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,

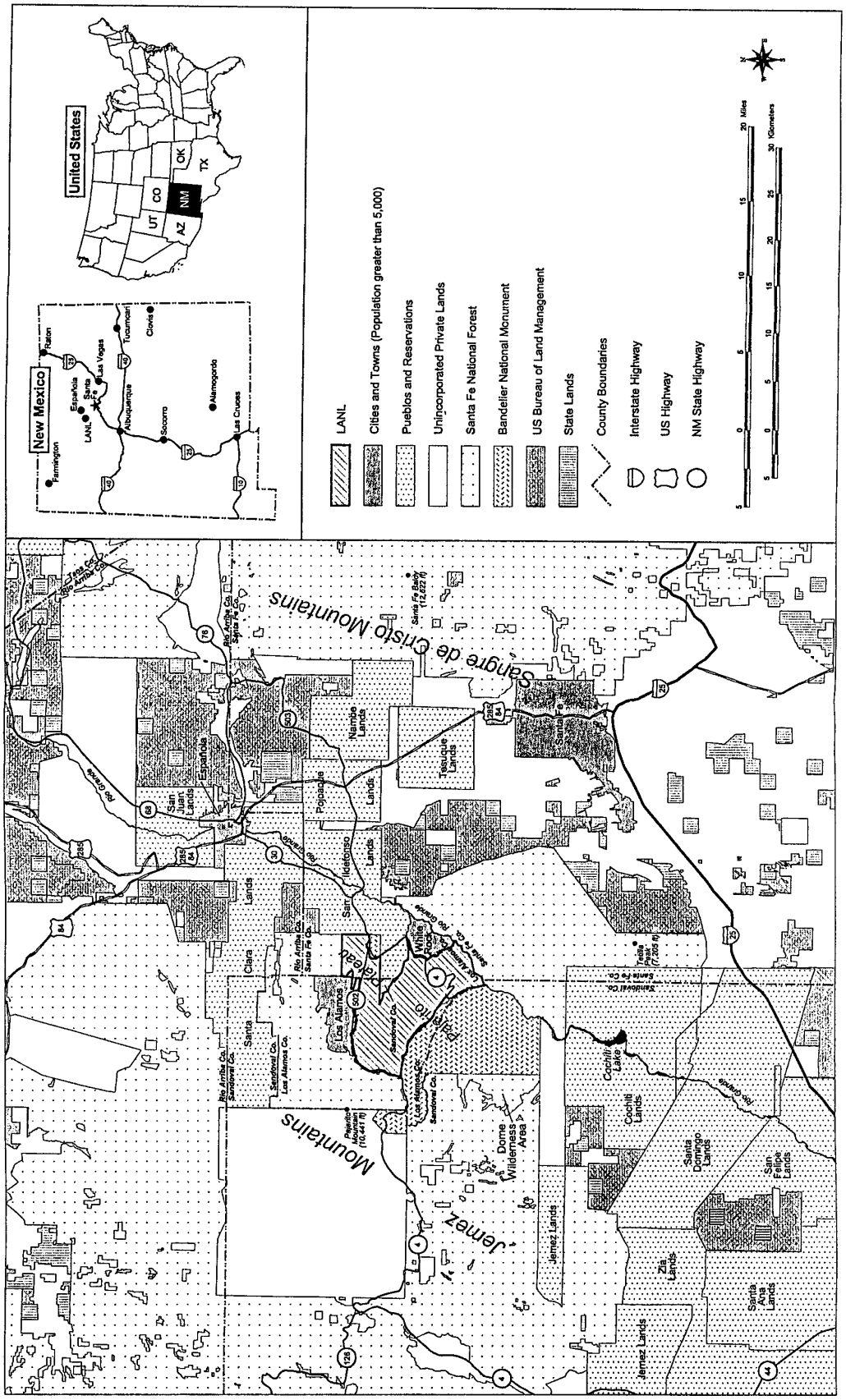


FIGURE 4.0–1.—*Location of LANL.*

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.

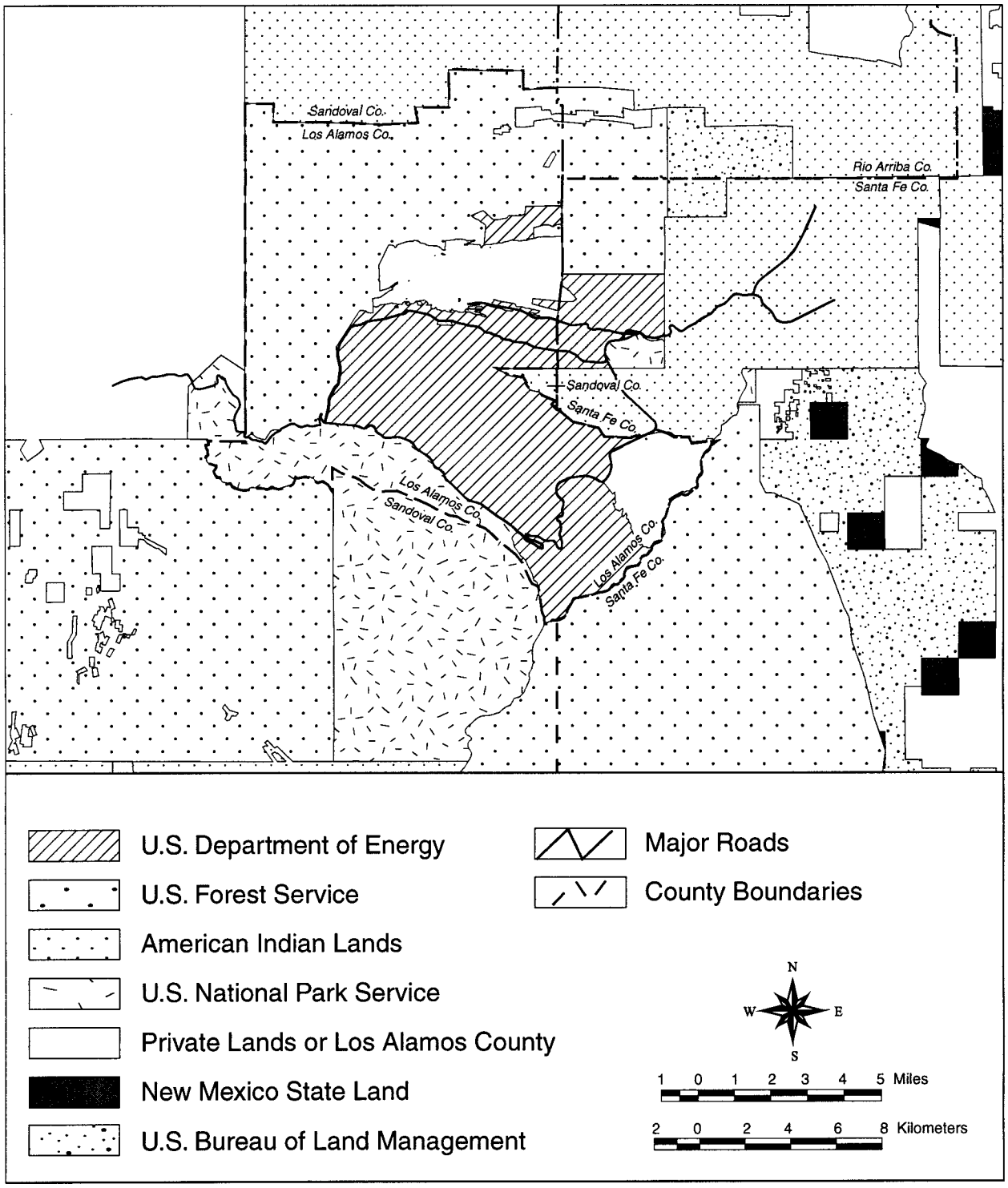


FIGURE 4.1.1–1.—*Land Stewardship in the LANL Area.*

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

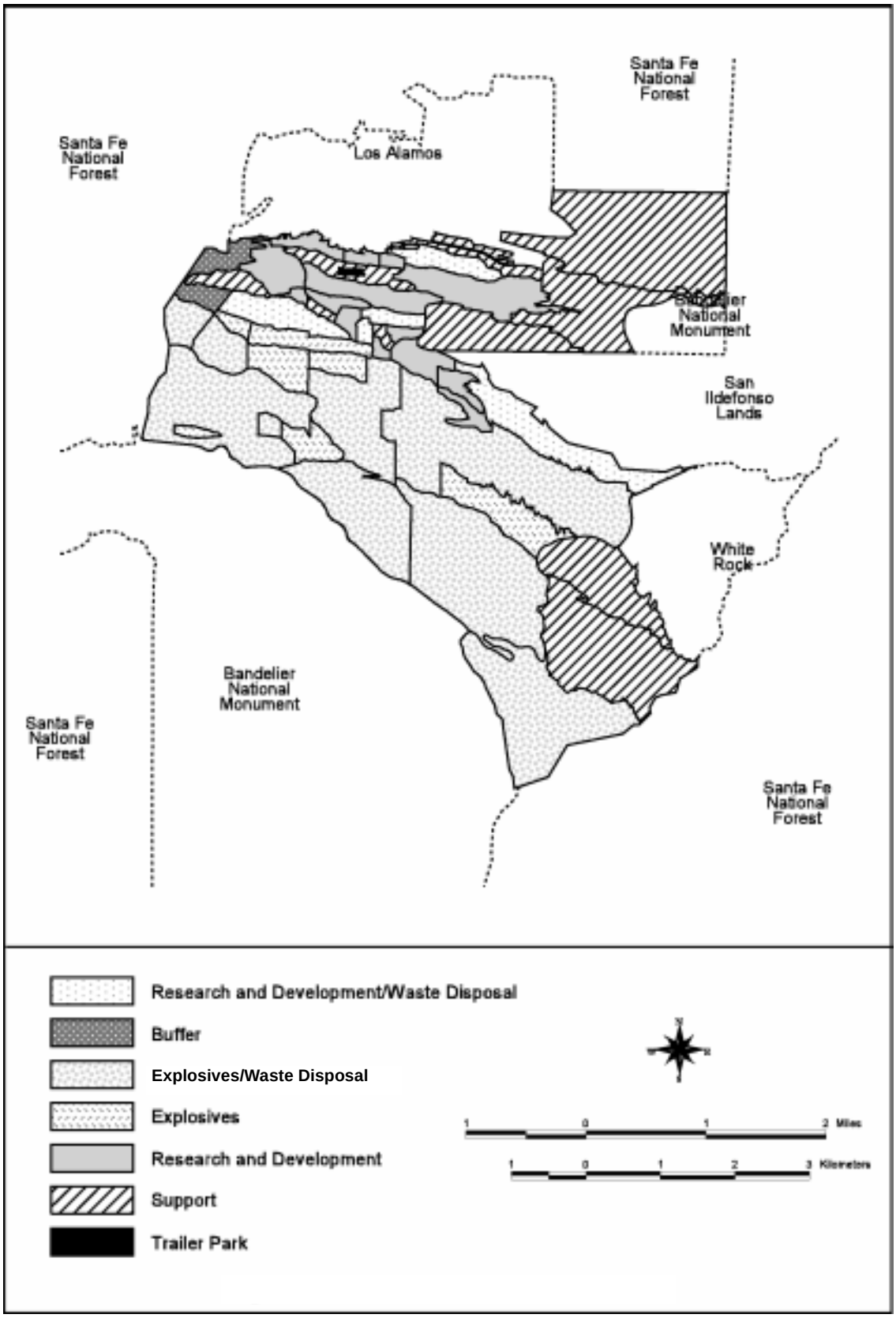


FIGURE 4.1.1.2–1.—*Land Use Within LANL Boundaries.*

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

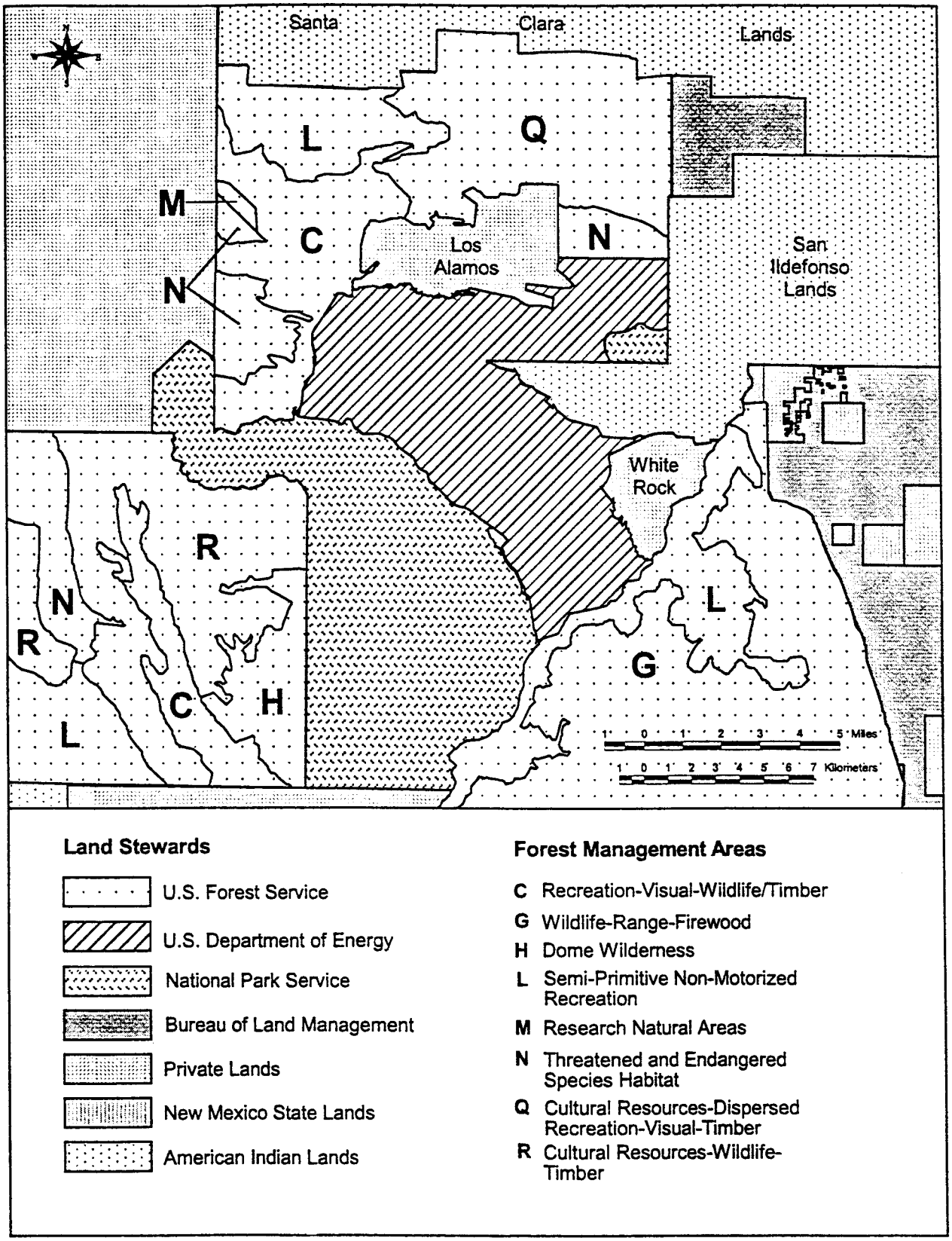


FIGURE 4.1.1.5–1.—*Santa Fe National Forest Management Areas.*

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.

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.

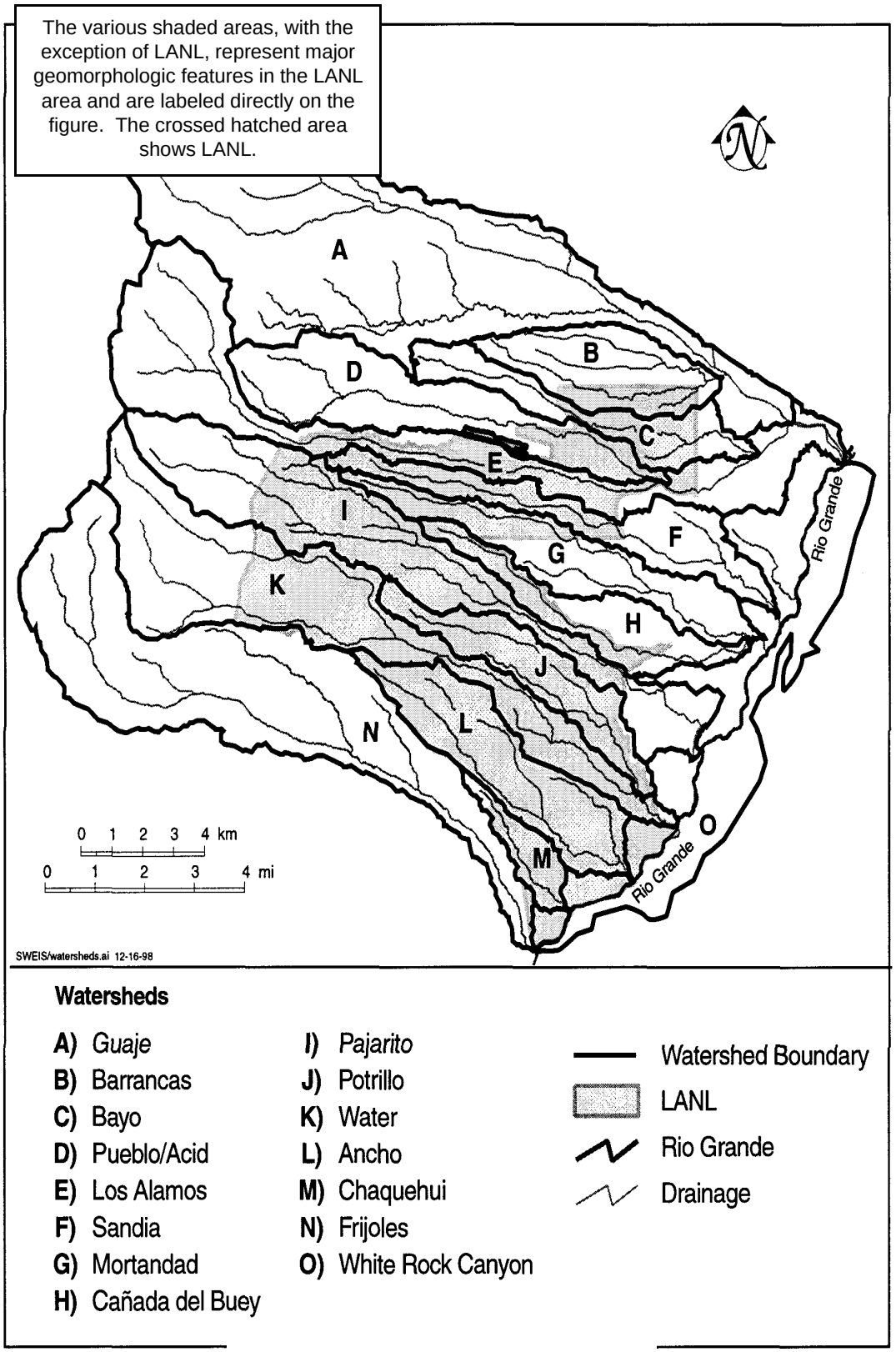
A Look Back In Time

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

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.

