Chapter 4
Affected Environment

CHAPTER 4
AFFECTED ENVIRONMENT

This chapter describes the environments that may be affected by the Proposed Action, whether the DARHT Baseline Alternative, No Action Alternative, or another analyzed alternative is chosen by DOE for implementation.

The Los Alamos National Laboratory (LANL) is located in north-central New Mexico in Los Alamos and Santa Fe counties. Most of LANL and the surrounding community development is situated on mesa tops. The areas that may be affected by the Proposed Action include land use, air quality and noise, water resources, geology and soils, biotic resources, cultural and paleontological resources, socioeconomic environment, and radiological and hazardous chemical environment. The scope of the affected environment differs from discipline to discipline, and the approach in this chapter is to describe the portion of the geographic area that is relevant to each resource type. Sufficient detail is presented for assessing the consequences of the analyzed alternatives for each area of the affected environment. The discussion in this chapter is augmented by the classified supplement for this EIS.

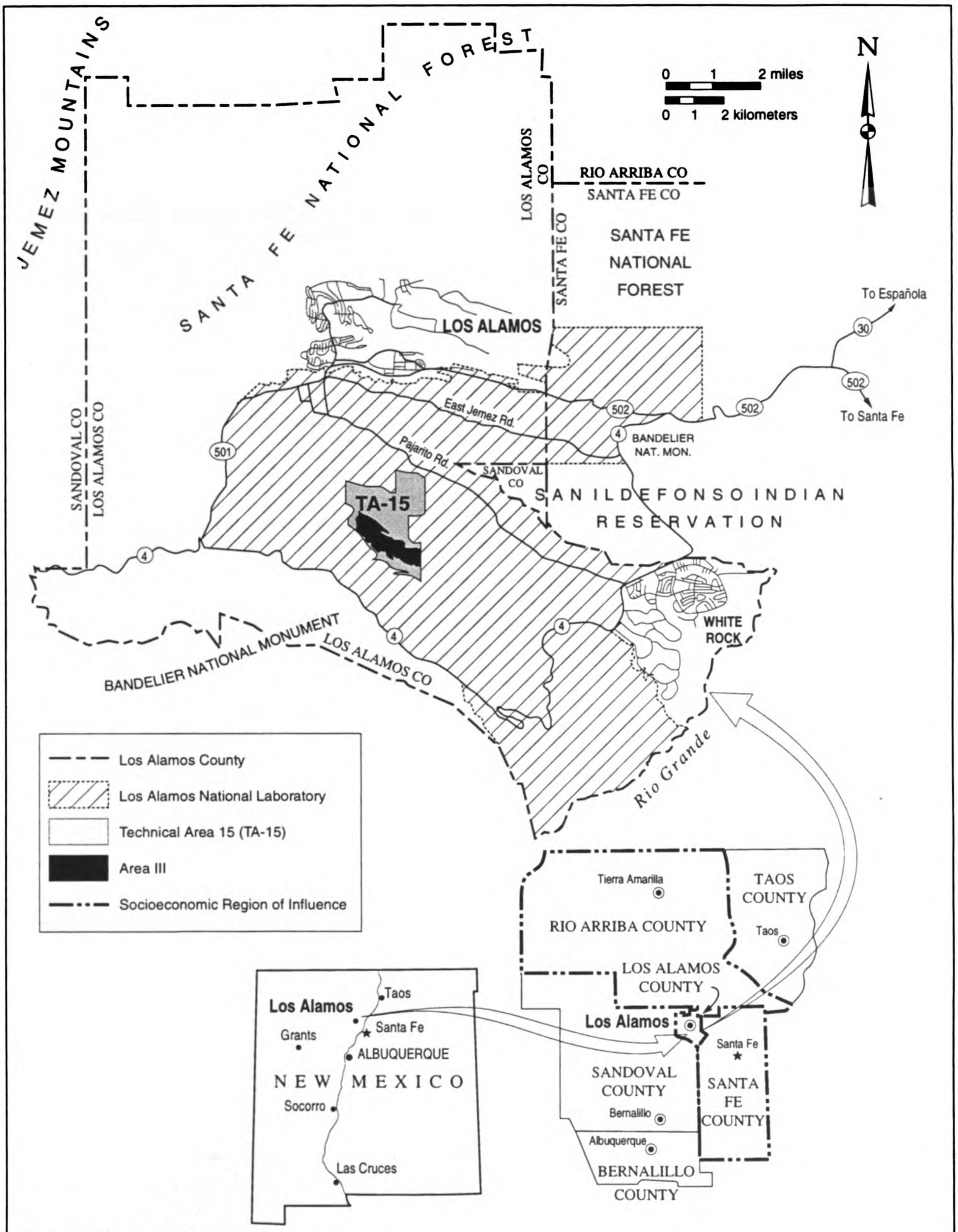
The PHERMEX site and the DARHT site, which are about 2,000 ft (600 m) apart, essentially constitute a single site for many of the environmental impact analyses. For the impact analyses, the combined sites are considered to be Area III (shown in figure 3-2) in Technical Area 15 (TA-15), as defined by LANL for safety, security, and control of the firing sites at PHERMEX and the DARHT Facility. In order to maintain clarity, the following terminology conventions are used in this chapter:

- "Site" refers to Area III containing both the PHERMEX and DARHT facilities.
- "PHERMEX site" or "DARHT site" refers to the area at, and immediately around, each respective facility.

This chapter describes the affected environment using information drawn from existing data on the specific technical areas (TAs), facilities and projects conducted in these areas, and LANL environmental protection/monitoring programs supporting compliance objectives. The data used to characterize the affected environment, while not all from the same calendar year(s), are the most recent and relevant published data available. These data are presented as representative of the conditions of the affected environment.

4.1 LAND RESOURCES

The study area for Land Resources is limited to Los Alamos National Laboratory (LANL) and its adjacent lands. LANL is located in north-central New Mexico, 60 mi (97 km) north-northeast of Albuquerque, 25 mi (40 km) northwest of Santa Fe, and 20 mi (32 km) southwest of Española in Los Alamos and Santa Fe counties. The associated communities of Los Alamos and White Rock are in Los Alamos County. Figure 4-1 shows the geographical location of LANL. The 28,000-ac (11,300-ha) LANL site and adjacent



Source: Adapted from Dunham 1995

FIGURE 4-1.—*The Regional Location of LANL Showing the Geographical Relationship to Adjacent Communities and the State of New Mexico.*

communities are situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep canyons that run from the Jemez Mountains on the west toward the Rio Grande Valley on the east. Mesa tops range in elevation from approximately 7,800 ft (2,400 m) on the west to about 6,200 ft (1,900 m) on the east (LANL 1994a). The developed acreage of LANL consists of 30 active Technical Areas (TAs) (see figure 3-1).

4.1.1 Land Use

Most developments within Los Alamos County are confined to mesa tops. The surrounding land is largely undeveloped with large tracts north, west, and south of the LANL site administered by the U.S. Forest Service (Santa Fe National Forest) the National Park Service (Bandelier National Monument), and Los Alamos County (figure 4-2). The San Ildefonso Pueblo borders the LANL site to the east (LANL 1994a).

Area III [approximately 1,400 ac (567 ha)] is located within TA-15 on Threemile Mesa, with Cañon de Valle to the southwest, Potrillo Canyon to the northeast, and Water Canyon to the south. The topography in the vicinity is varied, ranging from steep, precipitous canyon walls to gently sloping mesa tops. The elevation of Threemile Mesa ranges from 7,100 to 7,300 ft (2,165 to 2,225 m). The Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility and the Radiographic Support Laboratory (RSL) lie within Area III (as shown in figure 3-2). Eight ac (3 ha) of land at Area III have been disturbed for DARHT construction (Chastain 1995).

PHERMEX has a 4,100-ft (1,250-m) radius exclusion zone available, but typically a 2,460-ft (750-m) radius zone is used (shown in figure 4-3). The areas of these zones are 1,212 and 436 ac (490 and 176 ha), respectively. These exclusion zones are the areas surrounding the firing point that are cleared of all personnel for a test shot; they are concentric and are partially shared with exclusion areas for other test shot facilities. Facilities and development in this exclusion zone are limited to those needed in direct support of the firing site or which have use restrictions to ensure compatibility in the firing site. The *LANL Site Development Plan* (LANL 1994) defines a larger area, about 20 mi^2 (50 km^2), as the High Explosives Research and Development and Testing area; it separates explosives activity from noncompatible uses.

The major public roads that are used at LANL include State Road 501, State Road 4, and Pajarito Road. State Roads 501 and 4 are the closest to TA-15 (figure 4-1). Threemile Mesa is limited to Federal use, with no plans to release any portion of this mesa for public use.

4.1.2 Visual Resources

The topography of LANL affords spectacular views of the surrounding landscape of forested mountains, deep canyons, and the Rio Grande Valley. The mountain scenery, unusual geology, varied plant communities, and archeological heritage create a diverse visual environment. The scenery contrasts greatly with the functional industrial facilities of LANL. A majority of LANL's parking lots, security gates, and service and storage yards are highly visible to employees and visitors using public roads (LANL 1990). Most structures are cinderblock, frame, or metal, painted various shades of tan. Many of these buildings were constructed in the 1940s, 1950s, and 1960s.

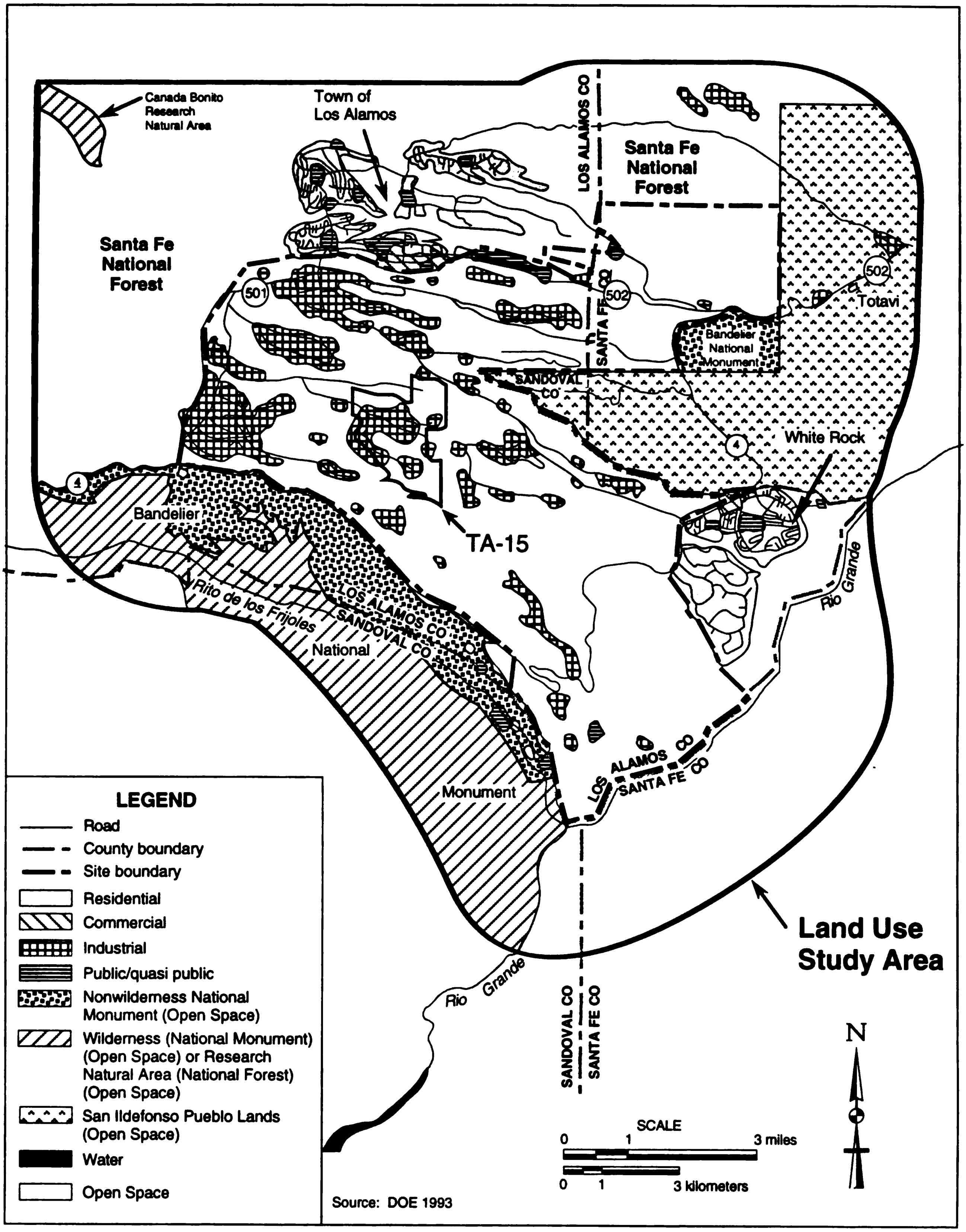


FIGURE 4-2.—*Generalized Land Use at LANL and Vicinity.*

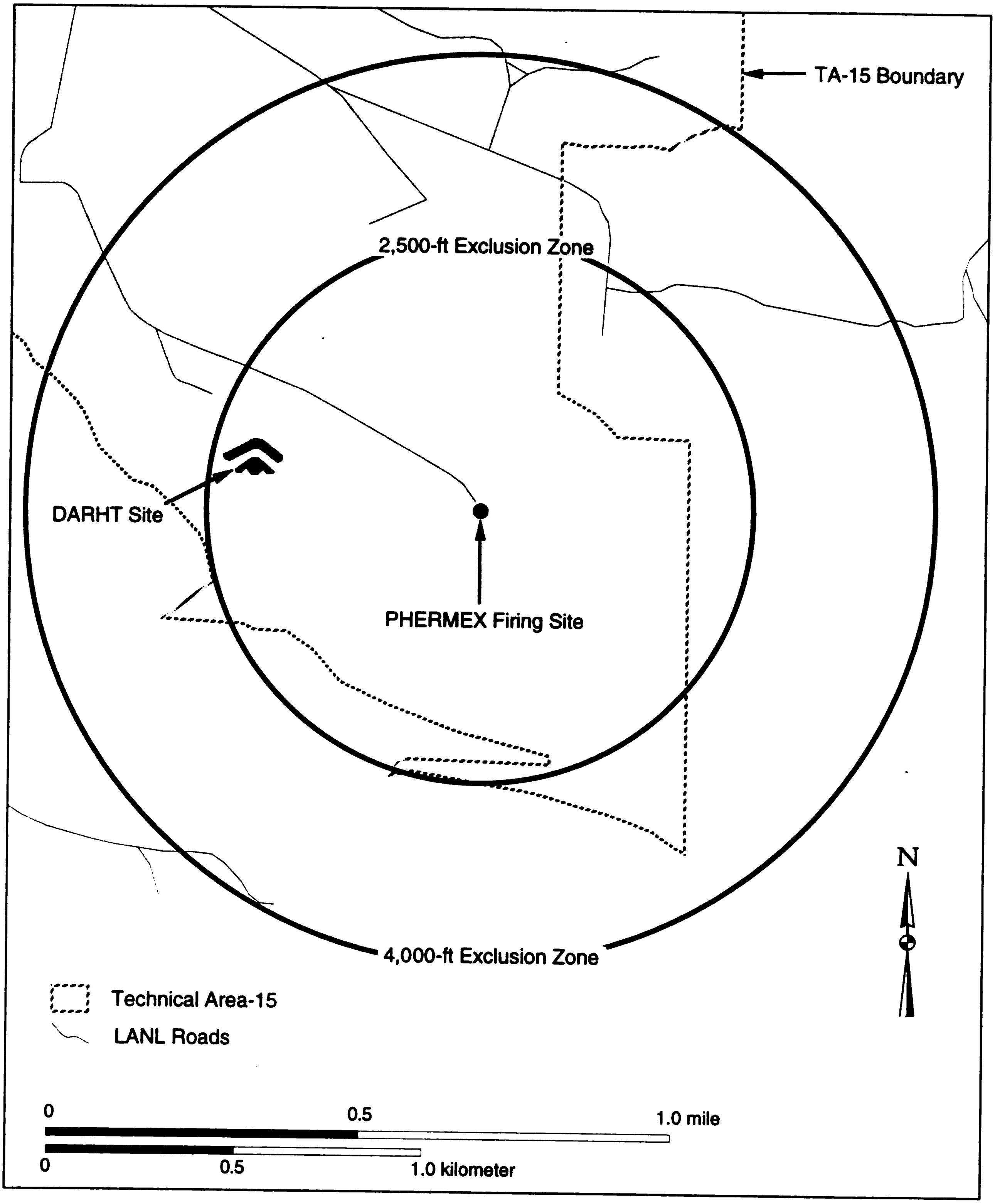


FIGURE 4-3.—*Exclusion Zones [2,500 ft (760 m) and 4,000 ft (1,200 m)] Surrounding the PHERMEX Firing Site.*

Area III, which is not visible from public roads, contains the same visual resources as LANL. However, at Area III, the facilities are widely separated, so that vistas include canyons, mesas, and forests with occasional buildings. Immediately following a large test at Area III, the smoke plume may be briefly visible offsite.

4.1.3 Regional Recreation

The public is allowed limited access to certain areas of LANL. An area north of Ancho Canyon between the Rio Grande and State Road 4 is open to the public for selected recreation activities such as hunting and hiking. Vehicles and certain activities, such as woodcutting, are prohibited. Portions of Mortandad and Pueblo Canyons are also open to the public. TA-15, including Area III, is restricted to the public, except for specially permitted activities. An archeological site (the Otowi tract), northwest of State Road 502 near White Rock, is open to the public, subject to restrictions imposed by regulations that protect cultural resources (LANL 1993a).

Although they are not on the LANL site, other recreational areas are nearby. Located immediately south of LANL (figure 4-2), Bandelier National Monument is a popular public attraction. Natural beauty, Indian ruins, abundant wildlife, and historic structures are present. It has 65 mi (105 km) of maintained hiking trails that range from easy to strenuous (Los Alamos County Chamber of Commerce 1995). Another portion of Bandelier National Monument, located north of White Rock and south of State Road 502, is open to the public. The Jemez Mountains rise above Los Alamos to the west and offer a vast array of scenic attractions. This mountainous terrain in the Santa Fe National Forest offers the public opportunities for fishing, hunting, skiing, hiking, swimming, camping, and horseback riding.

4.2 AIR QUALITY AND NOISE

The study area for this section includes LANL and the surrounding areas where affected air may move or where noise may be perceived. This section describes the climate, air quality, noise, and air monitoring at LANL and TA-15. LANL quantifies and assesses the radiologic and nonradiologic air emissions to determine compliance with the Federal standards set by the U.S. Environmental Protection Agency (EPA) and State standards set by the New Mexico Environmental Improvement Board. All of the areas within LANL and its surrounding counties are designated as attainment areas with respect to the National Ambient Air Quality Standards (NAAQS). These standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health (primary standards) and the public welfare (secondary standards).

4.2.1 Meteorology and Climatology

Los Alamos has a semiarid, temperate mountain climate. The climate averages for atmospheric variables such as temperature, pressure, moisture, and precipitation are based on observations made at the official LANL weather station at TA-59 from 1961 through 1990. The meteorological conditions described here are representative of conditions on the Pajarito Plateau at an elevation of approximately 7,200 ft (2,190 m) above sea level (LANL 1994a). The TA-59 weather station is approximately 2 mi (3 km) north of TA-15 and is considered representative of the weather conditions at TA-15.

In July, the average daily high temperature is 81 °F (27 °C), and the average nighttime low temperature is 55 °F (13 °C). The average January daily high is 40 °F (4 °C), and the average nighttime low is 17 °F (-8 °C). The highest recorded temperature is 95 °F (35 °C), and the lowest recorded temperature is -18 °F (-28 °C). The large daily range in temperature of approximately 23 °F (13 °C) results from the site's relatively high elevation and dry, clear atmosphere, which allows high insolation during the day and rapid radiative losses at night (LANL 1994a).

The average annual precipitation is 18.7 in (48 cm) but is quite variable from year to year. The lowest recorded annual precipitation is 6.8 in (17 cm), and the highest is 30.3 in (77 cm). The maximum precipitation recorded for a 24-hour period is 3.5 in (9 cm). Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. White Rock often receives about 5 in (13 cm) less annual precipitation than the official weather station at TA-59, and the eastern flanks of the Jemez Mountains often receive about 5 in (13 cm) more (Bowen 1992).

Approximately 36 percent of the annual precipitation normally occurs from thundershowers during July and August. Winter precipitation falls primarily as snow, with accumulations of about 59 in (150 cm) seasonally (LANL 1993a). The highest recorded snowfall for one season is 153 in (389 cm), and the highest recorded snowfall for a 24-hour period is 22 in (56 cm). In a typical winter season, snowfall equal to or exceeding 1 in (2.5 cm) will occur on 14 days, and snowfall equal to or exceeding 4 in (10 cm) will occur on 4 days. The snow is generally dry; on the average, 20 units of snow at LANL are equivalent to 1 unit of water (LANL 1994a).

Los Alamos winds are generally light, averaging 6.3 mi/h (10 km/h). Strong winds are most frequent during the spring when peak gusts during this season often exceed 50 mi/h (80 km/h). The highest recorded wind gust is 77 mi/h (124 km/h). The semiarid climate promotes strong surface heating by day and strong radiative cooling by night. Because the terrain is complex, heating and cooling rates are uneven over the LANL area, which results in local thermally generated winds. The distributions of wind direction and wind speed for the four measurement stations (located at TA-6, TA-49, TA-53, and TA-54) on the plateau are shown in figures 4-4 and 4-5 (LANL 1994a). The wind roses presented in these figures provide general information of the daytime and nighttime wind conditions surrounding TA-15.

During sunny, light-wind days, an upslope air flow often develops over the plateau in the morning hours. This flow is more pronounced along the western edge of the plateau, where the flow is 650 to 1,650 ft (200 to 500 m) deep. By noon, southerly flow usually prevails over the entire plateau.

At measurement sites closer to the eastern edge of the plateau, wind roses show a weak secondary peak in the daytime wind direction in the northeast sector. These northeasterlies also show up in the wind roses for observations made at 300 ft (92 m) and 1,670 ft (510 m) above the ground. They are thought to result from cold air drainage down the Rio Grande Valley that persists into the early morning hours (LANL 1994a).

The prevailing nighttime flow along the western edge of the plateau is west-southwesterly to northwesterly. These nighttime westerlies result from cold air drainage off the Jemez Mountains and the Pajarito Plateau; the drainage layer is typically 165 ft (50 m) deep in the vicinity of TA-3. At sites farther from the mountains, the nighttime direction is more variable but usually has a relatively strong westerly component. Just above the drainage layer, the prevailing nighttime flow is southwesterly, with minor

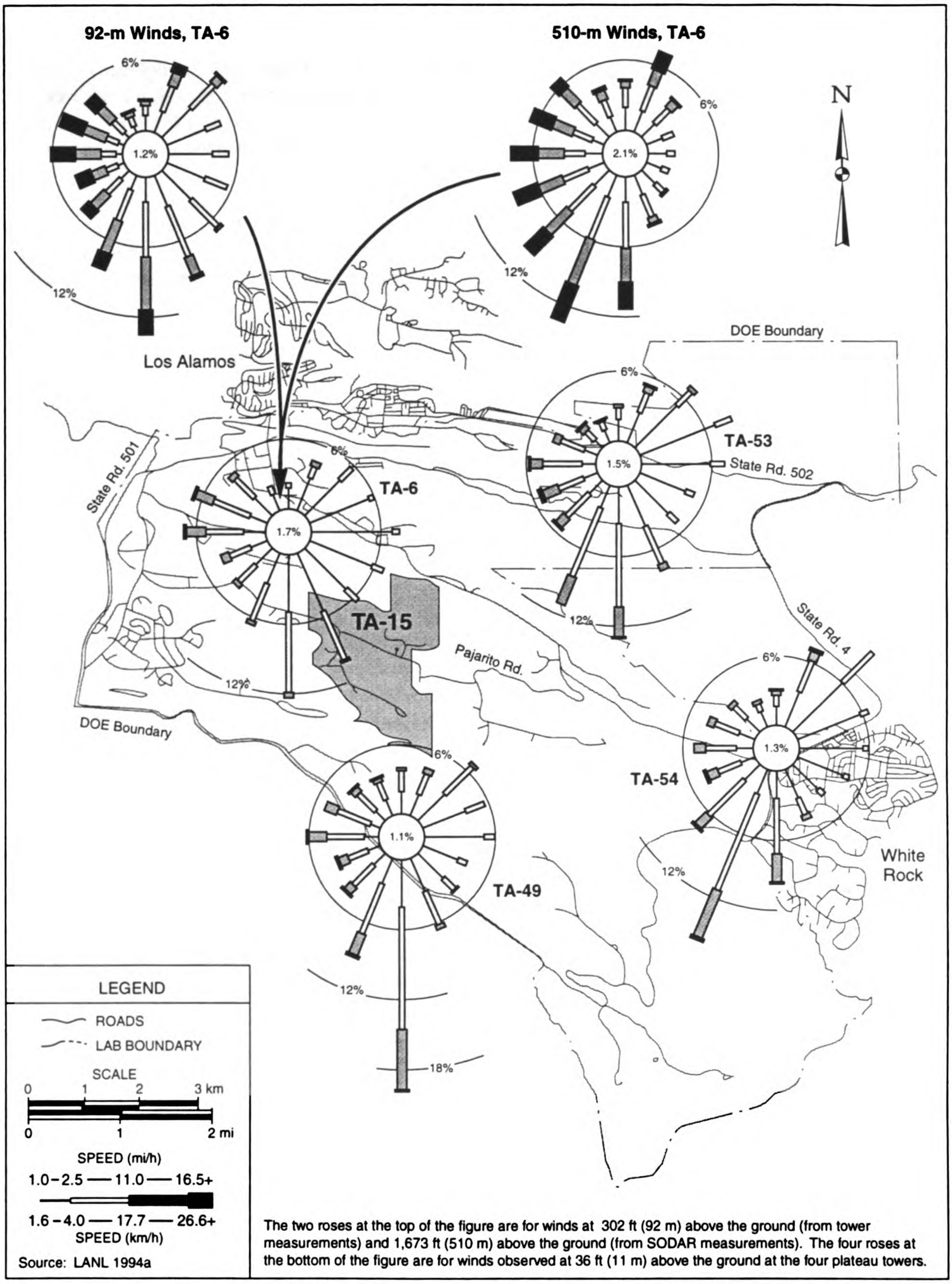
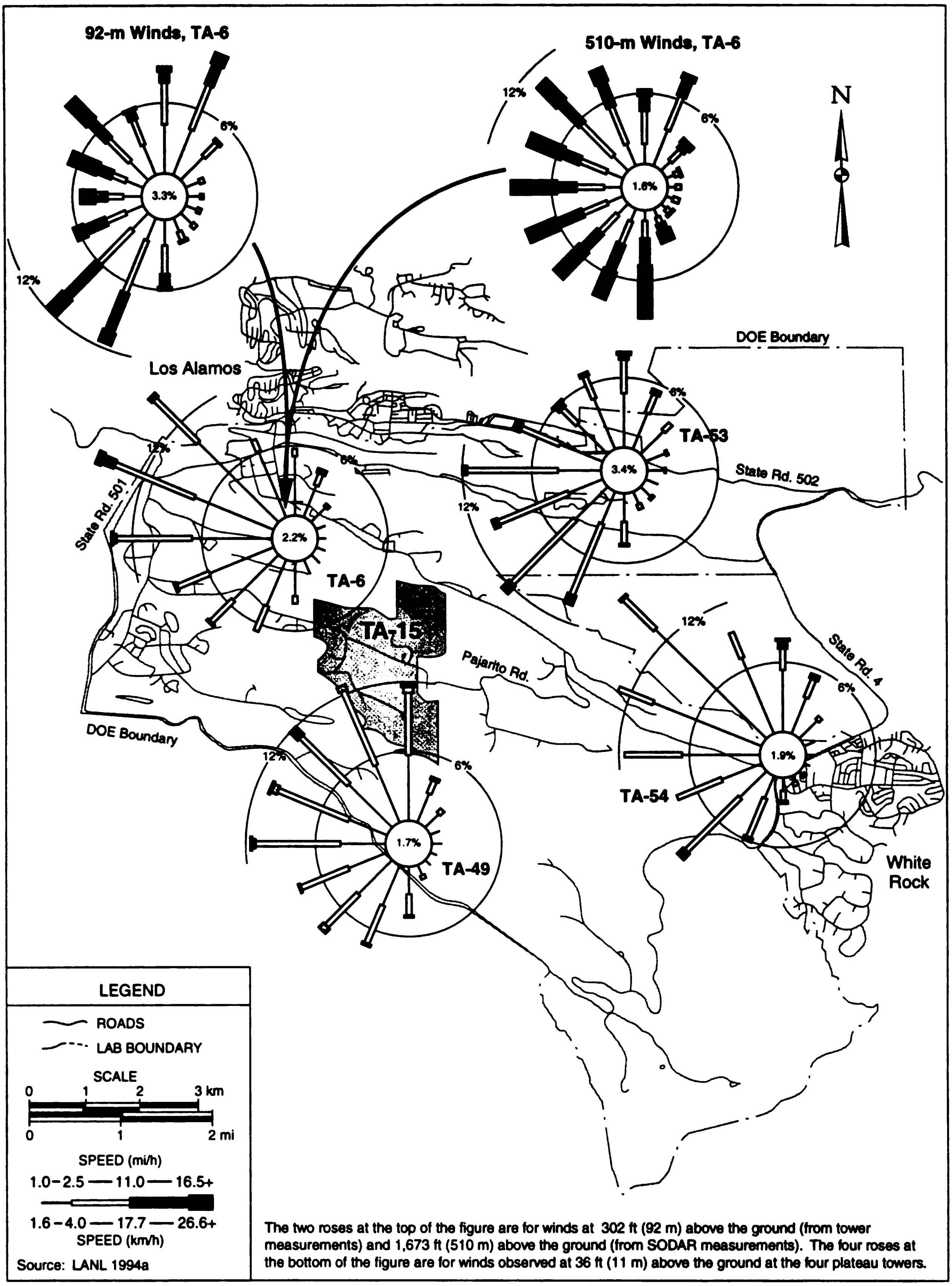


FIGURE 4-4.—*Wind Roses at LANL Monitoring Sites for Daytime Winds in 1992.*



The two roses at the top of the figure are for winds at 302 ft (92 m) above the ground (from tower measurements) and 1,673 ft (510 m) above the ground (from SODAR measurements). The four roses at the bottom of the figure are for winds observed at 36 ft (11 m) above the ground at the four plateau towers.

