CHAPTER 4
AFFECTED ENVIRONMENT

4.0 AFFECTED ENVIRONMENT

This chapter describes the environmental setting and existing conditions associated with Los Alamos National Laboratory (LANL) and the U.S. Department of Energy's (DOE) operations at the site. This chapter also provides baseline descriptions for use in evaluating the environmental impacts of the reasonable alternatives identified in Chapter 3. Since existing conditions at the site were described in detail in the *Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico (1999 SWEIS)* (DOE 1999a), information presented in that document is incorporated here by reference. The present chapter summarizes each resource area for context, based on the *1999 SWEIS*, but emphasizes the differences that have occurred in the environmental setting since its publication. Resource areas addressed include land resources, geology and soils, water resources, air quality and noise, ecological resources, human health, cultural resources, socioeconomics and infrastructure, waste management and pollution prevention, transportation, environmental justice, and environmental restoration.

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 (see **Figure 4–1**). 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 are divided north to south by the Rio Grande. LANL is located on the Pajarito Plateau, which is cut by 13 steeply sloped and deeply eroded canyons that have formed isolated finger-like mesas running west to east. Most structures at LANL are located on these mesas (DOE 1999a).

DOE evaluated the environmental impacts within defined regions of influence for each resource area. The regions of influence are specific to the type of effect evaluated, and encompass geographic areas within which any significant impact would be expected to occur. For example, human health risks to the general public from exposure to airborne contaminant emissions were assessed for an area within an 80-kilometer (50-mile) radius of the proposed facilities. Economic effects were evaluated within a socioeconomic region of influence that include the county in which the site is located and nearby counties in which substantial portions of the site's workforce reside. Brief descriptions of the regions of influence are given in **Table 4–1**.

This chapter presents information about the LANL environment to serve as a baseline against which impacts can be compared. Depending on the resource area being discussed, data are presented in different ways. For resource areas with annually quantifiable metrics (such as effluent discharges or radiological doses) data for a number of years are shown, generally for the years since the issuance of the *1999 SWEIS* through 2005. For other resource areas (such as land use, noise, ecology, and cultural resources), the data are current as of the end of 2005 unless otherwise noted.

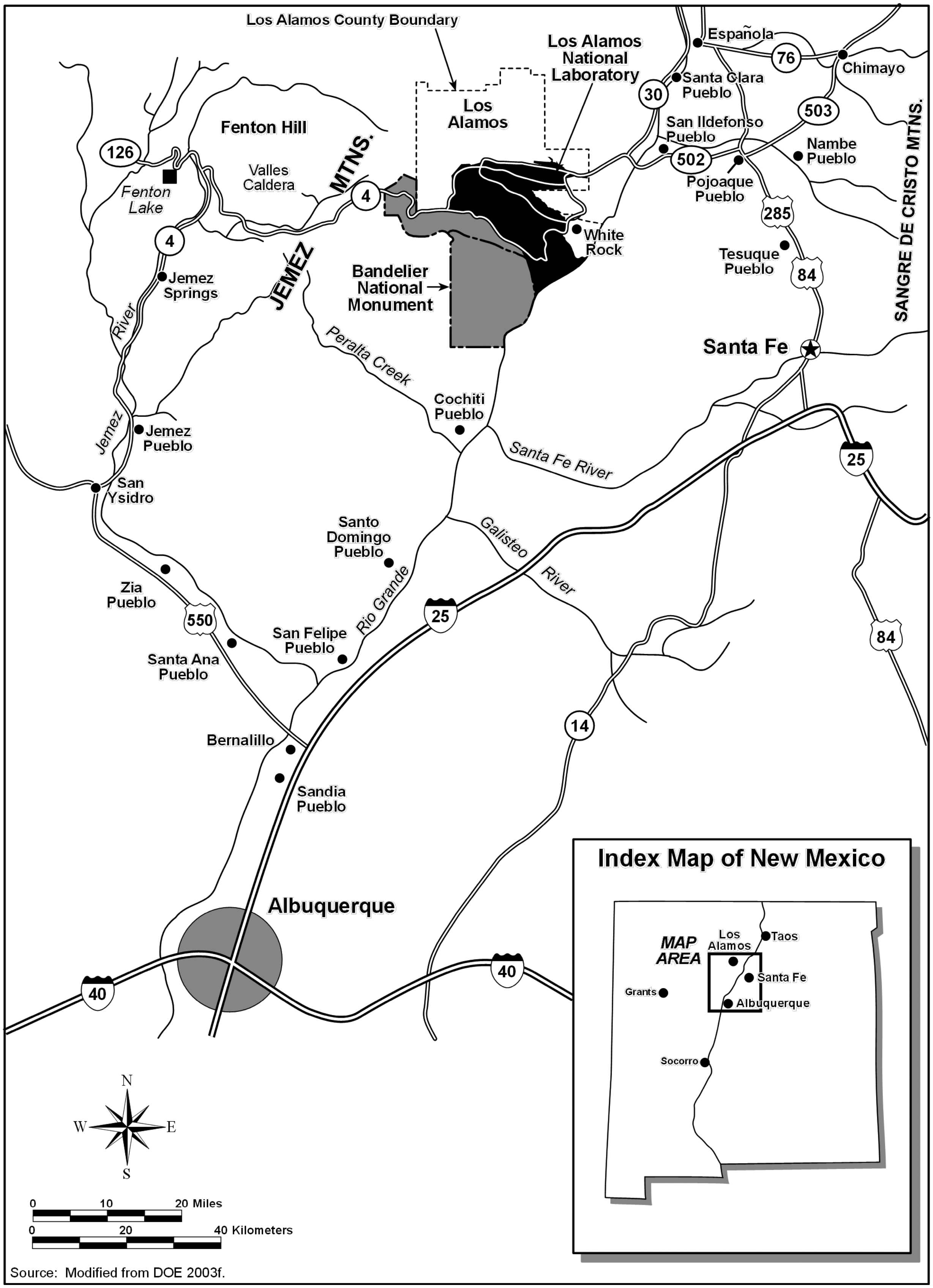


Figure 4–1 Location of Los Alamos National Laboratory

Table 4–1 General Regions of Influence for the Affected Environment

Environmental Resources	*Region of Influence*
Land Resources	The site and the areas immediately adjacent to the site
Geology and Soils	Geologic and soil resources within the site and nearby offsite areas
Water Resources	Surface water bodies and groundwater located onsite, on adjacent properties, and extending to northern New Mexico and southern Colorado
Air Quality and Noise	The site, nearby offsite areas within local air quality control regions, where significant air quality impacts may occur (air quality); the site, nearby offsite areas and access routes to the site (noise)
Ecological Resources	The site and adjacent areas
Human Health	The site and offsite areas within 50 miles of the site where worker and general population radiation, and hazardous chemical exposures may occur
Cultural Resources	The area within the site and adjacent to the site boundary
Socioeconomics and Infrastructure	The counties where approximately 90 percent of site employees reside (socioeconomics); the site (infrastructure)
Waste Management and Pollution Prevention	The site
Transportation	Local area and transportation corridors to offsite locations
Environmental Justice	The minority and low-income populations within 50 miles of the site
Environmental Restoration	The site

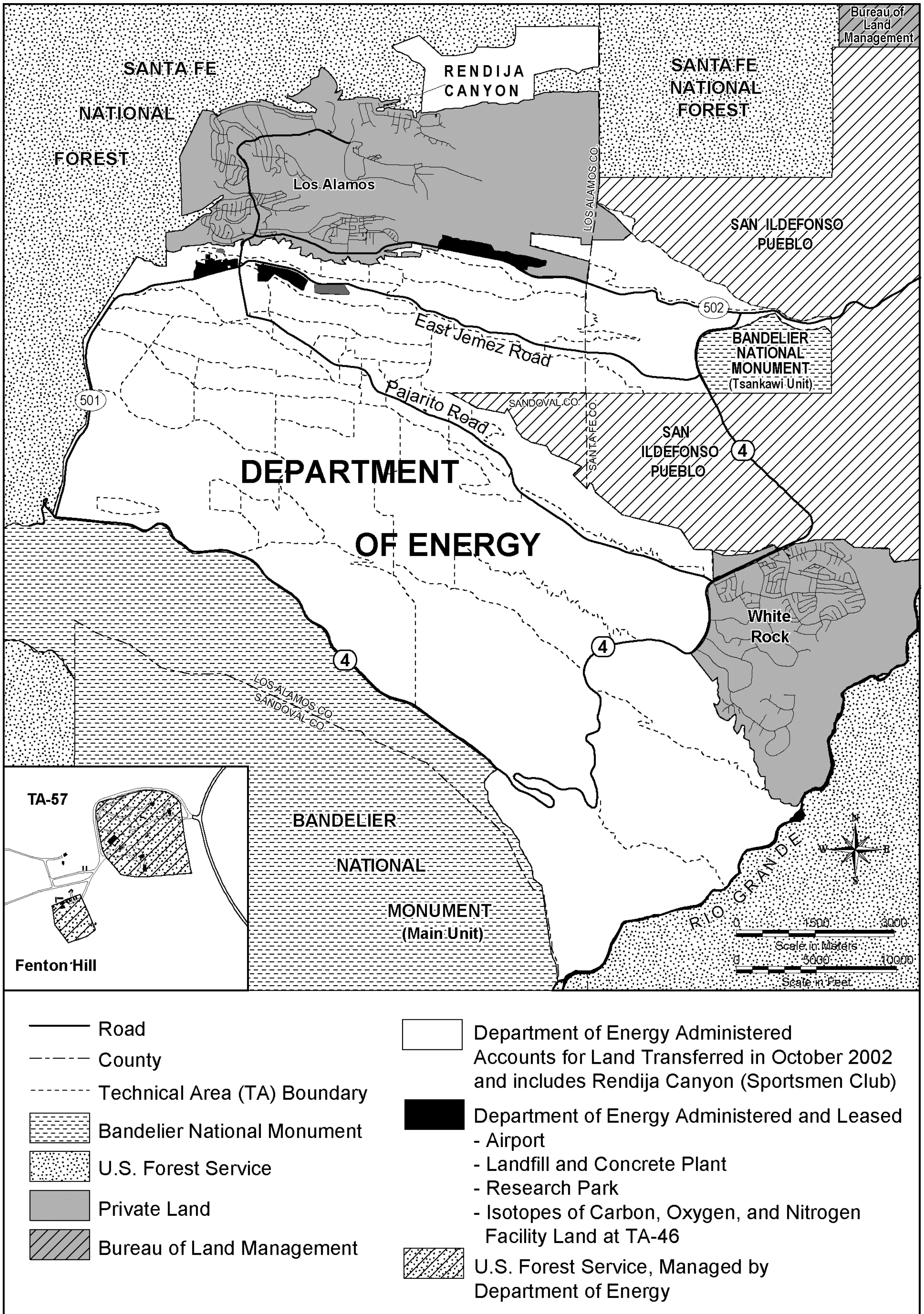
Note: To convert miles to kilometers, multiply by 1.6093.

4.1 Land Resources

Land resources include land use and visual resources. Land use is defined as the way land is developed and used in terms of the kinds of anthropogenic activities that occur (such as agriculture, residential areas, industrial areas) (EPA 2006a). Natural resource attributes and other environmental characteristics could make a site more suitable for some land uses than for others. Changes in land use may have both beneficial and adverse effects on other resources such as geological, atmospheric, ecological, and cultural resources. Visual resources are natural and manmade features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture. All four elements are present in every landscape (BLM 1986).

4.1.1 Land Use

Land use in the LANL region is linked to the economy of northern New Mexico, which depends heavily on tourism, recreation, agriculture, and Federal and state government employment for its economic base. Area communities generally are small and primarily support urban uses including residential, commercial, light industrial, and recreational facilities. The region also includes Native American communities; lands of the Pueblo of San Ildefonso share LANL's eastern border, and six other Pueblos are clustered nearby. Entities that serve as land stewards and determine land uses within the LANL region are depicted in **Figure 4–2**. These include DOE, the U.S. Forest Service, Native American pueblos, the U.S. National Park Service, the County of Los Alamos, private land-owners, the State of New Mexico, and the Bureau of Land Management.



Source: Modified from LANL 2004c.

Figure 4–2 Land Management and Ownership

LANL is divided into 48 technical areas (TAs) (not including TA-0, which comprises leased space within the Los Alamos townsite) covering 25,600 acres (10,360 hectares) with locations and spacing that reflect the site's historical development patterns, regional topography, and functional relationships (see **Figure 4–3**). In 1943, development of LANL began with the construction of a little more than 93,000 gross square feet (8,640 gross square meters) of space. At the end of 2005, LANL had approximately 8,600,000 gross square feet (800,000 gross square meters) of space. While the number of structures changes with time (due to frequent addition or removal of temporary structures and miscellaneous buildings), the current breakdown of structures is 952 permanent structures; 373 temporary structures (such as trailers, transportables, and transportainers); and 897 miscellaneous structures (such as sheds and utility structures) (LANL 2006a).

Only about 2,400,000 gross square feet (223,000 gross square meters) of space in 409 buildings are designed to house personnel in an office environment. In addition to onsite office space, 450,000 gross square feet (42,000 gross square meters) of space are leased within the Los Alamos townsite and White Rock community to provide workspace for an additional 1,683 people (LANL 2006a).

Overall, 43 percent of the structures at LANL (not including leased or rented space) are more than 40 years old, and 52 percent are more than 30 years old. A recent condition assessment survey determined the conditions of the facilities are: 23 percent in excellent condition; 17 percent in good; 11 percent in adequate; 17 percent in fair; 18 percent in poor; and 11 percent in failing condition. Condition assessment requirements cover a wide range of criteria and standards (such as safety, severity, and seismic) (LANL 2006a). This represents an improvement in both building age and condition since the *1999 SWEIS* was published.

Although developed areas play a vital role at LANL, they make up only a small part of the site. Most of the site is undeveloped to provide security, safety, and expansion possibilities for future mission-support requirements. There are no agricultural activities present on the LANL site, nor are there any prime farmlands in the vicinity. In 1977, DOE designated LANL as a National Environmental Research Park; in 1999, the White Rock Canyon Reserve was dedicated. The Reserve is about 1,000 acres (405 hectares) in size and is located on the southeast perimeter of LANL. It is managed jointly by DOE and the National Park Service for its significant ecological and cultural resources and research potential (DOE 2003d).

LANL is separated into the following internal land use categories: service and support, experimental science, high explosives research and development, high explosives testing, nuclear materials research and development, physical and technical support, public and corporate interface, reserve, theoretical and computational science, and waste management (see **Figure 4–4**) (LANL 2003h). Previously, a hazard-based system based on the most hazardous activity in each TA was used to characterize land use. Six land use categories were delineated under this system (DOE 1999a).

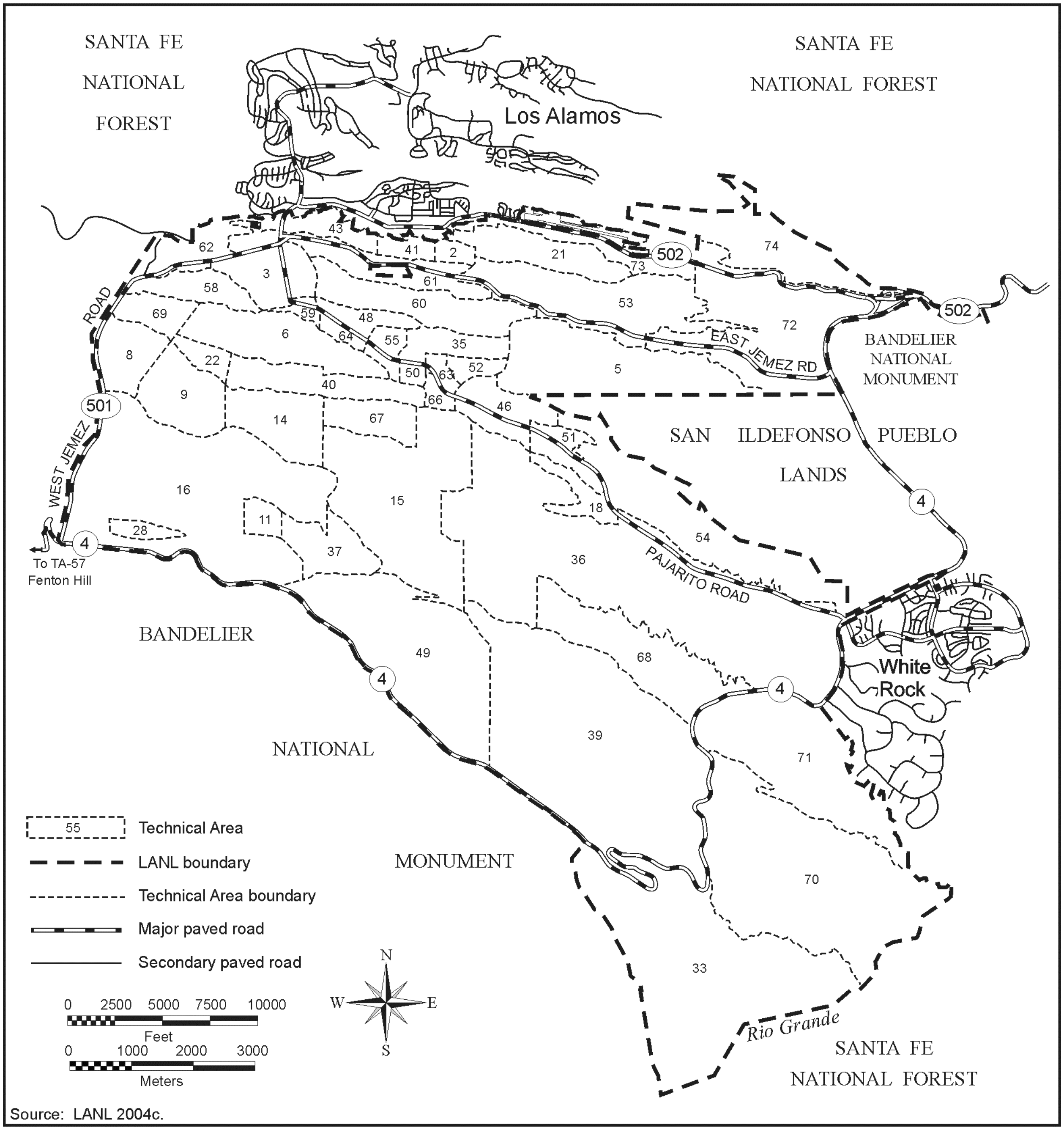
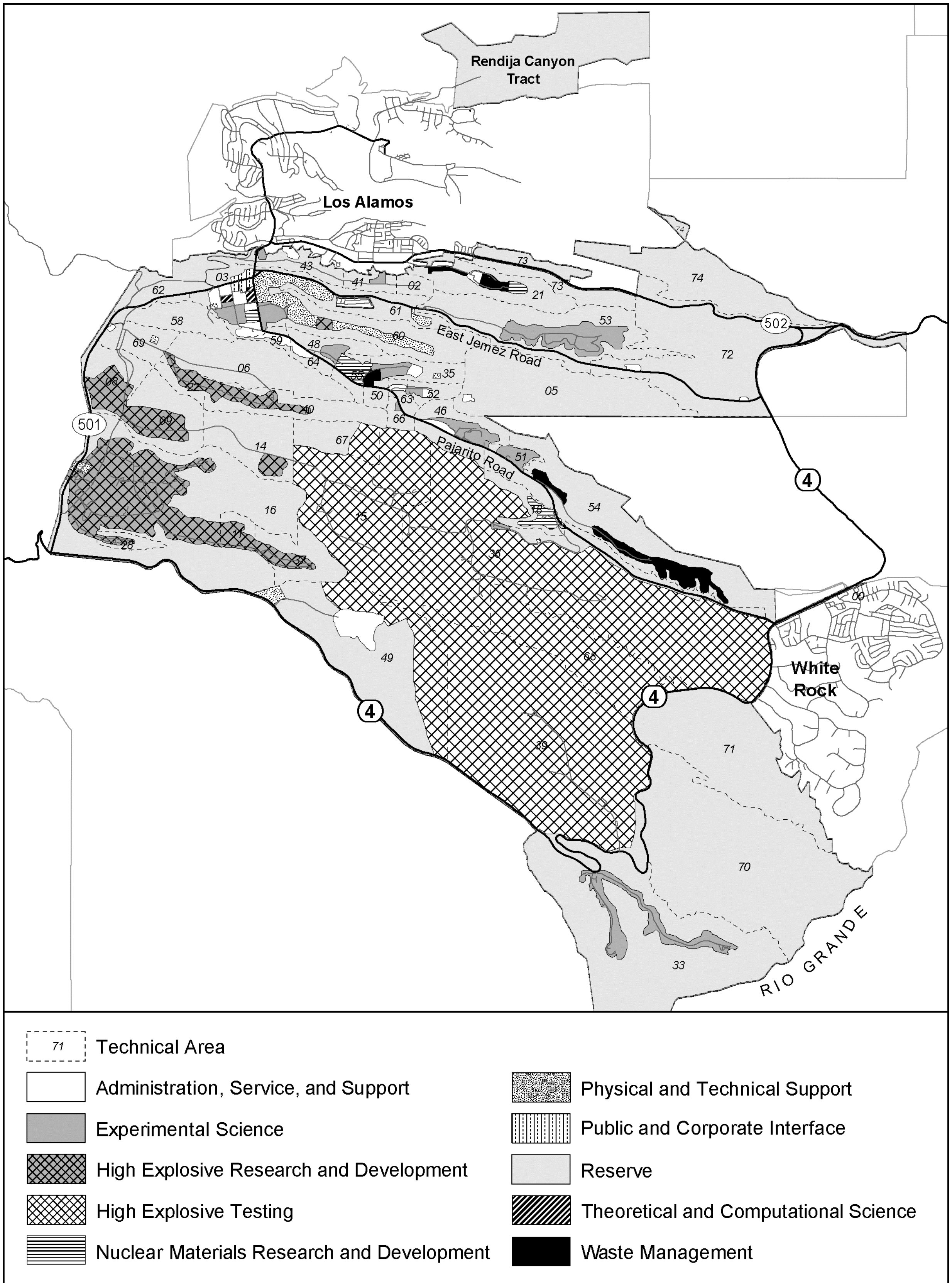


Figure 4–3 Technical Areas of Los Alamos National Laboratory



Source: LANL 2006a.

Figure 4–4 Los Alamos National Laboratory Site-Wide Land Use

The 10 land use categories noted above describe the activities at LANL and are defined below.

- *Administration, Service, and Support*—Administrative functions, nonprogrammatic technical expertise, support, and services for LANL management and employees.
- *Experimental Science*—Applied research and development activities tied to major programs.
- *High Explosives Research and Development*—Research and development of new explosive materials. This land is isolated for security and safety.
- *High Explosives Testing*—Large, isolated, exclusive-use areas required to maintain safety and environmental compliance during testing of newly developed explosive materials and new uses for existing materials. This land also includes exclusion and buffer areas.
- *Nuclear Materials Research and Development*—Isolated, secured areas for conducting research and development involving nuclear materials. This land use includes security and radiation hazard buffer zones. It does not include waste disposal sites.
- *Physical and Technical Support*—Includes roads, parking lots, and associated maintenance facilities; infrastructure such as communications and utilities; facility maintenance shops; and maintenance equipment storage. This land use generally is free from chemical, radiological, or explosives hazards.
- *Public and Corporate Interface*—Provides link with the general public and other outside entities conducting business at LANL, including technology transfer activities.
- *Reserve*—Areas that are not otherwise included in one of the previous categories. It may include environmental core and buffer areas, vacant land, and proposed land transfer areas.
- *Theoretical and Computational Science*—Interdisciplinary activities involving mathematical and computational research and related support activities.
- *Waste Management*—Provides for activities related to the handling, treatment, and disposal of all generated waste products, including solid, liquid, and hazardous materials (chemical, radiological, and explosive).

The U.S. Forest Service is responsible for the Santa Fe National Forest, which encompasses 1,567,181 acres (634,708 hectares) in the Sangre de Cristo Mountains to the east and Jemez Mountains to the west of LANL. The Santa Fe National Forest is managed for multiple-use activities such as logging, cattle grazing, hiking, fishing, hunting, camping, and skiing. The Dome Wilderness Area is located within the National Forest near Bandelier National Monument and provides habitat for a number of federally protected and state protected species (DOE 1999a).

The lands of the Pueblo of San Ildefonso are located immediately east of LANL (see Figure 4–2). Being neighbors of LANL, the Pueblo has a continuing interest in the site and its impact on Pueblo lands (see text box). The Pueblo owns or has use of 30,242 acres (12,239 hectares) of land, including approximately 2,106 acres (852 hectares) recently transferred from DOE (as described later in this subsection). Pueblo land use is a mixture of residential, gardening and farming, cattle grazing, hunting, fishing, food and medicinal plant gathering, and firewood production, along with general cultural and resource preservation. Most of the inhabitants of San Ildefonso live along New Mexico 30 (NM 30) in Santa Fe County, about 2.75 miles (4.43 kilometers) northeast of the LANL boundary. The Pueblo of San Ildefonso has not adopted a formal land use plan (DOE 1999a).

Pueblo of San Ildefonso Monitoring

The Pueblo of San Ildefonso, through various grants and in cooperation with DOE and the LANL operating contractor, conducts a program of environmental monitoring and assessment of associated risks. Under this program, the Pueblo environmental staff obtains environmental samples and monitors Pueblo of San Ildefonso lands. Environmental sampling and monitoring activities are conducted for air, water (both groundwater and surface water), sediment, biota, and radiation exposure. In addition, the Pueblo environmental staff tracks sampling sites on Pueblo of San Ildefonso lands that are used by Federal and state agencies, assists with maintaining these sites and collecting samples, and incorporates the sampling results from these external groups into their database. Monitoring activities are reported to DOE on a quarterly basis.

The National Park Service is responsible for Bandelier National Monument, which was established in 1916 and consists of two units: the Main Unit (32,937 acres [13,329 hectares]) located immediately south of LANL, and the Tsankawi Unit (790 acres [320 hectares]) located to the northeast of LANL. Only a small portion of the Main Unit has been developed for visitors; in fact, about 70 percent of this unit has been designated a Wilderness Area. The Tsankawi Unit is undeveloped. The number of visitors to the Monument peaked at 410,143 in 1997, but visitation declined to about 292,000 in 2002 (LANL 2006a).

Also located in the Los Alamos area is the Valles Caldera National Preserve, which was created in 2001 when the Federal Government purchased the 89,000-acre (36,017-hectare) Baca Ranch. It is located inside a volcanic caldera in the Jemez Mountain 20 miles (32.2 kilometers) west of Los Alamos. Studded with eruptive domes and featuring Redondo Peak (11,254 feet [3,430 meters]), this old ranch property is now being developed to explore a new way of managing public lands (Valles Caldera Trust 2005).

In 2004, Los Alamos County completed a preliminary draft of the *Los Alamos County Comprehensive Plan* (LAC 2004a). This action was part of the process to update its 1987 Plan (previously addressed in the *1999 SWEIS*). The county consists of approximately 69,860 acres (28,272 hectares), most of which is owned by the Federal Government. Only about 8,753 acres (3,542 hectares), including land that was conveyed from DOE (as described later in the subsection), are under county jurisdiction; much of this land is located within the Los Alamos townsite and White Rock. Among the nine land use types designated in the Plan, “Federal” applies to land owned by the Federal Government, primarily the U.S. Forest Service and DOE. Although the county government has no jurisdiction over these lands, it continues to seek the cooperation of each Federal entity to achieve the goals set forth in the *Los Alamos County Comprehensive Plan*. When Federal land changes ownership, the new owner is required to submit a proposed amendment to the general plan and an application for a zoning change before the land can be developed (LAC 2004a). In 1999, Los Alamos County leased 41.5 acres (16.8 hectares) of TA-3 from LANL for development of a research park; to date, about 5 acres (2 hectares) has been developed (LANL 2003h, 2006a).

On the evening of May 4, 2000, employees of the National Park Service ignited a prescribed burn in a forested area approximately 3.5 miles (2.2 kilometers) west of LANL. The area of the burn was within the boundaries of Bandelier National Monument along a mountain slope of the Cerro Grande (DOE 2000f). The next day, the fire was declared a wildfire. By the time it was fully contained on June 8, the fire had consumed approximately 43,000 acres (17,400 hectares), including about 7,700 acres (3,110 hectares) of LANL land (Balice, Bennett, and Wright 2004) (see **Figure 4–5**). Direct effects of the fire on LANL land use included impacts on numerous site structures. Of the 332 structures affected by the fire, 236 were impacted, 68 were damaged, and 28 were destroyed (ruined beyond economic repair). Fire mitigation work such as flood retention facilities affected about 50 acres (20.2 hectares) of undeveloped land (LANL 2003h). Following the fire, the Cerro Grande Rehabilitation Project was created to facilitate and implement post-fire remediation activities. A *Wildfire Hazard Reduction Project Plan* (LANL 2001b) was developed to identify and prioritize projects and to provide guidelines for project implementation. This Plan called for treatment, including thinning of existing stands, of up to 10,000 acres (4,047 hectares) to reduce wildfire hazard. Between 2001 and 2005, 9,150 acres (3,703 hectares) were treated. In addition, 800 acres (324 hectares) were thinned between 1997 and 1999 (LANL 2006g).

As a result of the passage of Public Law 105-119, Section 632, 10 tracts (consisting of a number of subtracts) comprising 4,078.4 acres (1,650.5 hectares) have been designated for conveyance from DOE to the Incorporated County of Los Alamos or the New Mexico Department of Transportation, as well as for transfer to the Department of the Interior to be held in trust for the Pueblo of San Ildefonso. The change in ownership was to be completed in 2007. However, as part of the fiscal year 2007 Defense Authorization Act, DOE has been given an additional 5 years to complete the conveyance and transfer process. To date, 2,258.87 acres (914.14 hectares) have been turned over, including all tracts to the Department of the Interior for the Pueblo of San Ildefonso (LANL 2006l, 2006a). This turnover reduced the size of LANL to about 25,600 acres (10,360 hectares).

Table 4–2 provides the acreage of each subtract, its status, and the designated recipient. **Figure 4–6** shows the location of the 10 tracts to be turned over. As noted above, under the draft *Los Alamos County Comprehensive Plan* (LAC 2004a), conveyed land falling under county jurisdiction would require a general plan amendment and zoning change before development would be permitted. Some of the lands proposed for transfer are in Santa Fe County and would require a similar planning process to establish land uses.

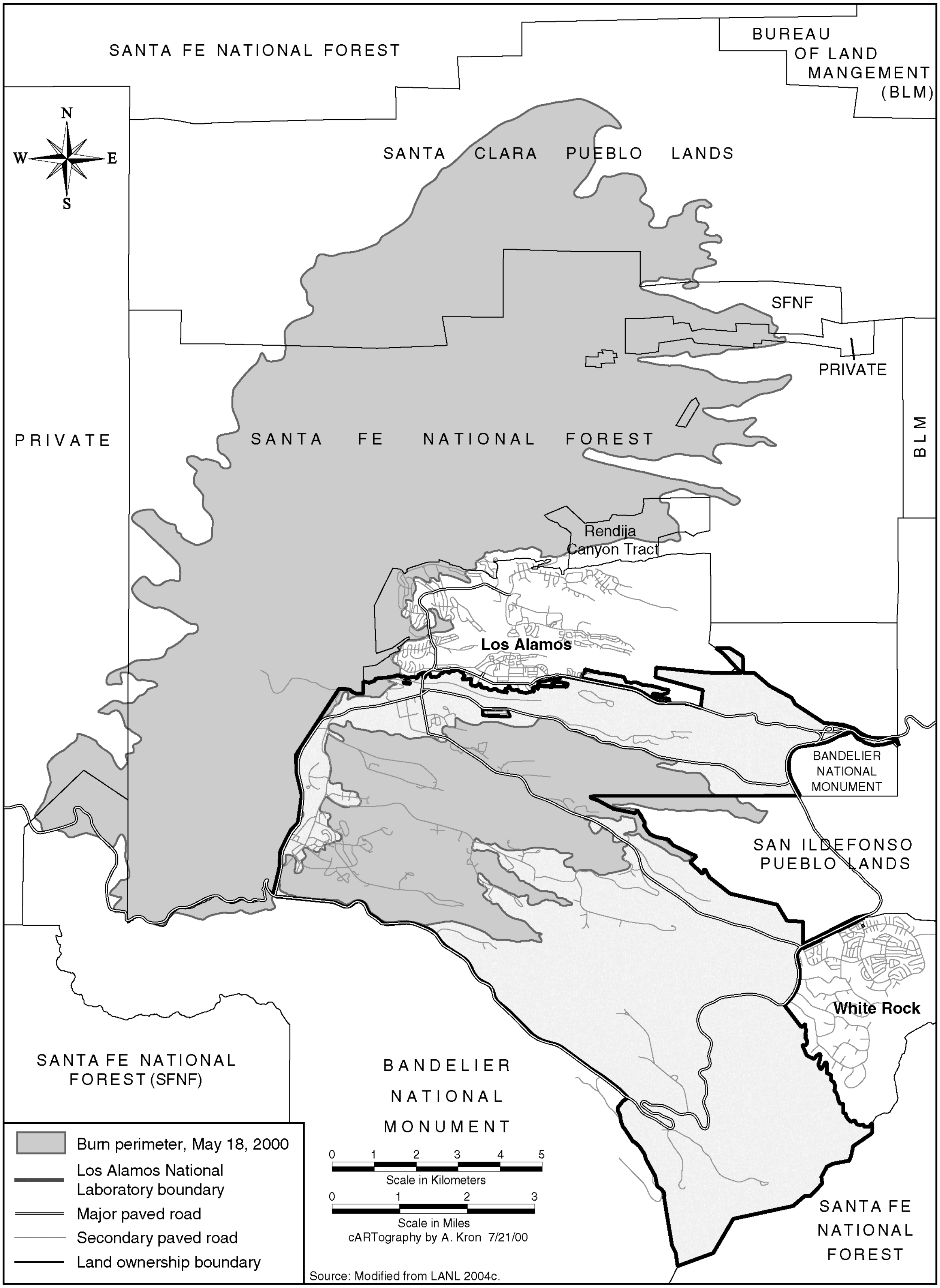
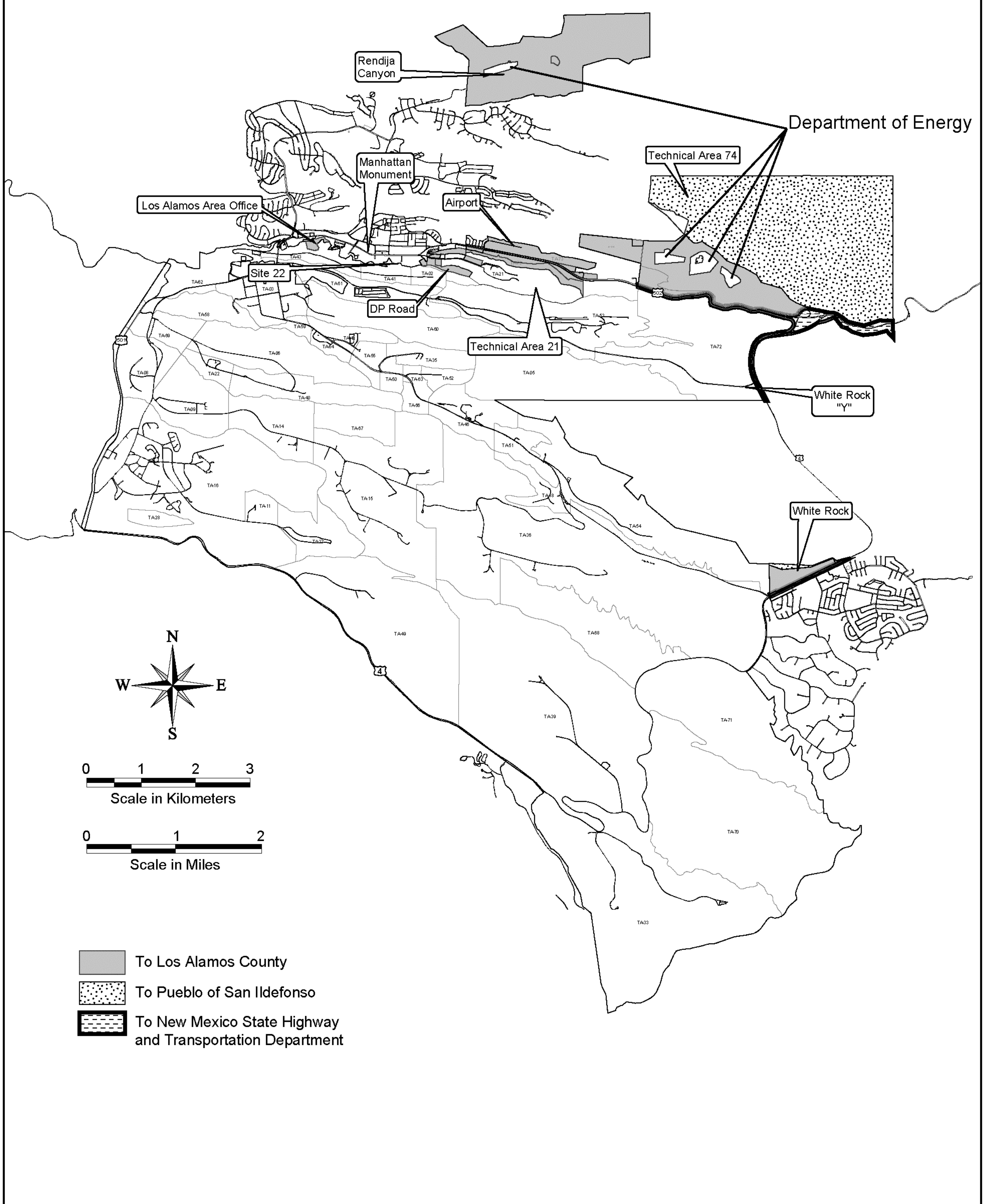


Figure 4–5 Cerro Grande Fire, Total Area Burned

Table 4–2 Lands Conveyed to Los Alamos County and Transferred to the Department of Interior to be Held in Trust for the Pueblo of San Ildefonso

Tract/Subtract				
Description	***Designator***	***Size (acres)***	***Status***	***Recipient***
Manhattan Monument	A-1	0.04	Conveyed	Los Alamos County
Site 22	A-2	0.17	Conveyed	Los Alamos County
Airport				
Airport-1 (East)	A-3	9.43	Conveyed	Los Alamos County
Airport-2 (North)	A-4	91.35	To be conveyed	Los Alamos County
Airport-3 (South)	A-5			
Unit 1	A-5-1	34.64	Conveyed	Los Alamos County
Unit 2	A-5-2	52.87	To be conveyed	Los Alamos County
Airport-4 (West)	A-6	4.18	Conveyed	Los Alamos County
Airport-5 (Central)	A-7	5.83	Conveyed	Los Alamos County
DP Road				
DP Road-1 (South)	A-8	25.01	To be conveyed	Los Alamos County
DP Road-2 (North)	A-9	4.25	Conveyed	Los Alamos County
DP Road-3 (East)	A-10	13.01	To be conveyed	Los Alamos County
DP Road-4 (West)	A-11	3.09	To be conveyed	Los Alamos County
Los Alamos Area Office				
Los Alamos Area Office-1 (East)	A-12	4.51	Conveyed	Los Alamos County
Los Alamos Area Office-2 (West)	A-13	8.81	To be conveyed	Los Alamos County
Rendija (A-14)	A-14	888.06	To be conveyed	Los Alamos County
Technical Area 21				
TA-21-1 (West)	A-15			
Unit 1	A-15-1	7.54	Conveyed	Los Alamos County
Unit 2	A-15-2	1.18	To be conveyed	Los Alamos County
Technical Area 74				
TA-74-1 (West)	A-17	5.52	Conveyed	Los Alamos County
TA-74-2 (South)	A-18	567.62	To be conveyed	Los Alamos County
TA-74-3 (North)	B-2	2,088.19	Transferred	Pueblo of San Ildefonso
TA-74-4 (Middle; Little Otowi)	B-3	3.36	Transferred	Pueblo of San Ildefonso
White Rock				
White Rock	C-1	15.39	To be conveyed	New Mexico Department of Transportation
White Rock-1	A-19	76.28	Conveyed	Los Alamos County
White Rock-2	B-1	14.93	Transferred	Pueblo of San Ildefonso
White Rock “Y”				
White Rock “Y”-1	C-2	104.0	To be conveyed	New Mexico Department of Transportation
White Rock “Y”-3	C-3	30.90	To be conveyed	New Mexico Department of Transportation
White Rock “Y”-4	C-4	18.24	To be conveyed	New Mexico Department of Transportation

Note: To convert acres to hectares, multiply by 0.40469.
Source: LANL 2006l.



Source: LANL 2006l.

Figure 4–6 Overview of Land Conveyance and Transfer

4.1.2 Visual Environment

The natural setting of the Los Alamos area is panoramic and scenic. The mountain landscape, unusual geology, varied plant communities, burned over areas, and archaeological heritage of the area create a diverse visual environment. The topography of northern New Mexico is rugged, especially in the vicinity of LANL. Mesa tops are cut by deep canyons, creating sharp angles in the land form. In some cases, slopes are nearly vertical. Often, little vegetation grows on these steep slopes, exposing the geology, with contrasting horizontal strata varying from bright reddish orange to almost white in color.

A variety of vegetation occurs in the region, the density and height of which may change over time and can affect the visibility of an area within the LANL viewshed. Generally, portions of LANL located along mesa tops at lower elevations 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, portions of LANL located at upper elevations toward the western boundary are more densely covered by tall mixed conifer forests that reduce the visibility of these areas (DOE 1999a).

The most obvious modern alteration of the natural landscape is development. Many buildings at LANL were built as temporary structures and present an austere, utilitarian appearance. Viewed from a distance at lower elevations, LANL is primarily distinguishable among the trees in the daytime by views of its water storage towers, emission stacks, the white-colored domes at TA-54, and occasional glimpses of older buildings. The new National Security Sciences Building is eight stories in height and is highly visible. The Los Alamos townsite appears mostly residential in character. The water storage towers are visible against the forested backdrop of the Jemez Mountains. At elevations above LANL, along the upper reaches of the Pajarito Plateau rim, the view of LANL is primarily of scattered buildings among heavily forested areas and the multi-storied buildings within TA-3. Similarly, the residential character of the Los Alamos townsite is predominately visible from higher elevation viewpoints (DOE 1999a, LANL 2004c).

At night, the lights of LANL, the 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, there are relatively few security light sources compared to the nearby communities; thus, at a distance, the distinction between LANL and the two communities is lost to the casual observer (DOE 1999a).

To decrease the impact of development, new structures generally have been designed and built in a more unified and modern style. Further, recent construction has been sensitive to the effects of taller, more visible structures on the visual environment. For example, radio towers and the Emergency Operations Center water tower, have been painted to blend with the background (LANL 2003h, DOE 2001).

Bandelier National Monument is an important area from which LANL may be viewed. Separate units of the Monument border LANL to the south (Main Unit) and northeast (Tsankawi Unit) (see Figure 4–2). Views from the Main Unit along NM 4 are of a generally natural landscape, although there are instances where LANL structures are visible. These include miscellaneous buildings and infrastructure located in TA-33, several facilities and infrastructure associated with

TA-49, and TA-16 facilities located east of NM 501 near where it meets NM 4. Visible near Bandelier's main entrance are a water tower and a National Radioastronomy Observatory Very Long Range Array telescope, both located within TA-33. Panoramic views of LANL and the Los Alamos townsite are available from higher elevations of the western portion of the Main Unit. Views from the Tsankawi Unit include the temporary truck inspection station and some of the taller structures found within LANL and the Los Alamos townsite.

Views from various locations in Los Alamos County and its immediate surroundings were altered by the Cerro Grande Fire of 2000. Although the visual environment is still diverse, interesting, and panoramic, both summer and winter vistas were severely affected by the fire. For example, rocky outcrops forming the mountains are now more visible through the burned forest areas than in the past, and the eastern slopes of the Jemez Mountains present a mosaic of burned and unburned areas. While many LANL facilities generally are screened from view, some developed areas that were previously screened by vegetation are now more visible to passing traffic (DOE 2000f, LANL 2004c).

Since 1997, wildfire prevention activities, such as forest thinning, have been implemented on the LANL site on an accelerated schedule. Between 1997 and 2005, 9,950 acres (4,027 hectares) of forests and woodlands were thinned resulting in a more open, park-like forest. This has, in turn, increased the visibility of some facilities. Additionally, an outbreak of bark beetles beginning in 2001 killed thousands of trees, further opening the forest and making LANL facilities more visible (LANL 2004c, 2006a).

To date, 2,259 acres (914 hectares) of land have been turned over to Los Alamos County and the Department of the Interior to be held in trust for the Pueblo of San Ildefonso (LANL 2004c). This turnover, however, has not changed the visual setting of either the LANL site or the surrounding area because development has not yet occurred on any of this land.

Following the events of September 11, 2001, a number of changes were initiated that limited or redirected public access to facilities at LANL. This has resulted in fewer opportunities for the public to view LANL facilities (LANL 2004c).

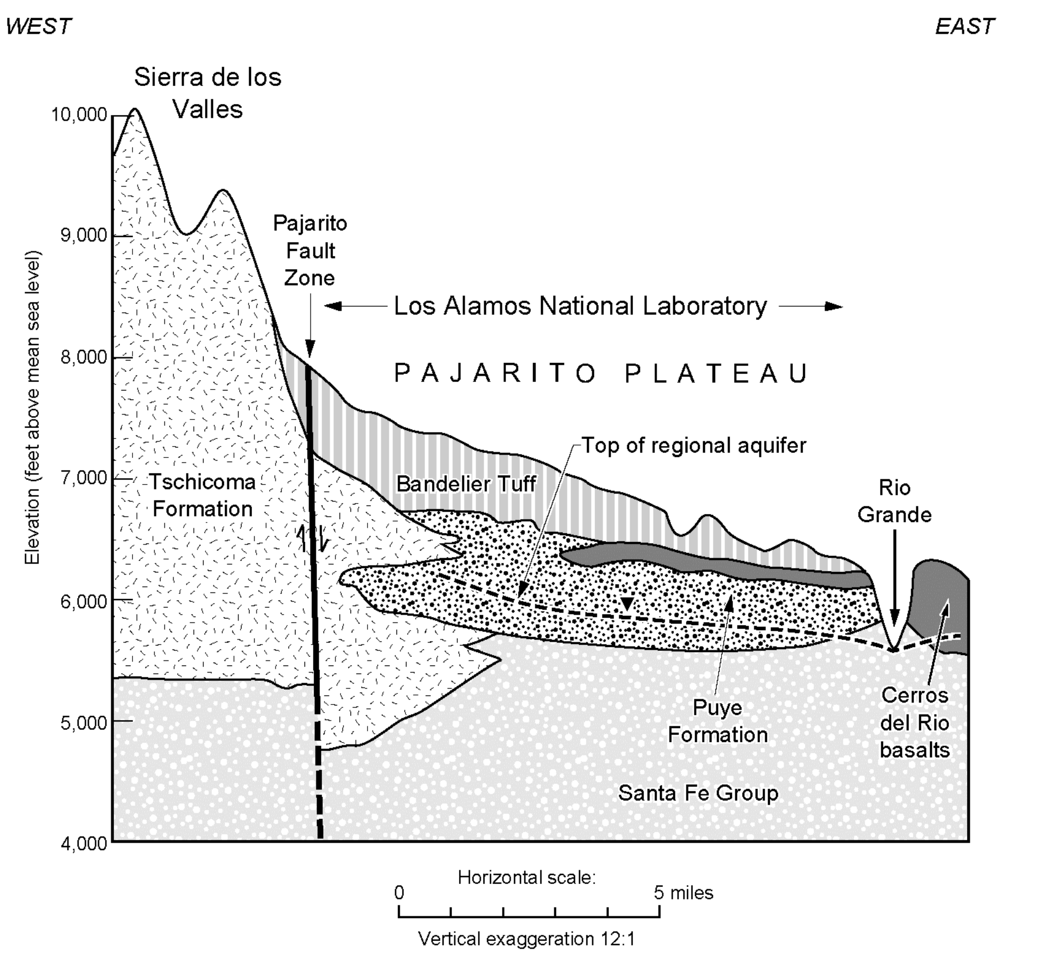
4.2 Geology and Soils

This section describes the geology, geologic conditions, soils, and mineral and geothermal resources present on the LANL site and in the surrounding area. In general, the information provided in Chapter 4, Section 4.2, of the *1999 SWEIS* is current; the most significant changes are updates to seismic conditions and the probabilistic seismic hazard analysis, as well as the effects of the 2000 Cerro Grande Fire on soil characteristics and erosion.

4.2.1 Geology

The geology of the LANL region is the result of complex faulting, sedimentation, volcanism, and erosion over the past 20 to 25 million years (DOE 1999a). LANL lies on the Pajarito Plateau, which is formed of volcanic tuffs (welded volcanic ash) deposited by past volcanic eruptions from the Jemez Mountains to the west (see **Figure 4–7**). The Jemez Mountains are a broad highland built up over the last 13 million years through volcanic activity. Late in the volcanic period, cataclysmic eruptions from calderas in the central part of the Jemez Mountains deposited the thick blankets of tuff that form the Pajarito Plateau (Broxton and Vaniman 2004). Volcanic activity culminated with the eruption of the rhyolitic Bandelier Tuff from 1.6 to 1.22 million years ago. During emplacement, intense heat and hot volcanic gases welded portions of these tuffs into the hard, resistant deposits that make up the upper surface of the plateau. Most of the bedrock on LANL property is composed of the salmon-colored Bandelier Tuff (DOE 1999a). The surface of the Pajarito Plateau is divided into numerous narrow, finger-like mesas separated by deep east-to-west-oriented canyons that drain to the Rio Grande. The canyons were formed by streams flowing eastward across the plateau from the Jemez Mountains to the Rio Grande.

Since the *1999 SWEIS* was issued, some specific geological information has been updated. The Cerro Toledo "Interval" of the Bandelier Tuff unit consists of volcaniclastic sediments and tephras reaching a thickness of 400 feet (122 meters) (LANL 2004c), an increase from the previously reported maximum thickness of 130 feet (40 meters) (DOE 1999a).



Notes:

1. The thickness of geologic units has been exaggerated on this figure to illustrate unit relationships and topography.
2. Offset of the Tschicoma formation on the Pajarito Fault zone is schematic due to the variation along the trace of the fault.
3. To convert feet to meters, multiply by 0.3048.

Source: LANL 2005h.

Figure 4–7 Generalized Cross-Section of the Los Alamos National Laboratory Area

4.2.2 Geologic Conditions

This subsection describes the geologic conditions that could affect the stability of buildings and infrastructure at LANL. It includes stratigraphy, volcanic activity, seismic activity (earthquakes), slope stability, surface subsidence, and soil liquefaction.

4.2.2.1 Stratigraphy

The upper sequence of rocks that underlie LANL are exposed in the 600- to 1,000-foot (183- to 305-meter)-deep, steep-sided canyons cut into the surface of the Pajarito Plateau. The exposed rocks range in age from middle Eocene sediments of the Santa Fe Group to Quaternary alluvium (LANL 1996a). The layers vary in hardness and resistance to erosion; the light-colored units tend to be softer and to form slopes on canyon walls, while darker-colored units tend to be harder and to form vertical cliffs. The following discussion briefly describes the geologic formations in relation to LANL.

The Santa Fe Group is the deepest sedimentary sequence beneath the site (see Figure 4–7). It was deposited in the Española basin, a Rio Grande rift basin that underlies the LANL area. The group ranges from early Eocene to late Pliocene in age; the uppermost sediments are late Miocene beneath the western and central Pajarito Plateau and grade upward into the late Pliocene to the east. The deposits consist of a series of light pink to buff-colored fluvial (stream deposited) siltstones and silty sandstones with a few lenses of conglomerate and clay. In some sections, the sediments are interbedded with basalt flows (NPS 2005a). To the east, these flows represent the Cerros del Rio Basalts (Broxton and Vaniman 2004).

The Puye Formation overlies the Santa Fe Group beneath the western and central Pajarito Plateau and thins beneath the eastern plateau (see Figure 4–7). It consists of coalescing alluvial fans that were shed eastward from the domes and flows of the Sierra de los Valles; as a result the formation overlaps and postdates the Tshicoma Formation. The sediments are late Miocene to late Pliocene in age and generally consist of interbedded gray-colored fluvial sandstones and gravels. The upper part of the Puye Formation is interlayered with lava flows. To the east, the flows represent the Cerros del Rio Basalts (see Figure 4–7), a series of basaltic and related lava flows separated by generally thin beds of sedimentary deposits of the Santa Fe Group and Puye Formation (Broxton and Vaniman 2004).

The Bandelier Tuff is the uppermost stratigraphic unit on the Pajarito Plateau. It forms the foundation for most LANL facilities as well as the canyon walls along LANL streams (LANL 1996a). The Bandelier is a late Pliocene to Quaternary volcanic deposit formed primarily by eruption of the Valles and Toledo calderas, which occurred 1.6 and 1.22 million years ago, respectively (DOE 1999a). These eruptions produced widespread, voluminous ash flow sheets composed of pumice, tuffs, and some interlayered sediments.

During and shortly after tuff deposition, extreme heat indurated (hardened by heating) some of the layers, forming welded tuff deposits. These welded tuffs and other volcanic deposits (including basalt flows) were fractured due to cooling and non-seismic processes. The size, extent, density, and orientation (vertical, horizontal, or inclined) of the fractures varies between successive layers and both vertically and laterally within individual layers. The induration and fracturing of the volcanic deposits on the LANL site are an important control on canyon wall formation, slope stability, subsurface fluid flow, seismic stability, and the engineering properties of the rocks.

The layers that form the Bandelier Tuff and the cliff-forming units are illustrated in **Figure 4–8**. Most LANL facility foundations are either on or within the Tshirege Member (upper member) of the Bandelier Tuff. The Tshirege Member consists of a series of generally thick, welded tuff sheets deposited by multiple volcanic flows. It contains several units, all of which are recognizable due to differences in physical and weathering properties. From the bottom to the top of the Member, the subunits are described as follows (LANL 1999a):

- The Tsankawi Pumice Bed is the basal pumice fallout deposit of the Member. This pumice bed is typically 20 to 30 inches (50 to 70 centimeters) thick on the LANL site. It is composed of angular to subangular volcanic rock particles up to 2.4 inches (6 centimeters) in diameter.

- Qbt 1g is the lowermost unit of the Member. It is a porous, nonwelded, poorly sorted, ash flow deposit. It is poorly indurated, but forms steep cliffs because a resistant bench near the top of the unit forms a protective cap over the softer underlying tuff. Qbt 1g underlies most of the mesas and is exposed in canyon walls on the Pajarito Plateau.

- Qbt 1v is a series of cliff- and slope-forming outcrops composed of porous, nonwelded, devitrified ash flow deposit. The base of the unit is a thin, horizontal zone of preferential weathering marking the abrupt transition from vitric tuffs below to devitrified tuffs above. The lower part of Qb1 1v is an orange-brown colored colonnade tuff (Qbt 1v-c) that forms a distinctive low cliff characterized by columnar jointing. The colonnade tuff is overlain by a white-colored band of slope-forming tuffs. Qbt 1v is exposed in canyon walls and is present beneath portions of canyon floors.

- Qbt 2 is a medium-brown, vertical cliff-forming ash flow deposit. It is devitrified, relatively highly welded, and forms the steep, narrow canyon walls in the central and eastern portions of the Pajarito Plateau. It underlies canyon flows in the central and western portions of the plateau. Qbt 2 forms a resistant caprock on mesa tops in the eastern portion of the Pajarito Plateau.

- Qbt 3 is a nonwelded to partly welded, devitrified ash flow deposit. The basal part of Qbt 3 is a soft, nonwelded tuff that forms a broad, gently sloping bench on top of Qbt 2 in canyon wall exposures and on the broad canyon floors in the central part of the Pajarito Plateau. The upper part of Qbt 3 is a partly welded tuff that forms the caprock of mesas in the central part of the Pajarito Plateau, such as at TA-50. This unit is more densely welded to the west and locally contains apparent horizontal bedding or fracturing.

- Qbt 4 is a partially to densely welded ash flow deposit characterized by small, sparse pumices and numerous intercalated surge deposits. The unit is exposed on mesa tops on the western part of the Pajarito Plateau such as at TA-3. Some of the most densely welded areas occur on the western margin of LANL.

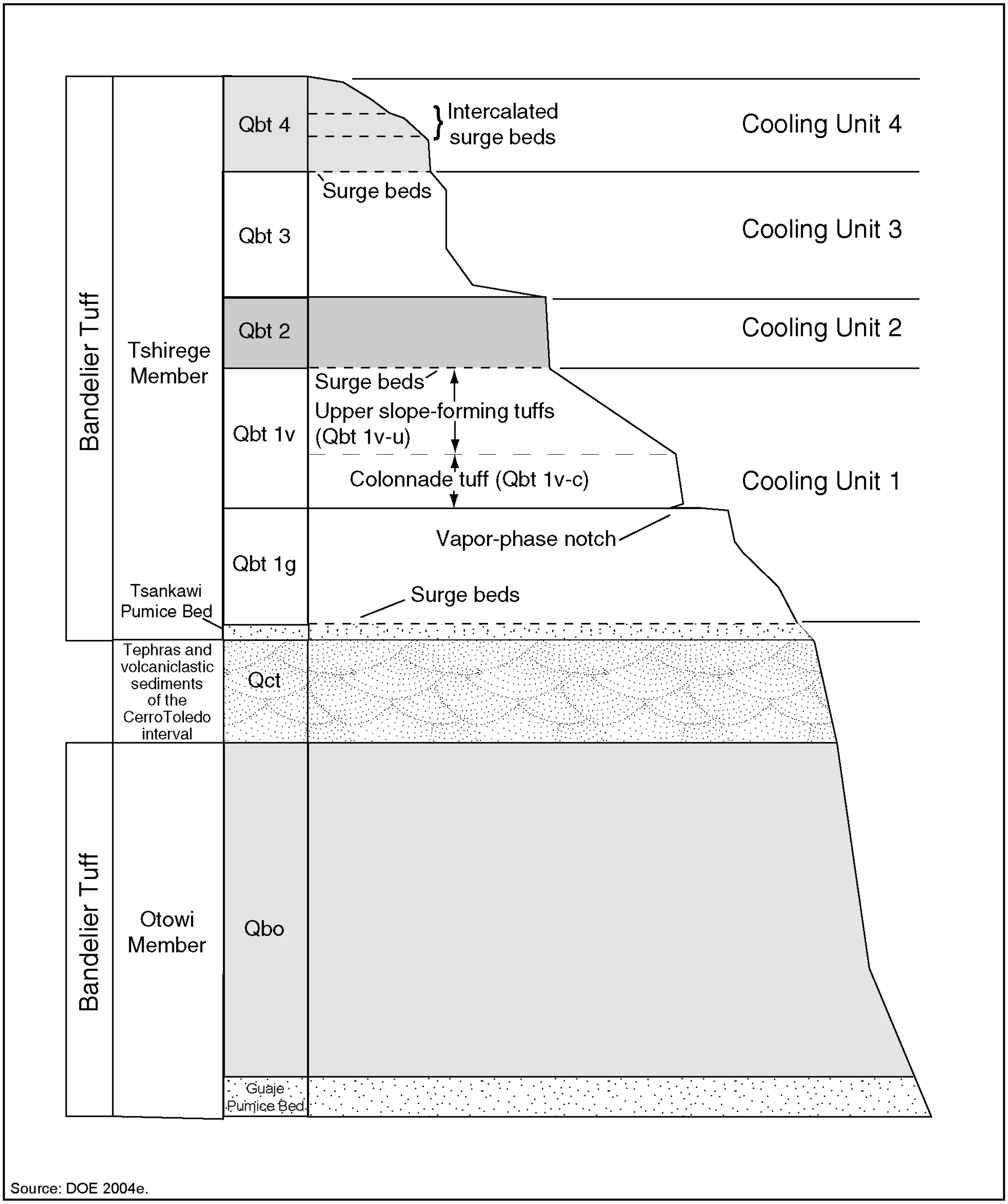


Figure 4–8 Stratigraphy of the Bandelier Tuff

In general, subunits of the Tshirege Member dip gently southeastward on the Pajarito Plateau. This dip is likely the primary initial dip, which mainly results from the burial of a southeast-dipping paleotopographic surface and thinning of units away from the volcanic source to the west.

Volcanic deposits postdating the eruption of the Bandelier Tuff are similar in character to the earlier unit. These deposits are intermittently present on the LANL site, with greater frequency of occurrence to the west.

Unconsolidated sediments form surficial, localized deposits across LANL. These deposits include colluvium and Quaternary alluvium. Colluvium, an accumulation of materials from rock falls and other gravity-driven processes, occurs at the base of slopes. Quaternary alluvium consists of recent stream deposits and occurs in and along LANL's canyons and watersheds as narrow bands of canyon-bottom sediments. Both materials consist of unconsolidated gravels, sands, and clays; however, colluvium is generally coarser-grained and less consolidated. Sediment is discussed in more detail in Section 4.3.1.5.

Overall, the complex interfingering and interlayering of strata beneath LANL results in variable properties that affect canyon wall formation, slope stability, subsurface fluid flow, seismic stability, and the engineering properties of the rocks. In general, poorly indurated and densely fractured layers tend to form canyon slopes that are susceptible to failure during erosion or seismic events and require remediation prior to installing engineered structures on the mesa surfaces, in the canyons, or crossing canyon walls. In such cases, the direction and density of the fractures is a critical engineering parameter. Beneath the Pajarito Plateau, the complex stratigraphy is reflected in the presence of perched groundwater zones. Perched groundwater occurs above welded tuffs in the Bandelier Tuff and other volcanic strata, above tuffs that have been altered to clays, above nonfractured basalt flows of the Cerro del Rio Basalts, and above fine-grained sedimentary deposits (such as lacustrine clays) in the Puye Formation (Robinson, Broxton, and Vaniman 2004). The upper surface of the regional aquifer (the water table) lies within the lower portion of the Puye Formation (see Figure 4–7). The aquifer includes the full thickness of the Santa Fe Group except along the Rio Grande, where the water table drops below the overlying Puye Formation. Interbedded basalt flows may account for localized confining conditions observed in the aquifer (NPS 2005a). The paleotopography and general dip to the southeast of the pre-Tshirege surface may strongly influence the direction of possible groundwater flow and contaminant migration in subsurface units. The paleotopography of the surface underlying the Bandelier Tuff may influence the flow direction of potential perched water zones (LANL 1999a).

In addition, the direction and rate of subsurface flow may be affected by the presence and orientation of fractures in some rock layers. As discussed above, these fractures may be related to cooling and formation of the individual strata. In some areas, faults related to seismic activity also may influence groundwater flow. The impact of geologic setting and geologic units on the hydrogeology beneath LANL is detailed in Appendix E.

4.2.2.2 Volcanism

There have been no significant changes to the information in this section from the *1999 SWEIS*; however, the unusually low amount of seismic activity in the Jemez Mountains has been reinterpreted to indicate that seismic signals of magma movement are partially absorbed deep in the subsurface due to elevated temperatures and high heat flow (LANL 2004c). The significance of this to LANL is that magma movement indicates that the Jemez Mountains continue to be a zone of potential volcanic activity, although at no greater probability than identified in the *1999 SWEIS*.

4.2.2.3 Seismic Activity

A comprehensive update to the LANL seismic hazards analysis was completed in June 2007 (LANL 2007a); the analysis presents estimated ground-shaking hazards and the ground motions that may result. The geological and geotechnical aspects of the study, along with a summary of the seismic setting, are incorporated in the following description. The relevance of the revised understanding of seismic hazards to LANL facilities is discussed in Chapter 5, Section 5.12, of this SWEIS.

The 2007 seismic hazard study updates the 1995 LANL study that was used for the *1999 SWEIS*. The studies consider all earthquake faults within 10 miles (16 kilometers) that meet the definition of the term "capable fault" as used by the U.S. Nuclear Regulatory Commission to assess the seismic safety of nuclear power reactors (Title 10 *Code of Federal Regulations* [CFR] Part 100, Appendix A).