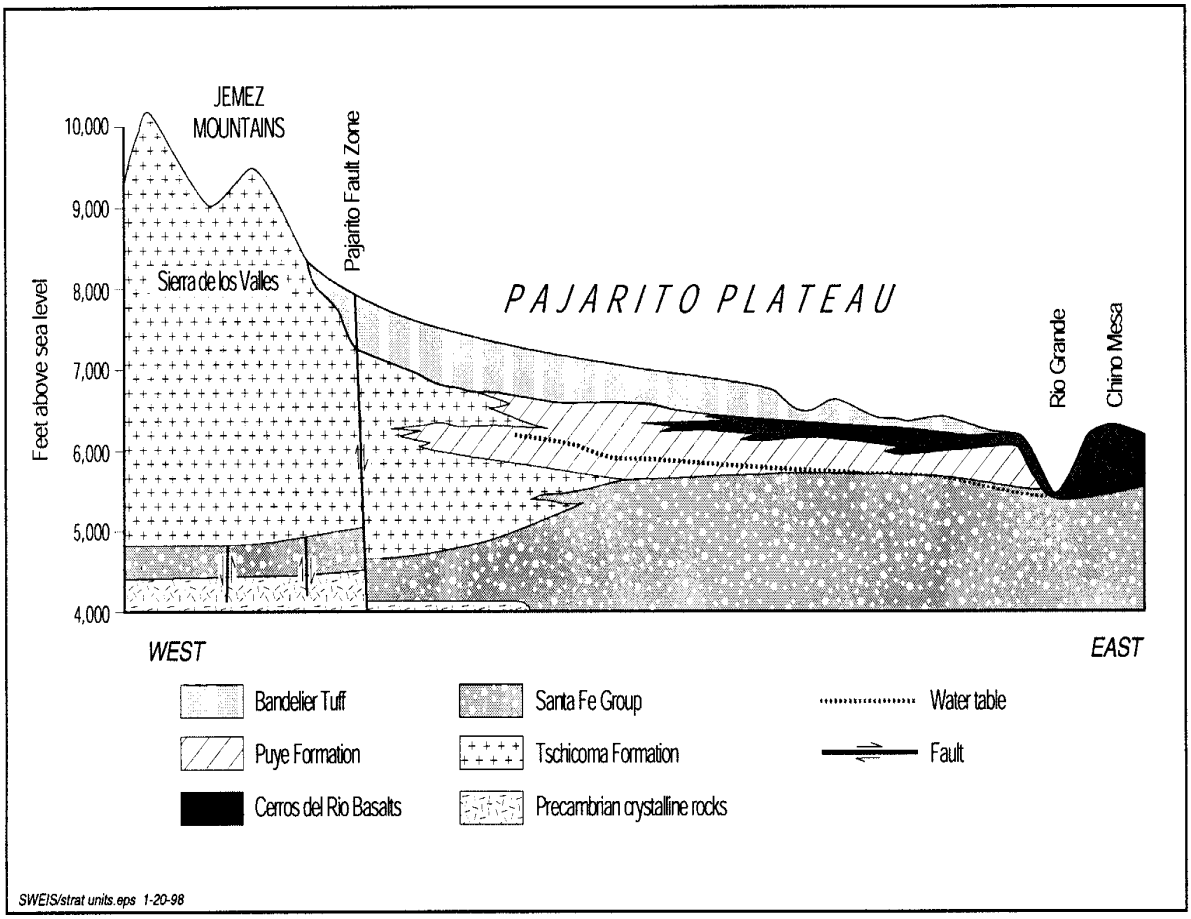
4.2.2 Geologic Conditions

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



SOURCE: Modified from LANL 1996f

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.

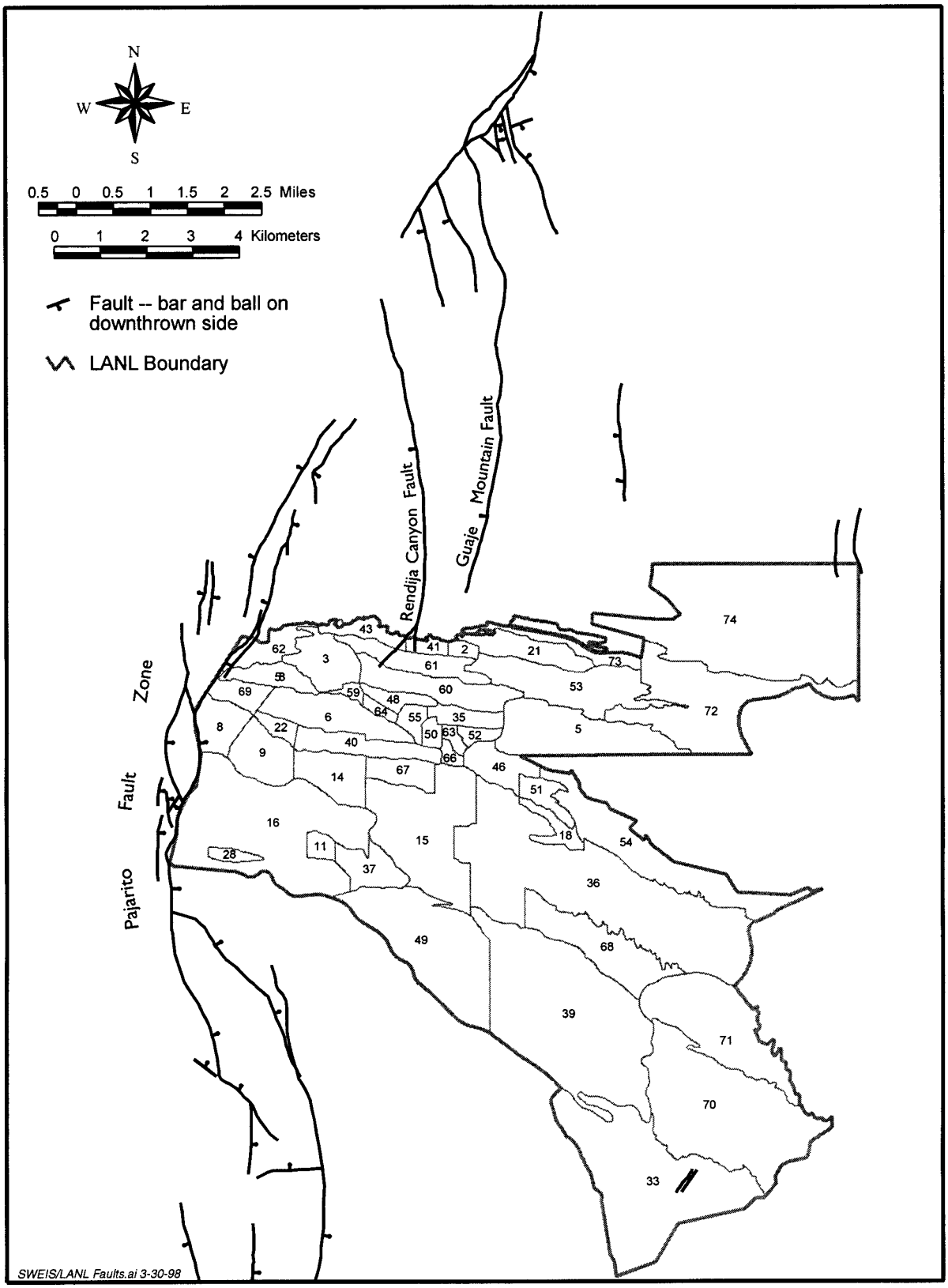
Volcanic activity is difficult to predict, and the accuracy of a prediction may depend on the type of eruption. Increasing seismic activity deep below the Earth's surface is often an indication that magma is migrating toward the surface. The Jemez Mountains show an unusually low amount of seismic activity, 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

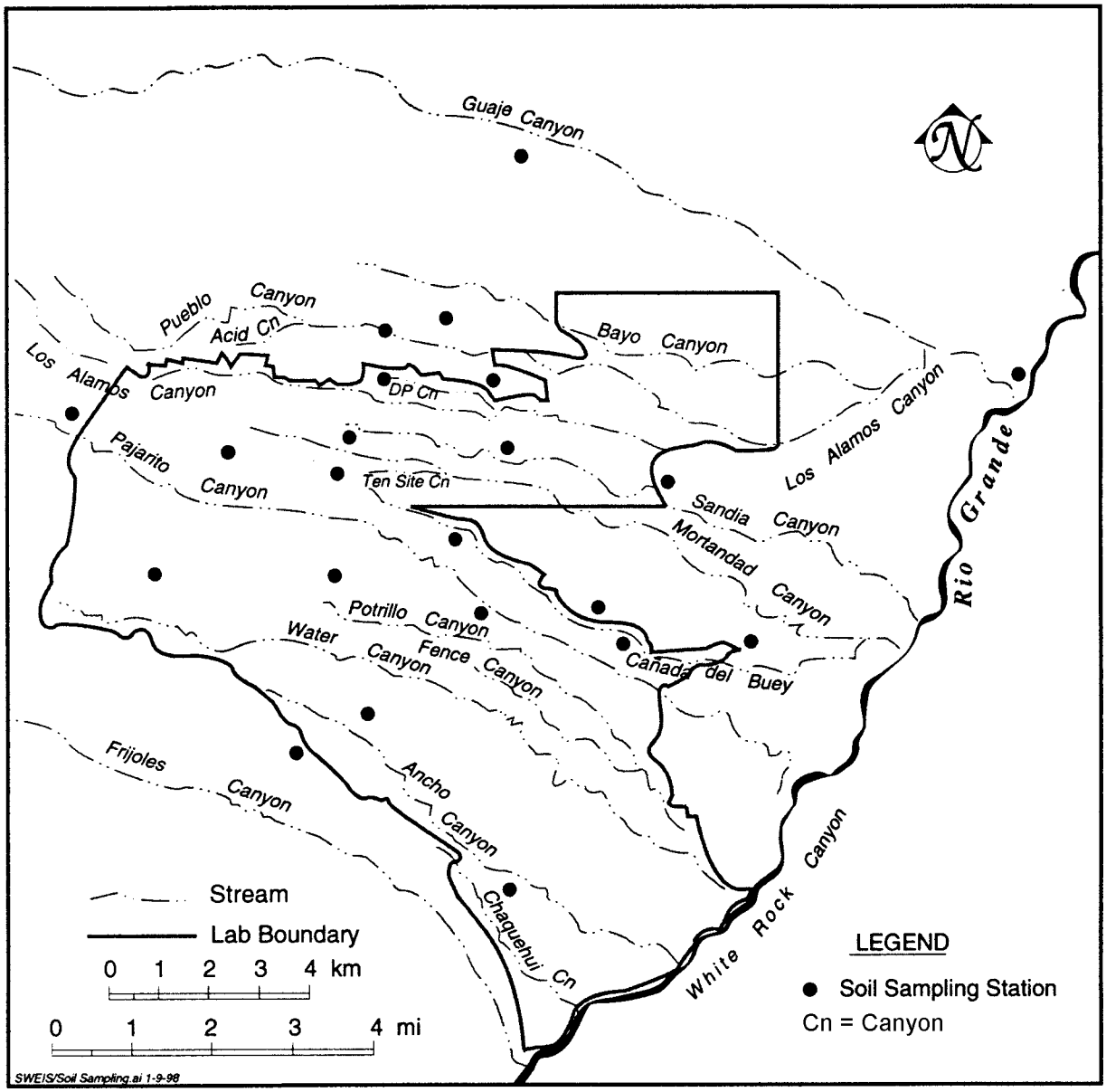
and 5400.5, provides information on the concentration and distribution of radionuclides in soils near LANL. Soil samples are collected from on-site, perimeter, and off-site locations shown in Figure 4.2.3.1–1. Additionally, background soil samples are collected from regional stations that are located 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.

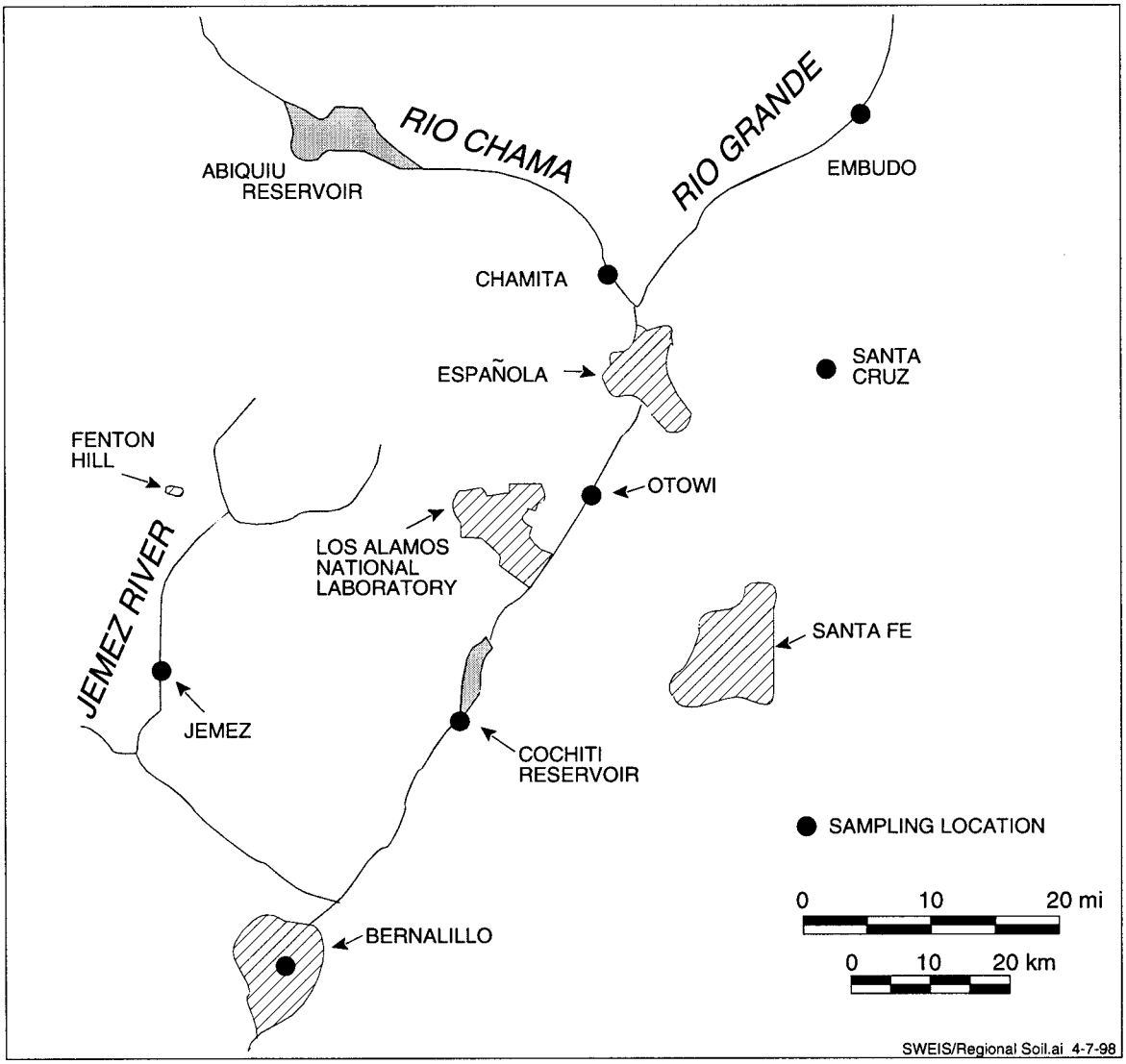
Sources of radionuclides in soil may include natural minerals, atmospheric fallout from nuclear weapons testing (Klement 1965), burn-up of nuclear-powered satellites (Perkins and Thomas 1980), and planned or unplanned releases of radioactive gases, liquids, and/or solids by LANL. Naturally occurring 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



SOURCE: LANL 1997c

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).

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.

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 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.