FIGURE 4-5.—*Wind Roses at LANL Monitoring Sites for Nighttime Winds in 1992.*

peaks in the distribution around northwest and northeast. At 1,673 ft (510 m) above the ground, the wind direction distribution exhibits a broad, flat peak covering the whole western half of the compass (LANL 1994a).

Atmospheric flow in the canyons is quite different than over the plateau. Data collected from Los Alamos Canyon suggest that at night a cold air drainage fills the lower portion of the canyon more than 75 percent of the time. The flow is steady and continues for about an hour after sunrise when it ceases abruptly and is followed by an unsteady up-canyon flow for a couple of hours. Down-canyon flow begins again around sunset, but the onset time appears to be more variable than cessation time in the morning (LANL 1994a).

4.2.2 Severe Weather

Thunderstorms are common at LANL, with 61 occurring in an average year. A thunderstorm day is defined as a day in which either a thunderstorm occurs or thunder is heard nearby. Most thunderstorm days occur during July and August, the so-called monsoon season. During this time of year, large-scale southerly and southeasterly winds bring moist air into New Mexico from the Gulf of Mexico and the Pacific Ocean. The combination of moist air, strong sunshine, and warm surface temperatures encourages the formation of afternoon and evening thundershowers, especially over the Jemez Mountains. Upper air winds often move the thunderstorms over TA-15. The resultant drainage patterns are discussed in section 4.4.1. No tornadoes have been reported to have touched down in Los Alamos County.

Lightning in LANL can be frequent and intense during some thunderstorms. Because lightning can cause occasional brief power outages, lightning protection is an important design factor for most facilities at LANL and the surrounding area. Lightning protection is used at PHERMEX and has been designed into the alternatives.

Hail is also very common at LANL. In fact, the area around Los Alamos has the most frequent hailstorms in New Mexico. Typically, the hailstones have diameters of about 0.25 in. (0.6 cm), with a few somewhat larger. Some storms produce measurable accumulation on the ground. Rarely, hailstorms cause significant damage to property and plants. Very little hail damage is expected on hydrodynamic testing operations.

Large-scale flooding is not common in New Mexico. However, flash floods from heavy thunderstorms are possible in susceptible areas, such as arroyos, canyons, and low spots. Severe flooding has never been observed in Los Alamos, but heavy downpour combined with already saturated soil caused flash flooding in Los Alamos on August 4, 1991. Flooding washed out sewer lines in Pueblo Canyon, with extensive flooding of streets and basements. This type of flooding is possible at TA-15 and could serve as a mechanism to transport contaminants.

Flooding is possible in the spring from snowmelt, although snowmelt flooding is usually confined to the larger rivers in the state. However, snowmelt can cause muddy conditions in the LANL area, along with minor flooding of streams in the Jemez Mountains (Bowen 1992). Flooding from snowmelt is not expected to impact TA-15.

4.2.3 Atmospheric Dispersion

The irregular and complex terrain at LANL affects the atmospheric dispersion. The terrain and forests create an aerodynamically rough surface, forcing increased horizontal and vertical turbulence and dispersion. The dispersion generally decreases at lower elevations where the terrain becomes smoother and less vegetated, and canyons also limit dispersion by channeling air flow. The frequent clear skies and light winds cause good daytime vertical dispersion, especially during the warm season.

Clear skies and light winds have a negative effect on dispersion at night, creating strong, shallow surface inversions. The inversions are especially strong during the winter. Overall dispersion is greater in the spring during strong winds. However, vertical dispersion is the greatest during summer afternoons (Bowen 1992).

4.2.4 Air Quality

The criteria pollutants – nitrogen dioxide (NO_2), carbon monoxide (CO), hydrocarbons, particulate matter, and sulfur dioxide (SO_2) – make up approximately 79 percent of the stationary source emissions at LANL. The source of these criteria pollutants is combustion in power plants, steam plants, asphalt plants, and local space heaters. Toxic and other hazardous pollutants represent the remaining 21 percent of emissions from stationary sources at LANL. These emissions are generated by equipment surface cleaning, coating processes, and acid baths, and include gases, vapors, metal dust, and miscellaneous emissions such as wood dust, hazardous gases, and plastics (LANL 1994a).

Table 4-1 shows the results of two studies that estimated emissions of nonradioactive chemicals. The 1987 emissions inventories were designed to collect information on emissions of these chemicals for the state's toxic air pollutant registration regulation. The 1990 inventory expanded the list of chemicals and sources and was designed to give LANL an estimate of its overall emissions. Data from the 1987 and 1990 inventories represent the only available listings of chemical emissions for LANL. The main difference between the two inventories is that the 1990 estimates included the emissions from the boilers, which accounts for the large emissions of nitrogen dioxide, carbon monoxide, and particulate matter. The amount and type of nonradioactive chemical emissions will also change from year to year as experiments change (LANL 1994a).

Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made during LANL's air sampling program. Worldwide background airborne radioactivity is largely composed of fallout from past atmospheric nuclear weapons tests, natural radioactive constituents from the decay of thorium and uranium attached to dust particles, and materials resulting from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Levels of background radioactivity in the atmosphere are summarized in table 4-2. Note that the measurements taken in Santa Fe on the roof of the Public Employment Retirement Association Building by the EPA are similar to those taken by LANL as regional background values (LANL 1994a).

The annual air emissions reports for CY 1992 (DOE 1993b) and CY 1993 (DOE 1994) have estimated the radiological dose assessment from nonpoint sources, as defined by the Clean Air Act, such as the experiments conducted at TA-15. In 1992, the contribution from TA-15 operations to the Effective Dose Equivalent from all LANL operations for the maximally exposed individual [located approximately

TABLE 4-1.—*Summary of Total LANL Estimated Emissions of Nonradioactive Air Pollutants[a] in 1987 and 1990[b] that may be Associated with Area III at TA-15[c]*

Pollutant	1987 Emissions (lb/yr)[d]	1990 Emissions (lb/yr)	Pollutant	1987 Emissions (lb/yr)	1990 Emissions (lb/yr)
Nitrogen dioxide	—[e]	118,772	Hydrogen fluoride as Fluorine	6	534
Nonmethane hydrocarbons	10,872	6,377	Trichlorethylene	1,229	463
Particulate Matter	—	5,629	Aluminum welding fumes	—	271
Ammonia	3,816	1,761	Heavy metals	—	251
Nitric acid	1,674	1,457	Tungsten (insoluble)	—	241
Hydrogen chloride	1,832	1,407	Ethylene glycol	50	159
Methyl alcohol	4,437	1,298	Nickel metal	—	122
Isopropyl alcohol	829	1,188	Aluminum (metal and oxide)	5	89
Acetic acid	96	1,184	Softwood	525	88
Welding fumes (not otherwise listed)	253	1,127	Mineral oil mist	13	76
Wood dust (certain hard woods)	—	1,003	Cyclohexane	9	62
Nitrogen oxide	1,049	944	Lead	—	57
Stoddard solvent	941	583	Hydrogen peroxide	17	43
Kerosene	15,265	574	Chlorine	29	29

[a] Only pollutants with 1990 emissions of 25 lb/yr or more are reported here.
[b] Data for these two years are not adjusted for changes in LANL activities. Only those materials likely to be used at a hydrodynamic testing facility are listed here.
[c] This table represents pollutants associated with Area III operations. Emissions stated in this table are for the entire LANL Site. For a complete listing of LANL emissions see the 1992 LANL Environmental Surveillance Report.
[d] Conversion factor: 1 lb/yr = 0.454 kg/yr.
[e] Data not collected for these pollutants.

Source: Adapted from LANL 1994a

2,600 ft (800 m) north-northeast of the Los Alamos Meson Physics Facility stack in TA-53] was 9×10^{-6} rem of the total of 7.9×10^{-3} rem (DOE 1993b). In 1993, the estimated dose from TA-15 operations was 6.6×10^{-5} rem (DOE 1994), which was higher for TA-15 but still very small. These values are less than 1 percent of the total annual LANL dose to the public.

Particulate radionuclide matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent on current meteorological conditions and human disturbance. Windy, dry days can increase the soil resuspension, whereas precipitation (rain or snow) can wash particulate matter out of the air. Consequently, there are often large daily and seasonal fluctuations in airborne radioactivity concentrations caused by changing meteorological conditions.

Construction of the DARHT Facility, which is 34 percent complete, affected the air quality of the immediate area. Dust and auto emissions increased during the period of construction because of the increase in vehicles and construction machinery in the area.

TABLE 4-2.—*Average Background Concentrations of Radioactivity in the Regional Atmosphere*

Radioactive Constituent	Units	Santa Fe 1988-1991	New Mexico[a] 1992	DOE Guideline 5400.5 for Uncontrolled Area
Tritium	10^{-12} µCi/mL	—	0.3 (0.8)[b]	200,000
Uranium (natural)	pg/m³	58.2 (19.5)	92.0 (15.0)	100,000
Uranium-234	10^{-18} µCi/mL	22.5 (7.5)	30.6 (9.0)	90,000
Uranium-235	10^{-18} µCi/mL	0.8 (0.4)	2.6 (0.7)	100,000
Uranium-238	10^{-18} µCi/mL	22.5 (7.5)	28.8 (8.0)	100,000
Plutonium-238	10^{-18} µCi/mL	0.3 (0.2)	0.6 (3.8)	30,000
Plutonium-239, 240	10^{-18} µCi/mL	0.2 (0.1)	1.5 (2.2)	20,000
Americium-241	10^{-18} µCi/mL	—	1.3 (4.1)	20,000

[a] Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken by LANL during 1992.
[b] Uncertainties (± 2σ) are in parentheses.

Source: LANL 1994a

4.2.5 Air Monitoring

The visibility at and near LANL has been monitored since 1988 at the Bandelier National Monument southwest of LANL off of State Road 4 (see figure 4-1). Visibility monitoring quantifies how well the visible information (i.e., images) is transmitted through the atmosphere to an observer some distance away.

The data are measured according to the Standard Visual Range (SVR), which can be interpreted as the farthest distance that a large black feature can be seen on the horizon. From summer 1993 to spring 1994, the SVR was measured during a four-hour average variation in visual air quality (excluding weather-affected data) at Bandelier National Monument. The SVR ranged from approximately 48 to 103 mi (77 to 166 km). This is a typical visibility range for the area according to data collected since 1988 (Air Resource Specialists 1994).

LANL operates or accesses a network of nonradiological ambient air monitors to routinely measure criteria pollutants, beryllium, acid precipitation, and visibility (see table 4-3). The nonradiological monitoring network consists of a variety of monitoring stations: 1 onsite criteria pollutant monitoring station, 17 beryllium monitors, 1 perimeter acid rain monitor, and 1 perimeter visibility monitoring station (LANL 1994a). Beginning in FY 1995, no measurements of the criteria pollutants are being made by LANL on a continuing basis because past observed values were low relative to standards. Measurements are made on an as-needed basis for activities with potential for pollution (Jardine 1995).

The 1992 sampling network for ambient airborne radioactivity consists of 55 continuously operating air sampling stations, including 17 offsite locations (3 regional and 14 perimeter), 14 onsite stations, and 5 onsite waste site stations. One station at TA-18 is inactive. The regional monitoring stations, 18 to 28 mi (29 to 45 km) from LANL, are located in Española, Pojoaque, and Santa Fe (figure 4-6). The data

TABLE 4-3.—*Nonradiological Ambient Air Monitoring Results in the LANL Region for 1992*

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards		Measured Concentration
				Primary	Secondary	
Sulfur dioxide[a]	Annual arithmetic mean	ppm	0.02	0.03		0.0005
	24 hours	ppm	0.10	0.14		
	3 hours	ppm			0.05	
	1 hour	ppm				0.009
Total suspended particulate matter	Annual Geometric Mean	$\mu g/m^3$	60			
	30 days	$\mu g/m^3$	90			
	7 days	$\mu g/m^3$	110			
	24 hours[c]	$\mu g/m^3$	150			
PM_{10}[a]	Annual arithmetic mean	$\mu g/m^3$		50	50	8
	24 hours	$\mu g/m^3$		150	150	21
Ozone[a]	1 hour	ppm	0.06	0.12	0.12	0.076
Nitrogen dioxide[a]	Annual arithmetic mean	ppm	0.05	0.053	0.053	0.002
	24 hours	ppm	0.10			
	1 hour	ppm				0.02
Lead	Calendar quarter	$\mu g/m^3$		1.5	1.5	
Beryllium[b]	30 day	$\mu g/m^3$	10			0.02
Heavy Metals	30 days	$\mu g/m^3$	10			

[a] Measurements made at Bandelier Monitoring Compound.
[b] Measurement made at TA-52.
[c] Maximum concentration, not to exceed more than once per year.

Source: LANL 1994a

from these stations are used as reference points for determining regional background levels of atmospheric radioactivity. Ambient air is routinely sampled for beryllium, tritium, isotopic plutonium and uranium, americium, iodine, gross alpha, beta, and gamma activity. Table 4-4 presents 1992 radionuclide releases from LANL operations (LANL 1994a).

Later in 1993, three air monitoring stations (76, 77, and 78 in figure 4-6) were added downwind of the firing site for PHERMEX and DARHT. The monitoring stations are about 320 to 3,300 ft (100 to 1,000 m) northeast of the firing site. Samples collected at these stations are analyzed for isotopic uranium, isotopic plutonium, gross alpha, beta, gamma, and beryllium (Jacobson 1995).

4.2.6 Noise

Noise measurements have been made in the standard unit for measuring noise levels in the A-weighted decibel (dBA) scale. Two kinds of noise are emitted from TA-15 – peak (or impact), which is high-level and short-duration noise, and continuous, which is of moderate level and relatively lengthy duration.

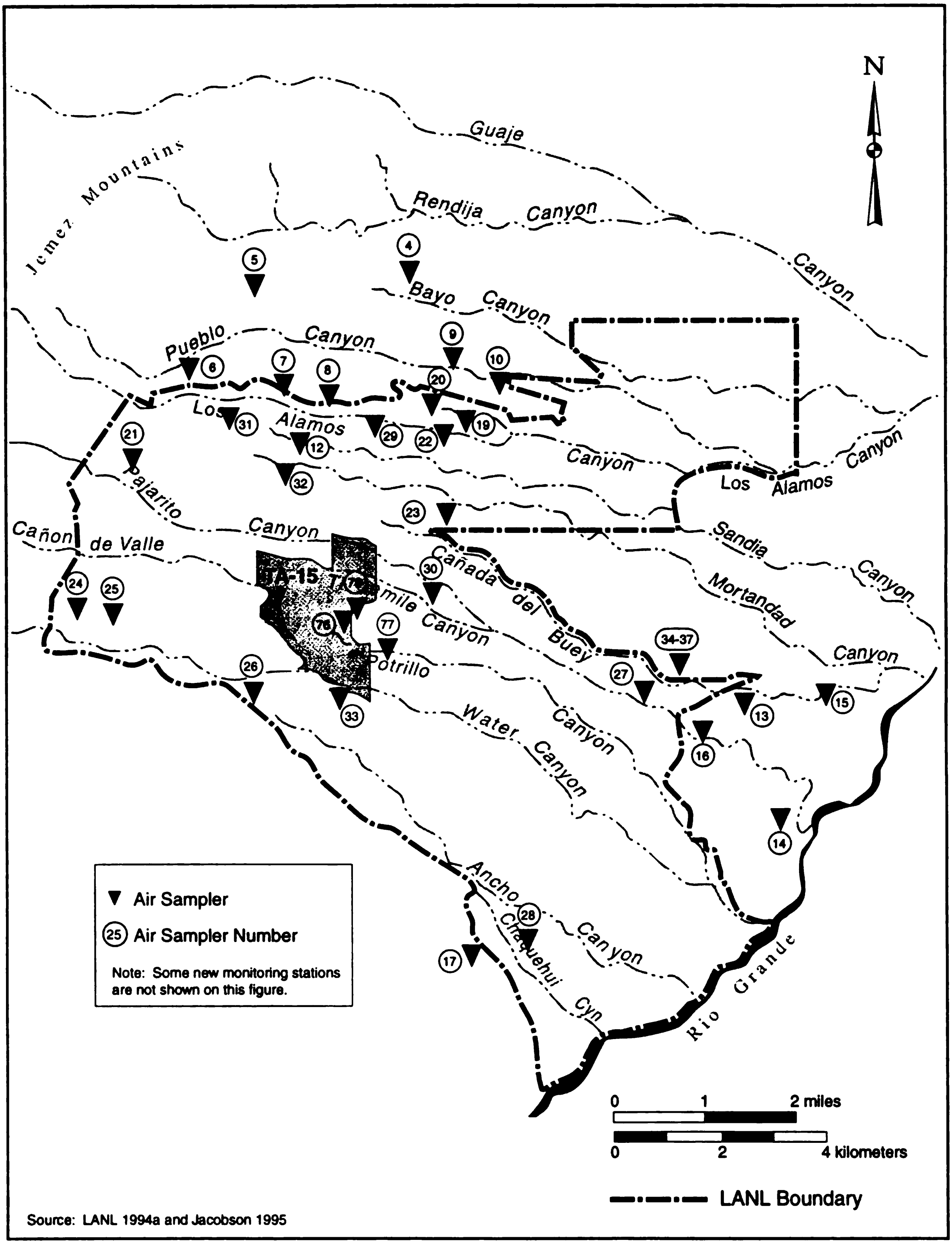


FIGURE 4-6.—*Approximate Locations for Offsite Perimeter and Onsite LANL Stations for Sampling Airborne Radionuclides in 1992 and TA-15 Stations added in Late 1993.*

TABLE 4-4.—*1992 Airborne Releases of Radionuclides from LANL Operations*

Radionuclide	Units	Activity Released 1992
Tritium	Ci	1,298
Phosphorus-32	µCi	9
Uranium	µCi	242[a]
Plutonium	µCi	12
Gaseous mixed activation products	Ci	71,950
Mixed fission products	µCi	275
Particulate/vapor activation products	Ci	0.73
Spallation products	Ci	< 0.1

[a] Does not include uncontained hydrodynamic testing. Reported releases are measured at 88 LANL discharge locations.

Source: LANL 1994a

Continuous noise at TA-15 results from background noise and from construction activities (such as the construction of DARHT which is currently halted). Background noise levels range from 31 to 35 dBA at the vicinity of the Bandelier National Monument entrance and State Road 4 (Vigil 1995). Background noise levels at White Rock range from 38 to 51 dBA (Burns 1995). The higher background noise levels at White Rock result from a greater amount of traffic. A sound level of 60 dBA is characteristic of normal conversation level.

The sources of peak noise are explosive experiments at PHERMEX and the surrounding TAs. Peak noise measurements of a test using 20 lb (9 kg) of trinitrotoluene (TNT) at TA-14 (northeast of TA-15) at a distance of 750 ft (230 m) from the source ranged from 140-148 dBA. Noise measurements on March 11, 1995, from 150 lb (70 kg) of TNT at PHERMEX showed levels of 71 dBA at State Highway 4 [closest public approach, 1.3 mi (2 km)], 60 dBA near the state highway entrance to Bandelier National Monument [nearby permanent residences, 2.6 mi (4.3 km)], and about 70 dBA in White Rock [a nearby residential community, 4 mi (6.4 km)]. These noise measurements were collected as the opportunity arose in connection with tests to measure airwaves and ground vibrations from simulated test shots. Currently, these are the only available data that relate to noise impacts from proposed operations at DARHT. More extensive data to account for varying atmospheric conditions would be useful, but the data obtained in the communities were consistent with expectations.

When recent construction was under way at the DARHT site, it included use of heavy equipment such as dozers, loaders, backhoes, and generators. While actual noise measurements were not made during the use of the heavy equipment, existing data are available to quantify the range of noise levels. The mean level of noise from these equipment types ranges from 81 to 85 dBA (Chastain 1995 and Wyle Labs 1981).

4.3 GEOLOGY AND SOILS

The geology of the affected environment includes consideration of two perspectives:

- The broad area that is the source of geologic phenomena (such as earthquakes) that could affect the proposed facility
- The immediate area where the hydrodynamic test facility would be located and might subsequently impact the environment.

This section of the EIS first describes the geologic setting of the broader area and then progresses toward the greater specificity of local geologic pressures and features of the Pajarito Plateau, where the site is located.

4.3.1 Geology

The broad geological area described here is in north-central New Mexico (see figure 4-1). The Pajarito Plateau lies between the Jemez Mountains on the west and the Rio Grande on the east (figure 4-7). Although Precambrian rocks more than a billion years in age are found in deep drill holes in the LANL region, the most important geologic events for understanding the environment occurred during the past 32 million years, particularly the last million years.

The primary controlling feature in the region is the Rio Grande rift that begins in northern Mexico, trends northward across central New Mexico, and ends in central Colorado. The rift owes its origins to tension along the crest of a broad, gentle crustal uplift some 32 million years ago. The rift now comprises a series of basins formed by faulting that dropped the basin rocks relative to the uplift, usually much more deeply on either the east or west margins. These basins are filled with sediments derived from highlands to the east and west as well as occasional lake deposits and lava flows. The rift basin in the Los Alamos and Santa Fe area is the Española Basin.

Faulting associated with the rifting provided conduits for volcanic activity such as the basaltic lavas that are interbedded with the basin-filling sediments. In addition, the deep faulting helped localize the expression of some major trends in volcanic activity. The volcanic vents in and near the Jemez Mountains lie at the intersection of a northeast trend of volcanic centers and the western edge of the Española Basin of the Rio Grande rift (Seager and Morgan 1979). Deposits from these Jemez Mountains vents buried the basin-filling sediments and the adjacent uplands over an area of more than 800 mi^2 (2,100 km^2).

The climactic eruptions occurred about 1.5 to 1.1 million years ago; during this time the Bandelier Tuff was laid down in a sequence of ash falls from individual eruptions in the series. Also, during these eruptions, the crater, Valles Caldera, formed by collapse when a great volume of magma was ejected along the ring-shaped fractures that now define the caldera structure.

The Rio Grande rift, along with its faulting and volcanism, is complicated in detail and is the subject of both extensive literature and ongoing research. This is evident in descriptive documents with extensive bibliographies that have been published by Turin and Rosenburg (1994), Wong et al. (1995), LANL (1993a), and Gardner and House (1987). The geologic summary provided here is generalized to the level of information needed for environmental assessment.

The major portion of LANL is underlain by the Tshirege member of the Bandelier Tuff, a sequence of ashfall strata dipping slightly to the south-southeast. Along the eastern portion of LANL, canyons have exposed underlying strata within the Bandelier Tuff and older, deeper formations.

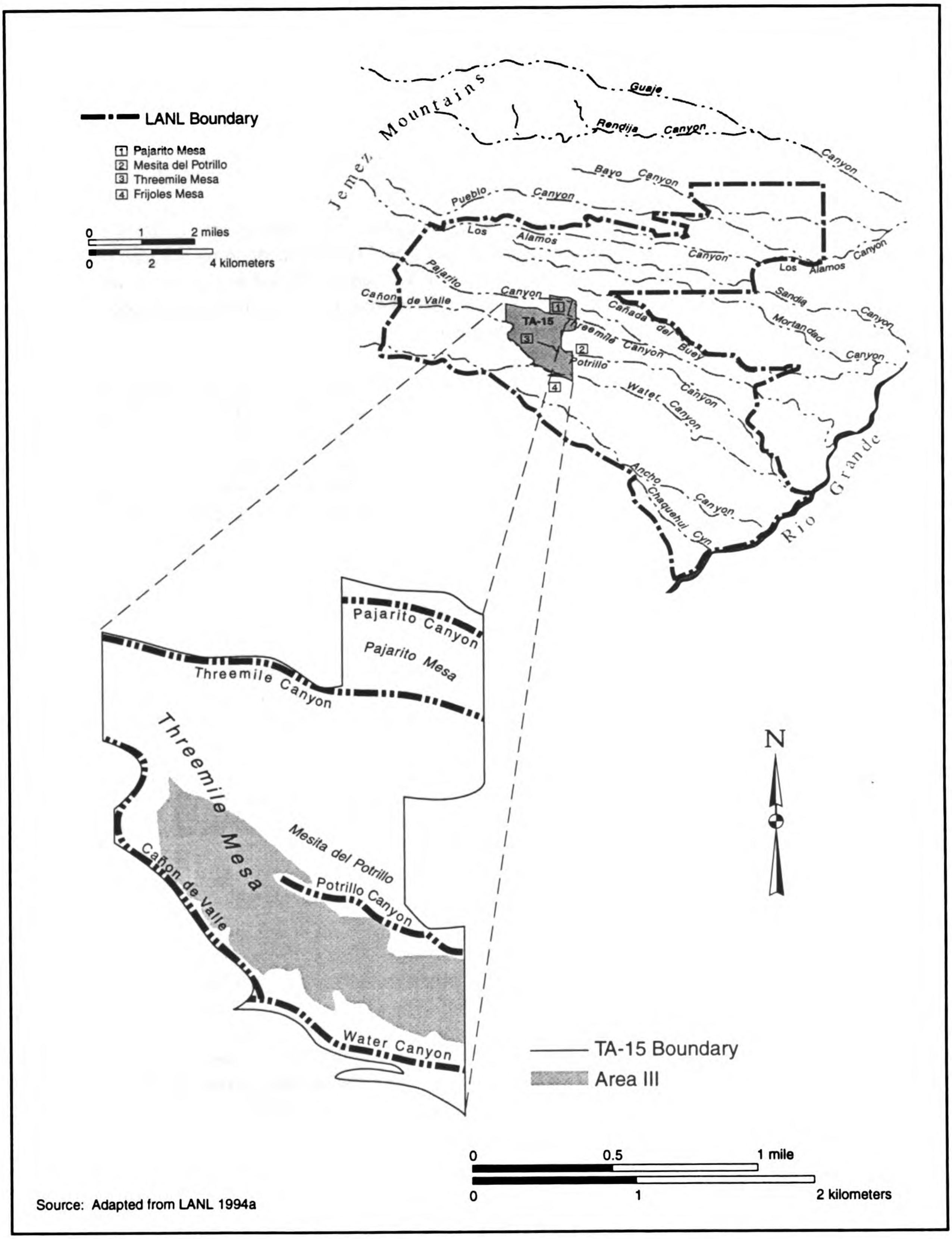


FIGURE 4-7.—*Mesas and Canyons on the LANL Site.*

4.3.2 Structure and Stratigraphy

Structure and stratigraphy are the key elements of the local geologic environment. The geologic structure at the site is dominated by three fault zones: the Pajarito, Rendija Canyon, and Guaje Mountain faults. These faults are clearly expressed by surface offsets at some locations and inferred from geologic evidence at others. Figure 4-8 shows the results of recent mapping of faults, including the young faulting that is significant to LANL in general and the proposed site in particular (Wong et al. 1995). The figure distinguishes between clearly observable faulting and photo lineaments that may indicate connections or extensions of the faults. Other geologic maps often show simpler and more continuous faults.