The primary changes in the 2007 seismic update are the use of more recent field study data and the application of the most current seismic analysis methods (LANL 2007a). The only new characterization data regarding the dynamic properties of the subsurface beneath LANL are those from investigations performed at the Chemistry and Metallurgy Research Replacement Facility. Recent geological studies have refined the understanding of fault geometry, slip characteristics, and the relationship of the faults in the LANL area. The methods used in the updated 2007 analysis follow the Senior Seismic Hazard Advisory Committee's guidelines for a Level 2 analysis in *Recommendations for Probabilistic Seismic Hazard Analysis – Guidance on Uncertainty and Use of Experts* (NUREG/CR-6327, 1997). The study was designed and performed under the following DOE standards:

- DOE Standard 1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities;
- DOE Standard 1022-94, Natural Phenomena Hazards Site Characterization Criteria; and
- DOE Standard 1023-95, Natural Phenomena Hazard Assessment Criteria.

The seismic hazards analysis report (LANL 2007a) includes details on refinement of the seismic source model, ground motion attenuation relationships, dynamic properties of the subsurface (particularly the Bandelier Tuff) beneath LANL, as well as the probabilistic seismic hazard, horizontal and vertical hazards, and design basis earthquake for LANL.

The dominant contributor to seismic risk at LANL is the Pajarito Fault System. The main element of the system is the Pajarito Fault. Secondary elements include the Santa Clara Canyon Fault, the Rendija Canyon Fault, the Guaje Mountain Faults, and the Sawyer Canyon Fault. The general fault geometry in the system is reflected in **Figure 4–9** (LANL 2004c).

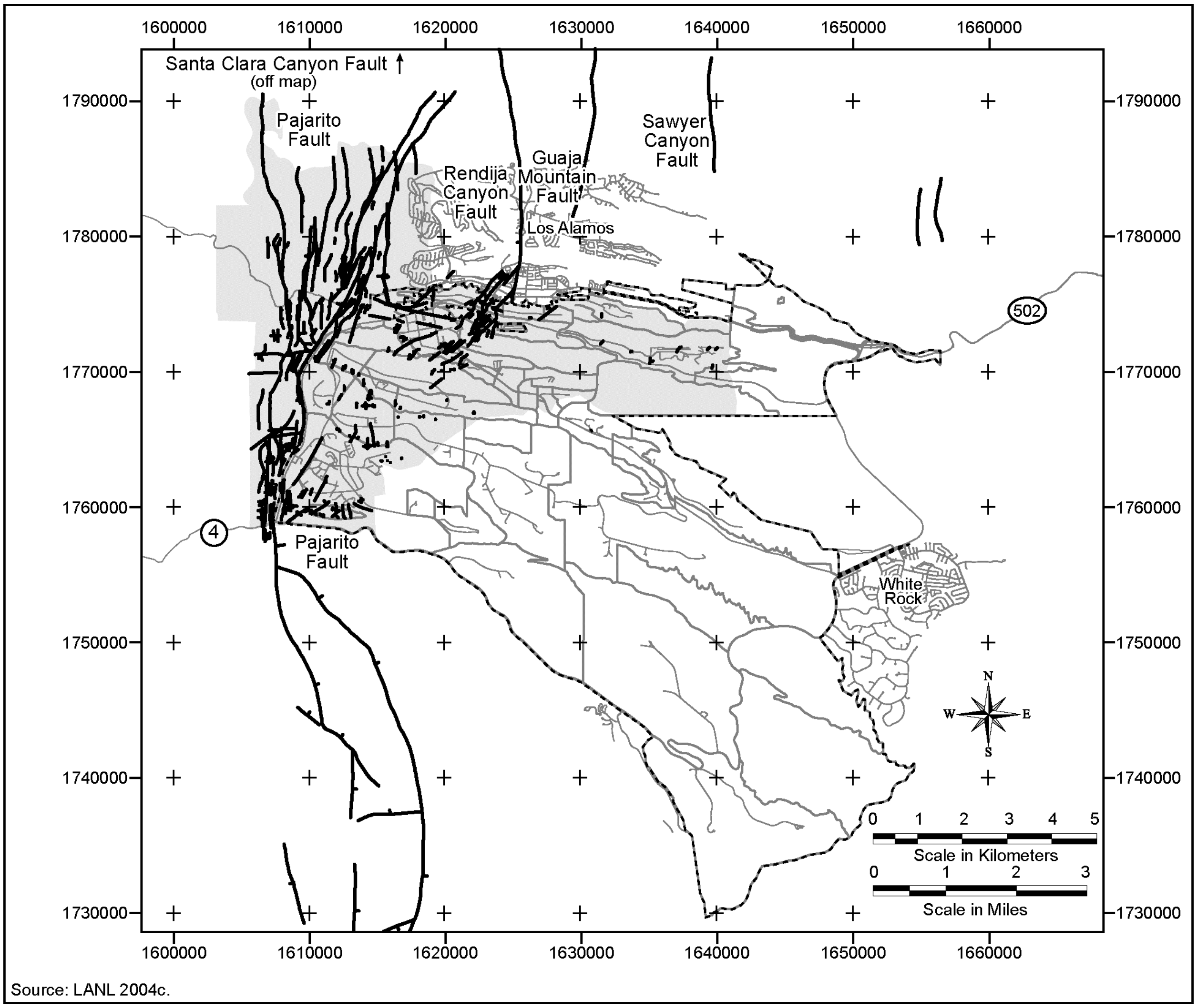


Figure 4–9 Mapped Faults in the Los Alamos National Laboratory Area

The descriptions of seismic settings and risk elements presented in the following sections are based on the 2007 seismic study (LANL 2007a) and data derived from trench and borehole studies, as well as other studies conducted on seismic hazards in the vicinity of LANL (LANL 2004c). These studies focused on the western third of LANL (the shaded area in Figure 4–9) because the principal faults, and thus the principal seismic risks at LANL, are located in that portion of the site.

Pajarito Fault

The Pajarito Fault is the main element of the Pajarito Fault System and contributes most of the seismic risk to LANL due to its proximity and level of seismic activity (LANL 2007a). It forms the main western margin of the Española Basin at LANL. The geometry of the Pajarito Fault varies appreciably along its north-south extent. Its shallow subsurface expression varies from a simple normal fault to broad zones of small faults to largely unfaulted monoclines. These features are all considered surface expressions of deep-seated normal faulting (LANL 2004c). Landslides along the main escarpment of the Pajarito Fault are cut by pronounced lineaments that are visible on aerial photographs and may express underlying faults, but this has not been confirmed.

The extent of movement along a fault may be approximated by the separation of stratigraphic layers on each side of the fault plane. Maximum stratigraphic separation on the Pajarito Fault occurs south-southwest of the LANL site, where down-to-the-east normal faulting shows up to 590 feet (180 meters) of stratigraphic separation on the Bandelier Tuff. Between Cañon de Valle and Pajarito Canyon, stratigraphic separation is approximately 475 feet (145 meters) on a series of faults over a lateral zone of about 3,300 feet (1,000 meters). In the vicinity of TA-16, deformation associated with the Pajarito Fault extends at least 5,000 feet (1,524 meters) to the east of the Pajarito Fault escarpment (LANL 2004c).

In the *1999 SWEIS*, the most recent faulting event along the Pajarito Fault was estimated to have occurred 45,000 years ago. More recent studies, including trench excavations and borehole stratigraphy and structure, indicated more recent movement (see **Table 4–3**) (LANL 2007a). Recent studies also indicated that movement on the Pajarito Fault may be linked to movement on the other fault segments in the Pajarito Fault System.

Table 4–3 Summary of Movement on Faults of the Pajarito Fault System

Name	***Approximate Length***	***Type***	***Most Recent Faulting Event***	***Maximum Earthquake Potential*** [a]
Pajarito	26 miles	Normal, down-to-the-east [b]	1,400 to 2,200 years ago	7
Rendija Canyon	8 miles	Normal, down-to-the-west	Less than 8,000 years ago	6.5
Guaje Mountain	8 miles	Normal, down-to-the-west	3,400 to 6,500 years ago	6.5

[a] Richter magnitude.
[b] The fault plane dips to the east and the crustal block on the east side of the fault slips downward to the east when fault movement occurs. Down-to-the-west reverses this fault plane angle and sense of movement.
Note: To convert miles to kilometers, multiply by 1.6093.
Sources: DOE 1999a, LANL 2004c, LANL 2007a.

Five small earthquakes (magnitudes of 2 or less on the Richter scale) have been recorded in the Pajarito Fault since 1991. These small events, which produced effects felt at the surface, are thought to be associated with ongoing tectonic activity within the Pajarito Fault zone (LANL 2004c).

The west-central area of LANL, generally between TA-3 and TA-16, lies within a part of the Pajarito Fault made up of subsidiary or distributed ruptures. Deformation extends at least 5,000 feet (1,500 meters) to the east of the Pajarito Fault Escarpment. The general north-south trend of the Pajarito Fault structure is disrupted in TA-62, TA-58, and TA-3 by some east-west trending faults. These faults may be related to the Pajarito Fault, the Rendija Canyon Fault (see below), or may be independent structures. These are areas of generally higher potential for seismic surface rupture, relative to locations farther removed from the Pajarito Fault zone.

Santa Clara Canyon Fault

The Santa Clara Canyon Fault is a secondary element of the Pajarito Fault System. It is located to the north of the Pajarito Fault (beyond the northern extent of Figure 4–9) and generally continues the northeastern trend of the Pajarito Fault as it extends north beyond LANL (LANL 2007a). It is another fault element that defines the western margin of the Española Basin, but it has less influence on seismicity at LANL due to its distance from the site. Although it continues the western Española Basin margin, there is a gap of approximately 3 miles (5 kilometers) between the mapped traces of the two faults. As discussed below, this gap may be accommodated by movement on the Rendija Canyon and Guaje Mountain faults.

Rendija Canyon Fault

Studies of the Rendija Canyon Fault (LANL 2007a) indicate that it is a dominantly down-to-the-west normal fault located approximately 2 miles (3 kilometers) east of the Pajarito Fault (see Figure 4–9 and Table 4–3). South of the Los Alamos townsite, the Rendija Canyon Fault turns southwest and splays into a zone of deformation about 1 mile (1.5 kilometers) wide. Displacement on the fault is up to 130 feet (40 meters), and the displacement gradually decreases to the south as the zone of deformation broadens (LANL 2004c). The fault probably ends just south of Twomile Canyon where displacement is about 30 feet (10 meters). At the southern end of the fault zone, east-west trending faults run between the Rendija Canyon and Pajarito Fault zones, generally within TA-63, TA-58, and TA-3 (see Figure 4–9). The east-west oriented faults may relate to the Pajarito and Rendija Canyon structures (in space or time or both) or they may record an independent history of brittle deformation. Additional study may determine the relationship between movement along the north-south and east-west fault zones at LANL. As mentioned above, these areas are associated with a higher potential for seismic surface rupture, however, previous analysis shows that the risk is not significant.

Trench exposures across the Rendija Canyon Fault at Guaje Pines cemetery indicate that the most recent surface rupture occurred about 8,600 to 23,000 years ago (LANL 2007a). Geologic mapping shows that there is no faulting in the near-surface directly beneath TA-55 (LANL 2004c). The closest fault is about 1,500 feet (460 meters) west of the TA-55 Plutonium Facility. The Rendija Canyon Fault, therefore, does not continue from the Los Alamos townsite directly south to TA-55.

Within TA-3, there is no evidence of faulting in a 1.2 million-year-old member of the Bandelier Tuff (Tshirege Member) beneath the site of the Metropolis Center for Modeling and Simulation and the Nonproliferation International Security Center. A study at the Chemistry and Metallurgy Building identified two small, closely spaced, parallel reverse faults with a combined vertical separation of 8 feet (2.4 meters). Drilling at the National Security Sciences Building identified a small normal fault with less than 3 feet (1 meter) of displacement. The Rendija Canyon Fault does not extend farther west than Pajarito Road, but its eastern extent has yet to be conclusively defined (LANL 2004c).

Guaje Mountain Fault

The Guaje Mountain Fault is subparallel to the Pajarito Fault and Rendija Canyon Fault and is located approximately 1.2 miles (2 kilometers) east of the Rendija Canyon Fault (see Figure 4–9) (LANL 2004c). It is somewhat shorter than the Rendija Canyon Fault and the southern extent is not well documented. The fault exhibits about 115 feet (35 meters) of down-to-the-west displacement on the south side of Guaje Mountain, between Rendija and Guaje Canyons (Carter and Winter 1995) (see Table 4–3). The fault continues to have topographic expression as far south as Bayo Canyon. However, the displacement along the length of the fault and the southern extent are generally not well defined.

Geologic surface mapping and trenching at Pajarito Mesa demonstrated the absence of faulting in that area for at least the last 50,000 to 60,000 years. Small displacement faults traverse the mesa, but no southward continuation of the Guaje Mountain Fault was identified (LANL 2004c).

Based on available data, a series of seismic events have been identified on the Guaje Mountain Fault. These range in age from 3,400 to 300,000 years ago and have up to approximately 7 feet (2 meters) of displacement (LANL 2004c, 2007a).

Sawyer Canyon Fault

The Sawyer Canyon Fault is a short, west-dipping fault that is subparallel to and located east of the Rendija Canyon and Guaje Mountain Faults. Its effect on seismicity at LANL is relatively small because the surface trace is located at a distance from the site and the structure migrates away from LANL at depth. This fault is included in the 2007 seismic update to simplify modeling (LANL 2007a).

Other Areas of LANL

Surveying of Bandelier Tuff contacts at Mesita del Buey (TA-54) revealed 37 faults with vertical displacements of 2 to 26 inches (5 to 65 centimeters). These small faults appear to be secondary effects associated with large earthquakes in the main Pajarito Fault zone, or perhaps earthquakes on other faults in the region (LANL 2004c).

Geologic mapping and related field and laboratory investigations in the north-central to northeastern portion of LANL (TAs 53, 5, 21, 72, and 73) revealed only small faults that have little potential for seismic surface rupture. The study identified six small-displacement (less than 5 feet [1.5 meters] vertical displacement) faults or fault zones. These faults are considered subsidiary to the principal faults of the Pajarito Fault system (that is, the Pajarito, Rendija Canyon, and Guaje Mountain Faults) and likely experienced small amounts of movement during earthquakes on the principal faults (LANL 2004c).

Pajarito Fault System Event Chronology and Probabilistic Seismic Hazard Analysis

Recent work has shown that the Pajarito Fault system is a broad zone of distributed deformation, and that the primary Pajarito Fault itself probably breaks the surface along only part of its length in the vicinity of LANL (LANL 2004c). Most of the geologic structures that have been the targets of seismic studies are, in fact, faults subsidiary to the primary and secondary segments of the Pajarito Fault System (LANL 2007a). Establishing the precise seismic relationship, timing of events, and probability of seismic activity on each segment is made more difficult because the individual faults do not provide a complete record of paleoseismic events for the entire system. Results from paleoseismic investigations indicate that there have been at least two and possibly three surface-rupturing events on the Pajarito Fault System since 11,000 years ago. Reaching back to the Late Quaternary (110,000 years ago), a total of five to nine events have been identified, suggesting a longer recurrence interval than in the more recent past. The apparent difference in recurrence interval may be due to the loss of event markers earlier in the geologic record.

The following discussion represents the 2007 update of the understanding of seismic hazards at LANL (LANL 2007a). Overall, the Pajarito Fault System acts as a broad zone of faults that form an articulated monoclinal flexure and consists of several distinct fault segments. These include the Pajarito Fault (the primary segment), Santa Clara Canyon Fault, Rendija Canyon Fault, Guaje Mountain Fault, and Sawyer Canyon Fault (secondary segments). These faults show evidence of progressive linkage in the recent past and exhibit complex rupture patterns, including the recent surface-rupturing pattern described above. As the primary fault segment in the Pajarito Fault System, the Pajarito Fault is the primary source of seismic risk at LANL. Movement on the primary fault may be temporally related to movement on the secondary faults.

A combination of empirical and site-specific attenuation relationships were used in the probabilistic seismic hazard analysis. As in the 1995 analysis, the lack of region-specific attenuation relationships was mitigated by use of a stochastic ground motion modeling approach. This approach was used for four target areas, including the Chemistry and Metallurgy Research Replacement Facility, TA-3, TA-16, and TA-55. The Chemistry and Metallurgy Research Replacement Facility and technical areas were selected for use in the calculations because they all contain LANL facilities of interest and field data were available to support the calculations. In addition, an attenuation relationship was developed for dacite at LANL. (Dacite is a type of igneous rock of volcanic origin.) In this application, it was used as a modeling analog for the Bandelier Tuff. By combining the depth to the top of dacite beneath an area and the dacite attenuation relationship, the probabilistic seismic hazard analysis can be applied beyond the four target areas to other areas of interest across LANL.

The probabilistic hazard for peak ground acceleration at all of the sites is dominated by the Pajarito Fault System for all return periods, and the Pajarito Fault System is in turn the primary contributor to seismic hazard at LANL. Peak ground acceleration for the Uniform Hazard Response Spectra is presented in **Table 4–4**; results are calculated for a range of recurrence intervals. Similarly, the peak ground acceleration calculated for Seismic Design Criteria for the target areas are presented in **Table 4–5**.

The estimated probabilistic hazard has increased significantly, up to 83 percent, compared to the 1995 probabilistic seismic hazard analysis (**Table 4–6**) (LANL 2007a), due in large part to recognition of increased seismic activity along the Pajarito Fault System. The 1995 probabilistic seismic hazard analysis was used to set the seismic hazard and design basis earthquake in the *1999 SWEIS* (DOE 1999a) and in this SWEIS, as well as to determine the design criteria for facilities at LANL. The 2007 probabilistic seismic hazard analysis updates these parameters and will require review and revision of the seismic hazard and the design basis earthquake for use in designing and establishing operating limits for LANL facilities. Earthquake hazard analyses for LANL facilities are discussed in Chapter 5, Section 5.12, of this SWEIS.

Table 4–4 Los Alamos National Laboratory Mean Peak Ground Acceleration Values (g) from the Uniform Hazard Response Spectra

Return Period (years)	*CMRR*		*TA-3*		*TA-16*		*TA-55*		*Site-Wide*		*Dacite*	
	Horiz.	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*
1,000	0.27	0.32	0.27	0.32	0.25	0.31	0.27	0.32	0.27	0.32	0.13	0.12
2,500	0.52	0.60	0.52	0.59	0.47	0.57	0.52	0.60	0.52	0.60	0.27	0.27
10,000	1.03	1.21	1.03	1.10	0.93	1.05	1.03	1.21	1.03	1.21	0.65	0.65
25,000	1.47	1.79	1.45	1.57	1.33	1.50	1.47	1.79	1.47	1.79	1.01	0.97
100,000	2.30	3.01	2.29	2.79	2.11	2.57	2.30	3.01	2.30	3.01	1.69	1.65

g = acceleration equal to gravity, Horiz. = horizontal, Vert. = vertical.
Source: LANL 2007a.

Table 4–5 Los Alamos National Laboratory Peak Ground Acceleration Values (g) from the Design Response Spectra

SDC	*CMRR*		*TA-3*		*TA-16*		*TA-55*		*Site-Wide*		*Dacite*	
	Horiz.	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*	*Horiz.*	*Vert.*
3	0.47	0.56	0.47	0.53	0.43	0.50	0.47	0.60	0.47	0.56	0.28	0.27
4	0.72	0.87	0.71	0.78	0.65	0.74	0.72	0.86	0.72	0.86	0.47	0.45
5	1.17	1.50	1.17	1.39	1.07	1.29	1.17	1.50	1.17	1.50	0.84	0.82

g = acceleration equal to gravity, SDC = seismic design criteria, Horiz. = horizontal, Vert. = vertical.
Source: LANL 2007a.

Table 4–6 Comparison of Probabilistic Peak Horizontal Accelerations in g's from 1995 and 2007 Studies

Return Period	*1,000 Years*		*2,500 Years*		*10,000 Years*	
	1995	*2007*	*1995*	*2007*	*1995*	*2007*
CMRR	–	0.27	–	0.52	–	1.03
TA-3	0.21	0.27	0.33	0.52	0.56	1.03
TA-16	0.21	0.25	0.32	0.47	0.53	0.93
TA-55	0.22	0.27	0.33	0.52	0.56	1.03

g = acceleration equal to gravity, CMRR = Chemistry and Metallurgy Research Replacement Facility, TA = technical area.
Source: LANL 2007a.

4.2.2.4 Slope Stability, Subsidence, and Soil Liquefaction

There are two changes to the *1999 SWEIS* relative to slope stability, subsidence, and soil liquefaction. The Cerro Grande Fire increased soil erosion due to loss of vegetative cover and hydrophobic soil formation. This in turn decreased slope stability in some localized areas. This effect is dissipating as vegetation returns (Gallaher and Koch 2004). The discussion in the *1999 SWEIS* of slope stability at the Omega West Facility is no longer pertinent because that facility was completely demolished in 2003 (LANL 2004c).

4.2.3 Soils

Most of the LANL facilities are located on mesa tops, where the soils are generally well-drained and thin (0 to 40 inches [0 to 102 centimeters]). A general description of LANL soils was included in the *1999 SWEIS*.

In May 2000, the Cerro Grande Fire burned approximately 43,000 acres (17,400 hectares), including about 7,700 acres (3,110 hectares) on LANL (Balice, Bennett, and Wright 2004). The fire severely burned much of the mountainside that drains onto LANL (Gallaher and Koch 2004). The effects of the fire included increased soil erosion due to loss of vegetative cover, formation of hydrophobic soils, and soil disturbance during construction of fire breaks, access roads, and staging areas (DOE 2000f). The increased potential for flooding and erosion led to construction of mitigation structures to retain floodwaters and reinforce road crossings (DOE 2002j).

Hydrophobic soils are formed by high intensity fires when compounds from plant litter are volatilized by the heat of the fire, forced deeper into the soil, and precipitate out as a waxy-like substance on cooler soil particle surfaces (Gallaher and Koch 2004). This limits the paths available for water percolation through the soil. Combined with loss of vegetation, hydrophobic soil formation enhances the potential for increased runoff, soil erosion, downslope flooding, and degradation of water quality. Approximately 9,310 acres (3,768 hectares) of hydrophobic soils were formed in the Jemez Mountains from the Cerro Grande Fire (DOE 2000f).

Soil composition was also affected by the Cerro Grande Fire. The high temperatures associated with forest fires cause a reduction in the oxidation state of metal constituents and combustion of organic carbon in surface soil. A change in the oxidation state of a metal can significantly alter its solubility; this may contribute to the observed release of manganese from soils affected by forest fires (Gallaher and Koch 2004). Studies show that these changes are temporary, usually lasting less than 5 years (Gallaher and Koch 2004).

4.2.3.1 Soil Monitoring

As described in the *1999 SWEIS*, soils on and surrounding LANL are sampled annually as part of the Environmental Surveillance and Compliance Program to determine if they have been contaminated by LANL operations. The soil sampling and analysis program provides information on the inventory, concentration, distribution, and changes over time of radionuclides in soils near LANL. The program has provided annual updates (through the yearbooks) to the data reported in the *1999 SWEIS*. Sediments, which occur along most segments of LANL canyons as narrow bands of canyon-bottom deposits, are not part of the soil monitoring program and are discussed in Section 4.3.1.4.

The following summarizes the discussion provided in *Information Document in Support of the Five-Year Review and Supplement Analysis for the Los Alamos National Laboratory Site-Wide Environmental Impact Statement* (LANL 2004c), except where otherwise noted. The soil monitoring program at LANL comprises: (1) an institutional component that monitors soil contaminants within and around LANL, and (2) a facility component that monitors soil contaminants within and around the principal low-level waste disposal area at LANL (Area G), as well as the principal explosive test facility at the site (Dual Axis Radiographic Hydrodynamic Test [DARHT]).

As part of the institutional program, soil samples are collected from onsite, perimeter, and offsite (regional) locations (see **Figure 4–10** and **Figure 4–11**). Onsite areas sampled at LANL are not potential release sites or wastewater outfalls. Instead, the majority of onsite sampling stations are located close to and downwind from major facilities and operations at LANL in an effort to assess radionuclide, radioactivity, heavy metals, and organics in soils that may have been contaminated as a result of air stack emissions and fugitive dust (such as the resuspension of dust from potential release sites).

The soil radionuclide and radioactivity samples collected from 1974 through 2005 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. As reported in LANL 2004c, sources of radionuclides in soil include natural minerals, atmospheric fallout, and planned or unplanned releases of radioactive gases, liquids, and solids from LANL operations. Naturally-occurring uranium is present in relatively high concentrations in soil and rocks due to the regional geologic setting. Plutonium sources at LANL include LANL operations and atmospheric fallout. Metals in soil may be naturally-occurring or may result from LANL releases (LANL 2004c).

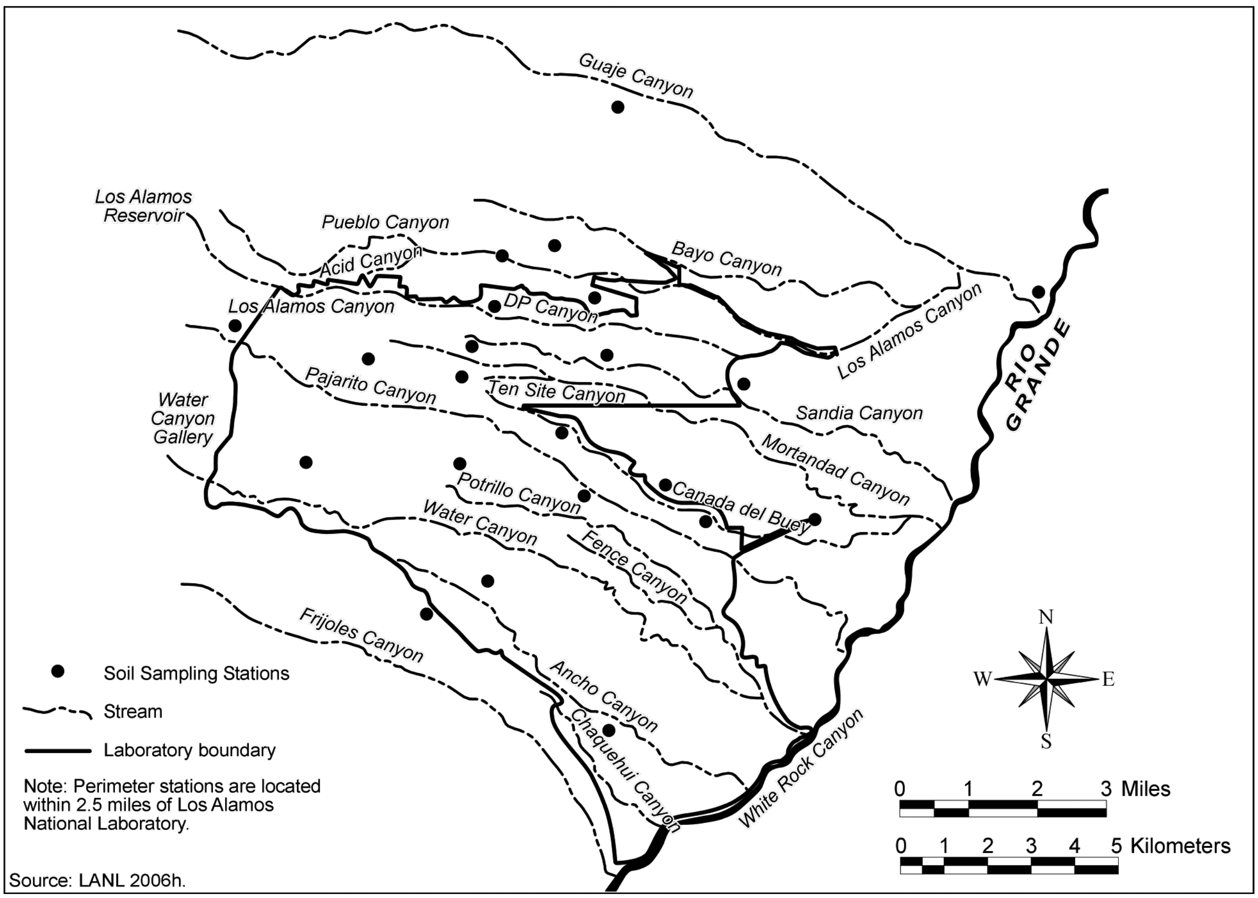


Figure 4–10 Onsite and Perimeter Soil Sampling Locations

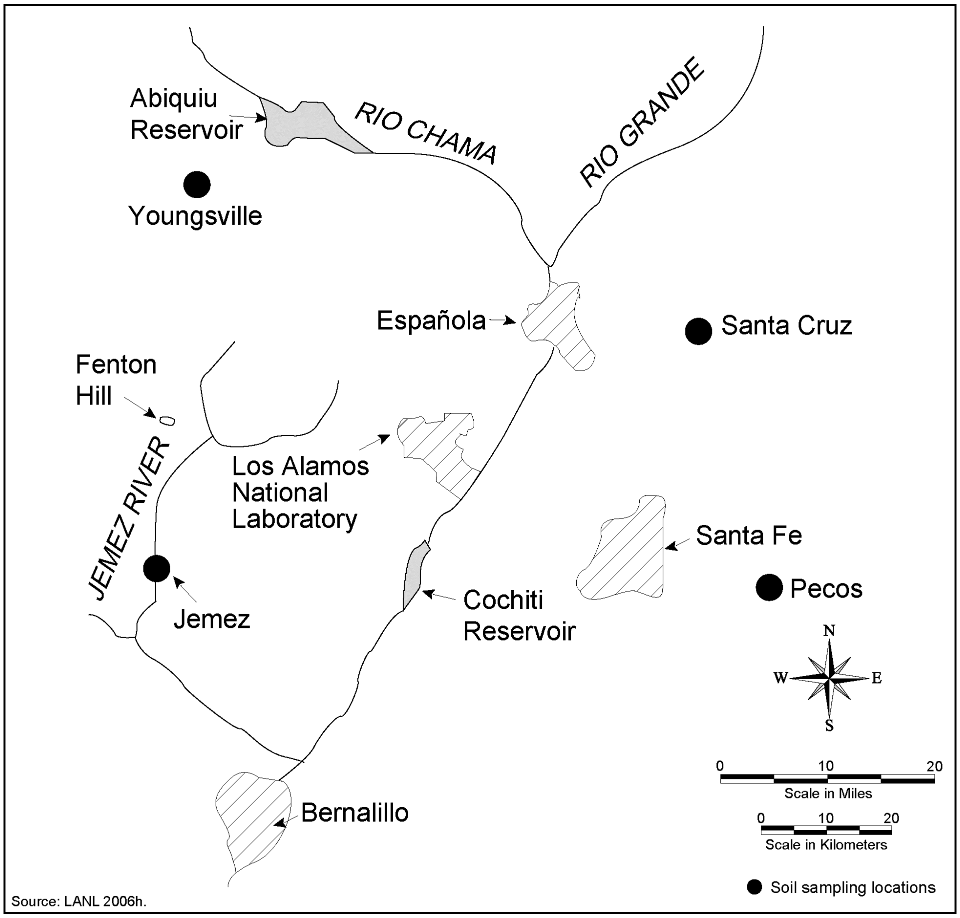


Figure 4–11 Offsite (Regional) Soil Sampling Locations – 2003

LANL onsite and perimeter soil samples are collected and analyzed for radiological and nonradiological constituents, and compared to the regional (background) locations. In general, based on the most recent data, most radionuclide concentrations (activity) in soils collected from individual perimeter and onsite stations were nondetectable (LANL 2004c). Of the radionuclides that were detected, most were still within regional statistical reference levels, indicating that they represent natural and fallout levels. This is consistent with the results presented in the *1999 SWEIS*.

Of the radionuclides detected in soils from perimeter and onsite stations that exceeded regional statistical reference levels, most were plutonium-239 and plutonium-240. Most of the detections were just above the regional statistical reference level, and were probably a result of fallout amplified by higher precipitation (rain) events. However, two soil samples, one onsite (at the DP Site in TA-21) and one at the site perimeter (at the west airport) contained concentrations above regional fallout levels. These levels were probably associated with activities at LANL. The west airport site is located just north and slightly downwind of the former Plutonium Processing Facility at TA-21; this is likely the source of the elevated plutonium result. The DP Site, a former plutonium processing facility that is currently undergoing decontamination and decommissioning, shows a great deal of variation in concentrations of plutonium-239 and plutonium-240 isotopes in soils over time. These variations are likely due to past facility operations or releases from potential release sites and not current operations (LANL 2004c).

Although soil samples at TA-21 (DP Site) contained plutonium-239 and plutonium-240 concentrations above regional statistical reference level, the values are still very low (picocuries range) and far below screening action levels. LANL screening action levels are used to identify the presence of contaminants of concern and are derived from a risk assessment pathway using a 15 millirem per year dose limit. The screening action levels in the *1999 SWEIS* were based on a 10 millirem per year dose limit. LANL also uses screening action levels to identify "hot spots" that require additional sampling and may require remediation. In every case, regional statistical reference levels are much lower than screening action levels.

Trend analyses show that most radionuclides and radioactivity in soils from onsite and perimeter areas at LANL have been decreasing over time. The exceptions are plutonium-238 and gross alpha concentrations not associated with specific radioisotopes. These observations continue the trends identified in the *1999 SWEIS*. The continuing decreases are likely due to: (1) the decrease in LANL operations and improvements in continuing facility operations, (2) the cessation of aboveground nuclear weapons testing in the early 1960s, (3) weathering (wind, water erosion, and leaching), and (4) radioactive decay (half-life). The persistence of plutonium-238 concentrations may be a result of low contaminant mobility, long half-life, and levels that approach background. The persistence of gross alpha levels may indicate that the observed levels approach background.

As part of the institutional program, soils were analyzed for trace and heavy metals. In general, few individual sites from either perimeter or onsite areas have metals concentrations above regional statistical reference levels. Metals that exceeded the regional statistical reference levels included barium, beryllium, mercury, and lead. Although above regional statistical reference levels, the detections were below U.S. Environmental Protection Agency (EPA) screening levels (LANL 2004c), indicating that they do not present a significant health concern. Trending analysis showed that the concentration of most metals does not appear to be rising over time; they appear to be remaining steady or decreasing. This was consistent with the trend reported in the *1999 SWEIS*, which suggested that facility operations are not a continuing source of metal contamination in site soils. However, mercury concentrations in all soils, including regional soils, appeared to be decreasing over time. This decrease was not entirely understood, but may be a reflection of better waste disposal methods and reduced air emissions from regional coal-fired manufacturing facilities (LANL 2006a).

Organic constituents were also studied within and around LANL, particularly after the 2000 Cerro Grande Fire. Volatile organic compounds, semivolatile organic compounds, organochlorine pesticides, polychlorinated biphenyls, high explosives, and dioxin and dioxin-like compounds were assessed in soils from LANL, perimeter, and background soil samples. Most organic compounds were not detected above reporting limits in any of the soils collected within or around LANL. However, two of the less toxic dioxin-like compounds (1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin [OCDD] and 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin [HpCDD]) were detected above reporting limits in most of the soil samples analyzed. These compounds are the least toxic of the six dioxin-like compounds analyzed. They are known byproducts of burning in natural (forest fires) and human-made (residential wood burning and municipal and industrial waste incinerators) settings. The highest observed concentrations of organic contaminants (3.7 parts per trillion of HpCDD and 29.1 OCDD) were from samples collected near the Los Alamos airport (TA-72). The total of these maximum detections is equivalent to

0.029 parts per trillion toxicity equivalents, which is well below the Agency for Toxic Substances and Disease Registry (ATSDR) soil screening level of 50 parts per trillion toxicity equivalents (ATSDR 1997, LANL 2004c). In addition, OCDD was detected at similar concentrations both upwind and downwind of the Cerro Grande Fire area, so it was probably not related to the fire (LANL 2004c).

Under the facility monitoring program, soils are monitored for contaminants around the perimeter of Area G and DARHT. Area G covers approximately 63 acres (25 hectares) in TA-54 at the east end of LANL. The soils and sediment are monitored for tritium, strontium-90, americium-241, cesium-137, plutonium isotopes, and uranium isotopes. Both tritium and plutonium isotopes have been detected at concentrations significantly above regional statistical reference levels, and tritium in soils in some locations is increasing over time. However, a special monitoring study of tritium determined that tritium in vegetation decreases to regional statistical reference levels at a distance of approximately 295 feet (90 meters) from Area G (LANL 2004c).

DARHT covers approximately 20 acres (8 hectares) and is located at TA-15 at the southwest end of LANL. Soils and sediments are monitored for the same radionuclides as at Area G, plus a number of heavy metals. Results are compared with baseline statistical reference levels established over a 4-year-long preoperational period prior to DARHT operations. After 4 years of operation at DARHT, sample analysis results demonstrate that most radionuclides and trace elements in soil, sediment, and biota are within baseline statistical reference levels (LANL 2004c).

As described in *Effects of the Cerro Grande Fire (Smoke and Fallout Ash) on Soil Chemical Properties Within and Around Los Alamos National Laboratory* (LANL 2000d), surface soil samples from LANL were evaluated to determine what effects the wildfire had on soil composition. The analytes were the same radionuclides, metals, and organic compounds as used in the soil monitoring program. For this analysis, the post-fire samples were compared to those collected in 1999 from the same sites. In general, the post-fire results were statistically similar to those collected before the fire, indicating that the impacts to soil chemistry as a result of the fire were minimal.

4.2.3.2 Soil Erosion

A general description of soil erosion at LANL was included in the *1999 SWEIS*. The Cerro Grande Fire increased soil erosion due to loss of vegetative cover and hydrophobic soil formation. This, in turn, increased the frequency and severity of flooding (DOE 2000g); total runoff volume in 2000 increased 50 percent over prefire years (Gallaher and Koch 2004). The increased potential for flooding and erosion led to construction of mitigation structures to retain floodwaters and reinforce road crossings (DOE 2002j). Tree loss due to the bark beetle increased soil erosion by decreasing vegetative cover.

Increased erosion results in steeper canyon walls with greater potential for slope failure. It also produces greater releases of soil particles, with their bound and interstitial legacy contaminants, to LANL streams. The waste legacy constituents are characterized under the soil monitoring program described above. The levels and fate of constituents in stream sediments is described in

Section 4.3.1.5. Increased runoff from fire-impacted areas continued in 2001, 2002, and 2003, but is expected to decrease over time as revegetation occurs (Gallaher and Koch 2004).

4.2.4 Mineral Resources

Potential mineral resources at LANL consist of rock and soil for use as backfill or borrow material for construction of remedial structures such as waste unit caps. Suitable borrow materials in the LANL area include Santa Fe Group sedimentary deposits and Pliocene-age volcanic rocks, especially poorly- to moderately-welded Bandelier Tuff (Stephens and Associates 2005). Quaternary alluvium deposits along stream channels could also be a source of borrow material, but these are typically of limited volume. Similarly, sediment deposits that have formed at the flood control structures built to mitigate the effects of the Cerro Grande Fire could be a potential borrow source, but these too are generally of limited volume.

The only borrow pit presently established onsite at LANL is the East Jemez Road Borrow Pit in TA-61 (Stephens and Associates 2005), which is currently used for soil and rubble storage and retrieval. The pit is cut into the upper Bandelier Tuff, which represents good source material for certain construction purposes (LANL 2005b).

There are numerous commercial offsite borrow pits and quarries in the vicinity; eleven are within 30 miles (48 kilometers) of LANL (this distance is taken as the upper economically viable limit for hauling borrow material to a cover site) (Stephens and Associates 2005). In general, these produce sand and gravel.

4.2.5 Paleontological Resources

A single paleontological artifact has been reported at a site within LANL boundaries (DOE 2003d). The artifact is described as a post-Pliocene (less than 1.6 million year-old) bison bone. It was found in the White Rock-Y area (LANL 2002f). Paleontological artifacts are generally not expected at LANL because near-surface stratigraphy is not conducive to preserving plant and animal remains. The near-surface materials are volcanic ash and pumice that were extremely hot when deposited; most carbon-based materials (such as bones or plant remains) would likely have been vaporized or burned, if present.

4.3 Water Resources

This section addresses surface water, groundwater, sediments, and floodplains located onsite, on adjacent properties, and extending to northern New Mexico and southern Colorado. Wetlands are discussed in Section 4.5.2 because they provide important habitat for many of the animals found on LANL. Water resources in the LANL region are used for human consumption, traditional and ceremonial uses by American Indians, aquatic and wildlife habitat, domestic livestock watering, irrigation, industry, and commercial purposes. Water resources in proximity to LANL may be affected by water withdrawals, effluent discharges, waste disposal, spills and unplanned releases, soil erosion, or stormwater runoff from LANL operations. The LANL area includes 15 subwatersheds as shown in **Figure 4–12**, with 12 local watersheds crossing LANL boundaries. The local watersheds are named for the canyons that receive their runoff.

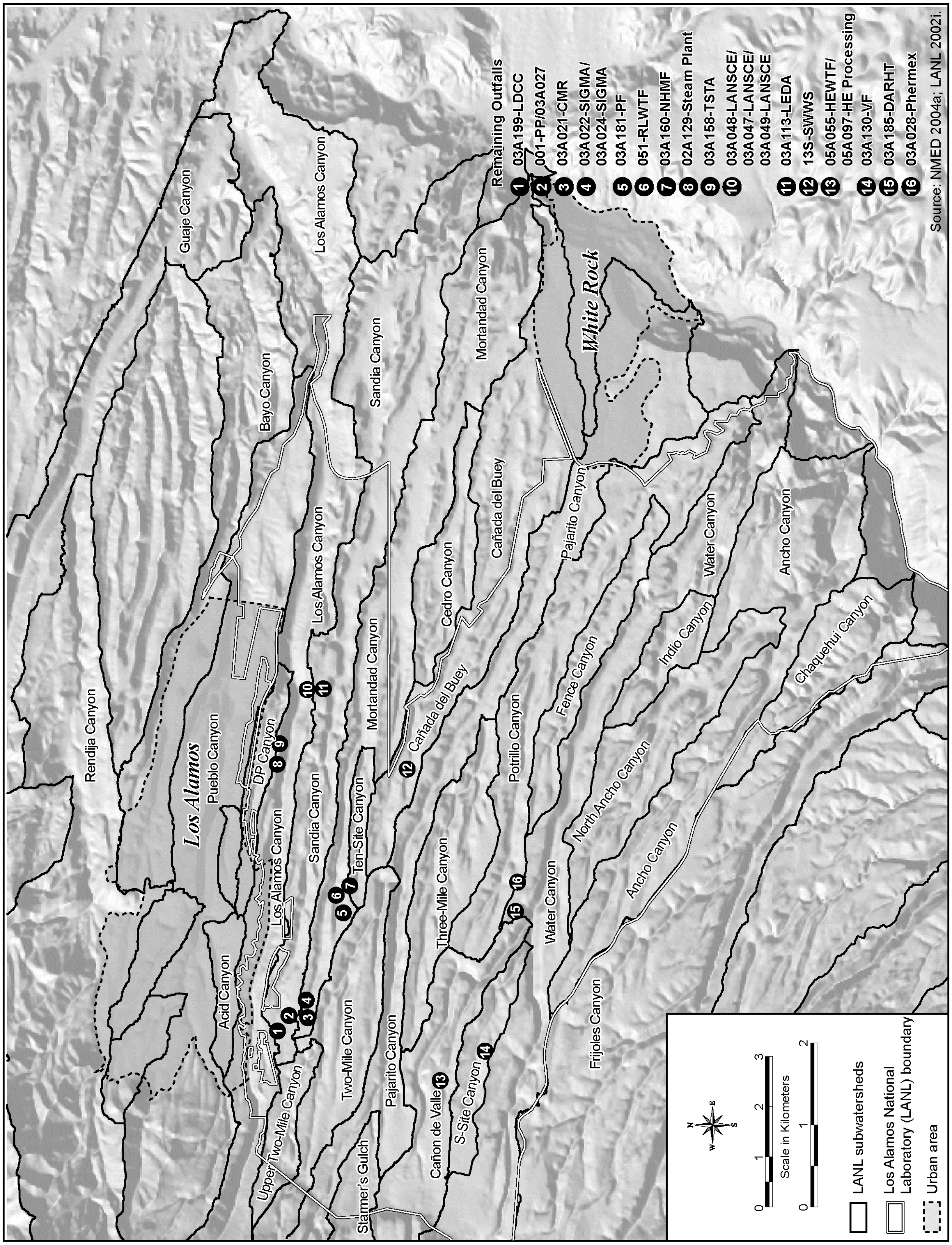


Figure 4–12 Watersheds in the Los Alamos National Laboratory Region

Detailed information on the geology, hydrology, and hydrogeology of the area was presented in Chapter 4, Sections 4.2 and 4.3, of the *1999 SWEIS*, with updated information provided annually in the *SWEIS Yearbooks* (LANL 2001e, 2002e, 2003h, 2004f, 2005f, 2006g, as well as Chapter 4, Section 4.2, and Appendix E of this SWEIS). Since the *1999 SWEIS* analysis, the Cerro Grande Fire changed the water resources environment by removing vegetation and surface organic layers, decreasing the ability of the soil to take in water. These changes caused increased surface water runoff and soil erosion to adversely affect local water resources by accelerating the movement of contaminants in sediments transported in stormwater downstream of LANL. An overview of the Cerro Grande Fire impacts on water resources is further discussed in Section 4.3.1.7.

Another change since the *1999 SWEIS* is related to the Fenton Hill site, a part of LANL located about 20 miles (32 kilometers) west of LANL. In 2003, DOE completed decommissioning the Fenton Hill Hot Dry Rock Geothermal Project by plugging and abandoning all remaining wells. In addition, most structures and equipment associated with the project were removed from the site. There are no environmental permits required for the operations remaining at the site, so Fenton Hill will not be discussed further in this section (LANL 2004c).

Water resources are regulated by a variety of standards, including the Clean Water Act, Safe Drinking Water Act, the New Mexico Water Quality Control Commission standards, and DOE Derived Concentration Guides. These standards and guides are discussed in Chapter 6 of this SWEIS.

Surface Water Terms

For the purposes of this SWEIS, the following terms apply to various forms of surface water.

- *Effluent* or *Discharge* applies only to industrial wastewater released to the environment through a National Pollutant Discharge Elimination System outfall.
- *Flow* applies to streams, springs, stormwater, or effluents, regardless of whether the water flows over an industrial site, a construction site, a natural landscape, or out of an outfall pipe.
- *Runoff* applies only to stormwater, because the precipitation runs off the surface, instead of infiltrating into the ground. Runoff is considered a "discharge" within the NPDES program, but that term will not be used for stormwater in this SWEIS for clarity.
- *Perennial* applies to streams that flow continuously due to natural springs or industrial effluents throughout the year in all years.
- *Ephemeral* applies to streams that flow only in response to local precipitation or snowmelt in the immediate area.
- *Intermittent* applies to streams that surface because the water table is higher than the streambed at certain times of the year.

4.3.1 Surface Water

Surface water may be affected by LANL operations when streams and springs receive industrial effluents discharged from LANL, stormwater flows over the site, and sediments are mobilized by stormwater runoff. At certain times of the year and under certain precipitation and flow conditions, surface water flowing through and from LANL can reach the Rio Grande.

Streams that drain the LANL area are dry for most of the year, and the area's surface water flows primarily in intermittent streams in response to local precipitation or snowmelt. Only about 2 miles (3.2 kilometers) of the over 85 miles (137 kilometers) of watercourses within LANL boundaries are naturally occurring perennial streams. Approximately 3 miles (4.8 kilometers) of watercourses are perennial waters created by supplemental flows from wastewater discharges.

Some of the surface water at LANL comes from shallow groundwater discharging as springs into canyons (LANL 2005h). Surface waters on- and offsite provide recharge to subsurface groundwater via infiltration to alluvial groundwater, intermediate perched groundwater, and the regional aquifer. Surface water is not a source of municipal, industrial, irrigation, or recreational water, though it is used by wildlife. While there is minimal direct use of the surface water within LANL, flows may extend beyond the site boundaries, where there is more potential for use of the water. Certain stream flows extend onto San Ildefonso Pueblo Tribal land and these may be used by Tribal members for traditional or ceremonial purposes, including ingestion or direct contact. Surface waters that flow off LANL property also may reach the Rio Grande, where contaminants could flow downstream.

4.3.1.1 Surface Water and Sediment Quality

Surface water quality is compared to many standards and reference guidelines established by Federal and state agencies. Drinking water standards are used for comparison, although surface water on the Pajarito Plateau is not used for this purpose. Sediments are also compared to several references and risk-based levels to determine if they could cause harm to human health or the environment. **Table 4–7** summarizes the standards and references used to evaluate surface water and sediment quality.

Table 4–8 summarizes the locations of LANL-impacted surface water and sediments. Surface water quality has been affected by LANL operations, with the greatest effects caused by past discharges into Acid, Pueblo, Los Alamos, and Mortandad Canyons.

After evaluating surface water quality data collected from streams within and downstream of LANL, the New Mexico Environment Department (NMED) identified several impaired stream reaches. These data were compared to the standards for the designated use of each stream, according to Section 303(d) of the Clean Water Act. Most surface water on the Pajarito Plateau is designated for use as wildlife habitat, livestock watering, and secondary contact. Some reaches have aquatic life designations. **Table 4–9** lists the impaired reaches within and downstream of LANL. These reaches are displayed in **Figure 4–13**.

Sources of Impacts to Surface Water Resources

LANL personnel recognize and manage the following sources that might impact local surface water resources:

- Industrial effluents discharged through National Pollutant Discharge Elimination System (NPDES) outfalls. This source is referred to as "NPDES-permitted outfalls" and includes point-source discharges from LANL wastewater treatment plants and cooling towers (see Section 4.3.1.2);
- Stormwater runoff, including stormwater runoff from certain industrial activities, construction activities, and solid waste management units (see Section 4.3.1.3);
- Dredge and fill activities or other work within perennial, intermittent, or ephemeral water courses (see Section 4.3.1.4); and
- Sediment transport (see Section 4.3.1.5).

Table 4–7 Standards and References Used for Evaluating Water Quality

			Potentially Applicable To				
			Pajarito Plateau			Rio Grande	
Type	*Source*	*Standard or Reference Value*	*Perennial Surface Water (spring supported, effluent supported)*	*Intermittent and Ephemeral Surface Waters*	*Sediments*	*Surface Water*	*Sediments*
Standard	NMWQCC	Irrigation	NA	NA	NA	X	NA
Standard	NMWQCC	Livestock Watering	X	X	NA	X	NA
Standard	NMWQCC	Wildlife Habitat	X	X	NA	X	NA
Standard	NMWQCC	Secondary Contact	X	X	NA	X	NA
Standard	NMWQCC	Coldwater Aquatic Life	X	NA	NA	X	NA
Standard	NMWQCC	Aquatic Life-acute	X	X	NA	X	NA
Standard	NMWQCC	Aquatic Life-chronic	X	NA	NA	X	NA
Standard	NMWQCC	Human Health (persistent contaminants)	X	X	NA	X	NA
Standard	NMWQCC	Human Health (cancer causing, or toxic)	X	NA	NA	X	NA
Reference	NMWQCC	Groundwater for Human Health	X (filtered samples)	X (filtered)	NA	NA	NA
Reference	NMWQCC	Groundwater other Standards for Domestic Water	X (filtered)	X (filtered)	NA	NA	NA
Reference	EPA	Drinking Water Systems MCL (filtered)	NA	NA	NA	X	NA
Reference	EPA	Fish Consumption and Water	NA	NA	NA	X	NA
Reference	EPA	EPA Region 6 Tap Water Screening Level	X	X (filtered)	NA	NA	NA
Risk-plant and animal	DOE	DOE BCGs (1 rad per day for aquatic animals and plants; 0.1 rad per day for terrestrial animals)	X	X	NA	NA	NA
Risk-human	EPA	EPA Region 6 Residential and Industrial Outdoor Worker Soil Screening Levels (metals, organics, chemicals)	NA	NA	X	NA	X
Risk-human	LANL/USGS	Residential Soil Screening Action Levels (radionuclides)	NA	NA	X	NA	X
Reference	Environment Canada	Guideline for Protection of Aquatic Life	NA	NA	NA	NA	X
Reference	LANL	Background radionuclides and metals	NA	NA	X	NA	NA
Reference	LANL	Background radionuclides	NA	NA	NA	NA	X
Reference	USGS	Prefire metals and organic chemicals	NA	NA	NA	NA	X
Reference	LANL/NMED	Prefire metals and radionuclides	X	X	X	X	X

NMWQCC = New Mexico Water Quality Control Commission, NA = not applicable, EPA = U.S. Environmental Protection Agency, MCL = maximum contaminant level, BCG = Biota Concentration Guide, USGS = U.S. Geological Survey, NMED = New Mexico Environment Department.
Sources: DOE 1990, 2002g; Environment Canada 2002; EPA 2002, 2007a; Gilliom, Mueller, and Nowell 1997; LANL 2006g, 2006h; NMAC 20.6.2; NMAC 20.6.4.

Table 4–8 Surface Water and Sediment Contamination Affected by Los Alamos National Laboratory Operations

Contaminant	*Onsite*	*Offsite*	*Significance*	*Trends*
Radionuclides in Sediments	Higher than background in sediments because of LANL contributions in Pueblo, DP, Los Alamos, Pajarito, and Mortandad Canyons.	Yes, in Los Alamos, Acid, and Pueblo Canyons; and slightly elevated in the Rio Grande and Cochiti Reservoir.	Sediments below health concern, except onsite along a short distance of Mortandad Canyon; exposure potential is limited.	Plutonium-239 and -240 and cesium-137 concentrations temporarily increased after the Cerro Grande Fire, but fell back to pre-fire levels in Pueblo and Los Alamos Canyons
Radionuclides in Surface Water	Higher than background in runoff in Pueblo, DP, Los Alamos, and Mortandad Canyons.	Yes, in Los Alamos and Pueblo Canyons.	Minimal exposure potential because storm events are sporadic. Mortandad Canyon surface water is 7 percent of Biota Concentration Guide.	Flows in Pueblo Canyon occurring more often after the Cerro Grande Fire. Flows in other LANL canyons recovered to near pre-fire levels.
Polychlorinated Biphenyls in Sediments	Detected in sediment in nearly every canyon.	Yes, particularly in Los Alamos and Pueblo Canyons.	Wildlife exposure potential in Sandia Canyon. Elsewhere, findings include non-LANL and LANL sources.	None
Polychlorinated Biphenyls in Surface Water	Detected in Los Alamos and Sandia Canyon runoff and base flow above New Mexico Stream Standards.	No	Wildlife exposure potential in Sandia Canyon. Elsewhere, findings include non-LANL and LANL sources.	Polychlorinated biphenyls are found everywhere in the Rio Grande, both upstream and downstream of LANL
Dissolved Copper, Lead, and Zinc in Surface Water	Detected in many canyons above New Mexico acute aquatic life standards.	Yes, in Los Alamos Canyon	Origins uncertain; probably multiple sources.	None
High Explosive Residues and Barium in Surface Water	Detections near or above screening values in Cañon de Valle base flow and runoff.	No	Minimal potential for exposure.	None
Benzo(a)pyrene	Detections near or above industrial screening levels in Los Alamos Canyon.	Yes, in Los Alamos and Acid Canyons.	Origins uncertain; probably multiple sources.	None

Sources: LANL 2005h, 2006h.

Other possible sources of surface water impacts are isolated spills, former photographic processing facilities, highway runoff, and residual Cerro Grande Fire ash (LANL 2005h). While most of the major sources were discussed in the *1999 SWEIS*, that evaluation focused on the NPDES-permitted outfalls and sediment transport (DOE 1999a; LANL 2004c). Over the past few years, regulatory emphasis has shifted away from the NPDES-permitted outfalls towards managing stormwater runoff from operating facilities, construction sites, and solid waste management units. As New Mexico stream water quality standards are becoming more stringent, LANL programs are emphasizing improved management of its stormwater runoff (NNSA 2004c).

Table 4–9 New Mexico Environment Department List of Impaired Reaches

Impaired Reach	*Unsupported Designated Uses*	*Probable Causes of Impairment*	*Probable Sources of Impairment*
Upper Rio Grande Watershed			
Guaje Canyon (San Ildefonso Pueblo boundary to headwaters)	- Livestock Watering - Wildlife Habitat - Secondary Contact	- Gross Alpha - Selenium	- Inappropriate Legacy Waste Disposal - Natural Sources - Post-development Erosion and Sedimentation - Surface Mining - Watershed Runoff following Forest Fire
Rendija Canyon (Guaje Canyon to headwaters)	- Wildlife Habitat - Secondary Contact	- Selenium	- Natural Sources - Post-development Erosion and Sedimentation - Surface Mining - Watershed Runoff following Forest Fire
Los Alamos Reservoir	- Coldwater Aquatic Life - Livestock Watering - Wildlife Habitat - Irrigation - Primary Contact	- Other	- Watershed Runoff following Forest Fire
Los Alamos Canyon Ephemeral and Intermittent Segments (San Ildefonso Pueblo boundary to Los Alamos Reservoir)	- Livestock Watering - Wildlife Habitat - Limited Aquatic Life - Secondary Contact	- Gross Alpha - Selenium	- Inappropriate Legacy Waste Disposal - Industrial and Commercial Site Stormwater Discharge (Permitted) - Natural Sources - Post-development Erosion and Sedimentation - Watershed Runoff following Forest Fire
Pueblo Canyon (Los Alamos Canyon to headwaters)	- Livestock Watering - Wildlife Habitat - Secondary Contact	- Gross Alpha - Mercury - Selenium	- Contaminated Sediments - Impervious Surface and Parking Lot Runoff - Inappropriate Legacy Waste Disposal - Industrial and Commercial Site Stormwater Discharge (Permitted) - Municipal (Urbanized High Density Area) - Natural Sources - Post-development Erosion and Sedimentation - RCRA Hazardous Waste Sites - Watershed Runoff following Forest Fire
Rio Grande – Santa Fe Watershed			
Sandia Canyon Perennial Segment (Sigma Canyon upstream to LANL NPDES Outfall 001)	- Coldwater Aquatic Life - Livestock Watering - Wildlife Habitat - Secondary Contact	- Polychlorinated biphenyl-1254 - Polychlorinated biphenyl-1260	- Atmospheric Deposition of Toxics - Inappropriate Legacy Waste Disposal - Landfills - Post-development Erosion and Sedimentation
Sandia Canyon Ephemeral and Intermittent Segments (San Ildefonso Pueblo boundary to Sigma Canyon)	- Livestock Watering - Wildlife Habitat - Limited Aquatic Life - Secondary Contact	- Polychlorinated biphenyl-1254 - Polychlorinated biphenyl-1260	- Atmospheric Deposition of Toxics - Inappropriate Legacy Waste Disposal - Landfills - Post-development Erosion and Sedimentation

Impaired Reach	*Unsupported Designated Uses*	*Probable Causes of Impairment*	*Probable Sources of Impairment*
Mortandad Canyon (San Ildefonso Pueblo boundary to headwaters)	- Livestock Watering - Wildlife Habitat - Limited Aquatic Life - Secondary Contact	- Gross Alpha - Selenium	- Impervious Surface and Parking Lot Runoff - Inappropriate Legacy Waste Disposal - Industrial Point Source Discharge - Natural Sources - Post-development Erosion and Sedimentation - Watershed Runoff following Forest Fire
Pajarito Canyon Perennial Segment (Arroyo de la Delfe upstream into Starmers Gulch and Starmers Spring)	- Coldwater Aquatic Life - Livestock Watering - Wildlife Habitat - Secondary Contact	- Gross Alpha - Selenium	- Inappropriate Legacy Waste Disposal - Natural Sources - Post-development Erosion and Sedimentation - Watershed Runoff Following Forest Fire
Pajarito Canyon (Rio Grande to Arroyo de la Delfe and upstream from Starmers Spring)	- Livestock Watering - Wildlife Habitat - Limited Aquatic Life - Secondary Contact	- Gross Alpha - Selenium	- Inappropriate Legacy Waste Disposal - Natural Sources - Post-development Erosion and Sedimentation - Watershed Runoff following Forest Fire
Water Canyon Perennial Segments (Area A Canyon upstream to NM 501) and Cañon de Valle Perennial Segment (LANL stream gage E256 upstream to Burning Ground Spring)	- Coldwater Aquatic Life - Livestock Watering - Wildlife Habitat - Secondary Contact	- Gross Alpha - Selenium	- Inappropriate Legacy Waste Disposal - Industrial Point Source Discharge - Industrial and Commercial Site Stormwater Discharge (Permitted) - Natural Sources - Post-development Erosion and Sedimentation - Watershed Runoff Following Forest Fire
Water Canyon and Cañon de Valle Ephemeral and Intermittent Segments (portions within DOE lands)	- Limited Aquatic Life - Livestock Watering - Wildlife Habitat - Secondary Contact	- Gross Alpha - Selenium	- Inappropriate Legacy Waste Disposal - Industrial Point Source Discharge - Industrial and Commercial Site Stormwater Discharge (Permitted) - Natural Sources - Post-development Erosion and Sedimentation - Watershed Runoff following Forest Fire
Rito de los Frijoles (Rio Grande to headwaters)	- High Quality Coldwater Fishery - Primary Contact - Secondary Contact	- DDT - Fecal Coliform - Water Temperature - Turbidity	- Natural Sources - Other Recreational Pollution Sources - Other Spill Related Impacts - Source Unknown

RCRA = Resource Conservation and Recovery Act, DDT = dichlorodiphenyl-trichlorethane, NPDES = National Pollutant Discharge Elimination System.
Sources: NMED 2004a, NMWCC 2006.

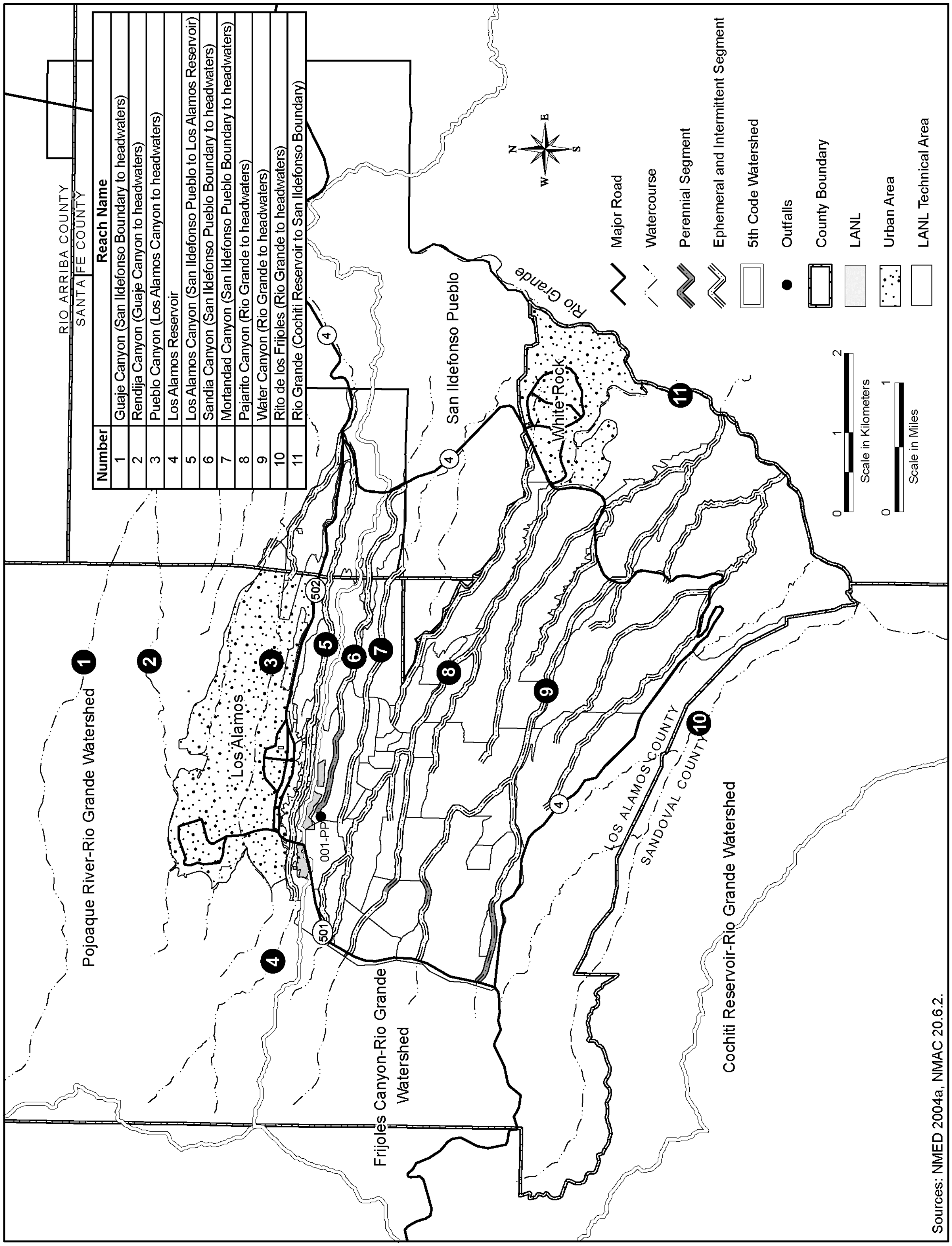


Figure 4–13 Impaired Reaches in the Vicinity of Los Alamos National Laboratory

In accordance with DOE Order 450.1, "Environmental Protection Program," and other statutory requirements, LANL personnel routinely monitor surface water, stormwater, and sediments as part of their ongoing environmental monitoring and surveillance program. The monitoring results are published annually in Environmental Surveillance Reports. One improvement since the *1999 SWEIS* is that LANL personnel expanded the focus to a site-wide monitoring program that integrates groundwater, surface water, stormwater, and sediment monitoring, on a watershed basis.