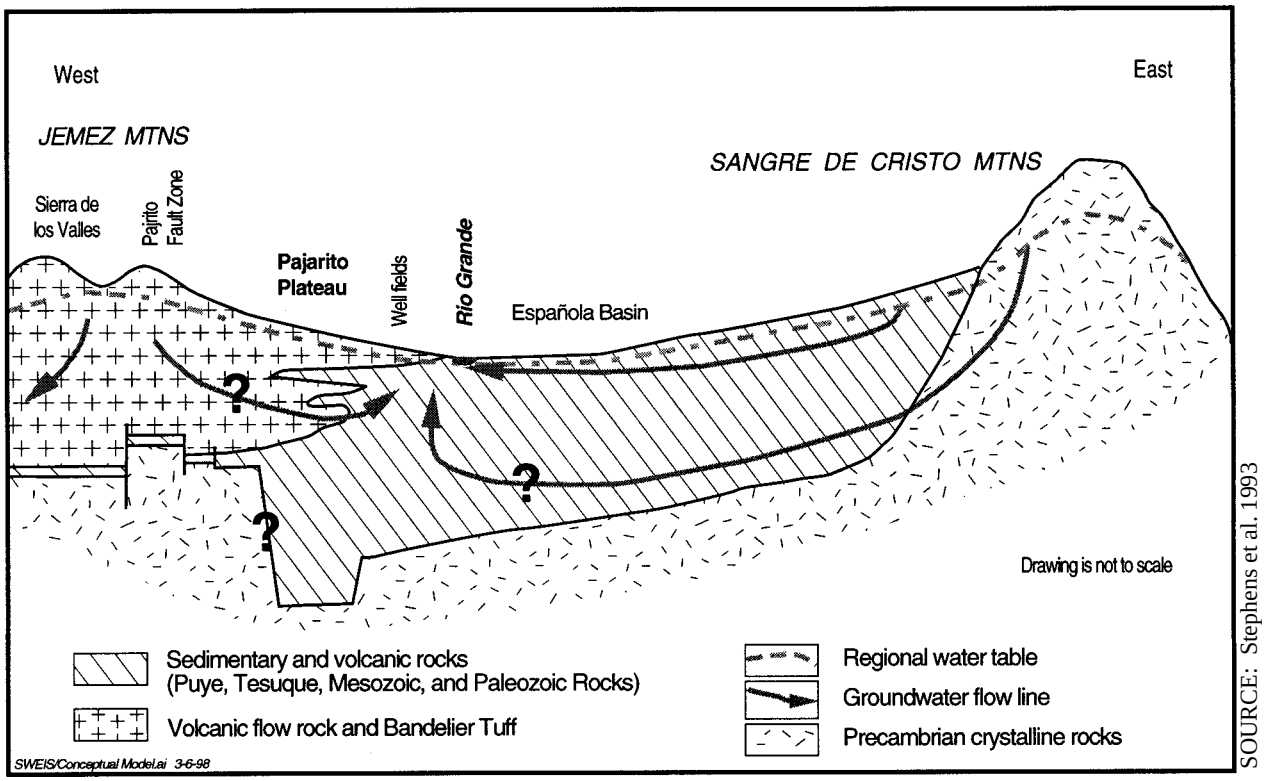


FIGURE 4.3–1.—*Conceptual Sketch of Groundwater Flow Paths in the Española Portion of the Northern Rio Grande Basin.*

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

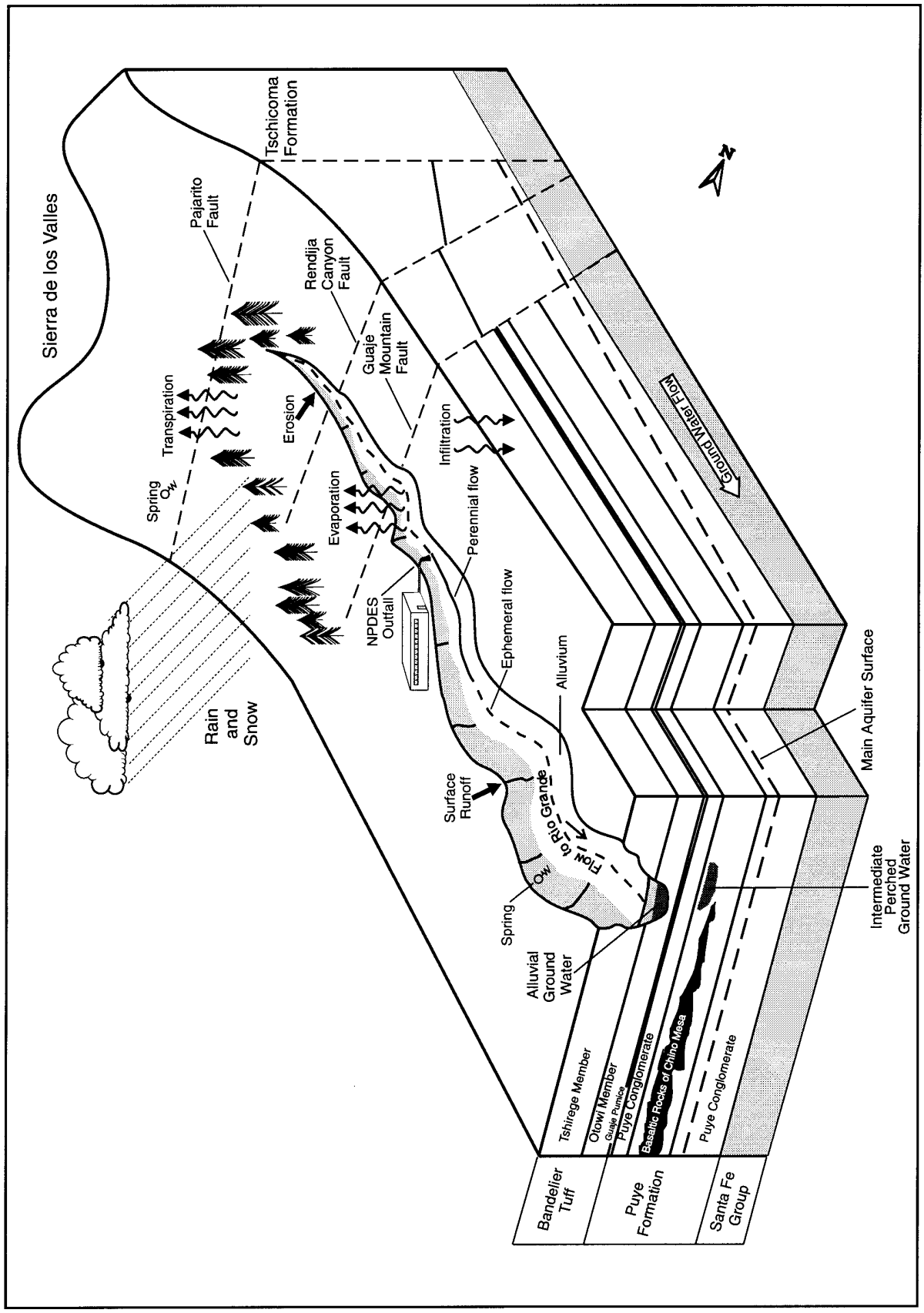


FIGURE 4.3–2.—*Conceptual Geohydrological Drawing of the Pajarito Plateau.*

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

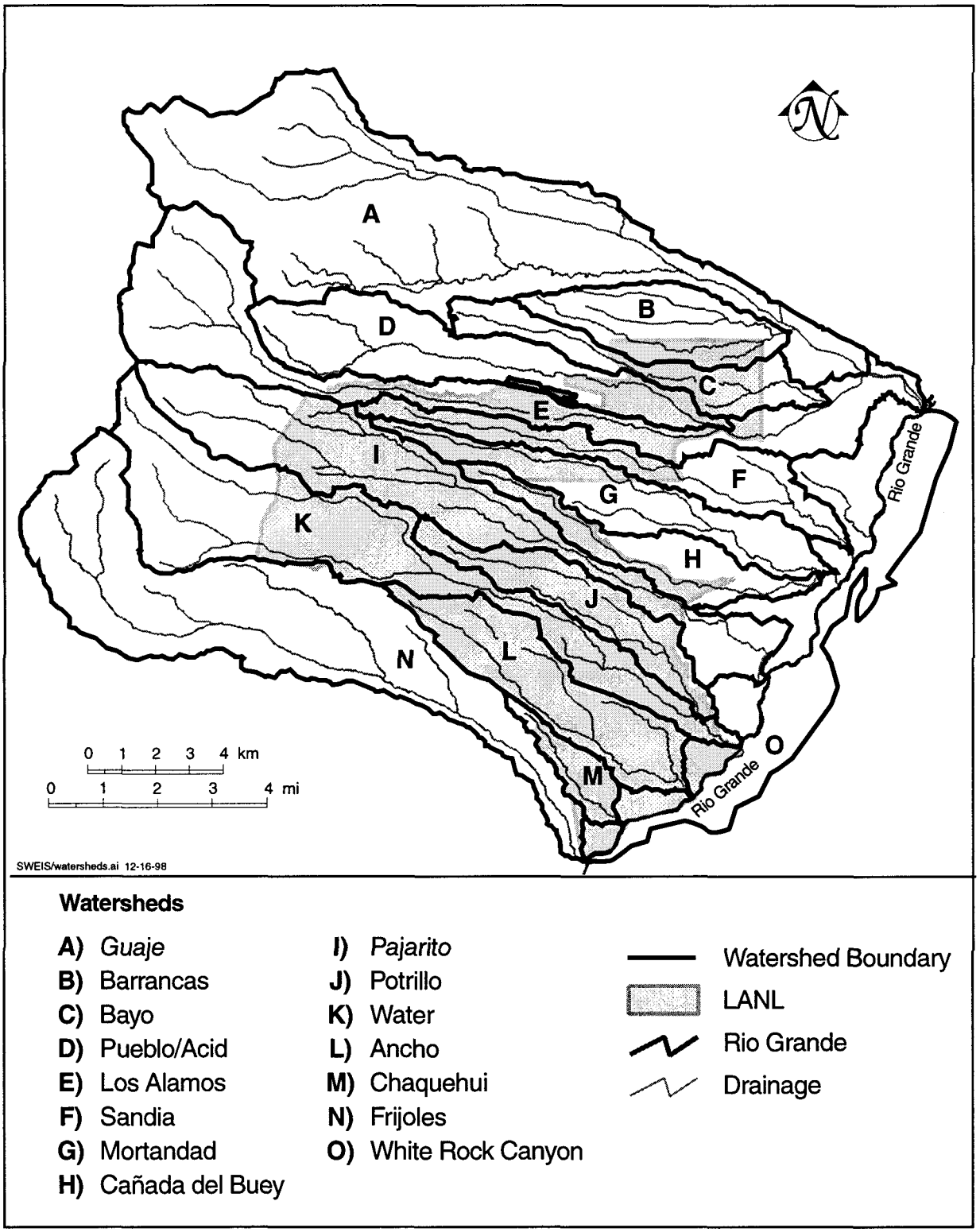
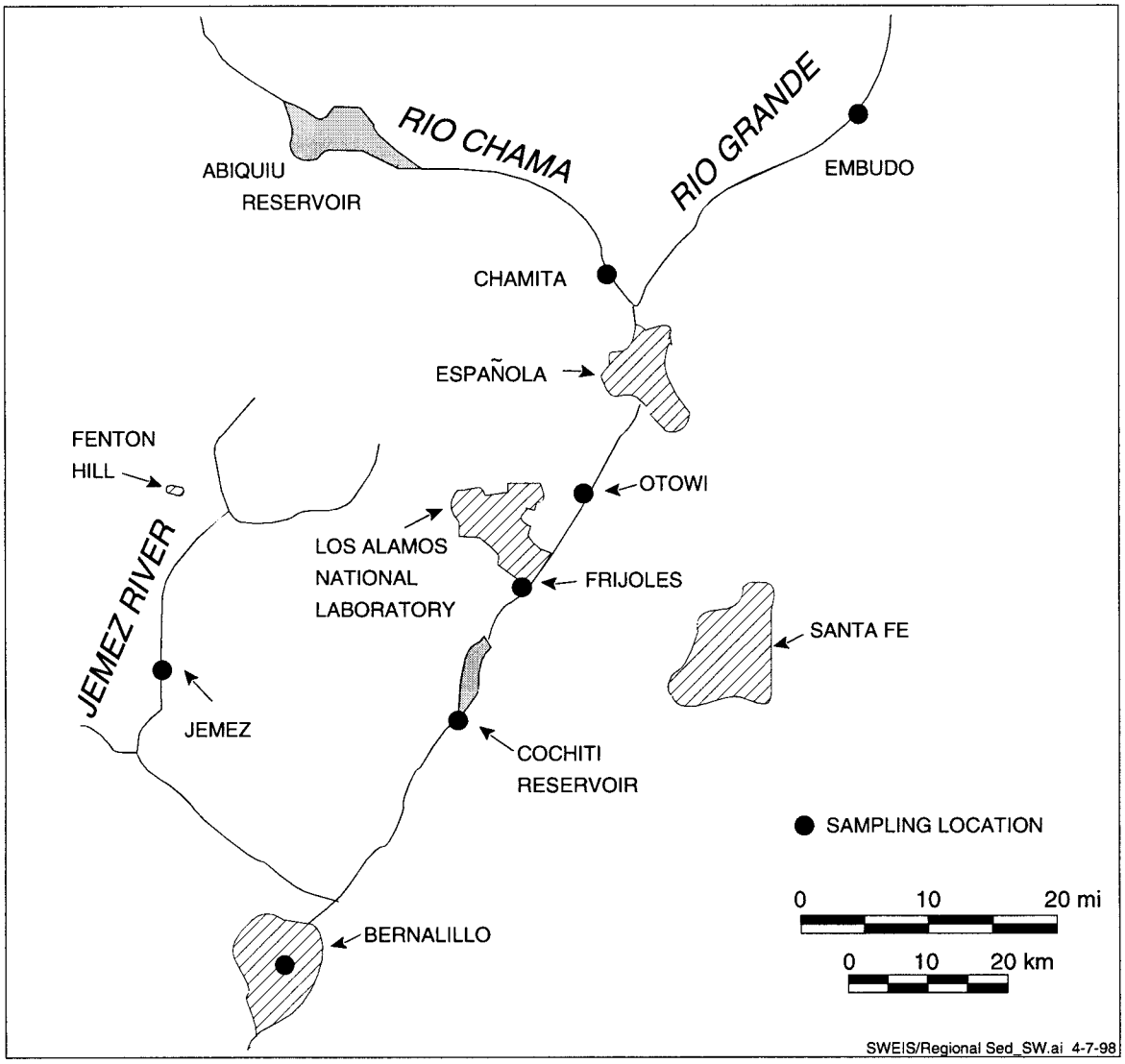
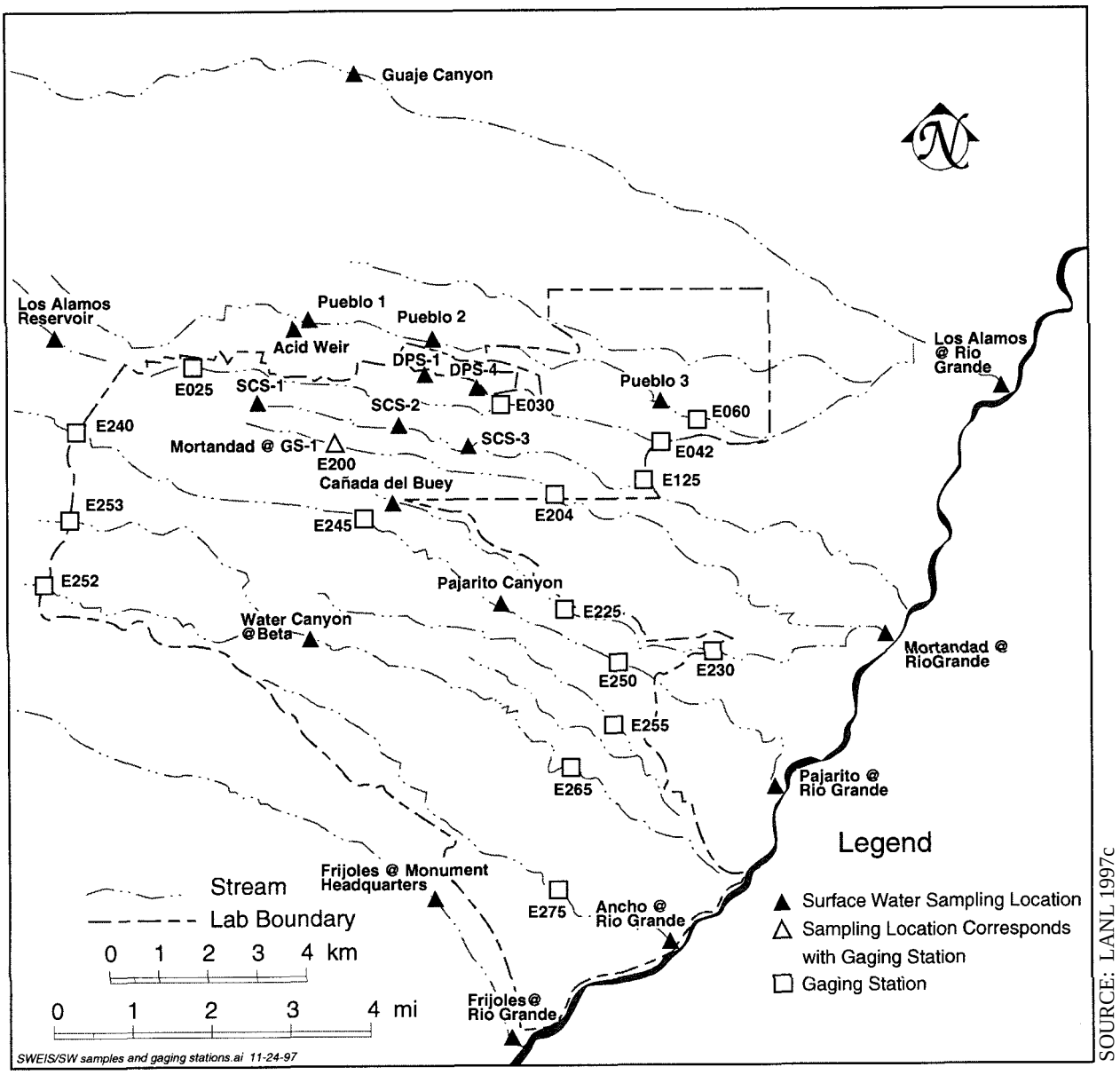