The Pajarito fault is thought to mark the currently active western boundary of the Española Basin (Wong et al. 1995). Prior to the Jemez Mountains volcanism, the basin boundary may have been farther west and under the present Valles Caldera. The Rendija Canyon and Guaje Mountain faults are shorter and secondary to the Pajarito fault. However, a recent investigation determined that all three faults are geologically young and are capable of producing future earthquakes (see table 4-5) (Wong et al. 1995).

TABLE 4-5.—*Major Faults at LANL*

Name	Approximate Length (mi)	Type[a]	Most Recent Movement	Maximum Earthquake[b] (Mw)
Pajarito	29	Normal, East Side Down	multiple in past 100,000 to 200,000 years	7
Rendija Canyon	6	Normal, West Side Down	8,000 to 9,000 years ago	6.5
Guaje Mountain	8	Normal, West Side Down	4,000 to 6,000 years ago	6.5

[a] Normal Fault: a steep to moderately steep fault for which the movement is downward for the rocks above the fault zone.
[b] Mw denotes the moment magnitude scale (Katsuyuki 1995), which is physically based and calibrated to the Richter local magnitude scale at the lower values.

Source: Wong et al. 1995

Earthquakes in the region are not always well correlated with faults that are expressed in the surface geology. Figure 4-8 shows the epicenters for reported earthquakes near LANL from 1873 through 1992 (Wong et al. 1995). A few of these epicenters are near the Pajarito and Rendija Canyon faults. However, the epicenter determinations necessarily have some uncertainties, and the true locations may be somewhat different. The important conclusion from both the geologic and seismic evidence is that faulting in the region is an ongoing process.

Figure 4-9 is a general cross section of the area from the east edge of the Jemez Mountains across the Pajarito Plateau to the Rio Grande (DOE 1979). This cross section shows the Pajarito fault, the Precambrian basement rocks, the basin-filling sediments, volcanic rocks of the Jemez Mountains, and the volcanic Bandelier Tuff that forms the Pajarito Plateau.

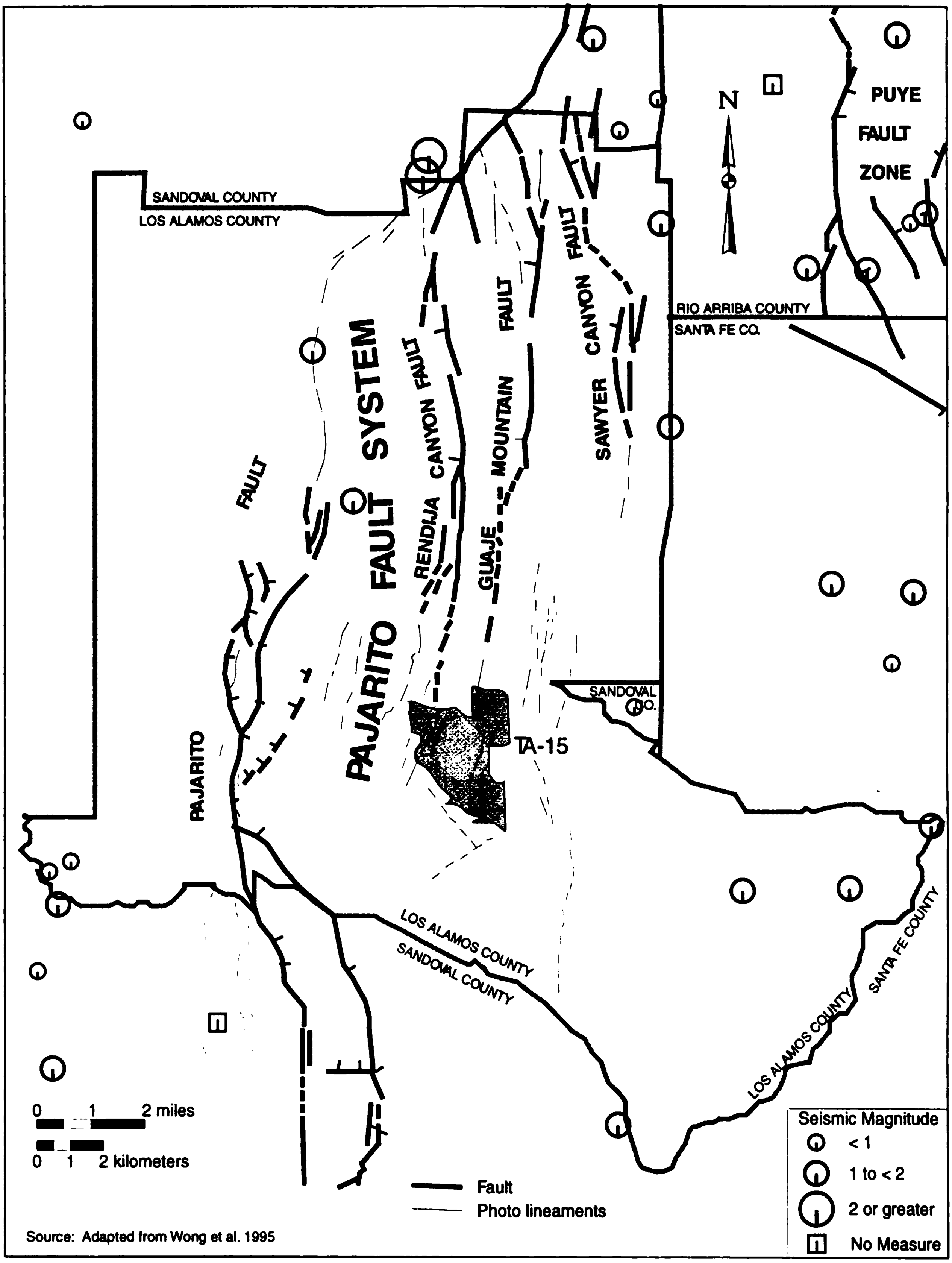
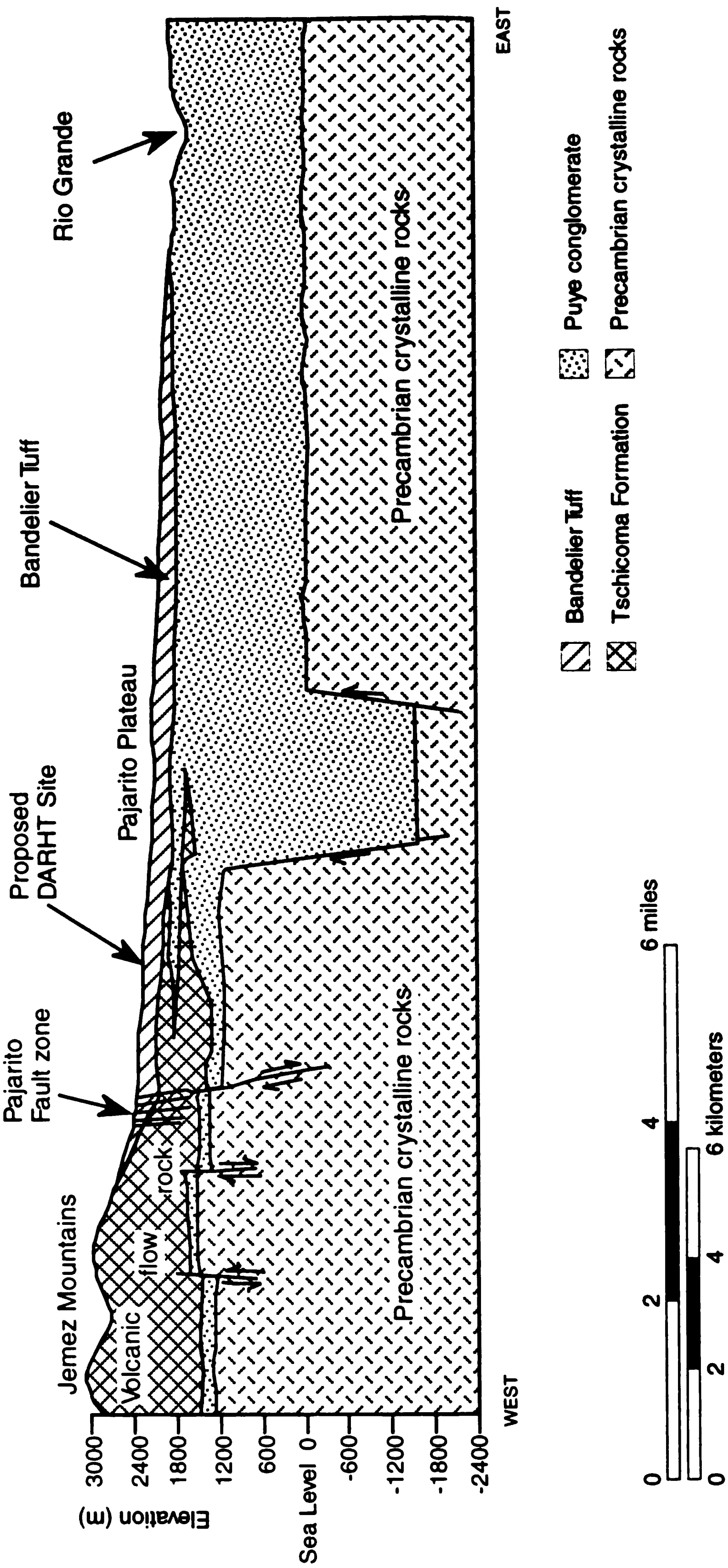


FIGURE 4-8.—*Recent Mapping of Faults, Photo Lineaments, and Earthquake Epicenters at LANL.*



Source: Burton 1982

FIGURE 4-9.—*Geologic Stratigraphic Relationships at LANL.*

A stratigraphic section for TA-67, about 1 mi (1.6 km) north of the proposed site is shown in figure 4-10 (adapted from Broxton et al. 1994). The Tshirege member of the Bandelier Tuff is divided into several distinct units. Units 4 and 3 are important as contributors to the mesa-top soils. Unit 3, because of its welding, is a comparatively strong rock and resists erosion sufficiently to form the mesa topography. Units 2 and 3, as well as the nonwelded bed between them, contribute to the soils in the canyons.

The main aquifer below the proposed site is estimated to be in the Puye formation some 1,100 to 1,200 ft (335 to 365 m) below the mesa top. The porosity, permeability, and fracture flow (if present) for these formations are described in section 4.4 on water resources and in appendix E4.

4.3.3 Soils

Several distinct soils have developed on the Pajarito Plateau as the result of interactions among the bedrock, surface morphology, and local climate. Nyhan et al. (1978) mapped these soils as shown in figure 4-11. The mineral components of the soils on Threemile Mesa are in large part derived from the Bandelier Tuff, but other underlying formations are locally important elsewhere on the Pajarito Plateau. Alluvium derived from the plateau, the Jemez Mountains, and windblown deposits contributes to soils in the canyons and also on some of the mesa tops. Layers of pumice from the El Cajete eruption in the Jemez Mountains and windblown sediment from beyond the Pajarito Plateau are also significant components of many soils on the plateau.

Soils on the mesas can vary widely in thickness and are typically thinnest near the edges of the mesas, where bedrock is often exposed. The walls of the canyons often consist of steep rock outcrops and patches of shallow, undeveloped colluvial soils. South-facing canyon walls are steep and usually have little or no soil material or vegetation. In contrast, the north-facing walls generally have areas of very shallow, dark-colored soils and are more heavily vegetated (LANL 1993a).

Soils at the proposed site on Threemile Mesa have been mapped but not studied in detail (Nyhan et al. 1978). These soils at the proposed site are mapped as the Pogna fine sandy loam, rock outcrop, and sandy loam that formed in material weathered from tuff on gently to strongly sloping mesa tops. Typically, these soils are light brownish grey, fine sandy loam, or sandy loam, over tuff bedrock at 10 to 20 in (25 to 51 cm).

Detailed soil studies at Pajarito Mesa, about a mile north of the DARHT site, can provide general expectations for the origin of both the surface and buried soils at the proposed site. The two localities have similar bedrock, topography, and local climate. Near-surface stratigraphic units on Pajarito Mesa include two general soil-stratigraphic units (pre- and post-60,000 years old) and an older consolidated alluvium (perhaps greater than 1 million years old) (Broxton et al. 1994).

The uppermost soil-stratigraphic unit at Pajarito Mesa includes the El Cajete pumice (about 60,000 years old) and overlying deposits. These deposits comprise the loosest material at Pajarito Mesa and are the deposits most susceptible to collapse. The average thickness of these deposits in mesa-top trenches is about 3 ft (0.9 m), although the deposits are probably thinner away from the mesa top. Pure deposits of El Cajete pumice generally occur as small patches beneath the mesa top. The pumice deposit reaches a maximum of 2.8 ft (0.85 m) thick. Elsewhere, the pumice is mixed into the fine-grained mesa-top soils

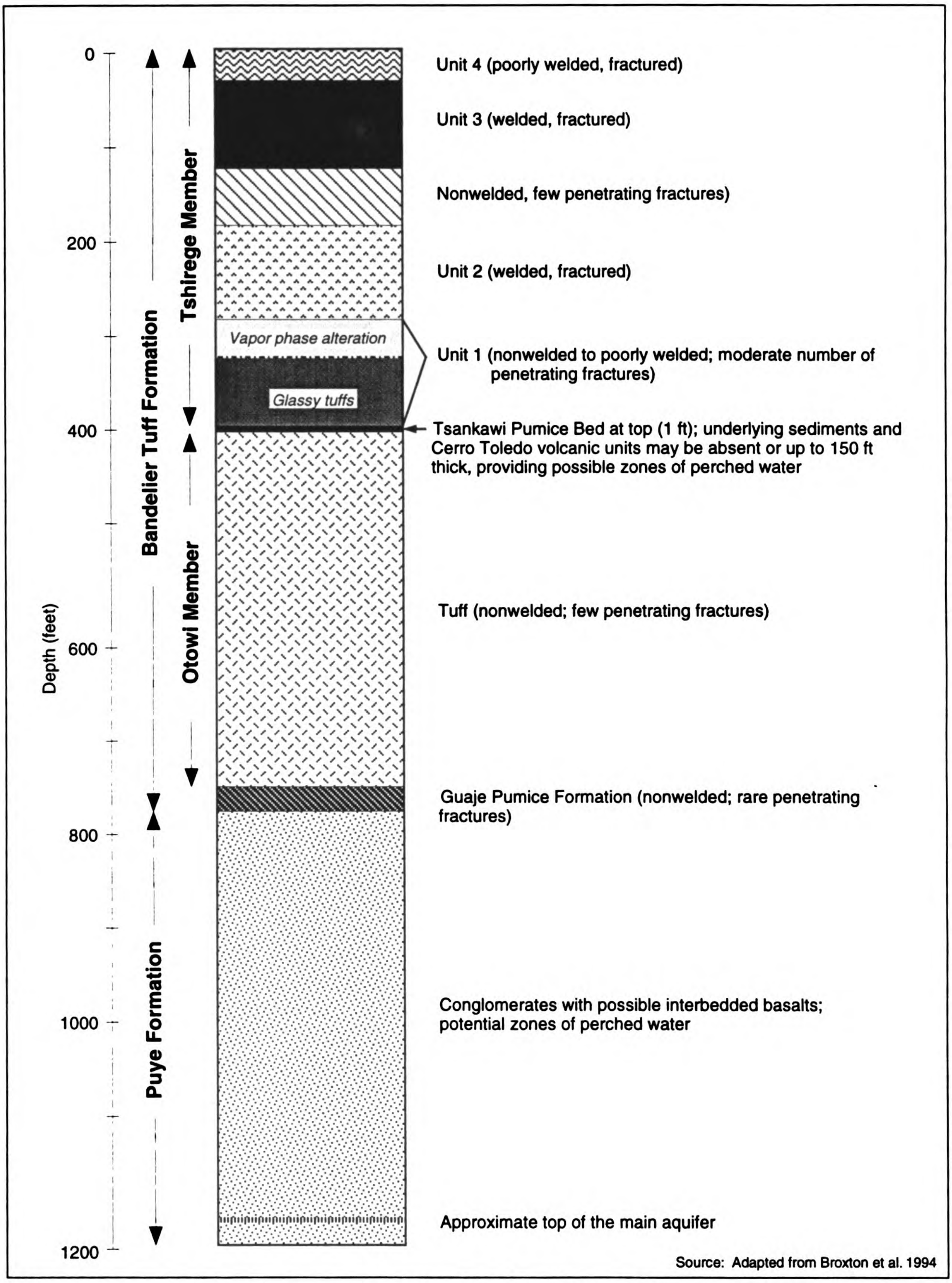


FIGURE 4-10.—*Stratigraphic Column at Threemile Mesa, TA-15.*

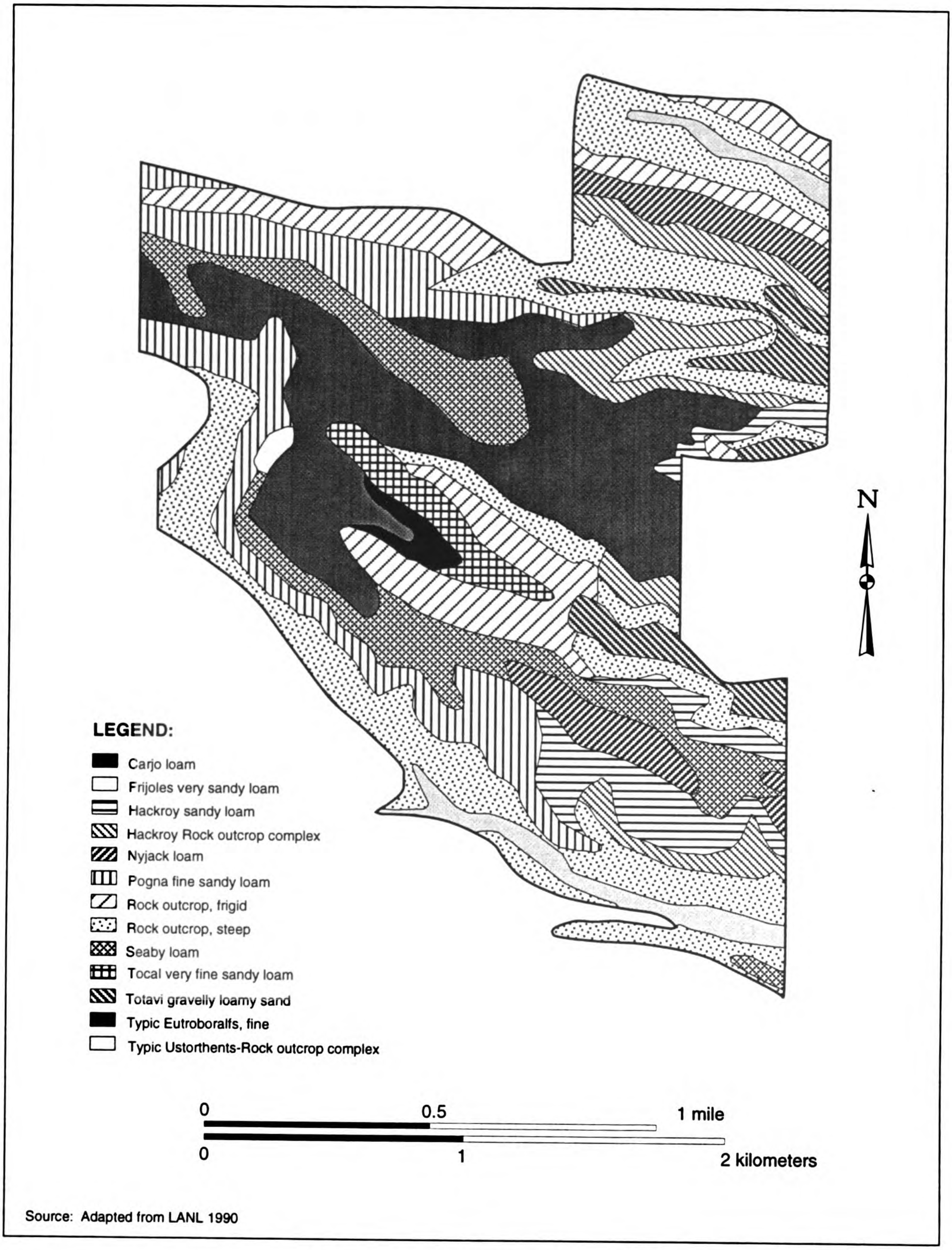


FIGURE 4-11.—*Soil Types in TA-15.*

(Broxton et al. 1994). A patch of El Cajete pumice is visible in an excavation for the DARHT site. Beneath the El Cajete pumice are older, consolidated soils that have thicknesses ranging from 0.2 to 6.7 ft (0.06 to 2.04 m), with their base typically occurring 4 to 6 ft (1 to 2 m) below the surface. This unit typically has a relatively high clay content and holds vertical walls (Broxton et al. 1994).

On Pajarito Mesa, some deposits of old, consolidated alluvium and associated pumice beds were found. These deposits may exceed 1 million years in age. They are up to 7 ft (2 m) thick, with their base up to 11 ft (3 m) below the surface. This unit is very cohesive and holds vertical walls.

The soil around PHERMEX is contaminated with materials which were part of the experiments exposed to high explosives. DOE has conducted studies, including aerial surveys using helicopters and soil-sampling surveys, that indicate that elevated levels of depleted uranium are found on the firing point (Fresquez and Mullen 1995). These studies indicate that gamma radiation levels decrease uniformly until only natural background levels are detected at about 460 ft (140 m) from the firing point. Another study (not radiological) indicated that approximately 90 percent of the depleted uranium remains within 490 ft (150 m) of the firing point (McClure 1995). No depleted uranium has been observed in samples obtained outside LANL.

4.3.4 Site Stability

Site stability could be affected by natural and engineered slopes near the hydrodynamic test facilities, erosional retreat of cliffs forming the mesa rims, and shaking from seismic ground motion. Engineering geology studies did not identify any slope stability problems at the DARHT site nor did they report any near-surface materials that would fail to support the buildings during seismic shaking (Korecki 1988). The PHERMEX site has similar near-surface geology, and has not experienced any slope stability problems during its operations since 1963. Geology studies of the stability of rocks near the rim of nearby Pajarito Mesa concluded that placing disposal facilities more than 200 ft (60 m) from the mesa rim would be adequate to ensure the integrity of such facilities for periods exceeding 10,000 yr (Reneau 1994). PHERMEX is, and the DARHT Facility would be, more than 200 ft (60 m) from the mesa edge. Seismic shaking may be an important triggering mechanism for major rock falls.

The three faults listed in table 4-5 control the estimates of seismic hazard at TA-15 because of their lengths, proximity, and evidence of geologically young movement. The maximum earthquakes could cause damage to structures not designed to resist such large earthquakes. It's important to note that the maximum earthquake on any of these faults would be a rare event. The WCFS report infers annual probabilities on the order of 10^{-4}, which corresponds to a return period of 10,000 yr. Even moderate earthquakes on these faults would have return periods of hundreds to thousands of years.

The firing-site facilities are engineered to withstand the blast wave and ground motion from detonating high explosives. However, vibratory ground motion from blasts has been raised as a possible concern for other structures, specifically for standing walls at cultural resources such as the Nake'muu ruin. Vibratory ground motion from detonation of high explosives was measured in conjunction with noise measurements (Vibronics 1995). Peak ground motion (particle velocity) for the energy transmitted through the ground was found to be less than the ground motion caused by the air wave pulse when it arrived. This result is reasonable because the high explosives are placed above ground and their energy is not transferred into the ground as efficiently as in blasting for construction or mining. These measurements indicate that ground motion from test shots would have less effect on structures than the corresponding air-wave pulse.

4.4 WATER RESOURCES

This section describes the surface and ground water resources at LANL. LANL continuously monitors these resources for primary pollutants and radionuclides. Area III has no streams or surface water bodies, but there are ground water resources; a portion of the main aquifer is present below the site.

4.4.1 Surface Water

The Rio Grande is the major source of surface water in north-central New Mexico. All surface water drainage and ground water discharge from the Pajarito Plateau ultimately arrives at the Rio Grande. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 14,300 mi^2 (37,037 km^2) in southern Colorado and northern New Mexico. The flow at Otowi has ranged from a minimum of 60 ft^3/s (1.7 m^3/s) in 1902 to 24,400 ft^3/s (691 m^3/s) in 1920. The river transports about 1 million tons of suspended sediments past Otowi annually (LANL 1993a).

The major canyons that contain reaches of perennial streams inside LANL are Pajarito, Water, Ancho, and Chaquehui Canyons. Los Alamos, Water, and Pajarito Canyons, and perennial streams originate upstream of LANL facilities or effluent discharge points (see figure 4-7) (LANL 1993a).

Perennial streams in the lower portions of Ancho and Chaquehui Canyons extend to the Rio Grande without being depleted. In lower Water Canyon, the perennial stream is very short and does not extend to the Rio Grande. In Pajarito Canyon, Homestead Spring feeds a perennial stream only a few hundred yards long, followed by intermittent flows for varying distances, depending on climate conditions (LANL 1993a).

Springs between 7,900 and 8,900 ft (2,408 and 2,713 m) elevation on the eastern slope of the Jemez Mountains supply base flow throughout the year to the upper reaches of Cañon de Valle, Los Alamos, Pajarito, and Water Canyons. These springs discharge water perched in the Bandelier Tuff and Tschicoma Formation at rates from 0.0045 to 0.30 ft^3/s (0.0001 to 0.0085 m^3/s). The volume of flow from the springs is insufficient to maintain surface flow within more than the western third of the canyons before it is depleted by evaporation, transpiration, and infiltration into the underlying alluvium (LANL 1993a).

Eleven drainage areas, with a total area of 82 mi^2 (212 km^2), pass through the eastern boundary of LANL. Runoff from heavy thunderstorms and heavy snowmelt reaches the Rio Grande several times a year from some drainages. Los Alamos, Pajarito, and Water Canyons have drainage areas greater than 10 mi^2 (26 km^2). Pueblo Canyon has 8 mi^2 (21 km^2), and all others have less than 5 mi^2 (13 km^2). Theoretical maximum flood peaks range from 24 ft^3/s (0.7 m^3/s) for a 2-year recurrence to 686 ft^3/s (19 m^3/s) for a 50-year recurrence. The overall flood risk to LANL and TA-15 buildings is low because nearly all the structures are located on the mesa tops, from which runoff drains rapidly into the deep canyons (LANL 1993a).

4.4.2 Ground Water

Ground water in the LANL area occurs in four modes – in shallow alluvium in canyons, perched water, in the unsaturated zone between the surface and the main aquifer, and the main aquifer (LANL 1994a).