The *1999 SWEIS* presented surface water quality data from 1991 to 1996. Updated information was collected and presented yearly in the LANL Environmental Surveillance Reports, and current data are now available through 2005 (LANL 2005h). An overview of the 2005 data is presented below to provide an understanding of the current surface water quality conditions.

- While nearly every major watershed shows some level of impact from LANL operations, the overall quality of most surface water is described as good. Most samples of 200 possible contaminants have concentrations that are far below regulatory standards or risk-based advisory levels (LANL 2006h).

- Past discharges of radioactive liquid effluents into Pueblo (including its tributary Acid Canyon), DP, and Los Alamos Canyons and current releases from the Radioactive Liquid Waste Treatment Facility into Mortandad Canyon have introduced americium-241, cesium-137, plutonium-238, plutonium-239, plutonium-240, strontium-90, and tritium into both surface waters and canyon sediments (LANL 2005h). The sum of the ratios of all radionuclides to their Biota Concentration Guides is less than 11 percent in the major canyons (LANL 2006h).

- Radioactivity in lower Pueblo Canyon and Mortandad Canyon surface water at locations below the Radioactive Liquid Waste Treatment Facility outfall, as compared to the DOE Biota Concentration Guide, is shown in **Table 4–10**. This is similar to the conditions described in the *1999 SWEIS* (DOE 1999a; LANL 2004d, 2006h).

In addition to environmental monitoring, LANL personnel maintain other compliance programs. Liquid effluents from NPDES-permitted outfalls are required to meet limits established by the NPDES permit program (see Section 4.3.1.2) and the groundwater discharge permit program. Currently, LANL has one groundwater discharge permit for the TA-46 sanitary wastewater systems plant, the Metropolis Center, and the TA-3 power plant combined outfalls, and has submitted an application for another groundwater discharge permit for the TA-50 Radioactive Liquid Waste Treatment Facility outfall.

LANL activities that require excavation, filling, or other work within a watercourse are subject to Section 404 of the *Clean Water Act* and require dredge and fill permits issued by the U.S. Army Corps of Engineers and certification per Section 401, Water Quality Certification, by the NMED. These permits include operating conditions that must be observed to protect water quality and wildlife and ensure compliance with New Mexico stream standards (LANL 2006h). These activities are referred to as dredge and fill or Sections 404 and 401 activities and are discussed further in Section 4.3.1.4.

Table 4–10 Estimated Average Annual Concentrations of Radionuclides in Base Flows in Pueblo and Mortandad Canyons Compared with the Biota Concentration Guides

Radionuclide	BCGs (picocuries per liter)	Lower Pueblo Canyon (at NM 502)		Mortandad Canyon below TA-50 Radioactive Liquid Waste Treatment Facility Outfall	
		Estimated 2005 Time-Weighted Annual Average (picocuries per liter)	Ratio to BCG	Estimated 2005 Time-Weighted Annual Average (picocuries per liter)	Ratio to BCG
Americium-241	400	0.4	0.001	5.1	0.013
Cesium-137	20,000	Not detected	0.0	20	0.001
Tritium	300,000,000	Not detected	0.0	237	0.0000008
Plutonium-238	200	Not detected	0.0	2.1	0.0105
Plutonium-239 and Plutonium-240	200	11	0.055	2.9	0.0145
Strontium-90	300	0.4	0.0013	3.4	0.0011
Uranium-234	200	1.7	0.0085	2.0	0.01
Uranium-235 and Uranium-236	200	0.1	0.0005	1.1	0.0055
Uranium-238	200	1.6	0.008	1.9	0.0095
Sum of Ratios			0.07	–	0.07

BCG = Biota Concentration Guide, TA = technical area.
Source: LANL 2006h.

4.3.1.2 Industrial Effluents

Liquid effluents from LANL's industrial and sanitary outfalls are permitted under the NPDES Industrial Point Source Outfall Program (called NPDES-permitted outfalls). The NPDES permit requires routine monitoring of discharges and reporting of sampling results. The permit specifies the parameters to be measured and the sampling frequency (EPA 2007b).

Notable changes since the *1999 SWEIS* include a reduction in the number of permitted outfalls and the total effluent flow from outfalls, changes to LANL treatment facilities at the Radioactive Liquid Waste Treatment Facility at TA-50 and the High-Explosives Wastewater Treatment Facility at TA-16, and water conservation projects that recycle treated effluent to cooling towers from the TA-46 Sanitary Wastewater Systems Plant (formerly known as the Sanitary Wastewater Systems Consolidation Plant).

LANL has 21 outfalls currently permitted under the industrial permit program. **Table 4–11** shows the number of outfalls and the type of effluent that is discharged through the outfalls.

The 21 NPDES-permitted outfalls at LANL discharge into five local canyons in the LANL region, with the amount of discharge varying from year to year. Figure 4–13 shows the location of the NPDES-permitted industrial outfalls. In 2005, approximately 198 million gallons (749 million liters) of effluent were discharged from all permitted outfalls. This represents a reduction in the number of outfalls, the number of watersheds receiving flow, and the total amount of effluent discharged since publication of the *1999 SWEIS*. Thirty-five outfalls were removed from service as a result of efforts to reroute and consolidate flows and eliminate outfalls; one outfall was reinstated to serve the Laboratory Data Communication Center (TA-3-1498) cooling towers (DOE 1999a, LANL 2005f). The annual flow from permitted outfalls and discharges by watershed is shown in **Table 4–12**.

Table 4–11 National Pollutant Discharge Elimination System Industrial Point Source Outfalls

Number of Outfalls	*Type of Discharge*
1	Power Plant Discharge
1	Boiler Blowdown Discharge
15	Treated Cooling Water Discharge
2	High Explosive Wastewater Treatment
1	Radioactive Liquid Waste Treatment
1	Sanitary Wastewater Treatment
Total 21	

Source: EPA 2007b.

Table 4–12 National Pollutant Discharge Elimination Systems Permitted Outfalls and Discharges by Watershed

Canyon	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Cañada del Buey [a]							
Number of permitted outfalls	3	1	1	1	1	1	1
Discharge (million gallons per year)	2.6	0	0	0	0	0	0
Guaje [b]							
Number of permitted outfalls	6	0	0	0	0	0	0
Discharge (million gallons per year)	1.7	0	0	0	0	0	0
Los Alamos							
Number of permitted outfalls	7	5	5	5	5	5	5
Discharge (million gallons per year)	45.2	37.4	19.34	36.79	34.52	29.57	53.58
Mortandad							
Number of permitted outfalls	6	5	5	5	5	5	5
Discharge (million gallons per year)	39.3	31.6	4.21	31.4	33.12	15.9	16.84
Pajarito [c]							
Number of permitted outfalls	2	0	0	0	0	0	0
Discharge (million gallons per year)	0	0	0	0	0	0	0
Pueblo							
Number of permitted outfalls	1	0	0	0	0	0	0
Discharge (million gallons per year)	0.9	0	0	0	0	0	0
Sandia							
Number of permitted outfalls	6	4	4	5	5	5	5
Discharge (million gallons per year)	213.2	180.2	100.38	108.58	140.41	116.43	127.54
Water [d]							
Number of permitted outfalls	5	5	5	5	5	5	5
Discharge (million gallons per year) (Includes discharge to Cañon de Valle, a tributary)	14.3	16.2	0.102	1.41	1.77	0.62	0.50
Totals							
Number of permitted outfalls	36	20	20	21	21	21	21
Discharge (million gallons per year)	317.2	265.4	124.04	178.18	209.82	162.52	198.46

[a] Includes Outfall 13S from the Sanitary Wastewater Systems Plant, which is permitted to discharge to Cañada del Buey or Sandia Canyon. The discharge is currently piped to TA-3 and ultimately discharged to Sandia Canyon via Outfall 001.
[b] Includes 04A-176 discharge to Rendija Canyon, a tributary to Guaje Canyon.
[c] Includes 06A-106 discharge to Threemile Canyon, a tributary to Pajarito Canyon.
[d] Includes 05A-055 discharge to Cañon de Valle, a tributary to Water Canyon.
Note: To convert gallons to liters, multiply by 3.7853.
Sources: LANL 2003h, 2004f, 2005f, 2006g.

Five canyons (Pueblo, Cañada del Buey, Guaje, Chaquehui, and Ancho Canyons) that previously received LANL discharges are no longer receiving any industrial effluent. Pajarito Canyon has not received any effluent since 1998. Water Canyon and its tributary, Cañon de Valle, Sandia Canyon, Mortandad Canyon, and Los Alamos Canyon continue to receive LANL effluent discharges. Cañada del Buey is permitted to receive effluent from the TA-46 Sanitary Wastewater Systems Plant, but that effluent has been routed to Sandia Canyon since the plant opened (LANL 2005f). Total effluent discharges to the canyons from LANL decreased by about 37 percent over the past 6 years.

It should be noted that the method used to measure and report flow rates at NPDES-permitted outfalls has significantly changed since the *1999 SWEIS*. Historically, instantaneous flow was measured and extrapolated over a 24-hour day, 7-day week period. Flow meters, used since 2001 in many (but not all) outfalls and measuring stations, provide more accurate flow measurements. At those outfalls without meters, the flow is still calculated according to the previous method. Without comparable values, trend analysis of yearly flows is difficult.

The distribution of total industrial effluent contributed by the various facilities (Key and non-Key Facilities) has also changed since the *1999 SWEIS*. Annual effluents generated and discharged are listed by facility in **Table 4–13**. Total effluent discharges from all facilities in 2005 were 63 percent of the total discharges in 1999. In 2005, Key Facilities discharged about 63 million gallons (240 million liters) of effluent, representing 32 percent of the total annual flow; and non-Key Facilities discharged about 135 million gallons (511 million liters) of effluent, or 68 percent of the annual flow. Flows from Key and non-Key Facilities have fluctuated, but generally decreased since 1999. The apparent increase in effluent from the Tritium Facility is due to increased effluent discharges from the TA-21 Steam Plant (LANL 2006g).

Quality of Effluent from NPDES-Permitted Outfalls

LANL personnel collect weekly, monthly and quarterly samples to analyze effluents for compliance with NPDES permit levels. The *1999 SWEIS* reported that LANL had "chronic problems meeting NPDES industrial/sanitary permit conditions" (DOE 1999a). This condition has improved significantly. Since 2000, LANL has maintained an average compliance rate with permit conditions of 99.75 percent. The current compliance rate is summarized in **Table 4–14**. Permit exceedance trends are shown in **Figure 4–14**. The number of samples exceeding permit limits in Table 4–14 may differ from the number of exceedances shown in Figure 4–14 because one sample may exceed two limits. Each of these samples were counted as two exceedances until October 2004, when the method of reporting exceedances was changed so a single sample could only represent one exceedance of permit limits (LANL 2006a). In the event that a permit level is exceeded, DOE reports the condition to the EPA and takes corrective action to address the noncompliance. Details of all exceedance events are provided in the Environmental Surveillance Reports for the respective years (LANL 1999b, 2000e, 2001f, 2002d, 2004a, 2004d, 2005h, 2006h). Generally, exceedances of permit standards in the 5 years since 2000 were of excess total residual chlorine.

Table 4–13 National Pollutant Discharge Elimination Systems Permitted Outfalls and Discharges by Facility

Facility	1999	2000	2001	2002	2003	2004	2005
Plutonium Complex							
Number of permitted outfalls	1	1	1	1	1	1	1
Discharge (million gallons per year)	8.6	6.5	0.41	2.82	3.02	2.72	2.40
Tritium Facility [a]							
Number of permitted outfalls	2	2	2	2	2	2	2
Discharge (million gallons per year)	9.0	8.6	0.39	13.4	19.03	22.09	32.98
CMR Building							
Number of permitted outfalls	1	1	1	1	1	1	1
Discharge (million gallons per year)	4.5	2.3	0.02	0.76	2.16	1.19	0.92
Sigma Complex							
Number of permitted outfalls	2	2	2	2	2	2	2
Discharge (million gallons per year)	5.77	3.9	0.06	2.00	7.62	1.97	3.80
High Explosives Processing Facility							
Number of permitted outfalls	3	3	3	3	3	3	3
Discharge (million gallons per year)	0.2	0.1	0.04	0.03	0.02	0.037	0.029
High Explosives Testing Facility							
Number of permitted outfalls	3	2	2	2	2	2	2
Discharge (million gallons per year)	14.3	16.1	9.00 [b]	1.38	1.75	0.58	0.47
LANSCE							
Number of permitted outfalls	4	4	4	4	4	4	4
Discharge (million gallons per year)	37.2	30.5	20.45	24.04	16.46	8.12	21.00
Biosciences Facilities (previously called Health Research Laboratory)							
Number of permitted outfalls	1	0	0	0	0	0	0
Discharge (million gallons per year)	0	0	0	0	0	0	0
Radiochemistry Facility							
Number of permitted outfalls	1	0	0	0	0	0	0
Discharge (million gallons per year)	0	0	0	0	0	0	0
Radioactive Liquid Waste Treatment Facility	1	1	1	1	1	1	1
Number of permitted outfalls	5.3	4.9	3.6	2.92	2.97	2.14	1.83
Discharge (million gallons per year)							
Number of permitted outfalls	0	0	0	0	0	0	0
Discharge (million gallons per year)	0	0	0	0	0	0	0
Applies to each of the following facilities: - Pajarito Site - MSL - TFF - Machine Shops - Waste Management - Operations							
Sub-Total Key Facilities							
Number of permitted outfalls	19	16	16	16	16	16	16
Discharge (million gallons per year)	85.0	72.5	24.99	47.17	53.03	38.85	63.43
Non-Key Facilities							
Number of permitted outfalls	17	4	4	5	5	5	5
Discharge (million gallons per year)	232	192.5	99.01	130.83	156.79	123.67	135.03
Totals							
Number of permitted outfalls	36	20	20	21	21	21	21
Discharge (million gallons per year)	317	265	124	178	209.8	162.52	198.46

CMR = Chemistry and Metallurgy Research, LANSCE = Los Alamos Neutron Science Center, MSL = Materials Science Laboratory, TFF = Target Fabrication Facility.

[a] The TA-21 Steam Plant Outfall is included in the Tritium Facility outfall totals and is usually 90 percent or more of the total flow attributed to this Key Facility, although it serves other facilities within that technical area.

[b] Value was incorrectly reported in the LANL 2003h Table 3.2-4 as .006638. The correct value is 9.0, per LANL 2004c.

Note: To convert gallons to liters, multiply by 3.785.

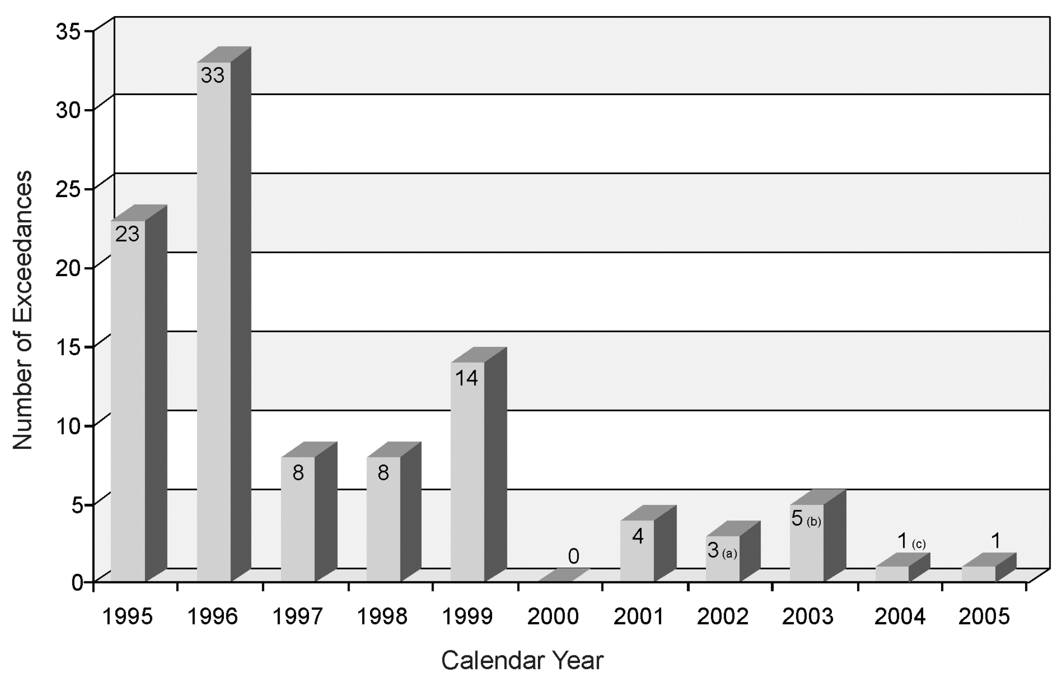
Source: LANL 2003h, 2004c, 2004f, 2005f, 2006g.

Table 4–14 Effluent Quality Monitoring and Compliance with Permit Limits for National Pollutant Discharge Elimination Systems-Permitted Outfalls

	1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Industrial Outfalls							
Number of permitted outfalls (as of end of calendar year)	19	20	20	20	20	21	21
Number of samples collected	1,248	1,121	1,085	1,084	958	1,283	949
Number of samples exceeding permit limits	14 [a]	0	4	2 [b]	3 [c]	1 [d]	1
Yearly compliance rate (percent)	98.88	100	99.63	99.82	99.69	99.92	99.89
Sanitary Outfalls							
Number of permitted outfalls (as of end of calendar year)	1	1	1	1	1	1	1
Number of samples collected	175	200	134	129	132	145	126
Number of samples exceeding permit limits	0	0	0	0	0	0	0
Compliance rate (percent)	100	100	100	100	100	100	100

[a] Number of samples differs from Environmental Surveillance Report for 1999 because two samples exceeding permit limits were taken from the Guaje Well, which had been transferred to Los Alamos County ownership in 1998 (LANL 2006a).
[b] One sample exceeded both monthly average and daily maximum permit limits, so it counted as two exceedances.
[c] Two samples exceeded both monthly average and daily maximum permit limits, so they each counted as two exceedances.
[d] One sample exceeded both monthly average and daily maximum permit limits, but is counted as one exceedance under the new reporting method.

Sources: LANL 1999b, 2000e, 2001f, 2002d, 2004a, 2004d, 2005h, 2006a, 2006h.



a) One sample exceeded both monthly average and daily maximum permit limits, so it counted as two exceedances.
b) Two samples exceeded both monthly average and daily maximum permit limits, so they each counted as two exceedances.
c) One sample exceeded both monthly average and daily maximum permit limits, but is counted as one exceedance under the new reporting method.

Sources: LANL 1996b, 1997c, 1999b, 2000e, 2001f, 2002e, 2004a, 2004d, 2005h, 2006a, 2006h.

Figure 4–14 National Pollutant Discharge Elimination Systems Permit Exceedance Trend

Wastewater Treatment Facility Outfalls

LANL has three wastewater treatment facilities permitted to discharge treated effluent. The sanitary outfall shown in Table 4–14 refers to the TA-46 Sanitary Wastewater System Plant. The other two wastewater treatment facilities are the TA-50 Radioactive Liquid Waste Treatment Facility and the TA-16 High Explosives Wastewater Treatment Facility. Information on the operations of treatment facilities is presented in Section 4.9. Details on the improvements made to the treatment processes at the various wastewater treatment facilities may be found in the *SWEIS Yearbooks* (LANL 2002e, 2003h, 2004f, 2005f, 2006g).

The volume of treated effluent discharged from the TA-50 Radioactive Liquid Waste Treatment Facility has steadily decreased since the *1999 SWEIS*. In 2005, the Radioactive Liquid Waste Treatment Facility discharged 1.83 million gallons (6.9 million liters) compared to the 5.3 million gallons (20 million liters) discharged in 1999. Annual effluent discharges are shown in Table 4–13.

Effluent quality from the Radioactive Liquid Waste Treatment Facility has improved since the *1999 SWEIS.* At that time, the Radioactive Liquid Waste Treatment Facility effluent did not meet water quality discharge standards, resulting in a letter of noncompliance issued by NMED to LANL (LANL 2004c). New treatment processes have been installed since then to improve effluent quality. With these improvements, calendar year 2005 marked the sixth consecutive year that the Radioactive Liquid Waste Treatment Facility effluent had no violations of the NPDES permit limits or exceedances of the DOE Derived Concentration Guides for radioactive liquid wastes (Del Signore and Watkins 2005, LANL 2006a).

During this same 6-year period, the Radioactive Liquid Waste Treatment Facility has also met voluntary NMED groundwater standards for nitrates, fluoride, and total dissolved solids. Similarly, perchlorate concentrations in Radioactive Liquid Waste Treatment Facility effluent has been below the detection limit since March 2002, when perchlorate treatment equipment was installed. In addition, Radioactive Liquid Waste Treatment Facility tritium discharges have been less than one percent of the DOE Derived Concentration Guide since March 2001. Tritium-contaminated effluent that exceeds this voluntary standard of 20,000 picocuries per liter, which is the EPA drinking water standard, is now treated via evaporation at the TA-53 Radioactive Liquid Waste Treatment Plant (LANL 2004d). **Table 4–15** summarizes the water quality in the Radioactive Liquid Waste Treatment Facility effluent for 2005 for certain contaminants.

Since 1999, construction of TA-16 High Explosives Wastewater Treatment Facility has been completed and full operation has begun to comply with Federal Facility Compliance Act Agreement AO Docket No. VI-94-1210. With the operation of this new facility, 19 NPDES-permitted outfalls that previously received contamination from high explosives discharges have been eliminated. Three high explosives processing outfalls remain in use and the effluent discharged through these outfalls was reduced to 0.029 million gallons (0.11 million liters) per year in 2005. Yearly effluent discharged is shown in Table 4–13, High Explosives Processing Facility. The High Explosives Wastewater Treatment Facility is discussed further in Section 4.9 (LANL 2004d, 2005f, 2006g).

Table 4–15 Selected Water Quality Data for Radioactive Liquid Waste Treatment Facility Effluent in 2005

Contaminant	*Average Effluent Concentration in 2005*	*Standard Concentration Limit*	*Water Quality Standard*
Sum of 39 radionuclide ratios, including tritium	Less than 0.18	1.0 Sum of Ratios	DOE Derived Concentration Guideline
Nitrogen as nitrate	3.7 milligrams per liter	10 milligrams per liter	NMED Groundwater Standard for Human Health
Fluoride	0.24 milligrams per liter	1.6 milligrams per liter	NMED Groundwater Standard for Human Health
Total dissolved solids	182 milligrams per liter	1,000 milligrams per liter	NMED Groundwater Standard for Domestic Water Supply
Perchlorate	Not detected	(a)	No current standard
Tritium	3,200 picocuries per liter	2,000,000 picocuries per liter	DOE Derived Concentration Guideline
		20,000 picocuries per liter	EPA Primary Drinking Water Standard

NMED = New Mexico Environment Department, EPA = U.S. Environmental Protection Agency.
[a] The EPA has proposed a drinking water standard for perchlorate of 4 micrograms per liter, but it has not been issued yet.
Sources: LANL 2005h, 2006a, 2006h; Del Signore and Watkins 2005.

Treated liquid effluent from the TA-46 Sanitary Wastewater Systems Plant is currently pumped to storage tanks at TA-3 for reuse or is discharged to Sandia Canyon through an NPDES-permitted outfall.

The *1999 SWEIS* reported that the Los Alamos County Bayo Wastewater Treatment Facility discharges into Pueblo Canyon where that effluent could mobilize sediment contaminants from former LANL operations in Acid Canyon downstream. This facility is not owned or operated by LANL, but it may have an impact on contaminant transport in surface water and groundwater contamination (LANL 2005h).

4.3.1.3 Stormwater Runoff

During New Mexico's summer rainy season, there can be a large volume of stormwater runoff flowing over LANL facilities and construction sites picking up pollutants. The most common pollutants transported in stormwater flows are radionuclides, polychlorinated biphenyls, and metals (LANL 2005h). At the time of publication of the *1999 SWEIS*, conventional programs were in place at LANL to manage and control stormwater runoff from its industrial activities and construction projects. Since then, LANL has improved its monitoring of stormwater runoff. The program improvements are the result of changes in the EPA NPDES stormwater permitting program, increased regulatory attention on stormwater flows from solid waste management units, and ongoing programmatic changes that improve monitoring activities and implement best management practices for stormwater pollution prevention.

Stormwater runoff at LANL was managed under a Multi-Sector General Permit for industrial activities and a General Permit for construction projects in 1999. The Multi-Sector General Permit covered stormwater runoff from 25 onsite industrial activities, which included all solid waste management units as one of those industrial activities. Until March 2003, the Construction General Permit requirements addressed the management of stormwater runoff from various construction activities disturbing 5 or more acres (2 hectares) (64 *Federal Register* [FR] 68721). After March 2003, the threshold for obtaining a permit was lowered to 1 acre (0.4 hectare).

As conditions of these general permits, LANL developed and implemented Stormwater Pollution Prevention Plans at industrial and construction sites. Stormwater monitoring was conducted downstream of the waste management areas (TA-54, Areas G and J, and TA-50) and in 29 locations within eight watersheds (DOE 1999a). Several new gaging stations and automated samplers have been added since 2001. Samples are analyzed and results are published biannually in the discharge monitoring reports. In addition, changes in the stormwater management program, including the status of stormwater pollution prevention plans and stormwater monitoring activities, have been reported in the annual Environmental Surveillance Reports.

Currently, DOE's strategy for managing stormwater runoff includes the following programs:

- The *NPDES Industrial Stormwater Permit Program*, which regulates stormwater runoff from industrial activities under a Multi-Sector General Permit. Stormwater monitoring and erosion controls are required at these sites.
- An integrated *Stormwater Monitoring Program* that monitors stormwater runoff on a watershed basis and at individual solid waste management units. Erosion controls are required at sites where a water quality threshold has been exceeded. LANL recently began to implement these programs in response to the 2004 Federal Facility Compliance Agreement between the EPA and DOE.
- The *NPDES Construction Stormwater Program*, which regulates stormwater from construction activities disturbing 1 acre (0.4 hectare) or more, per the EPA Construction General Permit.

Table 4–16 shows a summary of the stormwater program activity between 1999 and 2004. The current status of the program is discussed in the following sections.

Table 4–16 Summary of Stormwater Program Activity

	1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
National Pollutant Discharge Elimination System Industrial Stormwater Program							
Number of industrial activities permitted for discharge of stormwater	22	19	20	18	17	15	15
National Pollutant Discharge Elimination System Stormwater Construction Program							
Number of construction projects permitted under General Permit for Stormwater Discharges from Construction Activities	6	8	10	13	21	34	37
Number of stormwater pollution prevention plans implemented at construction sites	Not applicable	Not applicable	23 [a]	44 [a]	51 [b]	67 [b]	64 [b]
Number of stormwater pollution prevention plan inspections conducted at construction sites	Not applicable	Not applicable	Not applicable	435	675	616	833

[a] Required for construction sites disturbing 5 acres or more.
[b] Required for construction sites disturbing 1 acre or more.
Sources: LANL 1999b, 2000e, 2001f, 2002d, 2004a, 2004d, 2005h, 2006a, 2006g.

Recent data from stormwater runoff monitoring detected some contaminants onsite and offsite, but the exposure potential for these contaminants is limited (see Table 4–8). Radionuclides have been detected in runoff at higher levels than the 15 picocuries per liter livestock watering criterion in Guaje, Pueblo, Los Alamos, Mortandad, Pajarito, and Water Canyons, with sporadic detections extending offsite in Pueblo and Los Alamos Canyons. As the areas burned in the Cerro Grande Fire recovered, total suspended solids that transport radionuclides decreased along with the radionuclide concentrations. Los Alamos Canyon and Sandia Canyon runoff and base flows contain polychlorinated biphenyls at levels above New Mexico human health stream standards (NMAC 20.6.4.900.B), but polychlorinated biphenyl levels are above background levels both upstream and downstream of LANL in the Rio Grande. Dissolved copper, lead and zinc have been detected in many canyons above the New Mexico acute aquatic life stream standards, and these metals were detected offsite in Los Alamos Canyon. Some of these polychlorinated biphenyl and metals' detections were upstream of LANL facilities, which indicates that non-LANL urban runoff was one source of the contamination. Mercury was detected slightly above wildlife habitat stream standards in Los Alamos and Sandia Canyons. The installation of erosion controls near the polychlorinated biphenyl and mercury sources to minimize further migration of these contaminants is an example of the watershed-based approach to surface water quality protection. Surface water in Cañon de Valle, a tributary of Water Canyon, occasionally has explosive residue levels greater than the 6.1 parts per billion EPA Tap Water Health Advisory level, but the barium levels have dropped below the New Mexico Groundwater Standard (LANL 2005h). Other organics detected in stormwater runoff above New Mexico Water Quality Standards include benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene. Inorganics detected in stormwater runoff include aluminum, silver, arsenic, cadmium, and selenium (LANL 2006h).

NPDES Industrial Stormwater Permit Program

The NPDES Industrial Stormwater Permit Program regulates stormwater flows from industrial activities at LANL (including solid waste management units). Historically, these flows were managed under the 1995 NPDES Multi-Sector General Permit. The current EPA Multi-Sector General Permit, effective since December 2000, regulates stormwater runoff from the following conventional industrial activities at LANL:

- Hazardous waste treatment, storage, and disposal facilities (including solid waste management units);
- Landfills and land application sites;
- Steam and electric power generating facilities;
- Asphalt batch plant operations;
- Metal fabrication activities;
- Primary metal activities; and
- Vehicle maintenance activities, and warehousing.

Under the Multi-Sector General Permit, DOE maintains and implements stormwater pollution prevention plans for industrial locations; maintains and samples monitoring stations for each industrial activity; and implements best management practices to control runoff and erosion from the industrial locations (NNSA 2004b). A *Storm Water/Surface Water Pollution Prevention Best Management Practices Guidance Document* has been developed by DOE to describe these practices (LANL 1998b). As of 2005, LANL protected 25 industrial activity locations with 15 stormwater pollution prevention plans, sampled stormwater flow at over 70 monitoring stations, inspected and maintained best management practices, and published and reported monitoring results to EPA and NMED in discharge monitoring reports (LANL 2006b).

NPDES Stormwater Construction Program

At the time of the *1999 SWEIS*, stormwater from construction projects was regulated under an NPDES General Permit. EPA changed the disturbed land threshold requiring a Construction General Permit from 5 to 1 acre (2 to 0.4 hectares) in 2003, when it updated the Stormwater Construction regulations. Under the current Construction General Permit Program, permits are required for all LANL construction activities or other projects that disturb 1 acre (0.4 hectare) or more. Conditions of the permit require the development and implementation of site-specific stormwater pollution prevention plans and the use of best management practices to reduce or eliminate the potential for offsite erosion and stormwater contamination. Construction projects with stormwater pollution prevention plans are inspected regularly to ensure compliance with the terms of the Construction General Permit (LANL 2004d).

In 2004, the LANL *Engineering Standards Manual* and the *LANL Master Construction Specifications* were updated to require that all land-disturbing projects, regardless of size, control the transport of sediment and other pollutants from disturbed areas. Meeting this requirement would maintain sediment yield and stormwater runoff rates within the watershed at values equal to or less than those experienced prior to any development, significantly minimizing post-development impacts on the surrounding area. This would be accomplished by stabilizing all disturbed areas through revegetation or placement of permanent structures or other equivalent measures (asphalt, concrete, gravel), as well as managing runoff from the impermeable surfaces through permanent controls such as detention ponds with controlled outlets. Best management practices would prohibit the flow of stormwater runoff across a designated environmental restoration site (such as a potential release site, solid waste management unit, or area of concern), minimizing the potential for the transport of legacy pollutants from these areas (LANL 2004b, 2004j, 2006e). The current program protects more construction sites from erosion and contaminant transport than were covered in 1999.

Another improvement began in 2003 with the use of a geographic information system-based tracking system to help manage Construction General Permit sites. The tracking system maintains records for each construction site, such as site coordinates, inspections, conditions of best management practices, Stormwater Pollution Prevention Plan deficiencies, and deficiency corrections. Construction General Permit information for LANL is accessible to the public through postings in the Los Alamos County Municipal Building (LANL 2004d).

Information in Table 4–16 shows the increase in Stormwater Construction Program activities since the *1999 SWEIS*, including the number of permits issued, Stormwater Pollution Prevention Plans implemented, and inspections conducted.

Stormwater Monitoring from Solid Waste Management Units

The management of stormwater runoff from solid waste management units has changed significantly since the *1999 SWEIS*. From 1992 through 2003, solid waste management units were considered an industrial activity and stormwater runoff was managed under the Multi-Sector General Permit Program. Since 2003, DOE has been transitioning towards managing stormwater runoff from the solid waste management units under an individual NPDES industrial activity permit. DOE began implementing an integrated stormwater monitoring program to meet the anticipated requirements of the Federal Facility Compliance Agreement in mid-2004 and submitted the first part of an individual permit application in late 2004. The Federal Facility Compliance Agreement is an interim step for managing runoff from solid waste management units until the individual permit is issued. The Agreement was issued in 2005 and is to remain in effect until the goals of the agreement are completed. More information on the Federal Facility Compliance Agreement is provided in Chapter 6 of this SWEIS (EPA 2005a; NNSA 2004b, 2004c).

DOE's integrated stormwater program under the Federal Facility Compliance Agreement includes the following two major elements.

- A watershed-based monitoring program. This includes approximately 60 automated monitoring and gaging stations located within nine LANL watersheds. Watershed monitoring is performed under a Stormwater Monitoring Plan, which was submitted to EPA and NMED in 2004 and will be updated annually (LANL 2005f, NNSA 2004b).

- Site-specific sampling at solid waste management units and areas of concern. This program requires stormwater sampling immediately downstream of approximately 300 designated sites on a rotating basis over a four-year schedule. The program will be performed under a unit-specific stormwater pollution prevention plan.

For the watershed program, gaging stations monitor flow rates. Stormwater samples are analyzed for radionuclides, metals, polychlorinated biphenyls, dioxin and furan, high explosives, perchlorate, cyanide, and suspended sediment concentrations (EPA 2005a, LANL 2006h). The sampling data are routinely published in monthly and annual reports submitted to EPA and NMED. Monitoring results are compared to stormwater-specific screening action levels and are the basis for corrective actions, the use of best management practices, and potential source removal. Erosion control measures installed to minimize sediment transport or pollutant migration are inspected after major storm events. The plans for each program (the Stormwater Monitoring Program and the unit-specific stormwater pollution prevention plans) are updated annually to include new information and requirements to ensure continuous improvement of the program. The stormwater program information has been integrated into the geographic information system-based tracking system to help manage the monitoring sites and maintain records, including stormwater pollution prevention plan inspections, the condition of best management practices, and the progress of corrective actions.

Fully implemented in 2005, the integrated stormwater monitoring program triggers actions that will minimize erosion and the transport of pollutants from solid waste management units, and provides information on a watershed scale to identify problems that could violate New Mexico surface water quality standards. With these changes, the adverse impacts to surface water from stormwater runoff are expected to be less in the future than the impacts identified in the *1999 SWEIS* (LANL 2006e, NNSA 2004c).

4.3.1.4 Watercourse Protection

DOE conducts a variety of activities that require excavation, filling, crossing, working in, or otherwise disturbing a watercourse or wetland. These activities may be subject to Sections 401 and 404 of the Clean Water Act, commonly called the *Dredge and Fill 404 and 401 Permit Program*. A 404 and 401 permit sets specific conditions for the use of best management practices to protect water quality and to ensure compliance with New Mexico surface water quality standards (DOE 1999a). Since the *1999 SWEIS*, DOE has continued to obtain permits and comply with Sections 404 and 401 permit conditions for construction activities conducted in watercourses.

Table 4–17 shows a summary of the Clean Water Act Sections 404 and 401 permit activities between 1999 and 2004. Permitted activities typically last for less than one year.

As a result of increased runoff after the Cerro Grande Fire, DOE conducted numerous dredge and fill activities to stabilize road crossings, clean roadside culverts, and armor utility lines crossing LANL canyons. Each project was required to obtain a 404 and a 401 permit, implement stormwater pollution prevention plans and best management practices, and meet permit conditions to protect surface waters. Most of these project activities have now been completed, but the stormwater pollution prevention plans will remain in place until the sites have been stabilized (LANL 2004c).

Table 4–17 Summary of Dredge and Fill Permits Issued Each Year

	1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Dredge and Fill Permit (Section 404/401) Program							
Number of permits for dredge and fill activities in water courses	9	9	24	8	2	2	2

Sources: LANL 2006a, 2006h.

4.3.1.5 Watershed and Sediment Monitoring

DOE monitors watersheds and sediments onsite, offsite, and at regional locations. Several new onsite gaging stations and automated samplers have been added to the monitoring network since the Cerro Grande Fire. Flow records for LANL stream gages have been published annually since 1995. The most recent report is *Surface Water Data at Los Alamos National Laboratory, 2003 Water Year* (Schaull et al. 2004). Sediments are sampled from all major canyons that cross LANL (onsite and offsite), as well as from the Rio Grande and area reservoirs, along tributary canyons, in major canyons upstream and downstream of LANL, and at watercourse junctions with the Rio Grande. Detailed information about sampling activities and monitoring results are published annually in LANL Environmental Surveillance Reports.

Sediments deposited in and along canyons on the Pajarito Plateau occur as narrow bands that can be transported by surface water, effluent discharges, stormwater runoff, spills, or flooding within the canyons. Past LANL activities have resulted in contamination of sediments both onsite and downstream, primarily transported by effluent discharges from LANL outfalls and stormwater runoff (DOE 1999a). Polychlorinated biphenyls have been detected in sediments in all the major canyons that cross LANL property, with the exception of Ancho Canyon and Cañada del Buey. The highest concentrations of polychlorinated biphenyls were found in Sandia Canyon sediments below LANL's main TA. Polychlorinated biphenyls and benzo(a)pyrene were detected on a widespread basis in 2004 sediment samples. The *LANL 2004 Environmental Surveillance Report* presents maps showing the distribution and concentrations of these organic compounds. The highest concentrations of the benzo(a)pyrene were found in Los Alamos Canyon sediments near downtown Los Alamos. The highest concentrations were several times greater than EPA Region 6 screening levels for residential and industrial outdoor workers. Recent environmental restoration investigations concluded that the polycyclic aromatic hydrocarbons in this area were principally derived from urban sources, such as asphalt (LANL 2005h).

The condition of LANL stream flows and sediments has changed since 1999 as programs for monitoring sediments and watersheds have evolved and improved. Major program changes include the following:

- *Improved stormwater monitoring under the Federal Facilities Compliance Agreement*. As discussed in Section 4.3.1.3, DOE is implementing a site-wide Stormwater Monitoring Plan that prescribes an integrated, watershed-based approach for stormwater monitoring and includes controls to minimize erosion and sediment transport.

- *Redistribution of contaminated sediments following the Cerro Grande Fire*. Following the Cerro Grande Fire, contaminated sediments in canyons were transported and redistributed downstream by higher volumes of stormwater runoff from the affected areas (Ford-Schmid, Englert, and Bransford 2004). The post-fire changes to the canyons and sediments are discussed in Section 4.3.1.7.

- *Decreased discharge of effluent from LANL into canyons*. The number of outfalls discharging effluent to canyons has decreased from 36 in 1999 to 21 in 2004. Comparing 2005 operating data to 1999 data, discharges to Sandia Canyon decreased about 40 percent (85.7 million gallons [324 million liters] per year); Los Alamos Canyon discharges increased about 19 percent (about 8.4 million gallons [32 million liters] per year); discharges into Mortandad Canyon decreased about 57 percent (22.5 million gallons [85 million liters] per year); and discharges into Water Canyon decreased about 97 percent (about 13.8 million gallons [52.2 million liters] per year) (LANL 2006g).

- *Removal of contaminated sediments from Los Alamos Canyon.* In 2001, DOE removed contaminated sediment in Los Alamos Canyon, which was known to contain radionuclide contamination from LANL's past operations. Approximately 915 cubic yards (700 cubic meters) of soil and sediment were removed from a 2.5 acres (1 hectare) site, minimizing the potential for contaminant transport in the event of a flood.

Sediments in the LANL area contain naturally occurring minerals, metals, and radionuclides. Sediments also contain contaminants that are the result of historic LANL operations. The *1999 SWEIS* presented a general understanding of sediment quality with regard to the presence of radionuclides, metals, and organics, based on sampling results from 1994 through 1996. DOE continues to monitor for these constituents and has added polychlorinated biphenyls, high explosive residues, barium, and six radionuclides to the list of analyzed constituents (LANL 2005h, Gallaher and Koch 2004). Monitoring results are compared against a variety of reference standards, screening action levels, and background values as described in Table 4–7. With these improvements, DOE has a better understanding of sediment contamination in the area than in 1999.

During the 2005 monitoring season, most samples above background levels came from stormwater runoff (see the discussion of recent stormwater runoff data in Section 4.3.1.3). Sediments contaminated with radionuclides remained below residential screening action levels throughout the site, and temporary increases in plutonium-239, plutonium-240, and cesium-137 concentrations have decreased to near pre-Cerro Grande Fire levels.

4.3.1.6 Floodplains

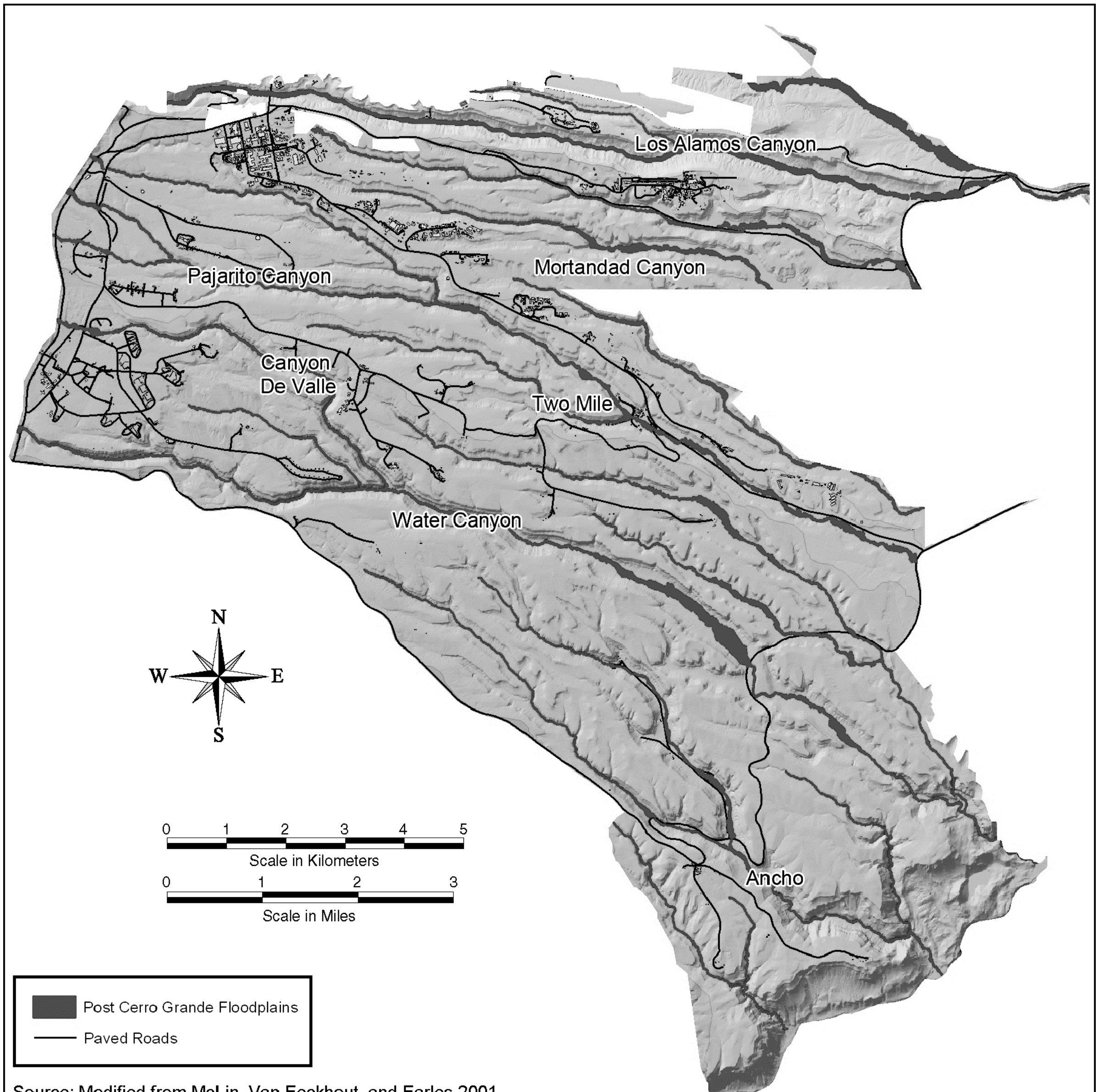
Floodplains are areas adjacent to watercourses that can become inundated with surface waters during high flows from runoff due to precipitation or snowmelt. At LANL, the floodplains are generally located in the canyons that lie between the mesa fingers (DOE 2002d). DOE regulations [10 CFR 1022.4] consider the critical action floodplain to be those areas affected during a 500-year flood (has a 0.2 percent chance of occurrence in any given year). The base floodplain, which is the floodplain considered by DOE's Resource Conservation and Recovery Act (RCRA) Permit, is the 100- year floodplain (has a 1.0 percent chance of occurrence in any given year) [40 CFR 270.14(b)(11)(iii)]. To meet the requirements of its RCRA permit, DOE delineated the 100-year floodplain boundaries within the facility in 1992 (McLin 1992). DOE considered the 100-year flood at LANL to be created by the 100-year, 6-hour storm (McLin, Van Eeckhout, and Earles 2001).

In May 2000, the Cerro Grande Fire changed the extent and elevation of the floodplains in the canyons that traverse LANL. The Cerro Grande Fire created hydrophobic soils and removed vegetation, so surface water runoff and soil erosion were greatly increased over pre-fire levels. Due to concerns about the increased potential for flooding of LANL facilities and homes down-canyon from the burned areas, several flood and sediment retention structures were constructed as part of the emergency response. These structures include:

- a flood retention structure in Pajarito Canyon to retain sediment and prevent flooding;
- a low-head weir and sediment detention basin in lower Los Alamos Canyon to retain and prevent sediments from moving offsite;
- reinforcements to the reservoir in upper Los Alamos Canyon to serve as a catchment basin for stormwater runoff and sediment.

- four road crossing reinforcements along Anchor Ranch Road in Twomile Canyon and along NM 501 at Twomile Canyon, Pajarito Canyon, and Water Canyon; and
- a steel diversion wall above TA-18 in Pajarito Canyon.

These structures will remain in place until vegetative growth returns the watershed to approximately pre-Cerro Grande Fire or at least stable conditions. When that occurs, all or part of the flood retention structure and the entire steel diversion wall above TA-18 will be removed (DOE 2002j). Due to the increased chance of flooding after the Cerro Grande Fire, the floodplain boundaries were remapped for all the major canyons within the LANL facility (see **Figure 4–15**) (McLin, Van Eeckhout, and Earles 2001).



Source: Modified from McLin, Van Eeckhout, and Earles 2001.

Figure 4–15 Post-Cerro Grande Fire Floodplains

Figure 4–15 represents a single point in time, as 4 years of vegetative growth in the burned forests west of LANL increased infiltration and reduced runoff volumes to the channels. The flood retention structures caused increased floodplain elevations upstream of the structures, and decreased flood elevations downstream. Sediment transport has altered the size and shape of the floodplains, so continued refinement of the post-fire floodplain maps is essential to determining an accurate picture of the LANL canyons (McLin, Van Eeckhout, and Earles 2001).

Using a geographic information system, LANL staff compared the post-Cerro Grande Fire floodplain files with the building location files. A list of buildings was generated including eight at TA-39 in Ancho Canyon, three at TA-41 in Los Alamos Canyon, and four at TA-72 in Los Alamos Canyon, that are completely within the post-Cerro Grande Fire 100-year floodplain boundaries. In addition, there were twelve buildings at TA-39, three buildings at TA-41, eight buildings at TA-72, one building at TA-18 in Pajarito Canyon, and one building at TA-36 in Potrillo Canyon that were partially within the post-Cerro Grande Fire 100-year floodplain boundaries. Most of these structures are small storage buildings, guard stations, well heads, water treatment stations, and some light laboratory buildings. Some facilities are characterized as moderate hazard due to the presence of sealed sources or x-ray equipment, but most have low hazard or no hazard designations. The Solution High-Energy Burst Assembly Building at TA-18 is within the 100-year floodplain, but the assembly is located there only during an experiment. The Omega West reactor is no longer located within the Los Alamos Canyon floodplain, as it was decommissioned and demolished in July 2003. There have never been waste management facilities in the 100-year floodplain (DOE 2002d; LANL 1998a, 2004c).

4.3.1.7 Overview of Cerro Grande Fire Impacts on Los Alamos Watersheds

The Cerro Grande Fire in May 2000 adversely affected the major canyons that cross LANL. The fire destroyed vegetation and changed the surface soils, causing increases in the amount of stormwater runoff entering the canyons. This increased stormwater runoff carried more soil, sediment, and ash from the entire affected watershed, including some areas at LANL that contain contaminants such as chemicals and radioactive materials (Ford-Schmid, Englert, and Bransford 2004). Sediment and ash from the burned areas of the Cerro Grande Fire have largely filled in the Los Alamos Reservoir. The reservoir now is periodically dredged to provide flood control, but it is no longer used for recreation, swimming, fishing, or irrigation (LANL 2004a). All of this raised concerns about adverse impacts to downstream water quality, as shown in Table 4–9, where selenium is listed as a probable cause of impairment due to mobilization from the Cerro Grande Fire.

Following the Cerro Grande Fire, the NMED contracted with Risk Assessment Corporation to perform a comprehensive, multi-media, analysis of risks to humans from exposure to LANL- and fire-associated contaminants (RAC 2002). One of the methods of contaminant transport analyzed was stormwater, which carried LANL- and fire-contaminated sediments and ash downstream of the LANL boundaries. After considering hypothetical exposures to radionuclides and chemicals through a variety of activities, such as farming, the report concluded that overall risks were within EPA acceptable ranges. Those findings were consistent with the conclusions of separate studies conducted by a multi-agency risk assessment team (IFRAT 2002) and by DOE (Kraig et. al. 2002).

After the Cerro Grande Fire, runoff events were monitored through the summer rainy seasons of 2000 through 2004. In 2005, DOE published two summary reports on the four years of post-fire monitoring and the resulting impacts to water quality and sediments (Gallaher and Koch 2004, LANL 2005j). The first report included results of sampling performed by DOE, as well as sampling performed by NMED and the U.S. Geological Survey. The second report is a summary of water quality and stream flow after the Cerro Grande Fire, that addresses issues raised by the after-effects of the fire (LANL 2005j). The NMED also published reports describing its findings of post-fire changes to stream flow and stormwater transport (Ford-Schmid and Englert 2004, Ford-Schmid, Englert, and Bransford 2004). A summary of the findings of these reports with regard to significant post-fire changes in runoff, sediment, and water quality is presented below.

In the first rainy season after the fire, water quality across the Los Alamos area was dominated by fire-created contaminants. By the end of the 2002 rainy season, most contaminant concentrations in surface water fell to near pre-fire levels (LANL 2004k). However, during 2003, the suspended sediment transport in downstream runoff continued to be elevated at about one order of magnitude higher than pre-fire conditions (Gallaher and Koch 2004).

Stormwater runoff increased significantly after the Cerro Grande Fire, due to the loss of vegetative cover. The first post-fire storms producing peak runoff flows in some drainages that were more than 1,000 times greater than pre-fire levels (LANL 2004a). Total runoff volumes for the year 2000 increased 50 percent over pre-fire years, and increased runoff continued in 2001, 2002, and 2003 at rates 2 to 4 times higher than pre-fire averages. In 2003, the total runoff from LANL was 2.7 times higher than pre-fire conditions, indicating that the effects from the fire are still present. Partial recovery of the area is indicated by the significantly lower peak flows and runoff yields from most drainages in 2002 and 2003. Unlike pre-fire years, most of the runoff in 2001 through 2003 was in Pueblo Canyon, where inventories of legacy contaminants are present in sediments. In 2002 and 2003, the runoff rates in areas south of Pueblo Canyon, which includes most of LANL, were similar to pre-fire conditions (Gallaher and Koch 2004). Significant urbanization of upper Pueblo Canyon may account for the continued high runoff volumes (LANL 2005j).

The most significant change after the Cerro Grande Fire was the increased concentration and transport of radionuclides, particularly plutonium-239 and plutonium-240, in stormwater runoff and sediments. This is due to higher stream flows that carry larger suspended sediment concentrations. Natural and LANL-derived radioactive particles are bound to these suspended sediments, so large floods in Pueblo Canyon, in particular, carried LANL-derived plutonium downstream. Median concentrations of total radionuclides in runoff increased 10 to 50 times from pre-fire levels, with most (95 percent or more) of the radionuclides bound to suspended sediments. LANL personnel estimate that the yearly movement of plutonium-239, and plutonium-240 beyond LANL boundaries during the 3 years after the fire increased by as much as 55 times over the previous 5-year average (LANL 2004k, 2005j; Gallaher and Koch 2004).

Plutonium has been transported beyond LANL boundaries in Pueblo Canyon, Los Alamos Canyon, and Acid Canyon. LANL-derived plutonium at levels near atmospheric fallout may have been transported 2 miles (3.2 kilometers) across the Pueblo of San Ildefonso boundary (LANL 2005h). Plutonium found in the Rio Grande riverbank and Cochiti Reservoir core sediments was analyzed using isotopic “fingerprinting” methods to determine its origin. This analysis found that about 60 percent of the Cochiti Reservoir sediment could be attributed to atmospheric fallout. The remaining 40 percent of the plutonium was primarily traceable to historic releases from the pre-1960s LANL operations in the Pueblo Canyon watershed (Gallaher and Efurd 2002).

Figures 4–16 and **4–17** show the changes in radionuclide concentrations in stormwater runoff and the increased transport of plutonium-239 and plutonium-240 in sediments compared to pre-fire levels. Concentrations of plutonium-238, plutonium-239, plutonium-240, and uranium in stormwater increased from pre-fire levels, with the most notable increase in plutonium-239, plutonium-240 concentrations from the pre-fire average of 2.3 picocuries per liter to a 2002 average of 105 picocuries per liter. The increases in plutonium-238, plutonium-239, plutonium-240, and americium-241 were attributed to contamination deposited during LANL historical operations, while cesium-137 and strontium-90 concentrations were attributed to fire-related effects and not LANL operations. By 2003, stormwater runoff from LANL contained significantly lower concentrations of radionuclides (except uranium), indicating improved conditions and reduced impacts from the Cerro Grande Fire. Uranium concentrations were attributed to runoff from LANL and from other sources (Gallaher and Koch 2004).

Downstream LANL Runoff, Pre-Cerro Grande Fire to 2003

Post-fire monitoring found that, by 2004, most flows had returned to normal conditions, so the pre- and post-fire monitoring data comparisons are limited to 2000 through 2003. Monitoring showed that storm events in 2001 through 2003 transported plutonium-contaminated sediments from Pueblo Canyon downstream into lower canyons at a level two orders of magnitude higher than pre-fire runoff (Gallaher and Koch 2004). NMED reported a similar rate of plutonium-239 and plutonium-240 transported in suspended sediments (Ford-Schmid, Englert, and Bransford 2004). From 2000 through 2003, DOE estimates that 64 millicuries of plutonium-239 and plutonium-240 were transported in suspended sediments in runoff downstream of Pueblo Canyon, representing about six percent of the inventory of plutonium in the canyon (Gallaher and Koch 2004). In comparison, NMED estimates 87 millicuries of plutonium-239 and plutonium-240 was transported between 2000 and 2002, representing about nine percent of the pre-fire plutonium inventory (Ford-Schmid, Englert, and Bransford 2004). A summary of estimated suspended transport of plutonium-239 and plutonium-240 by runoff before the Cerro Grande Fire and in the years 2000 through 2003 is presented in Figure 4–17. The total estimated plutonium-239 and plutonium-240 transported offsite in stormwater runoff was 5 microcuries in 2005 (LANL 2006h). Concentrations of americium and uranium in sediments also increased and are attributed to historic LANL activities (Gallaher and Koch 2004).

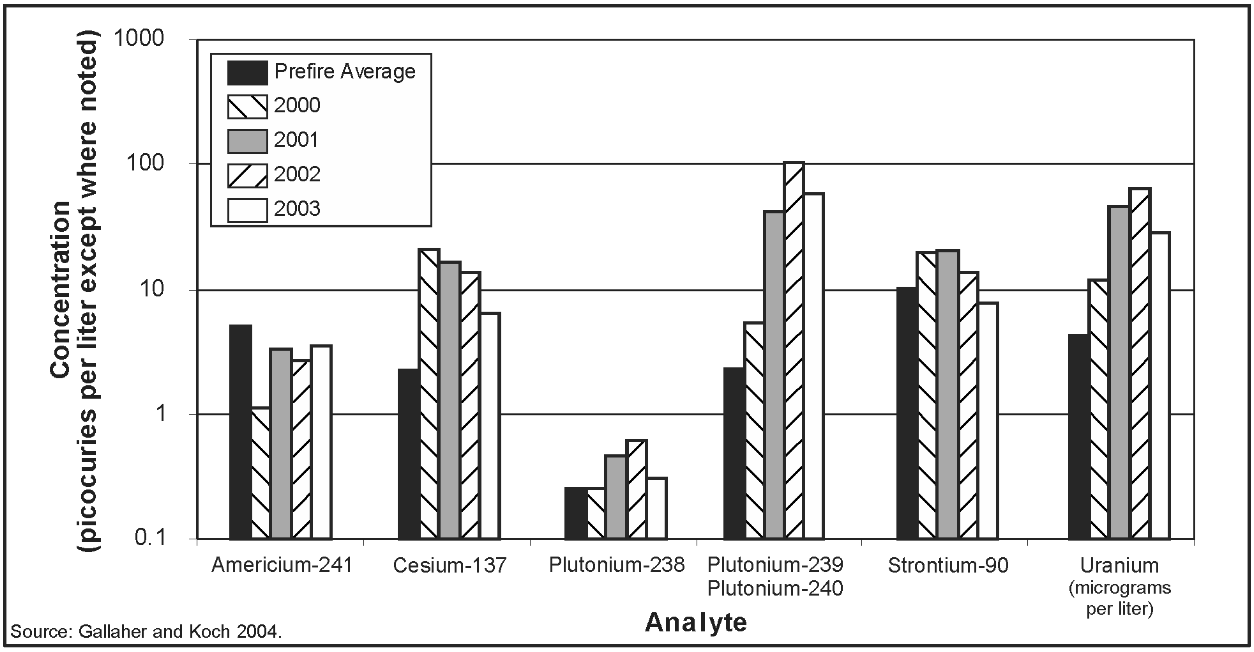


Figure 4–16 Flow-Weighted Average Concentrations of Radionuclides, Pre-Cerro Grande Fire to 2003

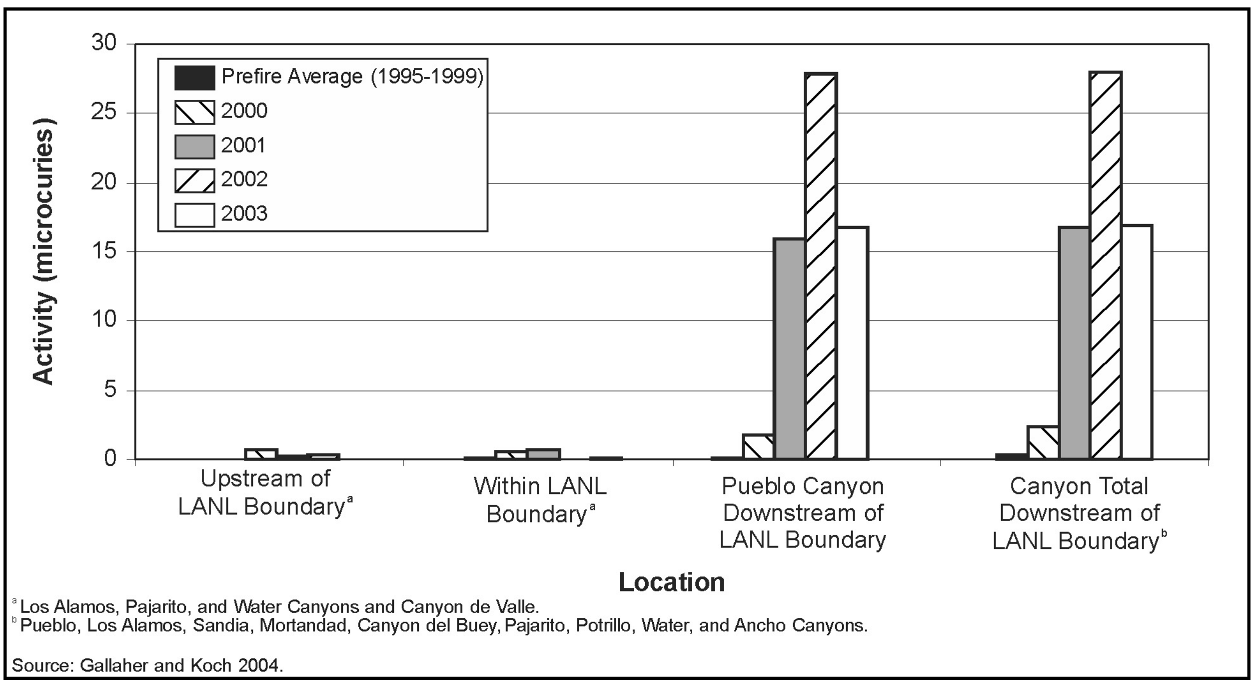


Figure 4–17 Estimated Plutonium-239 and Plutonium-240 Transported by Suspended Sediment in Runoff, Pre-Cerro Grande Fire to 2003

Post-fire stormwater runoff at LANL exceeded the applicable water standards for total gross alpha (New Mexico livestock watering standard) and the 100 millirem per year Derived Concentration Guide for plutonium-239 and plutonium-240. One runoff sample in 2000 contained plutonium-239 and plutonium-240, slightly higher than the EPA drinking water standard, so sediments were removed from the local area in 2001. A review of gross alpha results showed that concentrations at locations upstream of LANL were comparable to or higher than those within LANL. This indicates that other factors than LANL operations contributed to the high concentrations of gross alpha, which correlated with increased sediment concentrations in runoff after the fire. By 2003, the gross alpha activities in stormwater runoff were similar to those in pre-fire years. Concentrations of cesium-137, tritium, plutonium-238, strontium-90, and uranium in stormwater runoff between 2000 through 2003 remained within the applicable water quality standards. Amendable cyanide and total dissolved solids in runoff exceeded the New Mexico water quality standard in 2000 and 2001; however, amendable cyanide did not exceed standards during 2002 and 2003. Bicarbonate, calcium, cyanide, magnesium, nitrogen, phosphorous, potassium, barium, manganese, and strontium all showed elevated concentrations in post-fire runoff. The concentrations of these constituents declined progressively from 2000 through 2002 and were largely undetected in 2003 (Gallaher and Koch 2004).

