Environmental Surveillance at Los Alamos During 2006





Los Alamos
NATIONAL LABORATORY
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It is the policy of Los Alamos National Laboratory that we will be responsible stewards of our environment.
It is our policy to:

Manage and operate our site in compliance with environmental laws and standards and in harmony with the natural and human environment

Meet our environmental permit requirements

Use continuous improvement processes to recognize, monitor and minimize the consequences to the environment stemming from our past, present, and future operations

Prevent pollution

Foster sustainable use of natural resources

Work to increase the body of knowledge regarding our environment

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ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 2006

Environment and Remediation Support Services Division
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Environmental Protection Division
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Ecology and Air Quality Group
505-665-8855

Water Quality and RCRA Group
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Los Alamos, New Mexico 87545



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ABSTRACT

Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) environmental organization, as required by US Department of Energy Order 5400.1, *General Environmental Protection Program*, and US Department of Energy Order 231.1A, *Environment, Safety, and Health Reporting*.

These annual reports summarize environmental data that are used to determine compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, are also gathered and reported as part of the Laboratory's efforts to ensure public safety and to monitor environmental quality at and near the Laboratory.

Chapter 1 provides an overview of the Laboratory's major environmental programs. Chapter 2 reports the Laboratory's compliance status for 2006. Chapter 3 provides a summary of the maximum radiological dose the public and biota populations could have potentially received from Laboratory operations and discusses chemical exposures. The environmental surveillance and monitoring data are organized by environmental media (Chapter 4, air; Chapters 5 and 6, water and sediments; Chapter 7, soils; and Chapter 8, foodstuffs and biota) in a format to meet the needs of a general and scientific audience. Chapter 9 provides a summary of the status of environmental restoration work around LANL. Chapter 10, new for this year, explains the risks and the actions taken to reduce risks at the Laboratory from environmental legacies and waste management operations. A glossary and a list of acronyms and abbreviations are in the back of the report. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurements used in this report, Appendix C describes the Laboratory's technical areas and their associated programs, and Appendix D provides web links to more information.

In printed copies of this report or Executive Summary, we've also enclosed a disk with a copy of the full report in Adobe Acrobat (PDF) form and detailed supplemental tables of data from 2006 in Microsoft Excel format. These files are also available for download from the web.

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Environmental Surveillance at Los Alamos During 2006

Executive Summary





Los Alamos NATIONAL LABORATORY EST. 1943

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EXECUTIVE SUMMARY ➤ 2006

The Los Alamos National Laboratory (LANL or the Laboratory) is located in Los Alamos County, in north-central New Mexico (NM), approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure ES-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, a series of mesas separated by deep east-to-west-oriented canyons cut by stream channels. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft above the Rio Grande at White Rock Canyon. Most Laboratory and Los Alamos County community developments are confined to the mesa tops. With the exception of the towns of Los Alamos and White Rock, the surrounding land is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, the Bandelier National Monument, the US General Services Administration, and Los Alamos County. In addition, the Pueblo de San Ildefonso borders the Laboratory to the east.

The mission of LANL is to develop and apply science and technology to (1) ensure the safety and reliability of the US nuclear deterrent, (2) reduce global threats, and (3) solve other emerging national security challenges. Meeting this diverse mission requires excellence in science and technology to solve multiple national and international challenges. Inseparable from the Laboratory's focus on excellence in science and technology is the commitment to environmental stewardship and full compliance with environmental protection laws. Part of LANL's commitment is to report on its environmental performance. This report

- characterizes LANL's environmental management,
- summarizes environmental occurrences and responses,
- describes compliance with environmental standards and requirements, and
- highlights significant programs and efforts.

Environmental Management System

As part of its commitment to protect the environment and improve its environmental performance, LANL implemented an Environmental Management System (EMS) pursuant to US Department of Energy (DOE) Order 450.1 and the international standard (ISO) 14000-2004. DOE defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." The EMS provides a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results.

- *The Laboratory's environmental management system was fully certified to the international standard by an independent registrar.*
- *NNSA recognized the success of the EMS management by giving the Laboratory the 2006 NNSA "Best in Class" Award for EMS-developed projects.*

During 2006, the EMS was audited three times by an independent third-party ISO 14001 auditor. The auditors concluded that the LANL EMS meets all the requirements of the ISO 14001-2004 standard with no major nonconformities and recommended that LANL maintain full certification. On April 13, 2006, LANL received full certification of its EMS to the ISO 14001-2004 standard. LANL is the first DOE National Nuclear Security Agency (NNSA) national laboratory and the first University of California-operated facility to receive this distinction. NNSA recognized the success of the EMS management and the core teams' unique approach by giving the Laboratory the 2006 NNSA "Best in Class" Award for EMS-developed projects. The Laboratory's Pollution Prevention Program is an important component of the

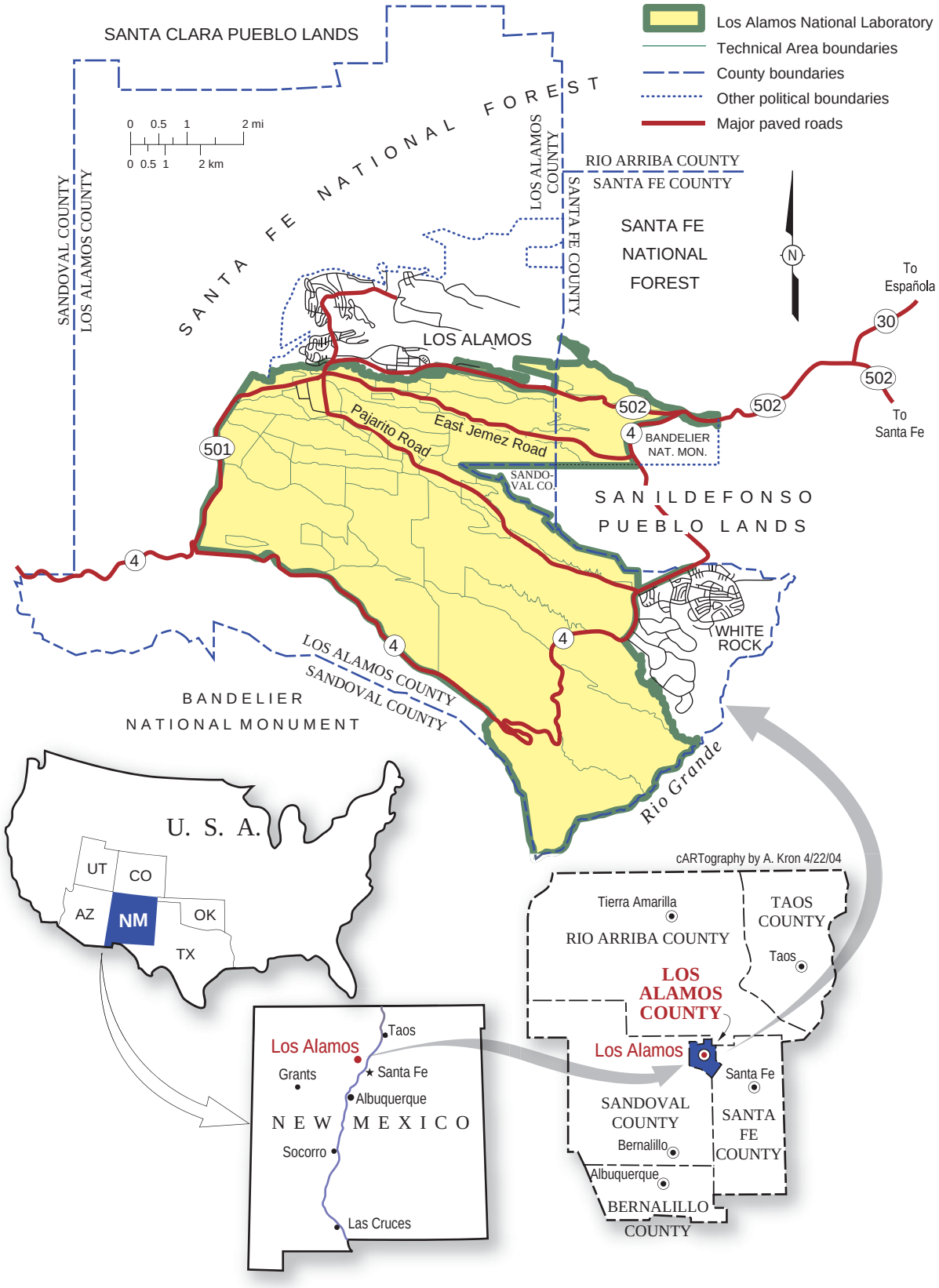

Figure ES-1. Regional location of Los Alamos National Laboratory.

EMS and received seven national NNSA Pollution Prevention awards for Laboratory projects in fiscal year 2006 (up from five awards in fiscal year 2005).

Federal Facility Compliance Agreement

During 2006, the DOE and the Laboratory continued to work under the requirements of a Federal Facility Compliance Agreement (FFCA) with the US Environmental Protection Agency (EPA) and the NM Environment Department (NMED). The agreement establishes a compliance plan for the regulation of storm water point source discharges from solid waste management units (SWMUs) and areas of concern at the Laboratory; the agreement will remain in effect until those sources are regulated by an individual storm water permit issued by EPA.

Compliance Order on Consent

The March 2005 Compliance Order on Consent (the Consent Order) between LANL, DOE, and the NMED is the principal regulatory driver the LANL's Environmental Restoration Program and the Water Stewardship Program. The Consent Order contains requirements for investigation and cleanup of SWMUs and areas of concern at the Laboratory. The major activities conducted by the Laboratory included investigations and cleanup actions. All major deliverables of the Consent Order were met by the Laboratory during 2006. The NMED issued three Notices of Violation to LANL and DOE pursuant to the Consent Order for alleged improper disposal of cleanup debris, failure to report a release of a groundwater contaminant, and improper storage of building debris.

➤ *The Consent Order is the principal regulatory driver for the Laboratory's Environmental Restoration Program and the Water Stewardship Program. It specifies actions that the Laboratory must complete to characterize contaminated sites and monitor the movement of contaminants.*

➤ *The Laboratory met all major deliverables of the Consent Order.*

➤ *The NMED issued three Notices of Violation to LANL and DOE related to the Consent Order for alleged improper disposal of cleanup debris, failure to report a release of a groundwater contaminant, and improper storage of building debris.*

Improvement Targets

Improvement goals for the Laboratory include continuing to improve Resource Conservation and Recovery Act (RCRA) compliance. The Laboratory improved its RCRA compliance in 2006. The Laboratory is improving processes, systems, and training to reduce the number of violations in the future. Under its new EMS, the Laboratory must identify and minimize environmental impacts and waste sources. Chromium discharged from a cooling tower in the 1960s through 1972 was discovered in the regional aquifer in early 2006 and LANL has installed monitoring wells to evaluate the extent of contamination. Though perchlorate and high explosives residues are no longer discharged, their movement from past effluent discharges is being monitored to determine if they could pose a threat to water sources.

Design of Surveillance System and Sample Locations

To achieve its mission activities, LANL uses a variety of materials, some of which are hazardous or radioactive. Experiments and mission activities result in air emissions, water discharges, and waste generation. These emissions and discharges have the potential to affect different receptors or components of the environment including people, air, water, soil, foodstuffs, plants, and animals by one or more pathways such as by inhalation of or contact with hazardous materials.