Threemile Canyon has a small drainage area that heads on the Pajarito Plateau, and ephemeral streamflow occurs in response to snowmelt runoff and from seasonal storms. The presence of a permanent perched or alluvial water body in this canyon is possible. Potrillo Canyon heads on the Pajarito Plateau at TA-15. Streamflow in the channel results from snowmelt and runoff from seasonal storms. The stream channel in the upper reaches of the watershed in TA-15 is cut directly into the Bandelier Tuff. There is little to no alluvial fill in this reach; therefore, it is unlikely that a permanent alluvial deposit exists in this canyon. No alluvial aquifers were found in the watershed further downstream where streamflow discharge is greater due to a larger contributing area (LANL 1993b).

Cañon de Valle heads on the flanks of the Sierra de los Valles. Cañon de Valle receives small amounts of recharge from springs in its uppermost reaches, but because of evapotranspiration and infiltration, streamflow from this source does not reach West Jemez Road. Cañon de Valle receives effluent from permitted wastewater discharge in the reaches below West Jemez Road but above TA-15.

Water Canyon is a large canyon that heads on the flanks of Sierra de Los Valles. Several springs discharge from perched aquifers in the tuff in upper Water Canyon. A short distance downstream from the confluence of Water Canyon and Cañon de Valle is Beta Hole, drilled along the side of the canyon floor to test a horizon at about 180 ft (55 m) down; no saturated sediments were found at any level in this hole. However, because of the hole's placement, it did not test sediments close to the channel axis where saturated shallow sediments most likely would be found. Further down the canyon within 1 mi (1.6 km), two other wells drilled in the 1960s in the canyon bottom found saturated sediments that suggest the possibility of local perched water in the canyon bottom. If a perched water zone exists there, it must be limited in areal extent, because two additional wells show this alluvium to be dry at a distance of about 1.5 mi (2.5 km) from Beta Hole. In addition, any such saturation of canyon bottom sediments could be temporal. Recent observations have noted the presence of small springs issuing from the lower slopes of Cañon de Valle, Pajarito, and Threemile canyons. There is considerable debate among hydrogeologists as to the source(s) of this spring flow. A possible source is perched ground water within the Bandelier Tuff. It is unknown whether such a perched water zone is present immediately under the DARHT site. There is a possibility of perched water zones lying above basalt flows that interfinger with sediment beds at intermediate depth.

The main aquifer in the LANL area is the only aquifer in the area capable of serving as a municipal water supply. The surface of the aquifer rises westward from the Rio Grande within the Santa Fe Group, a sequence of basin-filling sediments, passing into the lower part of the Puye Formation beneath the central and western part of the Pajarito Plateau (LANL 1994a). Based on the regional water table contour map presented in figure 4-10, the depth of the main aquifer beneath TA-15 is estimated to vary from about 1,150 to >1,200 ft (350 to >365 m) below the mesa tops, with depths increasing to the west and from valley bottoms to mesa tops (figure 4-12). Aquifer hydrologic characteristics vary (LANL 1993b). Recent drilling results suggest that the main aquifer may be as shallow as 650 ft (198 m) (Gardner et al. 1993).

The aquifer beneath TA-15 is located within the layers of rock known as the Chino Mesa basalts, Puye conglomerate, and the Santa Fe Group, as shown in figure 4-13. These units are composed of various

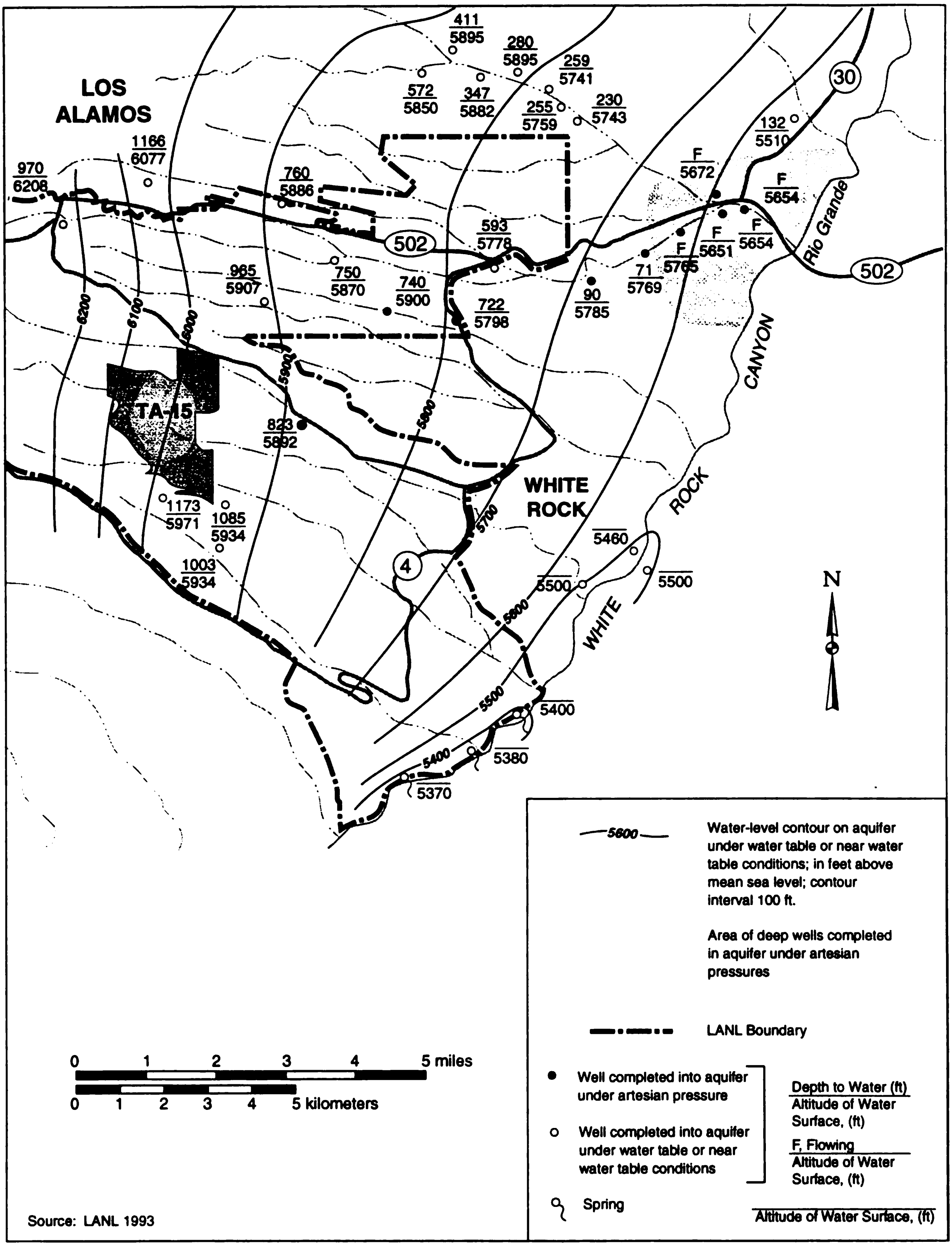


FIGURE 4-12.—*Generalized Contours on Top of the Main Aquifer in the LANL Area.*

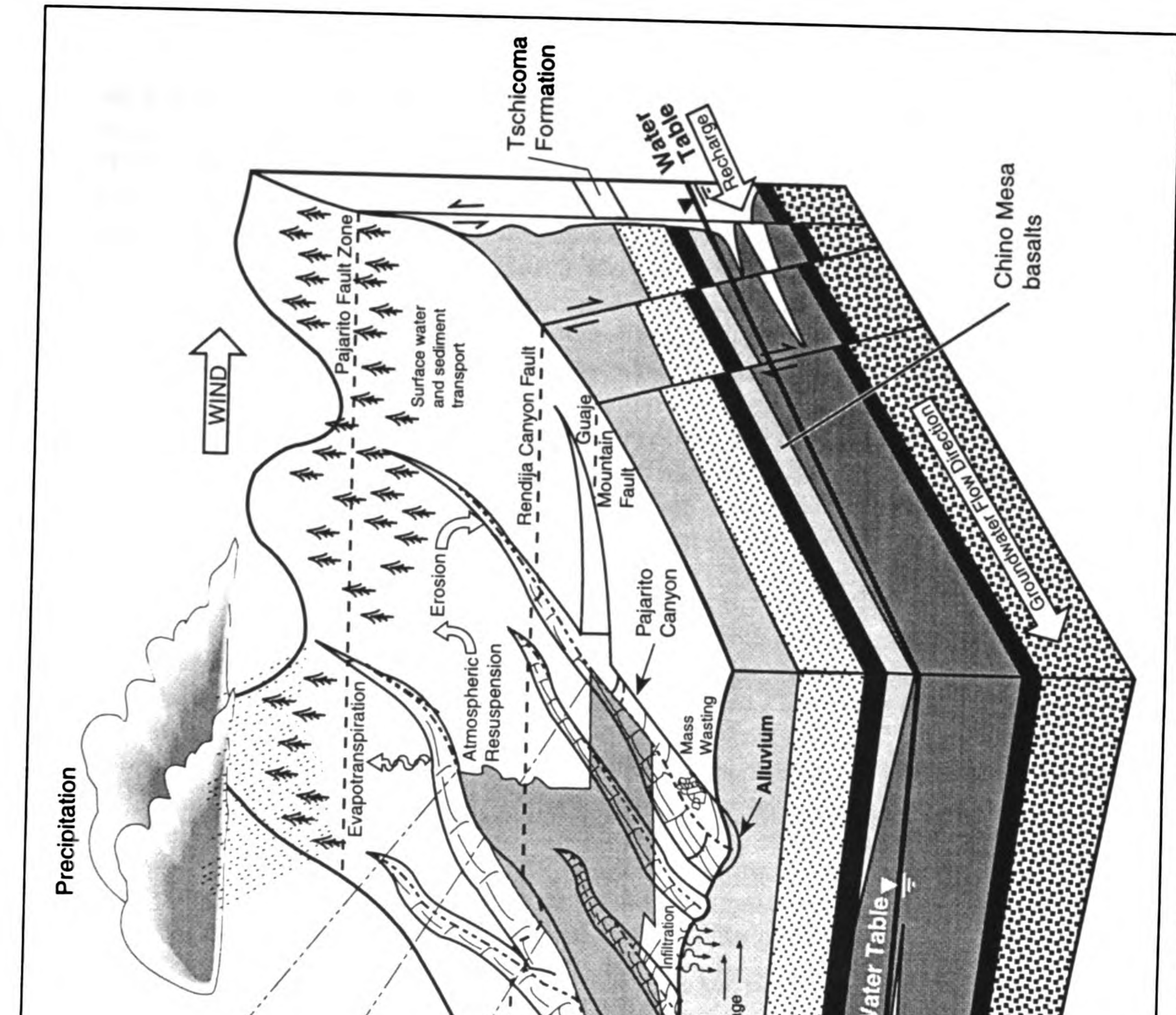


FIGURE 4-13.—*Conceptual Model of TA-15 Showing the General Relationship of Major Geologic and Hydrologic Units on the Pajarito Plateau.*

rock types – basalts, interflow breccias, conglomerates, sandstones, and siltstones. Not all of these rocks transmit water equally well. Thick basalts, siltstones, and fine-grained sandstones will not yield water as readily as coarse-grained conglomerates, sandstones, highly jointed basalts, and coarse sediments. To maximize production, supply and test wells are completed within a thick section of the aquifer to draw from multiple, highly permeable layers (figures 4-13 and 4-9) (LANL 1993a). The water in the aquifer moves from the main recharge area in the Valles Grande in the Jemez Mountains eastward towards the Rio Grande, where there is some discharge into the river through seeps and springs.

LANL, the nearby communities of Los Alamos and White Rock, and Bandelier National Monument are entirely dependent on ground water for their water supply. The water supply is primarily obtained from well fields. About 4.1 million gal/day (16 million L/day) are used by these communities (DOE 1993a). During 1992, total production from the wells and gallery for potable and nonpotable use was 3.9 million gal/d (15 million L/d) (LANL 1994a).

4.4.3 Water Monitoring

LANL monitors surface waters and ground waters to detect any contaminants from LANL. Measurable concentrations of radionuclides from operations (primarily during the early years) have been transported by surface water offsite to Pueblo and Los Alamos Canyons. Surface water transport almost certainly is the predominant mechanism for redistributing many of the contaminants at the DARHT site. Important contaminant transport mechanisms associated with surface water include:

- Erosion and sedimentation (sediment and contaminant accumulation) of contaminated surface and near-surface materials
- Infiltration of surface water that may be contaminated, or movement of water through a contaminated deposit that in turn carries contamination deeper into the soil/rock profile
- Movement of contaminants in surface water as solutes, suspended sediments, and bedload phases. (LANL 1993a).

Los Alamos, Sandia, and Mortandad Canyons currently receive treated industrial or sanitary effluent. Pueblo Canyon does not receive LANL effluents. Surface waters in these canyons are not a source of municipal, industrial, or agricultural water supply. Only during periods of heavy precipitation or snowmelt would waters from Pueblo, Los Alamos, or Sandia Canyons extend beyond LANL boundaries and reach the Rio Grande.

In Mortandad Canyon, no surface runoff to LANL's boundary has occurred since studies were initiated in 1960. Pueblo Canyon received both untreated and treated industrial effluents from 1944 to 1964. It currently receives treated sanitary effluents from Los Alamos County treatment plants in its upper and middle reaches.

Existing wastewater generation from LANL is approximately 183 million gal/yr (693 million L/yr) (DOE 1993a). Permitted effluent discharges at LANL emerge from 2 sanitary wastewater treatment facilities and 124 industrial outfalls. These outfalls include power plant discharges (1 outfall), boiler blowdown (2 outfalls), treated cooling wastewater (40 outfalls), noncontact cooling wastewater (44 outfalls), radioactive wastewater (1 outfall), high explosive production facilities wastewater (18 outfalls), photographic laboratory rinse wastewater (14 outfalls), asphalt plant wastewater (1 outfall), printed circuit board process wastewater (1 outfall), and sanitary wastewater (2 outfalls) (LANL 1994a).

Surface water sampling station locations near TA-15 are presented in figure 4-14. The radiochemical, trace metals, and chemical quality analyses of samples taken at Pajarito Canyon, Water Canyon, and Ancho Canyon at the Rio Grande are listed in tables 4-6 and 4-7 (LANL 1994a).

The perched alluvial ground water in offsite reaches of Pueblo and Los Alamos Canyons also shows the ongoing influence of both industrial and sanitary effluents. The hydraulic connections, and any associated flow rates, between known occurrences of perched, intermediate-depth ground water and the main aquifer are not known.

Ground water sampling station locations and results of analyses are presented in figures 4-15 and 4-16 and tables 4-8 and 4-9. Ground water samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer (LANL 1994a).

In 1991, in an effort to better understand the nature of recharge (replenishment of ground water) to the main aquifer in the Los Alamos area, LANL initiated a study to help define the sources and times of recharge. These studies include a range of geochemical and geochronological techniques to help identify ages and potential sources of water in the main aquifer.

"Age of water" means the time elapsed since the water, as precipitation, entered the ground and became isolated from the atmosphere. The precipitation at the time of entry into the ground is assumed to have contained atmospheric equilibrium amounts of both tritium and carbon-14. Therefore, the amount of tritium and carbon-14 in the aquifer would be an indicator of the water's age. Radioactive carbon-14 is mainly from natural sources, while tritium comes from both natural sources and fallout from atmospheric nuclear weapons testing. For comparative purposes, the studies included a series of isotope (tritium) and age-dating (carbon-14) measurements on ground water samples.

LANL has also collected samples from the test wells and the water supply production wells that penetrate the main aquifer and tested them with a variety of radioactive and stable isotope measurements. At present, a number of measurements of carbon-14 and low-level tritium are available that permit some preliminary estimates of the age of the water in the main aquifer at various locations (Gallaher 1995).

Before atmospheric nuclear testing, the tritium levels in atmospheric water were about 20 pCi/L, or about 6 tritium units (TU). By the mid 1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,400 pCi/L (2,000 TU) (annual average for 1963 to 1964). Since then, both radioactive decay and dilution by mixing through the global hydrologic cycle have reduced the concentrations of tritium in atmospheric water. At present, general levels of atmospheric water in northern New Mexico are about 30 pCi/L (10 TU). As a basis for comparison, the present EPA and New Mexico state drinking water standard is 20,000 pCi/L (6,200 TU). Routine compliance with the drinking water regulations is done by liquid scintillation counting with a detection limit of about 300 to 700 pCi/L (100 to 220 TU) (Gallaher 1995). See table 4-10 for the results of the most recent analyses from samples taken at wells near TA-15 (Gallaher 1995).

Four watersheds, each with an established stream channel drainage network, are present within TA-15. These watersheds are Threemile Canyon, Potrillo Canyon, Water Canyon, and Cañon de Valle. These

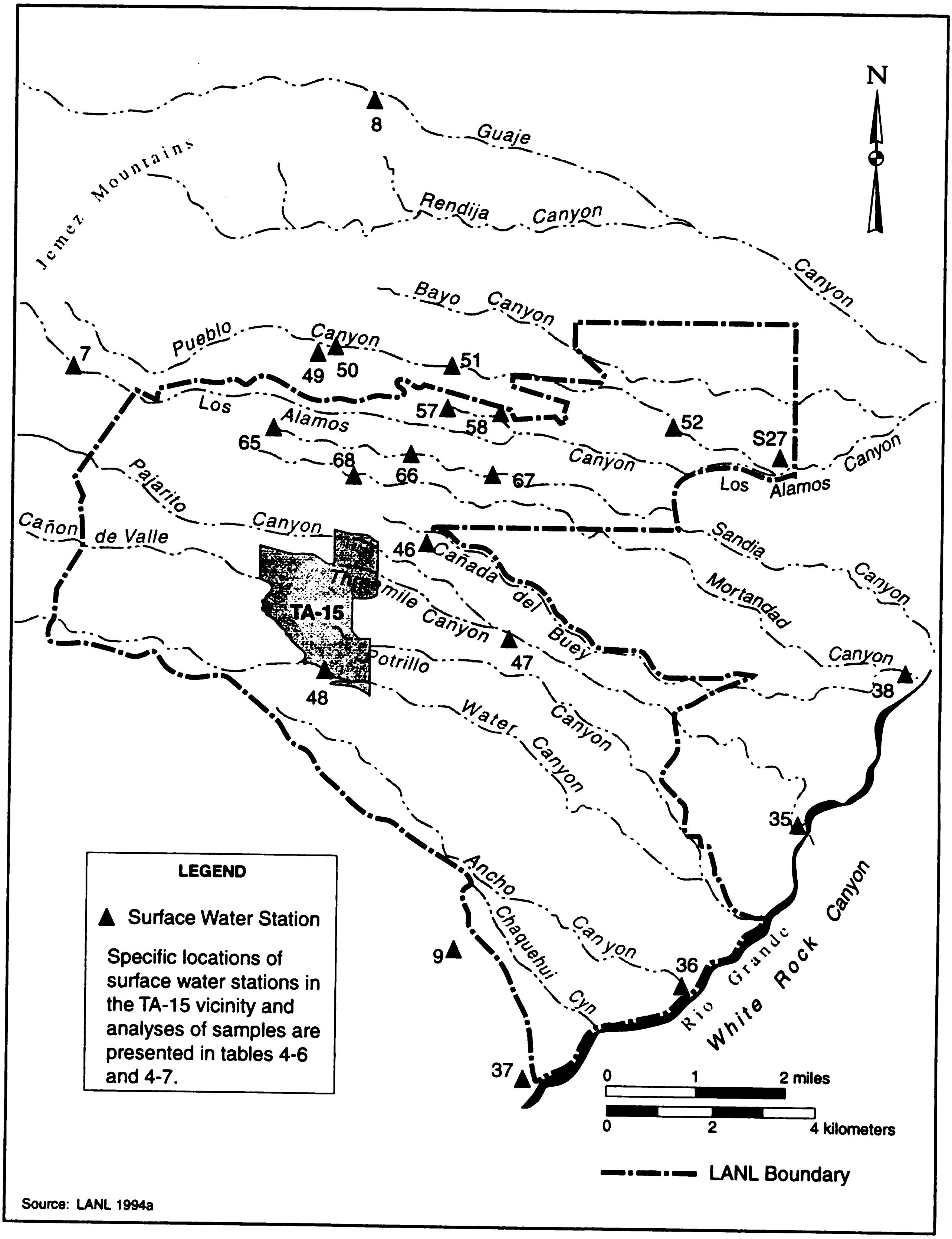


FIGURE 4-14.—*Surface Water Sampling Locations for LANL Onsite and Offsite Perimeter Locations.*

TABLE 4-6.—*Radiochemical Analyses of Surface Waters at LANL*

Location (Map Designation – see figure 4-10)	Tritium (nCi/L)[a]	Sr-90 (pCi/L)	Cs-137 (pCi/L)	Total Uranium (µg/L)	Pu-238 (pCi/L)	Pu-239,240 (pCi/L)	Am-241 (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	Gross Gamma (counts/min/L)
Water Quality Criteria	20,000 pCi/L[b]	8 pCi/L[b]	120 pCi/L[c]	—[d]	1.6 pCi/L[c]	1.2 pCi/L[c]	1.2 pCi/L[c]	15 pCi/L[b,e]	—[e]	—[d]	
Pajarito Canyon (47)[f]	0.4 (0.3)[h]	NA[i]	1.8 (1.2)	< 0.2[j] (0.0)	-0.013 (0.013)[k]	0.018 (0.011)	NA	0 (1)	5 (1)	0 (90)	
Water Canyon at Beta (48)a[g]	0.3 (0.3)	NA	53.60 (67.70)	0.3 (0.0)	-0.004 (0.004)	0.004 (0.004)[g]	NA	NA	NA	NA	10 (80)
Ancho at Rio Grande (36)[f]	0.4 (0.3)	0.0 (1.5)	3.3 (1.3)	0.4 (0.2)	-0.004 (0.004)	0.022 (0.012)	0.032 (0.030)	1 (1)	5 (1)	-30 (90)	

[a] Tritium as tritiated water in moisture distilled from sample.
[b] Maximum Contaminant Level (MCL) National Primary Drinking Water Regulations [40 CFR 141].
[c] U.S. Department of Energy derived concentration guides (DCG) for drinking water (DOE Order 5400.5).
[d] No specified limit.
[e] Screening limits for Gross Alpha are 5 pCi/L and for Gross Beta are 50 pCi/L.
[f] Results from 1992 sampling.
[g] Results from 1991 sampling (most recent data available) (LANL 1993).
[h] Radioactivity counting uncertainties (± one standard deviation) are shown in parentheses.
[i] NA means analysis not performed, lost in analysis, or not completed.
[j] Less than (<) means measurement was below the specified detection limit of the analytical method.
[k] Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative number values are included in the population calculations.

Source: Adapted from data LANL 1994a and LANL 1993

TABLE 4-7.—*Surface Water Quality Monitoring at LANL*

Parameter	Units of Measure	Water Quality Criteria	Pajarito Canyon[a] (47)[b]	Water Canyon at Beta[c] (48)	Ancho at Rio Grande[a] (36)
Aluminum	mg/L	0.05[f]	0.09	2.5	0.05
Beryllium	mg/L	0.004[g]	0.0026	<0.0003[e]	<0.0005
Bicarbonate	mg/L	—[d]	95	61	55
Calcium	mg/L	—[d]	25	15	14
Carbonate	mg/L	—[d]	<5	<2	16
Chlorine	mg/L	250[f]	17	9	3
Copper	mg/L	1[f]	<0.005	<0.002	0.007
Fluorine	mg/L	4[g]	0.3	<0.2	0.4
Magnesium	mg/L	—[d]	6.3	5	3.2
Mercury	mg/L	0.002[g]	<0.0001	<0.0002	<0.0001
Nitrate	mg/L	10[g]	0.12	2.7	0.91
pH	pH units[h]	6.5 – 8.5[f]	7.2	6.8	8.9
Phosphorus	mg/L	—[d]	0.0	0.2	<0.0
Potassium	mg/L	—[d]	4	4	2
Sodium	mg/L	—[d]	21	19	12
Sulfate	mg/L	250[f]	4	7	4
Total Dissolved Solids	mg/L	500[f]	196	168	90
Total Hardness	mg/L	—[d]	88	58	48

[a] Results from 1992 sampling.
[b] Sampling locations shown in figure 4-14.
[c] Results from 1991 sampling (most recent data available).
[d] No specified limit.
[e] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[f] Maximum contaminant level (MCL) for secondary constituents, applicable to drinking water system, given here for comparison only [40 CFR 143].
[g] MCL for primary constituents, applicable to drinking water systems, National Primary Drinking Water Regulations, given here for comparison only [40 CFR 141].
[h] Standard Units.

Source: Adapted from LANL 1994a and LANL 1993c

watersheds may be affected by runoff from the PHERMEX firing site that potentially is contaminated with depleted uranium and other materials released during explosive testing. However, environmental surveillance data, the Potrillo Canyon study, and simulations of uranium, beryllium, and lead migration have not revealed adverse impacts due to runoff from PHERMEX. A fifth watershed, Pajarito Canyon, receives runoff from a small, undeveloped area within TA-15 (LANL 1993a).

The presence of either perched or alluvial aquifers in Threemile, Potrillo, Cañon de Valle, or Water Canyons has not been confirmed; however, the geology and hydrology of these canyons are clearly consistent with the existence of perched and alluvial aquifers (LANL 1993a). These four perched or alluvial aquifers are within the influence of TA-15 operations.