Post-fire monitoring also detected metals in several locations. Total recoverable selenium was detected in many canyons at levels exceeding the New Mexico surface water stream standard for wildlife habitat of 5 micrograms per liter. Most of the selenium was probably due to non-LANL sources, because concentrations at locations upstream of LANL were comparable to or higher than those within LANL. In 2002, about 20 percent of storm runoff samples contained detectable concentrations of mercury, at levels below New Mexico short-term (acute) aquatic life standards. Spills of mercury have occurred at LANL in the past, but it remains uncertain if the mercury in the runoff is from LANL operations. Background levels of mercury in waters and sediments are appreciable. Mercury in runoff is a concern because it can enter the Rio Grande and accumulate in fish. Concentrations of mercury in Rio Grande sediments downstream of LANL were statistically similar to those measured upstream of the site. Dissolved metals concentrations in stormwater runoff were detected at concentrations greater than New Mexico groundwater standards for barium and chromium and New Mexico acute aquatic life surface water standards for copper and zinc. Because some of these higher concentrations were also found upstream or north of LANL, it is uncertain if they were due to site operations. Given the short duration of the stormwater runoff events, there is minimal opportunity for direct exposure to the water (LANL 2005h). The only metal consistently found at levels higher than New Mexico livestock watering and wildlife habitat stream standards was aluminum, which occurs naturally in soils (LANL 2005j).

With regard to changes in the Rio Grande and downstream reservoirs, LANL personnel concluded that post-fire runoff did not have an appreciable influence on flow rates or the water quality of the Rio Grande. Dissolved concentrations of radionuclides and metals in Rio Grande surface water were lower than EPA drinking water standards and comparable to pre-fire concentrations, indicating no lasting impacts to the river water from the fire. However, sediment samples collected from Cochiti Reservoir showed an increase in cesium-137, plutonium-238, and plutonium-239 concentrations from 3 to 6 times above pre-fire concentrations. These increases were attributed to the increased transport of LANL-impacted sediments from Pueblo Canyon.

Concentrations of cesium-137, plutonium-239, and plutonium-240 in the sediment were below risk-based screening levels (Gallaher and Koch 2004, LANL 2005j).

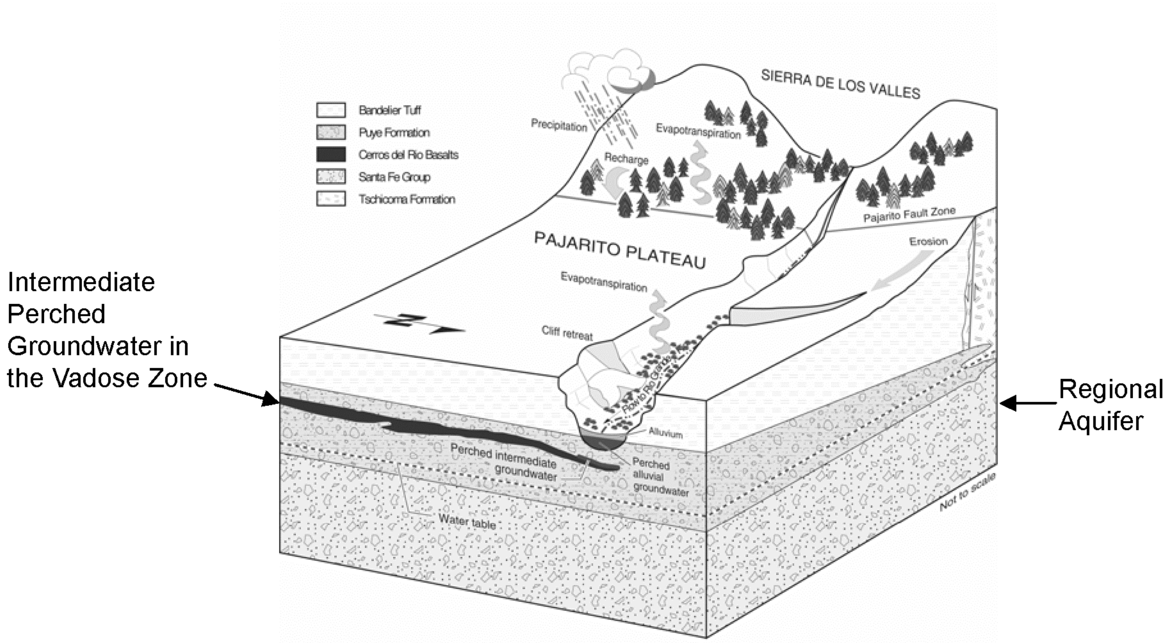
After the Cerro Grande Fire, NNSA constructed flood control structures at LANL and implemented a number of projects to control sediments and provide retention and deceleration of stormwater flows, as discussed in Section 4.3.1.6. The following projects continue to have beneficial impacts to the local canyons.

- Best management practices, including native vegetation planting and installation of jute matting, rock check dams, log silt barriers, and straw wattles, were implemented at 91 locations with possible contamination to control runoff and sediment transport.
- Contaminated sediment was removed from existing sediment traps in Mortandad Canyon, increasing the capacity of the existing traps and reducing further migration of the contamination.
- As discussed in Section 4.3.1.5, contaminated sediment was removed from areas in Los Alamos Canyon known to contain radionuclide contamination from LANL operations, minimizing the potential for contaminant transport in the event of a flood.
- The disposition of the flood control structures has not yet been determined. Options for complete or partial removal were evaluated in an Environmental Analysis document: *Proposed Future Disposition of Certain Cerro Grande Fire Flood and Sediment Retention Structures at LANL* (DOE 2002j). LANL personnel will continue monitoring and maintaining these structures until they are removed or until the affected watersheds are recovered or hydrologically stable (LANL 2004c).

Comparing post-fire and pre-fire conditions shows significant changes in the volume of stormwater runoff and sediment yield, which affects water quality. The increased stormwater flow and sediment transport is expected to diminish with time, as infiltration increases with the growth of new vegetation in the burned areas. Accelerated transport of legacy contaminants (radionuclides) occurred after the Cerro Grande Fire, with contaminated sediments moving from Pueblo Canyon into lower canyons. There are indications that stormwater runoff and sediment transport from most of the burned watersheds have improved and metal and radionuclide contaminant levels in stormwater runoff from the burned hillsides west of LANL have returned to near pre-fire levels. Sediment from these burned areas was deposited in the canyons, and erosion of this sediment continues, although the sediment load in stormwater runoff is decreasing. Watershed conditions are expected to return to pre-fire conditions by 2010 (DOE 2002j; LANL 2004d, 2005j).

4.3.2 Groundwater

Groundwater in the LANL area is located in several different places in the rocks underneath the site. **Figure 4–18** illustrates the hydrologic cycle on a typical watershed such as the Pajarito Plateau. Some precipitation runs off the ground surface into a local drainage (stormwater runoff); some soaks into the soil, where it is used by plants and released back into the atmosphere (evapotranspiration); and some infiltrates into the soil, passing through the plant root zone into the rocks, becoming part of the groundwater system (recharge).



Source: Modified from LANL 2005i.

Figure 4–18 Illustration of the Hydrologic Cycle at Los Alamos National Laboratory

The amount of rainfall in the LANL region is generally controlled by elevation. The Pajarito Plateau receives much less rainfall than the slopes of the Sierra de los Valles. Plants on the plateau use most of the water that enters the soil. Where the ground surface in the canyons is at or below the elevation of saturated layers of alluvium or rock, discharge of groundwater may occur as springs.

The three modes of groundwater occurrence are: 1) perched alluvial groundwater in canyon bottom sediments, 2) zones of intermediate-depth perched groundwater whose location is controlled by availability of recharge and by changes in rock permeability, and 3) the regional aquifer beneath the Pajarito Plateau. In wet canyons, stream runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff, maintaining shallow bodies of perched groundwater within the alluvium. If not impeded by less permeable layers, surface water will eventually reach the regional aquifer.

Underneath portions of Pueblo, Los Alamos, Mortandad, and Sandia Canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and within the underlying Puye Formation and Cerros del Rio Basalt. These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. Intermediate groundwater occurrence is controlled by availability of recharge and variations in permeability of the rocks underlying the plateau. Depths of the intermediate perched groundwater vary. For example, intermediate perched groundwater has been found a shallow as 120 feet (37 meters) in Pueblo Canyon and as deep as 750 feet (230 meters) in Mortandad Canyon.

Some intermediate perched water occurs in volcanics on the flanks of the Sierra de los Valles to the west of LANL. This water discharges at several springs (Armstead and American) and yields a significant flow from a gallery in Water Canyon. Intermediate perched water also occurs within the LANL border just east of the Sierra de los Valles, in the Bandelier Tuff at a depth of approximately 700 feet (210 meters). The source of this perched water may be infiltration from streams that discharge from canyons along the mountain front and underflow of recharge from the Sierra de los Valles. Refer to Appendix E, Section E.6.2.2, for further discussion of the occurrence of perched water.

The regional aquifer of the Los Alamos area occurs at a depth of approximately 1,200 feet (370 meters) along the western edge of the plateau and about 600 feet (180 meters) along the eastern edge. The regional aquifer lies about 1,000 feet (300 meters) beneath the mesa tops in the central part of the plateau. Water in the aquifer flows generally east or southeast toward the Rio Grande, and groundwater model studies indicate that underflow of groundwater from the Sierra de los Valles in the Jemez Mountains is the main source of recharge for the regional aquifer (Nylander et al. 2003). Groundwater flow from the Sierra de los Valles to the Pajarito Plateau may be affected by the Pajarito Fault.

Figure 4–18 illustrates the relationships between perched water, the regional groundwater table, and the rocks beneath the surface in the LANL area. About 350 to 620 feet (110 to 190 meters) of unsaturated tuff, basalt, and low moisture content sediments separate the alluvial and perched groundwater zones and the regional aquifer (LANL 2005h).

Perched groundwater occurs in alluvium (sediment deposited by streams), found in the canyon bottoms, or at greater depths in the Bandelier Tuff or Puye Formation. The zones of perched water are typically not continuous, but are created where rock layers with low permeability impede downward water movement (LANL 2005i). These rock layers vary greatly in their ability to transmit water in saturated and unsaturated states. None of these perched water zones (shallow or intermediate) provide enough water to be a source for municipal drinking water.

Runoff or effluent discharges that does not infiltrate into the mesa tops flows down the canyons, and can enter the alluvium to form an unconfined groundwater body, particularly during spring snowmelt and mid- to late-summer thunderstorms. There are major LANL discharges into Sandia, Mortandad, and Los Alamos Canyons that help create alluvial groundwater bodies below those canyons.

Deep below the ground surface, there is an area of saturation that forms the regional groundwater aquifer. The regional aquifer is the only aquifer in the area capable of serving as a municipal water supply; the regional aquifer suppliers various customers including LANL, Los Alamos County, and others located in parts of Santa Fe and Rio Arriba Counties (LANL 2005h). A regional aquifer model was created for the *1999 SWEIS* to estimate the amount of groundwater stored beneath the Pajarito Plateau. More recently developed models have focused on the amount of drawdown in the aquifer and the effects of pumping near the water supply wells for Los Alamos County. The recent regional drought would only affect water levels through increased withdrawals for water supply use, because recharge from the surface occurs at a slow rate that changes only over a period of decades. The annual drop in the water table remains at 1 to 2 feet (0.3 to 0.6 meters) per year as projected in the *1999 SWEIS*.

4.3.2.1 Flow and Transport of Groundwater

Knowledge about the mechanisms of groundwater recharge and contaminant transport into the regional aquifer has increased since the *1999 SWEIS* was prepared. Additional characterization wells have been drilled at LANL, and groundwater hydrology has been modeled as part of the Hydrogeologic Work Plan, to further understand the hydrogeology and detect contamination in the regional aquifer (LANL 2003c). Additional information on geology and hydrology in the LANL vicinity is presented in Appendix E.

The Bandelier Tuff is an important rock formation due to its resistance to downward flow and its ability to capture and hold contaminations. The tuff is a complex of several volcanic ash and pumice falls that occurred at different periods during the history of the region. The porosity, permeability, and water content of the tuff are the principal physical characteristics that affect groundwater movement. Refer to Appendix E, Section E.6.3, for additional discussion of the hydrogeologic characteristics of the Bandelier Tuff.

The chemical interaction between tuff and water is also important. Volcanic glass in the tuff captures some contaminants by chemically attaching them to mineral surfaces (adsorbing) or by taking them into the structure of the minerals themselves (absorbing). As a result, large volumes of contaminants can be trapped, some permanently and some temporarily. The combination of these physical and chemical processes in the unsaturated tuff slows the movement of some contaminants toward the regional groundwater table.

Most of the alluvium in the canyon channels is composed of weathered tuff and pumice fragments that strongly hold some of the contaminants. Some of the contaminants introduced to the canyons by LANL outfalls are held in these perched water zones by adsorption to the sediments. Lateral movement of contaminants in the canyon channels and movement of contaminants downward into local perched water bodies underlying the canyon channels are being monitored (LANL 2005i).

4.3.2.2 Groundwater Quality in the Los Alamos National Laboratory Area

Groundwater chemistry varies with some general properties of the groundwater environment, such as the acidity of the water and the chemistry of local rock. Uranium, silicon, sodium, arsenic, and other chemical constituents that are common in the volcanic rocks of the LANL area appear as natural constituents in the groundwater of the Jemez Mountains region. Of interest for regional groundwater quality are levels of contaminants larger than those expected from naturally occurring groundwater constituents.

Since the 1940s, liquid effluent disposal by DOE has degraded water quality in the shallow perched groundwater that lies beneath the floor of several canyons. These water quality impacts extend, in a few cases, to perched groundwater at depths of a few hundred feet beneath these canyons. Recharge to the regional aquifer from the shallow contaminated perched groundwater bodies occurs slowly because the perched water is separated from the regional aquifer by hundreds of feet of unsaturated rock. As a result, little contamination reaches the regional aquifer from the shallow perched groundwater bodies, and water quality impacts on the regional aquifer, although present, are small.

Groundwater Quality Standards

LANL staff currently applies regulatory standards and risk levels to evaluation of groundwater samples. Standards and risk levels exist for both radioactive and nonradioactive contaminants.

For radioactive contaminants, LANL staff compares concentrations in samples from water supply wells that draw water from the regional aquifer to (1) EPA maximum contaminant levels for public drinking water systems and (2) the derived concentration guides for ingested water calculated from DOE's 4-millirem[1] per year drinking water dose limit (see below). For risk-based radioactivity screening, groundwater samples from sources other than water supply wells are compared to EPA maximum contaminant levels and to DOE's 4-millirem drinking water derived concentration guides.

EPA's maximum contaminant levels for public drinking water systems are contained in 40 CFR Part 141 and were derived for radionuclides and nonradionuclides in accordance with the provisions of the Safe Drinking Water Act. EPA maximum contaminant levels were established on the basis of limiting the risk from consuming contaminants in the water to very small levels and are often used as a standard or for comparison purposes for groundwater protection or remediation. For radionuclides, the EPA standard limits the radiation dose to a person drinking water from a public drinking water system to 4 millirem per year from manmade radionuclides emitting beta and photon radiation. EPA maximum contaminant levels for these radionuclides represent the concentration of each radionuclide in water that would result in an annual dose of 4 millirem, assuming consumption of 2 liters of water per day. EPA has also established maximum contaminant levels for other radionuclides or for groups of radionuclides (such as alpha-emitting radionuclides). For example, the EPA maximum contaminant level for tritium is 20,000 picocuries per liter of water, while the EPA maximum contaminant level for strontium-90 is 8 picocuries per liter.

In DOE Order 5400.5, "Radiation Protection of the Public and the Environment," DOE limits the radiation dose that may be received by members of the public from all routine DOE activities to 100 millirem in a year from all pathways. DOE also limits the radiation dose to persons drinking water from a DOE-supplied system to 4 millirem per year from water consumption alone.[2] To assist in compliance with these requirements, and for screening purposes, DOE has established derived concentration guides for exposure to individual radionuclides through air and water pathways. The derived concentration guides for ingested water in DOE Order 5400.5 correspond to the concentrations of individual radionuclides in water that, if ingested at a rate of 2 liters per day, would result in an annual dose of 100 millirem (100-millirem DOE derived concentration guide). A 4-millirem derived concentration guide for a radionuclide is derived by multiplying the 100-millirem derived concentration guide for that radionuclide by 0.04 (4-millirem DOE derived concentration guide).

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[1] *A millirem is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. The dose is calculated by using radiation weighting factors and tissue weighting factors to adjust for the various types of radiation and the various tissues in the body receiving the radiation. Federal government standards limit the dose that the public may receive from operations at facilities such as LANL.*

[2] *DOE also requires operation of DOE facilities so that liquid effluents will not cause a private or public drinking water system downstream of the facility discharge to exceed the drinking water radiological limits in 40 CFR Part 141.*

For nonradioactive contaminants, the New Mexico drinking water regulations and EPA maximum contaminant levels for nonradioactive constituents apply as regulatory standards in water supply samples and may be used as risk-based screening levels for other groundwater samples.

The New Mexico Water Quality Control Commission groundwater standards apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples (NMAC 20.6.4). The toxic pollutants listed in the standards were screened at a risk level of 10^{-5} (1 chance in 100,000) for cancer-causing substances or a Hazard Index of one for non-cancer-causing substances. A Hazard Index of 1 or less indicates that no (noncancer) adverse human health effects are expected to occur. LANL staff uses the EPA Region 6 tap water screening levels to screen for New Mexico Water Quality Control Commission toxic pollutant compounds (EPA 2007a). For cancer-causing substances, because the Region 6 tap water screening levels are at a risk level of 10^{-6} (1 chance in a million), LANL staff uses 10 times these values to screen for a risk level of 10^{-5} (1 chance in 100,000). Because groundwater is a source of flow to springs and other surface waters that are used by neighboring Native American Tribes and wildlife, the standards for groundwater or the New Mexico Water Quality Control Commission surface water standards, including the wildlife habitat standards, apply to this water (LANL 2004d, NMAC 20.6.4). Examples of standards and screening levels used at LANL for nonradioactive contaminants include the 10-milligram-per-liter EPA drinking water maximum contaminant level for nitrate and the 1-milligram-per-liter New Mexico groundwater standard for molybdenum for irrigation use. The New Mexico groundwater standard for barium is 1 milligram per liter, while the EPA Region 6 tap water screening level for RDX (an explosive) is 6.1 parts per billion. For perchlorate, EPA established a drinking water equivalent level of 24.5 milligram per liter in 2006 (LANL 2006h).

Groundwater Monitoring Program

The March 1, 2005, Compliance Order on Consent (Consent Order) specifies the process for conducting groundwater monitoring at LANL and requires submittal of an Interim Facility Groundwater Monitoring Plan (Interim Plan) to NMED for approval. Prior to approval of this Interim Plan in June 2006, LANL staff expanded the number of groundwater locations monitored during 2005 to comply with the draft Consent Order. As the result of the Consent Order, DOE is changing the focus to watershed-specific investigations to find groundwater contamination and contaminant transport mechanisms.

From 1998 through 2004, 25 monitoring wells reaching to the regional aquifer were constructed. Additionally, six intermediate-depth wells were drilled (LANL 2005i).

By the end of 2005, 21 additional characterization wells were drilled using air rotary in the vadose zone and water, foam, mud, or EZ-MUD (a polymer) rotary in the saturated zone. Geologic cores were collected in the upper vadose zone in some of the wells. Geologic cuttings were collected at defined intervals during the drilling operations, and geophysical logging was conducted in each well to enhance understanding of the stratigraphy and rock characteristics (LANL 2006h).

Seven intermediate-depth wells were also installed on LANL property in and adjacent to Mortandad Canyon to improve the conceptual model of the geology, hydrogeology, and hydrochemistry of the area. The data collected from these intermediate wells will be used for numerical modeling studies addressing contaminant migration in the vadose (unsaturated) zone (LANL 2006h).

Sampling in 2006 indicated that chromium contamination is present in the regional aquifer in a limited area beneath Sandia and Mortandad Canyons and in perched groundwater beneath Mortandad Canyon. Chromium contamination was not detected in water-supply wells. In recognition of these results, the LANL contractor prepared an *Interim Measures Work Plan for Chromium Contamination in Groundwater* (LANL 2006d). The goals of the work plan are to:

- Determine the primary sources of chromium contamination and the nature of operations associated with the releases;
- Characterize the present-day spatial distribution of chromium and related constituents;
- Collect data to evaluate the geochemical and physical/hydrologic processes that govern chromium transport; and
- Collect and evaluate data to help guide subsequent investigations and remedy selection.

To accomplish these goals, work plan activities include:

- Conducting quarterly sampling of selected regional aquifer and intermediate groundwater wells;
- Investigating surface water and alluvial groundwater loss in Sandia Canyon;
- Installing six core holes in lower Sandia Canyon;
- Installing five alluvial wells in lower Sandia Canyon;
- Determining chromium distributions in the upper vadose zone from archival and new cores collected from Los Alamos, Sandia, and Mortandad Canyons;
- Rehabilitating well R-12 in lower Sandia Canyon;
- Refining the understanding of background concentrations and speciation of chromium in groundwater; and
- Collecting and synthesizing data and information to support conceptual model development and remedy selection.

Results of monitoring for contamination of environmental media around LANL are reported annually in LANL environmental surveillance reports. Contamination detected in monitoring samples reflects worldwide fallout of radioactive particles from nuclear weapons testing; nuclear accidents such as Chernobyl; releases from industrial, commercial, medical, and household uses of chemicals and radionuclides; and releases from decades of activities at LANL. Some contaminants are present onsite at levels above applicable standards and guidelines. Elevated levels are investigated to confirm the validity of the results, determine the source and extent of the contamination, and evaluate needed control and cleanup technologies.

Perched Alluvial and Intermediate-Depth Groundwater

Perched alluvial and intermediate-depth groundwaters are not used as drinking water supplies. The following review of sampling results is taken from the 2005 LANL environmental surveillance report (LANL 2006h).

The discharge of radioactive effluents has caused alluvial groundwater contamination in DP, Los Alamos, and Mortandad Canyons. Strontium-90 is consistently measured in these canyons at levels above its 8-picocuries-per-liter EPA drinking water maximum contaminant level. Mortandad Canyon also has a localized groundwater concentration of plutonium-238, plutonium-239, plutonium-240, and americium-241 above the 4-millirem DOE derived concentration guide for these radionuclides. Mortandad Canyon is the only location where in the mid 1990s, tritium was detected above the 20,000-picocuries per liter EPA drinking water maximum contaminant level; measured levels dropped below this standard in 2001, and have been dropping steadily since then. None of the radionuclide levels exceeded the 100-millirem-per-year DOE derived concentration guide for public dose from all pathways (LANL 2004d, 2005h).

In Pueblo Canyon, samples from one intermediate well contained 944 picocuries per liter of tritium. Tritium concentrations in other intermediate well samples ranged from nondetectable to 34 picocuries per liter. Samples from all four alluvial wells in Pueblo Canyon indicated strontium-90 in concentrations ranging from 6 percent to 14 percent of the 8 picocuries per liter EPA drinking water maximum contaminant level. Three wells had detectable levels of plutonium-239 and -240. In Los Alamos Canyon, samples from two intermediate wells that are downstream from a former radioactive liquid waste discharge into DP Canyon contained 4,300 and 890 picocuries per liter of tritium.

In DP and Los Alamos Canyons, alluvial groundwater samples showed strontium-90 in concentrations above the 8-picocuries per liter EPA drinking water maximum contaminant level, while in DP Spring, the strontium-90 concentrations were above the 4-millirem DOE derived concentration guide screening level. Other LANL-derived radionuclides were found in alluvial groundwater, but in concentrations well below the 4-millirem DOE derived concentration guide screening level. Since the cessation of discharges, tritium concentrations in alluvial groundwater samples from DP and Los Alamos Canyons have fallen to levels between 80 and 200 picocuries per liter. Plutonium-238 concentrations in samples from lower Los Alamos Canyon were just above the detection limit for this radionuclide.

Tritium was found in four wells in intermediate groundwater in Mortandad Canyon in concentrations ranging from 4,300 to 23,500 picocuries per liter. Upstream toward the effluent discharge location the tritium concentration was 136 picocuries per liter. Technetium-99 was detected in three wells in concentrations ranging from 2.6 to 7.9 picocuries per liter.

Radionuclide levels in Mortandad Canyon alluvial groundwater (which is not a source of drinking water) were, in general, highest in samples nearest to the TA-50 Radioactive Liquid Waste Treatment Facility outfall. In years prior to 2005, the concentrations of strontium-90, plutonium-238, plutonium-239 and -240, and americium-241 exceeded the 4-millirem DOE derived concentration guides for these radionuclides. In 2005, results for the following radionuclides were near or above their 4-millirem DOE derived concentration guide screening levels: strontium-90; total uranium (likely an outlier, it was not supported by a laboratory replicate); and unfiltered americium-241, plutonium-238, and plutonium-239 and -240. The strontium-90 levels were above the EPA drinking water maximum contaminant level by a factor of up to 5.4.

In Pajarito Canyon, tritium was found at a concentration of 60 picocuries per liter in an intermediate-depth borehole near the eastern LANL boundary. No LANL-derived radionuclides were found in samples from five intermediate springs in the canyon.

In the intermediate perched zone of the Water Canyon watershed, tritium was detected in three wells and in several springs. Concentrations ranged from 7 to 68 picocuries per liter for the wells and from 70 to 195 picocuries per liter for the springs. Plutonium-239 and -240 were found in concentrations just above the analytical method detection limit in one unfiltered sample from a well in an intermediate perched zone, but not in the filtered sample.

Until new treatment methods were installed in 1999 to remove nitrate and in 2002 to remove perchlorate, discharges from the Radioactive Liquid Waste Treatment Facility caused high levels of nitrate and perchlorate in both alluvial and intermediate perched groundwater in Mortandad Canyon. In 2003 and 2004, nitrate levels were below the 10-milligram-per-liter EPA maximum contaminant level in alluvial groundwater samples in Mortandad Canyon, after being close to or exceeding that level in previous years. Nitrate concentrations in Pueblo Canyon have been in the vicinity of the nitrate maximum contaminant level in recent years.

Perchlorate was detected in four Mortandad Canyon wells in concentrations ranging from 81 to 256 micrograms per liter. EPA has not established a drinking water standard for perchlorate, but in January 2006, established a Drinking Water Equivalent Value of 24.5 micrograms per liter. Perchlorate was detected in all groundwater zones in Mortandad Canyon in 2005 in Pueblo Canyon off the LANL site, and just above the perchlorate background level (0.08 micrograms per liter) in the alluvial groundwater in Cañon de Valle. Sample concentrations of perchlorate in Mortandad Canyon alluvial and intermediate groundwater exceeded the EPA Drinking Water Equivalent Value.

Perchlorate concentrations in alluvial wells in Pueblo Canyon ranged from nondetectable to 1.9 micrograms per liter. Perchlorate values from the intermediate zone were nondetectable or background, except for a sample result of 1.5 micrograms per liter from one well. In Los Alamos Canyon, samples from intermediate-depth wells contained 8.1 and 2.5 micrograms per liter of perchlorate. In Sandia Canyon, perchlorate was not detected in samples from the intermediate groundwater.

Except for Bulldog Spring, perchlorate was found at background levels in intermediate waters in Pajarito Canyon. The Bulldog Spring perchlorate concentration was 0.6 micrograms per liter. Sampling results for alluvial springs and wells showed that perchlorate was either not detected or within background ranges.

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[3] *Several of the newer monitoring wells are equipped with ports so that groundwater can be monitored at different depths.*

Perchlorate in the Water Canyon watershed intermediate wells and springs in the intermediate perched zones ranged from not detected to below background (0.58 micrograms per liter) for the wells and slightly above background (0.74 micrograms per liter) for the springs.

The chemical 1,4-dioxane was detected in two wells sampled from the perched intermediate zone in Mortandad Canyon. Although there is no Federal or state standard for 1,4-dioxane, LANL and NMED are working to determine the extent and impact of this contaminant.

Recently sampled perched water from intermediate and regional aquifer wells within the Mortandad, Los Alamos, and Sandia watersheds showed increasing concentrations of total dissolved chromium.

In Water Canyon, chromium concentrations were high in unfiltered samples and nickel concentrations were high in filtered and unfiltered samples taken from intermediate depths. At a depth of 755 feet (230 meters) below ground surface, unfiltered chromium concentrations ranged from 17 to 45 micrograms per liter; except in 2005 when the measured concentration was 153 micrograms per liter. The filtered chromium concentration at the same well and depth ranged from 0.8 micrograms to 6.2 micrograms per liter. If the values for filtered and unfiltered chromium were similar, which was not the case, it would indicate the presence of hexavalent chromium. At a depth of 892 feet (272 meters) below ground surface, unfiltered concentrations of chromium ranged from 6.7 micrograms to 35 micrograms per liter, except in 2005, when the value was 70 micrograms per liter. At the same well and depth, filtered chromium concentrations ranged between 0.7 and 1.9 micrograms per liter. These concentrations are less than the New Mexico standard of 50 micrograms per liter for chromium in filtered samples. For nickel, recent (2005) filtered concentrations at depths of 758 and 892 feet (231 and 272 meters) below ground surface were 720 micrograms and 520 micrograms per liter, respectively. The EPA maximum contaminant level for nickel is 100 micrograms per liter.

Samples from Test Well 1A in Pueblo Canyon, an older intermediate well, showed high iron, manganese, lead, and zinc concentrations related to rust and flaking from aging well components. Molybdenum is found in Los Alamos Canyon alluvial groundwater resulting from treatment chemicals no longer used in TA-53 cooling towers. Levels of molybdenum in the alluvial groundwater have been quite variable in recent years, perhaps because of large variations in stream flow caused by drought conditions. Barium and RDX (an explosive) are present in alluvial groundwater of Cañon de Valle in concentrations exceeding the New Mexico groundwater standard of 1 milligram per liter and the EPA Region 6 screening level of 6.1 parts per billion, respectively (LANL 2004d).

Regional Groundwater Quality

Water produced by regional aquifer wells at LANL continues to meet Federal and state drinking water standards, but contaminants reaching the regional aquifer have been documented (LANL 2005i). Naturally occurring uranium is the primary radionuclide detected in the regional aquifer and has been found in concentrations near the EPA drinking water maximum contaminant level of 30 micrograms per liter. Tritium is present at trace levels beneath Pueblo, Los Alamos, and Sandia Canyons. Tritium concentrations in Pueblo Canyon regional aquifer monitoring wells increased downstream, from nondetection at Test Well 4 (above a former outfall of radioactive wastewater in Acid Canyon, a tributary to Pueblo Canyon) to 117 picocuries per liter at Test Well 1 (near Otowi-1). Tritium in the former supply well Otowi-1 was measured at a concentration of 33 picocuries per liter. In Los Alamos Canyon, sample results indicated tritium concentrations up to 14.9 picocuries per liter (LANL 2006h).

Beneath Mortandad Canyon, a sample result from a regional aquifer well showed a technetium-99 concentration of 5.24 picocuries per liter, which is smaller than the 4-millirem DOE derived concentration guide of 4,000 picocuries per liter. After reanalysis, technetium-99 was not detected in three other samples from this well. Samples from another well showed that tritium concentrations increased from 2 picocuries per liter in 2000 to 31 picocuries per liter in 2005. This was attributed to some contribution of recent recharge to the regional aquifer. Samples from another well indicated tritium in concentrations up to 181 picocuries per liter. No other regional aquifer well in Mortandad Canyon had repeatable low-detection limit detections of tritium (the method detection limit is about 1 picocurie per liter).

Water supply wells on the mesa top south of Cañada del Buey had one sampling event in 2005. Tritium was detected in one sample, but was not detected in a reanalysis.

In 2005, samples from supply well PM-2 in Pajarito Canyon did not contain tritium detectable by the low-detection-limit method. Two apparent detections of DOE-derived radionuclides (cobalt-60 and combined plutonium-239 and -240) were found in Pajarito Canyon regional aquifer well samples. The cobalt-60 results are inconsistent with other data from two sampling events in 2005. Plutonium-239 and -240 detected in a filtered sample was not detected in the corresponding unfiltered sample, or in two reanalyses of the filtered sample. Samples from the only regional well in Pajarito Canyon that indicated tritium (well R-22, east of the low-level radioactive waste management facility MDA G) showed results of 2 to 3 picocuries per liter from 5 upper well screens and 11 picocuries per liter at the deepest well screens.

No tritium was found in any regional aquifer samples within the Water Canyon watershed. In Ancho Canyon, strontium-90 was found at a concentration slightly above its detection limit in a field blank and in one sample from a depth of 670 feet (204 meters) below ground surface. Strontium-90 was not detected in a filtered sample.

Perchlorate has been detected in the regional aquifer beneath Pueblo and Mortandad Canyons, with a few sample concentrations reaching as high as 6 parts per billion, and is present in concentrations smaller than 1 part per billion in groundwater throughout northern New Mexico. Perchlorate was detected in the regional aquifer in supply well Otowi-1 in Pueblo Canyon. Supply well Otowi-1 was taken off line because sample results indicated concentrations of perchlorate that averaged one tenth of the EPA Drinking Water Equivalent Value (or about 2.45 micrograms per liter). Perchlorate in a Los Alamos Canyon sample was 0.98 micrograms per liter, while samples from other regional aquifer and supply wells in Los Alamos Canyon were at background levels (smaller than 0.6 micrograms per liter). The PCB compound Aroclor-1254 was found in one sample, but was not found in any of the four samples collected during the previous year and is most likely an analytical artifact (LANL 2006h).

Samples from Sandia Canyon regional wells showed perchlorate concentrations in the range of 0.77 and 0.62 micrograms per liter, or slightly above the background range. Samples from supply wells PM-1 and PM-3 showed concentrations of about 0.42 micrograms per liter, also within the background range. Perchlorate in the regional aquifer below Mortandad Canyon has increased from less than 5 to 7 micrograms per liter. This increase was attributed to the lingering effects of well installation caused by the addition of water during drilling or well development or some change of concentration within the surrounding groundwater during this time. In other regional aquifer wells in Mortandad Canyon, perchlorate sample results were smaller than 0.5 micrograms per liter. Sampling at water supply wells PM-4 and PM-5 indicated a perchlorate presence of 0.34 micrograms per liter. This result was unchanged from previous samples and was similar to samples from other water supply wells in northern New Mexico.

In 2005, samples from supply well PM-2 in Pajarito Canyon showed an average perchlorate concentration of 0.31 micrograms per liter for six perchlorate analyses. These results were similar to prior data. Perchlorate was within its background range in samples from a regional aquifer well in the same canyon. Perchlorate concentrations in Water Canyon watershed samples were either not detected or were smaller than 0.31 micrograms per liter (background). Perchlorate in samples from a regional well located in Ancho Canyon was either not detected or was within the background range.

Samples from Water Canyon have shown elevated levels of the explosives compounds RDX and trinitrotoluene (TNT), as well as the organic solvents perchloroethylene and trichloroethylene. These solvents were found at levels near EPA Region 6 tap water screening levels, but slightly below EPA maximum contaminant levels (LANL 2004c, 2006h).

Naturally-occurring arsenic is present in Guaje Canyon wells in concentrations smaller than the EPA maximum contaminant levels. Several of the newer regional aquifer wells had high levels of aluminum, iron, and manganese due to drilling fluid or turbidity effects in samples.

On December 23, 2005, DOE notified NMED that samples collected in May, September, and November of 2005 from the regional aquifer in Mortandad Canyon contained chromium concentrations between 375 and 404 parts per billion. This exceeds the New Mexico Water Quality Control Commission standard of 50 parts per billion and the EPA maximum contaminant level of 100 parts per billion (Bearzi 2005). NMED directed DOE to provide an Interim Measures Work Plan. The plan was to provide a detailed assessment of hydraulic properties of the regional aquifer from data obtained from wells in Mortandad and Sandia Canyons and from monitoring wells in Los Alamos and Pajarito Canyons. Also, NMED required assessments of historical pumping, groundwater gradients, and effluent discharges. DOE was required to report the results of geochemical and geophysical studies related to the investigations, investigate surface water and alluvial water loss to the subsurface, and provide groundwater sampling plans.

An interim measures investigation was conducted by LANL and reported in November 2006 in accordance with the Consent Order. The report describes work performed to address chromium contamination problems in the groundwater at LANL and to ensure the protection of drinking water while long-term measures are being evaluated and implemented. Results of the investigation indicate that, although the predominant zone of infiltration into the vadose zone occurs in the middle reaches of Sandia Canyon, water-balance calculations show that infiltration may occur further up the canyon than initially thought (LANL 2006k).

Regional groundwater sampling data from monitoring wells and production wells showed that wells R-11 and R-28 have the highest levels of hexavalent chromium contamination (derived from past laboratory activities, primarily effluent from cooling-water systems). The highest concentration of total dissolved chromium was sampled at regional aquifer monitoring well R-28 in Mortandad Canyon, where the concentration increased from 375 to 428 micrograms per liter in filtered samples collected in 2005 and 2006. The hexavalent chromium concentration ranged from 376 to 423 micrograms per liter. The concentration of total dissolved chromium measured in regional aquifer monitoring well R-11 in Sandia Canyon increased from 18.4 to 29.4 micrograms per liter in samples collected during 2005 and 2006. The increasing concentrations imply that these wells may be on the leading edge of a chromium plume (LANL 2006k). Other wells may have slightly elevated chromium levels, but further assessments are required. Two deep wells are planned and the need for deep drilling is to be assessed as part of the next phase of the work plan. The focus will be on the nature and extent of all contamination and will not be limited to chromium (LANL 2006k).

Filtered samples collected at well R-15 showed concentrations of total dissolved chromium ranging from 2.6 to 7.9 micrograms per liter. Concentrations of hexavalent chromium in samples collected on January 30, 2006, ranged from 7 (filtered) to 7.1 (unfiltered) micrograms per liter. These results were slightly elevated for total dissolved chromium and hexavalent chromium compared to background concentrations for the regional aquifer. Detectable concentrations of total dissolved chromium and hexavalent chromium in samples collected from other wells ranged from 2.73 to 12.3 micrograms per liter for unfiltered samples and from 0.93 to 8.2 micrograms per liter for filtered samples (LANL 2006k). Hexavalent chromium concentrations in samples from a regional aquifer well in Sandia Canyon averaged 20 micrograms per liter in both filtered and unfiltered samples.

Chromium was found at 31.4 micrograms per liter in an unfiltered sample obtained from a well in Pajarito Canyon, at a depth of 907 feet below ground surface, but was found at 1.8 micrograms per liter in the filtered sample. Because prior unfiltered samples ranged from nondetectable to 3.2 micrograms per liter, the 2005 LANL Environmental Surveillance Report states that, "this latest unfiltered chromium result does not yet lend itself to a pattern that can be evaluated," (LANL 2006h).

4.4 Air Quality and Noise

4.4.1 Climatology and Meteorology

The LANL area climate is described in the *1999 SWEIS*. Changes in the meteorological data collection system at LANL and the meteorological data summary are discussed in this section, based on information in the *Information Document In Support of the Five-Year Review and Supplement Analysis for the Los Alamos National Laboratory Site-Wide Environmental Impact Statement* (LANL 2004c).

Climatological averages for atmospheric variables such as temperature, pressure, winds, and precipitation presented in this subsection are based on observations made at the official LANL meteorological weather station from 1971 to 2000. The current official weather station, which has five sample heights (4, 37.5, 75, 150, and 300 feet [1.2, 11, 23, 46, and 92 meters]), is located at TA-6 (LANL 2004c). Five other meteorological towers are also used at LANL. The locations of all six meteorological towers are shown in **Figure 4–19**.

Normal (30-year mean) minimum and maximum temperatures for the communities of Los Alamos and White Rock and Los Alamos Townsite temperature extremes are reported in the *1999 SWEIS*. Average rainfall and snowfall extremes are also reported in the *1999 SWEIS*. Normal (30-year mean) precipitation for the communities of Los Alamos and White Rock (see **Figure 4–20**) and the extremes of precipitation are unchanged for the expanded period 1971 through 2000 (DOE 1999a, LANL 2004c).

Figure 4–19 Los Alamos National Laboratory Meteorological Network

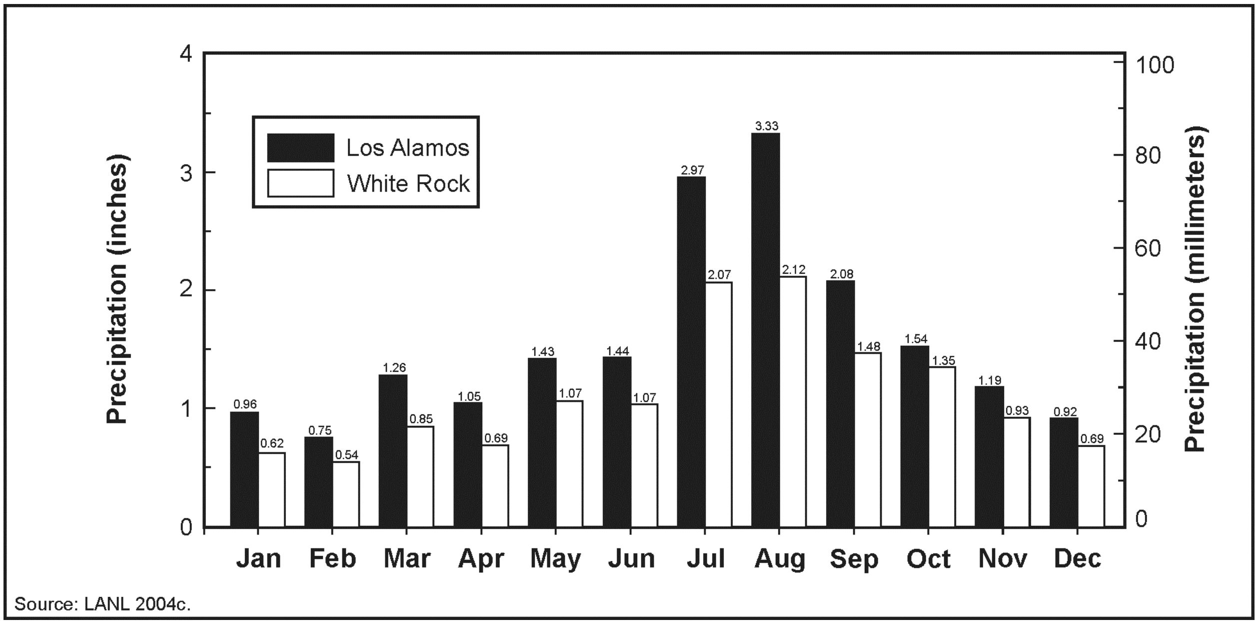

Figure 4–20 Los Alamos Area Mean Precipitation (1971 to 2000)

Since preparation of the *1999 SWEIS*, perhaps the most widespread and pervasive change in the region has been drought. LANL precipitation records show that between 1995 and 2004 there was only 1 year (1997) with above average precipitation. Precipitation patterns leading into the recent drought are strikingly similar, but of greater duration, to the period from 1953 to 1956, commonly referred to as the 1950s drought. The 1950s drought consisted of 4 years of progressively declining rainfall, with a sharp increase in precipitation in 1957 that ended the drought. The recent drought has been partially responsible for several disturbances that have greatly affected the regional environment. Dry weather facilitated the Cerro Grande Fire in May 2000, and set the stage for the bark beetle infestation that started around the summer of 2002 (LANL 2004c). Precipitation in 2004 was close to average, and in 2005 it was above average; however, there was a return to drought conditions toward the end of the year (LANL 2005h, 2006h).

4.4.1.1 Wind Conditions

Wind speed, direction, and turbulence are pertinent to air quality analysis. Los Alamos County winds average 7 miles per hour (3 meters per second). Wind speeds vary seasonally, 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 the region's complex terrain. Average wind direction and wind speed for the four primary measurement stations are plotted in wind roses and are presented in **Figures 4–21, 4–22**, and **4–23**. **Figure 4–24** presents the same wind information for the LANL measurement site on Pajarito Mountain and in Los Alamos Canyon at TA-41. For all stations except Pajarito Mountain, the data plotted are from 1996 through 2000. Pajarito Mountain's data spans 1998 through 2000. 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 (LANL 2004c).

In addition to seasonal changes in wind conditions, surface winds often vary with the time of day. An up-slope air flow can develop 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 (LANL 2004c).

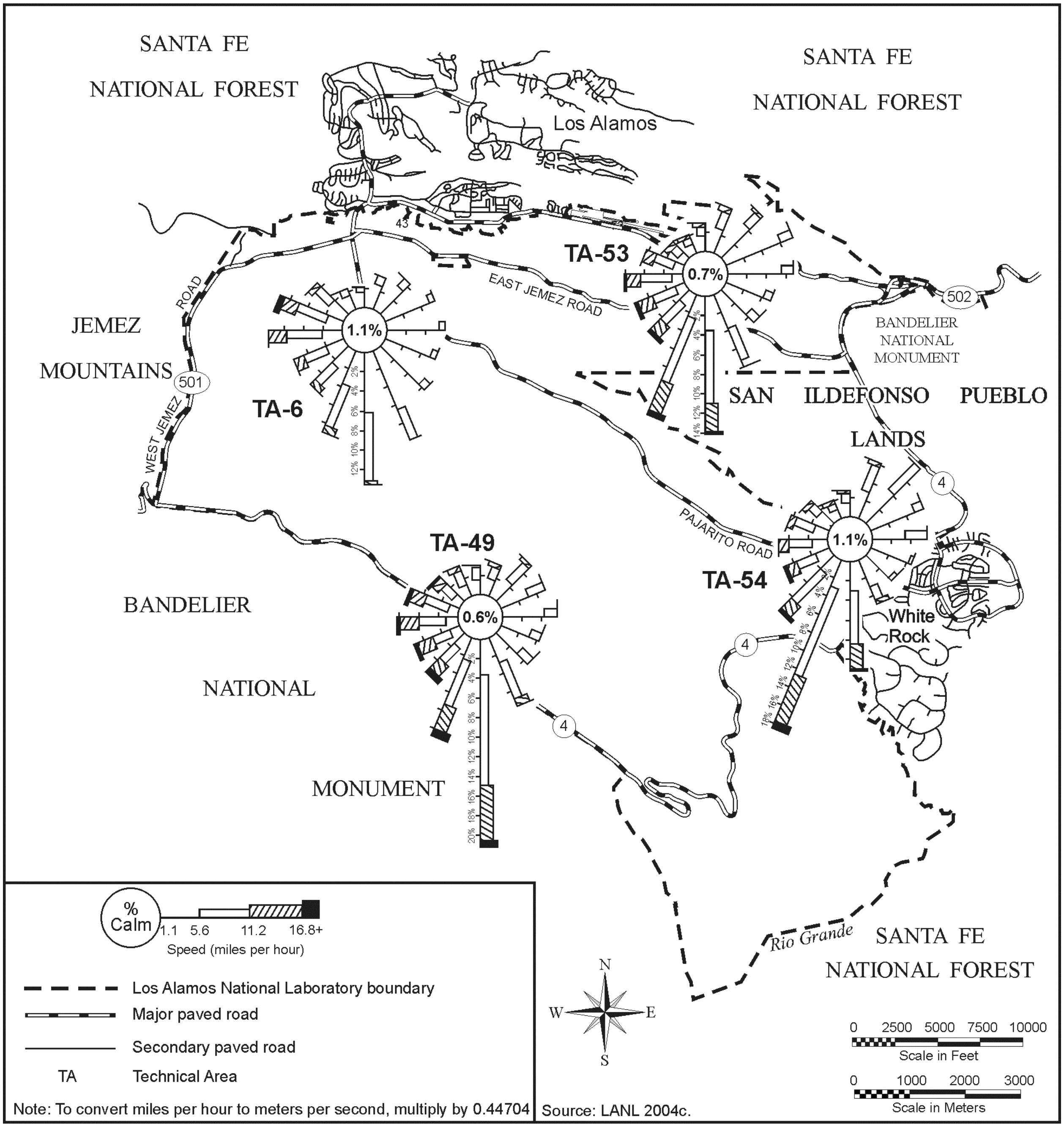

Figure 4–21 Los Alamos National Laboratory Meteorological Stations with Daytime Wind Rose Data

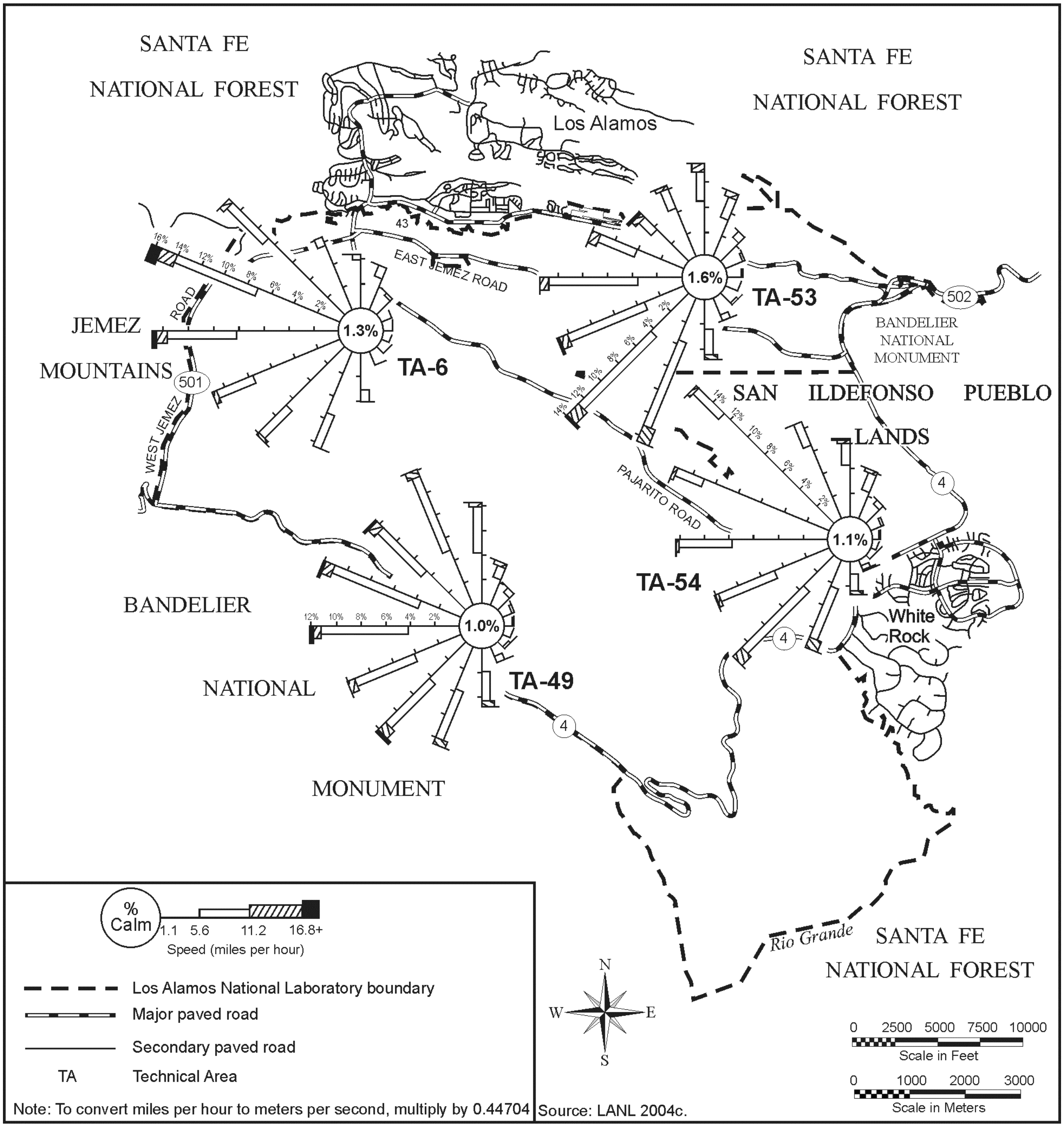

Figure 4–22 Los Alamos National Laboratory Meteorological Stations with Nighttime Wind Rose Data

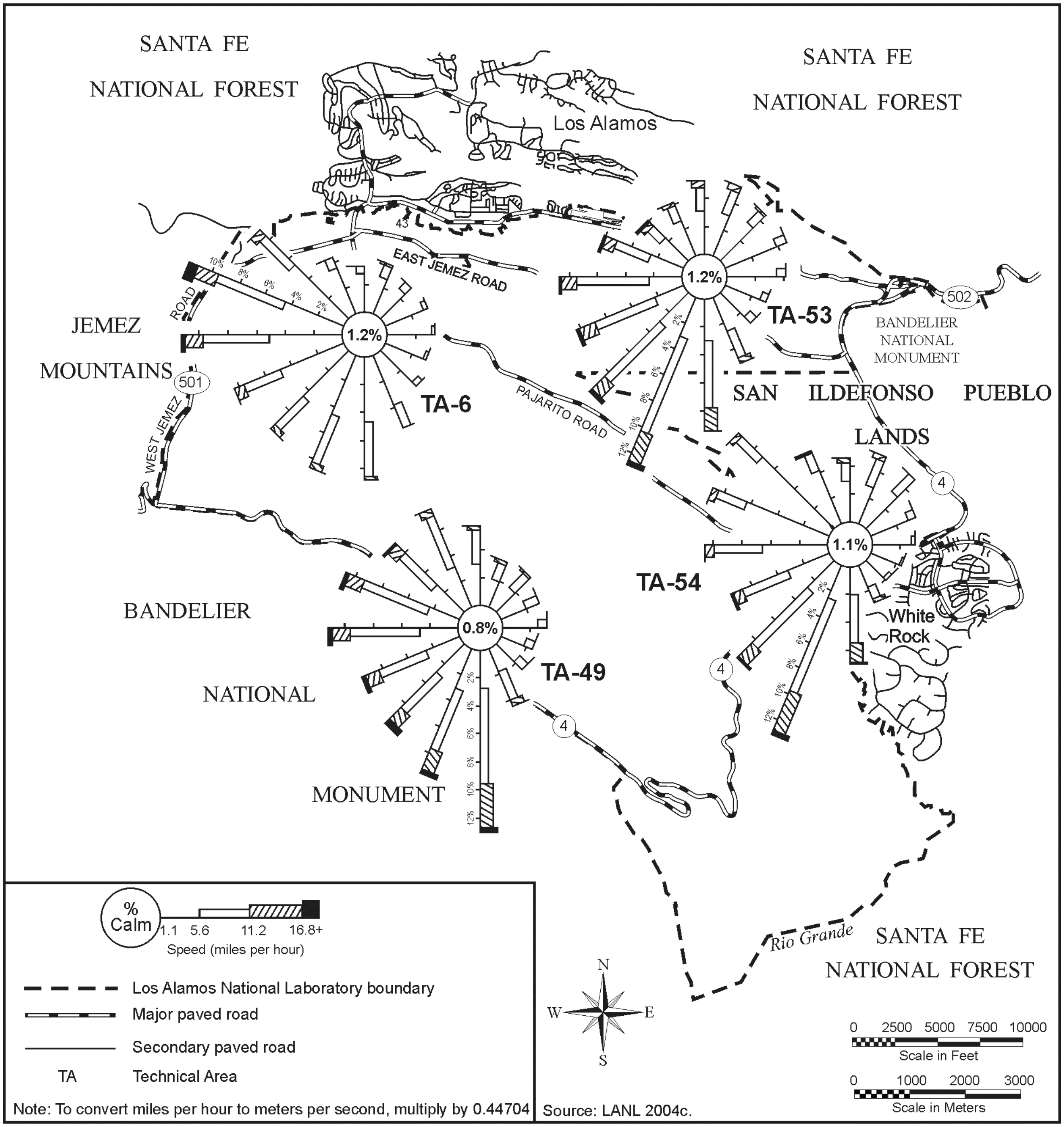

Figure 4–23 Los Alamos National Laboratory Meteorological Stations with Total Wind Rose Data

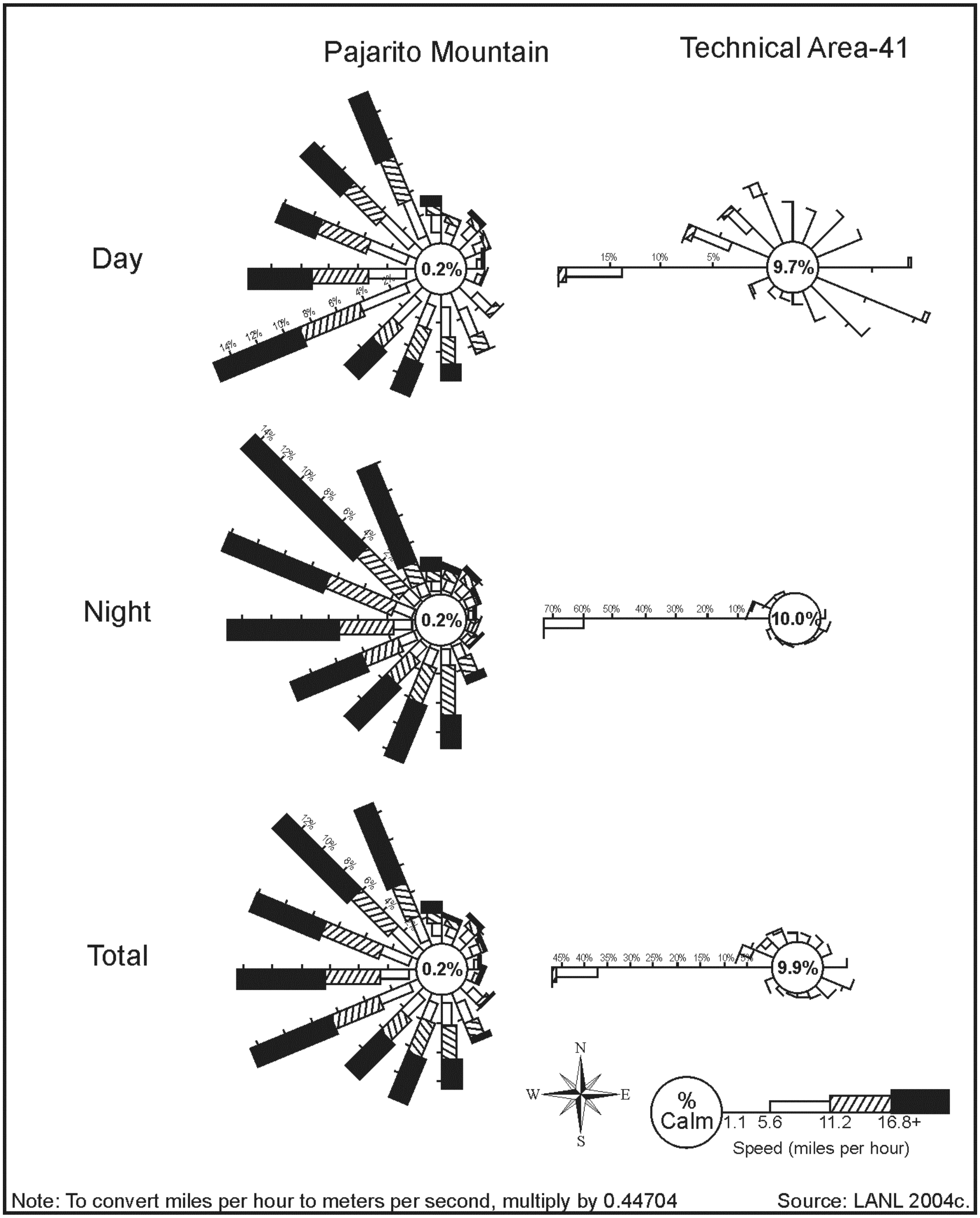

Figure 4–24 Pajarito Mountain and Technical Area 41 Associated Wind Rose Data

Analyses of Los Alamos Canyon wind data indicate a difference between the air flow in the canyon and the air 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. But, a turbulent longitudinal whirl or "rotor" that fills the canyon can develop when the wind over the Pajarito Plateau has a strong cross-canyon component (LANL 2004c).

The irregular and complex terrain and rough forest surfaces in the region 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 region's canyons channel the air flow which limits dispersion (LANL 2004c).

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. Inversions are most severe during the night and early morning. Overall dispersion is greater with strong winds in the spring. However, vertical dispersion is greatest during summer afternoons. Deep vertical mixing occurs in the summer afternoons, lowering concentrations near the surface (LANL 2004c).

4.4.1.2 Severe Weather

Thunderstorm and hailstorm frequency and occurrences of other severe weather events are discussed in the *1999 SWEIS*. An average of 60 thunderstorms occurs in Los Alamos County in a year. Hailstorms occur frequently with measurable accumulations.

4.4.2 Nonradiological Air Quality

LANL operations can result in the release of nonradiological air pollutants that can affect the air quality of the surrounding area. Information regarding the applicable air quality standards and guidelines and existing nonradiological air quality are presented in this section.

4.4.2.1 Applicable Requirements and Guidelines

The Clean Air Act mandates 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 July 18, 1997, in addition to the particulate matter equal to or less than 10 microns (10 micrometers) in aerodynamic diameter (PM_{10}), a new standard became effective for particulate matter equal to or less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$). EPA designated New Mexico as attaining the $PM_{2.5}$ standards (40 CFR 81.332) (LANL 2004c).

In 1997, EPA revised the NAAQS for ground-level ozone, setting it at 0.08 parts per million averaged over an 8-hour timeframe. Litigation delayed implementation of this standard for several years. However, in March 2002, the District of Columbia Circuit Court rejected all remaining challenges to the 8-hour ozone standard and EPA began implementing the requirements. The entire State of New Mexico, including Los Alamos County, has been designated as in attainment with the 8-hour ozone standard (40 CFR 81.332) (LANL 2004c).

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. A primary NAAQS has been established for carbon monoxide, and both primary and secondary standards have been established for the remaining criteria pollutants. The area encompassing LANL and Los Alamos County is classified as an attainment area for all six criteria pollutants (40 CFR 81.332) (LANL 2004c).

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 permit requirements 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 health-based limits. Because of the financial constraints and the unavailability of sufficient information on the effects of toxic air pollutants, New Mexico has not established ambient standards for toxic chemicals. To approach this issue, New Mexico has developed permit requirements that are used by the NMED for determining if a new or modified source emitting a toxic air pollutant would be issued a permit under Subpart IV 20.2.72 NMAC (New Mexico Administrative Code) (LANL 2004c). Although many operations at LANL were in existence before August 31, 1972, when NMED air permit regulations were first applicable, operations are now subject to a site-wide operating permit.

In accordance with Title V of the Clean Air Act, as amended, and 20.2.70 NMAC, the management and operating contractor and DOE submitted a Clean Air Act operating permit application to NMED in December 1995. In 2002, the management and operating contractor and DOE submitted a revised operating permit application as requested by NMED. NMED issued a Notice of Completeness for both applications and issued operating permit P100 in April 2004 (LANL 2004c, NMED 2004b), as well as a modified permit P100M1 in June 2006 (NMED 2006a). Air quality permits are discussed further in Chapter 6.

The primary purpose of the operating permit program is to identify all Federal and state air quality requirements applicable to LANL operations so that a single site-wide permit can be granted. Under this permit, the management and operating contractor at LANL tracks pollutant emissions by reporting semiannual emissions, based on chemical purchase data, material and fuel usage, knowledge of operations, and suitable emission factors (LANL 2004c). Appendix B, Table B–2, of the SWEIS lists chemicals used at LANL in 2004 (LANL 2005f).