The Laboratory uses data from monitoring (surveillance) of known release points and multiple receptors (people, air, water, soil, foodstuffs, plants, and animals) over a long time period as a basis for policy and to identify actions to protect or improve the environment. We collect data from the surrounding region to establish baseline environmental conditions not influenced by LANL operations. Regional monitoring also indicates whether LANL operations are impacting areas beyond LANL's boundaries. Examples of regional monitoring include the radiological air-sampling network (AIRNET) and foodstuffs and biota (plants and animals) sampling locations. We also collect data at the Laboratory perimeter to determine if operations are impacting LANL or neighboring properties (e.g., pueblo and county lands). Perimeter monitoring also measures the highest potential impact to the public. To better quantify releases, we monitor at specific discharge or release points or other locations on LANL property that are known to or have the potential to result in emissions or discharges. Examples of locations with this type of monitoring include facility stacks, the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility, the Los Alamos Neutron Science Center (LANSCE), remediation sites where legacy waste is being managed, decontamination and decommissioning projects, Area G at Technical Area (TA-) 54 (where waste is being handled and stored), and water discharge locations (outfalls). We use these data to demonstrate compliance with applicable environmental laws and regulations. During 2006, the Laboratory collected more than 8400 environmental monitoring samples from 780 locations and requested almost 200,000 analyses or measurements on these samples.

Compliance

As a key indicator of its environmental performance, the Laboratory uses the status of compliance with environmental requirements. Federal and state regulations provide specific requirements and standards to implement these statutes and maintain environmental quality. The EPA and the NMED are the principal administrative authorities for these laws. The Laboratory also is subject to DOE requirements for control of radionuclides. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations.

Unplanned Releases

There was one unplanned airborne release, of anhydrous ammonia, from LANL in 2006. There were no unplanned releases of radioactive liquids. There were six spills or releases of non-radioactive liquids which included fire suppression water (900 gal.), clean fill sediment from storm water runoff from a construction site, and potable water (44,000 gal.). All liquid releases were reported to NMED and will be administratively closed upon final inspection. A smoke opacity deviation of 24% (just above the permit limit of 20%) was observed at the asphalt plant.

➤ *Radiation dose to the hypothetical maximally exposed individual (MEI) was more than 13 times lower in 2006 compared to 2005 and was the lowest since 1999. LANSCE emissions, normally the largest source of public exposure, were greatly reduced because of new emissions controls systems.*

➤ *The MEI location was determined to be at the Los Alamos County Airport terminal. This location received a combination of low levels of radiation from stack emissions and low levels of contamination from the cleanup of an adjacent debris pile.*

Radiological Dose Assessment

Humans, plants, and animals potentially receive radiation doses from various Laboratory operations (Table ES-2). The DOE dose limits for the public and biota are the mandated criteria that are used to determine whether a measurement represents a potential exposure concern. Figure ES-2 shows doses to the hypothetical maximally exposed individual (MEI) over the last 13 years at an off-site location; this location was East Gate in all prior years but was determined to be at the Los Alamos County Airport terminal for 2006. The dose to the MEI was approximately 0.47 mrem,

Table ES-1
Environmental Statutes under which LANL Operates and Compliance Status in 2006

Federal Statute	What it Covers	Status
Resource Conservation and Recovery Act (RCRA)	Generation, management, and disposal of hazardous waste and cleanup of inactive, historical waste sites	NMED conducted one RCRA hazardous waste compliance inspection in 2006 but LANL received no further communication in 2006 regarding the inspection. The Laboratory completed 1,453 self-assessments that resulted in a nonconformance finding rate of 3.02%. The Consent Order replaces Module VIII of the Hazardous Waste Facility Permit. All deliverables required by the Consent Order were submitted to NMED on time. NMED issued three Notices of Violation to DOE and LANL that alleged improper disposal of cleanup debris, failure to report a release of a groundwater contaminant, and improper storage of building debris. The Laboratory is in compliance with groundwater monitoring requirements. Six alluvial characterization wells, one intermediate characterization well, and five piezometers (which measure water levels) were installed in Sandia Canyon in 2006.
Clean Air Act (CAA)	Air quality and emissions into the air from facility operations	The Laboratory met all permit limits for emissions to the air. Non-radiological air emissions were similar to the previous year. An smoke opacity deviation 4% greater than permit limits occurred at the asphalt plant. LANL continued to eliminate the use of refrigerants. The dose to the maximum exposed individual (MEI) from radioactive air emissions dropped to 0.47 mrem, the lowest level in eight years.
Clean Water Act (CWA)	Water quality and effluent discharges from facility operations	Only one (a total residual chlorine level) of 733 samples collected from industrial outfalls and none of the 113 samples collected from the Sanitary Wastewater Systems Plant's outfall exceeded effluent limits. About 94% of the Laboratory's permitted construction sites were compliant with National Pollutant Discharge Elimination System (NPDES) requirements contained in 57 construction site storm water pollution prevention plans. Institutional and programmatic controls were implemented to further improve and assure compliance under the Laboratory's construction general permit. The Laboratory continued to implement 15 Storm Water Pollution Prevention Plans covering 26 industrial facilities and site-wide SWMUs. This included sampling of storm water discharges from industrial activities and installing and maintaining Best Management Practices to manage pollutants and runoff at these locations.
Toxic Substances Control Act (TSCA)	Chemicals such as polychlorinated biphenyls (PCBs)	The Laboratory shipped 58 containers of PCB waste, 105 lbs of capacitors, and 2,661 lbs of fluorescent light ballasts for disposal or recycling in compliance with all manifesting, record keeping, and disposal requirements.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Storage and use of pesticides	The Laboratory remained in compliance with regulatory requirements regarding use of pesticides and herbicides.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public's right to know about chemicals released into the community	The Laboratory reported releases, waste disposal, and waste transfers totaling 11,069 lbs of lead. A leak of anhydrous ammonia exceeded reporting thresholds and was reported as required. No updates to Emergency Planning Notifications were necessary in 2006. Chemical Inventory Reports were updated to the Los Alamos County fire and police departments for 36 chemicals or explosives.

Table ES-1 (continued)

Federal Statute	What it Covers	Status
Endangered Species Act (ESA) & Migratory Bird Treaty Act (MBTA)	Rare species of plants and animals	The Laboratory maintained compliance with the ESA and MBTA. The Laboratory prepared biological assessments for three projects and continued to monitor endangered species status.
National Historic Preservation Act (NHPA) and others	Cultural resources	The Laboratory maintained compliance with the NHPA. The laboratory identified 13 new archaeological sites and 166 historic buildings. Twenty-three archaeological sites and 65 historic buildings were determined eligible for the National Register of Historic Places.
National Environmental Policy Act (NEPA)	Projects evaluated for environmental impacts	The NEPA team prepared or reviewed two analyses: a new LANL Site-wide Environmental Impact Statement and an Environmental Assessment for the construction and operation of a Biosafety Level-3 facility. No non-compliances were reported.

Table ES-2
What are the Sources of Radiological Doses?

Source	Dose	Location	Trends
Background (includes man-made sources)	~470 mrem/yr	All sites	Not applicable
Air (humans)	0.47 mrem/yr	Los Alamos County Airport Terminal	Lowest since 1999; expected to remain low
Direct irradiation (humans)	1.1 mrem/yr	San Ildefonso – offsite	None
Food (humans)	<0.1 mrem/yr	All sites	None
Drinking water (humans)	<0.1 mrem/yr	All sites	None
All (terrestrial animals)	<20 mrad/day	TA-15 EF site, TA-21 material disposal area (MDA) B	None
All (aquatic animals)	<85 mrad/day	TA-50 Effluent Canyon	None
All (terrestrial plants)	<50 mrad/day	TA-21 MDA B	None

compared to 6.46 mrem in 2005 and a regulatory limit of 10 mrem (Figure ES-2). Cleanup of a slightly-contaminated debris pile next to the terminal contributed to this low dose. The Laboratory calculated potential radiological doses to members of the public that resulted from LANL emissions and discharges. During 2006, the population within 80 km of LANL received a collective dose of about 0.6 person-rem, which is a substantial decrease from the dose of 2.46 person-rem reported for 2005. The doses received in 2006 from LANL operations by an average Los Alamos residence and an average White Rock residence totaled about 0.0125 mrem and 0.0145 mrem, respectively (about one-ninth and one-fourth, respectively, of the doses in 2005). The decrease in these doses from 2005 was attributable to greatly reduced emissions from the LANSCE accelerator facility, which releases very short-lived radioactive gasses from a location relatively close to the LANL boundary. A leak repair and an improved emissions control system installed in 2005 both helped to reduce emissions.

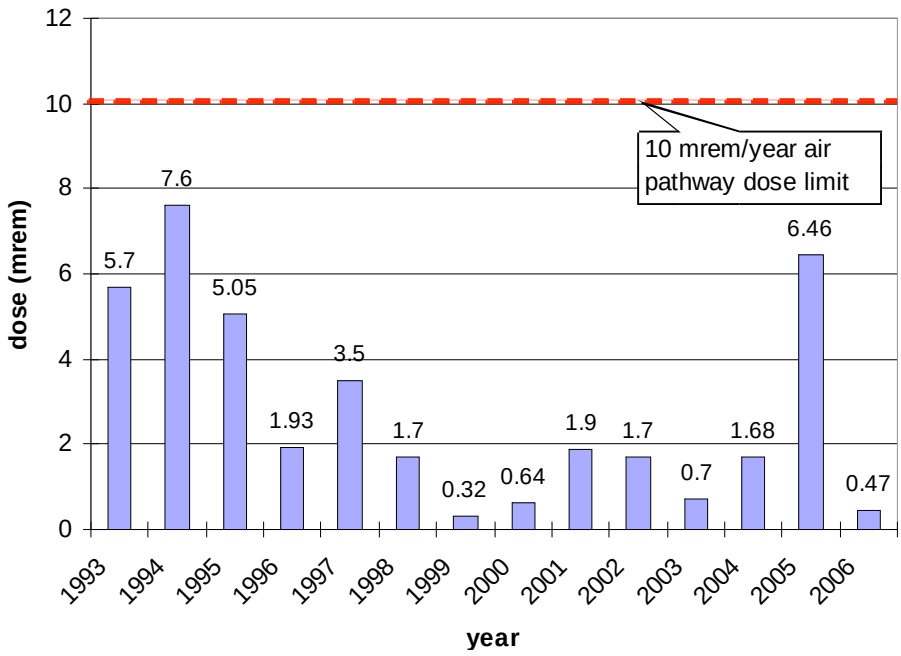

Figure ES-2. Annual airborne pathway dose (mrem) to the off-site MEI over the past 14 years. For the first time, the location of the calculated MEI changed from East Gate to the Los Alamos County Airport terminal.

Biota Dose

The DOE biota dose limits are intended to protect populations, especially with respect to preventing the impairment of reproductive capability within the biota population and are thus applied to biota populations rather than to individual plants and animals. We collected soil, sediment, vegetation, and small mammals from known contaminated areas (material disposal areas or MDAs), canyons, and operational sites (DAHRT). All radionuclide concentrations in terrestrial vegetation sampled were far below the 0.1 rad/day biota dose-based screening level (10% of 1 rad/day dose limit) and all radionuclide concentrations in terrestrial animals sampled were far below the 0.01 rad/day biota dose-based screening level (10% of 0.1 rad/day dose limit). A special dose assessment for plants and animals in Mortandad Canyon, based on new data collected as part of the canyon investigation, confirmed previous dose estimates and indicated the dose was about 0.007 rad/day to plants and 0.005 rad/day to animals, compared to limits of 1.0 rad/day and 0.1 rad/day, respectively.

Air Emissions and Air Quality

- *Measurable concentrations of radionuclides in ambient air were not detected at regional sampling locations nor at most perimeter locations.*
- *The highest mean air concentrations at perimeter locations were below 1% of the applicable EPA limits.*

The Laboratory measures the emissions of radionuclides at the emission sources (building stacks) and categorizes these radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products (radioactive elements created by the LANSCE particle accelerator beam), (3) tritium, and (4) air activation products. Similarly, the Laboratory takes air samples at general locations within LANL boundaries, at the LANL perimeter, and regionally to estimate the extent and concentration of radionuclides that may be released from Laboratory operations. These radionuclides include plutonium, americium, uranium, and tritium.

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In 2006, gaseous activated air product emissions from the LANSCE stack were the lowest since 1999. Emissions from all other stacks were comparable to previous years or slightly lower. Total stack emissions during 2006 were approximately 1,290 curies (Ci). Of this total, tritium emissions composed about 893 Ci and short-lived air activation products from LANSCE stacks contributed nearly 398 Ci. Combined airborne emissions of materials, such as plutonium, uranium, americium, and thorium, were less than 0.00002 Ci and emissions of particulate/vapor activation products increased in 2006 to 2.3 Ci.