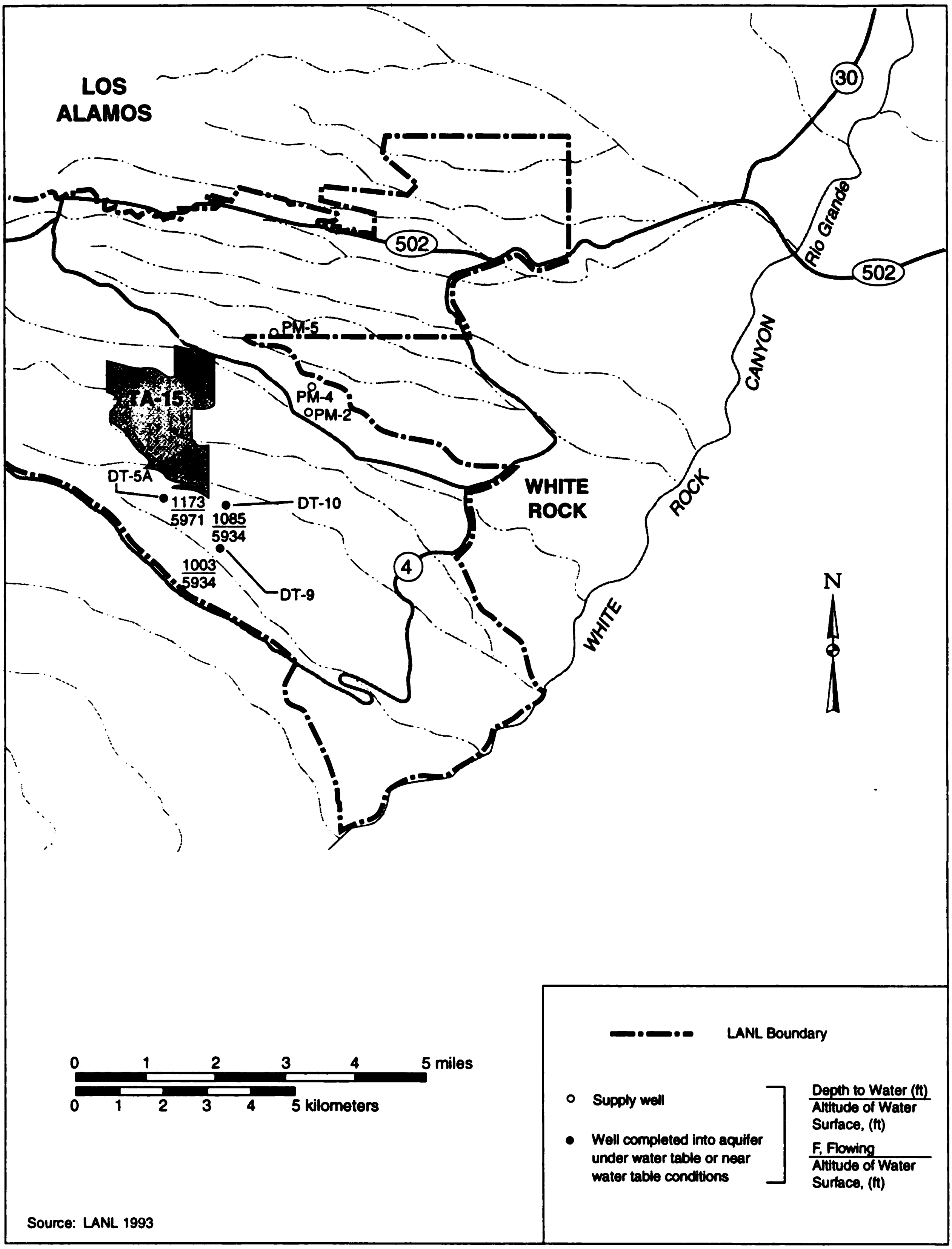


FIGURE 4-15.—*Ground Water Sampling Locations in the Vicinity of TA-15.*

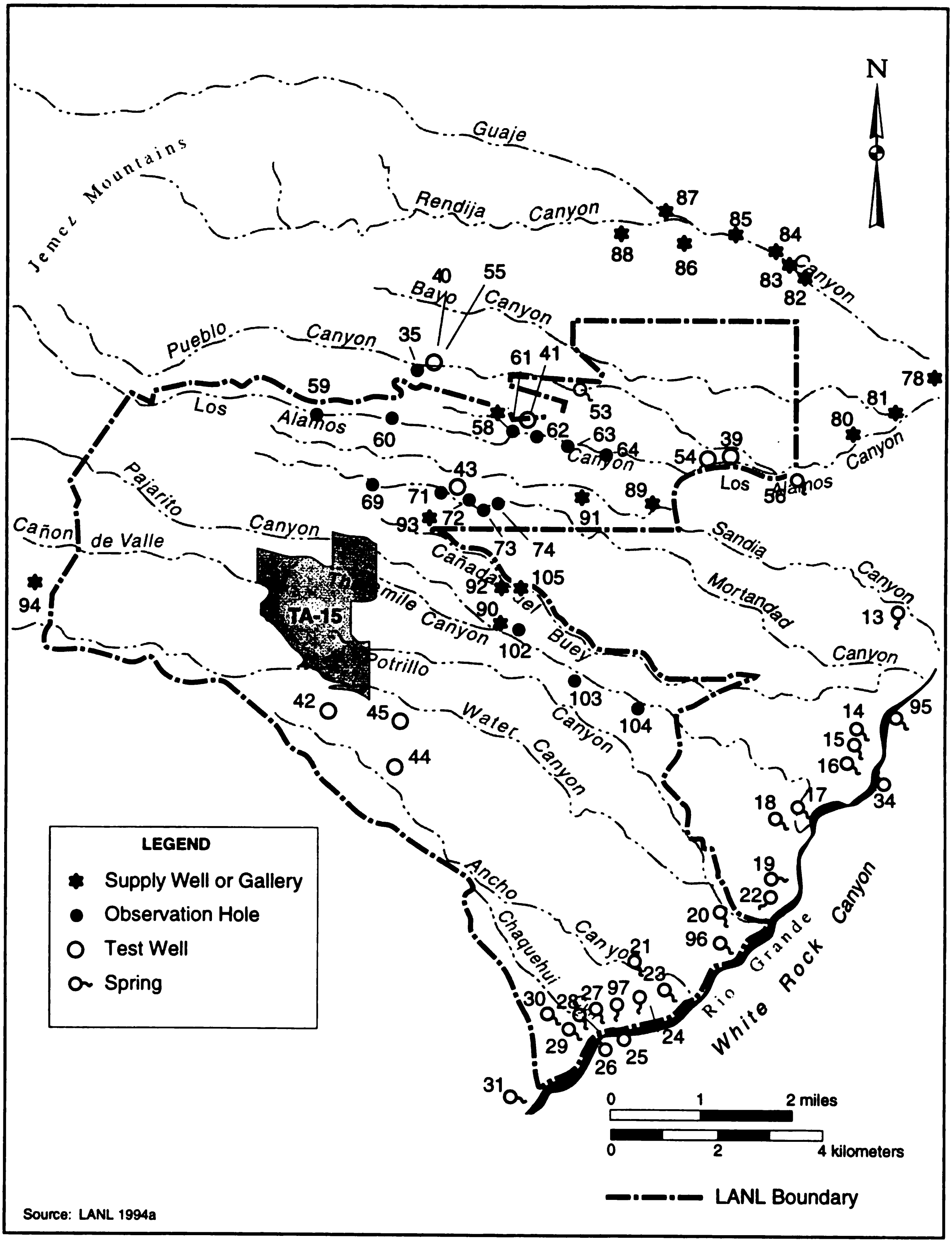


FIGURE 4-16.—*Ground Water Sampling Locations for LANL Onsite and Offsite Perimeter Locations.*

TABLE 4-8.—*Radiochemical Analyses of Ground Water Samples for 1992 at the Main Aquifer on the LANL Site*

Location	Tritium (nCi/L)	Sr-90 (pCi/L)	Cs-137 (pCi/L)	U (μg/L)	Pu-238 (pCi/L)	Pu-239,240 (pCi/L)	Am-241 (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Water Quality Criteria	20,000 pCi/L[a]	8 pCi/L[a]	120 pCi/L[b]	—[c]	1.6 pCi/L[b]	1.2 pCi/L[b]	1.2 pCi/L[b]	15 pCi/L[d]	—[d]	—[c]
Main Aquifer Onsite Test Wells										
Test Well DT-5A	0.3 (0.3)[e]	NA[f]	1.6 (1.1)	0.2 (0.1)	-0.005[g] (0.030)	-0.005 (0.020)	NA	1 (0)	2 (0)	40 (100)
Test Well DT-9	0.2 (0.3)	NA	1.3 (1.2)	< 1.0[h] (0.0)	-0.004 (0.030)	0.017 (0.020)	0.008 (0.030)	1 (1)	9 (1)	160 (100)
Test Well DT-10	0.1 (0.3)	NA	1.5 (1.1)	< 1.0 (0.0)	0.005 (0.030)	0.005 (0.020)	0.013 (0.030)	1 (1)	3 (0)	170 (100)
Water Supply Wells										
Well PM-2	0.2 (0.3)	NA	0.6 (1.0)	<0.6 (0.0)	0.008 (0.010)	0.008 (0.010)	0.020 (0.010)	0 (1)	2 (0)	50 (90)
Well PM-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Well PM-5	0.2 (0.3)	NA	0.3 (1.0)	<0.6 (0.0)	0.010 (0.012)	0.060 (0.019)	0.028 (0.015)	0 (1)	3 (1)	10 (90)

[a] Maximum Contaminant Level (MCL) National Primary Drinking Water Regulations [40 CFR 141].
[b] U.S. Department of Energy derived concentration guides (DCG) for drinking water (DOE Order 5400.5).
[c] No specified limit.
[d] Screening limits for Gross Alpha are 5 pCi/L and for Gross Beta are 50 pCi/L.
[e] Radioactivity counting uncertainties (±1 Standard Deviation) are shown in parentheses.
[f] NA means analysis not performed, lost in analysis, or not completed.
[g] Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative numbers values are included in the population calculations.
[h] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

Source: LANL 1994a

TABLE 4-9.—*Water Quality Criteria and Ground Water Monitoring Results at LANL*[a]

Parameter	Units of Measure	Water Quality Criteria	Test Well DT-5A[b]	Test Well DT-9[b]	Test Well DT-10[b]	Supply Well PM-2[b]	Supply Well PM-5[b]
Aluminum	mg/L	NA[c]	<0.02[d]	0.26	0.16	<0.03	<0.03
Beryllium	mg/L	NA	<0.0020	0.0020	0.0016	<0.0020	0.0020
Bicarbonate	mg/L	NA	51	51	66	47	74
Calcium	mg/L	NA	9	20	10	10	13
Carbonate	mg/L	NA	<5	<5	<5	<5	<5
Chlorine	mg/L	250[e]	2	3	3	2	3
Copper	mg/L	1[e]	<0.003	0.800	<0.100	<0.003	<0.003
Fluorine	mg/L	NA	0.4	0.6	0.5	0.2	0.3
Magnesium	mg/L	NA	2.3	5.4	3.0	2.9	4.7
Mercury	mg/L	0.002[f]	<0.0001	<0.0002	<0.0002	<0.0001	<0.0001
Nitrate	mg/L	10[f]	0.33	0.28	0.19	0.34	0.30
pH	pH units[g]	6.5 – 8.5[e]	7.6	7.9	8.2	7.9	7.5
Phosphorus	mg/L	NA	NA	NA	NA	0.0	0.1
Potassium	mg/L	NA	2	2	1	2	2
Sodium	mg/L	NA	11	22	9	11	14
Sulfate	mg/L	250[e]	3	3	3	3	3
Total Dissolved Solids	mg/L	500[e]	128	114	92	144	170
Total Hardness	mg/L	NA	31	72	37	36	51

[a] Results from 1992 sampling.
[b] These well locations are shown on figure 4-15.
[c] NA means analysis not performed, lost in analysis, or not completed.
[d] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[e] Maximum contaminant level (MCL) for secondary constituents, applicable to drinking water system, given here for comparison only [40 CFR141].
[f] MCL for primary constituents, applicable to drinking water systems, National Primary Drinking Water Regulations, given here for comparison only [40 CFR141].
[g] Standard Units.

Source: LANL 1994a

TABLE 4-10.—*Summary of Carbon-14 and Tritium-based Age Estimates for Wells Near TA-15*

Well Locations	Carbon-14 (% modern)	Carbon-14 Age Estimates		Tritium (pCi/L)[c]	Tritium Age Estimates	
		Minimum[a]	Maximum[b]		Piston Flow[d]	Well Mixed[e]
Los Alamos Supply Wells (Main Aquifer)						
PM-1	18.5	5,620	14,000	1.65	>45	>3,000
PM-2	62.7	50	3,860	1.59	>45	>3,000
PM-3	23.9	4,950	11,800	0.45	>70	>9,000
PM-3 @ 987 ft	28.2	6,770	10,500	0.42	>70	>9,000
PM-3 @ 1,226 ft	24.5	7,700	11,600	0.26	>70	>10,000
PM-3 @ 1,650 ft	22.9	7,910	12,200	0.03	>100	>10,000
PM-3 @ 2,000 ft	23.9	6,390	11,800	0.10	>100	>10,000
PM-5	53.7	1,040	5,140	0.29	>70	>10,000
Los Alamos Test Wells (Main Aquifer)						
DT-5A	57.6	1,810	4,560	0.23	>80	>10,000
DT-9	69.1	163	3,060	0.45	>70	>9,000
DT-10	82.0	<0[f]	1,640	1.33	~55	>4,500

[a] Assumes dilution by "dead" carbon from dissolution of carbonates, estimated by ratios of carbon isotopes.
[b] Assumes radioactive decay only, no dilution by dissolution of carbonates.
[c] 3.24 pCi/L = 1 Tritium Unit (TU); one tritium atom in 10^{18} hydrogen atoms.
[d] Piston Flow model assumes no mixing or dilution with other water.
[e] Well Mixed model assumes complete mixing in reservoir, inflow = outflow, no other inputs.
[f] Applying dilution factor (footnote[a]) results in meaningless minimum age.

Source: Gallaher 1995

There are no wells in TA-15; therefore, all inferences on the main aquifer beneath this technical site have been drawn from information derived from supply wells and deep test wells near TA-15 (table 4-11 and figure 4-15) (LANL 1993a). Data in the table are measures of the amount of water and its ability to move through the rocks.

4.5 BIOTIC RESOURCES

The LANL area contains a diversity of plant communities (figure 4-17) due in part to the dramatic 5,000-ft (1,500-m) elevational change from the Rio Grande on the east, to the Jemez Mountains 12 mi

TABLE 4-11.—*Hydrological Characteristics of Supply and Test Wells Near TA-15*

Well	Saturated Thickness (ft)	Specific Capacity (gpm/ft)	Transmissivity (gpd/ft)	Field Coefficient of Permeability (gpd/ft²)
PM-2	1,426	23.1	40,000	28
PM-4	1,828	36.8	44,000	24
DT-5A	643	5.7	11,000	17
DT-9	498	22	61,000	122
DT-10	324	16	36,100	111

Well locations shown on figure 4-14.

Source: LANL 1993

(20 km) on the west, and to the many canyons with abrupt surface slope changes that dissect the area (figure 4-7 shows the location of many of these features). Biological surveys of LANL have been carried out at various times – most recently in 1995 – to identify the plant and animal communities and species of the area. These studies were summarized by Dunham (1995), Risberg (1995), and Keller and Risberg (1995). Plant and animal species found in these surveys are listed in appendix F. This section describes the terrestrial resources, wetlands, and aquatic resources, and addresses threatened and endangered species at LANL, the DARHT site, and the proposed vessel cleanout facility sites.

4.5.1 Terrestrial Resources

Ecological diversity in terrestrial landscapes is typified by plant communities (assemblages of similar plant forms, each of which is dominated by one or two major species). Six major vegetative community types are found in Los Alamos County. Three of them – juniper-grassland, piñon-juniper, and ponderosa pine – are predominant, each occupying about one-third of LANL (figure 4-17). The other three are mixed-conifer, spruce-fir, and subalpine grassland (Risberg 1995).

The juniper-grassland community is found along the Rio Grande on the eastern border of the Pajarito plateau and extends upward on the south-facing sides of the canyons at 5,600 to 6,200 ft (1,700 to 1,900 m). Principal species in this community include one-seeded juniper (*Juniperus monosperma*), skunk bush sumac (*Rhus trilobata*), and sagebrush (*Artemisia spp*).

The piñon-juniper community, generally found in the 6,200- to 6,900-ft (1,900- to 2,100-m) elevation range, includes large portions of the mesa tops and north-facing slopes at the lower elevations. This woodland consists of stands of piñon pine (*Pinus edulis*) and one-seeded juniper, both dominant, and includes grasses such as blue grama (*Bouteloua gracilis*) and galleta (*Hilaria jamesii*) (Travis 1992).

The ponderosa pine community is found in the western portion of the plateau and on mesa tops in the 6,900- to 7,500-ft (2,100- to 2,300-m) elevation range. This community is characterized by ponderosa pine (*Pinus ponderosa*) as the primary overstory vegetation. It also contains Douglas fir (*Pseudotsuga menziesii*), Gambel oak (*Quercus gambelii*), mountain muhly (*Muhlenbergia montana*), and little bluestem grass (*Andropogon scoparius*) (Travis 1992).

The mixed conifer, at 7,500 to 9,500 ft (2,300 to 2,900 m), interfaces with the ponderosa pine in the deeper canyons and north slopes and extends to the west from the higher mesas on the slopes of the Jemez

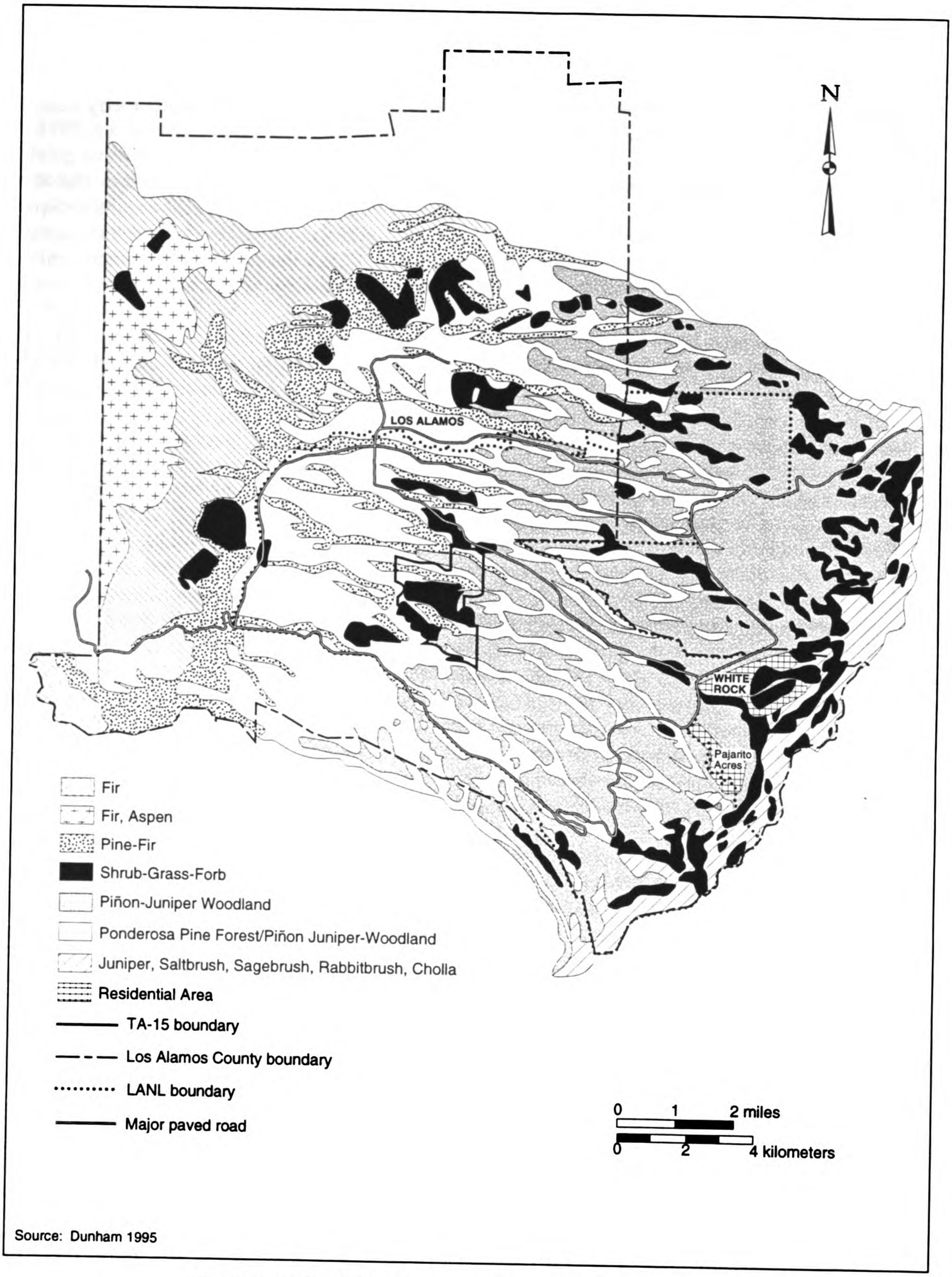


FIGURE 4-17.—*Plant Communities on the Pajarito Plateau.*

Mountains. The major species found here include quaking aspen (*Populus tremuloides*), Engelmann spruce (*Picea engelmannii*), Douglas fir, limber pine (*Pinus flexilis*), and white fir (*Abies concolor*). This community also has an understory of bearberry (*Arctostaphylos uvaursi*), creeping barberry (*Berberis repens*), and various grasses and forbs (Travis 1992).

The subalpine grassland is mixed with the spruce fir community at elevations of 9,500 to 10,500 ft (2,900 to 3,200 m). The pronounced east-west canyon and mesa orientation, with accompanying differences in soils, moisture, and solar radiation, produces an interlocking finger effect, resulting in transitional overlaps of plant and animal communities within small areas (DOE 1979). Species within this community include blue spruce (*Picea pungens*), Engelmann spruce, and mountain muhly.

The top of Threemile Mesa is characterized by piñon-juniper and ponderosa pine communities. The dominant overstory species are ponderosa pine, one-seed juniper, and piñon pine. Oak species (*Quercus spp.*) dominate the shrub layer. The dominant understory species are blue grama, mountain muhly, galleta, and big bluestem (*Andropogon gerardii*) grasses. A mixed-conifer forest of Douglas fir and mountain muhly covers the north-facing slopes. The south-facing slopes support a ponderosa pine forest and piñon-juniper woodland with ponderosa pine and wavyleaf oak (*Quercus undulata*). Douglas fir and open ponderosa pine forests make up the canyon bottom.

Undeveloped areas within LANL provide habitat for a diversity of terrestrial wildlife. Species lists have been compiled from observational data and published data, but the occurrence of some species has not been verified (Risberg 1995). Invertebrates at LANL include a number of ant species collected in 1986 as well as many other invertebrates (Risberg 1995). Among vertebrates, the collared lizard (*Crotaphytus collaris*), eastern fence lizard (*Sceloporus undulatus*), and whiptail lizard (*Cnemidophorus spp.*) are some of the reptiles found at LANL. Typically, these are found at elevations between 6,265 and 7,000 ft (1,910 and 2,134 m). Bird species which nest in the area include the Mexican spotted owl (*Strix occidentalis lucida*), great-horned owl (*Bubo virginianus*), and red-tailed hawk (*Buteo jamaicensis*) among the raptors, and Say's phoebe (*Sayornis saya*), lesser goldfinch (*Carpodacus psaltria*), and American robin (*Turdus migratorius*) among other types. Overwintering species include the scrub jay (*Aphelocoma coerulescens*), common raven (*Corvus corax*), and house finch (*Carpodacus mexicanus*) (Travis 1992, Keller and Risberg 1995).

Some of the larger mammals at LANL are the American black bear (*Ursus americanus*), coyote (*Canis latrans*), and raccoon (*Procyon lotor*) while the smaller species include the Mexican woodrat (*Neotoma mexicana*), deer mouse (*Peromyscus maniculatus*), Abert's squirrel (*Sciurus aberti*), and cottontail rabbit (*Sylvilagus nuttalli*) (Risberg 1995). The most important and prevalent big game species at LANL are the Rocky Mountain mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus canadensis*). LANL lands have traditionally been a transitional area for wintering elk and deer. More recently, these two species have been using LANL property on a year-round basis.

Throughout LANL's history, developments within various technical areas have caused significant alterations in the terrain and the general landscape of the Pajarito Plateau. These alterations have resulted in significant changes in land use by most groups of wildlife species, particularly birds and larger mammals that have large seasonal and/or daily ranges. Certain projects required the segregation of large areas, such as mesa tops, and in some cases, project areas were secured by virtually impenetrable fences around their perimeters. These have undoubtedly caused some species of wildlife, such as elk and deer, to alter their land use patterns by cutting off or altering seasonal and/or daily travel corridors to wintering areas, breeding habitat, foraging habitat, and bedding areas, as well as other necessary habitats.

In 1980, elk were primarily using the southwestern portion of LANL (White 1981). In addition, critical calving areas and important high-use areas were identified, all of which were primarily in the west and southwest part of LANL. Since 1980, the number of elk using LANL lands has increased significantly. Studies of elk conducted from 1991 to 1993 (Risberg 1995) reveal increased use of habitats north and northeast of previously documented high-use areas (White 1981). There have also been recent concerns about increases in motor vehicle accidents involving elk and deer in the LANL area (Kirk 1995). In general, however, little is known of habitat use patterns, population trends, and characteristics of elk on the Pajarito Plateau.

4.5.2 Wetlands

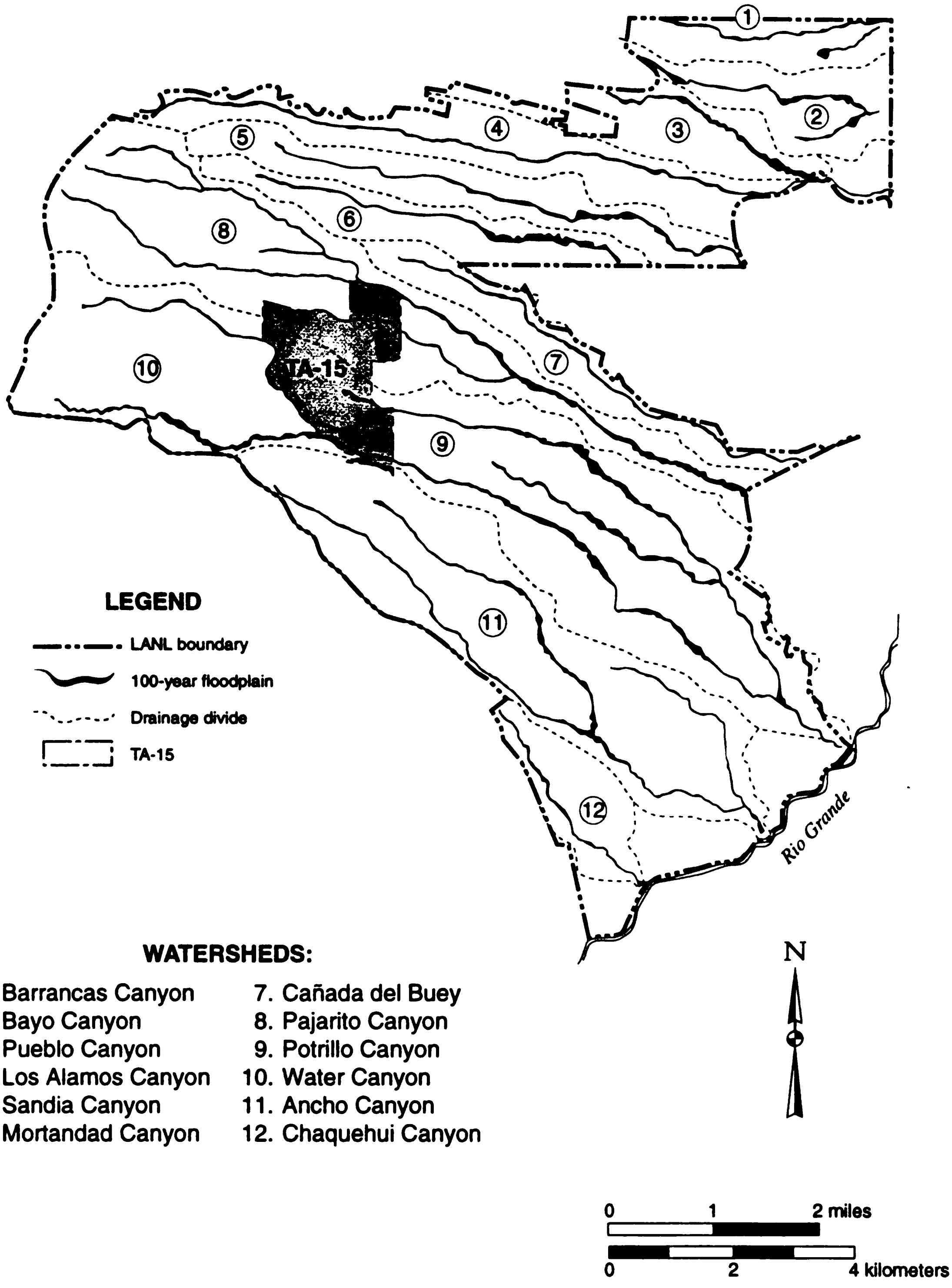
Wetlands have characteristics of both aquatic and terrestrial systems and include riparian (streambank) and floodplain ecosystems. Riparian areas are characterized by an abundance of deciduous and moisture-loving species. In the Southwest these zones have a higher diversity of plants providing cover, food, and breeding areas for a wider diversity of animals than the surrounding arid areas.

A 1992 LANL field study at TA-15 determined that no wetlands existed in the immediate area where the DARHT site is located (Dunham 1995). The proposed sites for the vessel cleanout facility building (see figure 3-6) were surveyed on July 6, 1995; it was determined that no wetlands existed on the sites. However, natural wetland areas, both floodplain and riparian, occur in some canyons of TA-15, and more extensive wetlands have developed as a result of effluent outfalls from LANL facilities (LANL 1993a). Floodplains are located at the bottom of Potrillo, Water, Threemile, and Pajarito Canyons, and Cañon de Valle (Dunham 1995). Narrow riparian areas line the intermittent stream channels in the canyon bottoms and in the perennial channel in Pajarito Canyon. These riparian zones consist of arroyos with water flowing intermittently during the spring runoff and summer monsoon season (usually July into August). The U.S. Fish and Wildlife Service (USFWS) has mapped the floodplain areas of LANL (figure 4-18).