Emissions of criteria and hazardous air pollutants from activities at LANL are subject to the limitations in the Title V operating permit. These limits are summarized in **Table 4–18**. In addition, there are limits on visible emissions. The permit also includes limitations derived from the New Source Performance Standard for Small Industrial-Commercial-Institutional Steam Generating Units (40 CFR Part 60 Subpart Dc), which is applicable to two TA-55 boilers;

Table 4–18 Operation Permit Emission Limits

Facility	Emissions (tons per year unless stated)					
	Nitrogen Oxides	Carbon Monoxide	Volatile Organic Compounds	Sulfur Dioxide	Particulate Matter	Hazardous Air Pollutants
LANL – Entire Facility	245	225	200	150	120	24 combined/ 8 individual
Asphalt Production (TA-60-BDM)	1.0	2.6	1.0	1.0	0.04 grams per dry standard cubic foot, 35.4 pounds per hour	NA
Beryllium Activities						
CMR Facility (TA-3-29)	NA	NA	NA	NA	Beryllium 10 grams per 24 hours	NA
Sigma Facility (TA-3-66)	NA	NA	NA	NA	Beryllium 10 grams per 24 hours	NA
Beryllium Test Facility (TA-3-141)	NA	NA	NA	NA	Beryllium 0.35 grams per 24 hours 3.5 grams per year	NA
TA-16-207	NA	NA	NA	NA	Beryllium 10 grams per 24 hours	NA
TA-35-87	NA	NA	NA	NA	Beryllium 10 grams per 24 hours	NA
Target Fabrication Facility (TA-35-213)	NA	NA	NA	NA	Beryllium 1.8×10^{-4} grams per hour, 0.36 grams per year	NA
Plutonium Facility (TA-55-PF4)						
Machining Operation	NA	NA	NA	NA	Beryllium - 0.12 grams per 24 hours, 2.99 grams per year Aluminum - 0.12 grams per 24 hours, 2.99 grams per year	NA
Foundry Operation	NA	NA	NA	NA	Beryllium - 3.49×10^{-5} grams per 24 hours, 8.73×10^{-4} grams per year Aluminum - 3.49×10^{-5} grams per 24 hours, 8.73×10^{-4} grams per year	NA
Boilers and Heaters [a]	80	80	50	50	50	NA
Carpenter Shops						
TA-15-563	NA	NA	NA	NA	2.81	NA
TA-3-38	NA	NA	NA	NA	3.07	NA
Chemical Usage (facility wide)	NA	NA	200	NA	NA	8 individual chemical 24 total
Degreasers – TA-55-DG-1, TA-55-DG-2, and TA-55-DG-3	NA	NA	200 facility wide	NA	NA	8 individual 24 total
Internal Combustion Sources						
TA-33-G-1 (diesel generator)	18.1 tons per year, 40.3 pounds per hour	15.2 tons per year, 33.7 pounds per hour	0.3 tons per year, 0.7 pounds per hour	2.5 tons per year, 5.5 pounds per hour	TSP 0.6 tons per year, 1.4 pounds per hour PM_{10} 0.6 tons per year, 1.4 pounds per hour	NA
Various Standby Generators [b]	NA	NA	NA	NA	NA	NA
Data Disintegrator/ Industrial Shredder	NA	NA	NA	NA	TSP 9.9 tons per year, 2.3 pounds per hour PM_{10} 9.9 tons per year, 2.3 pounds per hour	NA

Facility	Emissions (tons per year unless stated)					
	Nitrogen Oxides	Carbon Monoxide	Volatile Organic Compounds	Sulfur Dioxide	Particulate Matter	Hazardous Air Pollutants
Power Plant at TA-3-22						
TA-3-22-1	10.2 pounds per hour gas 11.3 pounds per hour oil	7.0 pounds per hour gas 6.5 pounds per hour oil	1.0 pounds per hour gas 0.3 pounds per hour oil	1.1 pounds per hour gas 9.6 pounds per hour oil	TSP 1.3 pounds per hour gas 4.3 pounds per hour oil PM_{10} 1.3 pounds per hour gas 3.0 pounds per hour oil	NA
TA-3-22-2	10.2 pounds per hour gas 11.3 pounds per hour oil	7.0 pounds per hour gas 6.5 pounds per hour oil	1.0 pounds per hour gas 0.3 pounds per hour oil	1.1 pounds per hour gas 9.6 pounds per hour oil	TSP 1.3 pounds per hour gas 4.3 pounds per hour oil PM_{10} 1.3 pounds per hour gas 3.0 pounds per hour oil	NA
TA-3-22-3	10.2 pounds per hour gas 11.3 pounds per hour oil	7.0 pounds per hour gas 6.5 pounds per hour oil	1.0 pounds per hour gas 0.3 pounds per hour oil	1.1 pounds per hour gas 9.6 pounds per hour oil	TSP 1.3 pounds per hour gas 4.3 pounds per hour oil PM_{10} 1.3 pounds per hour gas 3.0 pounds per hour oil	NA
Boilers Combined	60.2 tons per year	41.3 tons per year	5.6 tons per year	7.9 tons per year	TSP 8.4 tons per year PM_{10} 8.2 tons per year	NA
TA-3-22 CT-1	23.8 pounds per hour 33.2 tons per year	170.9 pounds per hour 19.8 tons per year	1.0 pounds per hour	1.4 pounds per hour 1.9 tons per year	TSP 1.6 pounds per hour 2.3 tons per year PM_{10} 1.6 pounds per hour 2.3 tons per year	NA

NA = not available, CMR = Chemistry and Metallurgy Research, TSP = total suspended particulate, PM^{10} = particulate matter less than 10 microns in aerodynamic diameter, TA = technical area.

[a] Including TA-16-1484-BS-1, TA-16-1484-BS-2, TA-21-357-1, TA-21-357-2, and TA-21-357-3, TA-48-1-BS-1, TA-48-1-BS-2, TA-48-1-BS-6, TA-50-2, TA-53-365-BHW-1, TA-53-365-BHW-2, TA-55-6-BHW-1, TA-55-6-BHW-2, TA-59-BHW-1, TA-59-BHW-2.

[b] Standby generators are limited to an average of 168 hours per year; tons per year to metric tons per year, multiply by 0.9072.

Note: To convert pounds per hour to kilograms per hour, multiply by 0.45359; tons per year to metric tons per year, multiply by 0.90718.

Source: NMED 2006a.

New Source Performance Standard for Hot Mix Asphalt Facilities (40 CFR Part 60 Subpart I); New Source Performance Standard for Stationary Gas Turbines (40 CFR Part 60 Subpart GG), which is applicable to the new gas turbine; National Emission Standards for Hazardous Air Pollutants for Beryllium (40 CFR Part 61 Subpart C) which is applicable to beryllium operations at TA-3, TA-16, TA-35, and TA-55; National Emission Standards for Hazardous Air Pollutants for Asbestos (40 CFR Part 61 Subpart M) which may be applicable to some demolition projects; National Emission Standards for Hazardous Air Pollutants for Radon Emissions from DOE Facilities (40 CFR Part 61 Subpart Q) applicable to operations at TA-55; and National Emission Standards for Hazardous Air Pollutants for Radionuclides other than Radon from DOE Facilities (40 CFR Part 61 Subpart H), which is discussed further in Chapter 4, Section 4.6.1.2 and in Appendix C, Section C.1.1.5. National Emissions Standards for Halogenated Solvent Cleaning (40 CFR Part 63 Subpart T) is applicable to certain activities at TA-55 and specifies applicable controls (NMED 2006a).

4.4.2.2 Sources of Nonradiological Emissions

Criteria pollutants released from LANL operations are emitted primarily from combustion sources such as boilers and emergency generators. Although motor vehicle emissions have an impact on local air quality, no quantitative analysis of vehicle emissions was performed as part of the *1999 SWEIS*. Instead, vehicle emissions were included in the assumed background concentrations for each of the criteria pollutants in the *LANL SWEIS* analysis (LANL 2004c).

Estimated emissions from operations at LANL for the years 1999 through 2004 are shown in **Table 4–19**. These data include emissions from the operation of facilities at LANL. Construction emissions from new facilities and facility upgrades during the period 1999 through 2004 resulted in temporary increases in LANL emissions. Construction emissions were not quantified in the *1999 SWEIS* or in the *SWEIS Yearbook 2005, Comparison of 2005 Data Projections of the Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory (SWEIS Yearbook – 2005)* (LANL 2006g). Most of the National Environmental Policy Act (NEPA) documents for activities that were under construction during the period 1999 to 2004 determined that impacts from construction emissions would be small and of short duration and similar to other construction activities at LANL. The data presented for criteria pollutants in the *SWEIS Yearbook – 2005* are summarized as annual emissions for each pollutant. Appendix B, Attachment 1, of the *1999 SWEIS* presents criteria pollutant emissions for individual combustion sources.

Table 4–19 Emissions of Criteria Pollutants

Pollutant [a]	Emissions (tons per year)						
	1999	2000	2001	2002	2003	2004 [b]	2005 [b]
Carbon monoxide	32	26	29.08	28.1	31.9	35.4	35.1
Nitrogen oxides	88	80	93.8	64.7	49.6	50.5	50.5
Particulate matter	4.5	3.8	5.5	15.5 [c]	22.1 [c]	4.8	5.0
Sulfur oxides	0.55	4.0 [d]	0.82	1.3 [e]	1.6 [e]	1.5	1.9

[a] Tons per year.
[b] Values include emissions from small boilers and heaters and standby generators not included in previous years' emissions inventories, but included on LANL's Title V Operating Permit Emissions Report.
[c] Increased emissions of particulate matter were primarily due to operation of three air curtain destructors used to burn wood and slash from the fire mitigation activities.
[d] The higher emissions of sulfur oxides were due to the main steam plant burning fuel oil during the Cerro Grande Fire.
[e] The increased emissions of sulfur oxides were due to operation of the three air curtain destructors used to burn wood and slash from fire mitigation activities.
Note: To convert tons per year to metric tons per year, multiply by 0.9072.
Sources: LANL 2003h, 2006g.

Increased particulate matter emissions in 2002 and 2003 were attributable primarily to operation of three air curtain destructors that were used to burn wood and slash from the fire mitigation activities around LANL. Operation of the air curtain destructors emitted 12.2 tons (10 metric tons) of particulate matter and 1 ton (0.9 metric tons) of sulfur oxides in 2002. The air curtain destructors emitted a total of 19.1 tons (17.3 metric tons) of particulate matter and 1.3 tons (1.2 metric tons) of sulfur oxides during 2003. The air curtain destructors were shut down in September 2003 (LANL 2003h, 2004f).

Sulfur oxides emissions in 2000 increased as a result of burning fuel oil in the main steam plant during the Cerro Grande Fire. Use of alternate fuel is not typical of steam plant operations and was necessary due to natural gas supplies being cut off to the area during the fire (LANL 2003h).

Approximately two-thirds of the most significant criteria pollutant, nitrogen oxides, results from the TA-3 steam plant. In late 2000, DOE received a permit from NMED to install flue gas recirculation equipment on the steam plant boilers to reduce emissions of nitrogen oxide. This equipment became operational in 2002, and initial source tests indicated a reduction in emissions, of approximately 64 percent. The water pump, which was a large source of nitrogen oxide emissions, was transferred to Los Alamos County in November 2001 (LANL 2003h, 2004f).

The Clean Air Act, as amended, requires that Federal actions conform to the host State's "State Implementation Plan." A State Implementation Plan provides for the implementation, maintenance, and enforcement of the NAAQS for the six criteria pollutants, sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. Conformance with the State Implementation Plan is required to eliminate or reduce the severity and number of violations of NAAQS and to expedite the attainment of NAAQS. No Department, agency, or instrumentality of the Federal Government shall engage in or support in any way (i.e., provide financial assistance for, license or permit, or approve) any activity that does not conform to an applicable implementation plan. The final rule for *Determining Conformity of General Federal Actions to State or Federal Implementation Plans* (58 FR 63214) took effect on January 31, 1994. LANL is within an area that is currently designated as an attainment area for criteria air pollutants. Therefore, the actions considered in the *1999 SWEIS* and the other proposed projects considered in this *SWEIS* do not require a conformity determination.

Air pollutant emissions for Key Facilities at LANL are presented in Appendix A of the *SWEIS Yearbook – 2005* and are based on chemical usage in these areas (LANL 2006g). Total emissions of hazardous air pollutants and volatile organic compounds for 2000 through 2005 are presented in **Table 4–20**.

Table 4–20 Emissions of Hazardous Air Pollutants and Volatile Organic Compounds from Chemical Use

Pollutant	***Emissions (tons per year)***					
	2000	***2001***	***2002***	***2003***	***2004***	***2005***
Hazardous Air Pollutants	6.5	7.4	7.74	7.32	5.71	5.4
Volatile Organic Compounds	10.7	18.6	14.9	11.2	7.95	11.2

Note: To convert tons per year to metric tons per year, multiply by 0.9072.
Source: LANL 2006g.

The total emissions of hazardous air pollutants and volatile organic compounds showed considerable variation over the period 2000 through 2005. Operation of the air curtain destructors resulted in increases of hazardous air pollutants and volatile organic compounds during 2002 and 2003. The air curtain destructors accounted for 2.1 and 22.9 tons (1.9 and 20.8 metric tons) of hazardous air pollutants and volatile organic compound, respectively, in 2002. In 2003, they accounted for 3.3 and 36.0 tons (3.0 and 32.7 metric tons) of hazardous air pollutants and volatile organic compounds, respectively. As noted above, the air curtain destructors were shutdown in September 2003 (LANL 2004f). With the completion of Cerro Grande Rehabilitation Project tree thinning and removal, emissions of hazardous air pollutants and volatile organic compounds returned to lower levels more typical of pre-fire conditions. Emissions of volatile organic compounds were lower in 2004 due to the shutdown of activities in July 2004 (LANL 2006g).

Toxic and hazardous 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 new operations for their potential to emit toxic and hazardous air pollutants. Toxic air pollutant emissions from the use of chemicals are generally below the levels for which the State of New Mexico would require a permit for a new source under its permit regulations for toxic air pollutant emissions (NMAC 20.2.72.400 - 502). The Title V operating permit limits the emissions of hazardous air pollutants such that operations at LANL are below the major source threshold for hazardous air pollutants. Emissions of hazardous air pollutants are monitored and reported annually to NMED as required by the permit. Past actual emissions of hazardous air pollutants have been well below the threshold (LANL 2004c).

In the *1999 SWEIS*, a list of 382 chemicals of interest was selected for evaluation. A comparison of a calculated maximum emission rate derived from health-based standards to the potential emission rate from key LANL facilities was made. In this analysis, a screening level emission value was developed for each chemical and for each TA where that chemical was used. A screening level evaluation value is a theoretical maximum emission rate that, if emitted at that TA over a short-term (8-hour) or long-term (1-year) period, would not exceed a health-based guideline value. This value was compared to the emission rate that would result if all the chemicals purchased for use in the facilities at that TA over the course of 1 year were available to become airborne (LANL 2004c).

Estimates for selected toxic and hazardous air pollutant emissions from key LANL facilities were made in the *1999 SWEIS* based on chemical use at LANL and assumed stack and building parameters. Chemical purchasing records for these key facilities have been reviewed each year and estimated emissions reported in the annual Yearbooks (LANL 2003h, LANL 2004f, LANL 2006g). The amount of individual chemicals purchased varies from year to year. However, in some areas the total amounts of the chemicals of interest have stayed relatively constant from year to year. For example, at TA-3 during the period 1999 and 2002, the total chemical usage has varied by about plus or minus 25 percent. The variation in estimated chemical emissions would be expected to be similar (LANL 2004c). At other areas such as at the High-Explosives Processing areas, chemical emissions show greater variability from year to year. Evaluation of emissions of individual chemicals indicates that most chemicals would be emitted at levels below the screening levels identified in the *1999 SWEIS*.

DOE Order 450.1, "Environmental Protection Program," requires DOE facilities to incorporate an environmental management system approach into their Integrated Safety Management Systems. This includes the protection of resources from wildland and operational fires. Fires are conducted from time to time at LANL for the reduction of forest fuel to reduce the potential for wildland fires. These fires result in emissions of various chemical compounds such as fine particulate matter, nitrogen oxides, carbon monoxide, and organic compounds. Some impairment of visibility at Bandelier National Monument can result from these fires. Air quality impacts from prescribed fires are controlled through proper planning and the regulatory process (NMAC 20.2.60 and 20.2.65) (DOE 2004f).

4.4.2.3 Existing Ambient Air Conditions

Only a limited amount of ambient air monitoring has been performed for nonradiological air pollutants within the LANL region. NMED operated a DOE-owned ambient air quality monitoring station adjacent to Bandelier National Monument between 1990 and 1994 to record sulfur dioxide, nitrogen dioxide, ozone, and PM_{10} levels as discussed in the *1999 SWEIS*. DOE and NMED discontinued operation of this station in fiscal year 1995 because recorded values were well below applicable standards.

The State of New Mexico does not have an ambient air quality standard for beryllium. Beryllium concentrations are monitored at over 20 sites located near potential beryllium sources at LANL or in nearby communities. For comparison purposes, the results are compared to the ambient standard from the National Emission Standard for Hazardous Air Pollutants standard for beryllium of 10 nanograms per cubic meter (40 CFR Part 61 Subpart C). DOE is not required to monitor to this standard because all beryllium-permitted sources meet the emission standards, but it is used in this case for comparative purposes. All monitored beryllium values were 2 percent or less of the National Emission Standard for Hazardous Air Pollutants Standard (LANL 2006h).

After the Cerro Grande Fire in the spring of 2000, there was concern that an adequate baseline of nonradiological ambient air sampling was not in place at LANL. Therefore, in 2001, DOE designed and implemented a new air monitoring program, entitled NonRadNET, to provide nonradiological background ambient data under normal conditions. The NonRadNET program includes real-time ambient sampling for PM_{10} and $PM_{2.5}$. Additionally, air samples were collected in the first year of this program and analyzed for up to 20 inorganic elements and up to 160 volatile organic compounds. The results for PM_{10} and $PM_{2.5}$ are included for 2005 in **Table 4–21**. Results for the inorganic elements and the volatile organic compounds were all below any published ambient or occupational exposure limits. More information about this ambient monitoring program can be found in the report entitled *Nonradioactive Ambient Air Monitoring at Los Alamos National Laboratory 2001-2002* (LANL 2004e).

Table 4–21 2005 Ambient Air Monitoring for Particulate Matter

Station Location	*Constituent*	*Annual Mean Monitored Value (micrograms per cubic meter)*	*NAAQS Primary Annual Standard (micrograms per cubic meter)*	*Maximum 24-Hour Monitored Value (micrograms per cubic meter)*	*NAAQS 24-Hour Standard (micrograms per cubic meter)*
48th Street, Los Alamos	PM_{10}	12	50	34	150
	$PM_{2.5}$	7	15	20	65
Los Alamos Medical Center	PM_{10}	15	50	55	150
	$PM_{2.5}$	8	15	27	65
White Rock Fire Station	PM_{10}	13	50	34	150
	$PM_{2.5}$	7	15	20	65

NAAQS = National Ambient Air Quality Standards, PM_n = Particulate matter less than n microns in aerodynamic diameter.
Source: LANL 2006h.

As part of the Title V operating permit application, NMED requested that the management and operating contractor at LANL provide a facility-wide air quality impacts analysis. The purpose of the analysis was to ensure that the emission limits requested in the Title V permit application would not cause exceedances of any NAAQS or New Mexico Ambient Air Quality Standards. The analysis also demonstrated that simultaneous operation of all regulated air emission units described in the Title V permit application, being operated at their maximum requested permit limits, would not result in exceedances of any ambient air quality standards (Jacobson, Johnson, and Rishel 2003).

4.4.3 Radiological Air Quality

Individuals are continuously exposed to airborne radioactive materials. These materials come primarily from natural resources, such as the short-lived decay products of radon, found worldwide. However, airborne radioactive materials can also be emitted by manmade operations. 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 (area) sources such as the radioactive materials in contaminated soils. The concentrations of radionuclides in point-source releases are 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. The radiological air quality at LANL described in the *1999 SWEIS* is based on data collected from 1991 through 1996. The sections below discuss radiological air quality on the basis of data collected between 1999 and 2005. Radiation doses from LANL airborne emissions and radiological emission standards are discussed in Section 4.6 of this *SWEIS*.

4.4.3.1 Radiological Monitoring

The LANL radiological air-sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides, such as plutonium, americium, uranium, tritium, and activation products that could be released from LANL operations. Most regional airborne radioactivity comes from the following sources: (1) natural radioactive constituents in particulate matter (such as uranium and thorium), (2) terrestrial radon diffusion out of the Earth and its subsequent decay products, (3) material formation from interaction with cosmic radiation, and (4) fallout from past atmospheric nuclear weapons tests conducted by several countries. **Table 4–22** summarizes regional levels of radioactivity in the atmosphere over the period 1999 to 2005.

In 2005, 28 stacks were continuously monitored for the emission of radioactive material to the ambient air. LANL staff categorizes these radioactive stack emissions into four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products. Measurements of LANL stack emissions during 2005 totaled approximately 19,100 curies. Of this total, tritium emissions composed approximately 704 curies, and air activation products from Los Alamos Neutron Science Center (LANSCE) stacks contributed nearly 18,400 curies. Combined airborne materials such as plutonium, uranium, americium, and thorium were less than 0.00002 curies. Emissions of particulate/vapor activation products totaled less than 0.02 curies (LANL 2006h). **Table 4–23** provides further detailed emissions data for buildings with sampled stacks in the years 1999 through 2005. Overall, radiological air emissions at LANL tend to be dominated by emissions from LANSCE stacks and tritium.

Table 4–22 Annual Average Background Concentration of Radioactivity in the Regional Atmosphere

	Units [a]	*EPA Concentration Limit* [b]	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Gross Alpha	fCi/m^3	NA	1	1	0.8	0.8	0.8	1.1	0.9
Gross Beta	fCi/m^3	NA	13.4	13	13.9	13.3	13.7	18.3	16.3
Tritium	pCi/m^3	1,500	0.5	0.8	NM	NM	NM	0.1	0.1
Strontium-90	aCi/m^3	19,000	NA	NA	NA	4	11	NA	NA
Plutonium-238	aCi/m^3	2,100	NM	0	0	0	NM	0.09	0
Plutonium-239 and Plutonium-240	aCi/m^3	2,000	0.1	0	0.1	0.3	NM	NM	0.1
Americium-241	aCi/m^3	1,900	NM	0.3	NM	0.3	NM	NM	0.1
Uranium-234	aCi/m^3	7,700	16.1	17.1	17.9	21.7	20.9	17.4	12.4
Uranium-235	aCi/m^3	7,100	1.2	0.9	1.3	2.4	1.8	1.17	1.2
Uranium-238	aCi/m^3	8,300	15.2	15.9	17.7	21.8	20.1	17.0	13.2

EPA = U.S. Environmental Protection Agency, NA = not available, NM = not measurable.
[a] m^3 = cubic meters, pCi = picocurie = 10^{-12} curie, fCi = femtocurie = 10^{-15} curie, aCi = attocurie = 10^{-18} curie.
[b] Each EPA limit corresponds to 10 millirem per year.
Source: LANL 2004d, 2005h, 2006h.

4.4.4 Visibility

In accordance with the Clean Air Act, as amended, and New Mexico regulations, the Bandelier National Monument and Wilderness Area have been designated as a Class I area (defined as wilderness areas that exceed 10,000 acres [4,047 hectares]) where visibility is considered to be an important value [40 CFR 81.421, NMAC 20.2.74] 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 National Park Service at the Bandelier National Monument since 1988. **Table 4–24** reflects average visibility from 1993 through 2002 from approximately 79 to 113 miles (127 to 182 kilometers) (LANL 2004c). This would represent a reduction in the visual range of 2 to 31 percent compared to the estimated natural median visual range for the western states of 110 to 115 miles (177 to 186 kilometers) (Malm 1999).

4.4.5 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 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 (DOE 1999a). Ecological resources are discussed in more detail in Section 4.5.

Table 4–23 Range of Annual Airborne Radioactive Emissions from Los Alamos National Laboratory Buildings with Sampled Stacks from 1999 through 2005 (curies)

TA Building	Tritium [a]	Americium-241	Plutonium [b]	Uranium [c]	Thorium [d]	P/VAP [e]	G-MAP [f]	Strontium-90
TA-3-029	–	1.3×10^{-7} - 2.6×10^{-6}	2.1×10^{-6} - 2.1×10^{-5}	2.8×10^{-6} - 9.8×10^{-6}	1.3×10^{-7} - 1.3×10^{-6}	2.2×10^{-5} [g]	–	2.1×10^{-7} - 3.9×10^{-7}
TA-3-102	–	1.0×10^{-10} [h]	3.9×10^{-10} [i]	4.4×10^{-9} - 3.3×10^{-7}	8.0×10^{-10} - 7.2×10^{-9}	–	–	–
TA-16-205	140-7900 [j]	–	–	–	–	–	–	–
TA-21-155	66-520	–	–	–	–	–	–	–
TA-21-209	61-760	–	–	–	–	–	–	–
TA-48-001	–	–	1.7×10^{-9} [i]	6.1×10^{-10} - 6.5×10^{-9}	1.1×10^{-9} [h]	0.00023-0.017	–	–
TA-50-001	–	6.9×10^{-9} - 1.3×10^{-7}	7.4×10^{-9} - 5.1×10^{-8}	2.5×10^{-8} [i]	3.7×10^{-8} - 7.0×10^{-8}	–	–	–
TA-50-037	–	5.8×10^{-10} [i]	8.9×10^{-10} [i]	1.9×10^{-8} [k]	3.4×10^{-9} [h]	–	–	3.4×10^{-9} [h]
TA-50-069	–	5.8×10^{-11} - 7.6×10^{-10}	9.9×10^{-11} - 5.3×10^{-9}	–	1.2×10^{-10} - 1.2×10^{-9}	–	–	–
TA-53-003	0.57-1.8	–	–	–	–	3.5×10^{-10} [h]	1.7- 8.4	–
TA-53-007	0.45-7.2	–	–	–	–	0.016-60	300-18,400	–
TA-55-004	1.8-61	6.2×10^{-9} - 5.9×10^{-7}	4.3×10^{-8} - 2.5×10^{-6}	7.1×10^{-8} - 2.3×10^{-7}	3.4×10^{-8} - 1.5×10^{-7}	–	–	5.6×10^{-8} [h]

TA = technical area.
[a] Includes both gaseous and oxide forms of tritium.
[b] Includes plutonium-238, plutonium-239, and plutonium-240.
[c] Includes uranium-234, uranium-235, and uranium-238.
[d] Includes thorium-228, thorium-230, and thorium-232.
[e] P/VAP - Particulate and vapor activation products.
[f] G-MAP - Gaseous mixed activation products.
[g] Only emitted during 2005.
[h] Only emitted during 2003.
[i] Only emitted during 2002.
[j] The 7,900 curies were an unanticipated one-time release in 2001.
[k] Only emitted during 1999.
Sources: LANL 2004d, 2005h, 2006h.

Table 4–24 Average Visibility Measurements at Bandelier National Monument (1993 to 2002) [a]

Season	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Winter	94	99	104	113	108	102	106	113	105	111
Spring	96	95	110	84	100	91	96	82	102	91
Summer	87	87	86	92	84	79	93	86	100	88
Fall	93	103	101	106	105	87	91	104	104	104

[a] Distance in miles.
Note: To convert miles to kilometers, multiply by 1.6093.
Source: LANL 2004c.

"Public noise" is the noise present outside 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 DOE 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 ground vibrations generated at LANL result from testing activities involving aboveground explosives research (DOE 1999a).

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 DOE 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 (DOE 1999a).

Loss of large forest areas from the Cerro Grande Fire in 2000 has had an adverse effect on the ability of the surrounding environment to absorb noise. However, types of noise and noise levels associated with LANL and from activities in surrounding communities have not changed significantly as a result of the fire (DOE 2000f).

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 buildings 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, could 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 (DOE 1999a).

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 (DOE 1999a).

4.4.5.1 Noise Level Regulatory Limits and Los Alamos National Laboratory Administrative Requirements

Noise generated by operations at LANL, 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 (that is 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 that noise is limited to 10 minutes in any one hour. Activities that do not meet the noise ordinance limits require a permit (LANL 2004c).

Noise standards related to protecting worker hearing at LANL includes an occupational exposure limit for steady-state noise, defined in terms of accumulated daily (8-hour) noise exposure that allows for both exposure level and duration of 85 dBA (LANL 2003g). When a worker is exposed for a shorter duration, the permitted noise level is increased. 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. No Exposure of an unprotected ear in excess of a C-weighted peak of 140 dB is permitted (LANL 2004c).

4.4.5.2 Existing Los Alamos National Laboratory 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 site 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's communities and surrounding areas. Noise and vibration sources at LANL and noise measurements are discussed in the *1999 SWEIS* (DOE 1999a).

Although the workforce has been above the Record of Decision (ROD) projections since 1997, reaching 13,504 at the end of 2005, or about 19 percent above the projected level (LANL 2006g), the resulting increase in traffic noise levels would be less than 1 dBA and would not be expected to result in increased annoyance to the public.

Construction is an ongoing activity at LANL and there have been temporary increases in construction traffic since 1999. These increases in noise levels from construction activity and traffic at LANL have not been reported to result in increased annoyance to the public. Operation of new and modified facilities has not been reported to result in increased annoyance to the public from offsite noise impacts.

In July 1999, with the appropriate DOE authorization, the DARHT Project Office initiated DARHT facility (a High Explosive Facility) operations on the DARHT first axis. In late fall of 2000, the first major hydrotest using the DARHT first axis was completed and testing has continued. As part of the DARHT Mitigation Action Plan, DOE has undertaken a long-term monitoring program at the ancestral pueblo of Nake'muu to assess the impact of these LANL mission activities on cultural resources. Nake'muu is the only pueblo at LANL that still contains its original standing walls. It dates circa A.D. 1200 to 1325 and contains 55 rooms, with walls standing up to 6 feet (1.8 meters) high. Over the six-year monitoring program, the site has witnessed a 0.6 percent displacement rate of chinking stones and 0.2 percent displacement of masonry blocks. The annual loss rate ranges from 0.5 to 2.0 percent for the chinking stones and 0.05 to 1.3 percent for the masonry blocks. Statistical analyses indicate that these displacement rates are significantly correlated with annual snowfall, but not with annual rainfall or shots from the DARHT Facility (LANL 2004c).

4.5 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and protected and sensitive species. Each of these areas, as well as biodiversity is addressed separately below. Field investigations are an important element in the evaluation of ecological conditions at LANL. Such studies, which are conducted by LANL staff and may involve handling animals in the field, help determine species present, seasonality, density, and overall health. Special ecological studies, such as the evaluation of site wetlands, may be undertaken by outside experts.

4.5.1 Terrestrial Ecology

LANL is located in a region of diverse landform, elevation, and climate. 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 at LANL and the region as a whole (DOE 1999a, LANL 2004c).

Five vegetation zones have been identified within LANL (see **Figure 4–25**). In general these zones result from changes in elevation, temperature, and moisture along the approximately 12-mile (19-kilometer) wide, 5,000-foot (1,500-meter) elevational gradient from the Rio Grande to the western edge of the site. The five zones include: Juniper (*Juniperus monosperma* [Engelm.] Sarg.) Savannas; Pinyon (*Pinus edulis* Engelm.)-Juniper Woodlands; Grasslands; Ponderosa Pine (*Pinus ponderosa* P. & C. Lawson) Forests; and Mixed Conifer Forests (Douglas fir [*Pseudotsuga menziesii* (Mimel) Franco], ponderosa pine, and white fir [*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.]). While Mixed Conifer Forests are prevalent at higher elevations to the west of LANL, within the site this vegetation zone is restricted to cooler north-facing canyons walls. This diversity in vegetative communities has resulted in the presence of over 900 species of vascular plants. There is a comparable diversity in regional wildlife with 57 species of mammals, 200 species of birds, 28 species of reptiles, 9 species of amphibians, and over 1,200 species of arthropods having been identified (DOE 1999a, LANL 2004c).

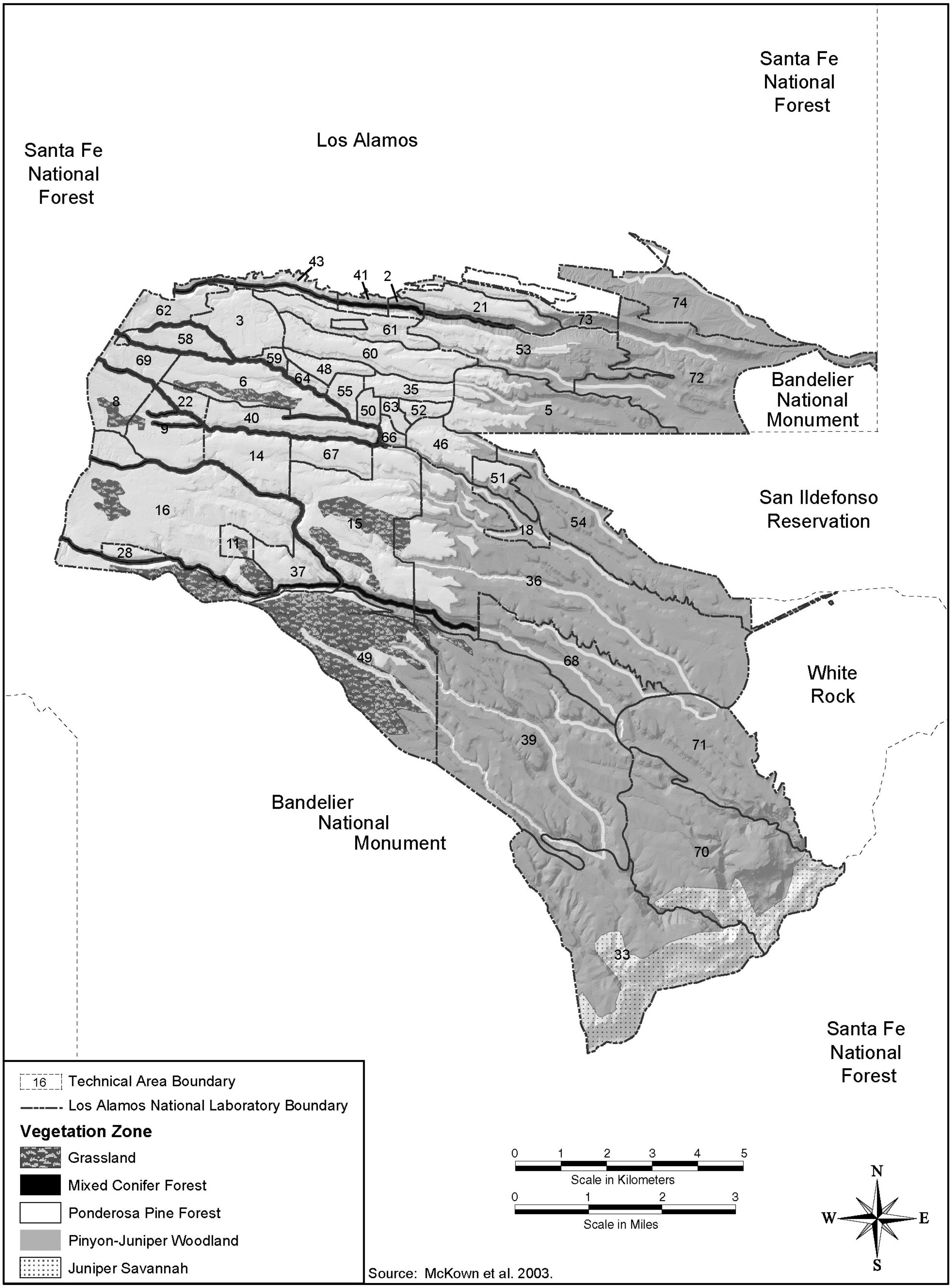

Figure 4–25 Los Alamos National Laboratory Vegetation Zones

Impacts to site terrestrial resources since publication of the *1999 SWEIS* have resulted from construction of new facilities, the Cerro Grande Fire, a bark beetle outbreak, and the conveyance and transfer of land. Major construction projects conducted between 1998 and 2003 have affected somewhat less than 100 acres (40 hectares) of previously undeveloped land. Impacts associated with this development include the loss of habitat and associated wildlife. In 2000, the Cerro Grande Fire burned 43,000 acres (17,400 hectares), including about 7,700 acres (3,110 hectares) on LANL (Balice, Bennett, and Wright 2004). Direct impacts on terrestrial resources included a reduction in habitat and the loss of wildlife (DOE 2000f). Fire mitigation work, such as flood retention facilities, affected about 50 acres (20 hectares) of undeveloped land (LANL 2005f). Additionally, about 9,950 acres (4,027 hectares) of forest have been thinned between 1997 and 2005 to reduce future wildfire potential (LANL 2006a). Thinning also creates a forest that appears more park-like with an increase in the diversity of shrubs, herbs, and grasses in the understory (Loftin 2001). An Interagency Wildfire Management Team, established in the late 1990s addresses continuing wildfire management and mitigation issues such as placement of fuel fire roads and breaks across the Pajarito Plateau (Webb and Carpenter 2001). There has been a decrease in elk (*Cervus elaphus*)-vehicle collisions since the fire. This is likely related to the amount of forage in burned areas west of LANL, as well as a lack of snowfall during the drought period. These factors have resulted in elk remaining at higher elevations away from major roadways (Sherwood, Biggs, and Hansen 2004).

Within two years of the Cerro Grande Fire a bark beetle outbreak occurred that resulted in 95 percent mortality of pinyon pine trees and 12 percent mortality of ponderosa pine trees across the Pajarito Plateau by the end of 2004. At lower elevations of the Mixed Conifer Forest Vegetation Zone on north-facing slopes of the canyons, up to 100 percent of the Douglas fir trees were also killed by the drought. The infestation could result in an increase in runoff, herbaceous growth, and the potential for wildfire. It would also be expected to impact wildlife populations. While at least partially the result of the fire, the bark beetle outbreak appears to be more a consequence of stress resulting from drought conditions and historical overstocking (LANL 2005f). Although precipitation was above average during much of 2005, there was a return to drought conditions toward the end of the year (LANL 2006h).

As noted in Section 4.1.1, approximately 2,259 acres (914 hectares) have been conveyed to Los Alamos County or transferred to the Department of the Interior to be held in trust for the Pueblo of San Ildefonso (LANL 2004c). This has reduced the size of LANL to about 25,600 acres (10,360 hectares). Much of the transferred land is in a natural state and falls within the Pinyon-Juniper Woodland and Ponderosa Pine Forest Vegetation Zones. To date, little of this land has been developed, although future development could result in both direct and indirect impacts to terrestrial habitats and species.

4.5.2 Wetlands

Wetlands are defined as, "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." Specific diagnostic criteria used by the U.S. Army Corps of Engineers to identify wetlands include vegetation, soil, and hydrology; these are spelled out in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

Approximately 34 acres (13.8 hectares) of wetlands have been identified within LANL boundaries during a survey in 2005 with 45 percent of these located in Pajarito Canyon. Dominant wetland plants found in site wetlands include reed canary grass (*Phalaris arundinacea* L.), narrow-leaf cattail (*Typha angustifolia* L.), coyote willow (*Salix exigua* Nutt.), Baltic rush (*Juncus balticus* Wildl.), wooly sedge (*Carex lanuginose* Michx.), American speedwell (*Veronica americana* Schwein. ex Benth.), common spike rush (*Eleocharis macrostachya* Britt.), and curly dock (*Rumex crispus* L.) (ACE 2005). Wetlands in the LANL region are primarily associated with canyon stream channels or are present on mesas, often in association with springs, seeps, or effluent outfalls. 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 that support wetlands. Wetlands in the general LANL region provide habitat for reptiles, amphibians, and invertebrates, and potentially contribute to the overall habitat requirements of a number of species, including sensitive species (LANL 2004c, DOE 1999a).

The *1999 SWEIS* reported that there were 50 acres of wetlands on LANL. However, many of the outfalls with which these wetlands were associated have been closed or re-routed and the wetlands no longer exist. A further explanation for the difference in wetland acreage found in 1999 is that the methodology used in the past included as wetlands waters of the United States (ACE 2005). These channel areas were not delineated in the present survey as wetlands since they do not meet the criteria of the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

During the Cerro Grande Fire, 16 acres (6.5 hectares) of the wetlands on LANL were burned at a low or moderate intensity. No wetlands within LANL were severely burned. Some riparian areas along the drainages also burned during the fire; however, these are not wetlands and are not included in the total acres of wetland. In addition to direct impacts from the fire, wetlands could receive increased sediment from stormwater runoff. While small amounts of sediment from the burned areas would enhance wetland growth, large amounts of deposited sediment could permanently alter the condition of existing wetlands and destroy them. The effects of the Cerro Grande Fire on LANL wetlands have yet to be fully assessed (DOE 2000f).

Fire suppression did not result in any direct impacts to wetlands since fire roads or breaks were not placed in wetlands. While construction of stormwater control projects following the fire resulted in minor impacts to wetlands (for example, culvert cleaning downstream from TA-18), these actions will protect downstream wetlands from erosion (DOE 2000f). Water retention structures built in drainages following the fire could develop wetland characteristics over time; however, with the ongoing drought, they have not yet been defined as wetlands (LANL 2006a).

To date, all or portions of 8 tracts have been conveyed or transferred to Los Alamos County and the Department of the Interior to be held in trust for the Pueblo of San Ildefonso (see Table 4–2). These tracts contain a total of about 9 acres (3.6 hectares) of wetlands, including stream channels. Although these wetlands are still protected by Federal and state regulations, they are no longer under the control of DOE. To date, there has been no change in the status of these wetlands because development has not taken place; however, future development could result in a direct loss of wetland structure and function and a potential increase in downstream and offsite sedimentation (DOE 1999d).

4.5.3 Aquatic Resources

The watersheds draining the Jemez Mountains and the Pajarito Plateau are tributary to the Rio Grande, the fifth largest watershed in North America. Approximately 11 miles (18 kilometers) of the eastern boundary of LANL border 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 construction of Cochiti Dam at the mouth of White Rock Canyon for flood and sediment control, recreation, and fish and wildlife purposes in the late 1960s, has significantly changed the features of White Rock Canyon and introduced new ecological components and processes. Twelve species of fish (found in the Rio Grande, Cochiti Lake, and the Rito de los Frijoles) have been identified in the LANL region (DOE 1999a, LANL 2004c).

While the Rio Grande and Rito de los Frijoles in Bandelier National Monument are the only truly perennial streams in the immediate vicinity, many canyon floors contain reaches of perennial surface water, such as the streams draining LANL property from lower Pajarito and Ancho Canyons to the Rio Grande. No fish species have been found within LANL boundaries (DOE 1999a, LANL 2004c). Actions taken since publication of the *1999 SWEIS* have not affected site aquatic resources.

4.5.4 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 years of human use. A number of special status species have been documented on LANL or in the immediate vicinity (see **Table 4–25**). Federally listed wildlife includes 2 endangered species, 2 threatened species, 1 candidate, and 8 species of concern. New Mexico protected and sensitive plants and animals include 3 endangered species, 7 threatened species, 2 species of concern, and 14 sensitive species. Additionally, 18 species of birds are listed as birds of conservation concern. Information related to the occurrence of these species within the LANL region is included in the table. Changes that have occurred in the number of protected and sensitive species since publication of the *1999 SWEIS* have resulted from changes in the Federal and state lists and more complete data on species occurrence acquired by LANL biologists.

Table 4–25 Protected and Sensitive Species

Common Name	***Scientific Name***	***Status*** [a]		***Notes***
		Federal	***State***	
Plants				
Sapello Canyon larkspur	*Delphinium sapellonis* (Tidestrom)		Species of Concern	
Springer's blazing star	*Mentzelia springeri* (Standley) Tidestrom		Species of Concern	
Wood lily (Mountain lily)	*Lilium philadelphicum* L. var. *anadinum* (Nutt.) Ker		Endangered	Observed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands
Yellow lady's slipper orchid	*Cyprepedium calceolus* L. var. *pubescens* (Willd.) Correll		Endangered	Observed on Bandelier National Monument lands
Insects				
New Mexico silverspot butterfly	*Speyeria nokomis nitocris*	Species of Concern		
Fish				
Rio Grande chub	*Gila pandora*		Sensitive	
Amphibians				
Jemez Mountain salamander	*Plethodon neomexicanus*	Species of Concern	Threatened	Permanent resident, Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands
Birds				
American peregrine falcon	*Falco peregrinus anatum*	Species of Concern, Conservation Concern	Threatened	Forages on LANL, nests and forages on adjacent lands
Arctic peregrine falcon	*Falco peregrinus tundrius*	Species of Concern, Conservation Concern	Threatened	
Bald Eagle	*Haliaeetus leucocephalus*	Threatened	Threatened	Observed as a migratory and winter resident along Rio Grande and adjacent LANL lands
Bendire's thrasher	*Toxostoma bendirei*	Conservation Concern		
Black-throated gray warbler	*Dendroica nigrescens*	Conservation Concern		
Crissal thrasher	*Toxostoma crissale*	Conservation Concern		
Feruginous hawk	*Buteo regalis*	Conservation Concern		Considered accidental or transient on Bandelier National Monument
Flammulated owl	*Otus flammeolus*	Conservation Concern		Permanent resident on LANL
Graces's warbler	*Dendroica graciae*	Conservation Concern		

Common Name	**Scientific Name**	**Status [a]**		**Notes**
		Federal	**State**	
Golden eagle	*Aquila chrysaetos*	Conservation Concern		Has been known to nest in the Los Alamos area, but not found every year
Gray vireo	*Vireo vicinior*	Conservation Concern	Threatened	Considered accidental or transient on Bandelier National Monument
Lewis's woodpecker	*Melanerpes lewis*	Conservation Concern		Breeding resident on LANL
Loggerhead shrike	*Lanius ludovicianus*		Sensitive	Considered accidental or transient on Bandelier National Monument
Mexican spotted owl	*Strix occidentalis lucida*	Threatened	Sensitive	Breeding resident on LANL, Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands; critical habitat designated on Santa Fe National Forest lands
Northern goshawk	*Accipiter gentilis*	Species of Concern	Sensitive	Observed as a breeding resident on Los Alamos County, LANL, Bandelier National Monument, and Santa Fe National Forest lands
Northern harrier	*Circus cyaneus*	Conservation Concern		Considered rare or occasional on Bandelier National Monument
Pinyon jay	*Gymnorhinus cyanocephalus*	Conservation Concern		Breeding resident on LANL
Prairie falcon	*Falco mexicanus*	Conservation Concern		
Sage sparrow	*Amphispiza belli*	Conservation Concern		Breeding resident on LANL
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	Endangered	Present on LANL and White Rock Canyon, Jemez Mountains, and near Española; potential nesting area on LANL
Virginia's warbler	*Vermivora virginiae*	Conservation Concern		Breeding resident on LANL
Williamson's sapsucker	*Sphyrapicus thyroideus*	Conservation Concern		Breeding resident on LANL
Yellow-billed cuckoo	*Coccyzus americanus*	Candidate, Conservation Concern	Sensitive	Has been recorded along Rio Grande, adjacent to LANL
Mammals				
Big free-tailed bat	*Nyctinomops macrotis*		Sensitive	Migratory visitor on Bandelier National Monument and Santa Fe National Forest lands; breeding resident on Los Alamos County
Black-footed ferret	*Mustella nigripes*	Endangered		
Fringed myotis	*Myotis thysanodes*		Sensitive	Breeding resident on LANL

Common Name	Scientific Name	Status [a]		Notes
		Federal	State	
Goat Peak pika	*Ochotona princeps nigrescens*	Species of Concern	Sensitive	Observed on Los Alamos County and Bandelier National Monument lands
Long-eared myotis	*Myotis evotis*		Sensitive	Breeding resident on LANL
Long-legged myotis	*Myotis volans*		Sensitive	Breeding resident on LANL
New Mexico meadow jumping mouse	*Zapus hudsonius luteus*	Species of Concern	Threatened	Permanent resident on Bandelier National Monument and Santa Fe National Forest lands; overwinters by hibernating
Ringtail	*Bassariscus astutus*		Sensitive	Observed in Los Alamos County
Spotted bat	*Euderma maculatum*		Threatened	Seasonal resident on LANL, Bandelier National Monument, and Santa Fe National Forest lands
Townsend's big-eared bat	*Plecotus townsendii*	Species of Concern	Sensitive	Seasonal resident on LANL
Western small-footed myotis	*Myotis ciliolabrum*		Sensitive	Seasonal resident on LANL
Yuma myotis	*Myotis yumanensis*		Sensitive	Summer resident on LANL, Los Alamos County, and Santa Fe National Forest lands

[a] Status:

Endangered:

Federal – in danger of extinction throughout all or a significant portion of its range.

State – Animal: any species or subspecies whose prospects of survival or recruitment in New Mexico are in jeopardy.

– Plant: a taxon listed as threatened or endangered under provision of the Federal Endangered Species Act, or is considered proposed under the tenets of the Act, or is a rare plant across its range within the State, and of such limited distribution and population size that unregulated taking could adversely impact it and jeopardize its survival in Mexico.

Threatened:

Federal – likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

State – Animal: any species or subspecies that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in New Mexico.

– Plant: New Mexico does not list plants as threatened.

Candidate: Substantial information exists in U.S. Fish and Wildlife Service files on biological vulnerability to support proposals to list as endangered or threatened.

Conservation Concern: Migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act.

Sensitive: Those taxa that, in the opinion of a qualified New Mexico Department of Game and Fish biologist, deserve special consideration in management and planning, and are not listed as threatened or endangered by the State of New Mexico.

Species of Concern:

Federal – conservation standing is of concern, but status information is still needed; they do not receive recognition under the Endangered Species Act.

State – a New Mexico plant species, which should be protected from land use impacts when possible because it is a unique and limited component of the regional floral.

Sources: LANL 2004c, 2006a, NMAC 19.21.2, NMDGF 2004a, 2004b, NMNHP 2004, NMSF 2004, USFWS 2002, 2004a, 2004b.

A brief summary discussion of the Federal and state endangered and threatened species is provided below. The reader is referred to the *1999 SWEIS* for more detailed information on these and other species presented in Table 4–25. DOE coordinates with the New Mexico Department of Game and Fish and the U.S. Fish and Wildlife Service to locate and conserve protected and sensitive species.

LANL's Habitat Management Plan Summary

The LANL *Threatened and Endangered Species Habitat Management Plan* was developed to provide protection for threatened and endangered species that may reside on or use LANL property, as well as facilitating the implementation of DOE's mission at LANL. The three goals of the 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. The Plan consists of Areas of Environmental Interest, Site Plans, and Monitoring Plans. Areas of Environmental Interest consist of a core area that contains important breeding or wintering habitat for a specific species and a buffer area around the core area. The Site Plans contain descriptions of individual species, the Area of Environmental Interest for that species, and current impacts in the Area Environmental Interest. Monitoring Plans describe the methodology used to determine if Federally listed species are present at LANL and may be designed to estimate reproduction, abundance, and distribution of the species at LANL.

The wood lily (*Lilium philadelphicum* L. var. *anadinum* (Nutt.) Ker) and yellow lady's slipper orchid (*Cyprepedium calceolus* L. var. *pubescens* (Willd.) Correll) are both listed as endangered in New Mexico. The wood lily grows in ponderosa pine, mixed-conifer, and spruce-fir forests and requires riparian areas. This plant has been observed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands. The yellow lady's slipper orchid, which grows in mixed-conifer forests, also requires riparian areas with moist soil conditions. It has been observed within the Bandelier National Monument (DOE 1999a).

The southwestern willow flycatcher (*Empidonax traillii extimus)* (federally and state-listed as endangered) occurs in riparian habitats along rivers, streams, or wetlands. Potential suitable nesting for this habitat species is present on LANL but is limited to a single canyon area. The southwestern willow flycatcher has 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. A migrant willow flycatcher was identified by song on LANL once during May 1997 and 2005. However, the willow flycatcher discovered on LANL cannot be confirmed to belong to the southwestern race (DOE 1999a, LANL 2006a).

The black-footed ferret (*Mustella nigripes*), which is listed as endangered by the U.S. Fish and Wildlife Service, was last reported in New Mexico in 1934. This species, which requires greater than 80 acres (32 hectares) of prairie dog towns (for its prey base), has a low potential of occurrence on LANL since no large prairie dog towns occur on the site (Keller and Koch 2001).

The Jemez Mountain salamander (*Plethodon neomexicanus*) is listed as threatened in New Mexico. It can be found in mixed-conifer forests and requires north-facing moist slopes. It is a permanent resident in Los Alamos County, Bandelier National Monument, and Santa Fe National Forest (DOE 1999a).

Two federally threatened birds, the bald eagle (*Haliaeetus leucocephalus*) and Mexican spotted owl (*Strix occidentalis lucida*), are found in the LANL region. State-listed threatened birds found in the area include the peregrine falcon (*Falco peregrinus*) (both subspecies), bald eagle, and gray vireo (*Vireo vicinior*). The bald eagle has been observed as a migratory and winter resident along the Rio Grande and on adjacent LANL lands. The Mexican spotted owl prefers tall, old-growth forest in canyons and moist areas for breeding. It is found in mixed conifer and ponderosa forests and is a breeding resident on LANL, Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands (DOE 1999a). Mexican spotted owls were recorded breeding on LANL from 1994 through 1999 and in 2005. Although adult birds were seen, there was no recorded breeding between 2000 and 2004 after the Cerro Grande fire. In 2004, a resident Mexican spotted owl was confirmed in the north-central part of LANL; however the nesting status of this bird was not determined. In 2005, a second occupied territory in the southwestern portion of LANL was confirmed to have a nesting pair and three young were fledged (LANL 2006a). The peregrine falcon, which requires cliffs for nesting, has been found within juniper savannah and pinyon-juniper, ponderosa pine, and mixed-conifer forests. It forages on LANL and nests and forages on adjacent lands. The gray vireo uses riparian areas in juniper savannah and pinyon-juniper forests. It has been observed on Bandelier National Monument.

Two state-threatened mammals have been found in the LANL area. These include the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) and spotted bat (*Euderma maculatum*). The former is found in mixed-conifer and spruce-fir forests and requires riparian areas. It is a permanent resident on Los Alamos County and Santa Fe National Forest lands. The spotted bat is found in pinyon-juniper woodland, ponderosa pine forest, and spruce-fir forest. It roosts in cliffs near water. This species is a seasonal resident on Bandelier National Monument and Santa Fe National Forest; it is a seasonal resident on LANL (DOE 1999a).

Habitat that is either occupied by federally protected species or that is potentially suitable for use by these species in the future has been delineated within LANL; occupied habitat is protected as if it were critical habitat[4] for the species. The *Los Alamos Threatened and Endangered Species Habitat Management Plan*, implemented in 1999, identifies Areas of Environmental Interest for various federally listed threatened or endangered species. In general, an Area of Environmental Interest consists of a core area that contains important breeding or wintering habitat for a specific species and a buffer area around the core area. The buffer protects the core area from disturbances that would degrade its value. Areas of Environmental Interest have been established at LANL for the Mexican spotted owl, bald eagle, and southwestern willow flycatcher (LANL 1998c). Recently, changes in the boundaries for all Mexican Spotted Owl Area of Environmental Interest have been approved by the U.S. Fish and Wildlife Service. These changes, which were made in response to implementation of a new habitat model, resulted in the removal of some areas from the Areas of Environmental Interest and the addition of other areas.

[4] *Critical habitat = specific areas occupied by a species on which are found those physical and biological features essential to its conservation and which may require special management consideration or protection. These areas are designated by the U.S. Fish and Wildlife Service under the Endangered Species Act of 1973.*

Areas of Environmental Interest have not been established for the black-footed ferret, since suitable habitat for this species does not occur at LANL (DOE 2003d).

Although many of the Mexican spotted owl Areas of Environmental Interest received moderate- and low-severity burns, part of the Sandia-Mortandad Area of Environmental Interest was severely burned during the Cerro Grande Fire. Habitat within the southwestern willow flycatcher and bald eagle Area of Environmental Interest did not burn (DOE 2000f). There is no evidence that the fire caused a long-term change to the overall number of federally listed threatened or endangered species inhabiting the region. LANL's species of greatest concern, the Mexican spotted owl, was seen within weeks of the fire and in all subsequent breeding seasons; however, there was no recorded breeding between 2000 and 2004. It was not until 2005 that a nested pair was observed. Some State-listed species, including the Jemez Mountain salamander (*Plethodon neomexicanus*), have undoubtedly been less fortunate and recovery of the species to pre-fire levels may take a long time (LANL 2003h, 2006a).

As noted above (see Section 4.1.1), 2,259 acres (914 hectares) have been conveyed to Los Alamos County and transferred to the Department of the Interior to be held in trust for the Pueblo of San Ildefonso. Some of the areas that have been turned over to these two entities have Areas of Environmental Interest for the Mexican spotted owl. However, the *LANL Threatened and Endangered Species Habitat Management Plan* (LANL 1998c), under which the Areas of Environmental Interest are designated, is no longer in effect for conveyed or transferred land (DOE 1999d).

4.5.5 Biodiversity

Biodiversity refers to the variety and variability among living organisms and the ecological complexes in which they occur (EPA 2005c). The major human-caused disturbance factors, which are addressed in detail in the *1999 SWEIS* and identified by the Council on Environmental Quality 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, and
- Global climate change (which is considered outside the scope of this analysis).

Since publication of the *1999 SWEIS*, development at LANL, the Cerro Grande Fire, the conveyance and transfer of land, the drought, and the bark beetle outbreak have all had (or have the potential to have) an effect on biodiversity. For example, development has reduced available habitat and fragmented the environment, thereby altering the composition of wildlife populations present on the site. Further, these factors may have broad scale detrimental impacts on soil erosion. The introduction of non-native plant species (also called exotic plants) can result from the elimination of native species through land disturbance. Presently there are 150 exotic plants growing at LANL. Certain actions initiated at LANL and at other land-management area across the Pajarito Plateau could act to positively affect the environment. For example, the thinning of forests will create a woodland environment closer to the one that existed prior to the advent of fire suppression activities in the 1890s, which may serve to attract a more diverse animal population back into the area.

Pollution impacts on ecosystems include direct lethal, sub-lethal, and reproductive effects (including those resulting from bioaccumulation) and degradation of habitat. 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. 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, as well as biomonitoring, have not demonstrated levels of contaminants that would pose a health risk, nor have there been obvious toxic effects observed. There is no evidence of any contaminants originating at LANL that would pose a risk to recreational fishing in the Rio Grande and downstream of Cochiti Lake (LANL 2004c). Monitoring data for a variety of environmental media are published annually in the site Environmental Surveillance Reports (LANL 2002d, 2004a, 2004d, 2005h, 2006h).

4.6 Human Health

The following sections summarize current information on public and worker health in and around LANL. The methods that are in place to monitor and reduce the risks to the public and workers from all hazards are described in the *1999 SWEIS* (see Chapter 4, Sections 4.6.1 and 4.6.2).

4.6.1 Public Health in the Los Alamos National Laboratory Vicinity

4.6.1.1 Cancer Incidence and Mortality in the Los Alamos Region

The *1999 SWEIS* presented a detailed discussion of cancer incidence and mortality in the Los Alamos region, based on national and regional statistics through about 1995. The *1999 SWEIS* summarized National Cancer Institute data for the State of New Mexico and its counties, as well as the results of independent studies conducted to investigate reported increased incidence of specific cancers in Los Alamos County and the surrounding communities. This section presents a summary of cancer incidence and mortality figures for the Los Alamos region as derived from the most recent data made available by the National Cancer Institute (through 2003).

Table 4–26 presents a summary of total cancer mortality, incidence of all cancers, and incidence of selected cancer types for the State of New Mexico, as well as Los Alamos, Santa Fe, Sandoval, and Rio Arriba Counties, for the period 1999 through 2003. During that period, the overall cancer incidence (412.2) and death rates (171.1) for the State of New Mexico were somewhat below the national average (462.2 and 195.7, respectively). Total cancer incidence in Los Alamos County (434.9) and two of the three contiguous counties exceeded the State average, although the rates in all four counties were below the national averages. As reported in the 1993

Los Alamos Cancer Rate Study (Athas and Key 1993), the incidence rates of melanoma of the skin, prostate cancer, and female breast cancer remain elevated in Los Alamos County with respect to the State averages. The rate of thyroid cancer also exceeded the State average for the period. Cancers of the lung, colon, and rectum occurred at rates below the State averages. Due to the small number of reported cases and resulting statistical unreliability of the data, the rates of non-Hodgkin's lymphoma, ovarian cancer, brain cancer, leukemia, and stomach cancer in Los Alamos County were not reported by the National Cancer Institute (NCI 2006).

Table 4–26 Five-Year Profile of Cancer Mortality and Incidence in the United States, New Mexico, and Los Alamos Region, 1999 through 2003 [a]

Statistic	*United States* [b]	*New Mexico*	*Los Alamos County*	*Santa Fe County*	*Sandoval County*	*Rio Arriba County*
Average Deaths Per Year	554,165	2,966	25	178	140	60
Annual Death Rate (per 100,000)	195.7 (195.5, 196.0)	171.1 (168.4, 173.9)	132.3 (109.5, 160.1)	147.7 (138.0, 158.0)	169.2 (156.9, 182.3)	163.4 (145.3, 183.3)
Annual Incidence Rate (per 100,000)						
All sites [c]	462.2 (461.4, 463.0)	412.2 (408.0, 416.5)	434.9 (394.0, 480.4)	478.1 (461.1, 495.5)	444.8 (424.9, 465.4)	337.0 (311.4, 364.3)
Brain and Other Nervous System	6.5 (6.4, 6.6)	5.6 (5.1, 6.1)	NA [d]	6.0 (4.3, 8.3)	4.7 (2.9, 7.3)	NA [d]
Breast (female)	124.9 (124.4, 125.5)	115.0 (112.0, 118.1)	127.2 (98.7, 165.7)	155.4 (142.9, 168.8)	123.6 (109.8, 138.7)	89.0 (72.0, 109.0)
Colon and Rectum	52.0 (51.7, 52.3)	42.9 (41.5, 44.3)	39.8 (28.0, 56.8)	44.2 (39.0, 49.8)	50.8 (44.2, 58.1)	40.6 (32.0, 50.9)
Leukemia	11.3 (11.2, 11.4)	12.5 (11.7, 13.2)	NA [d]	19.7 (16.3, 23.5)	13.3 (10.0, 17.3)	7.8 (4.4, 12.9)
Lung and Bronchus	67.5 (67.2, 67.8)	46.9 (45.5, 48.4)	28.5 (18.8, 43.7)	42.0 (36.9, 47.6)	48.1 (41.7, 55.4)	32.4 (24.6, 42.0)
Melanoma of Skin	16.6 (16.4, 16.7)	17.3 (16.4, 18.2)	29.6 (20.0, 44.4)	23.6 (20.0, 27.7)	19.1 (15.2, 23.6)	NA [d]
Non-Hodgkin's Lymphoma	18.4 (18.2, 18.5)	15.6 (14.7, 16.4)	NA [d]	19.8 (16.4, 23.7)	17.9 (14.0, 22.5)	12.6 (8.0, 19.1)
Ovary	13.1 (12.9, 13.2)	13.0 (12.0, 14.1)	NA [d]	15.3 (11.5, 20.1)	12.1 (8.1, 17.5)	NA [d]
Prostate	161.2 (160.4, 161.9)	152.2 (148.3, 156.1)	244.7 (202.4, 296.6)	198.3 (182.0, 216.1)	158.0 (140.3, 177.7)	151.4 (126.6, 180.2)
Stomach	7.1 (7.0, 7.2)	7.1 (6.5, 7.7)	NA [d]	7.1 (5.1, 9.7)	7.3 (5.0, 10.4)	12.1 (7.6, 18.6)
Thyroid	8.2 (8.1, 8.3)	10.2 (9.5, 10.9)	19.5 (11.3, 33.5)	10.8 (8.4, 13.6)	13.7 (10.5, 17.6)	12.6 (8.1, 18.9)

NA = not available.

[a] Age-adjusted incidence rates. 95 percent confidence interval in parentheses.

[b] The U.S. average number of deaths and annual death rate reported by the National Cancer Institute are for the entire 1999 through 2003 rate period. The U.S. annual incidence rates reported by the National Cancer Institute are for the year 2002.

[c] All cancers, all races, both sexes.