➤ *Emissions from the stacks at LANSCE, normally the source of most radionuclide emissions, were significantly lower in 2006 compared to 2005 because a leak that caused elevated emissions in 2005 was repaired and addition emissions controls were added.*

➤ *Emissions of radionuclides from other Laboratory stacks were comparable to previous years.*

Radionuclide concentrations from ambient air samples in 2006 were generally comparable with concentrations in past years. As in past years, the AIRNET system detected contamination from known areas of contamination below the Los Alamos Inn, at the Laboratory's waste disposal site at Area G, and from the former plutonium processing site at TA-21. New or increased airborne radioactivity was detected from cleanup operations at the Los Alamos County Airport, cleanup operations at MDA V at TA-21, and from disposal of the contaminated wastes at Area G. At regional locations away from Los Alamos, all air sample measurements were consistent with background. Annual mean radionuclide concentrations at all LANL perimeter stations were less than 1% of EPA limits for the public. Measurable amounts of tritium were reported at most on-site locations and at perimeter locations; the highest concentrations were measured at the Area G waste site in TA-54 after a decommissioned tank from TA-21 was moved to Area G. The tank was subsequently moved to the tritium shafts at Area G and tritium levels declined. The highest off-site tritium concentration (measured at the southwest LANL boundary) was 9 pCi/m^3 (0.6% of the EPA public dose limit of 1,500 pCi/m^3). Plutonium was detected at two LANL perimeter stations: near Los Alamos Inn at about 12 aCi/m^3 or about 1% of the EPA public dose limit (from historical activities at LANL's old main technical area), and near the Los Alamos County Airport (from remediation work at TA-21). On-site detections of plutonium occurred at TA-21 and at Area G (areas with known low levels of contamination) and were substantially below 0.2% of the DOE limit for workplace exposure. Americium-241 was detected only at TA-21 and at Area G at levels less than 0.001% of worker exposure limits. The maximum annual uranium concentrations were from natural uranium at locations with high dust levels from local soil disturbances such as dirt roads at the Los Alamos County Landfill and Area G. The regional and pueblo samples had higher average concentrations of uranium isotopes than the perimeter group at isotopic ratios that indicate natural sources. Depleted uranium (which has lower radioactivity than natural uranium) was detected in two samples from areas around LANL firing sites where depleted uranium was used in the past.

➤ *PM-10 and PM-2.5 particulate measurements in ambient air were well below EPA standards.*

➤ *Beryllium air concentrations for 2005 were similar to past years and were equal to or less than 2% of the NESHAP standard; a natural origin is indicated by the strong correlation with aluminum concentrations.*

Air monitoring for particles with diameters of 10 micrometers (µm) or less (PM-10) and for particles with diameters of 2.5 µm or less (PM-2.5) continued at one White Rock and two Los Alamos locations. The annual average at all locations for PM-10 was about 13 $micrograms/m^3$ and about 7 $micrograms/m^3$ for PM-2.5 and was mostly caused by natural dust and wildfire smoke. These averages are the same as in 2005 and well below the EPA standards. In addition, the 24-hour maxima for both PM-2.5 and PM-10 at all three locations were much less than the EPA standards.

The Laboratory analyzed filter samples from 23 sites for beryllium. These sites are located near potential beryllium sources at LANL or in nearby communities. Correlation with aluminum concentrations indicates that all measurements of beryllium are from naturally occurring beryllium in resuspended dust. Beryllium air concentrations for 2006 were similar to those measured in recent years. All values are equal to or less than 2% of the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard.

Groundwater Monitoring

Groundwater at the Laboratory occurs as a regional aquifer (water-bearing rock) at depths ranging from 600 to 1,200 ft and as perched groundwater of limited thickness and horizontal extent, either in canyon alluvium or at intermediate depths of a few hundred feet (Figure ES-3). All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate groundwater.

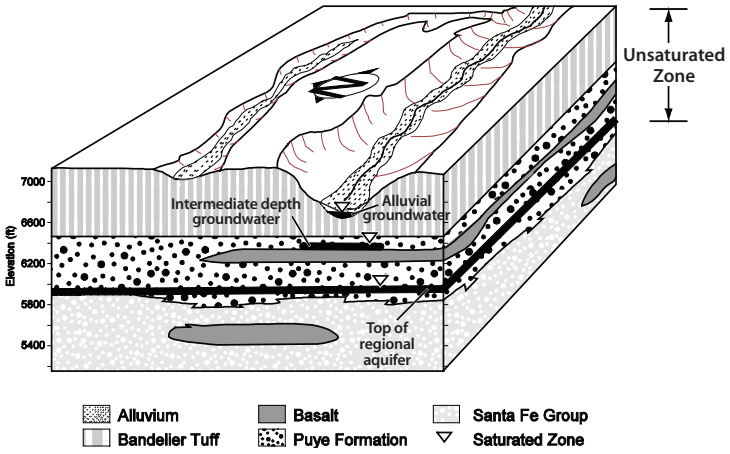

Figure ES-3. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

Laboratory contaminants have impacted deep groundwater, including intermediate perched zones and the regional aquifer, primarily through liquid effluent disposal. Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 17 active) and the volume of water released (by more than 80%). For 1993 to 1997, total estimated average flow was 1300 million gal./yr; in 2006, the flow was 222 million gal. All discharges met applicable standards. Where Laboratory contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location where large amounts of liquid effluent have been discharged. Table ES-3 summarizes contaminants found in portions of the groundwater system.

➤ *In general, groundwater quality is improving as LANL:*
- *Eliminates outfalls,*
- *Reduces quantity of discharges, and*
- *Improves water quality of the discharges.*

➤ *Contamination may be discovered in additional locations, however, as groundwater characterization continues.*

Drainages that received liquid radioactive effluents in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon; only Mortandad

Table ES-3
Where Can We See LANL Impacts on Groundwater that Result in Values Near or Above Regulatory Standards, Screening, or Risk Levels?

Chemical	On-Site	Off-Site	Significance	Trends
Tritium	Intermediate groundwater in Mortandad Canyon	No	Not used as a drinking water supply	Insufficient data to define trend
Other radionuclides	Alluvial groundwater in DP/Los Alamos, Pueblo, and Mortandad Canyons	No	Not used as a drinking water supply; radionuclides have not penetrated to deeper groundwater	Some constituents are fixed in location; some are decreasing as effluent quality increases
Chromium	Regional aquifer in Sandia and Mortandad Canyons, intermediate groundwater in Mortandad Canyon	No	Found in regional aquifer above groundwater standards; not affecting drinking water supply wells. Investigations and new wells are being installed to determine extent and predict future movement; source eliminated in 1972.	Insufficient data to define trends
Perchlorate	Alluvial and intermediate groundwater in Mortandad Canyon	No	Values near or above EPA Drinking Water Equivalent Level; supply well with values below risk level is permanently off line	Decreasing in Mortandad Canyon alluvial groundwater as effluent quality improves; insufficient data for other groundwater
Nitrate	Alluvial and Intermediate groundwater in Pueblo Canyon, regional aquifer in Sandia Canyon, intermediate groundwater and regional aquifer in Mortandad Canyon	Yes, in Pueblo Canyon	In Pueblo Canyon, may be due to Los Alamos County's Bayo Sewage Treatment Plant	Insufficient data in Mortandad Canyon, values in Pueblo Canyon are variable, values in Sandia Canyon rising
Molybdenum	Alluvial groundwater in Los Alamos Canyon	No	Not used as drinking water, limited in extent	Near NM groundwater limit for 10 years
Barium	Alluvial and intermediate groundwater in Cañon de Valle	No	Not used as drinking water, limited in area	Generally stable, seasonal fluctuations
RDX	Alluvial and intermediate groundwater in Cañon de Valle, alluvial groundwater in Pajarito Canyon	No	Limited in area	Generally stable

[a]Shallow groundwater includes alluvial and intermediate groundwater.



currently receives radioactive effluent from the Radioactive Liquid Waste Treatment Facility. For the past seven years, this facility has met all DOE radiological discharge standards in all but two months, all National Pollutant Discharge Elimination System (NPDES) requirements, and has voluntarily met NM groundwater standards for fluoride, nitrate, and total dissolved solids in all but two weeks.

The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so infiltration from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced.

➤ *LANL detected chromium contamination in the regional aquifer at concentrations above drinking water standards.*

➤ *The contamination is likely the result of discharges made in the mid-1950s through the early 1970s containing chromate in cooling tower discharges.*

➤ *No drinking water wells have been affected by the chromium contamination.*

Water Canyon and its tributary Cañon de Valle formerly received effluents produced by high explosives (HE) processing and experimentation. In past years, Los Alamos County has operated three sanitary treatment plants in Pueblo Canyon; currently only one plant is operating. The Laboratory also operated many sanitary treatment plants but currently operates only one plant that discharges into Sandia Canyon.

Figure ES-4 summarizes groundwater quality issues in the regional aquifer at the Laboratory. In 2006, the high explosive compound RDX was detected in the regional aquifer for the first time, at Pajarito Canyon well R-18. The concentration was near the analytical detection limit and at 2% of the EPA tap water screening level. RDX was not found in samples taken during 2005 from this well. Earlier detection of RDX in the regional aquifer at R-25 (to the south of R-18) was probably due to contamination from upper levels during well construction of this deep well. The Laboratory, in cooperation with NMED, is investigating these issues.

➤ *The Radioactive Liquid Waste Treatment Facility, which discharges into Mortandad Canyon, has met all DOE radiological discharge standards for 82 of the past 84 months; has met all NPDES requirements for seven consecutive years; and has met NM groundwater standards for fluoride, nitrate, and total dissolved solids for seven years except for fluoride in two weekly composite samples in 2003.*

The Laboratory found hexavalent chromium and nitrate in several monitoring wells. The hexavalent chromium is above the NM groundwater standard in one regional aquifer well and at 60% of the standard in another. Nitrate reaches 50% of the NM groundwater standard in two regional aquifer monitoring wells and fluoride is at 50% of the standard in one well. Traces of tritium and perchlorate are also found in the regional aquifer.

Naturally occurring uranium was the main radioactive element detected in the regional aquifer, springs, and wells throughout the Rio Grande Valley. High concentrations of naturally occurring arsenic are also found in groundwater samples from some regional aquifer wells and springs. Most other metals found at high concentrations in groundwater samples at LANL result from well sampling and well construction issues rather than from LANL contamination. The use of fluids to assist with well drilling and the use of other materials in well completion has affected the chemistry of some groundwater samples.

With one exception, drinking water wells in the Los Alamos area have not been adversely impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate is found at concentrations that average 1/10th of the EPA's Drinking Water Equivalent Level of 24.5 micrograms per liter (µg/L). This well is not used by Los Alamos County for water supply. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water requirements.