FIGURE 4.3.1–1.—*Watersheds in the LANL Region.*



SOURCE: LANL 1997c

FIGURE 4.3.1.1–1.—*Regional Surface Water and Sediment Sampling Locations.*



SOURCE: LANL 1997c

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

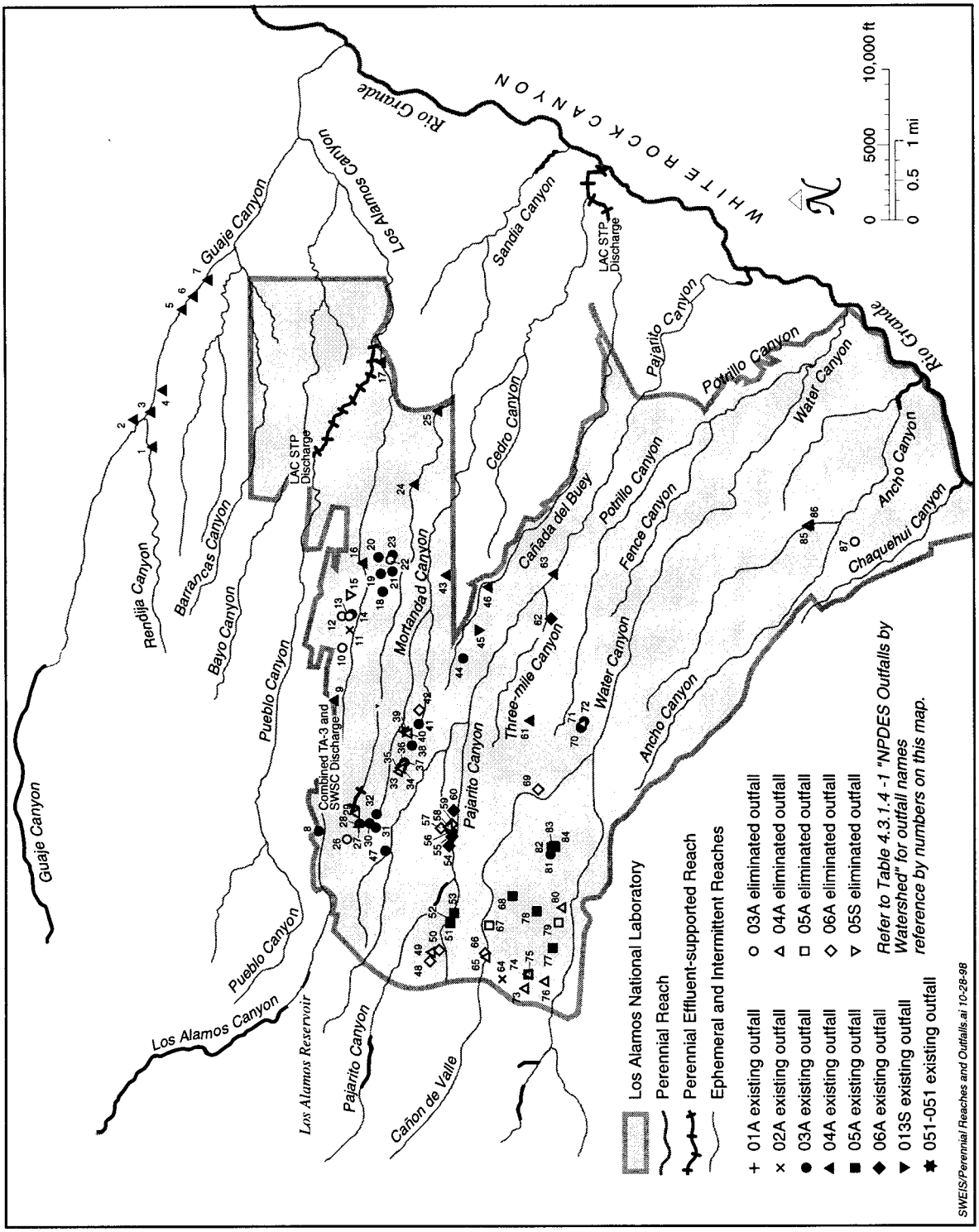
TABLE 4.3.1.3–1.—*NPDES Outfalls by Watershed*[a]-Continued

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



SOURCE: Stoker 1993

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

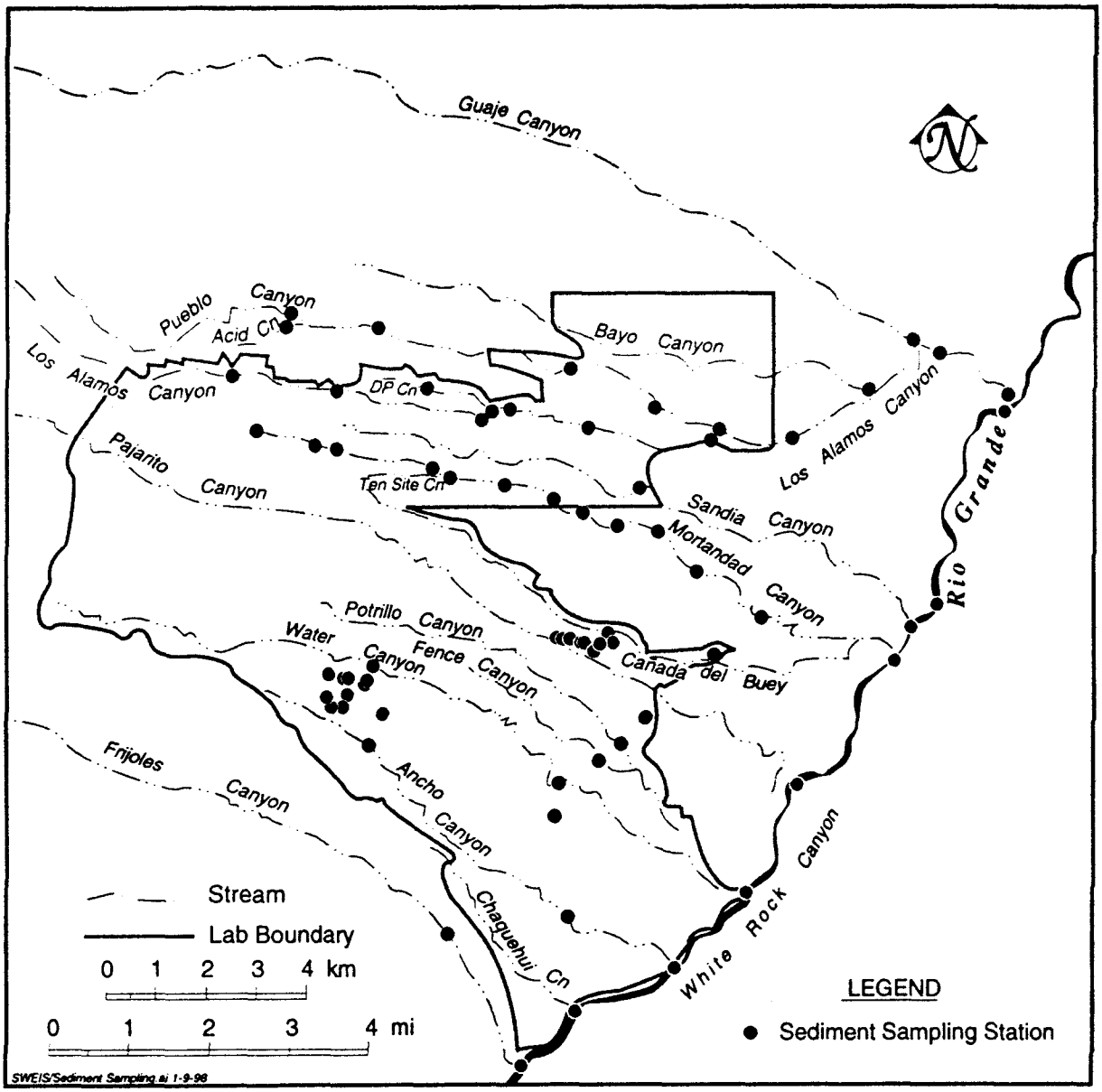


FIGURE 4.3.1.4–1.—*On-Site and Off-Site Perimeter Sediment Sampling Locations.*
(**Note:** Perimeter stations are located within 2.5 miles [4 kilometers] of LANL.)

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.

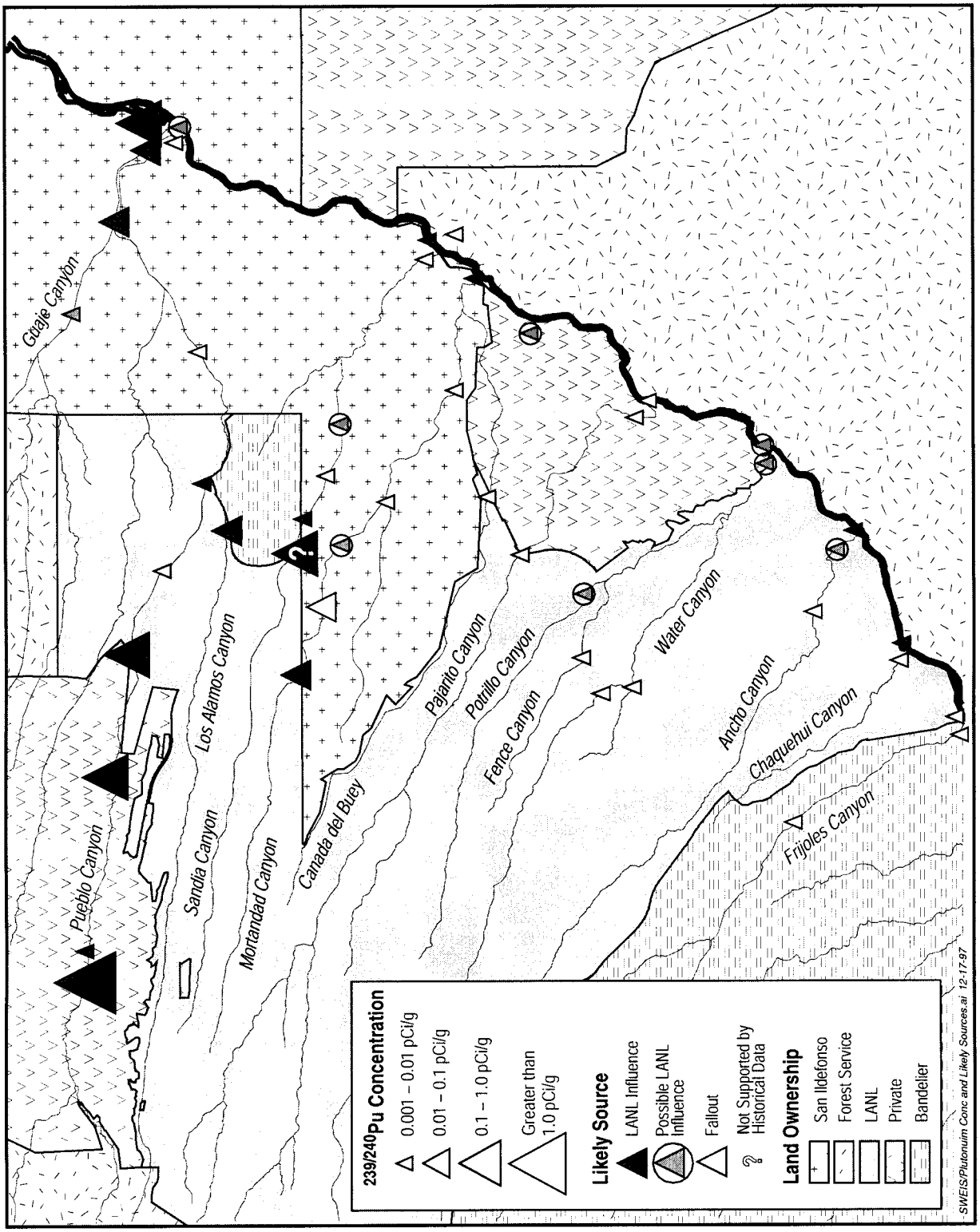
Off-Site Sediment Sampling

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

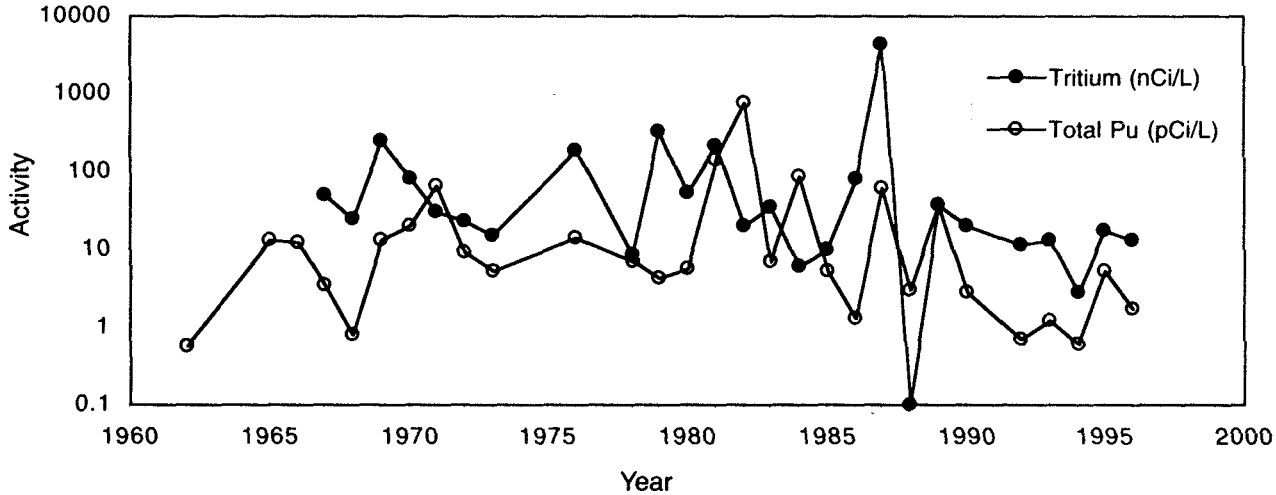


FIGURE 4.3.1.5–1.—*Tritium and Plutonium Activity at Mortandad Canyon at Gaging Station 1.*[a]

[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.