[d] Data not available. When the number of reported cases is small, some data are suppressed in National Cancer Institute reports to ensure confidentiality and stability of rate estimates.

Source: NCI 2006.

In a study entitled *Public Health Assessment, Final, Los Alamos National Laboratory,* the ATSDR of the U.S. Department of Health and Human Services Public Health Service reported on its review of possible public exposures to radioactive materials and other toxic substances in the environment near LANL (ATSDR 2006). The study also examined the results of the *Los Alamos Cancer Rate Study* (Athas and Key 1993), and a related work entitled *Investigation of Excess Thyroid Cancer Incidence in Los Alamos County* (Athas 1996), and determined that there were no data to link environmental factors, other than naturally occurring ultraviolet light from the sun, with the observed incidence of any cancer in Los Alamos County. The ATSDR report concluded that, "Overall, cancer rates in the Los Alamos area are similar to cancer rates found in other communities. In some time periods, some cancers will occur more frequently and others less frequently than seen in reference populations. Often, the elevated rates are not statistically significant."

4.6.1.2 Radiation in the Environment around Los Alamos National Laboratory

Radiation in the environment around LANL is attributed to external, naturally-occurring radiation and from past and present operations at LANL. External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from radionuclides naturally in the environment. Doses from cosmic radiation range from 50 millirem per year at lower elevations near the Rio Grande to about 90 millirem per year in the mountains. Doses from terrestrial radiation range from 50 to 150 millirem per year depending on the amounts of natural uranium, thorium, and potassium in the soil.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products, which contribute about 200 millirem per year. An additional 40 millirem per year results from naturally-occurring radioactive materials in the body, primarily potassium-40, which is present in all food and in all living cells.

In addition, members of the U.S. population receive an average dose of 50 millirem per year from medical and dental uses of radiation, 10 millirem per year from manmade products such as stone and adobe walls, and less than 1 millirem per year from global fallout from nuclear weapons tests. Because of the above factors, published estimates of the background doses received by people in the area around LANL generally give a range of rounded values, from a low of about 300 to a high of about 500 millirem per year (LANL 2006h). For this reason, the background dose varies and, for the purpose of this SWEIS, the typical LANL area resident is assumed to receive a dose near the middle of this range (approximately 400 millirem per year) from background sources.

Radiological Emissions Standards

Federal Government standards limit the dose that the public may receive from LANL operations. The DOE public dose limit to any individual from LANL operations is 100 millirem per year received from all pathways (that is, all ways in which people can be exposed to radiation, such as inhalation, ingestion, and direct radiation). The dose received from airborne emissions of radionuclides is further restricted by the EPA dose standard of 10 millirem per year (40 CFR Part 61). These doses are in addition to exposures from natural background, consumer products, and medical and dental radiation.

Radiological Dose Assessment

The LANL Environmental Surveillance and Compliance Program oversees the monitoring of the site and surrounding region foodstuffs, air, water, and soil for radiation, radioactive materials, and hazardous chemicals. The information is used for continually determining time trends and to assess potential risks to human health and the environment. The information is published annually in the LANL environmental surveillance report.

The *1999 SWEIS* provided a dose assessment as reported in the LANL *Environmental Surveillance and Compliance at Los Alamos During 1996* (LANL 1997c). The dose assessment provided below was reported in *Environmental Surveillance at Los Alamos During 2005* (LANL 2006h).

Doses, calculated and reported in the LANL Environmental Surveillance and Compliance Reports are incremental (above background) doses caused by operations at LANL. Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (external) radiation. Doses for the following cases are calculated:

- The entire population within 50 miles (80 kilometers) of the site,
- The maximally exposed individual (MEI) who is not on LANL or DOE property (referred to as the offsite MEI),
- Residents in the Los Alamos Townsite and White Rock.

The doses from the first two cases above, for the past 13 years, are shown in **Figures 4–26** and **4–27**. The two graphs are similar because LANSCE is the major contributor to both. Generally, the year-to-year fluctuations are the result of variations in the number of hours that LANSCE operates, whereas the downward trend is the result of efforts to reduce LANSCE emissions by installing delay lines and fixing small leaks. The increase in 2005 occurred because LANSCE operational time was over twice the 2004 level and a valve in the LANSCE emissions control system was defective.

In addition, offsite doses to individuals from water ingestion, food ingestion, and direct exposure from soil contamination are calculated based on measurements of radionuclide concentrations in groundwater, surface water, sediments, surface soil, and radioactive content of foods.

Population within 50 Miles (80 kilometers)

The distribution of population has changed since the *1999 SWEIS*. Details are shown in **Table 4–27**. There is an increase in the total population within a 50-mile (80-kilometer) radius of LANSCE (TA-53). The effects on the population dose and accident analyses of the shift in population will vary based on the meteorology of the area and which radionuclides are dominating the assessment.

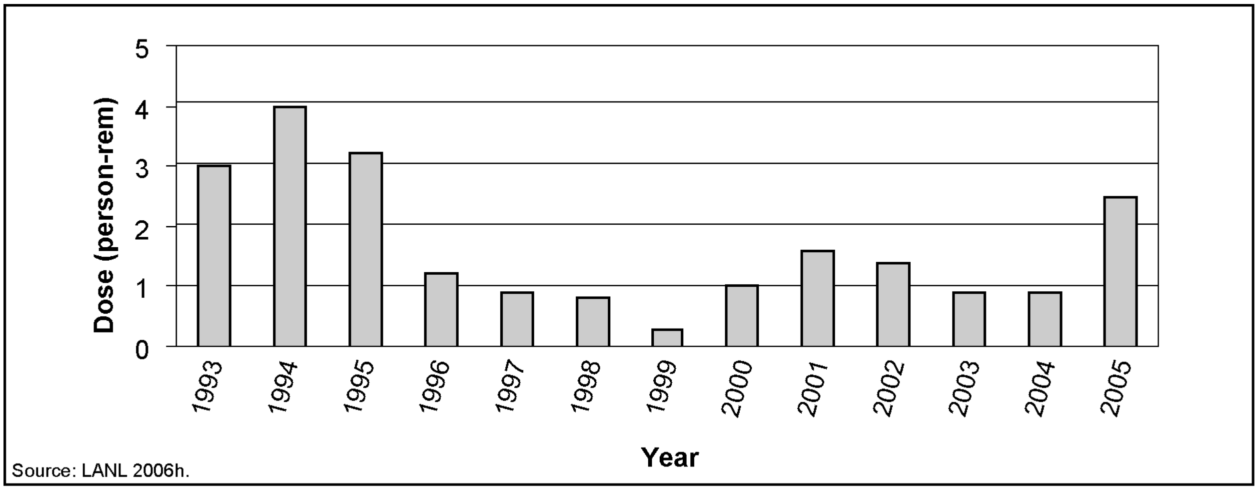

Figure 4–26 Annual Collective Dose (person-rem) to the Population within 50 Miles (80 kilometers) of Los Alamos National Laboratory

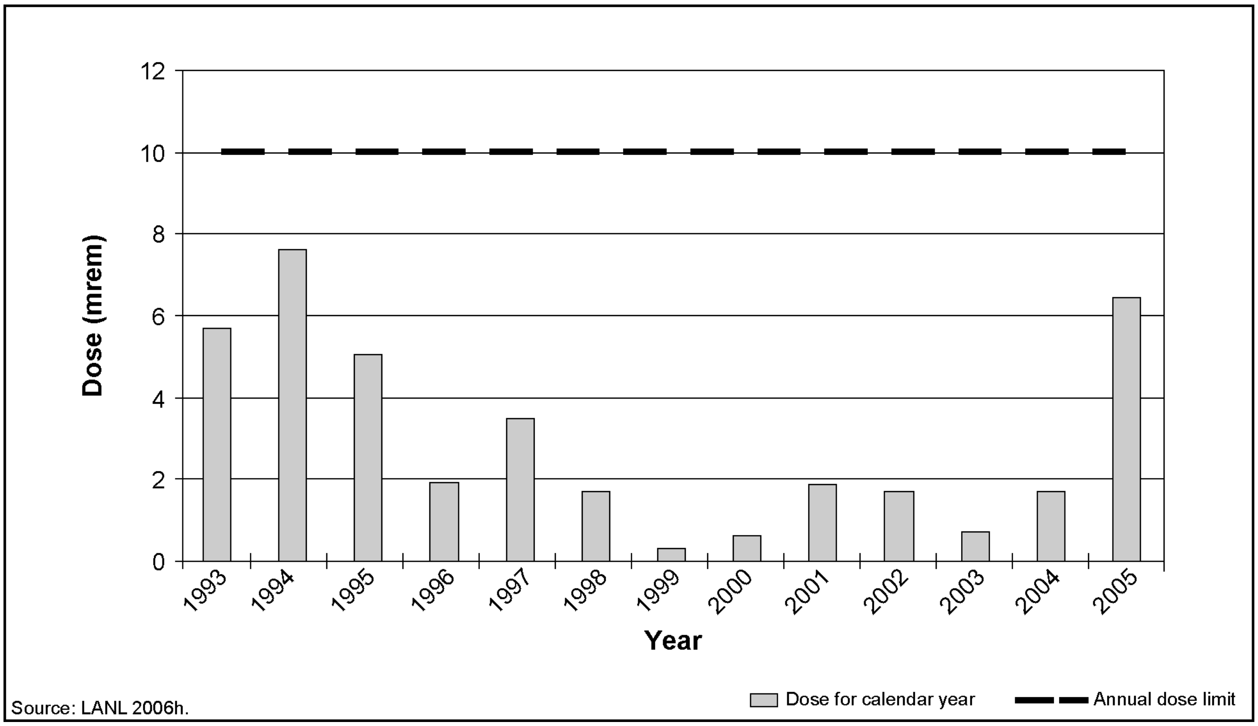

Figure 4–27 Annual Dose (millirem) to the Maximally Exposed Individual Offsite

Table 4–27 Changes in Population Distribution Since the *1999 SWEIS*

Miles from LANL [a]	*0 to 10*	*10 to 20*	*20 to 30*	*30 to 40*	*40 to 50*	*Total*	*Percent Increase*
1999 SWEIS	19,919	50,046	85,602	30,563	56,175	242,305	–
Current SWEIS	19,646	48,081	101,113	26,481	80,192	275,513	14 (33,208)

[a] Centered at the Los Alamos Neutron Science Center (TA-53).
Note: To convert miles to kilometers, multiply by 1.6093.
See Appendix C for further details.

The 2005 collective population dose attributable to LANL operations to persons living within 50 miles (80 kilometers) of the site was 2.46 person-rem. Tritium contributed about 17 percent of the dose, and short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 83 percent. This increase in the 2005 collective population dose was due to a longer beam time (over twice that of 2004) at LANSCE and a malfunction in the air emissions control system that was later fixed. Until 2005, population doses had declined from a high of about 4 person-rem in 1994 to less than 1 person-rem in 2004. As of November 2006, the collective population dose was expected to decrease in 2006 to the 2004 level.

Offsite Maximally Exposed Individual

The offsite MEI is a hypothetical member of the public who, while not on LANL property, would receive the largest dose from LANL operations. During 2005, two potential MEI locations were analyzed. One was at East Gate along NM 502, at the east side of Los Alamos County. East Gate is normally the location of greatest exposure because of its proximity to LANSCE. The total dose to the MEI at the East Gate in 2005 was estimated at 6.46 millirem, of which approximately 6.31 millirem would come from LANSCE. Emissions from LANSCE stacks were greatly elevated during 2005 due to longer beam operating time (almost 10 months in 2005 versus 4 months in 2004) and a malfunction in the air emissions control system. As of November 2006, the emissions were expected to return to the 2004 rates as a result of the system's repair and additional controls implemented in 2005.

The second location evaluated as a potential MEI in 2005 was the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G. The dose at this location was calculated to be approximately 0.9 millirem per year, less than the MEI dose at the East Gate. The MEI dose of 6.46 millirem is below the 10 millirem per year airborne emissions dose limit for the public (40 CFR Part 61). The year-to-year fluctuations in the emission rate from LANSCE are the result of variations in the number of hours that LANSCE runs. The downward trend indicated in recent years resulted from installing delay lines and fixing small leaks.

Onsite Maximally Exposed Individual

The onsite MEI is a member of the public who would receive a radiological dose from LANL operations while onsite. This MEI had been evaluated in previous years, but because of increased security restrictions, members of the public are prevented from accessing many of the technical areas. This change, combined with the relocation of significant radiation sources, makes an onsite MEI no longer applicable.

Doses in Los Alamos Townsite and White Rock

Los Alamos Townsite. During 2005, the measurable contributions to the dose at an average Los Alamos residence were as follows: 0.08 millirem from radionuclides produced at LANSCE and 0.01 millirem from tritium. Other nuclides contribute less than 0.02 millirem. These doses add up to 0.11 millirem.

White Rock. During 2005, the measurable contributions to the dose at an average White Rock residence were as follows: 0.04 millirem from emissions at LANSCE and 0.01 millirem from tritium. Other nuclides each contribute less than 0.01 millirem. These add up to 0.06 millirem.

Water (Ingestion Pathway)

The majority of radionuclides detected in groundwater samples collected during 2005 resulted from the presence of natural radioactivity in these sources. Tritium was the only radionuclide detected in these groundwater samples that could possibly be attributed to LANL operations. The highest concentration of tritium from a known or potential drinking water source (349 picocuries per liter) was measured in a sample from an alluvial spring in Upper Los Alamos Canyon, which is not a recognized drinking water supply. This concentration was far below the EPA maximum contaminant level of 20,000 picocuries per liter and results in a dose less than 0.1 millirem per year (LANL 2006h).

Soil (Direct Exposure Pathway)

Soil samples were collected on the perimeter of San Ildefonso Pueblo land within Mortandad Canyon, downwind of Area G. No samples had radionuclide concentrations above the Regional Statistical Reference Levels. As the strontium-90 and cesium-137 soil concentrations at the sample location were less than the Regional Statistical Reference Levels for both radionuclides, the doses from cesium-137 and strontium-90 concentrations in soil are most likely from global fallout, not LANL. The tritium could mainly come from three sources: cosmic rays, nuclear weapons testing, and LANL; however, the total dose from tritium in soil was virtually nonexistent. Similarly, transuranics (such as plutonium) may include a small contribution from LANL, but the dose would be less than 0.1 millirem per year. Finally, the isotopic mixture of uranium was consistent with natural uranium. Therefore, the LANL contribution to dose from soil is less than 0.1 millirem per year, and the majority of the radionuclides detected are primarily due to fallout (LANL 2006h).

Food (Ingestion Pathway)

Over the years, LANL staff has collected a variety of foodstuff samples (fruits, vegetables, grains, fish, milk, eggs, honey, herbal teas, mushrooms, pinyon nuts, domestic animals, and large and small game animals) from the surrounding area and communities to determine the impacts of LANL operations on human health via the human food chain. During 2005, predator and bottom-feeding fish were caught at Abiquiu and Cochiti Reservoirs and purslane (*Portulaca* species), a wild edible plant, was collected on the perimeter of San Ildefonso Pueblo within Mortandad Canyon, downwind of Area G. Fish caught at Abiquiu Reservoir serve as a background population that is essentially removed from the influence of LANL because the reservoir is upstream of the site. Cochiti Reservoir is downstream of LANL and fish caught there are potentially impacted by LANL operations. A review of the radionuclide concentrations indicated that the dose received from consuming predator and bottom-feeding fish caught at Cochiti Reservoir would be much less than 0.1 millirem per year.

Purslane was again chosen for analysis in 2005 to better define the reasons for slightly higher levels of some radionuclides in wild edible plants in 2004. The analyses of the nine radionuclides in purslane plants collected from Mortandad Canyon on San Ildefonso Pueblo lands showed that strontium-90 was the only radionuclide detected in concentrations above the Regional Statistical Reference Level. The highest level of strontium-90 in purslane plants from Mortandad Canyon was below the screening level of 1 picocurie per gram. Assuming consumption of approximately 30 pounds of purslane per year, a total dose of approximately 0.1 millirem would be received from the consumption of wild purslane. The LANL contribution to the dose from consuming foodstuffs would be on the order of 0.1 millirem per year if wild foodstuffs were collected and consumed. In summary, the total annual dose to an average resident from ingestion of fish and wild purslane was approximately 0.1 millirem.

4.6.1.3 Radionuclides and Chemicals in the Environment Around Los Alamos National Laboratory

The risk to the public health from ingestion of water, foodstuffs, and from incidental ingestion of soils and sediments was estimated in the *1999 SWEIS* from environmental surveillance data within and surrounding LANL. As indicated in the *1999 SWEIS*, the risk of toxicity and carcinogenicity continues to be dominated by existing concentrations of radionuclides and chemicals in environmental media due to naturally occurring materials, global fallout, and other anthropogenic sources affecting the region, and historical operations (including emissions and effluents, and accidental spills and releases).

Estimates of dose and risk from radioactive and nonradioactive contaminants potentially ingested by residents, recreational users of LANL lands, and via special pathways are evaluated in Appendix D of the *1999 SWEIS* based on contaminant data published in *Environmental Surveillance Reports* for the period between 1991 and 1997. According to the *1999 SWEIS*, the total worst-case ingestion doses for the offsite resident of Los Alamos County and Non-Los Alamos County resident would be 11 and 17 millirem per year, respectively. If this person is also a recreational user of the Los Alamos canyons, drinking canyon water and ingesting canyon sediments, the worst-case additional dose would range up to 1 millirem per year. If the individual has traditional American Indian or Hispanic lifestyles, the worst-case additional dose would be 3 millirem per year (DOE 1999a). Thus the worst-case individual could receive 15 and 21 millirem per year. The associated excess latent cancer fatality risk for the offsite resident would be in the range of 9 to 13 in one million (using a conversion risk factor of 0.0006 excess latent cancer fatalities per rem).

Estimates were also made in the *1999 SWEIS* of the potential health risk from nonradioactive contaminants in groundwater, surface water, soils, and sediments, vegetables, fruit, and fish. According to the *1999 SWEIS*, the hazard indices for all detectable metals were generally less than 1 (a Hazard Index of 1 or greater than 1 is considered indicative of a potential health hazard to the exposed individual) and the latent cancer fatality risk less than one in one million per year.

Appendix C, of this *SWEIS*, re-examines the potential health risk to specific receptors from contaminants in the environment around LANL. Dose and risk were estimated using environmental surveillance data reported over several years. The reported concentrations were averaged and a 95 percent upper confidence level (95 percent upper confidence limit) concentration was determined for each contaminant in each of several foodstuffs and environmental media. Using published guidelines, consumption rates for specific foodstuffs and environmental media were selected to depict the exposure of residents to environmental contaminants. Exposures were calculated for typical (average) and high levels of consumption. As represented by the Appendix C calculations, the ”Offsite Resident” is a person who depends heavily on locally acquired foodstuffs (including some fish, game, and other wild foods) and whose living habits and diet result in higher-than-average exposure to radionuclides and chemicals in the environment. Additional pathway components were analyzed to account for exposures to an avid recreational user of wildlands at LANL (the “Recreational User”). Finally, several additional diet items (“Special Pathways”) were analyzed to assess the potential added impacts to Native American, Hispanic, and other residents with traditional living habits and diets. Where appropriate, updated exposure pathway parameters and risk factors were used to estimate the dose and risk from radioactive and nonradioactive contaminants in the environment.

The results of these analyses are not much different from those presented in the *1999 SWEIS*. As represented by the sum of all the analyzed pathway components, the worst-case individual (an “Offsite Resident” who is also a “Recreational User” and consumes the “Special Pathways” diet items) would receive a radiation dose of 11 millirem per year and the associated excess latent cancer fatality risk would be 6.6 in one million. With the exception of several naturally-occurring metals, the hazard indices for all nonradioactive contaminants are again found to be generally less than 1 and the latent cancer fatality risk less than 1 in one million per year. The findings of the *1999 SWEIS* regarding exposure of Los Alamos County residents to naturally-occurring arsenic and beryllium are confirmed in Appendix C.

Arsenic and vanadium were identified as having a Hazard Index above 1 in groundwater that supplies Los Alamos County and San Ildefonso Pueblo. Excess latent cancer fatality risk from arsenic greater than 1 in one million per year was also estimated for consumption of soils, sediments, and surface water, by some residents and recreational users of LANL. While the risk associated with arsenic ingestion was greater than 1 in one million per year, the arsenic was not associated with discharges at LANL. Arsenic and vanadium are endemically present in the rocks, soils, groundwater, and surface waters in the region in which New Mexico is located (DOE 1999a).

Beryllium has no Hazard Index for ingestion exceeding 1. However, excess latent cancer fatality rates greater than 1 in one million are estimated in several pathways. Beryllium concentrations in waters, soils, and sediments are typical of those in background readings in the northern New Mexico region. Based on the environmental surveillance data from LANL, the portion of beryllium associated with LANL operations is not a significant contributor to beryllium concentrations in the immediate area of LANL (DOE 1999a).

Radionuclide and chemical concentrations in the environment around LANL are not expected to change significantly over time. If anything, they are expected to diminish with the radioactive decay of the radionuclide constituents. An event, however, with a potential for redistribution of radionuclide and chemical constituents in the vicinity of LANL was the Cerro Grande fire that occurred in May 2000. The Cerro Grande Fire burned areas that were known or suspected to be contaminated with radionuclides and chemicals, which raised concerns about health effects to the public offsite. Studies were conducted to determine radiological and nonradiological effects in the vicinity of LANL after the fire (RAC 2002, LANL 2002g).

The LANL study considered the possibility that the fire enhanced flooding in watersheds that have residual contamination from early LANL operations (LANL 2002g). The objective was to estimate potential radiological and nonradiological effects from the fire that might have been experienced by receptors most affected during calendar year 2000. Observations and sampling showed that the aftereffects of the Cerro Grande Fire resulted in increased concentrations of radioactive and chemical contaminants in runoff and in sediments deposited during 2000. The predominance of these effects was caused by the increased mobilization of locally deposited worldwide fallout or of naturally-occurring substances that were concentrated by the fire. The study concluded that none of the receptors most affected (residents of Totavi or direct and indirect users of Rio Grande water) was likely to have experienced health effects as a result of exposures to radioactive and nonradioactive contaminants during calendar year 2000.

The study performed by the Risk Assessment Corporation (RAC 2002), was performed at the request of the NMED and was funded by DOE. It was an independent assessment of public health risks from radionuclides and chemicals associated with LANL releases as a result of the fire. The assessment covered releases to the air and to surface waters.

With regard to air releases, the Risk Assessment Corporation assessment indicated that "exposure to LANL-derived chemicals and radionuclides released to the air during the Cerro Grande Fire did not result in a significant increase in health risk over the risk from the fire itself" (RAC 2002). The risk of cancer from exposure to radionuclides and carcinogenic metals released from vegetation that burned was greater than that from radionuclides and chemicals released from contaminated sites at LANL. All cancer risks were below the EPA established range acceptable risks of 1 in one million to 1 in 10,000. "Potential intakes of noncarcinogenic LANL-derived chemicals exceeded acceptable intakes established by EPA at some locations on LANL property" (RAC 2002). However, the estimated intakes were conservative, and the actual risks were likely overestimated.

Cancer risks from exposure to LANL-derived radionuclides and carcinogenic chemicals released to the surface water as a result of the Cerro Grande Fire were within acceptable limits established by the EPA. Estimated intakes of noncarcinogenic LANL-derived chemicals were also less than acceptable limits established by EPA. Of the exposure scenarios considered, the estimated health risks were highest for the hypothetical resident living year round on the bank of the Rio Grande near the confluence of Water Canyon. The most important type of exposure in terms of risk was eating fish. The potential annual cancer risk for that individual was calculated to be less than 3 in one million. For comparison, this *SWEIS* (Appendix C) estimates a worst case ingestion pathway dose of 0.0011 rem, which corresponds (using the current risk conversion factor of 0.0006 excess latent cancer fatalities per rem) to an excess latent cancer fatality risk of 6.6 in one million.

In the *Public Health Assessment* (ATSDR 2006), ATSDR reviewed environmental monitoring data from 1980 to 2001 and assessed past, current, and potential future human exposure situations. Based on the observed levels of various contaminants in the environment and the potential exposure pathways, the ATSDR concluded that no harmful exposures due to chemical or radioactive contamination detected in groundwater, surface soil, surface water and sediment, air or biota are occurring or expected to occur in the future. The data considered in the ATSDR assessment included at least one full year of environmental monitoring results from the period following the Cerro Grande fire. Retrieval of documents and data from the pre-1980 period is continuing. Based on the results of that retrieval effort, the ATSDR will determine if additional actions need to be taken to evaluate pre-1980 potential exposures.

In 1999, the Centers for Disease Control and Prevention began the Los Alamos Historical Document Retrieval and Assessment Project to systematically identify the information available concerning past releases of chemicals and radionuclides from the site between 1943 and the present. In January 2006, the project team issued an interim report summarizing historical operations at Los Alamos, materials that were used, materials that were likely released offsite, development of residential areas around Los Alamos, and the relative importance of identified releases in terms of potential health risks. The results of efforts to use plutonium measurements in soil around LANL to gain information about the potential magnitude of historical plutonium releases were also presented. The project is ongoing and the Centers for Disease Control and Prevention has expressed its intent to work with stakeholders to evaluate whether historical releases of radionuclides or other toxic materials from Los Alamos operations warrant more detailed evaluation (CDC 2006).

4.6.2 Los Alamos National Laboratory Worker Health

This section summarizes operational health risk experience at LANL, including exposure of workers to radioactive materials and hazardous materials resulting in intakes and recordable incidents due to exposure or physical injuries from workplace hazards. The *1999 SWEIS* contained a summary of radiological and chemical exposure and physical hazard incidents affecting worker health at LANL during the 1990s. It also included a summary of worker health-related studies at LANL as well as a description of all LANL worker health programs. This section provides information concerning worker safety, updated for the years 1999 to 2004.

Worker conditions at LANL have remained essentially the same as those identified in the *1999 SWEIS*. More than half the workforce remains routinely engaged in activities that are typical of office and computing industries. Much of the remainder of the workforce is engaged in light industrial and bench-scale research activities. Approximately one-tenth of the general workforce at LANL continues to be engaged in production, services, maintenance, and research and development within nuclear and moderate hazard facilities (LANL 2003h).

4.6.2.1 Worker Exposures to Ionizing Radiation

Occupational radiation exposures for workers at LANL from 1999 to 2005 are summarized in **Table 4–28**. The collective total effective dose equivalent (TEDE) for the LANL workforce during 2005 was 156 person-rem, considerably lower than the workforce dose of 704 person-rem projected in the *1999 SWEIS* ROD (LANL 2006h).

Table 4–29 summarizes the highest individual dose data for 1999 through 2005. The highest individual doses in 2005 were 2.051, 1.603, 1.398, 1.285, and 1.146 rem. There were no doses that exceeded DOE’s 5 rem per year Radiation Protection Standard. With one exception, all worker doses were below the 2 rem per year performance goal set by the as low as reasonably achievable Steering Committee in accordance with LANL procedures (LANL 2006g).

Table 4–28 Radiological Exposures of Los Alamos National Laboratory Workers

Parameter	Units	1999	2000	2001	2002	2003	2004	2005
Collective TEDE (external plus internal)	person-rem	131	196	113	164	241	125	156
Number of workers with measurable dose	Number	1,427	1,316	1,332	1,696	1,989	1,710	2,169
Average measurable dose (external plus internal)	Millirem	92	149	85	96	121	73	72
Average measurable dose (external only)	Millirem	90	65	83	95	111	68	69

TEDE = total effective dose equivalent.
Source: LANL 2006g.

Table 4–29 Highest Individual Doses to Los Alamos National Laboratory Workers [a]

1999	2000	2001	2002	2003	2004	2005
1.910	1.048	1.284	2.214	3.0 [b]	1.539	2.051
1.866	1.013	1.225	1.897	1.8 [b]	1.510	1.603
1.783	0.905	1.123	1.813	1.710	1.500	1.398
1.755	0.828	1.002	1.644	1.569	1.148	1.285
1.749	0.815	0.934	1.619	1.214	1.061	1.146

[a] Units = rem.
[b] Two workers were exposed to plutonium-238 while performing pre-inventory checks at TA-55. These radiation doses are revised down from what was originally reported.
Sources: LANL 2006g.

The collective TEDE for 2005 is 75 percent of the 208 person-rem for 1993 through 1995 used as a baseline in the *1999 SWEIS* and significantly less than the 704 person-rem collective TEDE projected in the *1999 SWEIS*. Several offsetting factors can be responsible for helping keep the dose below the *1999 SWEIS* baseline. The primary factor is that pit manufacturing has not become fully operational while other factors include: (1) changes in work load and types of work, and (2) improvements in the as low as reasonably achievable program (LANL 2006g).

4.6.2.2 Non-ionizing Radiation, Chemical and Biological Exposures

Non-ionizing radiation refers to any type of electromagnetic radiation that does not carry enough energy to ionize living material, that is, to completely remove an electron from an atom. Because non-ionizing radiation has lower energy than ionizing radiation, it has fewer health risks than ionizing radiation. Technologies used at LANL that generate non-ionizing radiation include lasers, microwave-generating and radiofrequency devices, technologies that generate ultraviolet radiation, video displays and instrumentation, welding, and security-related devices. Devices that generate nonionizing radiation are regulated by the U.S. Food and Drug Administration, while worker exposures are regulated by the Occupational Safety and Health Administration. Public exposures are not expected as any non-ionizing radiation generated by site operations are localized in nature. Devices that can generate larger amounts of non-ionizing radiation, such as some lasers, can cause eye injury to anyone who looks directly into the beam or its mirror reflection, or skin burns. Worker exposures could occur because of equipment failure, improper use of equipment, or non-adherence to procedures. Mitigation measures include regular equipment maintenance and inspections, use of design measures such as interlocks that prevent laser operation unless the enclosure is secured, and administrative controls and training. Workers who operate more powerful lasers are required to have an eye examination, complete a laser safety training course, and understand and follow applicable procedures.

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (for example, soil through direct contact or ingestion). Section 4.4.2 of this chapter presents the atmospheric concentrations of the more prevalent chemicals. The presence of chemicals in surface and groundwater at LANL is presented in Section 4.3.1.3 and Section 4.3.2. Soil conditions are presented in Section 4.2.3.1 while chemical wastes generated by site operations are presented in Section 4.9.3.

Adverse health impacts to the public are minimized through administrative and design controls to decrease hazardous chemical releases to the environment and to achieve compliance with permit requirements. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts to the public may occur during normal operations at LANL via inhalation of air containing hazardous chemicals released to the atmosphere by LANL operations. Risks to public health from ingestion of contaminated drinking water or direct exposure are also potential pathways.

Chemical exposure pathways to LANL workers during normal operations may include inhaling the workplace atmosphere, drinking LANL potable water, and possible other contact (that would lead to absorption through the skin) with hazardous materials associated with work assignments. Workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. LANL workers are also protected by adherence to the Occupational Safety and Health Administration and EPA occupational standards that limit atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring, which reflects the frequency and amounts of chemicals used in the operation processes, ensures that these standards are met. Additionally, DOE requirements ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at LANL are substantially better than required by standards.

LANL staff currently work with biological organisms as part of the national science and security missions of the site. Microorganisms are found naturally in the environment, yet only a very small percentage of these can cause infection and mild to severe disease in humans. Potential worker exposures to microorganisms could occur through inhalation, ingestion, or cutaneous contact with biological material generated from normal laboratory activity. In addition, other biohazardous materials with which workers may come in contact include animals and animal carcasses through wildlife management programs, and sanitary waste at the Sanitary Wastewater System, but these are considered minor sources of biological exposure as compared to the microbiological materials used in projects related to the national security missions. Work conducted in the LANL biosciences laboratories are governed by safety and security requirements for biohazardous materials as outlined in the document entitled "Biosafety in Microbiological and Biomedical Laboratories" by the Centers for Disease Control and

Prevention (see Appendix C). Worker exposure to biohazardous material is primarily regulated through the Occupational Safety and Health Administration. Laboratory safety and security measures are used to reduce or eliminate laboratory staff and the general public from potential exposures to microorganisms being researched at LANL. These mitigation measures include safety equipment, laboratory design, administrative controls, training, and containment measures for appropriate biohazardous material (see Appendix C). There have been no public health hazards attributed to LANL operations due to the use of these safety control measures for biological laboratories.

4.6.2.3 Occupational Injuries and Illness

Table 4–30 summarizes occupational injury and illness rates at LANL from 1999 through 2005. Occupational injury and illness rates for workers in 2005, although higher than some previous years, continue to be small as shown in the table. These rates correlate to reportable injuries and illnesses during the year for 200,000 hours worked or roughly 100 workers (LANL 2006g).

Table 4–30 Occupational Injury and Illness Rates at Los Alamos National Laboratory [a]

Calendar Year	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
TRC [b]	2.52	1.97	1.96	2.39	2.30	2.86	2.80
DART [c]	1.37	0.94	0.91	1.46	1.26	1.35	0.99

[a] All workers, including University of California workers.
[b] Total Recordable Cases, number per 200,000 hours worked.
[c] Days away, restricted, or transferred, number of cases per 200,000 hours worked.
Source: LANL 2006g.

4.6.3 Accident History

Accidents were discussed in the *1999 SWEIS*. Since 1999, accidents at LANL have included the following. On August 5, 2003, in a storage room in TA-55 a package containing residues from plutonium-238 operations breached while being handled by two workers performing a pre-inventory check. The breach was caused by degradation of the container. The pressurized release of materials from the package resulted in confirmed intakes of plutonium by both workers. The internal doses to the workers were initially estimated to be in excess of 10 rem committed effective dose equivalent. However, based on follow-up bioassay results, the assigned doses were later revised downward to about 1.8 and 3 rem (NNSA 2003). Cleanup of the storage room, including repackaging of the nuclear materials, is ongoing with containers at risk having been removed, or repackaged or temporarily mitigated prior to final repackaging. Decontamination of the room will be completed upon completion of repackaging or removal of the nuclear materials (LANL 2006a).

On February 15, 2001, plutonium-238 was released into the air from a glovebox when the hot nuclear material caused a crack in a technician's uninsulated glove. The accident was partially a result of the failure to follow procedures for safely handling plutonium-238. DOE investigated allegations concerning this incident, along with radiological incident reports from 1999 and 2000 at TA-55. As a result, recommendations were made, accepted by DOE, and instituted in corrective actions at TA-55 (DOE 2003f).

In March 2000, a radiological release of plutonium-238 occurred near a glovebox in the Plutonium Facility at TA-55. Seven workers had confirmed intakes of plutonium-238. The source of the release was a compression fitting in a contaminated vacuum line serving the glovebox. After an investigation was completed, lessons learned from this incident were documented by DOE. As a result, DOE performed a check of over 50,000 mechanical fittings at TA-55 and corrected leak problems (DOE 2000c).

Since 1945, there have been 13 criticality accidents at LANL (LANL 2000c). The accidents occurred during processing, critical experiment setups, and operations. These accidents resulted in various levels of radiation exposure to involved workers and in no or little damage to the equipment. The early criticality accidents (prior to 1946) resulted in worker fatalities. After 1947, remote criticality experiment facilities were constructed, leading to minimum doses to workers from criticality accidents. None of the accidents resulted in any significant exposure to members of the public. Although a number of criticality accidents were experienced at LANL in the period from 1945 to the early 1980s, a review of more recent LANL annual environmental and accident reports indicates that there have been no accidents since that time that have resulted in significant adverse impacts to workers, the public, or the environment. During the review period, from 1986 to 1990, site operations were much greater than in previous years and higher than anticipated for the future (DOE 2000c).

Beginning May 4, 2000, the Cerro Grande Fire damaged or destroyed 112 structures at LANL and about 230 residential structures in the Los Alamos Townsite. By the time it was contained (16 days later), it had burned about 7,700 acres (3,110 hectares) within the boundaries of LANL. DOE is conducting an extensive environmental monitoring and sampling program to evaluate the effects of that fire at LANL. The program will identify changes from pre-fire baseline conditions that will aid in evaluating potential future impacts, especially those from any contaminants that may have been transported offsite (LANL 2000c). Effects from the fire on different environmental resources are described in the applicable sections of this chapter.

In addition to the aforementioned radiological and wildfire accidents, a number of non-radiological accidents have occurred at LANL from 2000 to 2005. On July 14, 2004, an undergraduate student working with a LANL scientist using two lasers in an experiment suffered a retinal traumatic hole in one eye caused by pulsed laser light. This accident occurred because neither experiment participant was wearing the required laser eye protection and they looked directly down the laser beam path. The employees involved further exacerbated this accident by not reporting the incident immediately and securing the scene. After this accident the LANL director temporarily suspended all operations and ordered a complete safety review of the lab (LANL 2004h, 2004i).

On May 27, 2005, a chemical accident occurred in TA-9 Building 21 resulting in injury to two involved workers. The workers were weighing a normally inert chemical material when it experienced a chemical reaction that caused the release of energy. Both employees suffered a range of wounds, none of which were fatal and were treated at the Los Alamos Medical Center. One employee was released from the center on the same day as the accident. The event was localized to the area immediately surrounding the location of the chemical handling (Delucas 2005).

In June 2005, two LANL workers were mixing hydrochloric and nitric acid to form a corrosive liquid called aqua regia. They both inhaled vapors that evolved during the mixing operation. One employee had a temporary shortness of breath while the other suffered longer-term respiratory symptoms, which eventually caused him to be hospitalized for six days. Neither employee suffered permanent injuries. LANL management was not informed of this event until after the hospitalized employee returned to work (Lenderman 2005). During the last several years, a number of incidents have occurred at TA-55 PF-4, which resulted in worker contamination and doses due to plutonium-238 uptakes. DOE investigated each incident, analyzed it for root causes, and developed a set of recommendations. The DOE Lessons Learned Database was also updated with information from these incidents. In each case, LANL staff performed specific actions in the areas of procedures, training, inspection, and component upgrading and replacement in order to address the root causes and preclude reoccurrence of the event (DOE 2000b, 2003f, 2004b, 2004d).

4.6.4 Los Alamos National Laboratory Emergency Management and Response Program

Emergency response facilities and equipment, trained staff, and effective interface and integration with offsite emergency response authorities and organizations support LANL's emergency management system. LANL personnel maintain the necessary apparatus, equipment, and Emergency Operations Center to respond effectively to virtually any type of emergency, not only on the LANL site, but throughout the local community as well.

The Emergency Response and Management Program is operated out of a new two-story, 38,000-square foot (3,530-square-meter) Emergency Operations Center. Construction of the facility began in January 2002, and it became operational in December 2003. The building serves as the command center for responding agencies in an emergency and has space and resources to house up to 120 personnel, including representatives from neighboring Pueblos, the Federal Bureau of Investigation, the Federal Emergency Management Agency, DOE, U.S. Forest Service, National Park Service, National Guard, New Mexico State Police, Los Alamos County Police, Firefighters, Emergency Managers, the Red Cross, and others.

The Center's multi-faceted communications includes a multi-band radio system; a media interface and emergency broadcast system; a mobile communications van and mobile command center, to which essential functions can be transferred immediately in an emergency; fixed wing and helicopter surveillance; and emergency communications of all kinds. More than 600 telephone and high-speed data lines serve the Emergency Operations Center. The Emergency Operations Center can receive video from fixed cameras monitoring traffic at key points throughout Los Alamos County and LANL, and can control programmable signs that advise motorists of emergency or traffic conditions on the main roads. The Emergency Operations Center information network includes a data mirror with the latest information on facility conditions, hazardous material inventories, and other updates that would aid first responders.

LANL's Emergency Response and Management Program effectively combines Federal and local emergency response capabilities. A coordinated effort to share emergency information with Los Alamos County is a cornerstone of the Emergency Management Program. LANL emergency management staff and Los Alamos County police, fire, emergency medical, and 911 dispatch personnel operate out of the LANL Emergency Operations Center. It is the United States' first Emergency Operating Center that combines Federal and local operations. A computer-aided dispatch system provides a centralized dispatch capability for the Los Alamos Police and Fire Departments. First responders from different agencies share real-time information from the same Emergency Operations Center, resulting in a more coordinated emergency response.

The construction of the new Emergency Operations Center was initiated in response to the destructive wildfires in northern New Mexico in the summer of 2000. It replaces a cramped, outdated facility that was located in TA-59, could accommodate only 16 people, and had limited communications capabilities. DOE, with assistance from the LANL Emergency Response and Management staff, is responsible for initiating, coordinating, and reviewing all written emergency response agreements. The agreements serve as the basis for communicating roles and responsibilities, dispatching mutual aid, carrying out emergency operations, and providing for treatment and care of patients during an emergency event at LANL. These agreements and memoranda of understanding are established with county and state agencies, local fire and law enforcement entities, and local emergency medical centers. Key organizations and agencies having mutual aid agreements with DOE and LANL are Los Alamos County Mutual Aid, Los Alamos Medical Center, St. Vincent Hospital Mutual Assistance, Española Hospital, and University of New Mexico Hospital. DOE subcontracts with Los Alamos County for fire department services.

There are several mechanisms to coordinate site emergency response plans and training opportunities with local offsite response agencies. Routine coordination between LANL staff and offsite agencies is primarily handled through the Los Alamos County Local Emergency Planning Committee, which meets monthly and is headed by the Los Alamos County Emergency Manager. The Planning Committee includes representatives from the Emergency Response and Management Program, various Los Alamos County and nearby county emergency response agencies, the National Forest Service, the National Park Service, and other interested parties. County personnel are heavily involved in planning efforts for most LANL exercises, including discussions on scenario selection. Conversely, if a LANL training and exercise scenario does not meet the county's needs, the county runs its own scenario with LANL staff participating as a response organization. Furthermore, LANL personnel provide training at no cost to a variety of county-associated response entities, including members of the bomb disposal and crisis negotiation teams.

Operating under the oversight of the NNSA Los Alamos Site Office, LANL's emergency management and response system is a mature program with an acceptable level of readiness. The program operates in accordance with applicable Federal requirements, including DOE Order 151.1C *Comprehensive Emergency Management System*, and encompasses five main areas:

- Emergency planning activities, including the identification of hazards and threats, hazard mitigation, development and preparation of emergency plans and procedures, and identification of personnel and resources needed for an effective response;
- Emergency preparedness activities, including the acquisition and maintenance of resources and the implementation of a training, drill, and exercise program;
- Emergency response activities, including the application of available resources to mitigate the consequences of an emergency to workers, the public, the environment, national security, and the initiation of recovery planning. Trained LANL personnel, including specialized teams such as the HazMat, Crisis Negotiation, and Hazardous Devices teams are available to respond on a 24-hour basis;
- Emergency recovery activities, including planning and actions to return site or facility operations to a normal state following termination of the emergency; and
- Emergency readiness assurance activities, including assessments, documentation, and program management plans to ensure emergency capabilities are adequate.

LANL personnel are responsible for the development of the *Wildland Fire Management Plan*. It will be integrated into the existing Fire Protection Program and implemented and administered by the Emergency Response and Management Program.

4.6.5 Los Alamos National Laboratory Security Program

LANL maintains special nuclear material inventories, classified matter, and facilities that are essential to nuclear weapons production. These security interests are protected against a range of threats that include adversarial groups, theft or diversion of special nuclear material, sabotage, espionage, and loss or theft of classified matter or government property.

LANL's physical security protection strategy is based on a graded and layered approach supported by an armed guard force trained to detect, deter, and neutralize adversary activities and backed up by local, state, and Federal law enforcement agencies. This strategy employs the concept of defensible concentric layers where each layer provides addition controls and protections.

The defense-in-depth approach begins in the airspace above LANL, which is restricted to approximately 5,000 feet (1,500 meters) above the ground surface. On the ground protection begins at the site perimeter and hardened access control points and builds inwardly to facility exteriors and designated interior zones and control points.

Both staffed and automated access control systems limit entry into areas and facilities to authorized individuals. Additional security measures include random stops and inspections of cars. Automated access control systems use booths, turnstiles, doors, and gates controlled by magnetic-stripe badge readers and hand-geometry personal identifiers. Escorting requirements provide access controls for visitors entering security areas. Access control is also provided through control of the selection, use issuance, and safeguarding of keys and cores for locks.

Entrance and exit inspections and portal systems with metal detectors, nuclear material monitors, explosives detectors, and X-ray machines are used to prevent unauthorized introduction or removal of prohibited items and security interests. The guard force also performs random roving inspections throughout the site. Additionally, handlers use highly trained explosives detection and drug detection dogs to conduct random and systematic inspections. The LANL contractor uses truck and package inspection facilities with detection equipment and canine support to segregate, inspect, and stage materials prior to delivery.

Physical security protection also includes barriers, electronic surveillance systems, and intrusion detection systems that form a comprehensive site-wide network of monitored alarms. Various types of barriers are used to delay or channel personnel, or to deny access to classified matter, special nuclear material, and vital areas. Barriers are used to direct the flow of vehicles through designated entry control portals and to deter and prevent penetration by motorized vehicles where vehicular access could significantly enhance the likelihood of a successful malevolent act. Barriers may be passive and designed to require the use of special tools and high explosives to penetrate them. Barriers may also have an active component designed to dispense an obscuration agent, viscous barrier, or sensory irritant.

Tamper-protected surveillance, intrusion detection, and alarm systems designed to detect an adversary action or anomalous behavior inside and outside LANL facilities are paired with assessment systems to evaluate the nature of the adversary action. Random patrols and visual observation are also used to deter and detect intrusions. Penetration-resistant alarmed vaults and vault-type rooms are used to protect classified materials.

Guards are stationed in mobile and fixed posts around LANL 24 hours a day, 365 days a year. They are trained and equipped to respond to alarms and adversary action in accordance with well-designed and thoroughly tested plans using specialized equipment and weapons.

4.7 Cultural Resources

Cultural resources are human imprints on the landscape and are defined and protected by a series of Federal laws, regulations, and guidelines. To fully meet the requirements of these laws, regulations, and guidelines, DOE is implementing *A Plan for the Management of the Cultural Heritage at Los Alamos National Laboratory, New Mexico* (LANL 2006f). Implementation of this plan, which has undergone public review, involves a Programmatic Agreement between DOE, the Advisory Council on Historic Preservation, and the New Mexico State Historic Preservation Office (DOE 2006b). By carrying out the terms of the agreement, DOE will fulfill its responsibilities under Section 106 of the National Historic Preservation Act.

The three general categories of cultural resources addressed in this section are archaeological resources, historic buildings and structures, and traditional cultural properties. Archaeological resources include any material remains of past human life or activities which are of archaeological interest, including items such as pottery, basketry, bottles, weapons, rock art and carvings, graves, and human skeletal materials. The term also applies to sites that can provide information about past human lifeways. Historic buildings include buildings or other structures constructed after 1942 and LANL-era buildings that have been evaluated for eligibility to the National Register of Historic Places (NRHP). Traditional cultural properties are defined as a place of special heritage value to contemporary communities (often, but not necessarily, American Indian groups) because of their association with the cultural practices or beliefs that are rooted in the histories of those communities and are important in maintaining the cultural identity of the communities (LANL 2006f).

LANL's Cultural Resources Management Plan

A Plan for the Management of the Cultural Heritage at Los Alamos National Laboratory, New Mexico (Cultural Resources Management Plan) defines the responsibilities, requirements, and methods for managing cultural resources at LANL. It provides a series of steps and procedures for complying with Federal historic preservation laws and regulations, such as the National Historic Preservation Act and the Native American Graves Protection and Repatriation Act, as well as DOE policies and directives related to cultural resources protection.

Critical to success of the Cultural Resources Management Plan are strategies that effectively administer those cultural resources warranting long-term protection while at the same time facilitating land-use flexibility in support of the DOE mission at LANL. The Plan supports this by specifying steps for the timely integration of cultural resource concerns and reviews into program and project planning.

The initial step is notification about a proposed project by the responsible organization at LANL. Cultural resources in an area of potential effects are next identified by reviewing background information and conducting additional studies, as necessary. Approximately 800 to 1000 cultural resource reviews of projects are performed at LANL each year.

Cultural resources are then assessed to determine if adverse effects could occur and to identify ways to avoid, minimize, or resolve any anticipated consequences. Project reviews and evaluations might also involve field checks by qualified cultural resource managers. Additionally, DOE consults with State or Tribal Historic Preservation Officers, as well as other knowledgeable parties, as appropriate.

Finally, a plan is formulated to resolve any anticipated adverse effects. Actions that might be undertaken could include avoiding the cultural resource, modifying the undertaking to minimize adverse effects, completely documenting the property, and wholly or partially excavating the site. As necessary, the boundaries of a cultural resource are clearly marked prior to initiating physical work on a project to assist in avoiding any adverse effects.

Occupation and use of the Pajarito Plateau began as early as 10,000 BC as foraging groups used the area for gathering and hunting large game animals. Since that time a succession of peoples have populated the area as reflected in the rich archaeological resources and historic buildings and structures that are present. The chronological sequence associated with the cultural history for the northern Rio Grande is presented in **Table 4–31**. A detailed description of each period is provided in *A Plan for the Management of the Cultural Heritage at Los Alamos National Laboratory, New Mexico* (LANL 2006f).

Table 4–31 Culture History Chronology for Northern Rio Grande Specific to Los Alamos National Laboratory and the Pajarito Plateau

Culture Period Dates	*Culture Period Dates*	*Culture Period Dates*
Paleoindian	Clovis	9500 to 8000 BC
	Folsom	9000 to 8000 BC
	Late Paleoindian	8000 to 5500 BC
Archaic	Jay	5500 to 4800 BC
	Bajada	4800 to 3200 BC
	San Jose	3200 to 1800 BC
	Armijo	1800 to 800 BC
	En Medio	800 BC to AD 400
	Trujillo	AD 400 to 600
Ancestral Pueblo	Early Developmental	AD 600 to 900
	Late Developmental	AD 900 to 1150
	Coalition	AD 1150 to 1325
	Classic	AD 1325 to 1600
American Indian, Hispanic, and Euro-American	Early Historic Pajarito Plateau	AD 1600 to 1890
	Homestead	AD 1890 to 1943
Federal Scientific Laboratory	Manhattan Project	AD 1942 to 1946
	Cold War (Early Cold War)	AD 1956 to 1990 (AD 1946 to 1956)

Source: LANL 2006f.

Two potential National Historic Landmarks and one potential National Register Historic District have been proposed at LANL. The former includes the "Project Y" Manhattan Project and Los Alamos National Laboratory Ancestral Pueblo National Historic Landmarks. "Project Y" of the Manhattan Project lasted only four years (1942 through 1946), but represented one of the defining moments of recent world history. The main goal of "Project Y" was the immediate development and possible deployment of the world's first atomic weapon. The potential Los Alamos National Laboratory Ancestral Pueblo National Historic Landmark would consist of four discrete units totaling 132 acres (53.4 hectares) and would recognize a number of the Ancestral Pueblo archaeological sites that are especially important due to integrity of location and the nature of the resource (LANL 2006f).

The potential Los Alamos Archaeology National Register Historic District would consist of a number of sites and clusters of sites that, while not deemed of sufficient significance to be considered for inclusion in the two potential National Historic Landmarks, nevertheless are important to the State of New Mexico and to the Nation. The proposed National Register Historic District would contain a total of 10 discrete components with a combined size of 1,496 acres (605.4 hectares). Included are six complexes rich in resources dating from the Archaic Period through the Ancestral Pueblo Classic Period and four components relating to the Homestead Period (LANL 2006f).

4.7.1 Archaeological Resources

As of 2005, archaeological surveys have been conducted on approximately 90 percent of the land within LANL boundaries with 86 percent having been intensively surveyed. This represents an increase of 15 percent in the total area surveyed since publication of the *1999 SWEIS*. The majority of these surveys emphasized American Indian cultural resources. Information on these resources was obtained from the LANL cultural resources database, which is organized primarily by site type. A total of 1,915 archaeological resource sites have been identified at LANL. Of these, 1,776 are prehistoric sites related to the Paleoindian, Archaic, and Ancestral Pueblo Cultures and 139 are related to the early American Indian, Hispanic, and Euro-American Cultures. Although about 400 archaeological resource sites have been determined to be NRHP-eligible, most of the remaining sites have yet to be formally assessed and are therefore assumed to be eligible until assessed (LANL 2006f).

Following the Cerro Grande Fire, surveys identified 333 archaeological resource sites that were impacted. Of these sites, 269 were damaged by the fire, 35 by suppression activities, and 29 by rehabilitation activities. Damage included direct loss, soot staining, spalling, and cracking of stone masonry walls of Ancestral Pueblo field houses and room blocks, and exposure of artifacts from erosion. The fire offered the opportunity for rehabilitation of selected Ancestral Pueblo archaeological sites and such work, including erosion control, placing protective fences, and tree thinning (to protect sites from future fires), was conducted at 107 sites (LANL 2004c). The Cerro Grande Fire also affected a number of homestead era sites with many wooden structures being burned. The Grant and Gomez homesteads located in Water Canyon and north of Pajarito Canyon, respectively, are two examples where the fire and subsequent rehabilitation measures damaged or destroyed Homestead Period resources (LANL 2006f). Additionally, the fire, as well as the tree thinning measures taken to reduce wildfire hazard, resulted in the discovery of 447 new archaeological sites (LANL 2006a).

The conveyance and transfer of land has resulted in archaeological sites being removed from DOE protection (LANL 2002b). Archaeological protection easements are a means by which these resources may be protected. Such easements have been established on 79.5 acres (32 hectares) of TA-74, which has largely been conveyed to Los Alamos County in order to protect 31 archaeological sites. Protective easements will also be established in Rendija Canyon to protect traditional cultural properties and allow access to these properties by San Ildefonso and Santa Clara Pueblos. These easements are being set up with a private conservation trust to provide protection in perpetuity (LANL 2004c, 2004f).

Since publication of the *1999 SWEIS*, a number of actions have occurred that have affected archaeological resources at LANL. Vandalism to two sites within the Rendija Canyon Tract was caused when vehicles drove through the sites during a holiday weekend. This tract is to be conveyed to Los Alamos County. Additionally, a contractor associated with the West Jemez Road Upgrade Project drove through an archaeological site. In both cases, corrective actions were taken to prevent any recurrence (LANL 2006a).

4.7.2 Historic Buildings and Structures

In terms of the historic built environment, there are a total of 510 buildings and structures that date to the Manhattan Project and early Cold War. Of these, 31 date to the Manhattan Project. A total of 179 of these 510 buildings and structures have been evaluated for eligibility for inclusion in the NRHP, of which 98 have been determined eligible and 81 not eligible. These figures include a small number of structures younger than 50 years in age that are likely to be deemed of exceptional national significance and are thus eligible for inclusion in the NRHP despite not yet having achieved the 50-year-old age limit normally required for inclusion. These potentially exceptional structures are those identified as the 15 "SWEIS Key Facilities" in the *1999 SWEIS* (LANL 2006f).

A number of factors have served to greatly reduce the number of Manhattan Project buildings still extant as of October 2004. These include (1) the expedient initial construction of the original buildings and structures; (2) post-Manhattan Project infrastructure development particularly during the late 1950s and early 1960s, and again beginning in the late 1990s through the first decade of the 21st century; (3) the development of the Los Alamos townsite during the 1950s and 1960s; (4) the Cerro Grande Fire; and (5) contamination of some buildings by asbestos and radioactive isotopes. As of 2003, only 28 Manhattan Project buildings retained sufficient historical and physical integrity for listing on the NRHP, and only a handful are deemed suitable for long-term preservation and interpretation (LANL 2006f). Additionally, the decrease in the number of historic buildings reported in the *1999 SWEIS* is due to no longer counting temporary and modular properties, shed, and utility features associated with the Manhattan Project and Cold War Periods. These properties were removed from the count because they are exempt from review under terms of the Programmatic Agreement between DOE, the New Mexico State Historic Preservation Office, and the Advisory Council on Historic Preservation (DOE 2006b).

As a result of the conveyance and transfer of 2,259 acres (914 hectares) of land to Los Alamos County and the Pueblo of San Ildefonso, two historic buildings have been removed from DOE protection. Archaeological protection easements established within TA-74 (see Section 4.7.1) will protect one of these resources (LANL 2006a).

Since publication of the *1999 SWEIS*, two historic sites associated with the Manhattan Project have been affected by the TA-33 Remodeling Project and road construction at the TA-8 Gun Site. In the case of the TA-33 Remodeling Project, a rollup door on a Manhattan Project building was removed before consultation and documentation was carried out. Corrective action included photographic documentation of the building after the door was removed, along with the creation of archival quality negatives from digital photographs taken prior to the door removal. The Manhattan Project complex at the TA-8 Gun Site was disturbed by road construction; however, corrective actions, including restoring the parking lot area, establishing a new access road, constructing a retaining wall, and reseeding disturbed areas, have been completed (LANL 2006a). An additional Manhattan Project site, the V-site, was affected by the Cerro Grande Fire. The remaining standing building at the site is currently being stabilized as part of the "Save America Treasures" program (LANL 2006f).

4.7.3 Traditional Cultural Properties

Within LANL's boundaries there are ancestral villages, shrines, petroglyphs (carvings or line drawings on rocks), sacred springs, trails, and traditional use areas that could be identified by Pueblo and Hispanic communities as traditional cultural properties. According to the DOE compliance procedure, American Indian Tribes may request permission for visits to sacred sites within LANL boundaries for ceremonies (DOE 1999a).

When a project is proposed, LANL arranges site visits with Tribal representatives from the San Ildefonso, Santa Clara, Jemez, and Cochiti Pueblos as appropriate to solicit their concerns and to comply with applicable requirements and agreements. Provisions for coordination among these four Pueblos and DOE are contained in Accords that were entered into in 1992 for the purpose of improving communication and cooperation among Federal and Tribal Governments (DOE 1999a).

During preparation of the *1999 SWEIS*, consultations were conducted with 19 American Indian Tribes and two Hispanic communities to identify cultural properties important to them in the LANL region. All of the consulting groups stated that they had at least some traditional cultural properties present on or near LANL. Categories and numbers of traditional cultural properties identified included 15 ceremonial and archaeological sites, 14 natural features, 10 ethonobotanical sites, 7 artisan material sites, and 8 subsistence features. Although these resources were stated as being present throughout LANL and adjacent lands; no specific features or locations were identified that would permit formal evaluation and recognition as traditional cultural properties. 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 American Indian culture (DOE 1999a).

A “Comprehensive Plan for the Consideration of Traditional Cultural Properties and Sacred Sites at Los Alamos National Laboratory, New Mexico” was sent by DOE to 26 different Tribes to help complete the traditional cultural properties identification and evaluation process begun in the *1999 SWEIS*. As of September 30, 2005, this process had narrowed the number of Tribes with active traditional cultural properties concerns on LANL to the Pueblo of San Ildefonso, the Pueblo of Santa Clara (Rendija Canyon), and possibly the Pueblo of Cochiti. DOE maintains ongoing discussions with these pueblos. Such discussions with the Pueblo of San Ildefonso have identified one traditional cultural property, which is in the process being forwarded to the New Mexico State Historic Preservation Office for review and concurrence. In addition, several other locations have been identified by the Pueblo of San Ildefonso for consideration as traditional cultural properties. None of these are locations that would have a significant impact on current mission activities at LANL.

The Cerro Grande Fire did not damage any known traditional cultural properties with the exception of light damage to one site in Rendija Canyon. Subsequent rehabilitation and fire prevention was carried out at all traditional cultural properties within the Rendija Canyon. The conveyance of the Rendija Tract to Los Alamos County would affect a number of traditional cultural properties (LANL 2002b).

A number of traditional cultural properties were identified in the Rendija Canyon Tract in 1993 in response to the then proposed Bason Land Exchange (LANL 2002b); another traditional cultural property was identified during the Land Conveyance and Transfer Project. Although not directly disturbed, seven traditional cultural properties within the tract were threatened by persons driving through a traditional cultural properties-dense area and by disturbance through the removal of stones to use in the apparent burial of a pet. Corrective actions have been taken in order to prevent further damage to these sites including placing fencing around all traditional cultural properties in the Rendija Canyon Tract, posting areas as environmentally sensitive, documenting damage, strengthening gates, and installing surveillance cameras. Additionally, discussion have been held with Santa Fe National Forest archaeologists and recreation specialists to formulate a shared strategy for helping to prevent or limit future vandalism in Rendija Canyon (LANL 2006a).

4.8 Socioeconomics and Infrastructure

This section describes changes that have occurred in the LANL socioeconomic region of influence and LANL site infrastructure since the publication of the *1999 SWEIS*. These changes have been compared to impact projections made in the *1999 SWEIS* for the Expanded Operations Alternative at LANL. This comparison provides an appraisal of whether those projected impacts continue to fall within the operating envelope established by the *1999 SWEIS* with regard to impacts on socioeconomic conditions in the region of influence and demands and usage of LANL site infrastructure.

4.8.1 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics of a region. The number of jobs created by the Proposed Action could affect regional employment, income, and expenditures. Job creation is characterized by two types: (1) construction-related jobs, which are transient in nature and short in duration, and thus less likely to impact public services; and (2) operations-related jobs, which would last longer, and thus could create additional public service requirements in the region of influence.

In order to determine whether socioeconomic impacts in the region of influence since publication of the *1999 SWEIS* are below, at, or above levels predicted for the Expanded Operations Alternative, comparisons were made between site employment projections predicted in the *1999 SWEIS* and those reported in the *SWEIS Yearbook* – 2005 (LANL 2006g) and other site documents.

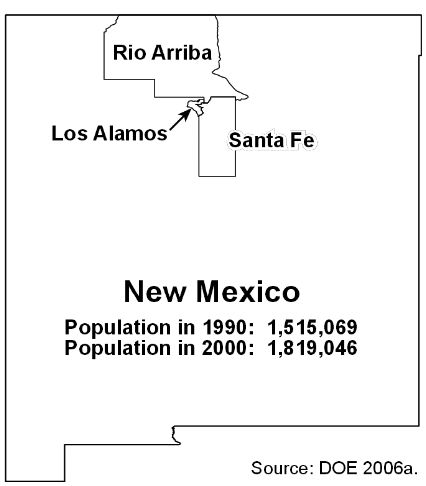

Figure 4–28 Counties in the Los Alamos National Laboratory Region of Influence

4.8.1.1 Regional Economic Characteristics

Socioeconomic impacts were analyzed in the *1999 SWEIS* for a region of influence that included the "Tri-County" region consisting of Los Alamos, Rio Arriba, and Santa Fe Counties in New Mexico (see **Figure 4–28**). Over 85 percent of LANL site employees and their families reside in these counties (see **Table 4–32**). Thus, the socioeconomic conditions of these counties have the most potential to be directly or indirectly affected by changes in operations at LANL. In 2005, a total of 13,504 persons were employed by LANL contractors, of which approximately 12,650 resided in New Mexico.

Table 4–32 Distribution of Los Alamos National Laboratory Affiliated Work Force by Place of Residence in the Region of Influence

Year	*Total LANL Employees*	*LANL Employees that Reside in the ROI*	*Percent of LANL Employees that Reside in the ROI*	*ROI Employed*	*LANL as a Percent of ROI Employed*
1996	11,155	9,913	88.9	86,038	11.5
1997	11,496	10,259	89.2	87,819	11.7
1998	12,008	10,703	89.1	90,046	11.9
1999	12,412	11,028	88.9	92,246	12.0
2000	12,015	10,780	89.7	96,258	11.2
2001	12,380	10,941	88.4	98,121	11.2
2002	13,524	11,867	87.7	99,960	11.9
2003	13,616	12,031	88.4	102,945	11.7
2004	13,261	11,727	88.4	104,185	11.3
2005	13,504	11,564	85.6	107,090	10.8
Average 1996 to 2005	12,537	11,081	88.4	96,471	11.5

ROI = Region of Influence.
Sources: NMDOL 2005, 2006a; LANL 2003h, 2004f, 2005f, 2006g.

Between 2000 and 2005, the civilian labor force in the Tri-County area increased 11.6 percent to the 2005 level of 112,003. In 2005, the annual unemployment average in the region of influence was 4.4 percent, which was smaller than the annual unemployment average of 5.3 percent for New Mexico (NMDOL 2006a).

In 2005, direct government employment represented the largest sector of employment in the Tri-County area (29.9 percent), followed by retail and wholesale trade (14.1 percent), leisure and hospitality (12.8 percent), and healthcare and social assistance (11.4 percent). The totals for these employment categories in New Mexico were 23.2 percent, 15.0 percent, 10.8 percent, and 11.1 percent, respectively (NMDOL 2006b).