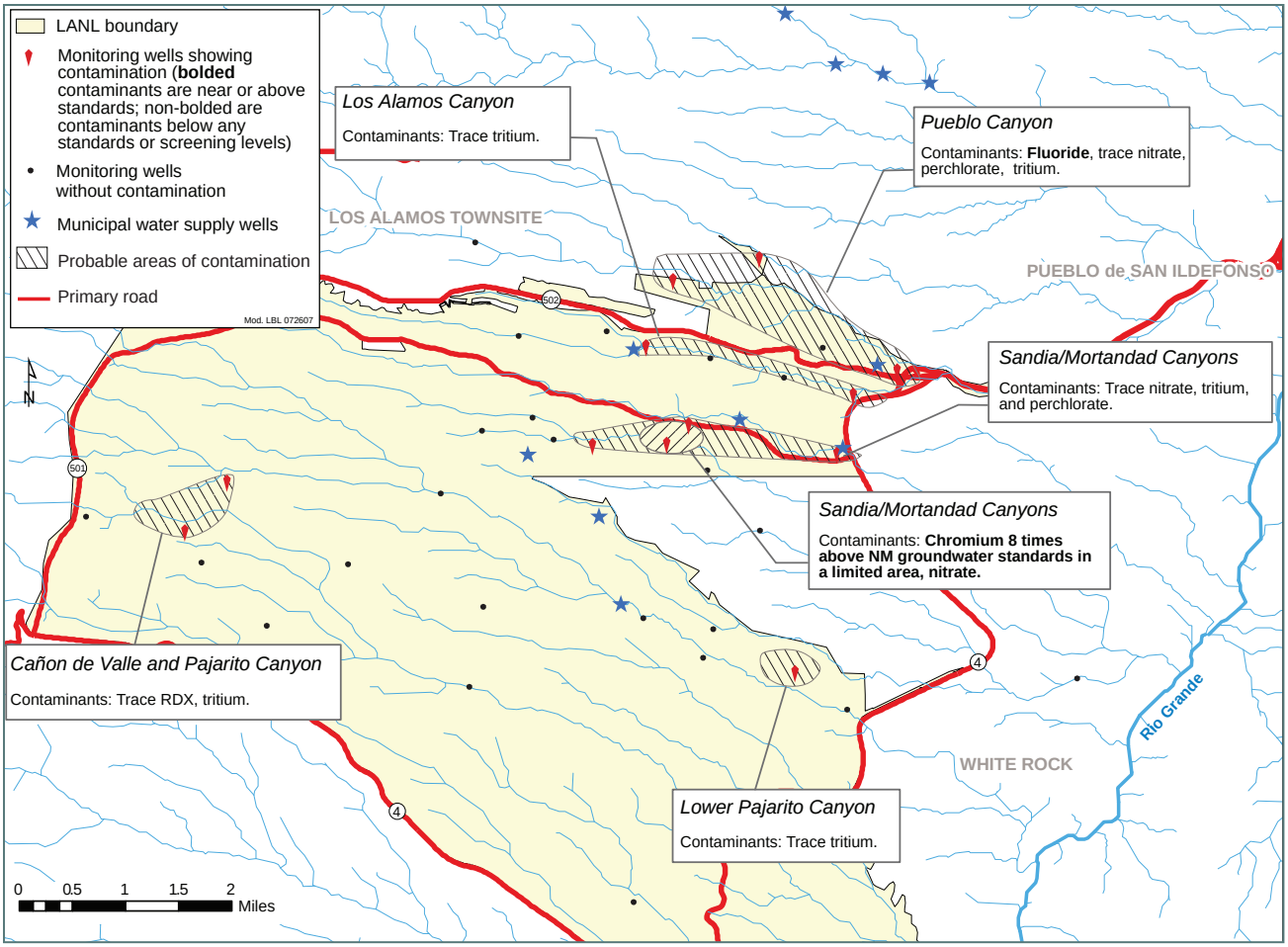

Figure ES-4. Summary of regional aquifer groundwater quality issues at Los Alamos National Laboratory.

The intermediate groundwater in various locations shows localized tritium, organic chemicals (RDX, chlorinated solvents, dioxane[1,4-]), and inorganic chemicals (hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate) from Laboratory operations. Dioxane[1,4-], a volatile organic compound used as a stabilizer for chlorinated organic solvents, was detected in two intermediate wells in Mortandad Canyon. The Laboratory, in cooperation with the NMED, is investigating this contamination.

The Laboratory uses federal and state drinking water and human health standards as "screening levels" to evaluate radionuclide concentrations in all groundwater, even though many of these standards only apply to drinking water. Only in the alluvial groundwater in portions of Mortandad and DP/Los Alamos Canyons does the total radionuclide activity from LANL activities exceed the guidance that is applicable to drinking water (4 mrem/yr). The maximum strontium-90 values in Mortandad Canyon and DP/Los Alamos Canyons alluvial groundwater were also above the EPA's drinking water standard.

Perchlorate is detected in most groundwater samples analyzed from across northern NM. The naturally-occurring perchlorate concentrations range from about 0.1 µg/L to 1.8 µg/L. Water samples from most LANL locations show low perchlorate concentrations in this range, but samples taken in Mortandad Canyon alluvial and intermediate groundwater show values near or above the EPA Drinking Water Equivalent of 24.5 µg/L. Discharge of perchlorate from the Radioactive Liquid Waste Treatment Facility dropped to near zero in 2002 and perchlorate values in alluvial groundwater downstream of the facility's discharge in Mortandad Canyon have been steadily declining.

Watershed Monitoring

Watersheds that drain LANL property are dry for most of the year. Of the more than 80 miles of watercourse, approximately two miles are naturally perennial, and approximately three miles are perennial water created by effluent discharges. No perennial surface water extends completely across the Laboratory in any canyon. Storm water runoff occasionally extends across the Laboratory but is short-lived. Wildlife drink from the stream channels when water is present but the water is not used for any other purpose.

➤ *The overall quality of most surface water within the Los Alamos area is very good.*

➤ *Of the more than 100 analytes, most are within normal ranges or at concentrations below regulatory standards or risk-based advisory levels.*

➤ *Nearly every major watershed, however, shows some effect from Laboratory operations.*

Hydrologic conditions in all LANL canyons have recovered to levels near those before the Cerro Grande Fire in 2000. However, flows in Pueblo Canyon continue to increase quickly after rainfall events, principally due to increased urbanization and changes to the storm drainage system that have occurred since the fire. Two near-100-year rainfall events in August 2006 led to record flows at some 20 stream gaging stations across the Pajarito Plateau. Despite the record flows, significant impacts to stream flow and water quality downstream of the Laboratory were not evident. The overall quality of most surface water in the Los Alamos area is very good, with low levels of dissolved solutes. Of the more than 100 constituents measured in sediment and surface water within the Laboratory, most are at concentrations far below regulatory standards or risk-based advisory levels. However, nearly every major watershed has some effect from Laboratory operations, often for just a few constituents.

Approximately eight of 10 surface water samples in 2006 contained gross alpha activity in the suspended sediment greater than the NM surface water standard for livestock watering. However, only alpha activity in Mortandad Canyon can regularly be attributed to Laboratory activities; the vast majority of all other results is due to natural sediment and soil carried in storm runoff. There is strong correlation between gross alpha activity and suspended sediment concentrations in the samples. Overall gross alpha levels in suspended sediments have declined over the past few years with the corresponding decrease in sediment load as fire-burned areas recover. The only radionuclide that is measured at more than 5% of the DOE biota concentration guide is radium-226, which is of natural origin.

➤ *Polychlorinated biphenyls (PCBs) are the most significant Laboratory-derived contaminants in surface water samples, with concentrations greater than the NM surface water standard often measured in Sandia and Los Alamos Canyons.*

➤ *Radioactive elements from past Laboratory operations are being transported by runoff events. All radionuclide levels are well below applicable guidelines or standards.*

➤ *PCBs and radionuclides adsorb onto sediment particles and thus overall water concentrations can probably be substantially reduced by slowing the stream flows.*

Laboratory activities have caused contamination of sediment in several canyons, mainly because of past industrial effluent discharges. These discharges and contaminated sediment also affect the quality of storm water runoff, which carries much of this sediment for short periods of intense flow. In some cases, sediment contamination is present from Laboratory operations conducted more than 50 years ago. Table ES-4 shows the locations of Laboratory-impacted surface water and sediment. All radionuclide levels are well below applicable guidelines or standards (Table ES-5).

The overall pattern of radioactivity in channel sediment, such as along lower Los Alamos Canyon, has not greatly changed in 2006. Sediment traps and other methods to slow or control sediment transport in these canyons reduce the potential for further transport down the canyons and potentially to the Rio Grande. Such a sediment trap, the Los Alamos Canyon Weir, has decreased transport of sediment from lower Los Alamos Canyon by about two thirds in 2005 and 2006.

Table ES-4
Where Can We See LANL Impacts on Surface Water and Sediment that Result in Values Near or Above Regulatory Standards or Risk Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Specific radionuclides	No	No	Exposure potential is limited. Los Alamos Canyon surface water 40% of DOE biota concentration guide for year; dose mainly from radium-226 that is of natural origin.	None
Gross alpha radioactivity	Mortandad Canyon	No	80% of surface water results from all canyons greater than NM livestock watering standard. Major source is naturally occurring radioactivity in sediments, except in Mortandad Canyon where there is a LANL contribution.	Steady in Mortandad; downward in fire-affected canyons as stream flows recover to pre-fire levels; upward in Pueblo Canyon as flows remain elevated after the fire due to increased urbanization and drainage system changes.
Polychlorinated biphenyls (PCBs)	Detected in sediment in nearly every canyon. Detected in Sandia Canyon runoff and base flow above NM stream standards	Yes, particularly in the Los Alamos/ Pueblo Canyons	Wildlife exposure potential in Sandia Canyon. Elsewhere findings include non-Laboratory and Laboratory sources	None
Selenium	No	No	Half of surface water samples after the fire greater than NM wildlife habitat standard. However, none of 2006 samples above standard.	Downward
Dissolved copper	Detected in many canyons above NM acute aquatic life standards	Yes, in Los Alamos Canyon	Origins uncertain, probably several sources	None

Table ES-5
Estimated Annual Average Unfiltered Surface Water Concentrations of Radionuclides in Selected Canyons Compared with the Biota Concentration Guides

Radionuclide	BCGs[a] (pCi/L)	Pueblo above Acid	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon between DP and State Road-4	LA Canyon at Rio Grande	Mortandad Canyon below Effluent Canyon	Max percent of BCG[a]
Am-241	400		0.01	0.1	0.5	0.01	9	2%
Cs-137[b]	20,000	0.1	0.2	2	2	0.3	33	0.2%
H-3	300,000,000		43	21	7	26	294	<0.01%
Pu-238	200		0.001	0.01	0.04	0.01	5	2%
Pu-239,240	200	0.01	0.3	0.1	0.5	0.04	7	4%
Sr-90	300	0.1	0.01	12	0.8	0.4	4	1%
U-234	200	0.3	0.4	0.6	1.3	1.5	2	1%
U-235,236	200	0.01	0.01	0.02	0.1	0.1	2	0.1%
U-238	200	0.4	1.0	0.4	1.3	1.4	0.1	1%
Ra-226	4	0.2	0.9	0.2	0.9	1.6	0.2	40%

[a] BCG = DOE Biota Concentration Guides

[b] The BCG for cesium-137 is a site-specific modified BCG

Blank cells indicate no analytical laboratory detection in 2006

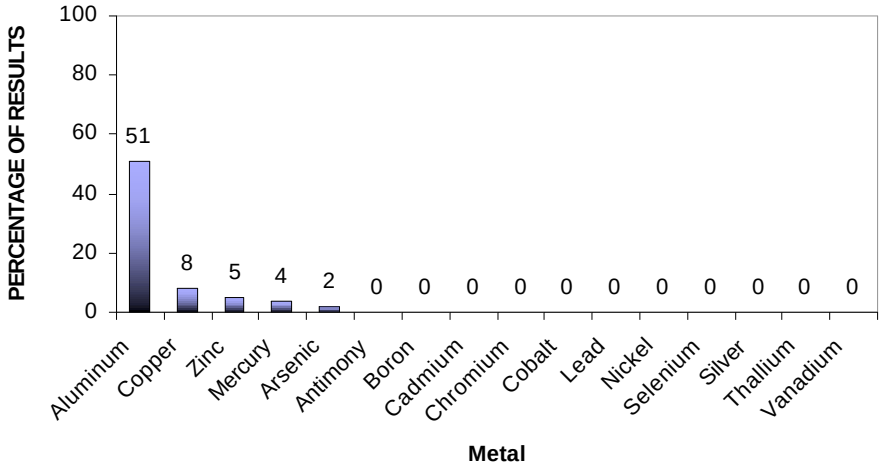

Figure ES-5. Frequency of metal results greater than the most restrictive NM stream standards.