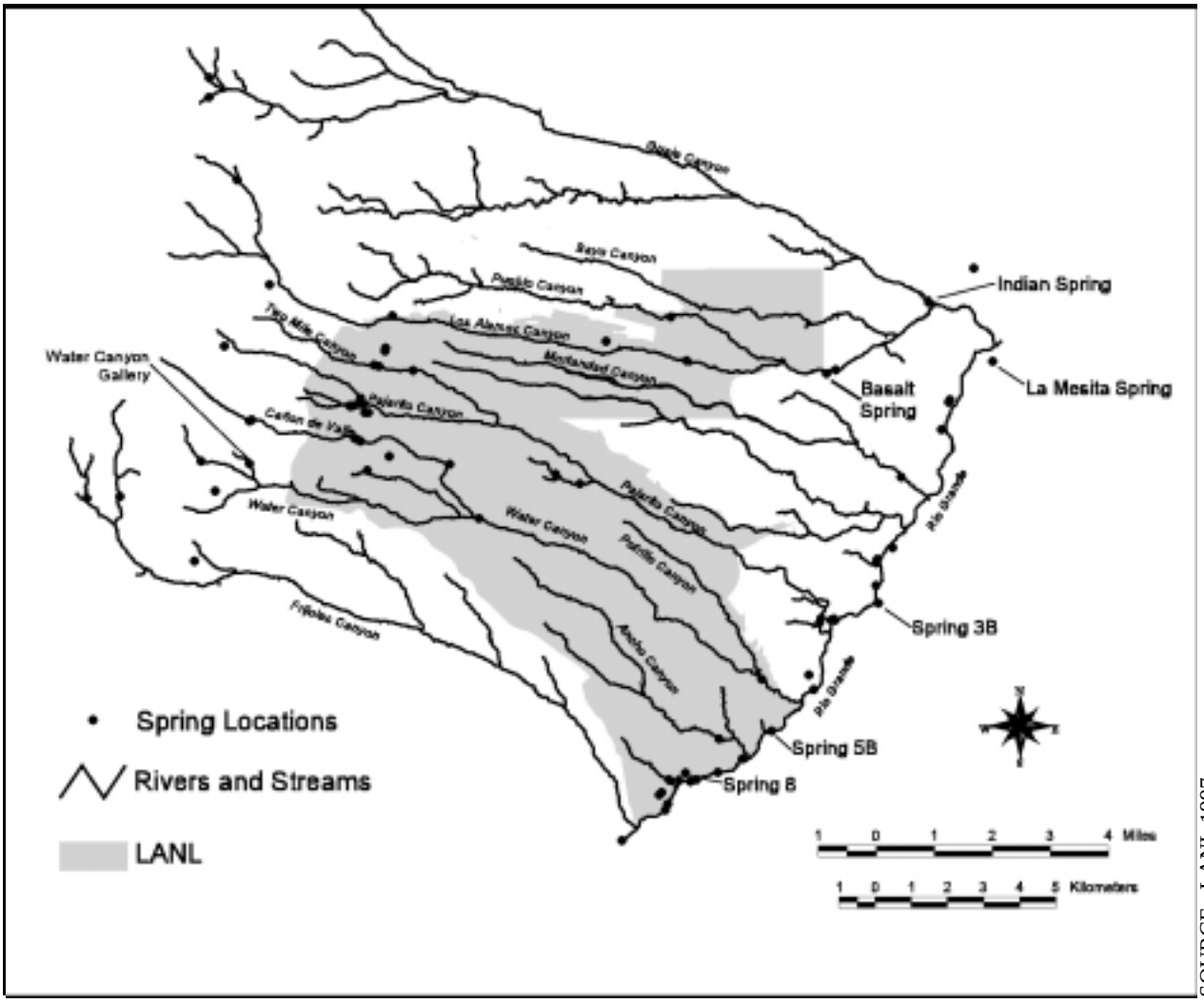
Intermediate perched groundwater bodies of limited extent occur beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons; in volcanic rocks on the sides of the Jemez Mountains to the west of LANL; and on the western portion of the Pajarito Plateau (LANL 1996i, LANL 1993a, and Purtymun 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*

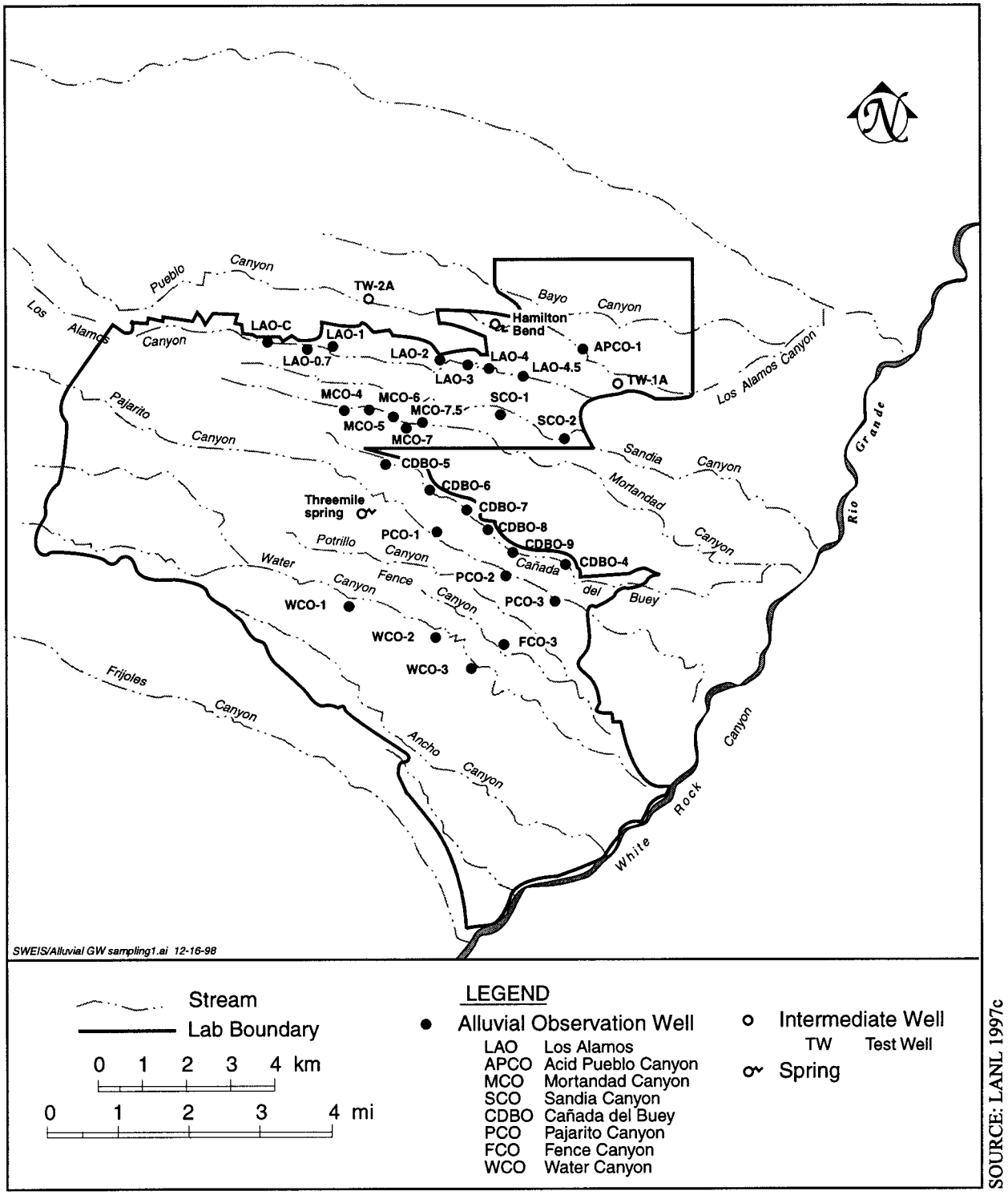
Groundwater monitoring is conducted within and near LANL. One of the objectives of LANL's groundwater monitoring program is to provide indications of the potential for human and environmental exposure from contaminated groundwater sources. Groundwater may accumulate contaminants from discharges to surface 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.*

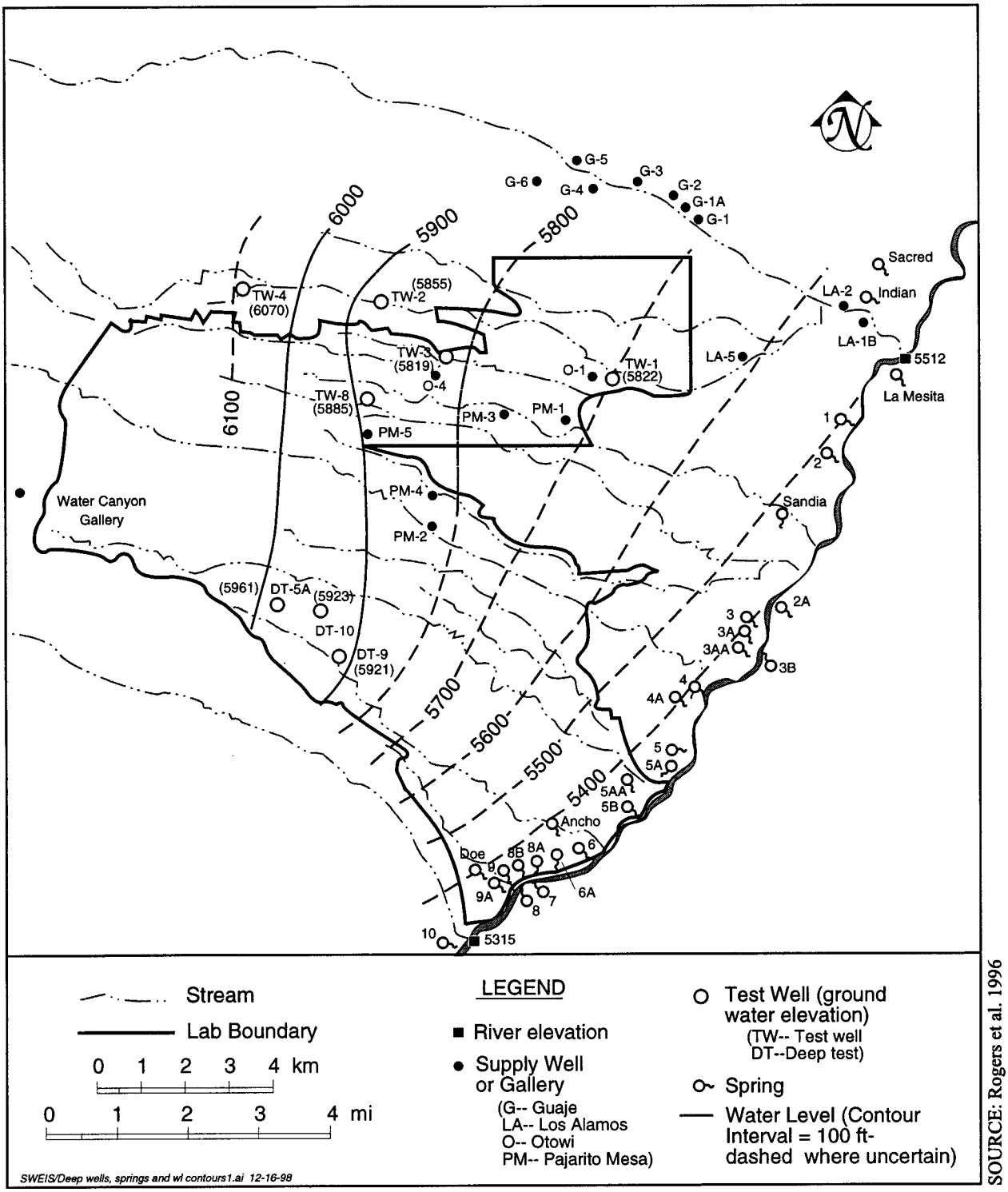


FIGURE 4.3.2.1–2.—*Regional Aquifer Test Wells, Supply Wells, Springs, and Water Level Contours*

(**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

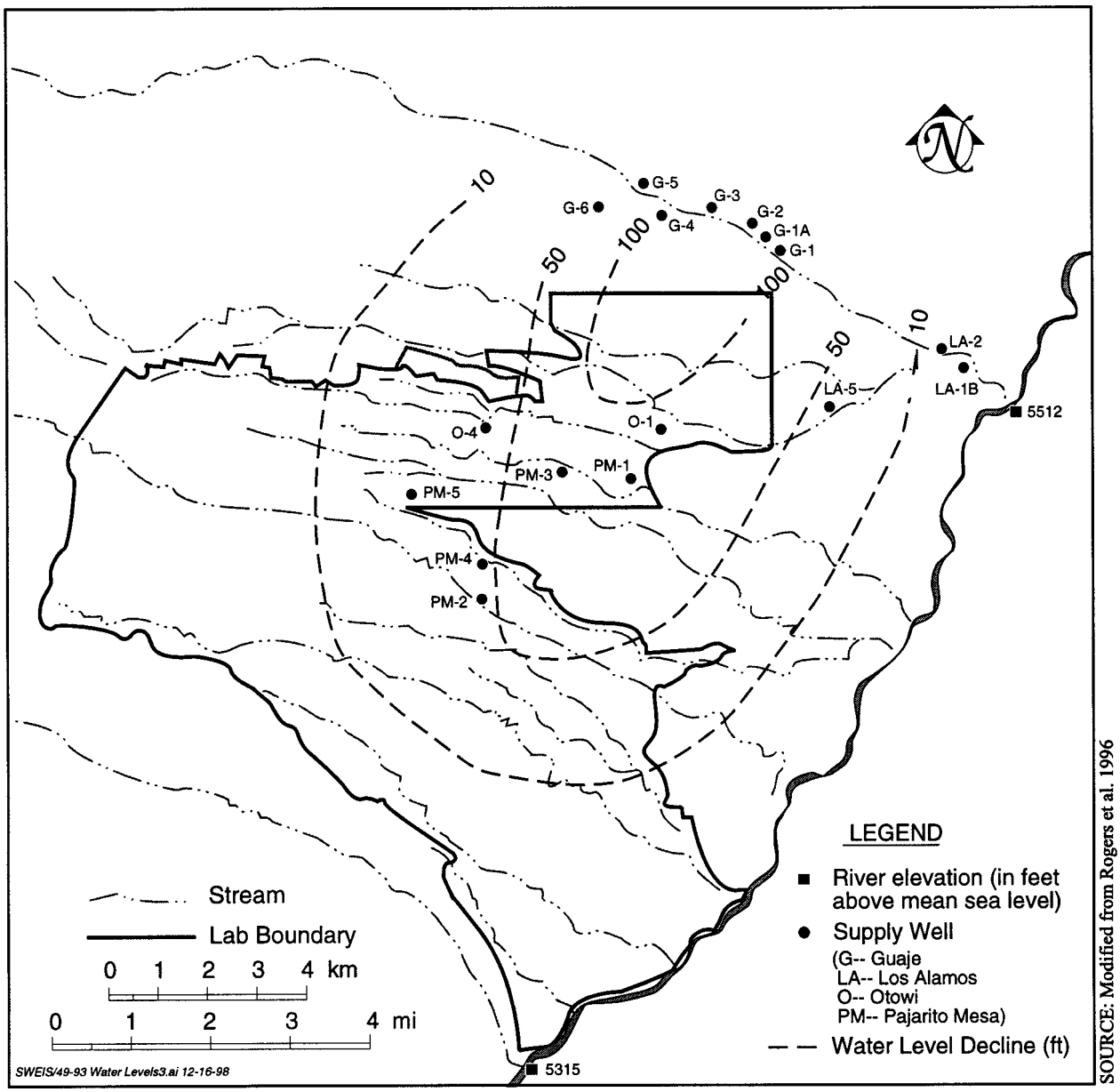


FIGURE 4.3.2.4–1.—*Approximate Aquifer Water Level Decline from 1949–1950 to 1993.*

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).

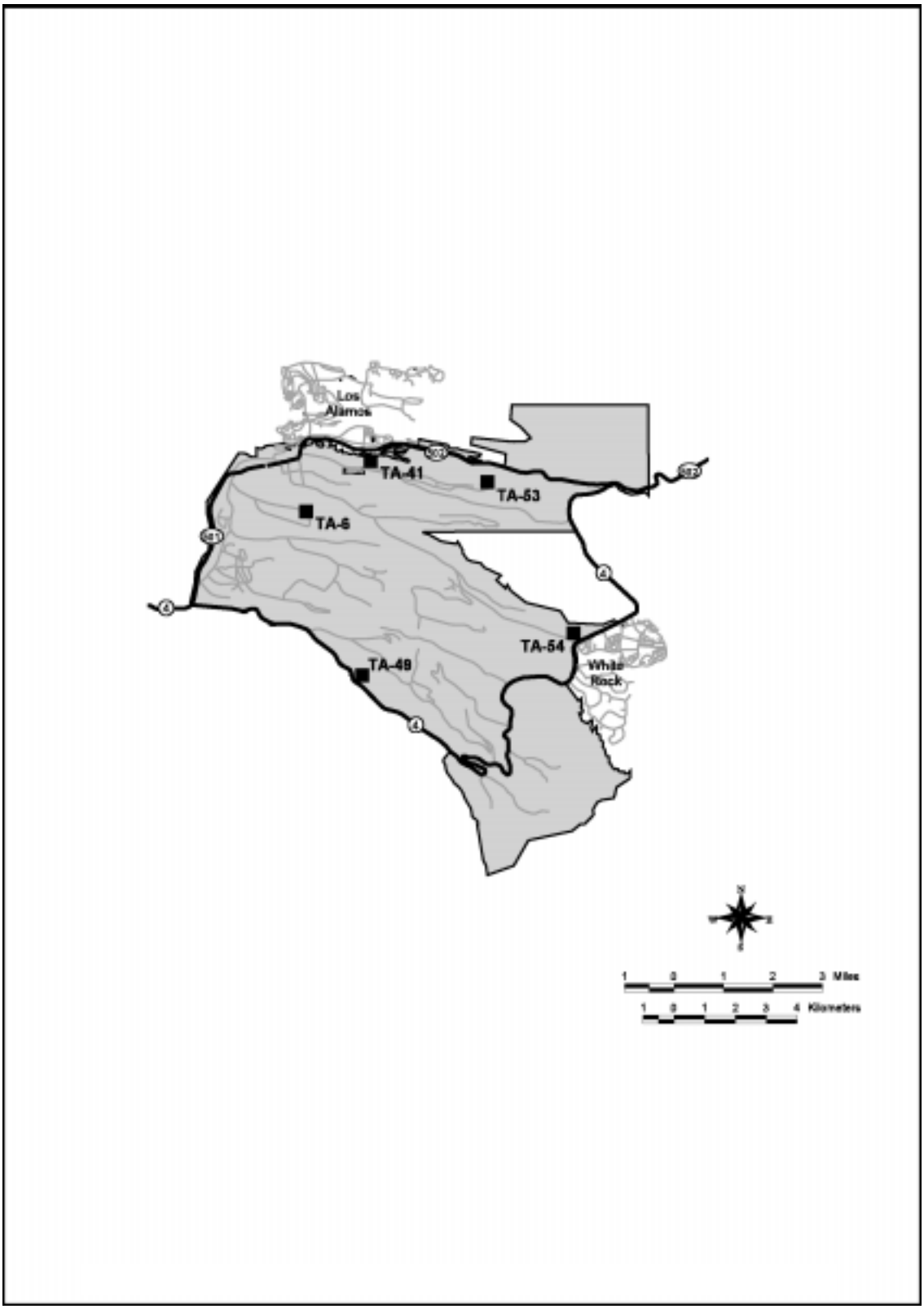
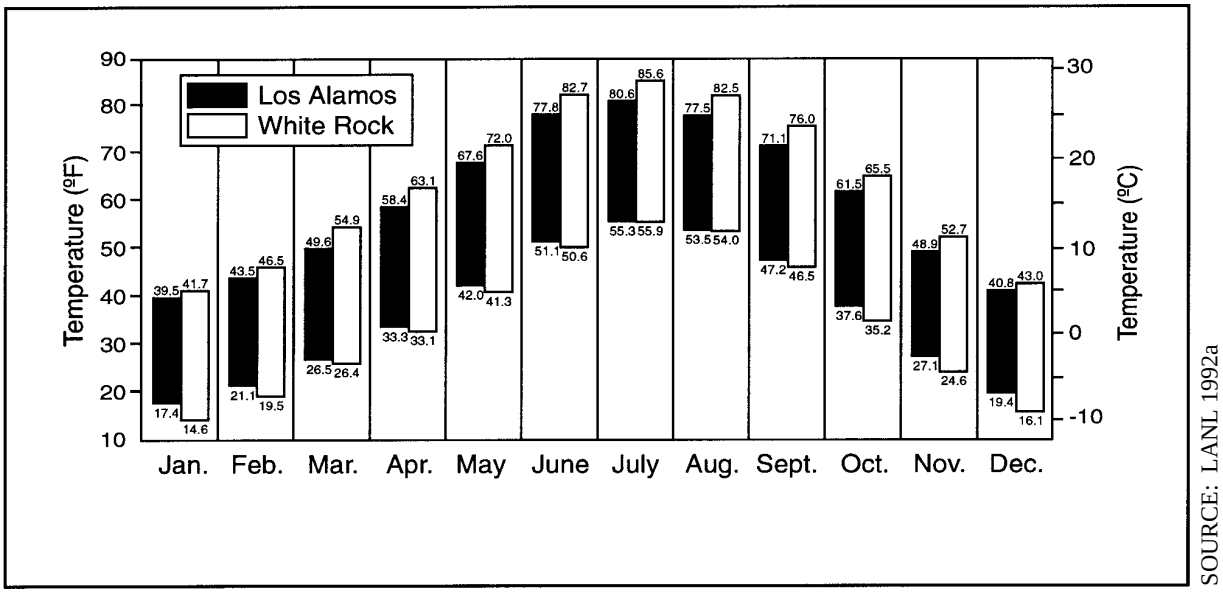
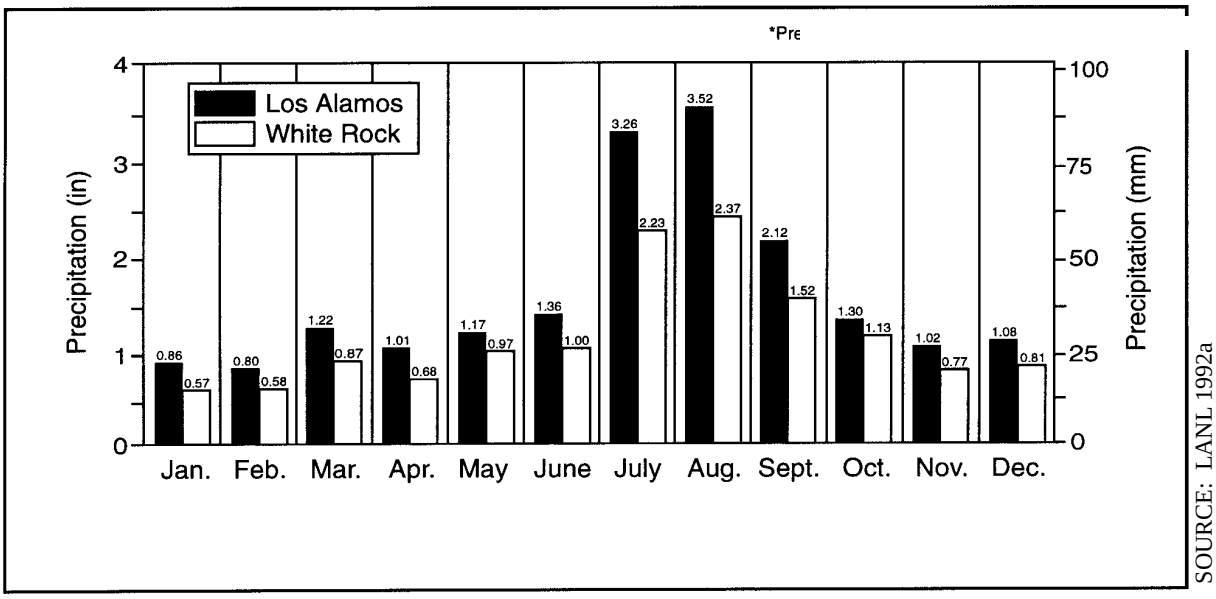