4.8.1.2 Demographic Characteristics

The 2000 demographic profile of the region of influence population and income information is included in **Table 4–33**. Persons self-designated as minority individuals in the Tri-County region comprise 57.9 percent of the total population. This minority population is composed largely of Hispanic or Latino and American Indian residents. The Pueblos of San Ildefonso, Santa Clara, San Juan, Nambe, Pojoaque, Tesuque, and part of the Jicarilla Apache Indian Reservation are included in the region of influence.

The *1999 SWEIS* projected that within the first year of expanded operations, the total population in the Tri-County region would grow by 2.5 percent. In the 10 years between the 1990 census and the 2000 census, the population in this area grew 24.7 percent, or approximately 2.3 percent a year (DOC 2006a, 2006b). In July 2005, the total population in the Tri-County region was estimated to be 200,292 (DOC 2007).

Table 4–33 Demographic Profile of the County Population in the Los Alamos National Laboratory Region of Influence

Population Group	*Los Alamos County – Population (percent)*	*Rio Arriba County – Population (percent)*	*Santa Fe County – Population (percent)*	*Region of Influence – Population (percent)*
Minority				
Hispanic alone	1,505 (8.2)	17,701 (43.0)	36,263 (28.0)	55,469 (29.4)
Black or African American	67 (0.4)	143 (0.3)	826 (0.6)	1,036 (0.5)
American Indian or Alaska Native	107 (0.6)	5,717 (13.9)	3,982 (3.1)	9,806 (5.2)
Asian	694 (3.8)	56 (0.1)	1,133 (0.9)	1,883 (1.0)
Native Hawaiian or Pacific Islander	6 (0.0)	47 (0.1)	94 (0.1)	147 (0.1)
Some other race	495 (2.7)	10,554 (25.6)	22,936 (17.7)	33,985 (18.0)
Two or more races	418 (2.3)	1,353 (3.3)	5,268 (4.1)	7,039 (3.7)
Total Minority	3,292 (17.9)	35,571 (86.4)	70,502 (54.5)	109,365 (57.9)
White alone	15,051 (82.1)	5,619 (13.6)	58,790 (45.5)	79,460 (42.1)
Total	18,343 (100.0)	41,190 (100.0)	129,292 (100.0)	188,825 (100.0)

Source: DOC 2006b.

4.8.1.3 Regional Income

Income information for the LANL region of influence is included in **Table 4–34**. There are major differences in the income levels among the three counties, especially between Rio Arriba County at the low end with a median household income in 2004 of $32,935 and a per capita income of $22,194 and Los Alamos County at the upper end with a median household income of $94,640 and a per capita income of $52,524. The median household income in Los Alamos County is over twice that of the New Mexico State average and is the highest for any county in the Nation (DOC 2006c). In 2004, only 3.2 percent of the population in Los Alamos County was below the official poverty level compared with 18.1 percent of the population of Rio Arriba County.

Table 4–34 Income Information for the Los Alamos National Laboratory Region of Influence

	Los Alamos County	*Rio Arriba County*	*Santa Fe County*	*New Mexico*
Median household income 2004 (dollars)	94,640	32,935	43,727	37,838
Per capita income 2004 (dollars)	52,524	22,194	36,095	26,679
Percent of persons below poverty line (2004)	3.2	18.1	12.0	16.7

Sources: BEA 2007, DOC 2006c.

The Pueblo of San Ildefonso is a minority-dominated community near LANL (see Figure 4–1) and had, in the year-2000 census, a median household income of $30,457. About 12.4 percent of the families lived below the poverty level. The median household incomes of four additional nearby pueblos were as follows (DOE 2004e):

- Santa Clara: $30,946 (16.4 percent of families below poverty level);
- Cochiti: $35,500 (13.2 percent of families below poverty level);

- Jemez: $28,889 (27.2 percent of families below poverty level); and
- Pojoaque: $34,256 (11.3 percent of families below poverty level).

4.8.1.4 Los Alamos National Laboratory-Affiliated Work Force

The LANL-affiliated workforce includes both management and operating contractor employees and subcontractors (see **Table 4–35**). From 1999 through 2005, the number of employees exceeded *1999 SWEIS* ROD projections. The 13,504 employees at the end of 2005 were 2,153 more employees than *1999 SWEIS* ROD projections of 11,351. The 1999 projections were based on 10,593 employees identified for the index year (employment as of March 1996) (LANL 2003h).

Table 4–35 Los Alamos National Laboratory-Affiliated Work Force

SWEIS ROD [a]	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
11,351	12,412	12,015	12,380	13,524	13,616	13,261	13,504

[a] The total number of employees was presented in the *1999 SWEIS;* the breakdown had to be calculated based on the percentage distribution shown in that document for the base year.
Sources: LANL 2003h, 2004f, 2005f, 2006g.

These employees have had a positive economic impact on northern New Mexico. Through 1998, DOE published a report each fiscal year regarding the economic impact of LANL on north-central New Mexico, as well as the State of New Mexico. The findings of these reports indicate that LANL's activities resulted in a total increase in economic activity in New Mexico of about $3.2 billion in 1996, $3.9 billion in 1997, and $3.8 billion in 1998. The publication of this report was discontinued after 1998 due to funding deficiencies. However, based on the increases in number of employees and payroll, it is assumed that LANL's yearly economic contribution has continued to increase (LANL 2004f).

4.8.1.5 Housing

Table 4–36 lists the total number of occupied housing units and vacancy rates in the region of influence. In 2000, there were a total of 83,654 housing units in the Tri-County area, with 89.7 percent occupied and 10.3 percent vacant. The median value of owner-occupied homes in Los Alamos County ($228,300) was the greatest of the three counties, and over twice the median value of owner-occupied homes in Rio Arriba County ($107,500). The vacancy rate was the smallest in Los Alamos County (5.5 percent) and highest in Rio Arriba County (16.5 percent). During the Cerro Grande Fire, approximately 230 housing units were destroyed or damaged in the northern portions of Los Alamos County (DOE 2000f) and as a result, vacancy rates likely decreased. Although available housing can change year to year, in 2005 there was generally a housing shortage in Los Alamos County.

The residential distribution of management and operating contractor employees reflects the overall housing market dynamics of the three counties. In 2005, approximately 86 percent of management and operating contractor employees continued to reside in the Tri-County area as shown in **Table 4–37**.

Table 4–36 Housing in the Los Alamos National Laboratory Region of Influence

	Los Alamos County	*Rio Arriba County*	*Santa Fe County*	*Region of Influence*
Housing (2000)				
Total units	7,937	18,016	57,701	83,654
Occupied housing units	7,497	15,044	52,482	75,023
Vacant units	440	2,972	5,219	8,631
Vacancy Rate (percent)	5.5	16.5	9.0	10.3
Median value (dollars)	228,300	107,500	189,400	175,067

Source: DOC 2006b.

Table 4–37 Percentage of Los Alamos National Laboratory Employees Residing in the Region of Influence

Year	*Los Alamos County*	*Rio Arriba County*	*Santa Fe County*	*Total*
1999	52.6	16.6	19.7	88.9
2000	52.6	17.0	20.1	89.7
2001	50.9	17.6	19.9	88.4
2002	49.5	17.5	20.8	87.7
2003	49.2	17.6	21.5	88.4
2004	48.3	18.5	21.6	88.4
2005	47.3	15.9	22.4	85.6

Sources: LANL 2003h, 2004f, 2005f, 2006g.

4.8.1.6 Local Government Finances

Local DOE activities directly and indirectly account for more than a third of employment, wage and salary income, and business activity in the Tri-County region. If there is a change in employment, employee incomes, or procurement at LANL, these changes would be expected to 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).

Table 4–38 shows the general funds revenues for the Tri-County region. Los Alamos County generates the highest revenues, more than double those of Santa Fe County and nearly 7 times those of Rio Arriba County. 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.

Table 4–38 General Funds Revenues in the Tri-County Region (Fiscal Year 2003)

Source	*Los Alamos County*	*Rio Arriba County* [a]	*Santa Fe County* [b]
Property Taxes	4,298,335	4,178,176	26,782,625
Gross Receipt Taxes	16,541,971	9,309,389	66,982,214
Oil, Gas and Mineral Taxes	Not available	7,256,598	0
Other Taxes, Penalties and Interest	428,236	721,654	9,426,917
Licenses, Permits, Fees and Service Charges	64,203,173	5,566,310	65,304,807
Misc. Income	Not available	3,536,397	16,905,470
Restricted Funds	Not available	5,146,384	16,928,997
Other	55,760,870	6,943,392	47,645,434
Total Receipts	141,232,585	42,658,300	249,976,464

[a] Includes revenues for Española.
[b] Includes revenues for the city of Santa Fe.
Source: LANL 2004c.

4.8.1.7 Services

New Mexico is divided into 89 school districts, 4 of which are predominantly within the Tri-County area. Total public school enrollment in these districts is 24,061 students for the 2005 to 2006 school year. In the Los Alamos School District, enrollment of 3,628 in 2005 to 2006 is essentially the same as it was 5 years earlier. Enrollment at the Española Public School District decreased by approximately 5 percent from 2000 to 2001 school year to the 2005 to 2006 school year; current enrollment is 4,702 students. At the Pojoaque Public School District, enrollment remained relatively stable over the same time frame with current enrollment at 1,991 students. Enrollment in the Santa Fe Public School District grew by 2.7 percent over that time frame to the current enrollment of 13,740 students (NMDOE 2002, NMPED 2006).

The Los Alamos County 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 six manned fire stations with 141 budgeted positions including 123 uniformed personnel (LAC 2006a).

The Los Alamos County Police Department has 31 officers and 10 detention staff. The ratio of commissioned police officers in Los Alamos County was 1.58 officers per 1,000 of population in 2000 compared to Albuquerque (2.02) or Santa Fe (2.14) (DOJ 2004).

Four hospitals serve the Tri-County region: Los Alamos Medical Center, Española Hospital, and St. Vincent Regional Medical Center and the Public Health Service Santa Fe Indian Hospital in Santa Fe. These hospitals have a bed capacity of 47, 80, 268, and 39, respectively (LAMC 2006, Presbyterian 2006, St. Vincent 2006, AHA 2007).

4.8.2 Infrastructure

Site infrastructure includes the physical resources required to support the construction and operation of LANL facilities. Utility infrastructure at LANL encompasses the electrical power, natural gas, steam, and water supply systems. Sanitary wastewater treatment and solid waste management are addressed in Sections 4.3 and 4.9, respectively. Transportation infrastructure is addressed in Section 4.10. There have been a number of developments at LANL regarding utility infrastructure since the *1999 SWEIS* was issued, both in terms of the trend in resource usage and infrastructure capacity availability as well as with regard to the purveyor of some utility services.

4.8.2.1 Electricity

Electrical service to LANL is supplied through a cooperative arrangement with Los Alamos County, known as the Los Alamos power pool, which was established in 1985. Electric power is supplied to the pool through two existing regional 115-kilovolt electric power lines. The first line (the Norton-Los Alamos line) is administered by DOE and originates from the Norton Substation east of White Rock, and the second line (the Reeves Line) is owned by the Public Service Company of New Mexico and originates from the Bernalillo-Algodones Substation south of LANL. Both substations are owned by the Public Service Company of New Mexico (DOE 2003d, LANL 2006g). These facilities are shown in **Figure 4–29**.

Import capacity is now limited only by the physical capability (thermal rating) of the transmission lines based on recent changes (as of August 1, 2002) in transmission agreements with the Public Service Company of New Mexico. The import capacity is approximately 110 to 120 megawatts from a number of hydroelectric, coal, and natural gas-powered generators throughout the western United States (LANL 2004c, 2006g). Previously, the pool's import capacity was contractually limited to 72 megawatts during the winter months and 94 megawatts during the spring and early summer months (DOE 1999a). In addition, renewable energy sources such as wind farms and solar plantations are providing a small (about 5 percent) but growing percentage of Public Service Company of New Mexico's total power portfolio (PNM Resources 2006, PSCNM 2006).

Within LANL, DOE also operates a natural gas-fired steam and electrical power generating plant at TA-3 (TA-3 Co-Generation Complex or Power Plant), which is currently capable of producing up to 20 megawatts of electric power that is shared by the power pool under contractual arrangement. Generally, onsite electricity production is used to fill the difference between peak loads and the electric power import capability. The DOE-maintained electric distribution system at LANL consists of various low-voltage transformers at LANL facilities and approximately 34 miles (55 kilometers) of 13.8-kilovolt distribution lines. It also consists of two older power distribution substations: the Eastern TA Substation and the TA-3 Substation (LANL 2004c; LANL 2006g). In 2002, DOE completed construction of the new Western TA Substation (see Figure 4–29). This 115-kilovolt (13.8-kilovolt distribution) substation has a main transformer rated at 56-megavolt-amperes or about 45 megawatts. The substation will provide redundant capacity for LANL and the Los Alamos Townsite in the event of an outage at either of LANL's two existing substations (LANL 2004c, 2006g).

The trends in peak electric load demand and total electrical energy consumption within the Los Alamos power pool are provided in **Table 4–39** and **Table 4–40**, respectively. Annual (fiscal year) observed peak load and total energy requirements for the period 1999 through 2005 are compared to projections made in the *1999 SWEIS* for the Expanded Operations Alternative. These data provide the basis for the projections made in Chapter 5 of this SWEIS.

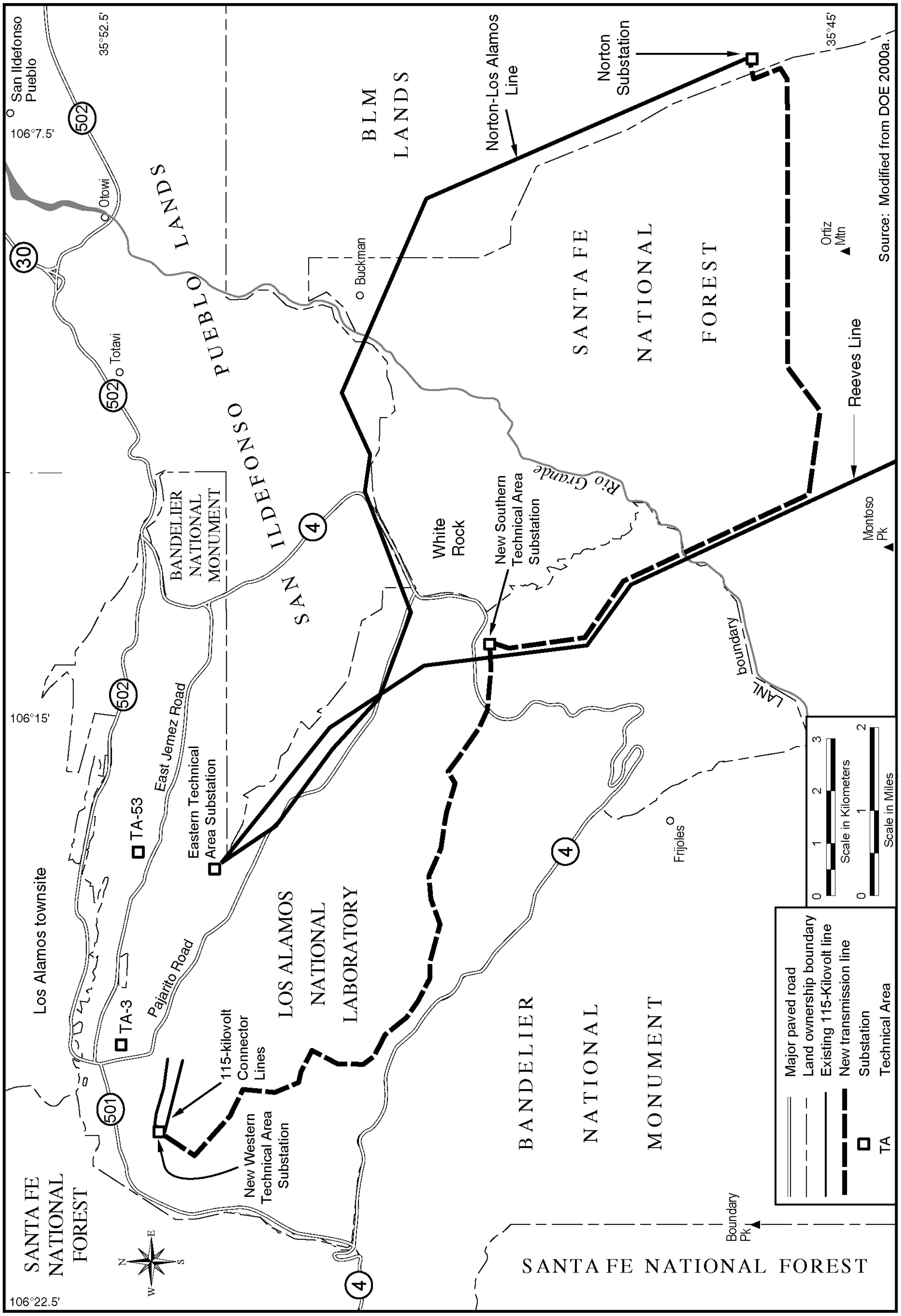

Figure 4–29 Los Alamos Area Electric Power Distribution System

Table 4–39 Trend in Peak Electric Load Demand for the Los Alamos Power Pool

Fiscal Year	*LANL Base*	*LANSCE*	*LANL Total*	*County Total*	*Pool Total*
1999 SWEIS [a]	50,000	63,000	113,000	Not projected	Not projected
1999	43,976	24,510	68,486	14,399	82,885
2000	45,104	20,343	65,447	15,176	80,623
2001	50,146	20,732	70,878	14,583	85,461
2002	45,809	20,938	66,747	16,653	83,400
2003	50,008	20,859	70,867	16,910	87,777
2004	47,608	21,811	69,419	16,231	85,650
2005	47,586	21,874	69,460	18,319	87,779

LANSCE = Los Alamos Neutron Science Center.
[a] Projections from the *1999 SWEIS* for the Expanded Operations Alternative.
Note: All values are in kilowatts consistent with the reporting convention used in the *LANL SWEIS Yearbooks*. To convert kilowatts to megawatts, divide by 1,000.
Sources: DOE 1999a; LANL 2000f, 2001e, 2002e, 2003h, 2004c, 2004f, 2006g.

Table 4–40 Trend in Total Electrical Energy Consumption for the Los Alamos Power Pool

Fiscal Year	*LANL Base*	*LANSCE*	*LANL Total*	*County Total*	*Pool Total*
1999 SWEIS [a]	345,000	437,000	782,000	Not projected	Not projected
1999	255,562	113,759	369,321	106,547	475,868
2000	263,970	117,183	381,153	112,216	493,369
2001	294,169	80,974	375,143	116,043	491,186
2002	299,422	94,966	394,398	121,013	515,401
2003	294,993	87,856	382,849	109,822	492,671
2004	327,117	86,275	413,392	127,429	540,821
2005	328,371	93,042	421,413	129,457	550,870

LANSCE = Los Alamos Neutron Science Center.
[a] Projections from the *1999 SWEIS* for the Expanded Operations Alternative (DOE 1999a).
Note: All values are in megawatt-hours. To convert megawatt-hours to kilowatt-hours, multiply by 1,000.
Sources: DOE 1999a; LANL 2004c, 2006g.

Electrical energy use at LANL remains below projections in the *1999 SWEIS*. Peak demand was projected to be 113 megawatts with 63 megawatts being used by LANSCE and about 50 megawatts being used by the rest of LANL. Annual electrical energy consumption was projected to be 782,000 megawatt-hours with 437,000 megawatt-hours being used by LANSCE and about 345,000 megawatt-hours being used by the rest of LANL. Actual use has fallen below these values to date, and the projected periods of brownouts have not occurred. On a regional basis, failures in the Public Service Company of New Mexico system have caused blackouts in northern New Mexico and elsewhere (LANL 2006g).

Historically, year-to-year fluctuations in LANL's total electrical energy use have largely been attributable to LANSCE operations. In recent years, an increase in LANL base peak load demand and particularly in base electrical energy use, independent of LANSCE operations, is evident. This is punctuated by the observed spike both in LANL base electrical energy use and in use by other Los Alamos County consumers since 2003 within the generally upward trend in total electricity demand (see Table 4–40).

Nevertheless, operations at several of the large LANL load centers have changed since 1999 including at LANSCE, which complicates attempts to forecast future electricity demands. For the past several years, LANSCE's electric load demand peaked with the rest of LANL, usually in July or August, but the peak load has now shifted to the winter (around January). This will change the overall electric demand for LANL, since LANSCE's peak load demand is such a large portion of the site's total peak load. Otherwise, LANSCE operations continued at reduced levels due to budgetary constraints that continued through fiscal year 2005. Also at TA-53, the Low-Energy Demonstration Accelerator which had not operated since fiscal year 2000 due to funding constraints was decommissioned in fiscal year 2003. This has reduced load demands by 2 to 4 megawatts (LANL 2006g). Regular, full-power operations of the Low-Energy Demonstration Accelerator as originally proposed would have tripled electric peak load demand to more than 60 megawatts, consistent with the projection from the *1999 SWEIS* (LANL 2006a). Further, while the National High Magnetic Field Laboratory in TA-35 has not operated since fiscal year 2000, the 60-Tesla superconducting magnet that failed in 2000 has been redesigned and reconstructed and has been operational since 2004 at about 2 megawatts of load. The DARHT facility began commissioning operations of its first axis in fiscal year 2001. The load level is about 1 megawatt for the first axis (LANL 2006g). LANL received authorization to begin full power operations of the second axis in January 2008.

Overall, in 2005 the total peak load was about 69.5 megawatts for LANL and about 18.3 megawatts for the rest of the power pool users (see Table 4–39). A total of 421,413 megawatt-hours of electricity were used at LANL in 2005. Other Los Alamos County users consumed an additional 129,457 megawatt-hours for a power pool total electric energy consumption of 550,870 megawatt-hours (see Table 4–40). Over the period 1999 to 2005, total maximum peak load demand has fluctuated, but has shown an upward trend, peaking again in 2005 when LANL and other Los Alamos County users required 59 percent of the capacity of the power pool. In a similar fashion, total maximum electric energy demand occurred in 2005 when 42 percent of the power pool system capacity was required. Electric power availability from the existing transmission system of the power pool is conservatively estimated at 963,600 megawatt-hours (reflecting the lower thermal rating of 110 megawatts for 8,760 hours per year available for import). An additional 20 megawatts (175,200 megawatt-hours per year) is currently available via the upgraded TA-3 Co-Generation Complex for a power pool total electric energy availability of 1,138,800 megawatt-hours.

The *1999 SWEIS* documented the limitations of the electric transmission lines that deliver electric power to the Los Alamos power pool, as well as the need to upgrade the aging TA-3 Co-Generation Complex and onsite electrical distribution system (DOE 1999a). Specifically, projects to improve the reliability of electric power transmission to the power pool include construction of a third transmission line and associated substation and uncrossing the two existing transmission lines (the Norton and Reeves Lines) where they cross on LANL (see Figure 4–29). The reliability of these lines in serving the power pool is compromised because they do not provide physically separate avenues for the delivery of power from independent power supply sources. The crossing of power lines results in a situation where a single outage event, such as a conductor or structural failure, could potentially cause a major power loss to the power pool. Loss of power from the regional electric system results in system isolation where the TA-3 Co-Generation Complex is the only source of sufficient capacity to prevent a total blackout. If such an event occurred when the TA-3 Co-Generation Complex was not operating or was being serviced or repaired, there would be no power available to the power pool. A single outage event could have serious and disruptive consequences to LANL and to the citizens of Los Alamos County. This vulnerability was noted by the Defense Nuclear Facilities Safety Board (LANL 2006g). For example, fire damage to transmission systems from the Cerro Grande Fire in 2000 resulted in the shutdown of both 115-kilovolt transmission lines. The steam turbines at the TA-3 Co-Generation Complex were operated and the critical electric power requirement of approximately 15 megawatts was maintained until the transmission lines could be repaired and power delivery through them resumed (LANL 2004c).

To address such situations, a new transmission line was proposed that would be constructed in two segments: (1) from the Norton Substation to a new substation (Southern TA) that is being constructed near White Rock, and (2) from the new Southern TA Substation to the Western TA Substation (see Figure 4–29). The first segment will be constructed at 345 kilovolts but operated in the short term at 115 kilovolts, as large pulse power loads at LANL will need the higher voltage in the future. The second segment will be constructed and operated at 115 kilovolts (LANL 2006g). Construction of the portion of the new transmission line from the Southern TA Substation to the Western TA Substation was completed in February 2006, and construction of the new Southern TA switchyard was finished in March 2006. Refurbishment of the existing Eastern TA Substation was completed in 2007. The project to uncross the two existing transmission lines is scheduled to be complete by 2010. The construction of the portion of the line from the Norton Substation to the Southern TA Substation is in the design phase (LANL 2006a).

In late 2005, project planning was initiated for a new TA-50 Substation on the existing LANL 115-kilovolt power distribution loop. The substation would be constructed with an installed transformer capacity of 50 megavolt-amperes (about 40 megawatts) and is intended to provide independent power feed to the existing TA-55 Plutonium Complex and new Chemistry and Metallurgy Research Replacement Building (LANL 2006a).

As previously described, onsite electrical generating capability for the power pool is limited by the existing TA-3 Co-Generation Complex, which is capable of producing up to 20 megawatts of electric power. Refurbishment of this facility began in 2003, and includes upgrades to the Number 3 steam turbine and to the steam path. The Number 3 steam turbine is currently a 10-megawatt unit, and rewinding of this unit is expected to increase its output to about 17 megawatts (LANL 2006g). However, due to limitations in auxiliary systems, including cooling water, the total net capacity of the TA-3 power plant will not increase. Refurbishment activities were completed in 2007 (LANL 2006a, 2006g). In addition, construction was completed on a new gas-fired combustion turbine generator at the TA-3 Co-Generation Complex. This new 20-megawatt unit also became operational in September 2007. A second generator may be constructed at a later date. At present, DOE has no timetable for installing the second new unit, which was proposed for reliability purposes only (LANL 2006a).

Also, as part of ongoing electric reliability upgrades at LANL, a conceptual design report for the Electrical Infrastructure and Safety Upgrades Project was completed in 1998. This project seeks to upgrade the electrical infrastructure in buildings throughout LANL to improve electrical safety. Thirty-one buildings were identified for upgrades and were prioritized based on the safety hazard they presented. Since then, the project has been coordinated with annual site planning activities, and subprojects have been removed from the list as the buildings have been identified for decommissioning and demolition. To date, five subprojects have been removed from the list, for a new total of 26 General Plant Projects. An evaluation of the LANL electrical safety maintenance backlog could increase the number of subprojects under the Electrical Infrastructure and Safety Upgrades Project. As of November 2006, five upgrade projects had been completed (TA-3-40-S&W, TA-3-40-N&E, TA-3-43, TA-16-200, TA-40-1), four projects were in construction (TA-3-261, TA-43-1, TA-46-31, TA-8-21), two projects were through design (TA-46-1, TA-53-2), and two projects were still undergoing final design (TA-48-1, TA-35-2) (LANL 2006a, 2006g).

4.8.2.2 Fuel

Natural gas is the primary heating fuel used at LANL and in Los Alamos County. The natural gas system includes a high-pressure main and distribution system to Los Alamos County and pressure-reducing stations at LANL buildings. LANL and the County both have delivery points where gas is monitored and measured (DOE 2003d). In August 1999, DOE sold the 130-mile-long (209-kilometer-long) main gas supply line and associated metering stations to the Public Service Company of New Mexico. This gas pipeline traverses the area from Kutz Canyon Processing Plant south of Bloomfield, New Mexico, to Los Alamos. Approximately 4 miles (6.4 kilometers) of the gas pipeline are within LANL boundaries (LANL 2006g). Natural gas is distributed to the point of use via some 62 miles (100 kilometers) of distribution piping (LANL 2000a).

Approximately 98 percent of the gas used by LANL is currently used for heating (both steam and hot air) with the TA-3 Co-Generation Complex being the principal user of natural gas at LANL. The remainder is used for steam-generated electrical power production at the TA-3 Co-Generation Complex (see Section 4.8.2.1) (LANL 2006g). The TA-3 Co-Generation Complex currently has three dual fuel boilers with associated steam turbine-generator sets, with natural gas being the primary fuel and No. 2 fuel oil available for use as a standby fuel (LANL 2003f). The low-pressure steam is supplied to the TA-3 district heating system and some process needs 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 (DOE 1999a). Steam for facility heating is also currently generated at the TA-21 steam plant. This facility has three relatively small boilers, each with only about 5 percent of the capacity of the units at the TA-3 Co-Generation Complex. They are primarily natural gas-fired but can also burn No. 2 fuel oil. Steam produced in the TA-21 steam plant is used to provide space heating for the buildings in TA-21. LANL also maintains about 200 other smaller boilers, which are primarily natural gas fired (LANL 2003f). As mentioned above, relatively small quantities of fuel oil are also stored at LANL as a backup fuel source for emergency generators.

The trends in natural gas consumption for the Los Alamos service area and associated steam production at LANL are provided in **Table 4–41** and **Table 4–42**, respectively. Annual (fiscal year) recorded natural gas consumption for the period 1999 through 2005 is compared to projections made in the *1999 SWEIS* for the Expanded Operations Alternative. Total LANL natural gas consumption remains below projections in the *1999 SWEIS*. Steam production was not projected in the *1999 SWEIS* but has been tracked at LANL as a secondary measure of energy consumption for facility heating and onsite electricity generation. Total LANL natural gas consumption was projected to be 1,840,000 decatherms annually (equivalent to approximately 1.84 billion cubic feet [52.1 million cubic meters]). As shown in Tables 4–41 and 4–42, total natural gas consumption and associated steam production has trended downward at LANL since 1999 in concert with a general decline in heating demand, while consumption for electricity production has fluctuated, sometimes dramatically, from year to year. The decline in heating demand in recent years is mainly attributable to warmer winters and secondarily due to replacement of older buildings and associated workforce consolidation into more energy-efficient structures. During fiscal year 2005, total LANL natural gas consumption was 1,187,855 decatherms (equivalent to about 1.19 billion cubic feet [33.7 million cubic meters]) and total steam production was 357,341 thousand pounds. For fiscal year 2005, natural gas consumption for electricity generation was again the lowest since issuance of the *1999 SWEIS*.

Table 4–41 Trend in Natural Gas Consumption for Los Alamos National Laboratory and Los Alamos County

Fiscal Year	*Natural Gas*			*Los Alamos County Consumption* [a]	*Total Los Alamos Area Consumption*
	Total LANL Consumption	*Total Used for Electric Production*	*Total Used for Heat Production*		
1999 SWEIS [b]	1,840,000	Not projected	Not projected	Not projected	Not projected
1999	1,428,568	241,490	1,187,078	No comparable data	No comparable data
2000	1,427,914	352,126	1,075,788	870,402	2,298,316
2001	1,492,635	273,312	1,219,323	928,329	2,420,964
2002	1,325,639	212,976	1,112,663	871,566	2,197,205
2003	1,220,137	41,632	1,178,505	933,439	2,153,576
2004	1,149,936	25,680	1,124,256	931,940	2,081,876
2005	1,187,855	20,086	1,167,768	943,559	2,111,327

[a] Los Alamos County's natural gas consumption data are based on its fiscal year, which runs from July to June, as opposed to the Federal fiscal year used by LANL, which runs from October to September.
[b] Projections from the *1999 SWEIS* for the Expanded Operations Alternative (DOE 1999a).
Note: All values are in decatherms. To convert decatherms to cubic feet, multiply by 1,000; cubic feet to cubic meters, multiply by 0.028317.
Sources: Arrowsmith 2005, 2006; DOE 1999a; LANL 2004c, 2006g.

Table 4–42 Trend in Steam Production for Los Alamos National Laboratory

Fiscal Year	*TA-3 Steam Production*	*TA-21 Steam Production*	*Total Steam Production*
1999	576,548	29,468	606,016
2000	634,758	27,840	662,598
2001	531,763	29,195	560,958
2002	478,007	26,206	504,213
2003	351,905	26,147	378,052
2004	347,110	23,910	371,020
2005	333,042	24,299	357,341

TA = technical area.
Note: All values are in thousands (1,000) of pounds which is the unit of measurement at LANL. To convert pounds to kilograms, multiply by 0.45359.
Sources: LANL 2004c, 2006g.

The observed downward trend in natural gas consumption at LANL is contrasted by the generally upward trend among other Los Alamos County users, which can be attributed to development and population growth within the region (see Table 4–41). In 2005, other Los Alamos County users consumed 943,559 decatherms (equivalent to about 944 million cubic feet [26.7 million cubic meters]) as compared to 870,402 decatherms (870 million cubic feet [24.6 million cubic meters]) in 2000. For 2005, total natural gas usage for the Los Alamos service area was 2,111,327 decatherms (equivalent to about 2.11 billion cubic feet [59.7 million cubic meters]). For the period, total maximum natural gas demand occurred in 2001 when LANL and other Los Alamos County users required 30 percent of the system supply capacity. However, natural gas is abundant in New Mexico, and the region has a high import capacity. The natural gas delivery system servicing the Los Alamos area has a contractually-limited capacity of about 8.07 billion cubic feet (229 million cubic meters) per year (DOE 2003d).

It was noted in the *1999 SWEIS* that the age of the natural gas transmission and distribution system serving LANL facilities and Los Alamos County dictated modification and upgrade. This need was stressed particularly should the TA-3 Co-Generation Plant be required to burn more natural gas to meet future electricity demands. Several segments of natural gas transmission and delivery pipeline have been upgraded, and redundant loops of pipeline have been installed across LANL and across New Mexico in general over the past two decades. The most recent major upgrades to the natural gas transmission line to LANL and Los Alamos County, which included the installation of relocated segments of redundant loops, occurred in the early to mid-1990s. Within that time frame, several additional segments of the aged supply pipeline, without redundant portions, were identified across northern New Mexico. Plans to provide redundant service supply were undertaken by Public Service Company of New Mexico to correct this supply system deficiency. A critical segment of 8.1-inch (20-centimeter) pipeline in Los Alamos County and within LANL's boundaries was identified as of being of non-standard size and construction making its replacement necessary.

DOE has issued an easement to the Public Service Commission of New Mexico to allow construction, operation, and maintenance of approximately 15,000 feet (4,500 meters) of 12-inch (30-centimeter) coated steel natural gas pipeline within LANL boundaries in Los Alamos Canyon. The new segment would replace the existing 8.1-inch (20-centimeter) segment, and would cross east across the site down Los Alamos Canyon from TA-21 to connect to the existing 12-inch (30-centimeter) coated steel gas transmission mainline located within the right-of-way of New Mexico 502 in TA-72 (DOE 2002h, NNSA 2005b). Construction of the pipeline was completed in late 2005, with tie-in to the existing transmission system that was completed at the end of 2006 (LANL 2006a).

4.8.2.3 Water

The Los Alamos County water production system consists of 14 deep wells, 153 miles (246 kilometers) of main distribution lines, pump stations, and storage tanks. The system supplies potable water to all of the County, LANL, and Bandelier National Monument. Specifically, the deep wells are located in three well fields (Guaje, Otowi, and Pajarito). Water is pumped into production lines, and booster pump stations lift this water to reservoir tanks for distribution. Prior to distribution, the entire water supply is disinfected with a process that replaces the formerly used chlorine disinfectant process (LANL 2004c, DOE 2003d).

On September 8, 1998, DOE transferred operation of the system from DOE to Los Alamos County under a lease agreement. Under the transfer agreement, DOE retained responsibility for operating the distribution system within LANL boundaries, whereas the county assumed full responsibility for ensuring compliance with Federal and state drinking water regulations. DOE's right to withdraw an equivalent of about 5,541 acre-feet or 1,806 million gallons (6,830 million liters) of water per year from the main aquifer and its right to purchase a water allocation of some 1,200 acre-feet or 391 million gallons (1,500 million liters) per year from the San Juan-Chama Transmountain Diversion Project were included in the transfer (DOE 2003d, LANL 2006g).

On September 5, 2001, DOE completed the transfer of ownership of the water production system to Los Alamos County, along with 70 percent (3,879 acre-feet or 1,264 million gallons [4,785 million liters] annually) of the DOE water rights. The remaining 30 percent (1,662 acre-feet or 542 million gallons [2,050 million liters] annually) of the water rights are leased by DOE to the County for 10 years, with the option to renew the lease for four additional 10-year terms. LANL is now considered a Los Alamos County water customer, and DOE is billed and pays for the water LANL uses. The current 10-year agreement (water service contract) with Los Alamos County, started in 1998, includes an escalating projection of future LANL water consumption (LANL 2006g). While the contract does not specify a supply limit to LANL, the water right owned by DOE and leased to the county (that is 1,662 acre-feet or 542 million gallons [2,050 million liters] per year) is a good target ceiling quantity under which LANL should remain (LANL 2001a). The distribution system serving LANL facilities now consists of a series of reservoir storage tanks, pipelines, and fire pumps. The LANL distribution system is gravity fed with pumps for high-demand fire situations at limited locations (LANL 2006g).

Los Alamos County continues to pursue the use of San Juan-Chama water as a means of preserving those water rights (DOE 2003d, LANL 2006g). Studies conducted in 2002 and 2003 determined the feasibility of accessing the San Juan-Chama water allocation by lifting it from the Rio Grande up onto the mesa that overlooks White Rock Canyon. Two options were evaluated for construction of a collector system that would allow the diversion of water from the layer of gravel beneath the Rio Grande. These include (1) pumping and piping the water from the Rio Grande up the side of White Rock Canyon and (2) boring a tunnel under the mesa and drilling a collector well on top to intercept the water flowing in the tunnel, which is environmentally preferable (LAC 2004b, Glasco 2005). Since completion of Los Alamos County's San Juan-Chama project water utilization study in 2004, other options under consideration by the county include direct delivery of project water to LANL in lieu of groundwater. This would facilitate a reduction in overall LANL water demand because of the large percentage of water used for cooling purposes at LANL. As a result, the use of the low-silica San Juan-Chama project water would allow LANL's cooling towers to be operated at higher (recirculation) cycles before the water must be discharged, resulting in lower total water use (Stephens 2006).

On September 19, 2006, New Mexico Governor Richardson signed new repayment contracts on behalf of five towns and cities and two counties, including Los Alamos County, that formally secured water rights with the Bureau of Reclamation for San Juan-Chama project water. Unlike the previous purchase form contracts, the repayment contract has no termination date, giving Los Alamos County and other municipalities perpetual rights and thus negating the need to renegotiate and renew contracts in the future. Los Alamos County will have permanent use of the water as long as it meets the terms of the contract (LAC 2006b, Newman 2006). Completion of this process was necessary before the County could move forward with additional investment in the project (Glasco 2005, LAC 2006b). Use of the San Juan-Chama project along with conservation are integral to the County's Long-Range Water Supply Plan, which was commissioned to provide a sustainable water supply for the next 40 years and was completed in August 2006 (Stephens 2006).

The trend in water use for LANL and other Los Alamos County users is shown in **Table 4–43**. Annual (fiscal year) observed water demands for the period 1999 through 2005 are compared to projections made in the *1999 SWEIS* for the Expanded Operations Alternative. Water use at LANL remains below projections made in the *1999 SWEIS*. In 2005, approximately 359.3 million gallons (1,360 million liters) of water were used at LANL. This was about 400 million gallons (1.51 billion liters) less than the *1999 SWEIS* projected consumption of 759 million gallons (2.87 billion liters) per year. Approximately 60 percent of LANL's water use has historically been used for cooling tower operation, resulting in evaporative losses (LANL 2001a). The three cooling towers at LANSCE historically required about 77 million gallons (291 million liters) of water annually, or about 15 percent of the water use for all of LANL (LANL 2006a). Construction of a new cooling tower (structures 53-963 and 53-952) was completed in 2000. These new units replaced cooling towers 53-60, 53-62, and 53-64, which have been taken off line (LANL 2006g).

Table 4–43 Trend in Water Use for Los Alamos National Laboratory and Los Alamos County

Calendar Year [a]	*LANL*	*Los Alamos County*	*Total*
1999 SWEIS [b]	759,000	Not projected	Not applicable
1999	453,094	880,282	1,333,376
2000	441,000	1,133,277	1,574,277
2001	393,123	1,033,764	1,426,887
2002	324,514	1,230,826	1,555,340
2003	377,768	1,179,799	1,557,567
2004	346,624	1,035,461	1,382,085
2005	359,252	1,033,923	1,393,175

[a] Water data are routinely collected and summarized by calendar year, rather than by fiscal year as is done for electricity and natural gas.
[b] Projection from the *1999 SWEIS* for the Expanded Operations Alternative.
Note: All values are in thousands (1,000) of gallons which is the unit of measurement at LANL. To convert thousands of gallons to millions of gallons, divide by 1,000; thousands of gallons to thousands of liters, multiply by 3.7854.
Sources: Arrowsmith 2006; DOE 1999a; Glasco 2005; LANL 2004c, 2006g.

Regular, full-power operation of the Low-Energy Demonstration Accelerator at LANSCE, now decommissioned as noted in Section 4.8.2.1, was originally forecast to more than double LANSCE's total water use after 2000, which was reflected in the *1999 SWEIS* projections for LANL site-wide water use (LANL 2006a). Current water use at LANL compared to the calculated NPDES-regulated industrial effluent discharge of 198.5 million gallons (751 million liters) in 2005 indicates that the site's consumptive water use (reflecting the volume evaporated or otherwise lost and not returned as effluent) is about 55 percent (LANL 2006g). Further, water demand at the site continues to be well below the 30 percent (1,662 acre-feet or 542 million gallons [2,050 million liters] per year) of DOE's water rights that are leased by DOE to the county. The firm rated capacity of the Los Alamos County water production system is 7,797 gallons per minute (29,500 liters per minute) or approximately 4.1 billion gallons (15.5 billion liters) annually. The firm rated capacity is the maximum amount of water that can be pumped immediately to meet peak demand (LANL 2001a).

While LANL total and consumptive water use has generally decreased from 1999 to 2005, water usage by other Los Alamos County users has exhibited a generally upward trend over the period. Water use by LANL and by other Los Alamos County users declined noticeably from 2003 to 2004, as 2003 was a very dry year in the Los Alamos area compared to 2004, which illustrates the close relationship between climate and water use in the arid Southwest. Water use for 2005 is very comparable to 2004. For the period, total maximum water demand occurred in 2000 (the year of the Cerro Grande wildfire) when LANL and other Los Alamos County users required 87 percent of the available water rights from the regional aquifer.

DOE continues to maintain the onsite distribution system by replacing portions of the greater than 50-year old system as problems arise. The condition of the water distribution system was identified as a concern in the *1999 SWEIS*. DOE is also in the process of installing additional water meters and a Supervisory Control and Data Acquisition and Equipment Surveillance System on the water distribution system to keep track of water usage and to determine the specific water use for various applications. Data are being accumulated to establish a baseline for conserving water. In remote areas, DOE is trying to automate monitoring of the system to be more responsive during emergencies such as the Cerro Grande Fire. DOE has instituted a number of conservation and gray-water[5]-reuse projects, including a cooling tower conservation project to reduce water usage further and ensure that future LANL initiatives are not limited by water availability. For example, treated wastewater from the Sanitary Wastewater System Plant at TA-46 is conveyed to the TA-3 Co-Generation Complex for reuse as cooling tower makeup water (LANL 2006g).

4.9 Waste Management and Pollution Prevention

A wide range of waste types are generated through activities at LANL related to research, production, maintenance, construction, decontamination, decommissioning, demolition and environmental restoration. These waste types include: wastewaters (sanitary liquid waste, high-explosive-contaminated liquid waste, and industrial effluent); solid (sanitary) waste, including routine household-type waste and construction and demolition debris; and radioactive and chemical wastes. These wastes, discussed in more detail in Section 4.9.1 through 4.9.3 below, are regulated by Federal and state regulations, applicable to specific waste classifications. Institutional requirements for waste management activities are determined and documented by the Laboratory Implementation Requirements Program. This program provides details on proper management of all process wastes and contaminated environmental media. The waste management operation tracks waste generating process; quantity; chemical and physical

[5] *Generally treated or untreated water that is not suitable for drinking but can be used for secondary purposes such as industrial cooling.*

characteristics; regulatory status; applicable treatment and disposal standards; and final disposition of the waste (LANL 2004f).

A significant portion of waste management operations take place in facilities designed for and dedicated to waste management. Liquid wastes are treated in the Sanitary Wastewater Systems Plant, the High Explosives Wastewater Treatment Facility, and the Radioactive Liquid Waste Treatment Facility. Specialized facilities in TA-50 and TA-54 house a variety of chemical and radioactive waste management operations, including size reduction, compaction, assaying, and storage. Many hazardous wastes are now accumulated for up to 90 days at consolidated storage facilities and are then shipped directly offsite. Four of these consolidated storage facilities exist at LANL and two more are planned (LANL 2003e)

Waste minimization and pollution prevention efforts at LANL are coordinated by the Pollution Prevention Program. Source reduction, including materials substitution and process improvements, is the preferred method of reducing waste. Recycling and reuse practices are also considered for wastes, together with volume reduction and treatment options. Progress in pollution prevention initiatives at LANL in measured annually against metrics approved by the DOE (LANL 2004l). In 1999, the DOE established the 2005 Pollution Prevention goals. These goals required that DOE meet the following waste reductions for routine waste, based on the 1993 baseline:

- greater than 80 percent reduction in low-level radioactive waste
- greater than 80 percent reduction in mixed low-level radioactive waste
- greater than 50 percent reduction in transuranic waste
- greater than 90 percent reduction in hazardous waste (includes New Mexico Special waste and Toxic Substances Control Act waste)
- greater than 10 percent reduction in clean up and stabilization waste
- greater than 55 percent reduction in per capita generation of solid sanitary waste
- greater than 50 percent recycle rate
- greater than 90 percent reduction in toxic release inventory chemical usage
- 100 percent replacement of specific ozone-depleting chillers
- 100 percent affirmative procurement purchases of EPA-designated recycled content items

DOE achieved an overall rating of 97 percent towards the DOE 2005 Pollution Prevention goals for fiscal year 2005. In 2004, DOE established a prevention-based Environmental Management System at LANL based on the International Standards Organization 14001 standard to meet DOE Order 450.1. The Environmental Management System is a systematic method for assessing mission activities, determining environmental impacts of those activities, prioritizing improvements, and measuring results (LANL 2004l). Environmental Management System action plans have been developed to address environmental issues, including objectives for pollution prevention, compliance and continual improvement.

4.9.1 Wastewater Treatment and Effluent Reduction

LANL has three primary sources of wastewater: sanitary liquid wastes, high explosives-contaminated liquid wastes, and industrial effluent. Radioactive liquid waste is addressed in Section 4.9.3.

4.9.1.1 Sanitary Liquid Waste

DOE continues to operate the TA-46 Sanitary Wastewater System Plant to treat liquid sanitary wastes, as described in the *1999 SWEIS*. Treated liquid effluent from the Sanitary Wastewater System Plant is pumped to storage tanks near the TA-3 Power Plant before being discharged to Sandia Canyon through NPDES-permitted outfall. The Sanitary Effluent Reclamation Facility treats some liquid effluent for reuse in the cooling towers at the Metropolis Center for Modeling and Simulation.

4.9.1.2 Sanitary Sludge

Sanitary sludge from the Sanitary Wastewater System Plant is dried for a minimum of 90 days to reduce pathogens and then disposed of as New Mexico Special Waste at an authorized, permitted landfill. The volume of sanitary sludge generated and disposed of by DOE is reported annually in the site environmental surveillance reports (for example, LANL 2005h).

Between 1997 and September 2000, sludge generated from the Sanitary Wastewater System Plant was managed as polychlorinated biphenyl-contaminated (50 to 499 parts per million) waste in accordance with the Toxic Substances Control Act and disposed of at a Toxic Substances Control Act-permitted landfill. This management practice was necessary because low-levels of polychlorinated biphenyls (less than 5 parts per million) had been repeatedly detected in the sludge. During this time, DOE completed an investigation that identified the source of the polychlorinated biphenyls and subsequently completed a cleanup of contaminated sewer lines. After cleanup was completed and verified by sampling, DOE notified EPA and began managing Sanitary Wastewater System sludge as New Mexico Special Waste (LANL 2001f, 2002d, 2004a, 2004d). Additional information may be found in the site annual environmental surveillance reports.

4.9.1.3 High Explosives-Contaminated Liquid Wastes

The High Explosives Wastewater Treatment Facility, located in TA-16, became fully operational in 1997. The High Explosives Wastewater Treatment Facility treats process waters containing high-explosive compounds, using three treatment technologies. Sand filtration is used to remove particulate high explosives; activated carbon is used to remove organic compounds and dissolved high explosives; and ion exchange units are used to remove perchlorate and barium. The High Explosives Wastewater Treatment Facility receives some wastewaters by truck from processing facilities located outside TA-16 (DOE 1999a, LANL 1999b).

Equipment upgrades were performed to replace water-sealed vacuum pumps and wet high explosives collection systems with systems that do not use water. In addition, sources of non-high explosives industrial wastewater have been eliminated from the high explosives processing areas (DOE 1999a). These upgrades have resulted in a significant reduction in quantities of high explosives wastewater treated and effluent discharged to NPDES-permitted outfalls. In 2005, the High Explosives Wastewater Treatment Facility discharged about 30,000 gallons (114,000 liters) to an outfall, compared to the *1999 SWEIS* projection of 170,000 gallons (644,000 liters) (LANL 2006g).

4.9.1.4 Industrial Effluent

Industrial effluent is discharged to a number of NPDES-permitted outfalls across LANL. Currently, LANL discharges wastewater to a total of 21 outfalls, down from the 55 outfalls identified in the *1999 SWEIS*. An effort to reduce the number of outfalls was initiated in 1997, with significant reductions realized in 1997 and 1998. Most of these reductions resulted from changes at the High-Explosives Processing Key Facility and High Explosives Testing Key Facility, with the redirection of some flows to the sewage plant at TA-46, and the routing of high explosives-contaminated flows through the High Explosives Wastewater Treatment Facility (LANL 2003h).

Discharges to outfalls are regulated under an NPDES permit, effective February 1, 2001. At most outfalls, actual flows are recorded by flow meters; at the remaining outfalls, flow is estimated based on instantaneous flows measured during field visits. With the exception of discharges during 1999, total discharges for the period of 1998 through 2005 from LANL outfalls have fallen within *1999 SWEIS* projections (LANL 2003h, 2004f, 2005f, 2006g).

4.9.2 Solid Waste

Sanitary solid waste is excess material that is not radioactive or hazardous and can be disposed of in a solid waste landfill. Solid waste generated at LANL is disposed of at the Los Alamos County Landfill, located within LANL boundaries, but operated by Los Alamos County. Solid waste includes paper, cardboard, plastic, glass, office supplies and furniture, food waste, brush, and construction and demolition debris. Through an aggressive waste minimization and recycling program, the amount of solid waste at LANL requiring disposal has been greatly reduced. In 2004, 6,380 tons (5,789 metric tons) of solid waste were generated at LANL, of which 4,240 tons (3,847 metric tons) was recycled (LANL 2004l). The per capita generation of routine solid waste (food, paper, plastic) at LANL has decreased by about 58 percent over the 10-year period from 1993 through 2003 (LANL 2004f). Nonroutine solid waste is generated by construction and demolition projects, and also includes waste generated by Cerro Grande Rehabilitation Project cleanup activities. Recycling of sanitary waste currently stands at 60 percent compared to 1993, when LANL recycled only about 10 percent of the sanitary waste. In 2005, the total amount of recycled sanitary waste reached 4,417 tons (4,007 metric tons), an increase from 2004 (LANL 2006g).

The *1999 SWEIS* projected that the Los Alamos County Landfill would not reach capacity until 2014, however, in accordance with direction from NMED, the County plans on closing the landfill (LAC 2006c). The landfill is expected to operate until fall 2008, when a new transfer station, operated by the County, will be used to sort and ship LANL sanitary wastes to a solid waste landfill outside the county (DOE 2005a).

Construction and Demolition Debris—Construction and demolition debris is regulated as a separate category of solid waste under the New Mexico Solid Waste Regulations. Construction and demolition debris is not hazardous and may be disposed of in a municipal landfill or a construction and demolition debris landfill (NMAC 20.9.1). This category of waste was included in the chemical waste projections in the *1999 SWEIS* and continues to be tracked as chemical waste in the *SWEIS Yearbooks*. Although construction and demolition debris continue to be included in the chemical waste category, recent LANL tracking and projection efforts also have created a subcategory for construction and demolition debris. In 2005, approximately 78 percent of the uncontaminated construction and demolition waste was recycled. The total amount of construction waste generated in 2005 increased by 10 percent from 2004 (LANL 2006g).

4.9.3 Radioactive and Chemical Waste

Radioactive and chemical wastes are generated by research, production, maintenance, construction and environmental cleanup activities. Radioactive wastes are divided into the following categories: low-level; mixed low-level; transuranic; and mixed transuranic. Chemical wastes are a broad category including hazardous waste (designated under the RCRA regulations), toxic waste, construction and demolition debris, and special waste. Waste quantities vary with level and type of operation, construction activities, and implementation of waste minimization activities. Waste minimization efforts have resulted in overall waste reduction across most categories, due to process improvements and substitutions of nonhazardous chemicals for commonly used hazardous chemicals (LANL 2004f).

Most wastes generated are subsequently managed through the LANL waste treatment, storage, and disposal infrastructure. This section evaluates waste generation rates and the capabilities of that infrastructure. An increasing amount of waste, including wastes generated through environmental restoration activities, are shipped directly from the point of generation to offsite facilities; these wastes have little impact on the LANL waste management infrastructure (LANL 2004g).

Table 4–44 summarizes the radioactive and chemical waste quantities generated from 1999 through 2004 by waste type. The quantities include contributions across LANL, including Key Facilities, non-Key Facilities and the LANL environmental restoration activities. Projections from the ROD for the *1999 SWEIS* are included for comparison.

Site-wide waste quantities for the 7-year period from 1999 through 2005 generally were below projections presented in the *1999 SWEIS* for all waste types, with a few exceptions discussed below. For each waste type, significant variances from the *1999 SWEIS* ROD projections are noted in footnotes to the waste generation tables that follow. Most variances are due to one-time events, such as maintenance, construction, or remediation activities, rather than higher quantities of operations waste. For most waste types, the quantities produced across LANL facilities did not approach the levels projected in the *1999 SWEIS*. Waste minimization efforts have reduced waste generation rates for specific waste types as facility processes were improved and nonhazardous product substitutions were implemented. In some cases, facility workloads were less than expected, resulting in less waste generated. Additional comparisons to *1999 SWEIS* projections are presented in the waste-specific sections that follow.

Table 4–44 Los Alamos National Laboratory Waste Types and Generation

Waste Type	*Units*	*1999 SWEIS ROD Projection*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Low-Level Radioactive Waste	cubic yards per year	16,000 [a]	2,190	5,530	3,400	9,560	7,640	19,400	7,080
Mixed Low-Level Radioactive Waste	cubic yards per year	830	30	780	80	30	50	50	90
Transuranic Waste	cubic yards per year	440	190	160	150	160	530	50	100
Mixed Transuranic Waste	cubic yards per year	150	110	120	60	110	210	30	130
Chemical Waste	10^3 pounds per year	7,160	34,000	61,000	60,800	3,820	1,520	2,460	4,340

ROD = Record of Decision.
[a] Values are rounded.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; pounds to kilograms, multiply by 0.4536.
Sources: LANL 2003h, 2004f, 2005f, 2006g.

Low-Level Radioactive Wastes—Low-level radioactive waste is defined as waste that is radioactive and does not fall within any of the following classifications: high-level radioactive waste, transuranic waste, spent nuclear fuel, or by-product materials (uranium and thorium mill tailings). These wastes are generated at LANL when materials, equipment, and water are used in radiological control areas as part of the work activities; when these contaminated items are no longer useable, they are removed from the area as low-level radioactive waste. Typical waste streams include: laboratory equipment, service and utility equipment, plastic bottles, disposable wipes, plastic sheeting and bags, paper, and electronic equipment (LANL 2004l). Environmental restoration and decontamination, decommissioning, and demolition (DD&D) activities also generate low-level radioactive waste, primarily in the form of contaminated soils and debris.

Most low-level radioactive waste generated at LANL is disposed of onsite at TA-54, Area G. Disposal operations expanded into Zone 4, providing sufficient capacity for operational wastes for the long term. The facility-specific low-level radioactive waste generation rates for the 7-year period are shown in **Table 4–45**. Contributions from non-Key Facilities exceeded *1999 SWEIS* projections for several years, primarily due to heightened operational activities and new construction (LANL 2004f, 2005f, 2006g). Although there were several instances of individual facilities exceeding *1999 SWEIS* projections, overall LANL low-level radioactive waste generation was well below those levels predicted in the *1999 SWEIS* for 6 years of the 7-year period. In 2004, the *1999 SWEIS* projection was exceeded due to heightened activities and new construction at non-Key Facilities (LANL 2005f).

Table 4–45 Low-Level Radioactive Waste Generation at Los Alamos National Laboratory by Facility (cubic yards per year)

Facility	*SWEIS ROD*	*1999* [a]	*2000* [a]	*2001* [a]	*2002* [a]	*2003* [b]	*2004* [c]	*2005* [d]
Chemistry and Metallurgy Research Building	2,380	240	345	586	509	553	175	237
Sigma Complex	1,256	80	68	< 1	264	162	< 1	83
Machine Shops	793	53	535	29	58	20	20	175
Materials Science Laboratory	0	0	0	0	0	0	0	0
High-Explosives Processing	21	11	4	1	11	37	0	5
High-Explosives Testing	1,229	< 1	< 1	0	0	0	114	< 1
Tritium Facilities	628	62	64	0	118	143	33	65
Pajarito Site	190	41	18	17	0	13	0	0
Target Fabrication Facility	13	0	0	< 1	< 1	0	0	0
Biological Sciences	45	18	0	0	0	0	4	8
Radiochemistry Laboratory	353	52	75	72	45	102	23	38
Radioactive Liquid Waste Treatment Facility	209	229	173	676 [e]	252	510 [f]	464 [g]	339 [h]
Los Alamos Neutron Science Center	1,419	92	37	< 1	0	92	3	67
Solid Radioactive and Chemical Waste Facilities	228	28	17	18	46	267	54	368 [i]
Plutonium Facilities	986 [j]	451	260	392	388	513	247	380
Total low-level radioactive waste for Key Facilities	9,750	1,358	1,597	1,794	1,692	2,412	1,138	1,766
Non-Key Facilities	680	458	3,637 [k]	744	698	4,948 [l]	18,262 [m]	1,368 [n]
Total low-level radioactive waste for Key and non-Key Facilities	10,430	1,816	5,234	2,538	2,390	7,366	19,400	3,134
Percentage of Total from Key Facilities	**94**	**75**	**44**	**71**	**71**	**33**	**6**	**56**
Environmental Restoration	5,572	374	296	812	7,173	283	1	3,945
Total low-level radioactive waste for non-Key Facilities and Environmental Restoration	6,252	832	3,933	1,556	7,871	5,231	18,263	5,313
Total low-level radioactive waste = Key + non-Key Facilities and Environmental Restoration	16,002	2,190	5,530	3,350	9,563	7,643	19,401	7,079
Percentage of Total from Key Facilities	**61**	**62**	**29**	**54**	**18**	**32**	**6**	**25**

ROD = Record of Decision.

[a] LANL 2003h.

[b] LANL 2004f.

[c] LANL 2005f.

[d] LANL 2006g.

[e] Amount includes approximately 497 cubic yards of water transferred to TA-53, due to high tritium content (LANL 2003h).

[f] *1999 SWEIS* ROD projection exceeded due in part to the removal of sludge from the concrete storage tank in WM-2 (LANL 2004f).

[g] *1999 SWEIS* ROD projection exceeded due to the generation of 46 cubic yards of water pumped from manholes, 194 cubic yards of aqueous evaporator bottoms, and 136 cubic yards of soil associated with construction of new influent tanks (LANL 2005f).

[h] *1999 SWEIS* ROD projection exceeded due to soil and debris generated during tank installation and the generation of aqueous evaporator bottoms (LANL 2006g).

[i] *1999 SWEIS* ROD projection exceeded due to empty drums resulting from repackaging of transuranic waste (LANL 2006g).

[j] Includes estimates of waste generated from the facility upgrades associated with pit fabrication (LANL 2003h).

[k] Amount includes waste generated from decontamination and demolition activities and from soil and sediment removal in Mortandad and Los Alamos Canyons (LANL 2003h).

[l] *1999 SWEIS* ROD projection exceeded due to heightened activities and new construction (LANL 2004f).

[m] *1999 SWEIS* ROD projection exceeded due to heightened activities and new construction (LANL 2005f).

[n] *1999 SWEIS* ROD projection exceeded due to heightened activities and new construction (LANL 2006g).

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

Mixed Low-Level Radioactive Wastes—Mixed low-level radioactive waste is waste that contains both low-level radioactive waste and hazardous waste as defined by the RCRA. Most of the operational mixed low-level radioactive waste is generated by the stockpile stewardship and research and development programs. Typical waste streams include: contaminated lead shielding bricks and debris, spent chemical solutions, fluorescent light bulbs, copper solder joints, and used oil. Environmental restoration and DD&D activities also produce some mixed low-level radioactive waste (LANL 2004l).

The facility-specific mixed low-level radioactive waste generation rates for the 7-year period are shown in **Table 4–46**. Although there were some facility-specific variances with *1999 SWEIS* projections of mixed low-level radioactive waste, LANL-wide quantities were relatively low. The largest single contributor to mixed low-level radioactive waste generation was the remediation of material disposal area (MDA) P (LANL 2004f). Overall LANL mixed low-level radioactive waste generation was below the *1999 SWEIS* projections for each year of the 7-year period.

Transuranic Wastes—Transuranic waste is waste containing greater than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years. This type of waste contains radioactive isotopes such as plutonium, neptunium, americium and curium. Specific categories are excluded from the definition of transuranic waste: 1) high-level waste; 2) waste that DOE has determined, and EPA has concurred, does not need the same degree of isolation as most transuranic waste; and 3) waste that the Nuclear Regulatory Commission has approved, on a case-by-case basis, for disposal at a low-level radioactive waste facility (LANL 2004l).

Transuranic waste is generated during research, development, and stockpile manufacturing and management activities. The waste forms include contaminated scrap and residues, plastics, lead gloves, glass, and personnel protective equipment. Transuranic waste may also be generated through environmental restoration, legacy waste retrieval, offsite source recovery, and DD&D activities. Transuranic waste is characterized and certified prior to shipment to the Waste Isolation Pilot Plant (WIPP) (LANL 2004l).

The facility-specific transuranic waste generation rates for the 7-year period are shown in **Table 4–47**. Non-Key Facilities exceeded *1999 SWEIS* projections for the years 2000 through 2005; these exceedances are all attributable to the Off-Site Source Recovery Project (LANL 2003h, LANL 2004f, LANL 2006g). Overall transuranic waste generation at LANL was well below the *1999 SWEIS* projections for 6 years of the 7-year period. In 2003, transuranic waste quantities exceeded the LANL-wide *1999 SWEIS* projection due to: (1) repackaging of legacy waste for shipment to WIPP, and (2) receipt and storage of waste by the Off-Site Source Recovery Project (LANL 2004f).