In 2006, all metal concentrations in sediment were below screening levels for recreational and residential uses. In surface water, the vast majority of results were below the most stringent applicable state stream standards, other than for metals of natural origin (for example, aluminum; Figure ES-5). Selenium concentrations have progressively declined since the fire in 2000 and no values greater than the wildlife habitat standard were measured in 2006. The water quality trends indicate that the elevated selenium concentrations were due to natural sources, probably the ash from the fire.

The types of organic compounds tested for varied depending on the location and typically included the following suites: pesticides/polychlorinated biphenyls (PCBs), HE, volatile organics, and semi-volatile

organics. On average, more than 70 different compounds were assessed at each site. PCBs are the only class of organic compounds that were definitively detected at concentrations greater than the NM water quality standards and are likely Laboratory-derived. The sources of PCBs on Laboratory lands are likely predominantly from past spills and leaks of transformers, rather than current effluent discharges. Despite the higher PCB concentrations measured in runoff within the Laboratory, monitoring results show no measurable effects in the Rio Grande.

All measurements of radioactivity in the Rio Grande and in Cochiti Reservoir were orders of magnitude below recreational or residential screening levels. In river sediments, no appreciable differences in radioactivity were measured above and below the Laboratory. Plutonium-239,240 concentrations were below analytical detection limits in the Rio Grande at both the Frijoles and Otowi stations.

Flows from the Pajarito Plateau (from all canyons combined) into the Rio Grande were never more than 1/1000th the flow volume in the Rio Grande. Sediment transport loads in the Rio Grande are 100 to 1000 times that contributed by Los Alamos Canyon. Thus, any impact to the Rio Grande from the transport of contaminated sediment will be very difficult to discern.

Soil Monitoring

Surface soil (mesa top) samples were collected from 17 on-site locations (generally downwind of major facilities or operations at LANL and not from known contaminated areas), 11 perimeter locations (North Mesa, Sportsman's Club, Quemazon Trail, west airport, east airport, White Rock, San Ildefonso, Otowi, Tsankawi/PM-1, US Forest Service property across from TA-8, and south on Bandelier National Monument property near TA-49), and six regional or background locations (near Ojo Sarco, Dixon, Borrego Mesa near Santa Cruz dam, Rowe Mesa near Pecos, Youngsville, and Jemez).

- *LANL-derived radionuclides were detected in soils collected from areas generally downwind of major facilities or operations, including the former plutonium facility on DP Road (TA-21) and the waste management area at Area G, TA-54.*
- *No new areas of contamination were detected and levels are comparable to those measured in previous years.*
- *The detected levels of radionuclides in soils around the LANL boundary are all well below levels considered safe for residential uses.*

Table ES-6 summarizes contaminants found in soil around LANL. All radionuclide (activity) concentrations in soil collected from on site and perimeter areas in 2006 were low and most were either not detected or below regional statistical reference levels (RSRLs, equal to the average plus three standard deviations). The few detected radionuclides above RSRLs in soil collected from perimeter areas included cesium-137 and plutonium-239,240 at the TA-8 location; plutonium-239,240 at the west airport location; and uranium-234 and uranium-238 at the Tsankawi/PM-1 location. The locations where plutonium were detected lie north of the Laboratory and mostly downwind of the former plutonium processing facility at TA-21 or east of Area G at TA-54. The ratio of uranium-234 and uranium-238 in the soil at the Tsankawi/PM-1 location indicates the uranium is naturally occurring. All of the radionuclide concentrations in these samples were just slightly above the RSRLs and were below residential screening levels and thus do not pose a potential unacceptable dose to the public.

Nearly all of the inorganic chemical concentrations from on-site and perimeter areas were below RSRLs. The few heavy metals just above the RSRL included mercury at the Sportsman's Club north of LANL and thallium at the Two-Mile Mesa location at TA-6. The concentrations detected are far below the appropriate screening levels and do not pose a potential hazard to human health.

Table ES-6
Where Can We See LANL Impacts on Mesa-Top Surface Soil that Result in Values Near or Above Regulatory Standards or Risk Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Tritium	Yes, above background at some sites, particularly TA-54, Area G	No	Far below residential screening levels	Consistently detected in the south sections of Area G, but not increasing
Plutonium-239,240	Yes, above background along State Road 502 at TA-73 (downwind of TA-21) and at Area G	Yes, above background along State Road 502 on the west side of the airport (downwind of TA-21)	Far below residential screening levels	Plutonium-239,240 downwind of TA-21 is highly variable from sample to sample but is generally not increasing. Also, consistently detected on the north and northeast sections of Area G, but not increasing
Other Radionuclides	Mostly depleted uranium at DARHT	One sample above background for cesium-137	Far below residential screening levels	Uranium-238 is increasing over time at DARHT
Inorganic Chemicals	Few detections: beryllium at DARHT is just above background	Few detections	Far below industrial and occupational screening levels	Steady
PCBs	All below detection limits except one sample at Area G at TA-54	No	Far below industrial and occupational screening levels	Insufficient data at TA-54; re-sampling to be conducted at same site in 2007
High Explosives	All below detection limits	No	Minimal potential for exposure	None
Semi-volatile Organic Compounds (SVOCs)	One sample along State Road 502 on TA-73 contained some SVOCs	No	Far below industrial and occupational screening levels; from asphalt (not a LANL source)	None

All PCBs, HE, and nearly all semi-volatile organics in soil from perimeter and on-site locations were below detection limits. Only one site showed some semi-volatile organic compounds; this site is located on the south side of State Road 502 and east of the Los Alamos Fire Department and contained considerable amounts of asphalt. Asphalt, a petroleum-based product, contains a host of polyaromatic hydrocarbons, but the amounts detected were all below the occupational screening levels and do not pose a potential risk to human health. Sampling of soil around Area G shows concentrations similar to past years, including above-background concentrations of tritium in soil along the southern portion of Area G where the tritium shafts are located; and above-background americium and plutonium along the perimeter of the northern, northeastern, and eastern sections. After a spill of contaminated soil (during moving operations at Area G), additional soil samples collected around the northwestern perimeter section of Area G contained tritium, americium, and plutonium two to nearly six times higher than previous results. However, all concentrations are below residential screening levels and do not pose a potential unacceptable dose to human health.

Concentrations of americium-241, plutonium-238, and plutonium-239,240 in most of the soil samples collected along a transect starting from the northeast portion of Area G and extending to the Pueblo de

San Ildefonso fence line are above RSRLs. All concentrations are far below residential screening levels, and concentrations of all radionuclides decrease to background levels within a short distance from the Pueblo fence line.

At DARHT, soil samples contain slightly elevated levels of beryllium and greatly elevated levels of depleted uranium near the firing point. However, the concentrations of these elements are not elevated past the DARHT perimeter fence line.

➤ *Soil samples from off-site locations show radionuclides and metals have not increased over the past years and are mostly at background levels.*

➤ *All PCBs, high explosives, and nearly all semi-volatile organics in soil from perimeter and on-site locations are below detection limits.*

An evaluation of beryllium from samples collected around the Laboratory since 1992 shows that all on-site areas, except for DARHT, contained no beryllium levels above RSRLs. There are no increasing trends over time at any of the on-site or perimeter sample sites.

Foodstuffs and Nonfoodstuffs Biota Monitoring

Data from past years on radionuclides in domestic crop plants (vegetables and fruits) from all communities surrounding the Laboratory are indistinguishable from natural or fallout levels. Similarly, all trace element concentrations in vegetable and fruit samples are within or similar to the RSRLs and show no increasing trends in concentrations.

Table ES-7 summarizes contaminants found in biota around LANL. Foodstuffs samples collected in 2006 included wild edible plants, common lambsquarters, and pigweed amaranth collected from within Mortandad Canyon on Pueblo de San Ildefonso land. Concentrations, trends, and doses were assessed. The only radionuclide detected above the RSRL in both common lambsquarters and pigweed amaranth was strontium-90 in samples from Mortandad Canyon. The levels are similar to levels in other wild food plants collected from this same location in previous years and may be related to the lower calcium content in the soil because both elements are chemically similar and the plants do not differentiate between the two. The highest strontium-90 concentrations are below levels that would result in a dose of 0.1 mrem for each pound of common lambsquarters and pigweed amaranth consumed, which is 0.4% of the DOE pathway dose constraint of 25 mrem/yr.

➤ *In vegetation collected at area G (TA-54), all radionuclide concentrations were indistinguishable from background reference levels except tritium and plutonium in samples from areas with known contamination.*

➤ *At DAHRT, uranium in overstory (but not in understory) vegetation appears to be increasing over the past seven years.*

➤ *All radionuclides in vegetation and other biota from Area G and DARHT, including bees, birds, and small mammals, were well below screening levels.*

All inorganic chemical concentrations in common lambsquarters and pigweed amaranth samples collected from within Mortandad Canyon on Pueblo de San Ildefonso land are not detected or below RSRLs.

Native understory vegetation was collected from 17 on-site, 11 perimeter, and six regional locations. Most concentrations of radionuclides in native understory plants collected from both on-site and perimeter areas were either not detected or below RSRLs. The very few detected radionuclides higher than RSRLs in vegetation are from on-site and perimeter areas including strontium-90 and plutonium-238 in a sample collected east of Area G at TA-54; cesium-137 in a sample collected east of White Rock; tritium in a sample collected along State Road 502 at TA-73; and plutonium-239,240 in a sample collected west of the former plutonium processing facility

Table ES-7
Where Can We See LANL Impacts on Foodstuffs and Nonfoodstuffs Biota that Result in Values Near or Above Regulatory Standards or Risk Levels?

Media	LANL Impact	On-Site	Off-Site	Significance	Trends
Wild edible plants	Radionuclides	Not collected in 2006, but historically slightly higher in Mortandad Canyon than background	Above background concentrations for strontium-90 in plants from Mortandad Canyon on Pueblo de San Ildefonso land	Far below screening level. Higher strontium-90 in wild plants is a function of low calcium in the soil and not to increased contamination levels	Steady
	Inorganic chemicals	Not collected in 2006	No	No data	Steady
Native vegetation	Radionuclides	Mostly tritium and plutonium-239,240 at Area G; and depleted uranium at DARHT	Few detections	Far below screening levels	Tritium and plutonium-239,240 are steady at Area G but uranium-238 in trees is increasing over time at DARHT
	Inorganic chemicals	Few detections: arsenic in one plant sample at DARHT	No	Above screening levels but other media show no arsenic problems so outlier is suspected	Steady for most metals
Small mammals, bees, and birds	Radionuclides	Depleted uranium at DARHT. Some radionuclides in biota upstream of the Los Alamos Canyon Weir and the Pajarito Canyon Flood Retention Structure	None collected	Far below screening levels	Steady for most radionuclides
	Inorganic chemicals	Some detections in a bird at DARHT	None collected	One sample out of two	Insufficient data

at TA-21. All of these detected concentrations are below screening levels (set at 10% of the relevant standard) and do not result in adverse effects to the vegetation.

Most inorganic chemicals in native vegetation from on-site and perimeter areas are below RSRLs. The few inorganic chemicals in native vegetation from on-site and perimeter areas above RSRLs included mostly zinc and cadmium at levels that do not pose a hazard to the plants.

In vegetation collected at Area G at TA-54, all radionuclide concentrations are indistinguishable from background reference levels, except tritium and plutonium in plants next to the disposal area, where results are similar to past years and correlate well with levels measured in soil. All concentrations of inorganic chemicals, with the exception of zinc in both vegetation samples, were either not detected or below the RSRLs.

At DARHT, all radionuclide concentrations in vegetation are indistinguishable from RSRLs, except for uranium in overstory vegetation collected from the north and east sides of the complex. The ratio of uranium-234 to uranium-238 is consistent with that of depleted uranium, which is used as a substitute for enriched uranium in the testing performed at the site. Uranium in overstory (but not in understory) vegetation appears to be increasing over the past seven years. The only inorganic chemical detected above RSRLs is arsenic in one overstory plant sample collected on the south side of the DARHT facility. No other arsenic detections occur in previous or concurrent samples and soil levels are normal.