FIGURE 4.4.1–1.—*LANL Meteorological Stations.*



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

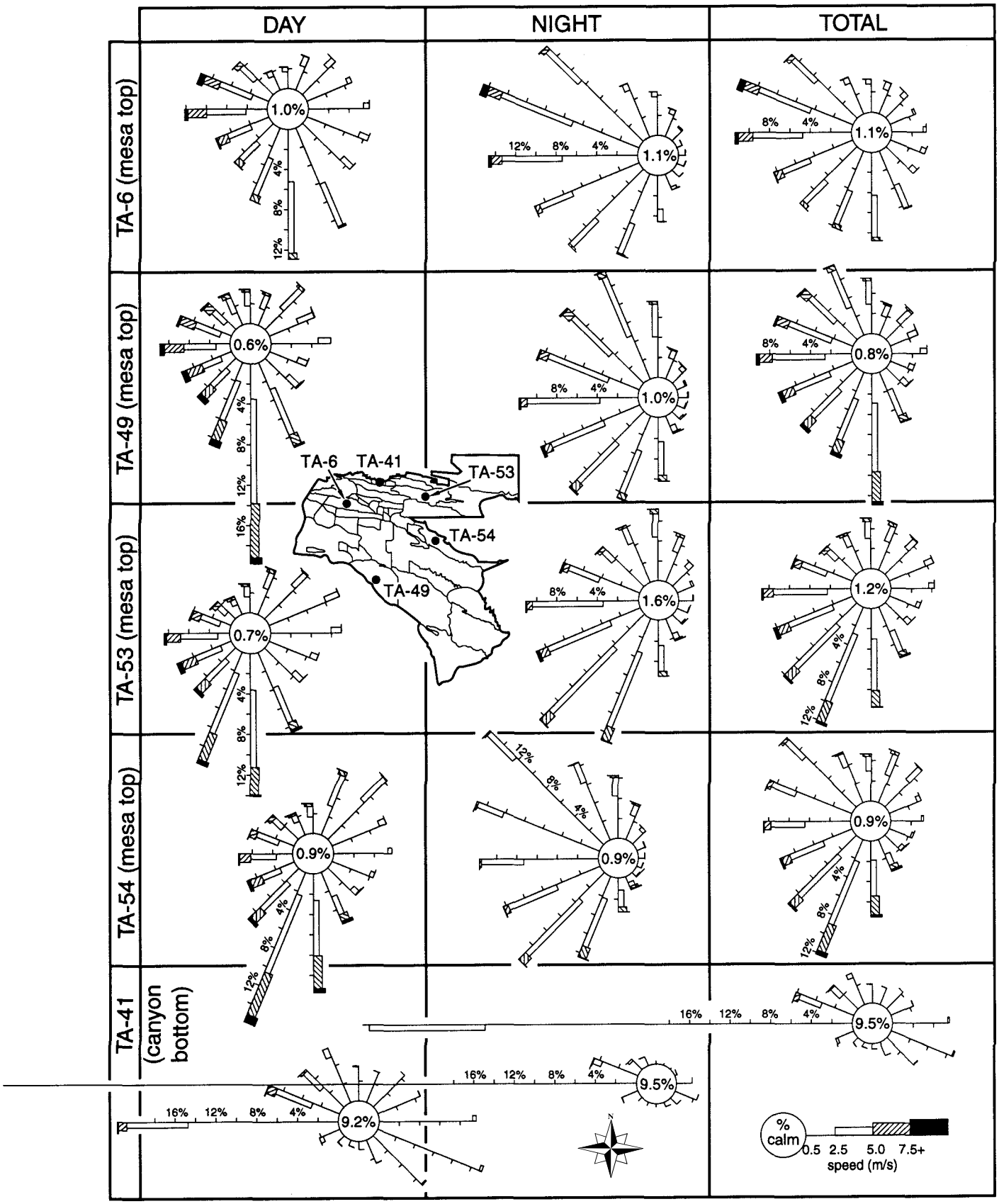


FIGURE 4.4.1.1–1.—*LANL Meteorological Stations with Associated Wind Rose Data.*

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

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

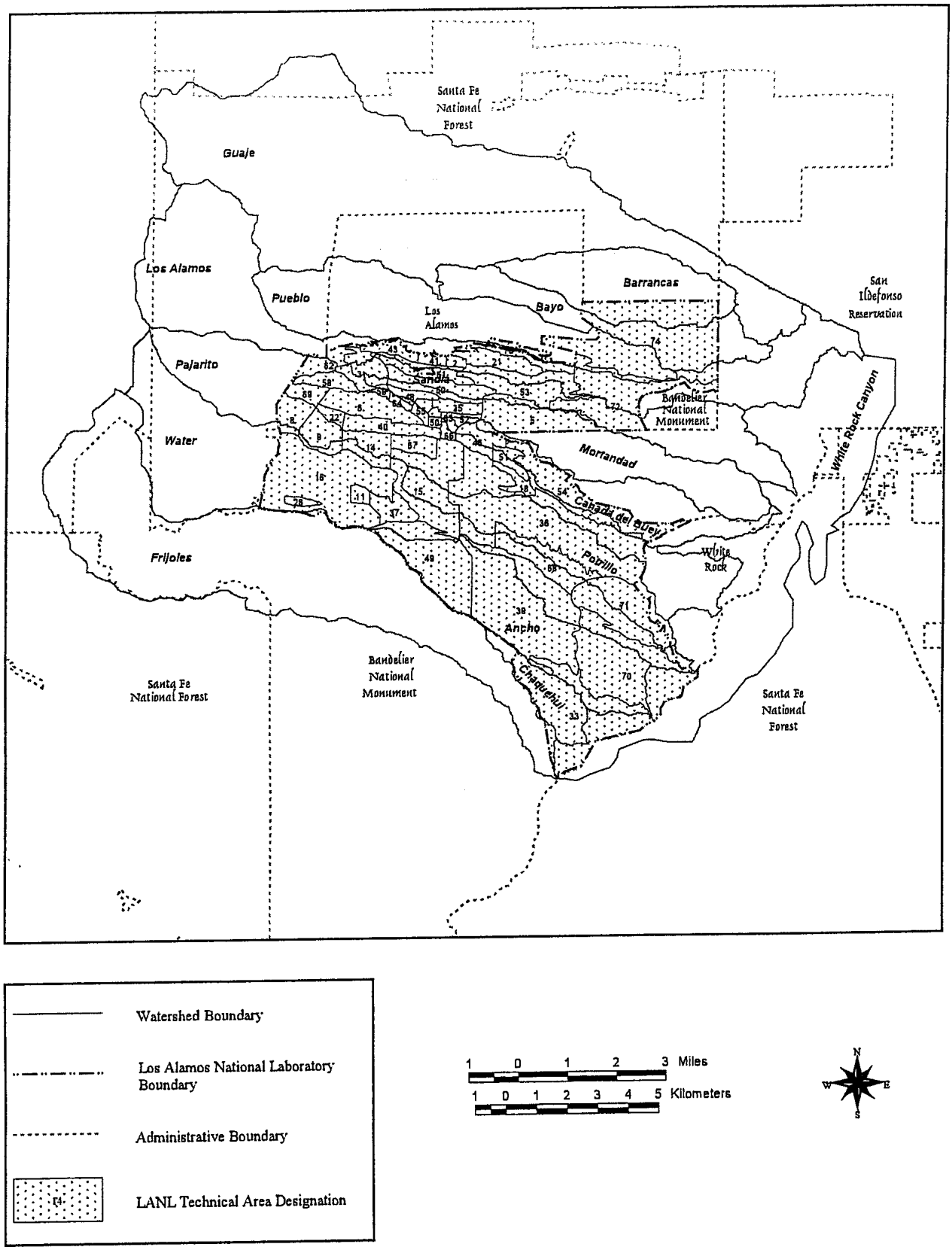


FIGURE 4.5.1.1–1.—*LANL Technical Areas and Watersheds.*

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

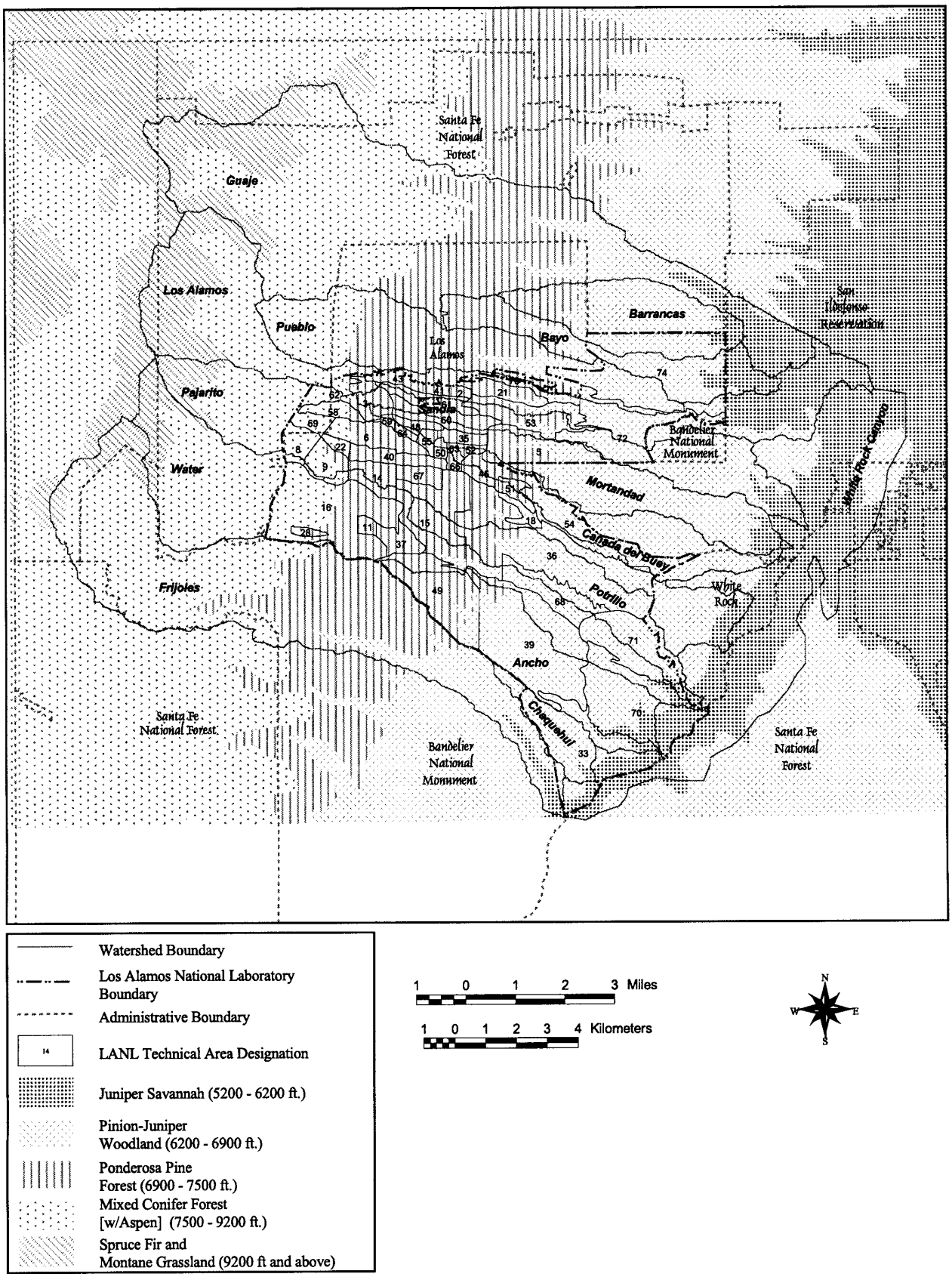


FIGURE 4.5.1.1–2.—*LANL Technical Areas and Watersheds with Vegetation Zones.*

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 VEGETATION 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 VEGETATION 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

