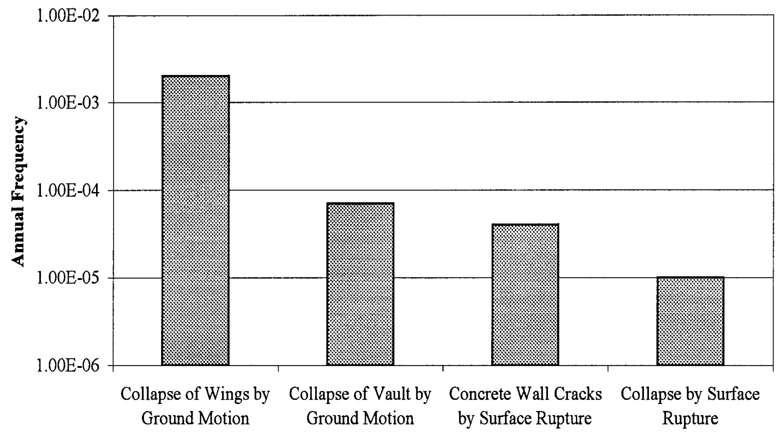

Figure 9 – Frequency of Seismic Induced Damage at CMR Building

5.2 Design Ground Motion

Of the current seismic hazard studies, only the paleoseismic investigations could influence the design ground motion at LANL. At this time only the information from the FY97 study can be assessed for its impact.

The design ground motion at LANL is based on the results of the probabilistic seismic hazard analysis (PSHA) presented in Reference 2. According to this reference, the net slip rate of the Pajarito fault is the most important input parameter in the PSHA. For this fault the PSHA assumed the slip rates shown in Table 5. One of the objectives of the paleoseismic investigations is to get a more accurate assessment of the slip rate on the Pajarito fault.

Table 5 – Net Slip Rates for Pajarito Fault Used In PSHA

Net Slip Rate (mm/yr)	Probability[1]	Percentile[2]
0.01	0.1	5th
0.05	0.2	20th
0.09	0.4	50th
0.20	0.2	80th
0.95	0.1	95th

[1]Probability used in PSHA Logic Tree
[2]Cumulative percentile

Based on the results of the FY97 paleoseismic investigation (Ref. 3) on the Pajarito fault, the net slip rate is 0.06-0.21 mm/yr. The lower of the two values is less than the median slip rate value of 0.09 mm/yr assumed in the PSHA. The higher of the two values is approximately equal to 80th

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percentile motion assumed in PSHA. Therefore, the slip rates calculated in the 1997 study are already covered in the PSHA documented in Reference 2.

Questions concerning the dependency of the three major faults are based on the physical location and style of deformation of the three faults. Their relative proximity to one another and style of deformation could lead to the conclusion that they must be connected at depth below the earth's surface. However, based on the paleoseismic studies to date, there is no evidence that supports this conclusion. The MRE on the Pajarito fault, dated at 1500-2000 years, is not coincident with either the MRE on the Guaje Mountain fault, dated at 4000-6000 years or the MRE on the Rendija Canyon fault, dated at either 8 or 23 thousand years. The trenches on the Pajarito do not show evidence for either a second (or third) earthquake at either 4000-6000 years or 8000 years.

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References

1. Gardner, Lavine, Vaniman, WoldeGabriel, "High-Precision Geologic Mapping to Evaluate the Potential for Seismic Surface Rupture at TA-55, Los Alamos National Laboratory", LA-13456-MS, Los Alamos National Laboratory, Los Alamos, New Mexico, June, 1998

2. Wong, Kelson, Olig, Kolbe, Hemphill-Haley, Bott, Green, Kanakari, Sawyer, Silva, Stark , Haraden, Fenton, Unruh, Gardner, Reneau and House, "Seismic Hazard Evaluation of the Los Alamos National Laboratory", Woodward Clyde Federal Services, Oakland, California, February, 1995

3. McCalpin, "Late Quaternary Faulting on the Pajarito Fault, West of Los Alamos National Laboratory, North-Central New Mexico: Results from the Seven-Trench Transect Excavated in Summer of 1997", GEO-HAZ Consulting, Inc., Estes Park Colorado, August, 1998.

4. Krier, Caporuscio, Gardner and Lavine, "Stratigraphy and Geologic Structure at the Chemistry and Metallurgical Research (CMR) Building, Technical Area 3, Los Alamos National Laboratory, New Mexico", LA-13522-MS, Los Alamos National Laboratory, Los Alamos, New Mexico, October, 1998

5. Krier, Caporuscio, Lavine and Gardner. "Stratigraphy and Geologic Structure at the SCC and NISC Building Sites, Technical Area 3, Los Alamos National Laboratory, New Mexico", LA-13507-MS, Los Alamos National Laboratory, Los Alamos, New Mexico, September, 1998

6. Olig, Youngs and Wong, "Probabilistic Seismic Hazard Analysis for Surface Fault Displacement at TA-3 Los Alamos National Laboratory", Woodward Clyde Federal Services, Oakland, California, July, 1998

7. U.S. Department of Energy, "DOE G 420.1, Interim Guidelines for the Mitigation of Natural Phenomena Hazards for DOE Nuclear and Non-Nuclear Facilities", ***DRAFT***, November, 1995

8. U.S. Department of Energy, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems and Components", DOE STD 1021-93, January, 1996

9. U.S. Department of Energy, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities", DOE STD 1020-94, January, 1996

10. U.S. Department of Energy, "Natural Phenomena Hazards Characterization Criteria", DOE STD 1022-94, January, 1996

11. U.S. Department of Energy, "Natural Phenomena Hazards Assessment Criteria", DOE STD 1023-95, January, 1996

12. Goen, Los Alamos National Laboratory Memorandum from Larry Goen to Chris Steele, "Summary Report – Seismic/Structural Review of the CMR Building In Support of the BIO/TSR Project", ESA-EA:97-290, December 9, 1997