Deer mice were collected from the north and northeast side of the DARHT facility. Only uranium-234 in the whole body of mice collected downwind of DARHT was detected above RSRLs. The level of uranium-234 is far below the screening level and does not pose a hazard to the mice. The distribution of uranium-234 and uranium-238 indicate the uranium in mice is depleted uranium.

All radionuclides in two composite samples of birds collected west of the DARHT facility are either not detected or below the RSRLs. In contrast, many inorganic chemicals were detected above RSRLs in one bird (a spotted towhee), including aluminum, barium, beryllium, iron, manganese, vanadium, arsenic, lead, and silver. The reason for the elevated levels in only one bird is not understood, but is probably from sources other than DARHT.

Most concentrations of radionuclides and all nonradionuclides in bees sampled from four hives located northeast of the DARHT facility are below RSRLs. The exception is uranium-234 and uranium-238 in three out of the four bee samples. The distribution of these isotopes shows that one of these samples contains depleted uranium.

In sediment upstream of the Los Alamos Canyon Weir, cesium-137, plutonium-238, plutonium-239,240, americium-241, silver, mercury, lead, and Aroclor-1260 were detected in concentrations higher than the RSRLs. Also, strontium-90, plutonium-239,240, americium-241, and lead in overstory plants and plutonium-239,240, americium-241, uranium-234, and uranium-238 in whole body mice are higher than RSRLs. All concentrations are below screening levels and do not pose a potential unacceptable dose to human health or to the biota sampled.

Upstream of the Pajarito Canyon Flood Retention Structure, sediment concentrations of cesium-137, plutonium-239,240, uranium-234, uranium-238, copper, cadmium, silver, mercury, and Aroclor-1254 are above RSRLs; vegetation has concentrations of uranium-234, uranium-238, lead, and silver above RSRLs; and the small mammals have concentrations of plutonium isotopes, americium-241, uranium-234, and uranium-238 above RSRLs. All concentrations of radionuclides and nonradionuclides in all media, however, are below screening levels and do not pose a potential unacceptable dose to human health or to the biota sampled.

➤ *All radionuclide concentrations in wild edible plants from Mortandad Canyon on Pueblo de San Ildefonso land were below levels that would result in 0.4% of the DOE pathway dose constraint of 25 mrem/yr.*

Along the north perimeter fence line of MDA B, four composite samples of tree shoot tips were collected from every tree growing along a 100-yard section starting from the east end. Most isotopes are not detected or below RSRLs. The few radionuclides above RSRLs—cesium-137 in one sample and plutonium-239,240 in another sample—are below screening levels used to assess the dose to the trees. Chromium and nickel in one sample and zinc and lead in another sample are above RSRLs; differences between MDA B trees and regional trees were small. All elements are below screening levels and do not cause a significant dose to the trees.

Environmental Restoration Program

Corrective actions proposed and/or conducted at LANL in 2006 follow the requirements of the Consent Order. The goal of the investigation efforts is to ensure that waste and contaminants from past operations do not threaten human or environmental health and safety. Accomplishments include the completion of investigation activities, approvals of proposed investigation activities, and approvals of the work completed at some sites. Field activities conducted in 2006 included: investigation activities at MDAs A, C, T, U and V; final remedy construction for the TA-73 Airport Landfill; field investigations in Pueblo Canyon, Guaje, Barrancas/Rendija Canyons Aggregate Area, North Canyons, and Pajarito Canyon; accelerated corrective actions at a former storage area with petroleum contamination; and investigations at a former petroleum-contaminated storage area, a site with an oil-water separator and drainline and a former high explosive storage magazine, a former experimental area with potential radionuclide and metals contamination, a former explosives processing site, a former vacuum-pump oil disposal and storage site, and the groundwater in Mortandad Canyon. During 2006, environmental restoration activities collected over 3,330 samples from over 1,100 locations and requested over 418,000 analyses or measurements on these samples.

- *Characterization and cleanup of sites contaminated or potentially contaminated by past LANL activities follow the Consent Order.*
- *16 investigation work plans and 14 investigation reports were submitted to NMED in 2006.*
- *28 sites were granted certificates of completion.*

Under the Consent Order, 16 investigation work plans and 14 investigation reports were submitted to NMED. In 2006, NMED approved a total of 10 investigation work plans and 10 investigation reports, some with modifications or directions. Of the documents approved, LANL submitted eight work plans and five reports in 2006; the other approved plans were submitted in previous years. A total of 28 SWMUs and areas of concern were granted certificates of completion, which signifies that the investigations have been completed. In addition, NMED is reviewing four work plans and three reports as of the end of the calendar year.

The investigation activities are designed to characterize SWMUs, areas of concern, consolidated units, aggregate areas, and watersheds. The characterization activities conducted include surface and subsurface sampling, drilling boreholes, geophysical studies, and installation of monitoring wells. Corrective action activities performed included the removal of structures (e.g., buildings, septic systems, sumps, and drainlines), excavation of contaminated media, and confirmatory sampling. These activities defined the nature and extent of contamination and determined the potential risks and doses to human health and the environment.

- *Investigations included drilling a substantial number of boreholes, collecting thousands of samples, and obtaining hundreds of thousands of analytical results.*
- *Cleanup activities included the removal of structures (e.g., buildings, septic systems, sumps, and drainlines), soil vapor extraction, excavation of contaminated media, and confirmatory sampling.*
- *In 2006, 28% of all environmental samples collected and 68% of all sample analyses were for environmental characterization and remediation work at LANL.*

Risk Reduction

Risk is evaluated either as current (present-day) or prospective (future) risk. The Laboratory assesses hazards and the corresponding risks by evaluating environmental data, measurements, inventories of buried or stored materials, and potential exposure pathways and scenarios. Models, data, and computer programs are used to assist with these estimates.

Over the years, the Laboratory has decreased its release of materials into the environment and has reduced the amount of legacy contamination. Examples include the reduction in both the number of outfalls (plant and process discharges) and the volume of water released from these, the reduction in air emissions, changes to effluent treatment processes at the Radioactive Liquid Waste Treatment Facility at TA-50, and the removal of contaminated material and waste at sites such as MDA P. These efforts together have significantly reduced or eliminated potential exposure and risk to workers, the public, and the environment.

Examples of ongoing risk reduction activities include: the transport of stored legacy transuranic waste from Area G to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM; the planned cleanup and remediation of the former plutonium processing facility at TA-21; ongoing studies of groundwater contamination to evaluate future hazards and risks; additional emission controls added in 2005 to reduce radioactive gas emissions from LANSCE; and numerous investigations and corrective actions at potentially contaminated sites, such as cleanup of a legacy disposal area and landfill site next to the Los Alamos County Airport and the remediation activities at MDA V where three absorption beds and other contaminated soil and tuff were excavated.

The sensitivity of measurements obtained by LANL's environmental surveillance program can detect hazardous and radioactive materials and other contaminants during cleanup or normal operations at near and remote locations. Each possible pathway to people and the environment is monitored. The data from monitoring can be used to assist with possible mitigation of impacts. Air monitoring by the AIRNET system has regularly detected airborne contaminants where both known and unexpected contamination is present on the surface; in many cases, remediation was initiated to remove the source, though levels have never approached regulatory limits. The AIRNET system can detect low levels of radionuclides that are dispersed during cleanup operations and many additional samplers have been added in anticipation of upcoming cleanup operations. The Direct Penetrating Radiation network detects neutrons and gamma rays from the stored waste at Area G and is used to help keep radiation levels as low as reasonably achievable. Biota and foodstuffs monitoring is conducted to ensure there is no spread of contamination into plants and foods. The monitoring of constituents in groundwater keeps track of the movement of previously-released contaminants and their potential migration in the aquifers.

➤ *Past risk reduction successes include the reduction in the number of outfalls (plant and process discharges) and the volume of water released from them, the reduction in air emissions over the past several years, changes to effluent treatment processes at the Radioactive Liquid Waste Treatment Facility at Technical Area 50, and the removal of contaminated material and waste at former waste disposal sites.*

➤ *Ongoing risk reduction efforts include the transport of waste from Area G to permanent disposal at WIPP, studies of the movement of contaminants in groundwater, and planned or active cleanup operations at former waste and radionuclide processing sites.*

➤ *The environmental surveillance programs can detect very low levels of potential contaminants and thus enable the detection of new hazards and the evaluation of the associated level of risk.*



1. Introduction



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A. BACKGROUND AND REPORT OBJECTIVES

1. Introduction to Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. Although planners originally expected that the task would require only 100 scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. Through May 2006, the Laboratory was managed by the Regents of the University of California (UC) under a contract administered by the National Nuclear Security Administration (NNSA) of the US Department of Energy (DOE) through the Los Alamos Site Office and the NNSA Service Center based in Albuquerque, N.M. In June 2006, a new management organization, Los Alamos National Security (LANS), LLC, took over management of the Laboratory.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, US priorities, and the world community have changed. The current mission is to develop and apply science and technology to

- Ensure the safety and reliability of the US nuclear deterrent;
- Reduce global threats; and
- Solve other emerging national security challenges (LANL 2005a).

Los Alamos National Laboratory's vision is "Los Alamos, the premier national security science laboratory." The Laboratory has identified 12 strategic goals to implement its vision and mission:

- Make safety and security integral to every activity we do.
- Implement a cyber security system that reduces risk while providing exemplary service and productivity.
- Establish excellence in environmental stewardship.
- Assess the safety, reliability, and performance of LANL weapons systems.
- Transform the Laboratory and the nation's nuclear weapons stockpile to achieve the 2030 vision, in partnership with the Complex.

- Leverage our science and technology advantage to anticipate, counter, and defeat global threats and meet national priorities, including energy security.
- Be the premier national security science laboratory and realize our vision for a capabilities-based organization.
- Provide efficient, responsive, and secure infrastructure and disciplined operations that effectively support the Laboratory mission and its workforce.
- Implement a performance-based management system that drives mission and operational excellence.
- Deliver improved business processes, systems, and tools that meet the needs of our employees, reduce the cost of doing business, and improve the Laboratory's mission performance.
- Communicate effectively with our employees, customers, community, stakeholders, and the public at large.
- Develop employees and create a work environment to achieve employee and Laboratory success.

Inseparable from the Laboratory's commitment to excellence in science and technology is its commitment to complete all work in a safe, secure, and environmentally responsible manner. The Laboratory uses Integrated Safety Management (ISM) to set, implement, and sustain safety performance and meet environmental expectations. In addition, the Laboratory uses an International Standards Organization (ISO) 14001-2004 registered Environmental Management System (EMS) as part of ISM to focus on environmental performance, protection, and stewardship (see Section D of this chapter for additional information). The foundation of the EMS and the demonstration of the Laboratory's commitment is the LANL environmental policy:

> *It is the policy of Los Alamos National Laboratory that we will be responsible stewards of our environment. It is our policy to: Manage and operate our site in compliance with environmental laws and standards and in harmony with the natural and human environment; Meet our environmental permit requirements; Use continuous improvement processes to recognize, monitor and minimize the consequences to the environment stemming from our past, present, and future operations; Prevent pollution; Foster sustainable use of natural resources; Work to increase the body of knowledge regarding our environment.*

2. Objectives

As part of the Laboratory's commitment to our environmental policy, we will monitor and report on how Laboratory activities are affecting the environment. The objectives of this environmental surveillance report, as directed by DOE Order 231.1 (DOE 2003a, DOE 2004), are to

- Characterize site environmental management performance including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment.
- Summarize environmental occurrences and responses reported during the calendar year.
- Confirm compliance with environmental standards and requirements.
- Highlight significant programs and efforts, including environmental performance indicators and/or performance measures programs.

Over and above the DOE requirements, the Laboratory establishes annual environmental objectives, targets, and key performance indicators through its EMS. The current objectives are to

- Ensure environmental compliance.
- Reduce waste.
- Improve Laboratory-wide energy and fuel conservation.
- Conduct Laboratory-wide cleanout activities to dispose of unneeded equipment, materials, chemicals, and associated waste by October 2011.
- Achieve zero liquid discharge by 2012.