The canyon riparian zones manifest a mixed-conifer tree canopy dominated by ponderosa pine. The understory layer is a mixed-deciduous woodland, dominated by boxelder (*Acer negundo*). The shrub layer consists of various oak (*Quercus*) species along with mountain mahogany (*Cercocarpus montanus*) and Apache plume (*Fallugia paradoxa*). The herbaceous layer is dominated by redtop (*Agrostis spp.*), accompanying other grasses, notably bluegrass (*Poa spp.*), bromegrass (*Bromus spp.*), and blue grama. This layer also contains a number of forbs, particularly meadowrue bedstraw (*Thalictrum fendleri*) (Dunham 1995).

4.5.3 Aquatic Resources

Aquatic habitats at LANL are limited to the Rio Grande and several springs and intermittent streams in the canyons. These habitats currently receive National Pollutant Discharge Elimination System (NPDES)-permitted wastewater discharges. The springs and streams at LANL do not support fish; however, many other aquatic species thrive in these waters (DOE 1993a; Cross 1994; Bennett 1994).



Source: Dunham 1995

FIGURE 4-18.—*Floodplain map of LANL.*

4.5.4 Threatened and Endangered Species

The Mexican spotted owl is listed as a federally listed threatened species. These owls were first observed in canyons within 2 mi (3.2 km) of the DARHT site by a 54 LANL Ecological Studies Team in the spring of 1995. These sightings were confirmed in June 1995 and, in addition, a nest site was found approximately 0.4 mi (0.6 km) from the DARHT construction site. Two young were fledged from this nest during the 1995 breeding season (March 1 to August 31).

Canyons surrounding the DARHT site provide nesting, roosting, and foraging habitats for the Mexican spotted owl. Foraging habitat near the DARHT site has been diminished by the removal of 7 ac (2.8 ha) of ponderosa pine/piñon-juniper vegetation. A slight decrease in prey abundance may have resulted from this removal. Vegetation loss may also add to noise impacts that affect owls; however, the topography and vegetation within the surrounding canyons also reduce sound levels over much of the nesting and roosting habitat.

There are eleven other species that are listed as threatened or endangered by either the USFWS or the New Mexico Department of Game and Fish that may occur on the proposed DARHT or vessel cleanout facility sites. Twelve more are considered candidates for inclusion on the federal endangered or threatened list (table 4-12). The most recent biological survey did not find any of these other species within the project site; however, highly suitable habitat exists for many of these species within the project area (Keller and Risberg 1995).

4.6 CULTURAL AND PALEONTOLOGICAL RESOURCES

This section provides a summary evaluation of the prehistoric and historic cultural resources within a 2,500-ft (750-m) radius of shrapnel of the DARHT site. The published data on cultural and paleontological resources were presented relative to the DARHT site, rather than the site as defined in the introduction. There are other archeological sites within the PHERMEX hazard radius of 4,000 ft (1,250 m) of that facility, but none have standing walls other than those at Nake'muu.

Prehistoric cultural resources refer to any material remains of items used or modified by people prior to the establishment of a European presence in the upper Rio Grande valley in the early 17th century (Spanish Colonial and Territorial Periods as shown on table 4-13). Historic cultural resources include all material remains and any other physical alterations of the landscape since the arrival of Europeans in the region. An overview of the prehistory and history of the LANL area is summarized in table 4-13 (Larson 1995).

Types of prehistoric sites identified in the vicinity of LANL include large multi-room pueblos, pithouse villages, field houses, talus houses, cave kivas, shrines, towers, rockshelters, animal traps, hunting blinds, water control features, agricultural fields and terraces, quarries, rock art, trails, campsites, windbreaks, rock rings, and limited activity sites. Approximately 75 percent of LANL has been inventoried for cultural resources. Coverage for some inventories has been less than 100 percent; however, about 60 percent of LANL has received 100 percent coverage. Over 975 prehistoric sites have been recorded; about 95 percent of these sites are considered eligible or potentially eligible for the National Register for Historic Places (NRHP) (DOE 1993a).

TABLE 4-12.—*Threatened, Endangered, and Candidate Species Potentially Present at Area III, TA-15*

Scientific Name	Common Name	Status	Habitat	Potential for Occurrence
PLANTS				
Fritillaria atropurpurea	Checker lily[c]	SE[f]	Mixed conifer	Low to Moderate
Lilium philadelphicum	Wood lily[c]	SE[f]	Ponderosa to mixed conifer, cliffs 6,000 to 10,000 ft (1,829 to 3,048 m)	Low to Moderate
Mammillaria wrightii	Wright's fishhook cactus[c]	SE[f]	Desert grassland to piñon-juniper 3,000 to 7,000 ft (914 to 2,134 m)	Unlikely to Low[i]
Opuntia viridiflora	Santa Fe cholla[c]	FC[e],SE[f]	Piñon-juniper 7,200 to 8,000 ft (2,195 to 2,438 m)	Unlikely to Low[i]
Pediocactus papyracanthus	Grama grass cactus[a,c]	FC[e]	Grasslands, piñon-juniper woodlands 5,000 to 7,300 ft (1,524 to 2,225 m)	Unlikely to Moderate[i]
ANIMALS				
Plethodon neomexicanus	Jemez Mountain salamander[a]	FC[e], SE[g]	Densely wooded, shady canyons	Unlikely to Low
Accipiter gentilis	Northern goshawk[a,b,c]	FC[e]	Ponderosa; dense, mature, or old-growth coniferous forest	Low to Moderate
Buteo regalis	Ferruginous hawk[a]	FC[e]	Grasslands	Unlikely to Low[i]
Buteogallus anthracinus	Common black hawk[c]	SE[g]	Riparian with cottonwood	Unlikely[i]
Cynanthus latirostris	Broad-billed hummingbird[b,c]	SE[g]	Riparian woodlands	Unlikely[i]
Empidonax traillii extimus	Southwestern willow flycatcher[c]	FE[e], SE[g]	Riparian woodlands dominated by cottonwoods 3,700 to 8,900 ft (1,147 to 2,759 m)	Unlikely[i]
Falco peregrinus	Peregrine falcon[a,b,c]	FE[e], SE[g]	Ponderosa-piñon, streams and lakes	Low
Haliaeetus leucocephalus	Bald eagle[a,b,c]	FE[e], SE[g]	Riparian near streams and lakes	Unlikely to Low[i]
Ictinia mississippiensis	Mississippi kite[c]	SE[h]	Riparian and shelterbelts	Unlikely[i]
Lanius ludovicianus	Loggerhead shrike[a]	FC[e]	Grasslands, open woodland	Unlikely to Low[i]
Plegadis chihi	White-faced ibis[a]	FC[e]	Streams, marshes, ponds	Unlikely[i]
Strix occidentalis lucida	Mexican spotted owl[a,b,c]	FT[e]	Mixed conifer; mountains and canyons, uneven-aged, multi-storied forest with closed canopy	High
Euderma maculatum	Spotted bat[a,b,c]	FC[e], SE[g]	Ponderosa, piñon-juniper, cliffs and rock crevices	Low

TABLE 4-12.—*Threatened, Endangered, and Candidate Species Potentially Present at Area III, TA-15 – Continued*

Scientific Name	Common Name	Status	Habitat	Potential for Occurrence
Myotis evotis	Long-eared myotis[c]	FC[e]	Spruce-fir community	High
Myotis lucifugus occultus	Occult little brown bat[a]	FC[e]	Mountains, caves, and hollow trees	Unlikely [i]
Myotis thysanodes	Fringed myotis[c]	FC[e]	Water bodies at various elevations	High
Myotis volans	Long-legged myotis[c]	FC[e]	Ponderosa pine and higher elevations, water bodies	High
Myotis yumanensis	Yuma myotis[c]	FC[e]	Permanent watercourses	High
Ochotona princeps nigrescens	Goat peak pika[a]	FC[e]	Lava boulders	Unlikely [i]
Zapus hudsonius luteus	New Mexican jumping mouse[a]	FC[e], SE[g]	Near streams and vegetation	Low

[a] From U.S. Department of Interior Fish and Wildlife Service letter, January 23, 1995 (USFWS 1995).
[b] From Biological and Floodplain/Wetland Assessment for the DARHT, 1995 (Risberg 1995).
[c] From Biological and Floodplain/Wetland Assessment for OU 1086, TA-15, 1995 (Dunham 1995).
[d] From Draft Biological and Floodplain/Wetland Assessment for the Dual-Axis Radiographic Hydrodynamics Test Facility (DARHT) (Keller and Risberg 1995).
[e] From U.S. Department of the Interior Fish and Wildlife Service Memo, June 19, 1995 (USFWS 1995).
[f] From New Mexico Energy, Minerals and Natural Resources Department, NMFRCD Rule No. 91-1.
[g] From New Mexico Department of Game and Fish, Regulation #682, 11/30/90.
[h] Until recently, listed as State endangered by the New Mexico Department of Game and Fish.
[i] Suitable habitat for this species does not occur in the proposed project area (Keller and Risberg 1995).

STATUS:
SE: State Endangered: New Mexico-listed species protected as threatened or endangered under the Wildlife Conservation Act.
FC: Federal Candidate "...[Any species] for which the USFWS has on file enough substantial information of biological vulnerability and threat, [or] for which other information now in the possession of the USFWS indicates that proposing to list them as threatened or endangered is possibly appropriate..." [Federal Register Vol. 56, No. 255].
FE: Federal Endangered: "...Any species that is in danger of extinction throughout all or a significant portion of its range" [Federal Register Vol. 56, No. 255].
FT: Federal Threatened: "...any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." (Endangered Species Act of 1973).

POTENTIAL FOR OCCURRENCE:
Unlikely – Suitable habitat for species does not exist within or near operable unit.
Low – Potential for occurrence due to habitat requirements but not found during field survey or not known to occur in general project area.
Moderate – Known to occur in habitat similar to project area or general area of operable unit.
High – Species observed during field survey or known populations exist near project area.

Note: Potential for occurrence sometimes given as a range due to variations in findings by different researchers at various times.

TABLE 4-13.—*Summary of Cultural Periods for the Central Pajarito Plateau*

	Cultural Period	Years	Characteristics
Prehistoric	Paleo-Indian Period	10,000 B.C. to 4,000 B.C.	Small groups of big game hunters who may have followed game herds along the Rio Grande, with trips onto the Pajarito Plateau to procure obsidian and other resources. This period is represented at LANL by occasional surface finds of diagnostic projectile points made from both local obsidian and exotic unidentified chert.
	Archaic Period	4,000 B.C. to A.D. 600	Small groups who may have used the Pajarito Plateau for hunting and for seasonal uses of certain wild plants. This period is represented at LANL as scatters of lithic tools, chipping debris, and diagnostic projectile points. Little research has been conducted for this period; it is possible that buried habitation sites are also present at LANL.
	Early Developmental Period	A.D. 600 to 900	Settled hunter-gatherers living in semi-subterranean pithouses and making simple pottery. Some possible pithouse locations and associated artifacts have been identified at LANL, but identification is tenuous.
	Late Developmental Period	A.D. 900 to 1100	Small groups of maize horticulturalists who also relied to a great extent on gathering wild plants. Sites are typically small adobe, sometimes crude masonry, pueblo structures. Very few sites from this period are at LANL; most of those recorded are located close to the Rio Grande in the vicinity of Chaquehui Mesa and Lower Water Canyon.
	Coalition Period	A.D. 1100 to 1325	Maize horticulturalists. Early sites are adobe and masonry rectangular structures, and later sites are large masonry enclosed plaza roomblocks of over 100 rooms. Most of the ruins recorded at LANL can be attributed to this time period; 700 ruins have been recorded. Some researchers attribute the increase in site density to migration while others see the increase in site numbers as a result of local population growth.
	Classic Period	A.D. 1325 to 1600	Intensive maize horticulturists. Settlements on the Pajarito Plateau aggregated into three population clusters with outlying one- to two-room fieldhouses. The central site cluster consists of four temporally overlapping sites: Navawi, Otowi, Tsankawi, and Tsirege. Otowi and Tsirege are at LANL. These ruins are ancestral to the Tewa speakers now living at San Ildefonso Pueblo.
Historic	Spanish Colonial and Territorial Periods	A.D. 1600 to 1900	Grazing and seasonal use of the Plateau during this time by non-Indian groups is highly probable but has not been thoroughly documented.
	Homesteading Period	A.D. 1890 to 1943	This was an outgrowth of the earlier undocumented use of the plateau for cattle grazing, timbering, and farming activities. Hispanic and Anglo homestead era sites are characterized by wooden cabin and corral structures, rock or cement cisterns, and scattering of debris associated with household and farming/grazing activities. In 1918 the Los Alamos Ranch School, a school for boys, was founded in present day Los Alamos.
	Post 1943	A.D. 1943 to Present	In the 1940s during the early stages of the Manhattan Project, many of the Los Alamos Ranch School buildings were appropriated for use by the U.S. Government. The central portion of the Pajarito Plateau is now owned by either the Federal government, Los Alamos County, San Ildefonso Pueblo, or by private citizens.

4.6.1 Prehistoric Archeological Resources

Three field surveys were conducted and a fourth is planned to determine the presence of archeological and historical cultural resources in the area of potential effects for the DARHT site. Each is described below. The first survey was conducted between June 1987 and November 1988 in the DARHT construction area and involved examination of 24.7 acres (10 ha). Three archeological sites were recorded in the construction area. Laboratory of Anthropology (LA) 71408, LA 71409 and LA 71410 (tables 4-14 and 4-15). The New Mexico State Historic Preservation Officer (NM SHPO) concurred that these sites were eligible for the National Register of Historic Places (NRHP) based solely on their research potential (Criterion D) in correspondence with the DOE dated February 21, 1989) (Merlan 1989). An additional archeological site was also discussed in this report, LA 12655, also known as "Nake'muu," and will be discussed below.

The second survey was conducted in the summer of 1992 as part of a larger survey conducted for the LANL Environmental Restoration (ER) Program site characterizations of TA -15, -16, and -49. The larger ER survey included areas within the 2,500-ft (750-m) hazard radius around the DARHT firing point. A total of 35 archeological sites have been located as a result of these two surveys. Thirty-two of these are eligible for nomination to the NRHP under criterion D (research potential), and one archeological site (Nake'muu) is also eligible under criterion C (excellent state of preservation) (tables 4-14 and 4-15). The remaining resources were recommended as not eligible for nomination to the NRHP because their research potential has been exhausted through data retrieval. Evaluations of potential effect for individual cultural resources and recommendations/concurrences for "determinations of no effect" and/or "determinations of no adverse effect" will be presented in chapter 5. The third survey was conducted on July 6, 1995, in the proposed vessel cleanout facility areas (figure 3-6) and no archeological sites were found.

A fourth survey is under way to identify cultural resources in the remaining unsurveyed areas within the 2,500-ft (750-m) radius. Additional archeological sites recorded in this survey are anticipated to be similar to those previously recorded as eligible for the National Register under criterion D. The evaluation of cultural resources identified in this survey will be coordinated with the NM SHPO for concurrence of eligibility determinations and potential effects.

The Nake'muu site, LA 12655, is an enclosed plaza pueblo located 1,100 ft (335 m) to the southwest from the DARHT Facility. Unique architectural features are still visible, making it eligible for NRHP nomination under both criteria D and C. The NM SHPO concurred in this determination in correspondence to the DOE dated February 21, 1989 (SHPO 1989). This site is an irregular-shaped pueblo of possibly 50 rooms. The site has been described as the best-preserved ruin in this region.

This site is unusual in that it is located at a high elevation, 7,175 ft (2,187 m), and is built on bedrock somewhat distant from agricultural resources as compared to other similar sites in the LANL area. Nake'muu is positioned on a high point of rocks above the junction of Cañon de Valle and Water Canyon, which at first appears to be for defensive purposes, yet the mesita above the ruin to the west allows easy access to it, and there is no sign of any defensive work west of the site (Larson 1988).

Assigning occupational dates to the Nake'muu site is difficult. Based on masonry style, which is notable for the large size of tuff masonry blocks and excellent workmanship, the ruin resembles other classic period sites on the Pajarito Plateau. The roomblock arrangement around a central plaza is also more typical of Classic Period ruins than of Early Coalition ruins. There is very little pottery on the surface of

TABLE 4-14.—*Archeology Sites within a 2,500-ft (750-m) Radius of the DARHT Firing Site*

Site Number[a,b]	Site Type	Tech Area	General Location	National Register Eligibility
Q 65	Artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
Q 76	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
Q 78	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 87	Rock shelter	15	Water Canyon	Eligible – Criterion D
Q 88	Water control structure	15	Mesita del Potrillo	Not eligible
Q 90	Artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
Q 91	Cavate	15	Water Canyon	Not eligible
Q 105	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
Q 111	Cavate	15	Water Canyon	Eligible – Criterion D
Q 112	Rock art	15	Water Canyon	Eligible – Criterion D
Q 113	Rock shelter	15	Water Canyon	Eligible – Criterion D
Q 114	Cavate	15	Water Canyon	Eligible – Criterion D
Q 140	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 142	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 146	Recent structure (Laboratory era)	15	Potrillo Canyon	Eligible – Criterion D
Q 147	Historic structure	15	Potrillo Canyon	Eligible – Criterion D
Q 159	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 4663	Single roomblock pueblo	15	Threemile Mesa	Eligible – Criterion D
LA 4664	Single roomblock pueblo	15	Threemile Mesa	Eligible – Criterion D
LA 4665	Enclosed plaza pueblo	15	Threemile Mesa	Eligible – Criterion D
LA 4667	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 4668	One- to three-room structure	15	Threemile Mesa	Not eligible (excavated)
LA 4669	One- to three-room structure	15	Threemile Mesa	Eligible – Criterion D
LA 12657C	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 12657D	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 12657E	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 12657F	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 12657G	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 89759	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 89760	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 71408	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D, SHPO concurrence
LA 71409	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D, SHPO concurrence
LA 71410	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D, SHPO concurrence
LA 12655	Nake'muu – enclosed plaza pueblo	15	Mesita del Potrillo	Eligible – Criteria C & D, SHPO concurrence

[a] LA - New Mexico Laboratory of Anthropology number; Q - LANL Field Number
[b] Certain sites are not listed as a result of consultations with Indian tribes, but are considered in the impact analysis. These consultations were conducted in accordance with AIRFA, NHPA, ARPA, and other cultural resources laws and regulations.

Source: Larson 1995

TABLE 4-15.—*Archeology Sites within a 2,500-ft (750-m) and 4,000-ft (1,250-m) Radius of the PHERMEX Firing Site*

Site Number[a]	Site Type	Tech Area	General Location	National Register Eligibility
2,500-ft Radius				
Q 77	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 4665	Enclosed plaza pueblo	15	Threemile Mesa	Eligible – Criterion D
LA 4668	One- to three-room structure	15	Threemile Mesa	Not eligible (excavated)
LA 4669	One- to three-room structure	15	Threemile Mesa	Eligible – Criterion D
LA 108732	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 108733	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 61	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 73	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 74	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 75	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 83	Artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
Q 84	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 85	Artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
Q 86	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 145	Rock shelter	36	Potrillo Canyon	Eligible – Criterion D
Q 155	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
W 15	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
W 16	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
W 19	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
LA 4667	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 108734	Rock shelter	15	Water Canyon	Eligible – Criterion D
LA 108735	Water control feature	15	Potrillo Canyon	Not eligible
LA 108736	Artifact scatter	15	Potrillo Canyon	Eligible – Criterion D
LA 108737	Cavate	15	Mesita del Potrillo	Not eligible
LA 108745	Historic structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 108746	Historic rockpile and artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
Q 62	Artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
Q 64	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
Q 66	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
Q 67	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
Q 69	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
Q 70	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
Q 72	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 92	Cavate	15	Water Canyon	Eligible – Criterion D
Q 138	Water control feature	15	Mesita del Potrillo	Not Eligible
Q 144	Rock art	36	Potrillo Canyon	Eligible – Criterion D
V 6	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
V 9	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
LA 4682	Enclosed plaza pueblo	15	Mesita del Potrillo	Eligible – Criterion D
LA 4683	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
LA 21366	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
LA 71408	Single roomblock pueblo	15	Water Mesa	Eligible – Criterion
LA 71410	One- to three-room structure	15	Water Mesa	D,SHPO Concurrence
LA 89759	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion

TABLE 4-15.—*Archeology Sites within a 2,500-ft (750-m) and 4,000-ft (1,250-m) Radius of the PHERMEX Firing Site – Continued*

Site Number[a]	Site Type	Tech Area	General Location	National Register Eligibility
LA 89760	One- to three-room structure	49	Frijoles Mesa	D,SHPO Concurrence
LA 108731	Artifact scatter	15	Mesita del Potrillo	Eligible – Criterion D
LA 108738	One- to three-room structure	15	Mesita del Potrillo	Eligible – Criterion D
LA 108739	Cavate	15	Water Canyon	Eligible – Criterion D
LA 108740	Rock Art	15	Water Canyon	Eligible – Criterion D
LA 108743	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
LA 108744	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
4,000-ft Radius				
Q 63	Artifact scatter	36	Mesita del Potrillo	Eligible – Criterion D
Q 68	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
Q 71	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
Q 79	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
Q 80	Water control feature	36	Mesita del Potrillo	Eligible – Criterion D
Q 81	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
Q 82	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
Q 137	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
Q 139	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
V 2	Water control feature	36	Mesita del Potrillo	Not Eligible
V 3	Water control feature	36	Mesita del Potrillo	Not Eligible
V 4	Water control feature	36	Mesita del Potrillo	Not Eligible
V 5	Water control feature	36	Mesita del Potrillo	Not Eligible
V 7	One- to three-room structure	36	Mesita del Potrillo	Eligible – Criterion D
V 12	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
V 13	Water control feature	36	Mesita del Potrillo	Not Eligible
V 14	Water control feature	36	Mesita del Potrillo	Not Eligible
LA 4664	Single roomblock pueblo	15	Threemile Mesa	Eligible – Criterion D
LA 4679	Single roomblock pueblo	36	Mesita del Potrillo	Eligible – Criterion D
LA 4680	One- to three-room structure	36	Mesita del Potrillo	Not eligible (excavated)
LA 4681	Single roomblock pueblo	15	Mesita del Potrillo	Eligible – Criterion D
LA 4686	One- to three-room structure	15	Mesita del Potrillo	Not eligible (excavated)
LA 4696A	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 4697A	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 4697B	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 12655A	Enclosed plaza pueblo	37	TA-16 Mesa	Eligible – Criterion C,SHPO Concurrence
LA 12657E	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 12657F	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 12657G	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 71409	Single roomblock pueblo	15	Water Mesa	Eligible – Criterion D,SHPO Concurrence
LA 89761	Artifact scatter	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89762	Cavate	49	Branch of Water Canyon	Potentially eligible – Crit. D
LA 89763	Rock shelter	49	Water Canyon	Potentially eligible – Crit. D
LA 108741	Rock shelter	15	Water Canyon	Eligible – Criterion D
Q 95	One- to three-room structure	15	Potrillo Canyon	Eligible – Criterion D
Q 96	Cavate	15	Potrillo Canyon	Eligible – Criterion D

TABLE 4-15.—*Archeology Sites within a 2,500-ft (750-m) and 4,000-ft (1,250-m) Radius of the PHERMEX Firing Site – Continued*

Site Number[a]	Site Type	Tech Area	General Location	National Register Eligibility
LA 4698	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 4698	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 4699	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 4699	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 12657	Single roomblock pueblo	49	Frijoles Mesa	Eligible – Criterion D
LA 12657	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 12657	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 13286	Cairn	15	Threemile Mesa	Not eligible (excavated)
LA 21322	Artifact scatter	36	Potrillo Canyon	Potentially eligible – Crit. D
LA 89736	Artifact scatter	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89738	Artifact scatter	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89739	Water control feature	49	Frijoles Mesa	Not Eligible
LA 89740	Artifact scatter	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89741	Artifact scatter	49	Frijoles Canyon	Potentially eligible – Crit. D
LA 89742	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 89744	Rubble Mound	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89745	Rubble Mound	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89746	Rubble Mound	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 89756	One- to three-room structure	49	Frijoles Mesa	Eligible – Criterion D
LA 89757	Artifact scatter	49	Frijoles Mesa	Potentially eligible – Crit. D
LA 108742	Cavate	15	Water Canyon	Eligible – Criterion D

[a] LA - New Mexico Laboratory of Anthropology number; Q - LANL Field Number.

Source: Larson 1995

the site. It is possible that trash was thrown over the steep canyon walls, leaving very little in the way of datable material immediately near the site (Larson 1988). The fourth survey will investigate the area in Water Canyon and Cañon de Valle below Nake'muu and will resurvey the mesa where Nake'muu is located in an effort to find additional cultural material that can be used to establish the dates of occupation for the pueblo.

LA 71408 and LA 71409 are located outside the construction zone proper, but early plans for the facility placed the access road adjacent to the sites. The access road was re-sited in 1989 to avoid contact with the site boundaries, and the two sites were fenced to protect them from any accidental disturbance during construction work. The NM SHPO, in correspondence to the DOE dated February 21, 1989, stated satisfaction "... that adequate consideration has been given to measures to avoid adverse effects to the recorded sites." (Merlan 1989)

LA 71410 is located in the construction zone under the earth berm to the north of the firing point. Realignment of the berm in order to avoid disturbing this archeological site would have exposed Nake'muu to more potential debris from blasting (see chapter 5 for a full discussion). At the request of the Pueblo San Ildefonso (Torres 1994) and with the concurrence of the NM SHPO (Merlan 1994), LA 71410 was thoroughly recorded and then capped with clean earth on April 26, 1994, and buried several days later under the earth berm.

4.6.2. Historical Resources

There are two Manhattan Project/Early Cold War buildings in the 2,500-ft (750-m) radius which are potentially eligible for inclusion on the NRHP under criterion A: Control Chamber B (TA-15-9) and Firing Pit H/Camera Chamber (TA-15-92). The PHERMEX Facility itself, although not 50 years old, is also potentially eligible for NRHP inclusion because of its association with the Cold War. A thematic NRHP nomination of LANL structures associated with the Manhattan Project and the Cold War Era is ongoing.

4.6.3. Native American Cultural Resources

Cultural resources are of special importance to Native Americans. Those resources, located on LANL, may consist of prehistoric sites with ceremonial features such as kivas, village shrines, petroglyphs, or burials, or may consist of traditional cultural properties with no observable man-made features. Figure 4-19 shows the locations of Native American reservations in the immediate vicinity of LANL. Consultations with local Native Americans to identify any such cultural resources have been conducted in the past and are currently ongoing. These consultations will continue, as appropriate, throughout the life of activities at DARHT and PHERMEX.

In the spring of 1993, consultations with San Ildefonso Pueblo were renewed. On December 6, 1993, a tribal representative visited LA 71410, LA 714108, and LA 71409 to discuss mitigation alternatives for LA 71410. A copy of the 1988 cultural resource survey report was given to this representative to present to the tribal council. On January 27, 1994, the DOE sent a copy of the cultural resource survey report and all relevant SHPO consultation to the governor of San Ildefonso Pueblo and specifically asked for recommendations for mitigation of LA 71410. Council representatives visited LA 71408, LA 71409, and LA 71410 on February 7, 1994. Another copy of the original 1988 cultural resource survey report was sent on February 11, 1994, to the governor of San Ildefonso Pueblo, the Native American group with the most direct claim to descent from the prehistoric inhabitants of what is now TA-15. No response was received. Representatives from San Ildefonso Pueblo, Jemez Pueblo, and Cochiti Pueblo were given a briefing on the DARHT project on December 2, 1994, and visited Nake'muu as well as LA 71408 and LA 71409 (LA 71410 had already been buried beneath the earth berm). Native American input on possible effects to unidentified traditional cultural properties was requested during this visit. During May, June, and July of 1995, DOE consulted with representatives of the four Accord Tribal governments (San Ildefonso, Santa Clara, Jemez, and Cochiti) on the content of the draft EIS, specifically in regard to the provisions of AIRFA. Numerous comments on the draft were recorded from the Tribal governments. In particular, concerns regarding the identification of archeological and cultural resources in the draft EIS were resolved through changes in this final EIS. DOE will continue to consult with the four Accord tribes on a government-to-government basis to ensure protection of traditional cultural properties.