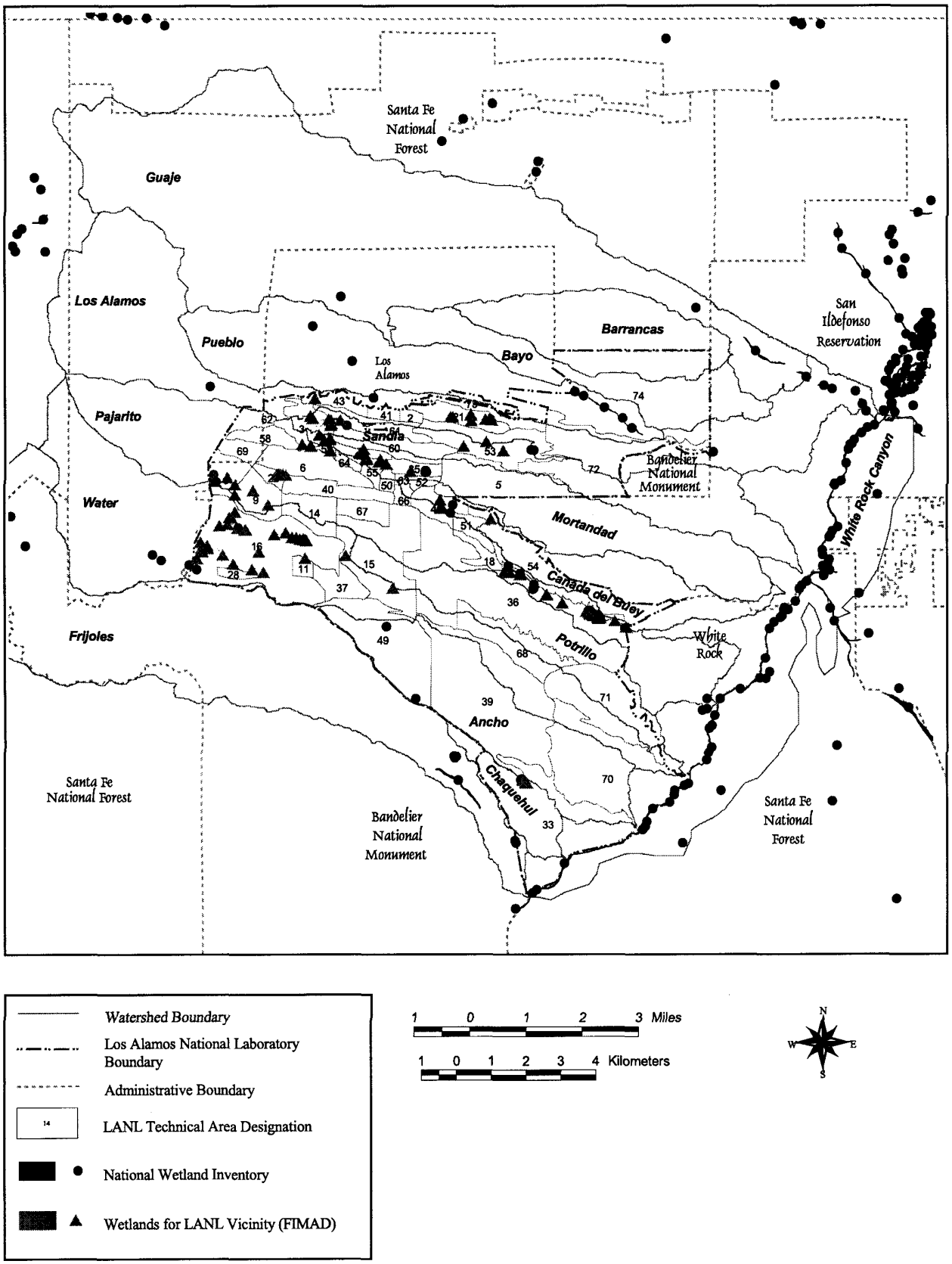


FIGURE 4.5.1.2–1.—*LANL Technical Areas and Watersheds with Wetland Locations.*

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.*

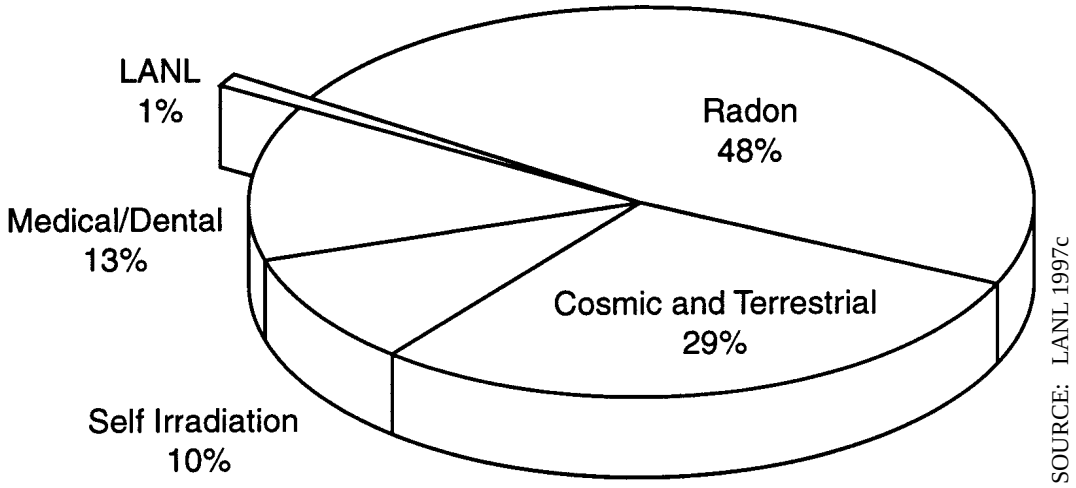


FIGURE 4.6.1.1–1.—*Total Contributions to 1996 Dose for LANL's Maximally Exposed Individual.*

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).

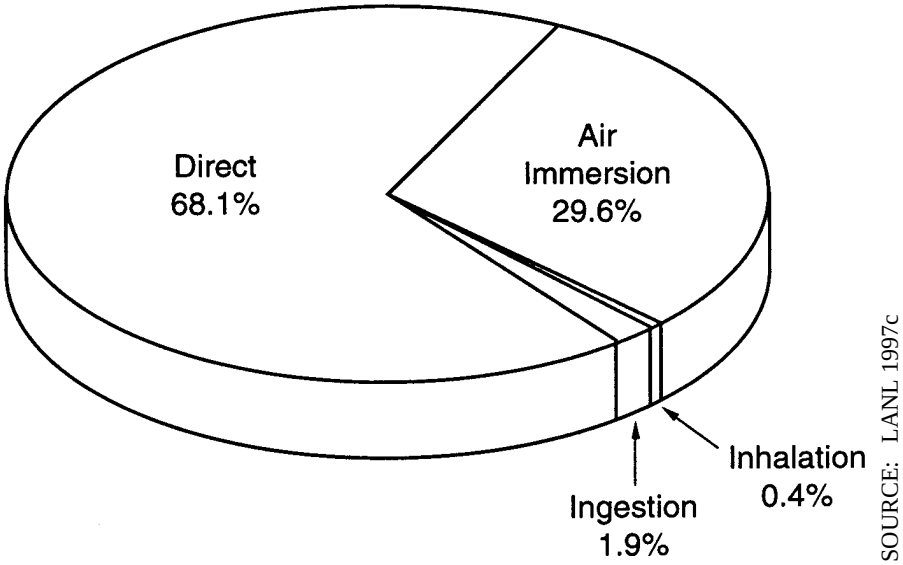


FIGURE 4.6.1.1–2.—*LANL's Contribution to Dose by Pathway for LANL's Maximally Exposed Individual.*

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 95th percentile value, and 2.9 millirem for the median dose, or 50th 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 95th 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.

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.

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

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.

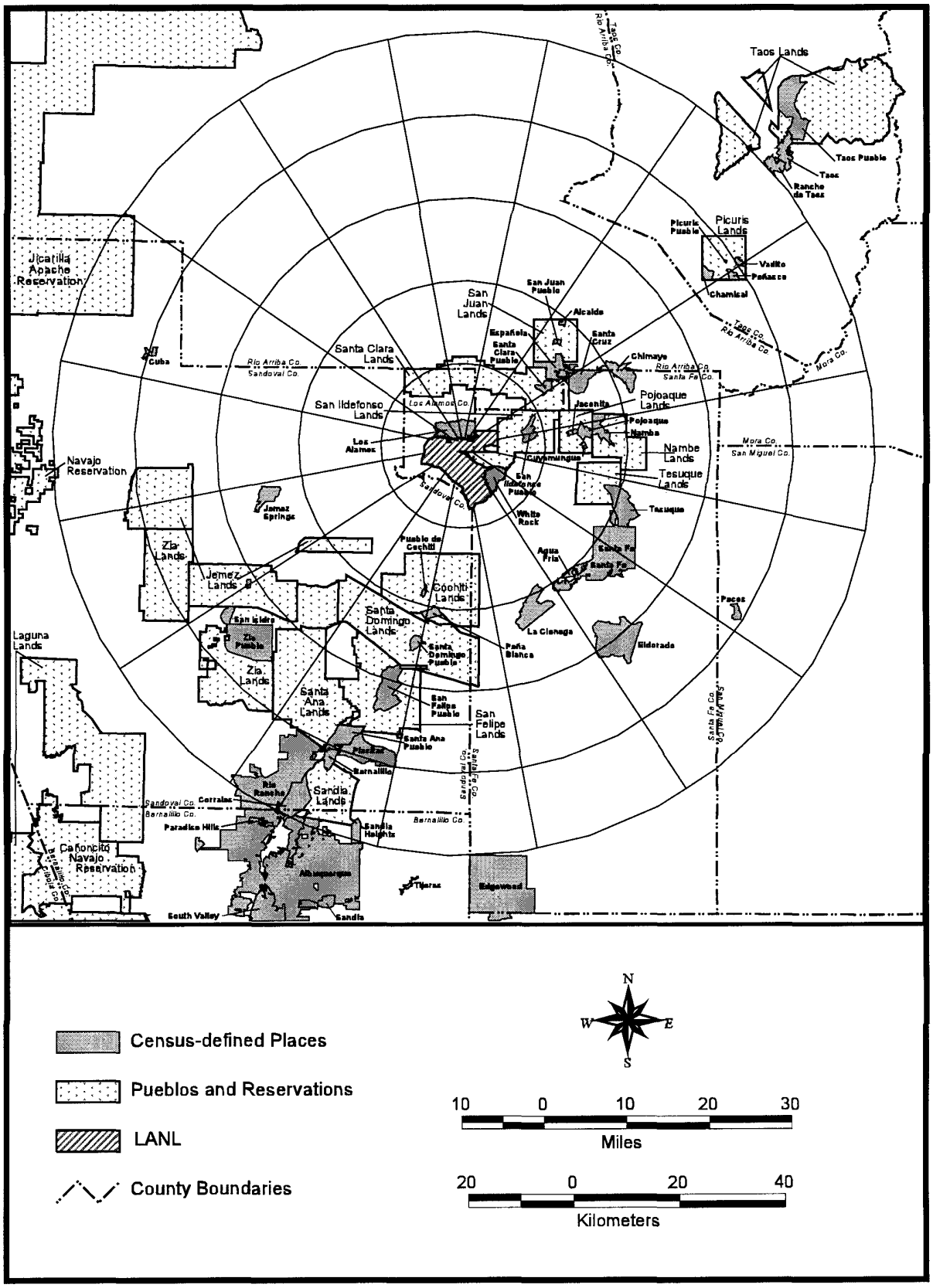


FIGURE 4.7.1–1.—*Sectors Used for Environmental Justice Analysis Within 50 Miles (80 Kilometers) of LANL.*

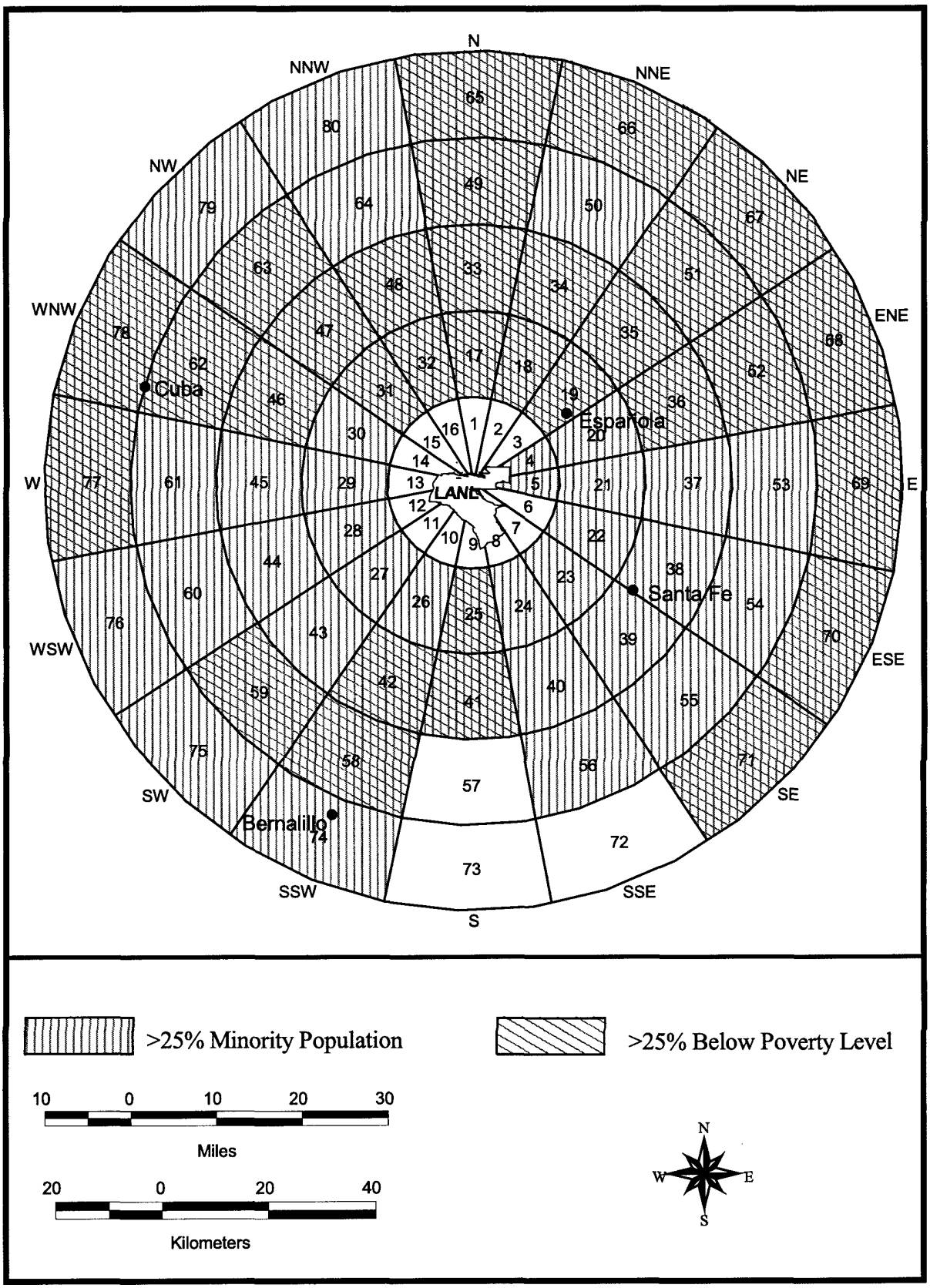


FIGURE 4.7.1–2.—*Sectors with Minority and Low-Income Populations Greater Than 25 Percent of the Sector Population.*

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

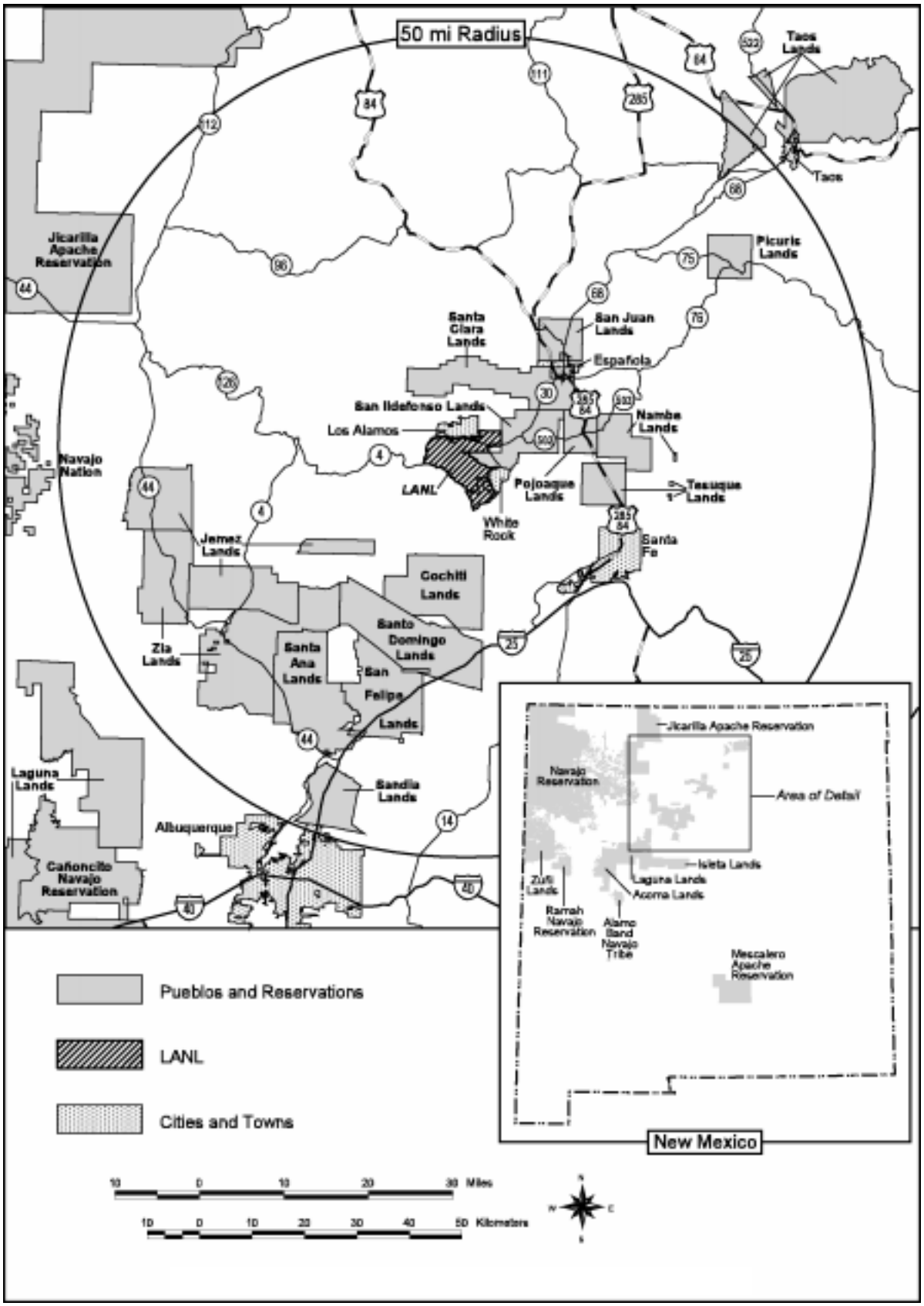


FIGURE 4.8–1.—*Pueblos and Reservations in the LANL Region*.