B. ENVIRONMENTAL SETTING

1. Location

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico (NM), approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west-oriented canyons cut by streams. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft near the Rio Grande Canyon. Most Laboratory and community developments are confined to the mesa tops.

The surrounding land is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and the Los Alamos County. Pueblo de San Ildefonso borders the Laboratory to the east.

2. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. Three major potentially active local faults constitute the modern rift boundary. Studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al., 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-2) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains volcanic center 1.2–1.6 million years ago, the tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. The Cerros del Rio Basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

Surface water in the Los Alamos region occurs primarily as short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory property before the water is depleted by evaporation, transpiration, and infiltration.

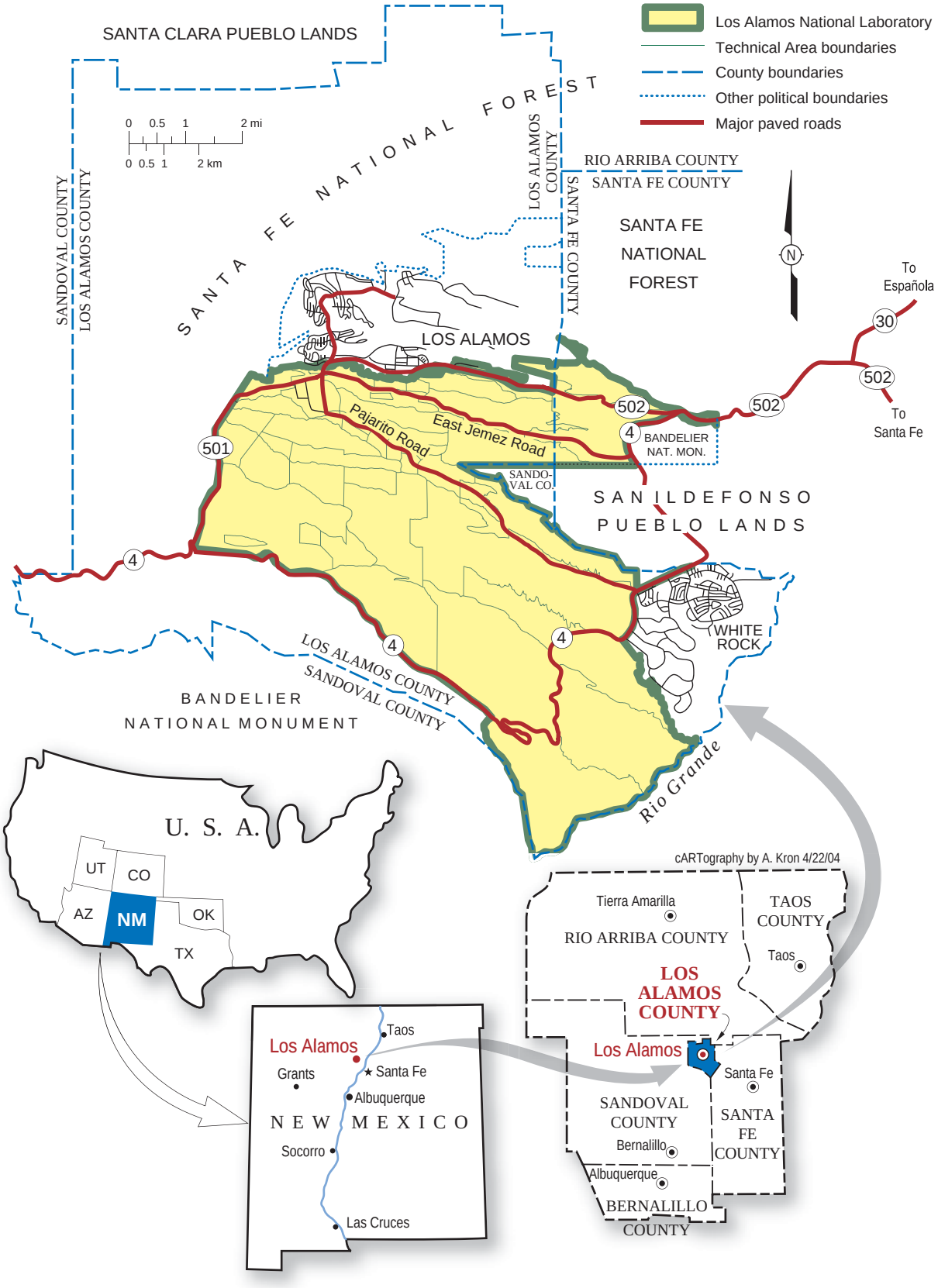

Figure 1-1. Regional location of Los Alamos National Laboratory.

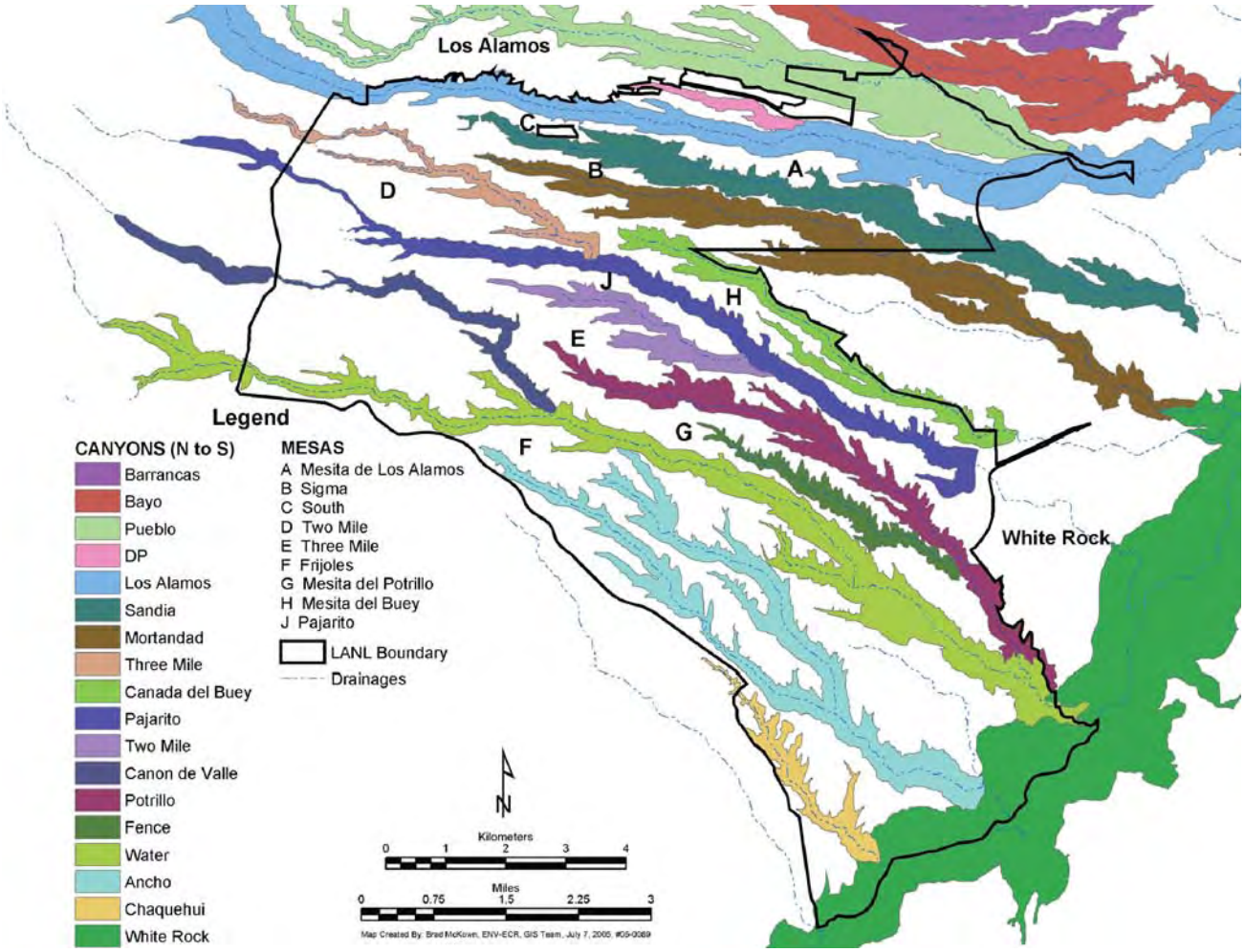

Figure 1-2. Major canyons and mesas on Laboratory land.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the regional aquifer, which is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer is in artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen 1974). The source of most recharge to the aquifer appears to be infiltration of precipitation that falls on the Jemez Mountains. The regional aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 11.5-mi reach of the river in White Rock Canyon, between Otowi Bridge and the mouth of Rio de los Frijoles, receives an estimated 4,300–5,500 ac-ft of water from the regional aquifer.

3. Biological Resources

The Pajarito Plateau, including the Los Alamos area, is biologically diverse. This diversity of ecosystems is due partly to the dramatic 5,000-ft elevation gradient from the Rio Grande on the east of the plateau up to the Jemez Mountains 12 mi (20 km) to the west and partly to the many steep canyons that dissect the area. Five major vegetative cover types are found in Los Alamos County. The juniper (*Juniperus monosperma* Englem. Sarg.)-savanna community is found along the Rio Grande on the eastern border of the plateau and extends upward on the south-facing sides of canyons at elevations between 5,600 and 6,200 ft. The piñon (*Pinus*

edulis Engelm.)-juniper cover type, generally between 6,200 to 6,900 ft in elevation, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine (*Pinus ponderosa* P. & C. Lawson) communities are found in the western portion of the plateau between 6,900 and 7,500 ft in elevation. These three vegetation types predominate, each occupying roughly one-third of the Laboratory site. The mixed conifer cover type, at an elevation of 7,500 to 9,500 ft, overlaps the Ponderosa pine community in the deeper canyons and on north-facing slopes and extends from the higher mesas onto the slopes of the Jemez Mountains. Spruce (*Picea* spp.)-fir (*Abies* spp.) is at higher elevations of 9,500 to 10,500 ft. Several wetlands and riparian areas enrich the diversity of plants and animals found on LANL lands.

In May 2000, the Cerro Grande fire burned over 43,000 ac of forest in and around LANL. Most of the habitat damage occurred on Forest Service property to the west and north of LANL. Approximately 7,684 ac, or 28% of the vegetation at LANL, was burned to varying degrees by the fire. However, few areas on LANL property were burned severely. Wetlands in Mortandad, Pajarito, and Water Canyons received increased amounts of ash and hydromulch runoff because of the fire.

The extreme drought conditions prevalent in the Los Alamos area and all of New Mexico from 1998 to the present have resulted directly and indirectly in the mortality of many trees. Between 2002 and 2005 more than 90% of the piñon trees greater than 10 ft tall have died in the Los Alamos area. Lower levels of mortality have also occurred in ponderosa and mixed conifer stands. Mixed conifers on north-facing canyon slopes at lower elevations have experienced widespread mortality. These changes likely will have long-lasting impacts to vegetation community composition and distribution.

4. Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 86% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1,800 sites have been recorded. During fiscal year (FY) 2006, sites that have been excavated since the 1950s were removed from the overall site count numbers. Thus, the number of recorded sites is less than in reports from previous years. More than 85% of the resources are Ancestral Pueblo and date from the 13th, 14th, and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 5,800 and 7,100 ft. Almost three-quarters of all cultural resources are found on mesa tops. Buildings and structures from the Manhattan Project and the early Cold War period (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places, and more than 320 buildings have been evaluated to date. In addition, "key facilities" (facilities considered of national historic significance) dating from 1963 to the end of the Cold War in 1990 are also being evaluated.

5. Climate

Los Alamos County has a temperate, semiarid mountain climate. Large differences in locally observed temperature and precipitation exist because of the 1,000-ft elevation change across the Laboratory site and the complex topography. Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with occasional afternoon thunderstorms. Fall is typically dry, cool, and calm.