4.6.4 Paleontological Resources

No paleontological sites are reported on Threemile Mesa, and the near-surface stratigraphy is not conducive to preserving plant and animal remains. These near-surface materials are volcanic ash and

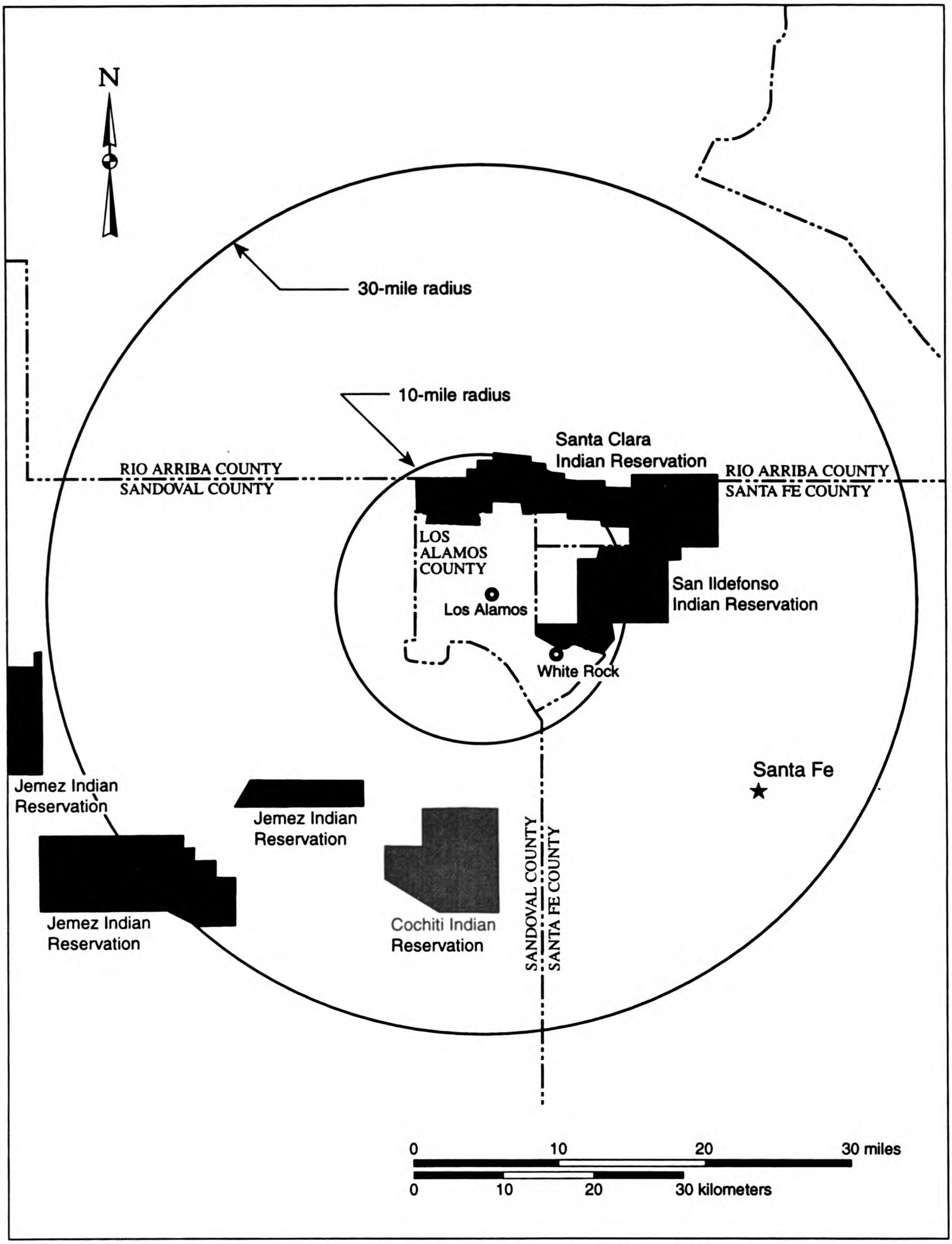


FIGURE 4-19.—*Locations of Indian Reservations of Four Pueblo Tribes in Accord with LANL and DOE.*

pumice that may have been hot when deposited. Occasionally, some charcoal is found at the base of an ashfall. The deposits date mostly from about one million years ago and have a total thickness of about 750 ft (229 m).

4.7 SOCIOECONOMIC ENVIRONMENT

Any major changes in activities undertaken at LANL have the most immediate socioeconomic effects on LANL employees and their respective communities. These communities are located throughout Los Alamos, Santa Fe, and Rio Arriba counties in north-central New Mexico (see figure 4-1). The LANL Office of Community Relations estimates that 91.6 percent of the LANL employees reside in this tri-county region (LANL 1994c). Furthermore, the U.S. census estimated that 95.6 percent of the Los Alamos County workforce resided in this tri-county region in 1990 (Bureau of the Census 1994). Based on both considerations, any major changes in activities at the LANL site would potentially have their most immediate socioeconomic effects on residents in this tri-county region. A description of this affected environment is provided in the following sections based on a summary of its demographic, economic, and social characteristics.

4.7.1 Demographic Characteristics

The predominant population in the region-of-interest is white caucasian with 50.1 percent having Hispanic ethnic background (see table 4-16). Native Americans residing in Los Alamos, Rio Arriba, and Santa Fe counties account for 5 percent of the general population. Extending this region to include Sandoval county increases the percentage of Native Americans to just under 10 percent of the greater general population. The Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara are important centers of these Native American populations.

Some 62.5 percent of the total population in the tri-county region is between the ages of 18 and 65. Approximately 80.7 percent of this population has completed high school, and 30.5 percent has attained a baccalaureate degree or higher. A significant difference exists in educational attainment levels within the region, as evidenced by Los Alamos and Rio Arriba counties.

The median and per capita income levels of the population in the region were $30,408 and $14,538 in 1990. While both of these income levels are close to their respective state averages of $27,623 and $14,254, there are very significant differences in income levels among the various counties. At the time of the 1990 Census, it was estimated that 15 percent of the tri-county residents fell below official poverty thresholds. Poverty thresholds vary by size of family and number of related children under 18 years (Bureau of the Census 1990). For example, in 1989, $14,990 was the official poverty threshold for a family of five persons.

4.7.2 Economic Base

This section summarizes the economic base of the tri-county region. An overview of the economic base is shown in figure 4-20 in terms of income and expenditure flows between LANL, households, businesses, and governments.

TABLE 4-16.—*Demographic Profile of the Population in the Tri-County Region-of-interest*

Parameters	Los Alamos	Santa Fe	Rio Arriba	Regional Total
Total Population (1990)	18,115	98,928	34,365	151,408
Households (1990)	7,213	37,840	11,461	56,514
Persons per Household (1990)	2.50	2.54	2.97	2.67
Race (1990) – Percent of Total Population				
White	94	80	70	79
Black	1	1	1	1
Native American	1	3	15	5
Asian	2	1	1	1
Other	2	15	13	14
Ethnicity (1990)				
Hispanic	2,008	48,939	24,955	75,902
Percent of total population	11.1	49.5	72.6	50.13
Ages (1990)				
Percent under 18	26.0	26.0	32.4	27.6
Percent 65 and over	9.2	10.1	9.7	9.90
Education (1990) – Persons 25 years and older				
Percent High School Graduate or Higher	94.7	82.6	65.9	80.7
Percent Bachelor's Degree or Higher	53.4	32.3	10.3	30.5
Income (1989)				
Median Household Income ($)	54,801	29,403	18,373	30,408
Per Capita Income ($)	22,900	15,327	7,859	14,538
Percent of Persons Below Poverty Line	2.4	13.0	27.5	15.0

Source: Bureau of the Census 1994

LANL is the largest employer in the tri-county region. Its *direct* economic impact on the tri-county region is significant even after deducting procurement and wage/salary payments made outside the tri-county region – denoted as leakage(s). For FY 1993, the LANL payroll for the tri-county region was $450 million for 7,256 full-time personnel (LANL 1994c). During the same year, LANL spent approximately $220 million in procurement in the tri-county region (LANL 1994c). Therefore $670 million ($450 + $220) in direct income was available for households and businesses to make additional purchases of products and services within or outside the tri-county region. A description of employment and wage earnings by economic sector within the tri-county region is provided in table 4-17.

The average annual employment in the tri-county region during CY 1993 covered 71,776 workers who earned a total of $1.82 billion in wages (New Mexico State Department of Labor 1994). At the sectoral

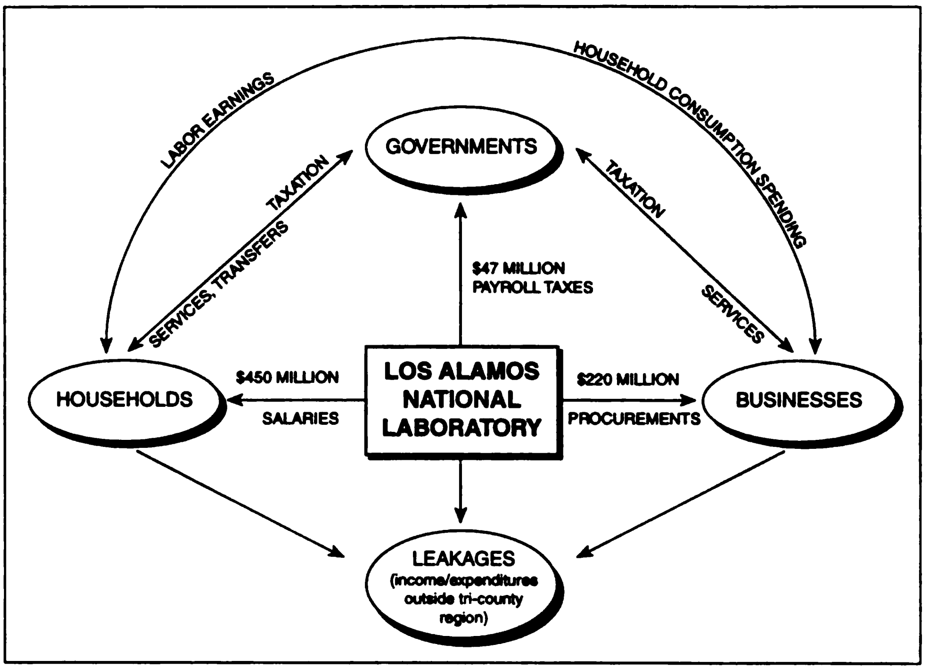


FIGURE 4-20.—*Income and Expenditure Flows from LANL to Businesses, Households, and Governments for FY 1993.*

level, employment and wages were highest in the service, State or Federal Governments (including LANL), and gross trade sectors of the regional economy. Together these sectors accounted for 76 percent of the employment and 79 percent of the wages in the regional economy. Meanwhile, the unemployment rate for the tri-county region as a whole was 5.5 percent.

The sectoral patterns of employment and wages are significantly different from county to county. Employment and wages during 1993 were highest in Santa Fe, followed by Los Alamos and Rio Arriba counties. Meanwhile, the unemployment rate in Rio Arriba County during 1993 was nearly three times that of Santa Fe County and more than five times that of Los Alamos County.

The flow of income and expenditures from LANL also generates direct State and local tax revenue. In FY 1993, LANL paid $41 million in payroll taxes and $6 million in additional tax payments within the tri-county region. Consequently, significant changes in the level of LANL activities could potentially affect government tax revenues, payments, and services in the tri-county region.

The operating costs associated with PHERMEX for FY 1994 were about $3.5 million. The allocation for FY 1995 is $4.2 million. These annual costs are considered reasonably typical. This funding provides support for operating personnel, physics support, clearance staff, firing crew, fire department, LANL's facility space tax, contractor support, facility scheduling, and a safety and environmental compliance program. Contractor support includes janitorial services, routine maintenance, minor upgrades, and firing point cleanup. DOE has invested about $1 million per year in maintenance, minor upgrades, and replacement parts for PHERMEX. This would be expected to increase each year as long as the facility is operated. The current amount is less than 0.2 percent of LANL's total annual expenditures.

TABLE 4-17.—*1993 Employment and Wage Profile in the Tri-County Region-of-interest*

Economic Sectors	Santa Fe		Los Alamos		Rio Arriba		Total	
	Employment	Total Wages (in millions)	Employment	Total Wages (in millions)	Employment	Total Wages (in millions)	Employment	Total Wages (in millions)
Agriculture	364	$ 6.08	28	$ 0.42	59	$ 0.55	451	$ 7.05
Construction and Mining	3,120	65.57	170	2.90	382	6.87	3,672	75.34
Manufacturing	2,016	48.24	63	1.27	315	5.01	2,394	54.52
Transportation and Utilities	1,056	26.18	66	1.29	268	8.37	1,390	35.84
Trade	12,725	190.80	1,236	19.40	1,480	18.50	15,441	228.70
F.I.R.E.	2,311	69.21	341	8.38	216	3.96	2,868	81.55
Services	13,520	281.33	4,424	133.38	2,331	35.76	20,275	450.47
Government								
Federal	1,510	51.54	190	7.38	455	11.96	2,155	70.88
State	9,104	225.84	157	1.88	493	9.87	9,754	237.59
LANL	NA	NA	7,256	450.00	NA	NA	7,256	450.00
Local	3,613	75.27	1,081	29.55	1,426	25.89	6,120	130.71
Totals	49,339	$1,040.06	15,012	$ 655.85	7,425	$ 126.74	71,776	$1,822.71
Percent Unemployment	4.9		2.1		11.8		5.5	

Sources: The covered employment and wage figures presented here are based on counts of employees covered under the New Mexico Unemployment Compensation Law, consistent with the ES-202 series reported to the U.S. Bureau of Labor and Statistics (New Mexico Department of Labor 1994). The reported unemployment figures are published by the U.S. Department of Census (Bureau of the Census 1994). Note that the employment and wage data are based on survey data by place of residence while the unemployment data is based on survey information reported by place of work.

4.7.3 Community Infrastructure and Social Services

This section describes community infrastructure and social services within the tri-county region. Table 4-18 lists the status of occupied and vacant housing units in the tri-county region and the number of new private housing units authorized by building permits for the period 1990-1992 (Bureau of the Census 1994).

In 1990, the tri-county region contained a total of 63,386 housing units, of which 40,206 were owner-occupied and 16,308 were renter-occupied. The median value of owner-occupied units was $126,100 in Los Alamos County, which is higher than both other counties in the region. The median gross rent was lowest in Rio Arriba County and about the same in both Los Alamos and Santa Fe Counties. Coincidentally, the vacancy rate was lowest in Los Alamos County and highest in Rio Arriba County. Santa Fe County appeared to be the fastest growing county in the region, as measured by the number of new housing permits issued during the period 1990 to 1992 relative to the existing housing stock in 1990.

TABLE 4-18.—*Status of Housing Infrastructure by County in the Region-of-interest*

Criteria	Los Alamos	Santa Fe	Rio Arriba	Total
Total housing units (1990)	7,565	41,464	14,357	63,386
Occupied Units	7,213	37,840	11,461	56,514
Owner occupied (1990)	5,367	25,621	9,218	40,206
Percent owner occupied (1990)	74.4	67.7	80.4	71
Median value (1990)	$126,100	$103,300	$58,800	NA
Renter occupied (1990)	1,846	12,219	2,243	16,308
Median gross rent (1990)	$467	$489	$285	NA
Vacant units (1990)	352	3,624	2,896	6,872
Vacancy rate	4.7	8.7	20.2	10.8
New housing building permits (1990-1992)	119	1188	28	1,335
Percent of 1990 housing stock	1.6	2.9	0.2	NA

Source: Bureau of the Census 1994

Community infrastructure is further defined by education and health-care infrastructure in the tri-county region. Each county government provides its own public education and health-care services. Table 4-19 lists the status of these two elements by county.

In 1990, student enrollment totaled 40,414 in selected school districts throughout Los Alamos, Santa Fe, and Rio Arriba counties (Bureau of the Census 1994). These students attended 102 schools within the tri-county region (New Mexico State Department of Education 1994). Similarly, health care services and facilities are heavily concentrated in Santa Fe County relative to the other two counties in the region.

4.7.4 Environmental Justice

Under Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, Federal agencies are responsible for identifying and addressing the possibility of disproportionately high and adverse health and environmental impacts of programs and activities on minority and low-income populations. Hereafter, minority populations refer to all people of color, exclusive of white non-Hispanics. Low-income populations refer to household incomes below $15,000 per year. Figures 4-21 through 4-24 illustrate the percentages of minority populations and low-income households within a 10-, 30-, and 50-mi (16-, 48-, and 80-km) radius of the site. This area spans portions of Los Alamos, Rio Arriba, Santa Fe, and Sandoval counties.

Figure 4-21 also illustrates that a relatively small proportion of Hispanics or Native Americans live within a 10-mi (16-km) radius. A much larger concentration of minority populations resides between 10, 30, and 50 mi (16, 48, and 80 km) from the site (figures 4-21 and 4-22). Table 4-20 describes the geographic distribution of these minority populations in relation to distance from the site. Of a total population of 18,115 persons living within a 10-mi (16-km) radius of the proposed site, minorities account for 14 percent of the population. In contrast, minorities account for 65 percent of the general population

TABLE 4-19.—*Education and Health Care Infrastructure by County in the Region-of-interest*

Criteria	Los Alamos	Santa Fe	Rio Arriba	Total
Total School Enrollment[a] (1990)	5,020	25,743	9,651	40,414
College (1990)	1,288	6,727	1,808	9,823
Elementary or high school (1990)	3,236	17,363	7,316	27,915
Percent public (1990)	96.2	90.6	91.7	
Number of Schools[a] (1994)	12	67	23	102
Public (1994)	7	25	14	46
Private (1994)	5	42	9	56
Community Hospitals (1990)	1	1	1	3
Number of beds (1990)	53	226	54	333
Number of physicians (1990)	42	228	26	296

[a] The figures presented are for county school districts. Only in the case of Los Alamos County are they comparable to the county-wide figures.

Source: The figures on pupil enrollment and health care services are from the U.S. Census County Data Book, 1994 (Bureau of the Census 1994). The figures on number and composition of schools in the county districts are from the New Mexico State Department of Education (1994).

living 10 to 30 mi (16 to 48 km) from the site. The overall percentage of minorities within 30 and 50 mi (48 and 80 km) from the site exceeds the white non-Hispanic segment of the population.

Table 4-21 and figures 4-23 and 4-24 provide similar descriptions of the concentration of low-income households within 10, 30, and 50 mi (16, 48, and 80 km) of the site. Of a total of 55,411 households in the 30-mi (48-km) radius, 13,536 (24 percent) had incomes below $15,000. However, the number of these relatively low-income households increases sharply beyond the 10-mi (16-km) radius. Only 581 (2 percent) households had incomes below $15,000 within 10 mi (16 km) from the site while 12,995 (23 percent) households had equally low incomes between 10 and 30 mi (16 and 48 km) from the site. Within a 50-mi (80-km) radius of the site, 18,519 (24 percent) households had annual incomes of $15,000 or less in 1990.

4.8 RADIOLOGICAL AND CHEMICAL ENVIRONMENT

This section describes the radiological and chemical environments at LANL and Area III.

4.8.1 Regional Environment

The regional study area for the radiological and chemical environment includes LANL and a number of sampling stations up to approximately 20 mi (30 km) from LANL. LANL routinely monitors for radioactive and nonradioactive pollutants on LANL sites and in the surrounding region.

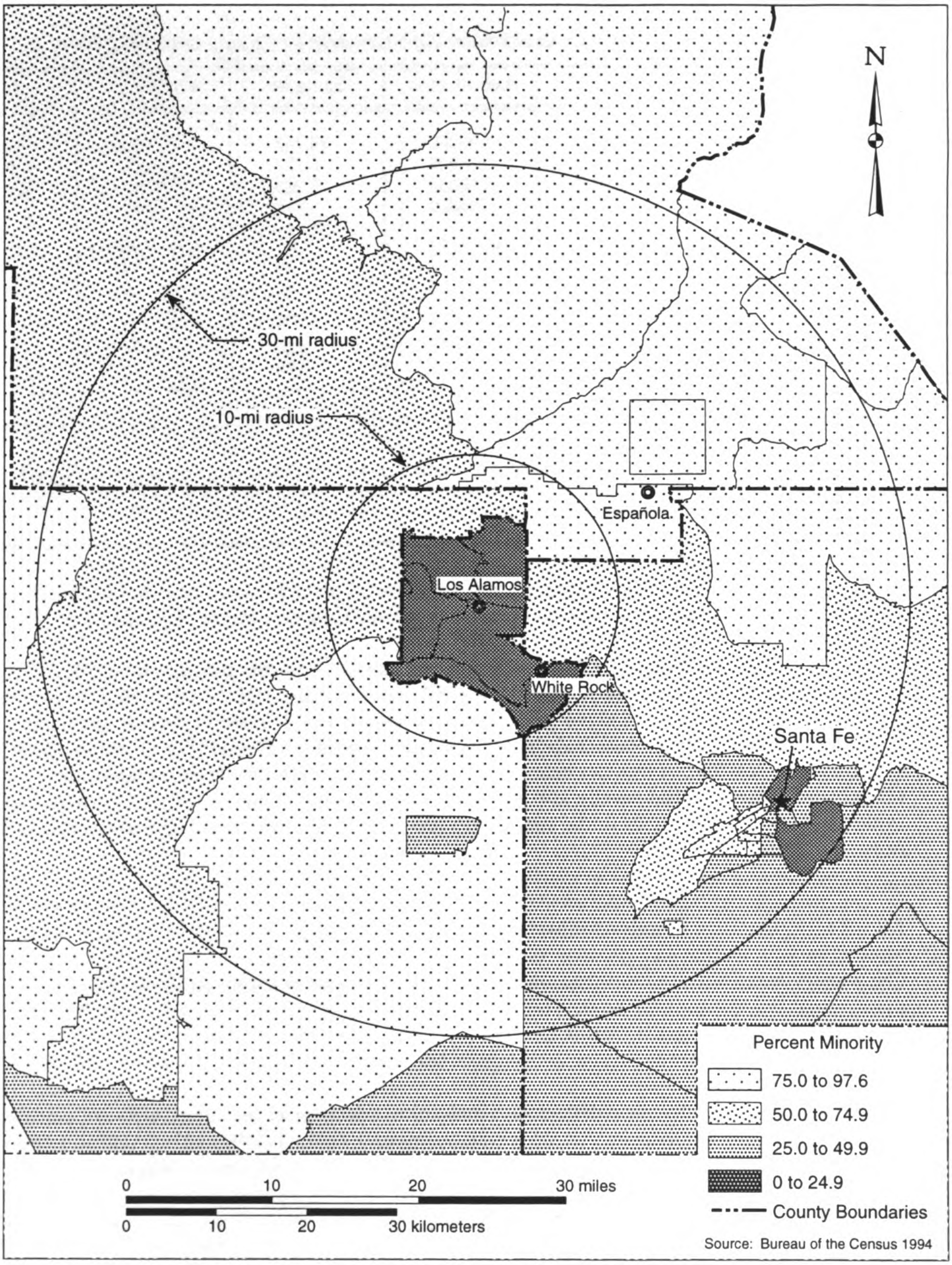


FIGURE 4-21.—*Distribution of Minority Population within a 30-mi (48-km) Radius of the DARHT Site.*

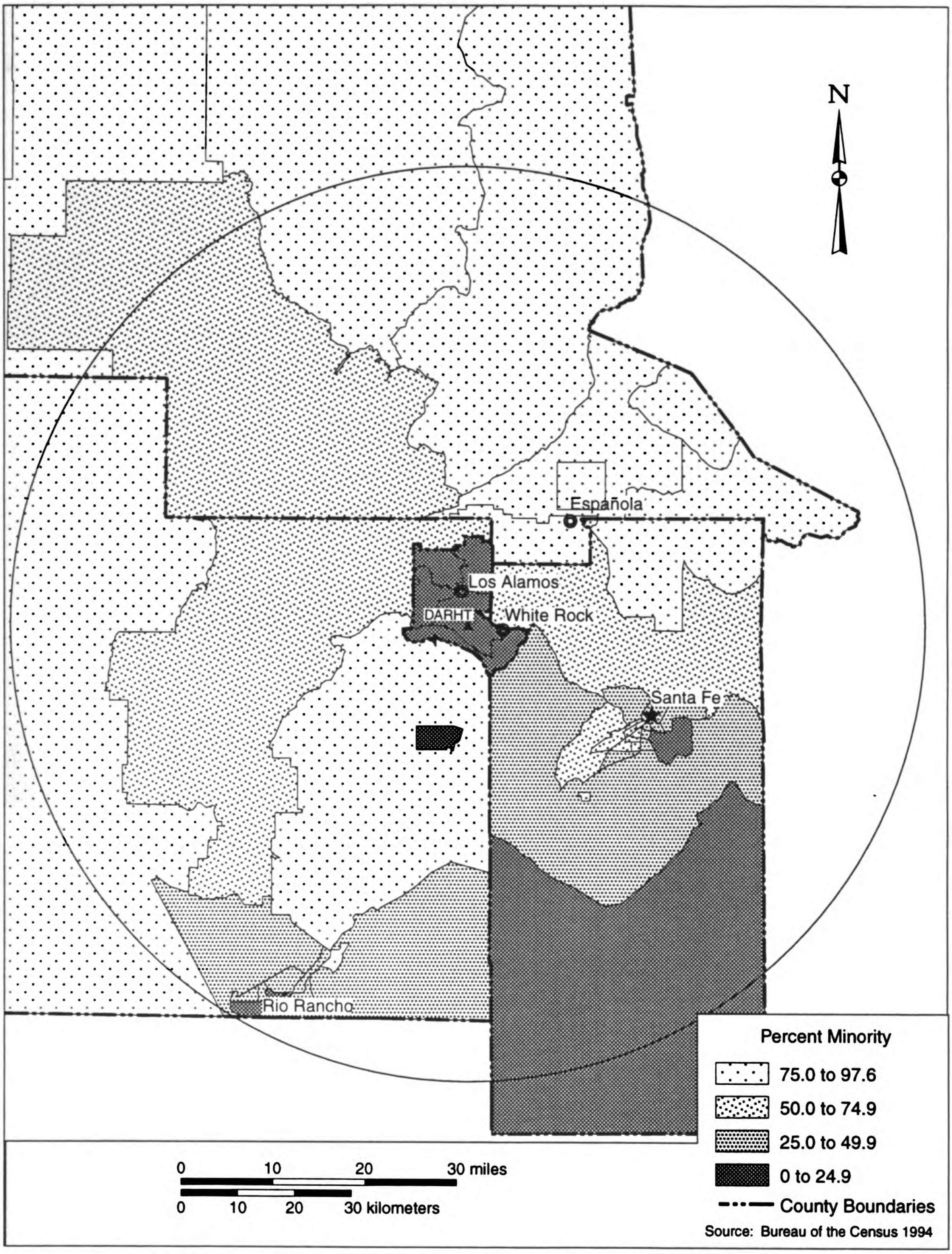


FIGURE 4-22.—*Distribution of Minority Population within a 50-mi (80-km) Radius of the DARHT Site.*