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

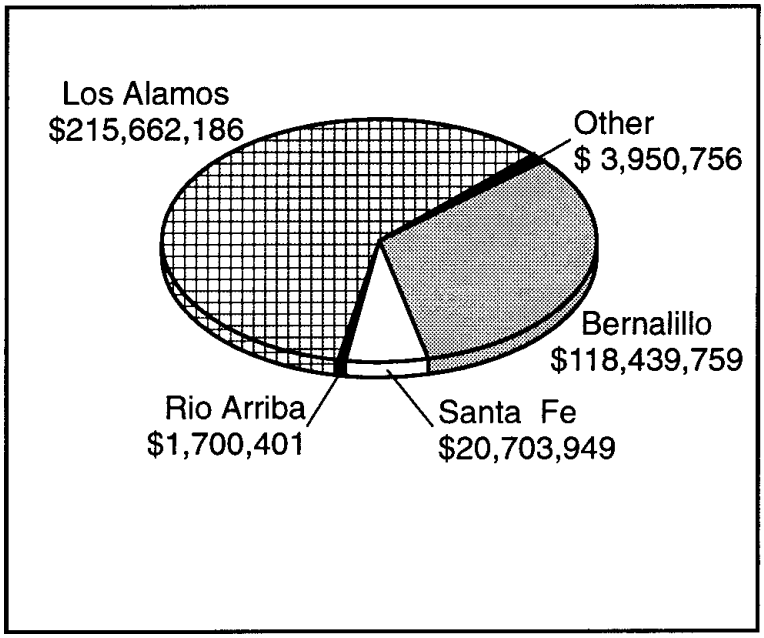


FIGURE 4.9.1.6–1.—*University of California Procurement in New Mexico Counties, Fiscal Year 1995*.

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 x 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 x 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

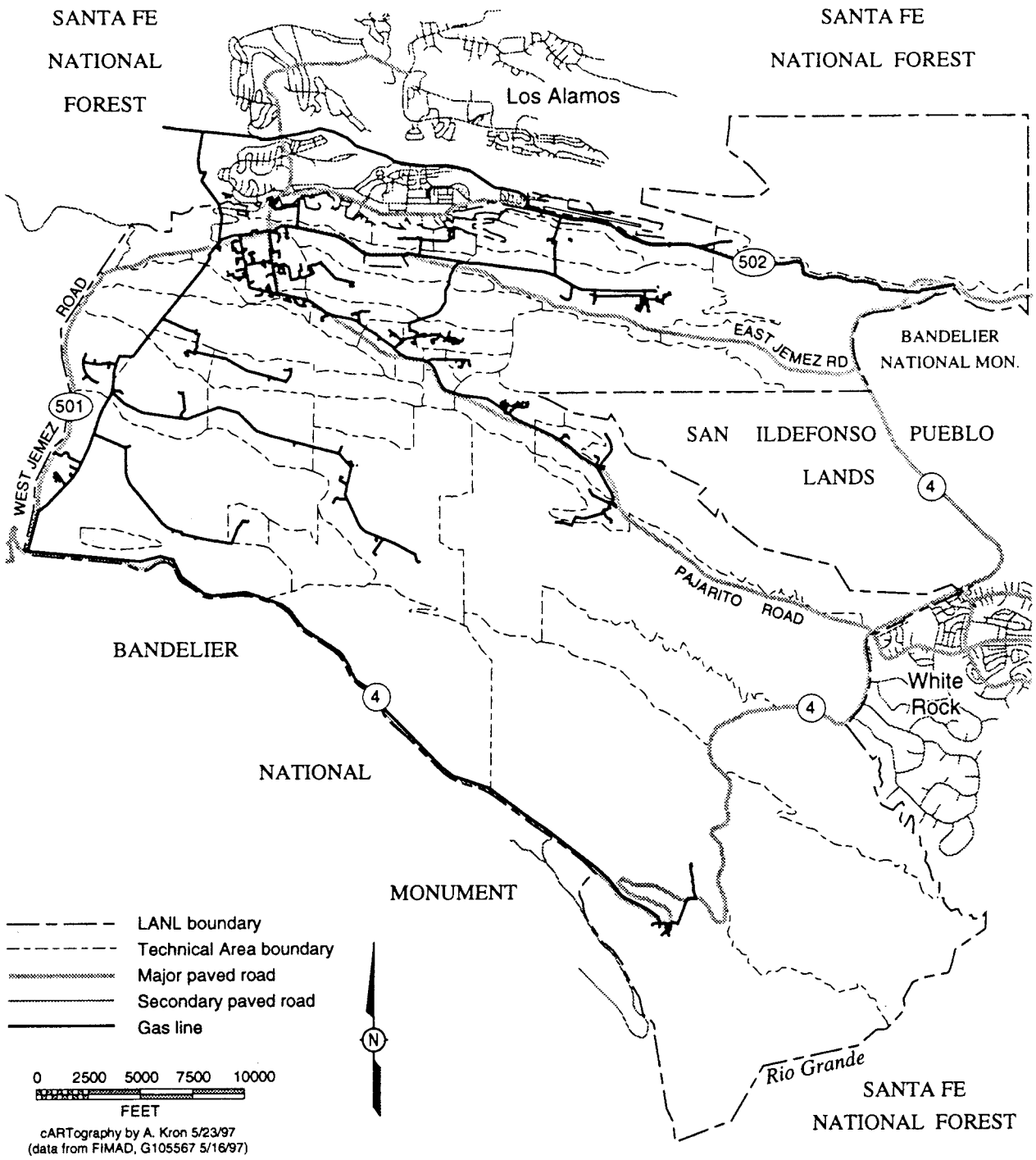


FIGURE 4.9.2.1–1.—*Los Alamos Area Natural Gas Distribution System.*

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

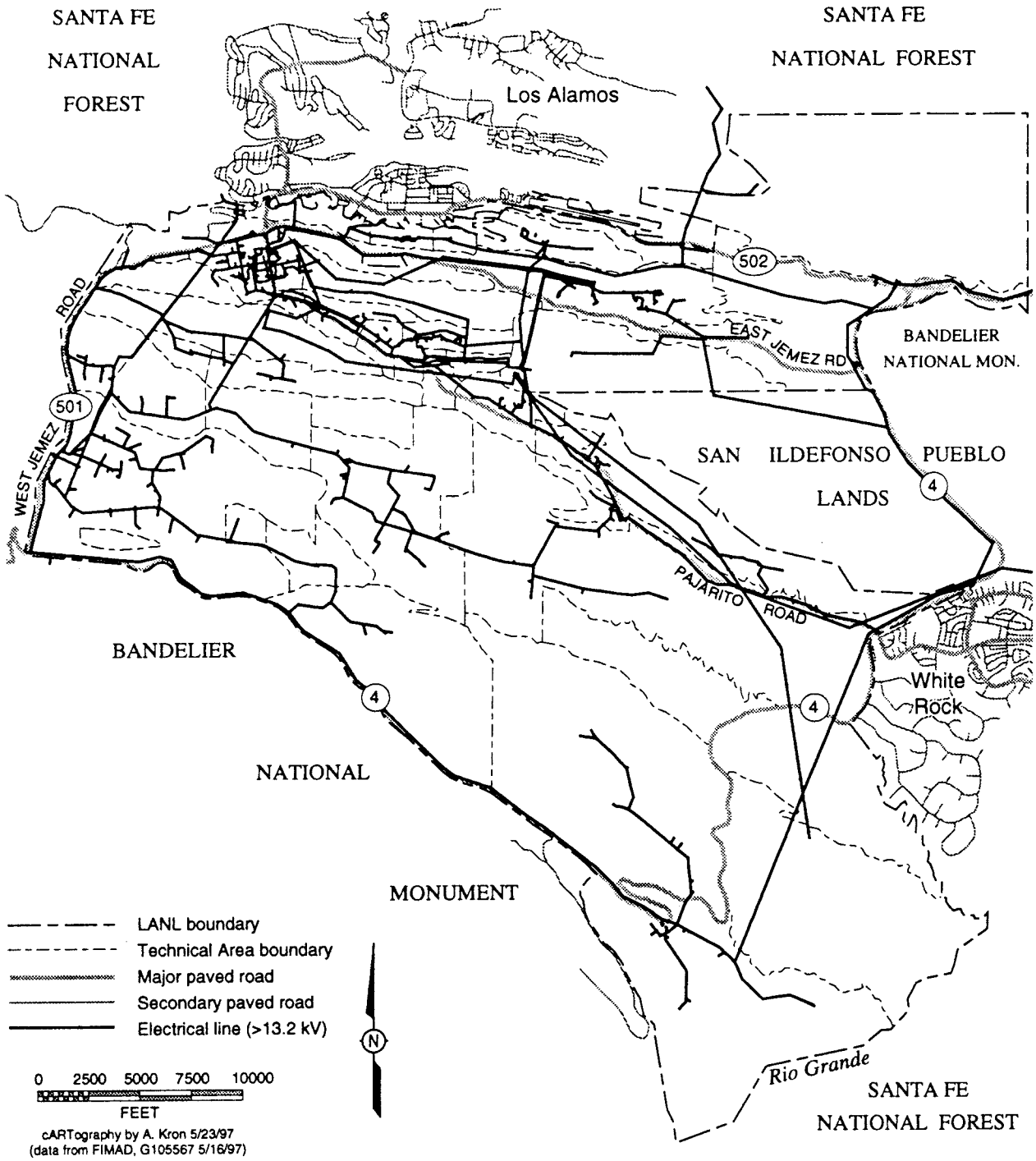


FIGURE 4.9.2.1–2.—*Los Alamos Area Electrical Power Distribution System.*

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

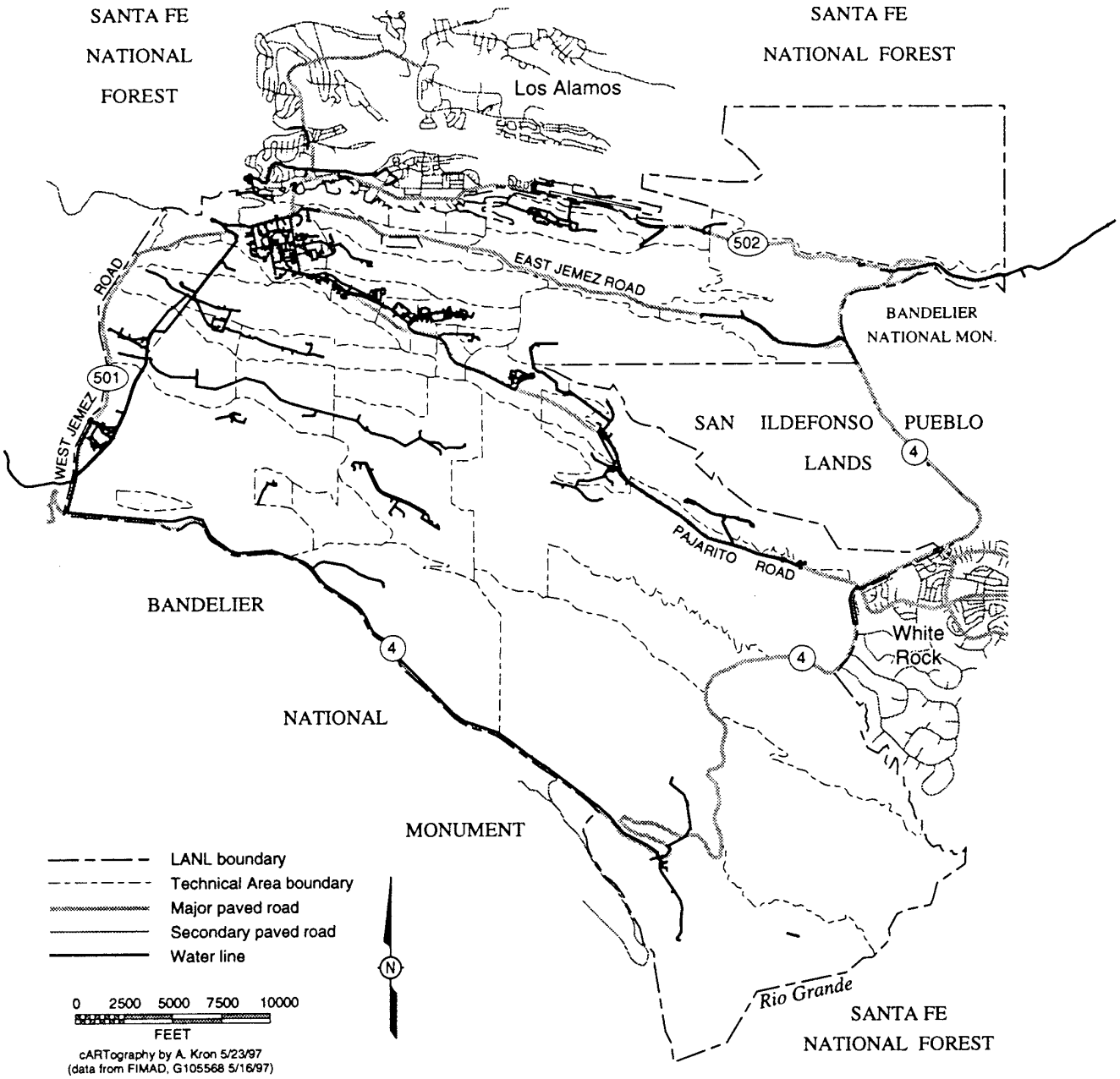


FIGURE 4.9.2.1–3.—*Los Alamos Area Water Distribution System.*

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.

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).

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

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

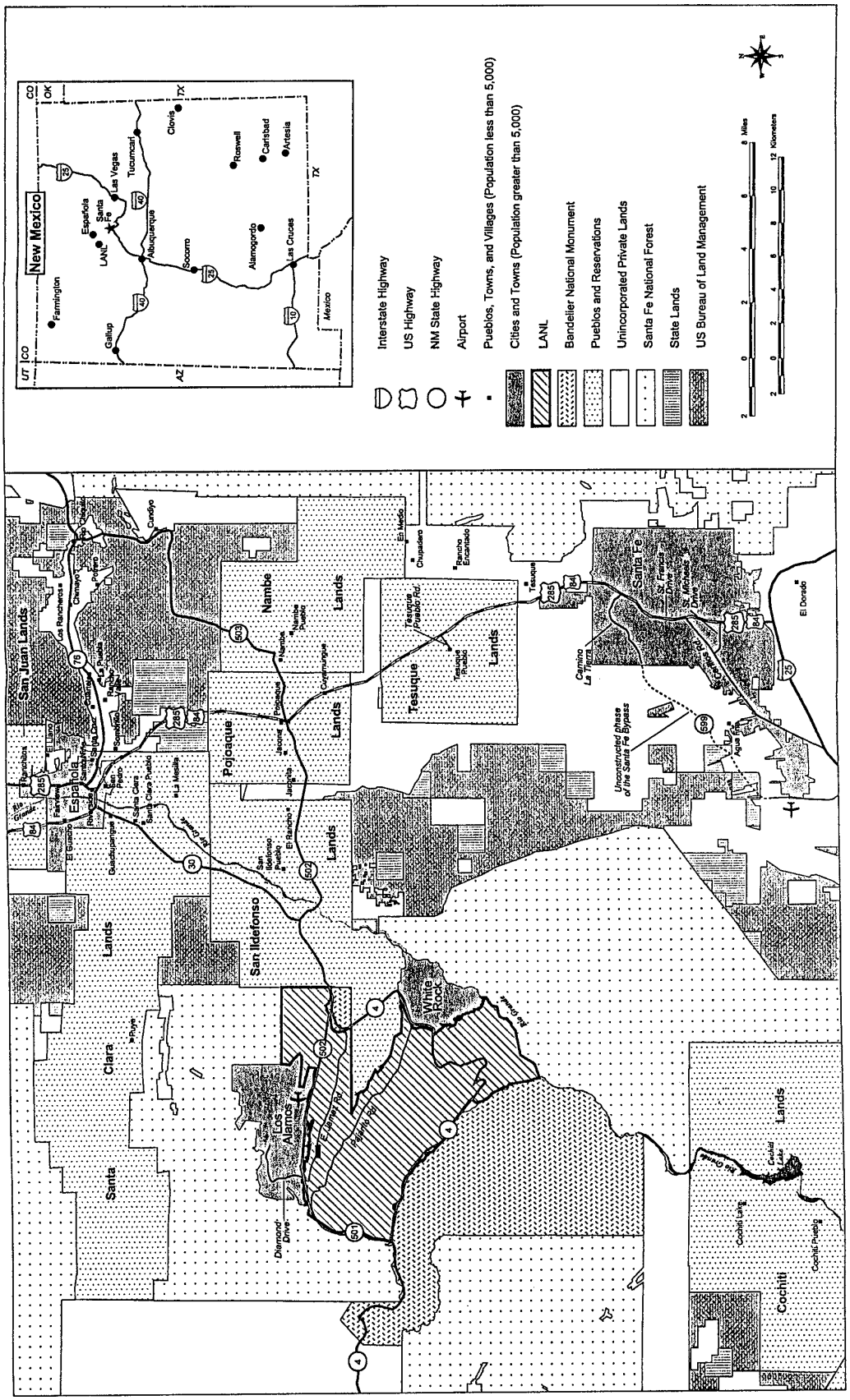


FIGURE 4.10.1–1.—*Regional Transportation Map.*

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

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