Table 4–46 Mixed Low-Level Radioactive Waste Generation at Los Alamos National Laboratory by Facility (cubic yards per year)

Facility	*SWEIS ROD*	*1999* [a]	*2000* [a]	*2001* [a]	*2002* [a]	*2003* [b]	*2004* [c]	*2005* [d]
Chemistry and Metallurgy Research Building	25	< 1	< 1	< 1	1	6	< 1	6
Sigma Complex	5	< 1	0	2	0	0	7	0
Machine Shops	0	0	< 1	< 1	0	0	0	0
Materials Science Laboratory	0	< 1	0	0	0	0	0	0
High-Explosives Processing	0.3	0	0	0	0	0	0	0
High-Explosives Testing	1	0	0	0	0	0	25 [e]	0
Tritium Facilities	4	0	0	< 1	1	2	< 1	< 1
Pajarito Site	2	10 [f]	0	0	0	0	0	0
Target Fabrication Facility	0.5	0	0	0	0	0	< 1	0
Biological Sciences	4	< 1	0	0	0	0	0	0
Radiochemistry Laboratory	5	< 1	2	4	3	8	2	< 1
Radioactive Liquid Waste Treatment Facility	0	4 [g]	3 [g]	3 [g]	5 [g]	0	< 1	0
Los Alamos Neutron Science Center	1	< 1	6	< 1	1	< 1	0	< 1
Solid Radioactive and Chemical Waste Facilities	5	0	0	0	0	0	0	0
Plutonium Facilities	17 [h]	5	2	17	4	5	2	17
Total mixed low-level radioactive waste for Key Facilities	70	25	15	30	15	22	40	26
Non-Key Facilities	39	3	13	12	11	26	13	3
Total mixed low-level radioactive waste for Key and non-Key Facilities	109	28	28	42	26	48	53	29
Percentage of Total from Key Facilities	**65**	**89**	**52**	**71**	**58**	**45**	**75**	**90**
Environmental Restoration	717	2	755 [i]	38	0	0	0	66
Total mixed low-level radioactive waste for non-Key Facilities and Environmental Restoration	756	5	768	50	11	26	13	69
Total mixed low-level radioactive waste = Key + non-Key Facilities and Environmental Restoration	826	30	783	80	26	48	53	95
Percentage of Total from Key Facilities	**9**	**83**	**2**	**38**	**58**	**45**	**75**	**27**

ROD = Record of Decision.
[a] LANL 2003h.
[b] LANL 2004f.
[c] LANL 2005f.
[d] LANL 2006g.
[e] Amount consisted mostly of lead bricks and shielding, contaminated with beryllium and depleted uranium (LANL 2005f).
[f] *1999 SWEIS* ROD projection exceeded due to maintenance activities (LANL 2003h).
[g] *1999 SWEIS* ROD projections did not envision use of Resource Conservation and Recovery Act listed hazardous chemicals in the facility or the resulting mixed waste (LANL 2003h).
[h] Includes estimates of waste generated from the facility upgrades associated with pit fabrication (LANL 2003h).
[i] Amount includes 751 cubic yards of waste generated as the result of emergency cleanups following the Cerro Grande Fire (LANL 2003h).
Note: To convert cubic yards to cubic meters, multiply by 0.76456.

Table 4–47 Transuranic Waste Generation at Los Alamos National Laboratory by Facility (cubic yards per year)

Facility	SWEIS ROD	1999 [a]	2000 [a]	2001 [a]	2002 [a]	2003 [b]	2004 [c]	2005 [d]
Chemistry and Metallurgy Research Building	37 [e]	12	32	61 [f]	13	10	6	12
Sigma Complex	0	0	0	0	0	0	0	0
Machine Shops	0	0	0	0	0	0	0	0
Materials Science Laboratory	0	0	0	0	0	0	0	0
High-Explosives Processing	0	0	0	0	0	0	0	0
High-Explosives Testing (listed as transuranic/mixed transuranic)	0.3	0	0	0	0	0	0	0
Tritium Facilities	0	0	0	0	0	0	0	0
Pajarito Site	0	0	0	0	0	0	0	0
Target Fabrication Facility	0	0	0	0	0	0	0	0
Biological Sciences	0	0	0	0	0	0	0	0
Radiochemistry Laboratory	0	0	0	0	0	2	< 1	0
Radioactive Liquid Waste Treatment Facility	39	0	21	< 1	3	0	0	0
Los Alamos Neutron Science Center	0	0	0	0	0	0	0	0
Solid Radioactive and Chemical Waste Facilities	35	52	35	13	39	115 [g]	0	< 1
Plutonium Facilities	310 [e]	123	71	47	53	283	18	62
Total transuranic Waste for Key Facilities	421	187	159	122	108	410	25	75
Non-Key Facilities [h]	0	0	4	32	48	118	28	23
Total transuranic Waste for Key and non-Key Facilities	421	187	163	154	156	528	53	98
Percentage of Total from Key Facilities	**100**	**100**	**98**	**79**	**69**	**78**	**47**	**76**
Environmental Restoration	14	0	0	0	0	0	0	0
Total transuranic Waste for non-Key Facilities and Environmental Restoration	14	0	4	32	48	118	28	23
Total transuranic = Key + non-Key Facilities and Environmental Restoration	436	187	163	154	156	528	53	98
Percentage of Total from Key Facilities	**97**	**100**	**98**	**79**	**69**	**78**	**47**	**76**

ROD = Record of Decision.
[a] LANL 2003h.
[b] LANL 2004f.
[c] LANL 2005f.
[d] LANL 2006g.
[e] *1999 SWEIS* projections modified to reflect the ROD determination to produce nominally 20 pits per year (LANL 2003h).
[f] *1999 SWEIS* ROD projection exceeded due to remodeling activities (LANL 2003h).
[g] *1999 SWEIS* ROD projection exceeded due to Decontamination and Volume Reduction System repackaging of legacy transuranic waste (LANL 2004f).
[h] *1999 SWEIS* ROD projections exceeded due to wastes received by the Off-Site Source Recovery Project. Because this waste comes from shipping and receiving, it is attributed to non-Key Facilities (LANL 2003h, 2004f, 2005f, 2006g).
Note: To convert cubic yards to cubic meters, multiply by 0.76456.

Mixed Transuranic Wastes—Mixed transuranic waste is waste that contains both transuranic waste and hazardous waste as defined by RCRA. Mixed transuranic waste is generated through research, development, and stockpile manufacturing and management activities. The waste forms include contaminated scrap and residues, plastics, lead gloves, glass, and personnel protective equipment. Mixed transuranic waste may also be generated through environmental restoration, legacy waste retrieval, and DD&D activities. Mixed transuranic waste is characterized and certified prior to shipment to the WIPP (LANL 2004l).

The facility-specific mixed transuranic waste generation rates for the 7-year period are shown in **Table 4–48**. Generally, facility-specific generation rates are within the *1999 SWEIS* projections, with only a limited number of facilities producing mixed transuranic wastes. In the year 2000, Non-Key Facilities generated 82 cubic yards (63 cubic meters) of mixed transuranic waste compared to a *1999 SWEIS* projection of zero; the mixed transuranic waste generation for this category is solely attributable to the Transuranic Waste Inspection and Storage Project drum retrieval project (LANL 2001e). The Solid Radioactive and Chemical Waste Facilities generated mixed transuranic waste beyond that projected for the years 2000 through 2004, most notably in 2003 due to increased rates of transuranic waste repackaging for shipment to WIPP (LANL 2003h, LANL 2004f, LANL 2005f). The increasing trend, through 2003, in mixed transuranic waste generation for the Plutonium Complex and the Chemistry and Metallurgy Research Building reflect operations scaling toward full-scale production of war reserve pits (LANL 2004f). In 2004, mixed transuranic waste generation rates at the Plutonium Complex and Chemistry and Metallurgy Research Building were lower due to the 2004 work suspension and less than full-scale production (LANL 2005f). Overall mixed transuranic waste generation at LANL was below the *1999 SWEIS* projections for 6 years of the 7-year period. In 2003, mixed transuranic waste quantities exceeded the *1999 SWEIS* projection due to repackaging of legacy waste for shipment to WIPP (LANL 2004f).

Chemical Wastes—At LANL, chemical wastes are defined as a broad category including: hazardous waste (designated under RCRA regulations); toxic waste (asbestos and polychlorinated biphenyls, designated under the Toxic Substances Control Act); and special waste (designated under the New Mexico Solid Waste Regulations and including industrial waste, infectious waste, and petroleum contaminated soils). Construction and demolition debris was also included in the chemical waste category in the *1999 SWEIS* and continues to be tracked as chemical waste in the *SWEIS Yearbooks*, although this debris is disposed of as solid waste. The chemical waste category also includes all other nonradioactive waste that is managed through the Solid Chemical and Radioactive Waste Facilities, generally because the waste type is not accepted by solid waste disposal facilities (LANL 2005f). Typical hazardous waste streams include solvents, unused chemicals, acids and bases, solids such as barium-containing explosive materials, laboratory trash, and cleanup materials such as rags. Chemical waste is generated by many routine operations throughout LANL and also by environmental restoration and DD&D activities (LANL 2004l).

Table 4–48 Mixed Transuranic Waste Generation at Los Alamos National Laboratory by Facility (cubic yards per year)

Facility	*SWEIS ROD*	*1999* [a]	*2000* [a]	*2001* [a]	*2002* [a]	*2003* [b]	*2004* [c]	*2005* [d]
Chemistry and Metallurgy Research Building	17 [e]	3	1	1	22 [f]	15	< 1	4
Sigma Complex	0	0	0	0	0	0	0	0
Machine Shops	0	0	0	0	0	0	0	0
Materials Science Laboratory	0	0	0	0	0	0	0	0
High-Explosives Processing	0	0	0	0	0	0	0	0
High-Explosives Testing (Listed as transuranic/Mixed transuranic)	0.3	0	0	0	0	0	0	0
Tritium Facilities	0	0	0	0	0	0	0	0
Pajarito Site	0	0	0	0	0	0	0	0
Target Fabrication Facility	0	0	0	0	0	0	0	0
Biological Sciences	0	0	0	0	0	0	0	0
Radiochemistry Laboratory	0	0	0	0	0	0	0	0
Radioactive Liquid Waste Treatment Facility	0	6	0	6	< 1	4	0	0
Los Alamos Neutron Science Center	0	0	0	0	0	0	0	0
Solid Radioactive and Chemical Waste Facilities	0	0	10	17	20	77 [g]	< 1	3
Plutonium Facilities	133 [e]	86	22	39	72	102	31	125
Total of Mixed transuranic for Key Facilities	150	95	33	63	115	198	33	132
Non-Key Facilities	0	20	82	0	< 1	8 [h]	0	< 1
Total Mixed transuranic Waste for Key and non-Key Facilities	150	114	116	63	114	206	31	133
Percentage Total from Key Facilities	**100**	**83**	**29**	**100**	**99**	**96**	**100**	**99**
Environmental Restoration	0	0	0	< 1	0	0	0	0
Total of Mixed transuranic Waste for non-Key Facilities and Environmental Restoration	0	20	82	< 1	< 1	8	0	< 1
Total Mixed transuranic = Key + non-Key Facilities and Environmental Restoration	150	115	115	63	116	206	33	133
Percentage of Total from Key Facilities	**100**	**83**	**29**	**99**	**99**	**96**	**100**	**99**

ROD = Record of Decision.
[a] LANL 2003h.
[b] LANL 2004f.
[c] LANL 2005f.
[d] LANL 2006g.
[e] *1999 SWEIS* projections modified to reflect the ROD determination to produce nominally 20 pits per year (LANL 2003h).
[f] *1999 SWEIS* ROD projection exceeded due to remodeling activities (LANL 2003h).
[g] *1999 SWEIS* ROD projection exceeded due to Decontamination and Volume Reduction System repackaging of legacy transuranic waste (LANL 2004f).
[h] Waste generated by recovery operations at Area G involving new compactible fiberglass-reinforced crates. Because this waste was generated at a building not identified as part of the Solid Radioactive and Chemical Waste Key Facility, it is attributed to non-Key Facilities (LANL 2006g).
Note: To convert cubic yards to cubic meters, multiply by 0.76456.

The facility-specific chemical waste generation rates for the 7-year period are shown in **Table 4–49**. From 1999 through 2001, large quantities of chemical wastes were generated by environmental restoration activities through cleanups in TA-16, including MDA P, PRS 3-056(c) in TA-3, and MDA R (LANL 2003h). Wastes generated by environmental restoration activities generally are shipped offsite for treatment and disposal and do not directly impact LANL waste management resources. Numerous facility-specific variances to the *1999 SWEIS* ROD projections occurred, mostly due to one-time events as documented in Table 4–49.

Table 4–49 Chemical Waste Generated at Los Alamos National Laboratory by Facility (pounds per year)

Facility	*SWEIS ROD*	*1999* [a]	*2000* [a]	*2001* [a]	*2002* [a]	*2003* [b]	*2004* [c]	*2005* [d]
CMR Building	23,800	10,640	4,050	1,490	1,560	3,640	3,890	370
Sigma Complex	22,050	7,070	8,100	2,790	71,420 [e]	1,940	86,620 [f]	4,890
Machine Shops	1,045,000	8,720	1,960	58,370	4,460	340	910	850
MSL	1,320	340	1,940 [g]	560	330	430	450	390
High-Explosives Processing	28,700	29,400	2,277,300 [h]	827,300 [i]	33,300 [j]	53,400 [k]	16,100	9,100
High-Explosives Testing	77,800	2,240	133,240 [l]	2,950	2,830	2,330	30	2,700
Tritium Facilities	3,750	70	20	5,770 [m]	11,390 [n]	90	20	20
Pajarito Site	8,820	3,760	280	200	180	60	60	10
Target Fabrication Facility	8,380	1,310	2,340	1,470	1,990	2,890	1,840	17,030 [o]
Biological Sciences	28,660	3,730	5,230	3,000	9,930	6,330	1,540	3,380
Radiochemistry Laboratory	7,280	3,340	27,470 [p]	39,080 [q]	410,350 [r]	10,710 [s]	68,100 [t]	1,060
Radioactive Liquid Waste Treatment Facility	4,850	440	850	151,700 [u]	2,520	150	210	20
Los Alamos Neutron Science Center	36,600	24,400	2,660	8,940	4,410	15,240	214,520 [v]	1,980
Solid Radioactive and Chemical Waste Facilities	2,030	70	1,780	990	1,900	1,800	2,640 [w]	6,240 [x]
Plutonium Facilities	18,500	5,600	3,450	25,800 [y]	31,400 [z]	42,670 [aa]	17,200	2,840
Total Chemical Waste for Key Facilities	1,317,540	101,130	2,470,670	1,130,410	587,970	142,020	414,130	50,880
Non-Key Facilities	1,435,000	1,687,400 [bb]	810,800	2,766,100 [cc]	737,100	1,377,500	2,047,100 [dd]	1,374,190
Total Chemical Waste for Key and non-Key Facilities	2,752,540	1,788,530	3,281,470	3,896,510	1,325,070	1,519,520	2,461,230	1,425,070
Percentage of Total from Key Facilities	**48**	**6**	**75**	**29**	**44**	**9**	**17**	**4**
Environmental Restoration	4,409,200	32,252,800 [ee]	57,728,200 [ff]	63,526,800 [ff]	2,497,300	68,300	207,200	2,914,400
Total Chemical Waste for non-Key Facilities and Environmental Restoration	5,844,200	33,940,200	58,539,000	66,292,900	3,234,400	1,445,800	2,254,300	4,288,590
Total Waste = Key + non-Key Facilities and Environmental Restoration	7,161,740	34,041,330	61,009,670	67,423,310	3,822,370	1,587,820	2,668,430	4,339,470

Facility	*SWEIS ROD*	*1999* [a]	*2000* [a]	*2001* [a]	*2002* [a]	*2003* [b]	*2004* [c]	*2005* [d]
Percentage of Total from Key Facilities	**18**	**< 1**	**4**	**2**	**15**	**9**	**16**	**1**

CMR = Chemistry and Metallurgy Research, MSL = Materials Science Laboratory, ROD = Record of Decision.

[a] LANL 2003h.

[b] LANL 2004f.

[c] LANL 2005f.

[d] LANL 2006g.

[e] Amount includes a significant quantity of waste generated by structure rehabilitation and equipment disposal associated with bringing the Press Building back on-line (LANL 2003h).

[f] *1999 SWEIS* ROD projection exceeded due to disposal of four years accumulation of graphite waste (nonhazardous but not accepted at solid waste or recycling facilities) and beryllium waste from the Beryllium Technology Facility (LANL 2005f).

[g] *1999 SWEIS* ROD projection exceeded due to remodeling of a C-Wing laboratory (LANL 2003h).

[h] Cleanup of MDA R generated 2,225,932 pounds of waste (LANL 2003h).

[i] Cleanup of MDA R generated 815,975 pounds of waste (LANL 2003h).

[j] *1999 SWEIS* ROD projection exceeded due to wastes disposed of through chemical cleanout initiative (LANL 2003h).

[k] *1999 SWEIS* ROD projection exceeded due to the demolition of Buildings TA-16-220, -222, -223, -224, -225, and -226 (LANL 2003h).

[l] *1999 SWEIS* ROD projection exceeded due to cleanup following the Cerro Grande Fire (LANL 2003h).

[m] Amount includes 5,181 pounds generated by refrigerant replacement at TA-16-450 (LANL 2003h).

[n] Amount includes 8,818 pounds generated by refrigerant replacement at TA-16-450 (LANL 2003h).

[o] *1999 SWEIS* ROD projection exceeded due to disposal of beryllium contaminated waste, including wastes from cleanout of a beryllium operations room and disposal of excess equipment originally from Rocky Flats (LANL 2006g).

[p] Amount includes 24,160 pounds of construction and demolition debris generated during cleanup following the Cerro Grande Fire (LANL 2003h).

[q] Amount includes 19,535 pounds of waste generated through chemical cleanout initiative (LANL 2003h).

[r] Amount includes 403,204 pounds of contaminated soil excavated during a construction project outside TA-48-1 (LANL 2003h).

[s] Amount includes waste generated through chemical cleanout initiative and the recycling of two mercury-containing shields weighing a total of 8,000 pounds (LANL 2004f).

[t] Amount includes waste generated through chemical cleanout initiative and disposal of mercury shielding as part of the facility radiological status downgrade effort (LANL 2005f).

[u] Amount includes 151,200 pounds of waste (soil and asphalt) generated as a result of replacement of storage tanks and plumbing (LANL 2003h).

[v] Amount includes four year accumulation of metals which could not be recycled due to the DOE moratorium on commercial recycling of metals from radiological areas. The moratorium metal was shipped to Oak Ridge for evaluation and disposition.

[w] *1999 SWEIS* ROD projection exceeded due to the Decontamination and Volume Reduction System repackaging of legacy transuranic waste (LANL 2005f).

[x] *1999 SWEIS* ROD projection exceeded due to generation of cutting fluids (nonhazardous mineral oil and water) during repacking of transuranic waste (LANL 2006g).

[y] Amount includes 23,001 pounds of contaminated soil and debris from the replacement of hydraulic cylinders at the front gate (LANL 2003h).

[z] Amount includes oil-contaminated soil generated when a transformer was dropped during relocation (LANL 2003h).

[aa] Amount includes 22,000 pounds of soil contaminated with diesel fuel, 1,887 pounds of waste solutions from experiments, and an additional 818 pounds of soil contaminated with diesel fuel (LANL 2004f).

[bb] *1999 SWEIS* ROD projection exceeded due to environmental restoration cleanups (LANL 2000f).

[cc] Amount includes 161,926 pounds of construction and demolition debris resulting from cleanup following the Cerro Grande Fire (LANL 2003h).

[dd] *1999 SWEIS* ROD projection exceeded due to heightened activities and new construction (LANL 2005f).

[ee] *1999 SWEIS* ROD projection exceeded due to soils excavated during remediation of MDA P (LANL 2003h).

[ff] Amount includes industrial and other chemical waste resulting from the cleanup following the Cerro Grande Fire (LANL 2003h).

Note: To convert pounds to kilograms, multiply by 0.45359.

Radioactive Liquid Waste Treated at LANL—Radioactive liquid waste treatment takes place at three facilities located at TA-21, TA-53, and TA-50. Treatment facilities are connected to source facilities by 22,000 feet (6,706 meters) of piping. The treatment facility at TA-50 handles the vast majority of radioactive liquid waste, receiving liquid waste from about 1,800 points across LANL. The Radioactive Liquid Waste Treatment Facility at TA-50 is over 40 years old, and many systems are at the end of their design life.

Radioactive liquid waste treatment rates and waste quantities for the 7-year period are shown in **Table 4–50**. The *1999 SWEIS* contained projections of volumes treated and resulting effluents and waste quantities, including the following categories: pretreatment liquids, effluent discharges, and low-level waste sludges. Of these categories, the most significant parameter is annual effluent discharge from the Radioactive Liquid Waste Treatment Facility. For the 7-year period of 1999 through 2005, all annual effluent quantities from the Radioactive Liquid Waste Treatment Facility were well within the *1999 SWEIS* projection. Source reduction efforts and process improvements were the two factors that contributed to reduced waste volumes (LANL 2005f, 2006g).

Projections made within the *1999 SWEIS* were exceeded for individual treatment activities in several instances, all related to quantities of sludge to be dewatered or solidified; the liquid waste treatment increases due to these activities are small compared to radioactive liquid treatment capacity. The overall radioactive liquid waste treatment rates at LANL were consistent with the *1999 SWEIS* projections for each year of the 7-year period.

4.9.4 Offsite Shipments of Radioactive and Chemical Wastes

Most of the radioactive and chemical wastes generated at LANL are shipped offsite for treatment and disposal. The quantities of wastes shipped offsite during 2002 through 2005 are presented in **Table 4–51**. Although low-level radioactive waste may be disposed of onsite at LANL, some is transported offsite for disposal. All mixed low-level radioactive waste is transported offsite for treatment and disposal. Transuranic and mixed transuranic wastes are characterized, certified, and placed in drums or other containers, which are then loaded into shipment containers for transport to the WIPP. Although there have been delays in meeting the planned schedule for transuranic waste shipments, process improvements have been made and recent gains in shipment numbers have been realized. In October 2006, the one-hundredth shipment of transuranic waste for the year was shipped, exceeding the number of annual shipments for any previous year (LANL 2006g). Additionally, the volume of waste shipped in 2006 (684 cubic yards [523 cubic meters]) was more than three times that of 2005 (LANL 2006a). In 2007, 823 cubic yards (629 cubic meters) of transuranic waste was sent to WIPP in 121 shipments. All chemical wastes are shipped offsite for treatment and disposal. For the subset of chemical wastes that are regulated under RCRA, onsite storage is limited to 1 year. The environment impacts associated with shipments of radioactive and chemical wastes are described in Section 4.10.

Table 4–50 Radioactive Liquid Waste Treated at Los Alamos National Laboratory

Facility	SWEIS ROD	1999 [a]	2000 [a]	2001 [a]	2002 [a]	2003 [b]	2004	2005 [c]
Pretreatment of radioactive liquid waste at TA-21	237,800 gallons per year	11,900 gallons	11,900 gallons	120,700 gallons	8,000 gallons	6,510 gallons	0	0
Percentage of SWEIS projection of pretreatment at TA-21	–	5	5	51	3	3	0	0
Pretreatment of radioactive liquid waste from TA-55	21,100 gallons per year	Less than 21,100 gallons	2,380 gallons	5,810 gallons	9,350 gallons	13,700 gallons	13,700 gallons	0
Percentage of SWEIS projection of pretreatment from TA-55	–	Less than 100	10	30	40	70	70	0
Solidification of transuranic (transuranic) sludge at TA-50	4 cubic yards per year	7 cubic yards	7 cubic yards	None	None	4 cubic yards	0	0
Percentage of SWEIS projection of solidification of transuranic sludge	–	170	170	0	0	100	0	0
Radioactive liquid waste treated at TA-50	9,246,000 gallons per year	5,283,400 gallons	5,019,300 gallons	3,698,400 gallons	3,038,000 gallons	3,566,300 gallons	2,166,200 gallons	1,796,400 gallons
Percentage of SWEIS projection of radioactive liquid waste treated at TA-50	–	57	54	40	33	39	23	19
De-water low-level radioactive waste sludge at TA-50	13 cubic yards per year	48 cubic yards	63 cubic yards	79 cubic yards	13 cubic yards	38 cubic yards	18 cubic yards	0
Percentage of SWEIS projection of low-level radioactive waste sludge de-watered at TA-50	–	370	480	600	100	290	137	0
Radioactive liquid waste treated at TA-53	Not projected	(d)	(d)	(d)	64,200 gallons	103,900 [e] gallons	88,800 [f] gallons	93,800 [f] gallons
Percentage of SWEIS projection of radioactive liquid waste treated at TA-53	NA	NA	NA	NA	NA	NA	NA	NA

ROD = Record of Decision, TA = technical area, NA = not available.
[a] LANL 2003h.
[b] LANL 2004f.
[c] LANL 2006g.
[d] Flows into the TA-53 surface impoundments started in 2000, but were first reported in the *2002 Yearbook* (LANL 2003h).
[e] LANL 2004c.
[f] LANL 2006a.
Note: To convert gallons to liters, multiply by 3.7853; cubic yards to cubic meters, multiply by 0.76456.

Table 4–51 Amount of Radioactive and Chemical Wastes Shipped Offsite

Type of Waste	Year			
	2002	2003	2004	2005
Low-Level Radioactive (cubic yards)	5	2,070	390	1,510
Mixed Low-Level Radioactive (cubic yards)	50	90	90	20
Transuranic (including mixed transuranic) (cubic yards) [a]	1	370	0	216
Chemical (pounds)	1,690,700	1,805,200	2,517,800	1,645,100

[a] Data is for fiscal year.
Note: To convert cubic yards to cubic meters, multiply by 0.76456; pounds to kilograms, multiply by 0.45359.
Sources: LANL 2006a, 2006j.

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 onsite and offsite traffic volumes are presented in this subsection.

4.10.1 Regional and Site Transportation Routes

Motor vehicles are the primary means of transportation to LANL. The nearest commercial bus terminal is in Santa Fe. The nearest commercial rail connection is at Lamy, New Mexico, 52 miles (83 kilometers) southeast of LANL. There is a spur into central Santa Fe used by the Santa Fe Southern Railway. However, LANL does not currently use rail for commercial shipments.

Park-and-ride services are provided by a commercial corporation, in conjunction with the New Mexico Department of Transportation. Over 80 daily departures between Santa Fe and Española, Santa Fe and Los Alamos, Española and Los Alamos, and Albuquerque and Santa Fe and Los Alamos are provided for commuters. Monthly passes are available for unlimited use of most park-and-ride services. **Table 4–52** shows the pick-up and drop-off locations that are included among those currently serviced by this public transportation service. Typical weekday riderships for the two park-and-ride routes serving Los Alamos are shown in **Table 4–53**.

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. 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, U.S. Federal Aviation Administration-licensed pilots and pilots of transient aircraft may be issued permits to use the airport facilities.

Table 4–52 Park and Ride Pickup and Drop-Off Locations

Santa Fe
CORDOVA/CERRILLOS – This is located on the Southeast corner of Cerrillos and Cordova in the State Highway Department General Office parking lot. The bus pulls up on the Northwest corner of the parking area in front of the building.
ALTA VISTA – This is located on Alta Vista, just east of Cerrillos on the north side. The parking area is marked with signs and is just west of the Railroad crossing on Alta Vista.
SHERIDAN/PALACE – This pick up and drop off point only (no vehicle parking) is on Sheridan, just south of Marcy. It is also the north transfer point for Santa Fe Trails.
PERA – PERA Building is on the Northeast corner of Paseo de Peralta and the Old Santa Fe Trail. The boarding area is near the middle of the parking lot on the West side of the building.
DISTRICT 5 – This parking lot is located on Jaguar Street, west of Cerrillos on the south side. It is a fenced lot on the New Mexico Department of Transportation property.
Española
ESPAÑOLA – This parking lot is located on Onate, about 0.25 miles west of Riverside (US84/285) on the south side.
Los Alamos
TA-3 – This parking area and shuttle pick up area for LANL is located just east of Diamond Drive on Jemez Road on the south side.
CENTRAL/20th – This parking and drop off area is in front of the Los Alamos Library, just west of 20th Street.

Note: To convert miles to kilometers, multiply by 1.6093.
Source: All Aboard America 2005.

Table 4–53 Park and Ride Use

Route	*Dates*	*Average Number of Riders - Daily*	*Percent of Capacity*
Blue Route: Santa Fe/Los Alamos	October 24-28, 2005	369	71
Green Route: Española/Los Alamos	October 24-28, 2005	165	66

Source: NMDOT 2005b.

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 4–30**. Regional transportation routes connecting LANL with Albuquerque and Santa Fe are I–25 to US 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 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 at LANL's main access points are presented in **Table 4–54**.

Table 4–54 Los Alamos National Laboratory Main Access Points

Location	*Average Daily Vehicle Trips*
Diamond Drive across the Los Alamos Canyon Bridge	24,545
Pajarito Road at NM 4	4,984
East Jemez Road at NM 4	9,502
West Jemez Road at NM 4	2,010
DP Road at Trinity Drive	1,255
Total	42,296

Source: KSL 2004, LAC 2005.

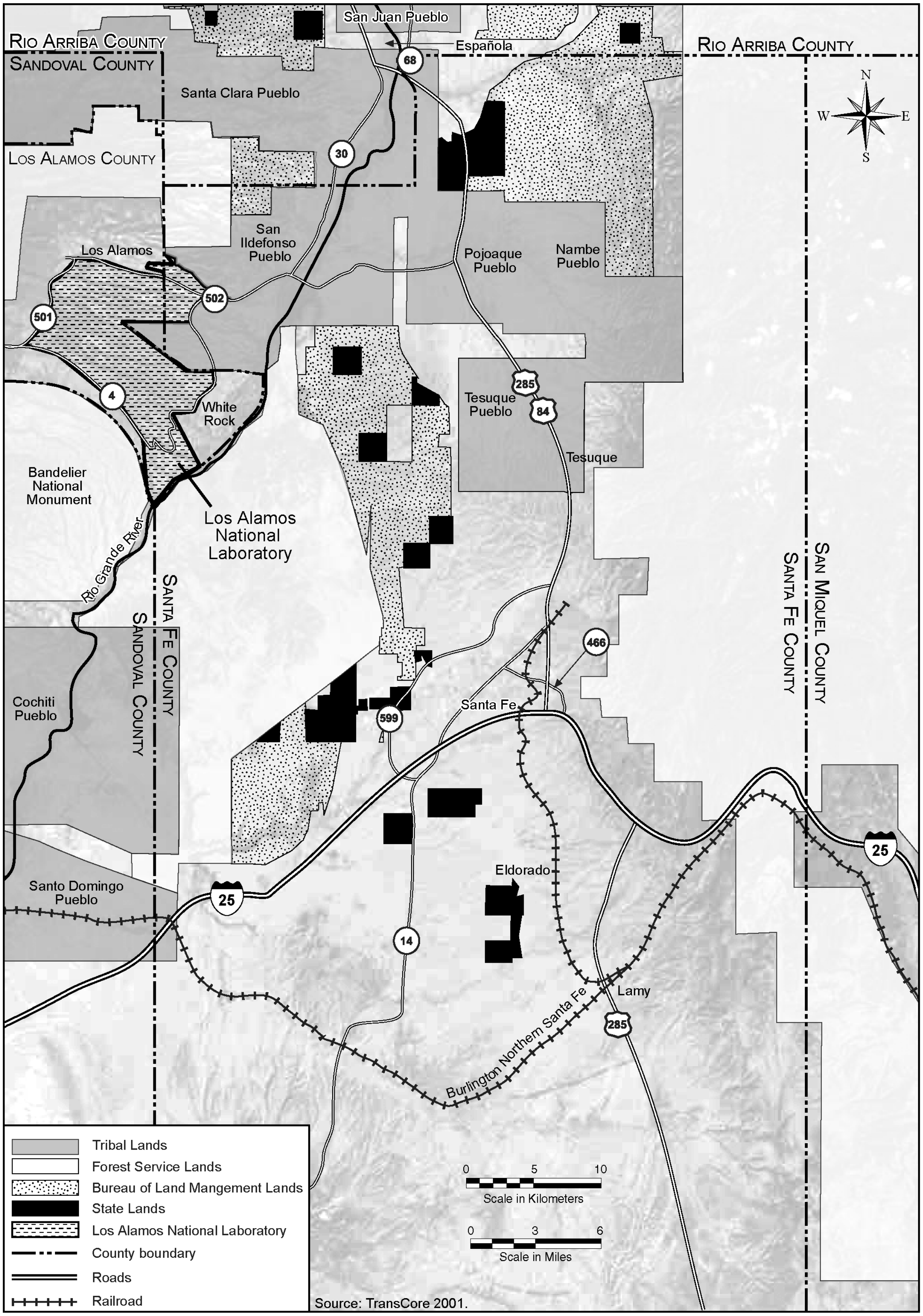

Figure 4–30 Los Alamos National Laboratory Vicinity Regional Highway System and Major Roads

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. Most commuter traffic originates from Los Alamos County or east of Los Alamos County (Rio Grande Valley and Santa Fe) as a result of the large number of LANL employees that live in these areas (see Section 4.8.1). A small number of LANL employees commute to LANL from the west along NM 4. The average weekday traffic volume at various points in the vicinity of NM 502 and NM 4 measured in September 2004 are presented in **Table 4–55**.

Table 4–55 Average Weekday Traffic Volume in the Vicinity of NM 502 and NM 4

Location	*Average Daily Vehicle Trips*
Eastbound on NM 502 east of the intersection with NM 4	10,100
Westbound on NM 502 east of the intersection with NM 4	7,765
Eastbound on NM 502 west of the intersection of NM 502 and NM 4	6,540
Westbound on NM 502 west of the intersection of NM 502 and NM 4	4,045
Westbound on NM 4 between East Jemez Road and the NM 502/4 intersection	6,505
Eastbound on NM 4 between East Jemez Road and the NM 502/4 intersection	6,665
Transition road from northbound NM 4 to eastbound NM 502	5,170
Transition road from eastbound NM 502 to southbound NM 4	1,610

Source: LSC 2004.

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 Interstate–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 bypasses the city of Santa Fe on NM 599 to Interstate–25.

4.10.2 Transportation Accidents

Motor vehicle accidents in Los Alamos County and nearby counties are reported in **Table 4–56**. In 2004, there were over 5,700 motor vehicle accidents in Los Alamos, Rio Arriba, and Santa Fe Counties resulting in 58 fatalities. When accidents are considered per 100 million vehicle miles traveled, travel in Santa Fe County was the most dangerous in the region of influence during 2004, although Rio Arriba County had the highest fatality rate. Since the *1999 SWEIS* was issued, there have been two fatal traffic accidents on the site. On November 1, 1999, there was one fatality as a result of two private vehicles colliding at the intersection of Eniwetok Drive and Diamond Drive, and on October 2, 2001, a motorcyclist was killed after colliding with a private vehicle at the intersection of Sigma Road and Diamond Drive (LANL 2006a).

Table 4–56 New Mexico Traffic Accidents in Los Alamos and Nearby Counties, 2004

County	Total Accidents	Crash Rate [a]	Fatalities	Death Rate [b]
Los Alamos	274	246	0	0
Rio Arriba	698	144	32	6.61
Santa Fe	4,744	267	26	1.46
New Mexico	52,288	223	522	2.23

[a] Crash rate measures crashes per 100 million vehicle miles traveled.
[b] Death rate measures deaths per 100 million vehicle miles traveled.
Source: NMDOT 2006.

Table 4–57 shows the accident history for Los Alamos County from 1999 through 2004. As shown in the table, the county's crash rate and death rate were lower than the state average during this period.

Table 4–57 Los Alamos County Traffic Accidents, 1999 - 2004

Year	Total Accidents	Crash Rate [a]	Fatalities	Death Rate [b]
1999	252	119	1	0.47
2000	252	123	0	0
2001	270	132	3	1.46
2002	307	310	0	0
2003	259	221	1	0.85
2004	274	246	0	0
County Average 99-04	269	192	0.8	0.46
State Average 99-04	48,359	210	462	2.0

[a] Crash rate measures crashes per 100 million vehicle miles traveled.
[b] Death rate measures deaths per 100 million vehicle miles traveled.
Sources: NMDOT 2001, 2002, 2003, 2004, 2005a, 2006.

4.10.3 Los Alamos National Laboratory 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 special nuclear material (plutonium, enriched uranium), medical radioisotopes, and other miscellaneous radioactive materials. Offsite shipments, both to and from LANL, are carried by commercial carriers (including truck, air-freight, and government trucks), and by DOE safe secure transport trailers. Numerous regulations and requirements govern the transportation of hazardous and radioactive materials, including those of the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, DOE, U.S. Federal Aviation Administration, International Air Traffic Association, and LANL.

4.10.3.1 Onsite Shipments

Onsite hazardous and radioactive material shipments are transported in conformance with U.S. Department of Transportation regulations. A shipment is considered an onsite shipment if both the origin and destination are at LANL. These shipments are transported in 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 safe secure trailers. Maintenance of these vehicles is closely monitored for physical performance as well as security.

Hazardous 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.

Onsite radioactive material shipments are transported in conformance with U.S. Nuclear Regulatory Commission 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 DOE to meet these stringent packaging requirements. In such cases, roads are temporarily closed during the shipments; DOE safety requirements still apply in these cases.

Onsite transport constitutes the majority of activities that are part of routine operations in support of various programs. The radioactive materials transported onsite between TAs are mainly of limited quantities, short travel distances, and mostly on closed roads. The impacts of these activities are part of the normal operations at these areas. For example, worker dose from handling and transporting the radioactive materials are included as part of operational activities. Specific analyses performed in the *1999 SWEIS* indicated that the projected collective radiation dose for LANL drivers from a projected 10,750 onsite shipments to be 10.3 person-rem per year, or on average, less than 1 millirem per transport. Review of recent onsite radioactive materials transportation indicates a much smaller number of shipments than those projected in the *1999 SWEIS*.

4.10.3.2 Offsite Shipments

Offsite transports of radioactive materials would occur using both trucks and airfreight. The radioactive materials transported would include tritium, plutonium, uranium (both depleted and enriched), offsite source recovery, medical isotopes, small quantities of activation products, low-level radioactive waste, and transuranic waste. At LANL, DOE transports and receives radioactive and other hazardous materials and waste shipments to and from other DOE facilities and commercial facilities nationwide. As discussed above, shipments meet applicable U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, U.S. Federal Aviation Administration, regulations or DOE requirements. Most unclassified shipments are transported via commercial carriers.

From 2002 through 2005, there was an average of 273 offsite waste shipments per year. These consisted, on average, of 199 shipments of hazardous materials and 74 shipments of radioactive materials as shown in **Table 4–58**. Significant year-to-year changes in the volume of waste generated are discussed in Section 4.9.2 and provide the basis for the fluctuations shown in Table 4–58.

Table 4–58 Offsite Waste Shipments 2002 - 2005

Waste Type	*2002*	*2003*	*2004*	*2005*	*Total*
Hazardous	154	157	262	225	798
Low-Level Radioactive	3	68	12	50	133
Mixed Low-Level Radioactive	17	19	19	16	71
Transuranic	1	46	0	44	91
Total	175	290	293	335	1,093

Source: LANL 2006a.

DOE regulations require that safe secure trailers be used for offsite shipments of special nuclear material, weapons components, and explosive-like assemblies in DOE custody. Safe secure 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 safe secure trailers.

The primary regulatory approach to promote safety from radiological exposure is the specification of standards for the packaging of radioactive materials. Packaging represents the primary barrier between the radioactive material being transported and radiation exposure to the public, workers, and the environment. Transportation packaging for radioactive materials must be designed, constructed, and maintained to contain and shield its contents during normal transport conditions. For highly radioactive material such as high-level radioactive waste or spent nuclear fuel, packagings must contain and shield its contents in the event of severe accident conditions. The type of packaging used is determined by the total radioactive hazard presented by the material within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. See Appendix K for additional information on the shipment of radioactive materials to and from LANL.

4.11 Environmental Justice

Under Executive Order 12898, DOE is responsible for identifying and addressing potential disproportionately high and adverse human health and environmental impacts on minority or low-income populations. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, or multi-racial (with at least one race designated as a minority race under Council on Environmental Quality Guidelines [CEQ 1997]). Persons whose income is below the Federal poverty threshold are designated as low income.

Disproportionately High and Adverse Human Health Effects

Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as defined by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ 1997).

Disproportionately High and Adverse Environmental Effects

A disproportionately high environmental impact that is significant (as defined by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as defined by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian Tribes are considered (CEQ 1997).

4.11.1 Region of Analysis

The region of analysis for environmental justice corresponds to the region of analysis for the resource area being considered. The source of offsite impacts addressed in the SWEIS is radiological air emissions. The study area considered in the *1999 SWEIS* environmental justice analysis was the area within a 50-mile (80-kilometer) radius of LANL. **Figure 4–31** shows areas potentially at radiological risk from the current missions performed at LANL. These areas include the city of Santa Fe and Indian Reservations in North Central New Mexico. Eight counties are included or partially included in the potentially affected area (see **Figure 4–32**): Bernalillo, Los Alamos, Mora, Rio Arriba, Sandoval, San Miguel, Santa Fe, and Taos.

The center of the area was the emissions stack at LANSCE in TA-53. The LANSCE stack was chosen because it was the primary source of LANL airborne radionuclide emissions and therefore has the greatest potential for affecting offsite populations. Today, LANSCE is still the largest contributor to radioactive air emissions (LANL 2005h). Sampling data collected from vegetation, animals, fish, water and soils onsite or near LANL were used to estimate doses from ingestion by individuals existing on a subsistence diet. On this basis, the same study area is used for this environmental justice analysis of human health impacts. The use of a 50-mile (80-kilometer) radius is patterned after the methodology used by the U.S. Nuclear Regulatory Commission for assessing potential risks to populations from nuclear power plants and is intended to encompass the potential impacts from LANL operations (DOE 1999a). The location of minority and low-income populations within the 50-mile (80-kilometer) radius circle remained unchanged since the publication of the *1999 SWEIS*. However, the number of persons in these communities rose slightly over the past 5 years.

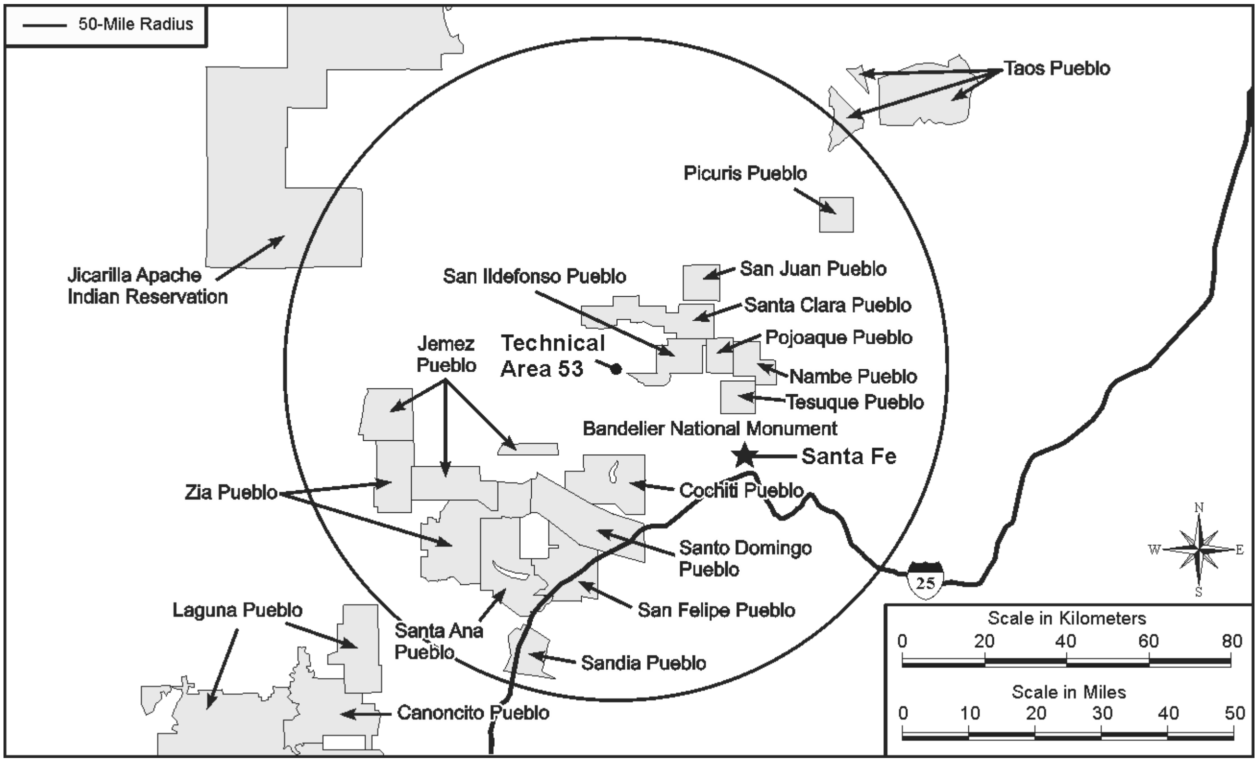

Figure 4–31 Location of Technical Area 53 and Indian Reservations Surrounding Los Alamos National Laboratory

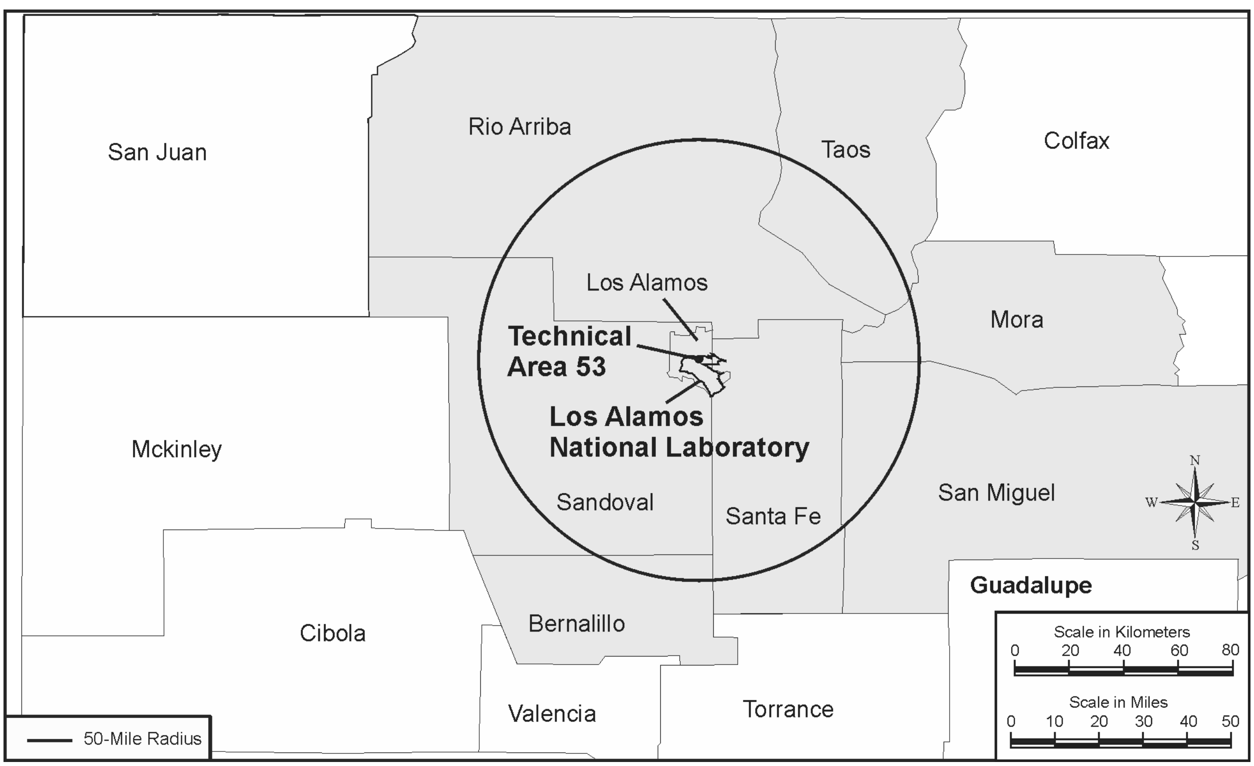

Figure 4–32 Potentially Affected Counties Surrounding Los Alamos National Laboratory

4.11.2 Changes Since the *1999 SWEIS*

To determine the extent of changes in minority and low-income populations in potentially affected counties surrounding LANL since the publication of the *1999 SWEIS*, comparisons were made between population estimates based on 1990 and 2000 census data. However, caution must be used when interpreting these changes, because of changes in the definitions of race and ethnicity used in the 2000 census. As a result, 2000 census data on race are not directly comparable with data from the 1990 or earlier censuses. Nevertheless, census data demonstrate that the minority population in these potentially affected counties grew by 33 percent between 1990 and 2000.

Table 4–59 provides the racial and Hispanic composition for these counties using data obtained from the census conducted in 2000. In the year 2000, a majority (54 percent) of these county residents designated themselves as members of a minority population. Hispanics and American Indians or Alaska Natives comprised approximately 91 percent of the minority population. As a percentage of the total resident population in 2000, New Mexico had the largest percentage minority population (55 percent) among the contiguous states and the second largest percentage minority population among all states (only Hawaii had a larger percentage minority population [77 percent]).

Table 4–59 Populations in Potentially Affected Counties Surrounding Los Alamos National Laboratory in 2000

Population Group	*Population*	*Percentage of Total*
Minority	490,172	54.4
Hispanic	400,725	44.5
Black or African American	15,945	1.8
American Indian or Alaska Native	44,468	4.9
Asian	12,188	1.4
Native Hawaiian or Pacific Islander	527	0.1
Two or more races	14,859	1.6
Some other race	1,460	0.2
White	410,524	45.6
Total	900,696	100.0

Source: DOC 2006b.

The percentage of low-income population for whom poverty status was determined was approximately 13 percent of those residing in potentially affected counties in 2000. In 2000, nearly 18 percent of the total population of New Mexico reported incomes less than the poverty threshold.

In terms of percentages, minority populations and low-income resident populations in potentially impacted counties were lower than the State percentage in 2000. Despite slight increases in the percentage of minority and low-income populations in the potentially affected counties, impacts to these populations over the past 5 years have not been disproportionately high or adverse, due to the overall low level of potential impacts. The effects of new construction projects since the publication of the *1999 SWEIS* were either minor, confined to the site, or within the historical operational effects of LANL.

Since 1990, the minority population in potentially affected counties surrounding LANL grew by about 33 percent (from 49.3 percent in 1990 to 54.4 percent in 2000) of the total population in the potentially affected counties (see **Table 4–60**). The area's largest minority group, the Hispanic population, grew by 30 percent, followed by American Indians (26 percent) and Asians (52 percent). The African-American population remained relatively unchanged.

Table 4–60 Populations in Potentially Affected Counties Surrounding Los Alamos National Laboratory in 1990

Population Group	*Population*	*Percentage of Total*
Minority	368,785	49.3
Hispanic	309,520	41.4
Black	15,595	1.8
American Indian, Eskimo, or Aleut	35,319	4.7
Asian or Pacific Islander	8,038	1.1
Some other race	2,313	0.3
White	379,644	50.7
Total	748,429	100.0

Source: DOC 2007.

In 1989, 21 percent of the population of New Mexico lived below the poverty threshold (DOE 1999a). In 1999, 18 percent of the population of New Mexico lived below the poverty threshold (see Section 4.11.4).

4.11.3 Minority Population in 2000

According to 2000 census data, approximately 153,518 minority individuals resided within the 50-mile (80-kilometer) radius of LANL. This represented 55 percent of the total population within the 50-mile (80-kilometer) radius. The largest minority group in the study area was the Hispanic population (127,671 or about 46 percent), followed by American Indians (17,371 or about 6 percent). Minorities are about 18 percent of Los Alamos County's population, with Hispanics being the largest minority group (12 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.

Census block groups with minority populations exceeding 50 percent were considered minority block groups. Based on 2000 census data, **Figure 4–33** shows minority block groups within the study area where more than 50 percent of the block group population is minority.

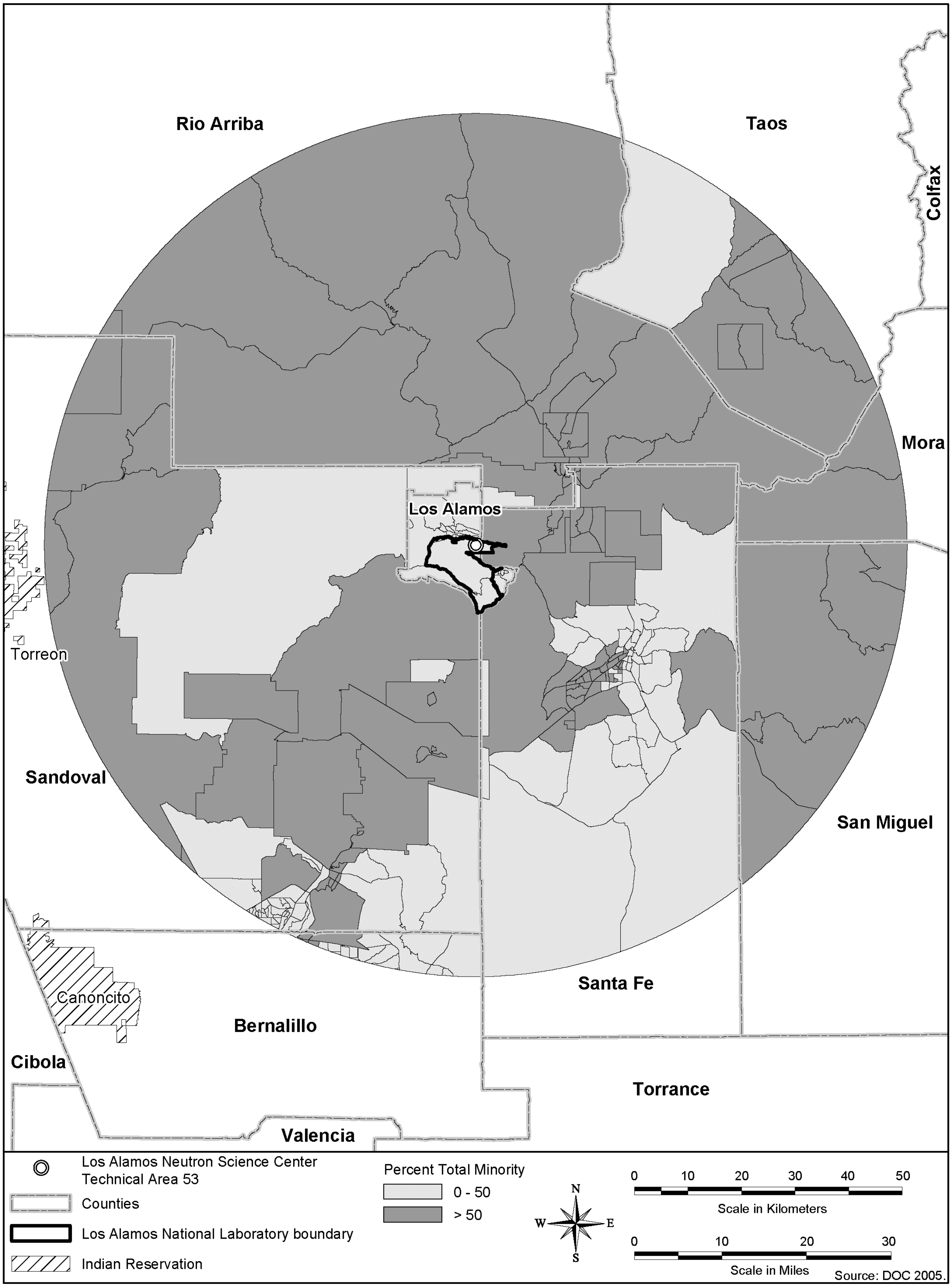

Figure 4–33 Minority Population – Block Groups with More Than 50 Percent Minority Population within a 50-Mile (80-kilometer) Radius of Los Alamos National Laboratory

4.11.4 Low-Income Population in 2000

According to 2000 census data, approximately 44,278 individuals residing within the 50-mile (80-kilometer) radius of LANL were identified as living below the Federal poverty threshold, which represent approximately 16 percent of the study area population. The median household income for New Mexico in 1999 was $34,133, while 18 percent of the population was determined to be living below the Federal poverty threshold ($17,029 for a family of four).

Los Alamos County had the highest median income ($78,993) within the State, and the lowest percentage (2.9 percent) of individuals living below the poverty level when compared to other counties in the area.

Census block groups were considered low-income block groups if the percentage of the populations living below the Federal poverty threshold exceeded 18 percent. Based on 2000 Census data, **Figure 4–34** shows low-income block groups within the study area where more than 18 percent of the block group population is living below the Federal poverty threshold.

4.12 Environmental Restoration

Environmental restoration activities are designed to reduce the risks associated with the legacy of past operations that resulted in releases of contaminants. As the LANL environmental restoration effort completes site investigations and cleanups, this progress translates to a reduction in the risk posed by past releases, and, in some cases, provides additional land use options in and around LANL. The *1999 SWEIS* evaluated environmental restoration impacts in the ecological and human health risk assessments and in analyses related to the transport, treatment, storage, and disposal of waste.

The LANL environmental restoration staff originally identified over 2,100 potential release sites, at and around LANL, including 1,099 regulated by the NMED under RCRA and 1,025 regulated by DOE. However, as a result of investigations, remediations, no further action determinations, and consolidation of geographically proximate sites, a total of 829 potential release sites remained within the environmental restoration program at the end of 2005 (LANL 2006g).

Each site remediation reduces potential impacts to ecological and human health. The environmental restoration project has made significant progress in the last 6 years. A multi-year cleanup at MDA P was completed in 2002, resulting in the excavation of more the 52,500 cubic yards (40,100 cubic meters) of soil and debris. Over this same timeframe, three wastewater surface impoundments at TA-53 were remediated (LANL 2003h). The project has also completed a number of source removals through voluntary corrective actions and has continued site investigations (LANL 2003h, 2004f). In 2005, the LANL environmental restoration staff completed nine characterization and remediation reports, performed soil and sediment sampling at a number of locations, and planned and performed accelerated remediation work in support of infrastructure improvements (LANL 2006g). In 2005, numerous characterization and remediation plans and reports were submitted to NMED in accordance with the Consent Order. In addition, accelerated remediation activities were implemented at sites that potentially could be affected by upcoming infrastructure and construction projects. NMED issued certificates of completion (replacing former no further action determinations) for eight sites (LANL 2006g).

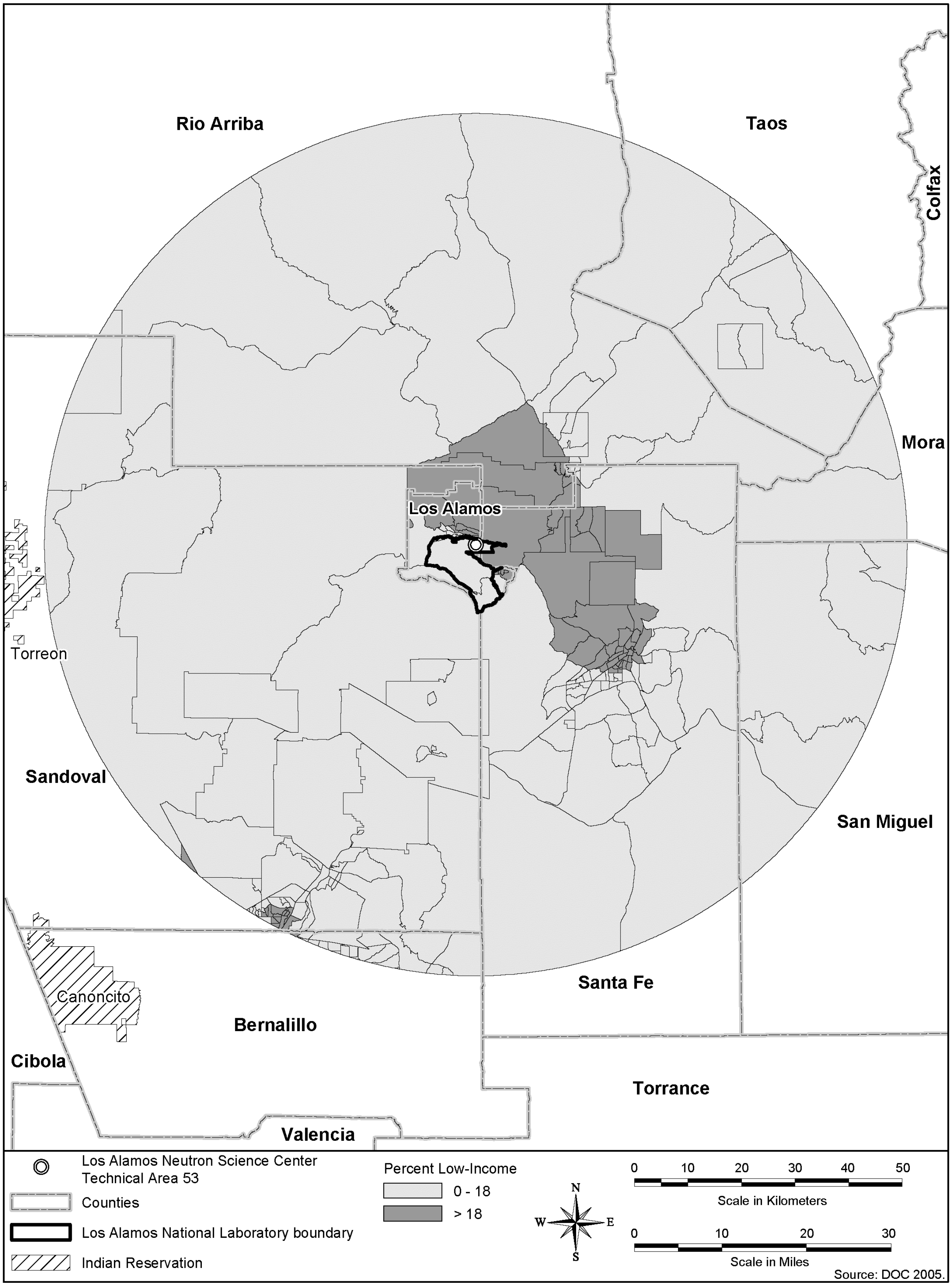

Figure 4–34 Low-Income Population – Block Groups with More Than 18 Percent of the Population Living Below the Federal Poverty Threshold within a 50-mile (80-kilometer) Radius of Los Alamos National Laboratory

Major unplanned environmental restoration activities were undertaken by LANL in response to the Cerro Grande Fire. Due to the threat of erosion and enhanced contaminant transport, the following activities were performed: evaluation and stabilization of sites touched by the fire; baseline sampling to characterize conditions in fire-impacted watersheds; and evaluation, stabilization or removal of sites subject to flooding. Accelerated cleanups in response to the fire were conducted at MDA R and in Los Alamos Canyon (LANL 2003h)

The large-scale cleanups have generated significant quantities of mostly chemical wastes, as discussed in Section 4.9. Because waste types and quantities at environmental restoration sites are difficult to estimate in advance, the generation of chemical waste exceeded *1999 SWEIS* ROD projections for several years out of the previous six. For many site cleanups, wastes are transported directly offsite from the point of generation, minimizing impacts on LANL waste management infrastructure.

Other environmental restoration-related impacts addressed qualitatively in the *1999 SWEIS* include fugitive dust, surface runoff, soil and sediment erosion, and worker health and safety risks (DOE 1999a). The controls presented in the *1999 SWEIS* to mitigate these impacts continue to be implemented, and in many cases, have been enhanced in response to the Cerro Grande Fire.

The successful site cleanups have produced beneficial environmental impacts, including risk reductions and land transfers. Actions taken in response to the Cerro Grande Fire prevented additional impacts that could have resulted from increased erosion and enhanced mobility of contaminants. With the exception of the chemical waste generation rates discussed in Section 4.9, environmental restoration activities have operated within the envelope evaluated in the *1999 SWEIS*.

Requirement for correction actions performed at LANL in accordance with RCRA and its Hazardous and Solid Waste Amendments (HSWA) has been transferred from the LANL's RCRA Permit to a Compliance Order on Consent (Consent Order), signed on March 1, 2005 (NMED 2005). The Consent Order is a comprehensive agreement that documents the investigation and remediation steps necessary to complete RCRA- and HSWA-driven environmental restoration activities at LANL by the year 2015. However, the Consent Order does not cover more than 500 sites that received no further action decisions from the EPA when it had primary authority, preventing duplication of completed work. The Consent Order also does not address releases of radionuclides, which are under the regulatory authority of DOE. Nonetheless, 125 non-HSWA module sites previously approved by DOE for no further action will be re-evaluated by NMED under the terms of the Consent Order. Notwithstanding the Order, LANL's environmental restoration activities and associated impacts have remained within the scope of the *1999 SWEIS* and the ROD projections.