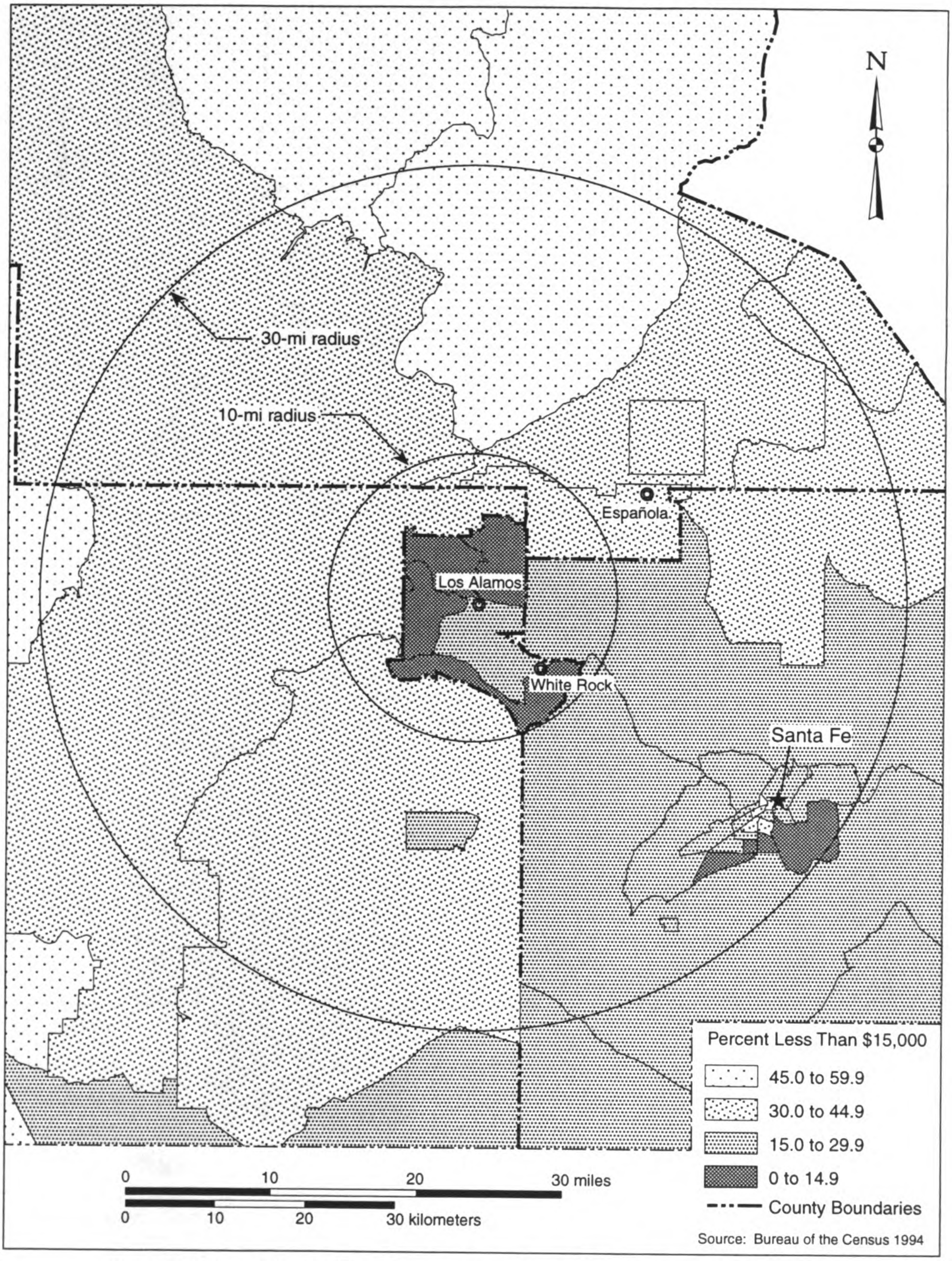


FIGURE 4-23.—*Distribution of Low-income Population within a 30-mi (48-km) Radius of the DARHT Site.*

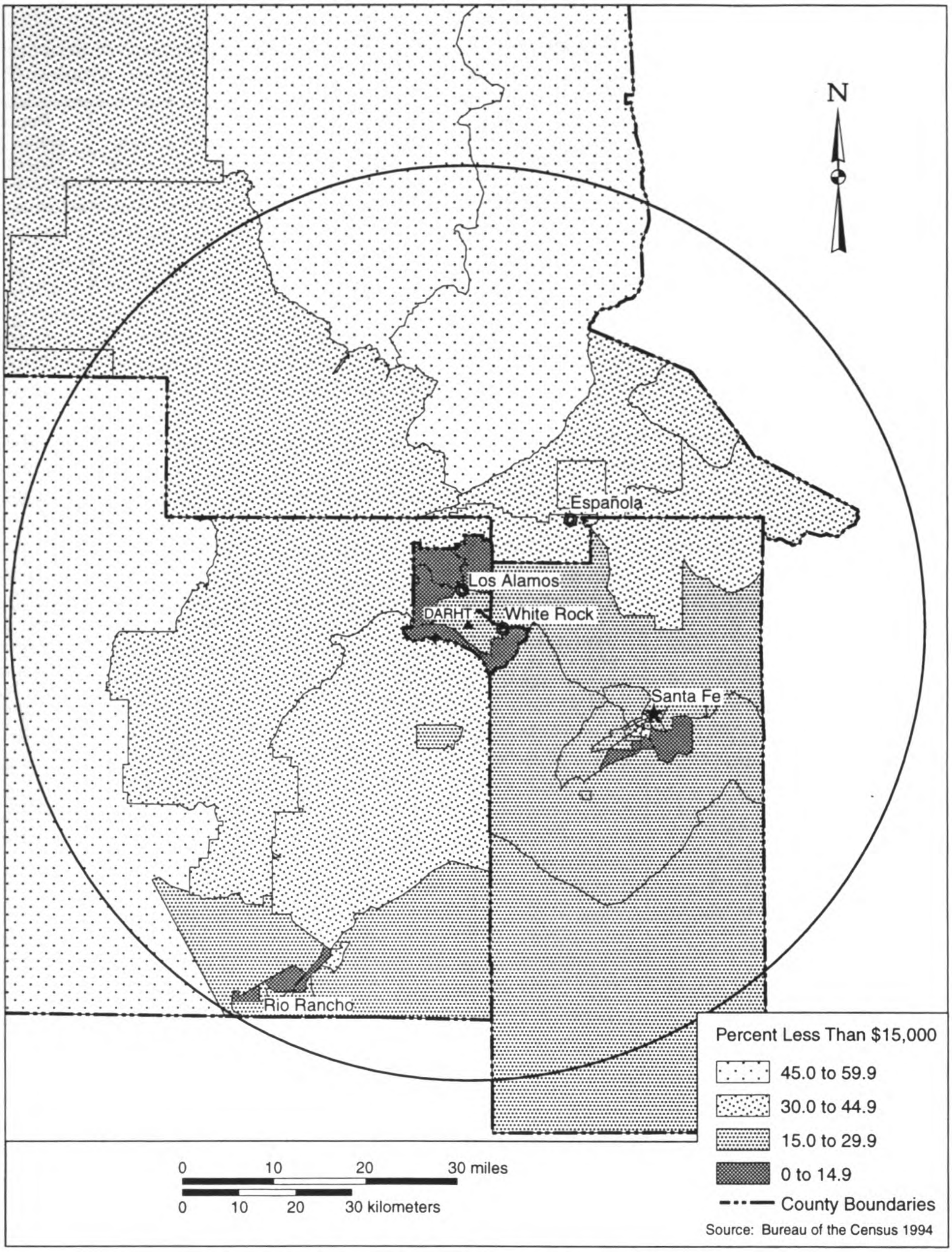


FIGURE 4-24.—*Distribution of Low-income Population within a 50-mi (80-km) Radius of the DARHT Site.*

TABLE 4-20.—*Distribution of Population by Ethnicity within a 50-mi (80-km) Radius of the DARHT Site*

Population Group	Population within a 10-mi (16-km) Radius of the Site	Population within a 10- to 30-mi (16- to 48-km) Radius of the Site	Population within a 30-mi (48-km) Radius of the Site	Population within a 50-mi (80-km) Radius of the Site
Total	18,115	133,028	151,143	214,727
Total Nonminority	15,556	47,059	62,615	99,257
Total Minority	2,559	85,969	88,528	115,470
Hispanic Origin	1,933	72,470	74,403	92,954
Native American	154	12,368	12,522	19,421
Other Minority	472	1,131	1,603	3,095
Percent Minority	14	65	59	54
Percent Nonminority	86	35	41	46

Source: Bureau of the Census 1994

TABLE 4-21.—*Distribution of Population by Income within a 50-mi (80-km) Radius of the DARHT Site*

Income Class	No. of Households within a 10-mi (16-km) Radius of the Site	No. of Households within a 10- to 30-mi (16- to 48-km) Radius of the Site	No. of Households within a 30-mi (48-km) Radius of the Site	No. of Households within a 50-mi (80-km) Radius of the Site
Total Households	7,211	48,200	55,411	77,448
< $15,000	581	12,955	13,536	18,519
$15,000 to $24,999	597	9,582	10,179	14,531
$25,000 to $34,999	704	7,694	8,398	12,983
$35,000 to $49,999	1,281	7,943	9,224	13,600
$50,000 to $74,999	2,092	6,389	8,481	11,283
$75,000 to $99,999	1,219	1,792	3,011	3,572
$100,000 or more	737	1,845	2,582	2,960

Source: Bureau of the Census 1994.

4.8.1.1 Radiological

Many of the activities that take place at LANL involve handling radioactive materials and operating radiation-producing equipment. Radiological doses are calculated to estimate the potential health impacts of any releases of radioactivity to the public. Standards exist which limit the maximum effective dose equivalent (EDE) to the public. The DOE's public dose limit (PDL) is 100 mrem/yr EDE received from all pathways, and EPA restricts the EDE received by air to 10 mrem/yr. These values are in addition to those from normal background, consumer products, and medical sources, which total about 300 to 350 mrem/yr. Both standards apply to locations of maximum probable exposure to an individual in an offsite, uncontrolled area.

EPA-approved methods were used to calculate radiation doses to the public from LANL emissions and demonstrate compliance with National Emissions Standards for Hazardous Air Pollutants (NESHAP) requirements [40 CFR 61]. EPA-approved methods do not allow LANL to take into account shielding or occupancy standards. In 1992, that EDE was 7.9 mrem, which is in compliance with EPA standards of 10 mrem/yr from the air pathway (DOE 1993b). However, in 1990, the Los Alamos Meson Physics Facility (LAMPF) at LANL exceeded the EPA annual standard for radionuclide emissions and was cited. The maximum probability of a latent cancer fatality from such a dose would be 4×10^{-6}. The estimated maximum EDE resulting from LANL operations in 1993 was 5.6 mrem (DOE 1994). Thus, 1992 is considered a representative year for recent LANL operations. The 1993 EDE shows a reduction which may be indicative of DOE's change in mission which halted production of weapons.

DOE directs use of site-specific input data, where available, and realistic dose calculation estimates for annual site environmental reporting. In 1992, the estimated maximum EDE resulting from LANL operations was 6.1 mrem, taking into account shielding by buildings (30 percent reduction) and occupancy (100 percent for residences, 25 percent for businesses). The maximum probability of a latent cancer fatality from such a dose would be 3×10^{-6}. This dose is 6 percent of DOE's 100 mrem/yr PDL for all pathways (LANL 1994a). Approximately 95 percent of the dose (DOE 1993b) was from external radiation from short-lived, airborne emissions from a linear particle accelerator at LAMPF.

In 1992, the annual collective dose to the population from operations at LANL was 1.4 person-rem. No latent cancer fatalities (7×10^{-4} LCFs) would be expected among the members of the population. Table 4-22 presents a comparison of the 1992 annual EDEs with DOE dose limits and background values. The estimated maximum EDE from LANL operations is less than 2 percent of the 346 mrem received from background radiation and other sources in Los Alamos during 1992 (figure 4-25).

LANL measures environmental external penetrating radiation (including x-rays, gamma rays, and charged-particle contributions from cosmic, terrestrial, and LANL sources) with thermoluminescent dosimeters (TLDs) at 166 locations within three independent networks, including 4 regional and 23 perimeter offsite locations (Jacobson 1995 and LANL 1994a). The locations of these networks are onsite at LANL and offsite (perimeter and regional) at the LANL boundary north of the LAMPF, and at low-level radioactive waste management areas as shown in figure 4-26 (LANL 1994a). The natural terrestrial components are primarily from the decay of potassium-40 and the radionuclides in the decay chains of thorium and uranium. In 1992, the annual average TLD measurement taken from offsite regional stations was 102 mrem. This offsite average was generally the same as the average TLD measurement taken from perimeter stations and onsite stations which averaged 119 mrem and 128 mrem, respectively (LANL 1994a). The average dose at the Frijoles Mesa station, which is the closest station to PHERMEX, was 119 mrem.

Samples of foods (produce, fish, and honey) are collected and analyzed for radioactivity in an effort to monitor potential contamination in the food chain resulting from LANL operations (figure 4-27). The two main objectives of the foodstuffs monitoring program are to:

TABLE 4-22.—*Comparison of 1992 Annual Effective Dose Equivalents Near LANL Operations with Dose Limits and Background*

Criteria	Maximum Individual Dose[a]	Average Dose to Nearby Residents		Collective Dose[b]
		Los Alamos	White Rock	
Dose Attributable to LANL	6.1 mrem	0.12 mrem	0.11 mrem	1.4 person-rem
Location	Residence north of TA-53	—	—	Area within 50 mi (80 km) of LANL
Natural Background	340 mrem	340 mrem	327 mrem	72,000 person-rem
DOE Public Dose Limit	100 mrem	—	—	—
Percentage of Public Dose Limit	6.1	0.12	0.11	—
Percentage of Background	2	0.04	0.03	0.002

[a] The maximum individual dose to any individual at or outside LANL at sites where the highest dose rate occurs (the location of the maximum exposed individual [MEI]). Calculations take into account occupancy (the fraction of time a person is actually at that location) and shielding by buildings, as specified by the DOE 5400.5 for calculating public dose limits (PDL).
[b] Collective dose to population within 50 mi (80 km) of LANL.
[c] This value includes a radon contribution on the order of 200 mrem, but such a value can vary considerably.

Source: LANL 1994a

- Compare levels of radionuclides in foodstuffs collected from offsite regional (background) areas to levels in foods collected from LANL and perimeter areas
- Calculate any additional radiation dose to LANL and area residents (Los Alamos and White Rock) based on the data collected.

The data also are compared to radiation protection standards recommended by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements (LANL 1994a).

In 1992, surface- and bottom-feeding fish were collected upstream of LANL at Abiqui, Heron and/or El Vado reservoirs, and downstream of LANL at Cochiti reservoir to determine tissue radiation levels. The mean total uranium level in the surface-feeding fish was 1.2±1.5 (2σ) ng/dry g for the upstream reservoirs and 5.4±18.6 (2σ) ng/dry g for the downstream reservoir. In the bottom-feeding fish, the mean total uranium level was 5.2±8.0 (2σ) ng/dry g for the upstream reservoirs and 8.8±6.4 (2σ) ng/dry g for the downstream reservoir (Fresquez et al. 1994a).

Elk *(Cervus elaphus)* spend the winter in areas at LANL that may contain radioactivity above natural and/or worldwide fallout levels. A LANL study found no significant differences in radionuclide contents in any tissue samples collected from elk on LANL lands compared with elk collected from offsite locations (Fresquez et al. 1994b).

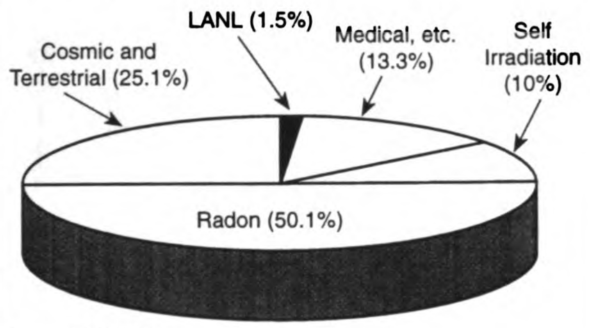


FIGURE 4-25.—*Components of the 1992 Effective Dose Equivalent (EDE) at LANL's Maximum Exposed Individual (MEI) Location.*

TABLE 4-23.—*Background Concentrations of Selected Elements in Soils at LANL*

Element	All Soils and Fracture Fill Materials (ppm)[a] Mean	Horizon A[b] Concentration (ppm)[a]
Be	1.23 2.37[c]	0.71
Cu	6.6	6.5
Pb	16.7 28.36[c]	15.8
U	0.94	0.9

[a] Using SW846 – An EPA toxicity characteristic leaching procedure test method.
[b] Horizon A is the uppermost soil horizon characterized during background investigation.
[c] Hydrofluoric acid used in sample dissolution.

Source: Longmire 1994

4.8.1.2 Chemical

The regional chemical environment is described by background chemical data for soils and the LANL activities that may produce hazardous/toxic wastes. Some activities at LANL use chemicals that may present a significant risk to humans and the environment.

Recent background chemical data for soils collected at Los Alamos are shown in table 4-23. These data were collected from soils, which may have application for fill or reworked unconsolidated material found at the townsites and other disturbed areas of LANL. Table 4-23 contains chemical data for all soils and fracture fill material and chemical data from the A horizons, the uppermost soils found on the Pajarito Plateau at LANL.

4.8.2 Local Environment

This section describes the local radiological and chemical environment.

4.8.2.1 Radiological

In 1992, PHERMEX operations contributed less than 1 percent of the total dose from LANL operations to the maximally exposed members of the public from LANL operations. The annual collective dose to the population from operations at PHERMEX was approximately 0.1 person-rem. No latent cancer fatalities (5×10^{-5} LCFs) would be expected among the members of the population.

PHERMEX is an insignificant contributor to environmental levels of tritium. Honey samples are periodically collected and analyzed for radioactivity in an effort to monitor potential contamination in the food chain resulting from TA-15 operations. Tritium levels in honey collected from TA-15 from 1979 to 1993 ranged from 0.5 to 26.0 (± 6.0) pCi/mL (Fresquez et al. 1995).

The soil around PHERMEX is contaminated with materials that were part of the experiments that used high explosives. DOE has conducted studies, including aerial surveys using helicopters and soil-sampling surveys, that indicate that elevated levels of depleted uranium are found on the firing point (Fresquez and

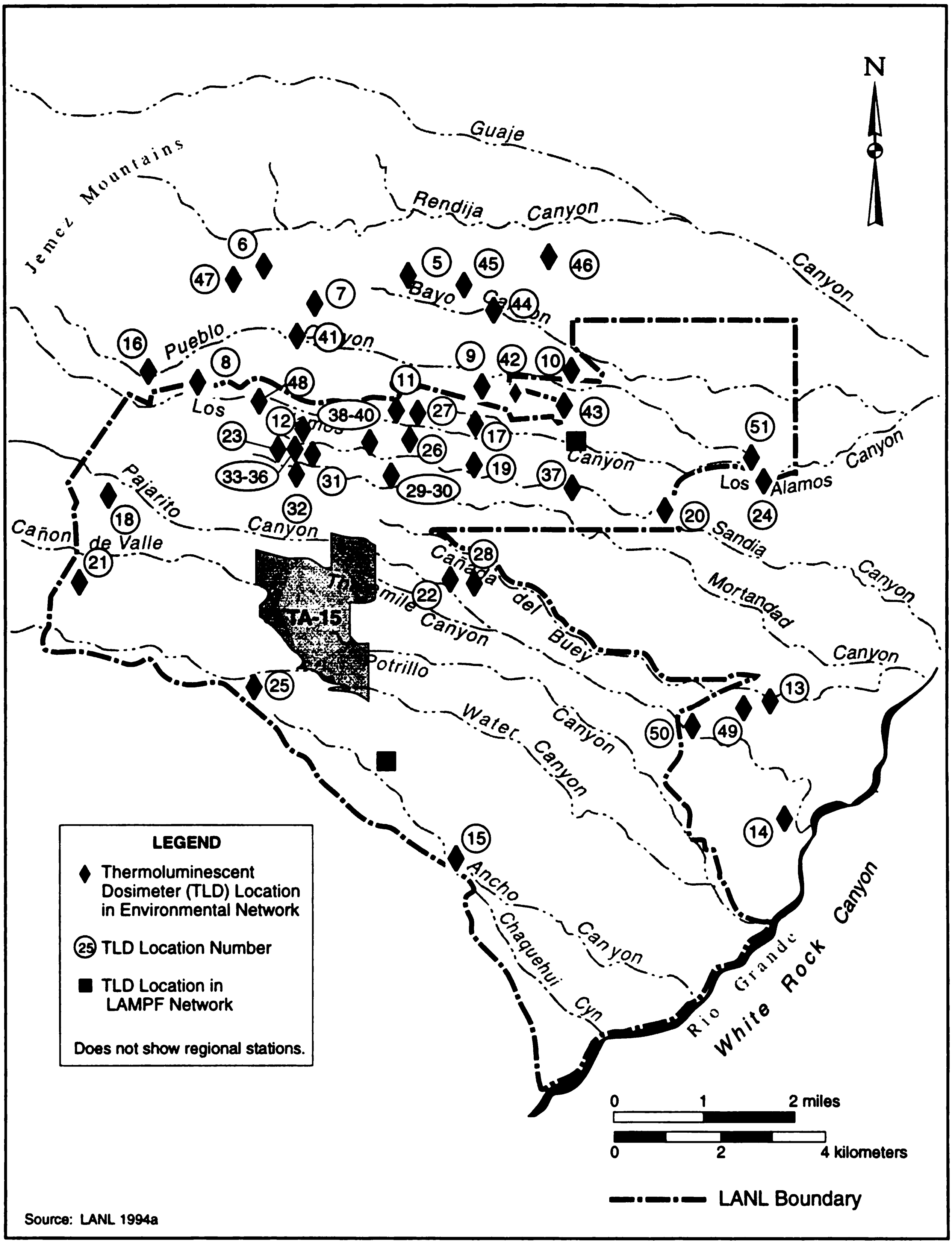


FIGURE 4-26.—*Offsite Perimeter and Onsite LANL TLD Locations.*

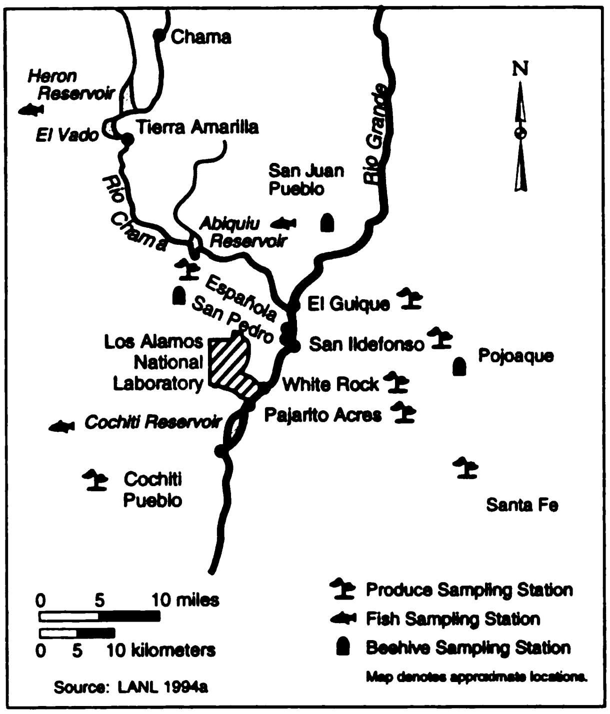


FIGURE 4-27.—*Locations of Offsite Sampling of Produce, Fish, and Beehives.*

Mullen, 1995). A detailed discussion of these studies can be found in section 4.3.3.

4.8.2.2 Chemical

Materials released during open-air tests at the PHERMEX Facility have resulted in low but observable quantities of lead, beryllium, and mercury on or near the firing site. Soil sample surveys conducted in 1993 indicate that no lead, beryllium, or mercury are observed beyond 200 ft (60 m) of the firing point (Fresquez 1994). This survey is described in detail in appendix D.

4.9 HISTORY OF ACCIDENTS AT PHERMEX

Two environmental occurrences or spills have been reported since 1991, the first year that occurrence reporting database information was available. In 1992, there was a transitory discharge to the PHERMEX outfall of 0.49 ppm cyanide, in excess of the NPDES permit level of 0.2 ppm cyanide. This occurrence was traced to a single discharge of film processing chemicals, discharged when film bath chemicals were exchanged. In 1995, seven Los Alamos firemen were exposed to smoke and potential detonation by-products when a firing-site debris pile near PHERMEX caught on fire as a result of a firing site detonation. All firemen were checked for exposure to depleted uranium and potential hazardous substances in the pile; all results were negative.

During the most recent ten-year period (1985 to 1994), the statistics for PHERMEX indicate that there was a total of 19 lost work days. None of these injuries – a contusion, a concussion, and numerous back strains caused by common workplace accidents – were considered serious. There have been no accidents associated with the detonation of explosives.

The PHERMEX accidents, environmental occurrences, and spills reported above have been minor and had negligible consequences to workers, the environment, and the public. A summary of accidents which may occur at the PHERMEX facility is shown in table 4-24.

LANL has developed and maintains an emergency management system that, through emergency planning, emergency preparedness, and effective response capabilities, is capable of responding to and mitigating the potential consequences of emergencies. The Emergency Management Plan incorporates in one document a description of the entire process designed to plan for, respond to, and mitigate the potential consequences of an emergency (LANL 1994a). PHERMEX has an emergency response plan and procedures to initiate a sitewide response, if necessary, through the sitewide program. The PHERMEX plan requires pre-staging of the LANL fire department for uncontained detonations.

TABLE 4-24.—*Hazards at Hydrodynamic Test Facilities*

Hazard	Location	Comments
Ionizing Radiation Exposure		
Personnel inside exclusion areas during beam pulsing	Accelerator bay, optical room, and firing pad	Beam pulse with up to 2,000 rad x-rays at one meter on axis
Electrical		
Personnel in contact with the power supplies or capacitor banks	Accelerator room and power supply rooms	Power supplies with voltages up to 4MV, high energy-densities in capacitor banks
Personnel in contact with laser power supplies	Accelerator bay and laser rooms	Power supplies with voltages up to 35kV
High Explosive Blast		
Personnel in the hazard radius exclusion area during testing	Firing site exclusion area	Area radius is 2,500 ft (750 m), personnel OK in R-184 and R-310
Accidental detonation of explosive	Firing pad	
Nonionizing Radiation		
Operating personnel intersect laser beam	Laser room	
Mechanical		
Crane maintenance and operation	Accelerator bay, power supply rooms, equipment and assembly rooms	Potential for misuse
Occupational		
Slippery surfaces due to fluids	Accelerator bay, power supply rooms, equipment room	Leaks or spills from tanks, valves, or connections
Gases		
Helium	Firing pad, diagnostics area	Used to drive high-speed cameras
Sulfur hexafluoride	Accelerator hall, power supply room	Leaks from spark gaps
Chemicals/Solvents		
Acetone, ethanol	Accelerator bay and assembly room	Inhalation hazards
Fire		
Insulating oil	Accelerator bay and power supply rooms	EXXON 1830 type insulating oil has a flash point above 330°F (149°C)
Wicking of insulating oil	Power supply rooms	Oil soaked rags
Acetone, ethanol	Accelerator bay and assembly room	Volatile cleaning solvents
Electrical control cables, high voltage cables, and components	Accelerator bay, power supply rooms, equipment room	Faulty items may cause sparks to ignite oil, etc.
Fire from parked vehicles	Parking and delivery area	Gasoline in fuel tanks
Natural gas	Equipment room	Hot water boiler
Trash and rag accumulation	Accelerator bay, power supply rooms, equipment room	Ignition source for oil
Forest or brush fire	External to building	May arise from explosives or natural causes
Natural Phenomena		
High Winds	TA-15	Damage to utilities
Lightning	TA-15	Damage to utilities
Earthquake	TA-15	Damage to any of LANL infrastructure, design level is 0.22 G for DARHT, current expectation is 0.5 to 0.6 G for max. earthquake.

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