Daily temperatures are highly variable (a 23˚F range on average). On average, winter temperatures range from 30˚F to 50˚F during the daytime and from 15˚F to 25˚F during the nighttime. The Sangre de Cristo Mountains to the east of the Rio Grande Valley act as a barrier to wintertime arctic air masses that descend into the central United States, making the occurrence of local subzero temperatures rare. On average, summer temperatures range from 70˚F to 88˚F during the daytime and from 50˚F to 59˚F during the nighttime.

From 1971 to 2000, the average annual precipitation (which includes both rain and the water equivalent of frozen precipitation) was 18.95 in., and the average annual snowfall amount was 58.7 in. (NOTE: By convention, full decades are used to calculate climate averages [WMO 1984].) The months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning. Local lightning density, among the highest in the United States, is estimated at 15 strikes per square mile per year. Lightning is most commonly observed between May and September (about 97% of the local lightning activity).

The complex topography of the Pajarito Plateau influences local wind patterns. Often a distinct diurnal cycle of winds occurs. Daytime winds measured in the Los Alamos area are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds (sunset to sunrise) on the Pajarito Plateau are lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope flow of cooled mountain air. Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest, mainly because of the prevailing westerly winds.

C. LABORATORY ACTIVITIES AND FACILITIES

The Laboratory is divided into technical areas (TAs) that are used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (Appendix C and Figure 1-3). However, these uses account for only a small part of the total land area; much of the LANL land provides buffer areas for security and safety or is held in reserve for future use. The Laboratory has about 2,000 structures with approximately 8.6 million square feet under roof, spread over an area of approximately 40 square miles.

In its 1999 Site-Wide Environmental Impact Statement (SWEIS) (DOE 1999), LANL identified 15 Laboratory facilities as "Key Facilities" for the purposes of facilitating a logical and comprehensive evaluation of the potential environmental impacts of LANL operations (Table 1-1). Operations in the Key Facilities represent the majority of exposures associated with LANL operations. In 2005, DOE/NNSA decided to prepare a new SWEIS. The new SWEIS will be completed in the summer of 2007, with a Record of Decision (ROD) scheduled to be issued in December 2007. Until a ROD is issued for the new SWEIS, LANL operations will continue to be conducted under the existing 1999 SWEIS ROD. The facilities identified as "key" for the purposes of the 1999 SWEIS are those that house activities critical to meeting work assignments given to LANL and also include the following:

- In-house operations that could potentially cause significant environmental impacts,
- Activities or operations of most interest or concern to the public based on SWEIS scoping comments, or
- Activities or operations that would be the most subject to change because of programmatic decisions.

In the 1999 SWEIS and in the new SWEIS, the remaining LANL facilities were identified as "Non-Key Facilities" because these facilities do not meet the above criteria. The Non-Key Facilities comprise all or the majority of 30 of LANL's 48 TAs and approximately 14,224 ac of LANL's 26,480 ac (Table 1-1). The Non-Key Facilities also currently employ about 42% of the total LANL workforce. The Non-Key Facilities include such important buildings and operations as the Nicholas C. Metropolis Center for Modeling and Simulation, the Nonproliferation and International Security Center (NISC), the new National Security Sciences Building (NSSB) that is now the main administration building, and the TA-46 sewage treatment facility.

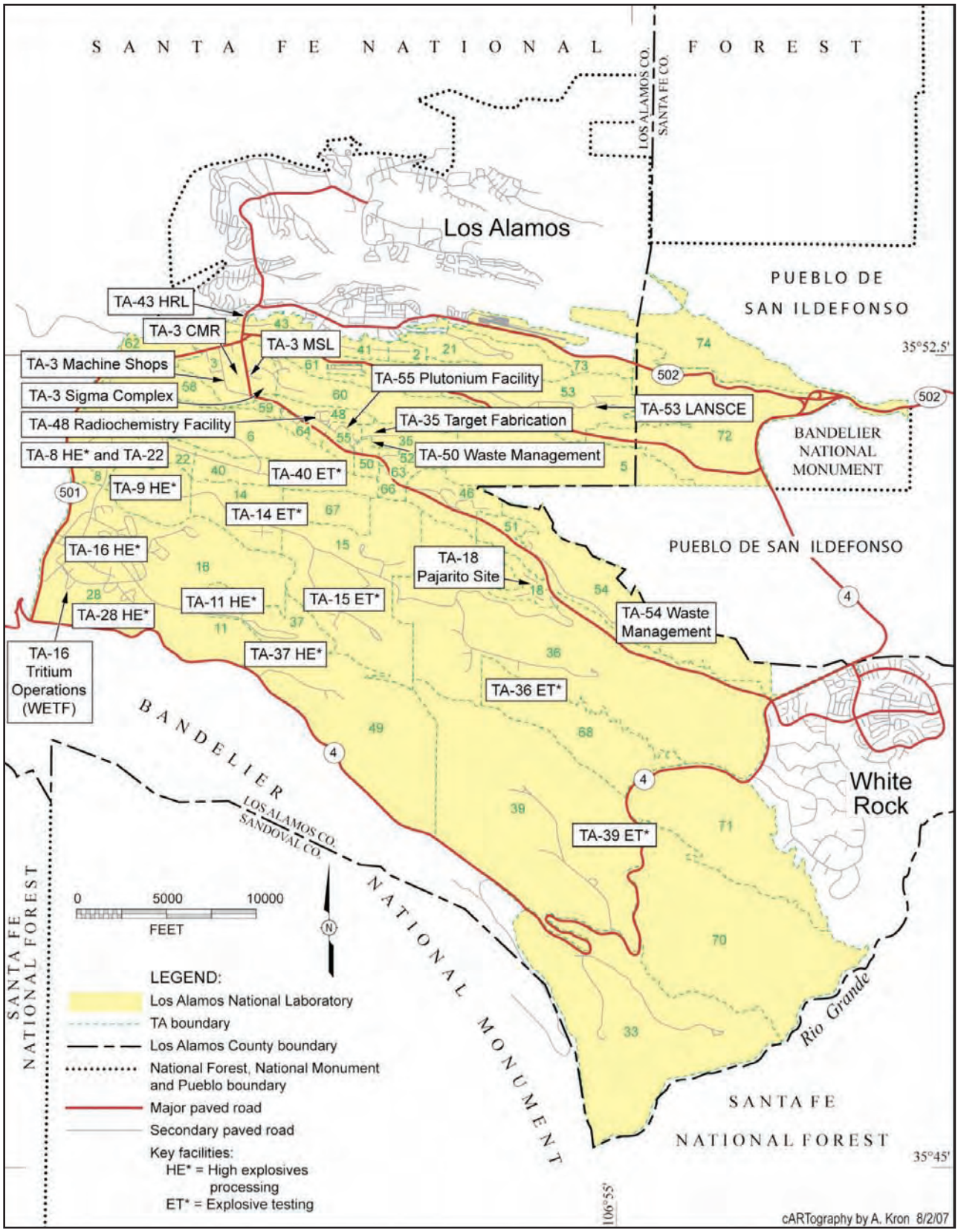

Figure 1-3. **Technical Areas (TAs) and key facilities of Los Alamos National Laboratory in relation to surrounding landholdings.**

Table 1-1
Key Facilities[a]

		Size (Acres)
Plutonium Complex	TA-55	93
Tritium Facilities	TA-16 & TA-21	312
Chemical and Metallurgy Research (CMR) Building	TA-03	14
Pajarito Site	TA-18	131
Sigma Complex	TA-03	11
Materials Science Laboratory (MSL)	TA-03	2
Target Fabrication Facility (TFF)	TA-35	3
Machine Shops	TA-03	8
High-Explosives Processing	TA-08, -09, -11, -16, -22, -28, -37	1,115
High-Explosives Testing	TA-14, -15, -36, -39, -40	8,691
Los Alamos Neutron Science Center (LANSCE)	TA-53	751
Biosciences Facilities (formerly Health Research Laboratory)	TA-43, -03, -16, -35, -46	4
Radiochemistry Facility	TA-48	116
Radioactive Liquid Waste Treatment Facility (RLWTF)	TA-50	62
Solid Radioactive and Chemical Waste Facilities	TA-50 & TA-54	943
Subtotal, Key Facilities		**12,256**
Non-Key Facilities	30 of 48 TAs	14,224
LANL Acreage		**26,480**

[a] Data from SWEIS Yearbook – 2003 (LANL 2004).

The operation of the 15 Key Facilities, together with functions conducted in other Non-Key Facilities, formed the basis of the description of LANL facilities and operations analyzed in the 1999 SWEIS for potential environmental impacts. For the purpose of the impact analysis provided by the new SWEIS, the identity of the LANL Key Facilities has been modified to reflect subsequent DOE decisions that resulted in changes to LANL facilities and operations. The Nicholas C. Metropolis Center for Modeling and Simulation (Metropolis Center) has been added as a Key Facility because of the amounts of electricity and water it may use. Security Category I and II materials and operations have been moved from the TA-18 Pajarito Site. Under either of the Action Alternatives evaluated in the new SWEIS, Security Category III and IV materials and operations would be removed from the Pajarito Site and it would be eliminated as a Key Facility. Under the No Action Alternative, the Pajarito Site would remain a Key Facility. Tritium operations at Technical Area 21 have ceased and both the Tritium Science Test Assembly Facility and Tritium Science and Fabrication Facility are planned for decontamination, decommissioning, and eventual demolition. When the ROD is issued in FY 2008, TA-21 will also no longer be a Key Facility.

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Integrated Safety Management (ISM) provides the Laboratory with a comprehensive, systematic, standards-based performance-driven management system for setting, implementing, and sustaining safety performance and meeting environmental expectations. The term "integrated" is used to indicate that the safety and environmental management system is a normal and natural element of the performance of work. Safety, protection of the environment, and compliance with environmental, safety, and health (ES&H) laws and regulations are an integral part of how the Laboratory does business. ISM is the way that we meet the ethical

commitment to avoid injury to people and the environment and the business imperative to meet the safety and environmental requirements of the contract for managing and operating the Laboratory.

ISM is integral to accomplishing the Laboratory mission. The goal of ISM is to establish "safety" (used generically to encompass all aspects of environment, safety, and health) as a fundamental value for operating the Laboratory and that this value is reflected in the attitudes and behaviors of all workers. ISM is structured to manage and control work at the institutional, the facility, and the activity level. A seamless integration of ES&H with the work being done is fundamental. Inseparable from this concept is the important principle that line management is responsible for safety, with clear and unambiguous roles and lines of responsibility, authority, and accountability at all organizational levels and with full participation of the workforce. ISM requires that all work and all workers meet the safety and environmental requirements defined by the Laboratory requirements system.

1. Environmental Management Program

The Laboratory is committed to protecting the environment while conducting its important national security and energy-related missions. In support of this commitment, LANL has implemented a pollution-prevention-based EMS pursuant to DOE Order 450.1, Environmental Protection Program. An EMS is a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. DOE Order 450.1 defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." This DOE Order mandates that the EMS be integrated with an existing management system already established pursuant to DOE Policy 450.4. Although it significantly exceeds DOE Order 450.1 requirements, LANL pursued and achieved registration to the ISO 14001:2004 standard in April 2006.

The EMS program met several milestones in 2006. Implementing Procedures (IMP 401, 402, 403) governing communications, legal and other requirements, and environmental aspects were updated to reflect the new LANS management. These procedures defined EMS roles and responsibilities from the Laboratory Director to individual staff levels. In addition to these institutional policy changes, each Division Director was asked to sign an EMS charter for his/her Division that reiterated commitment to the process.

In 2006, the EMS process was executed by multi-disciplinary teams from each Division (all 31 LANL Divisions that existed until June 2006) and the security subcontractor (Protection Technologies Los Alamos [PTLA]). These organizations identified their activities, products, and services and their potential environmental aspects. They prioritized these aspects to determine which were significant and developed an Environmental Action Plan designed to prevent or eliminate the environmental risk associated with those aspects. The Division teams were aided by a trained support person from the EMS Core Team, whose members were trained in ISO 14001:2004 systems.

All 31 LANL Divisions and PTLA completed the Division Environmental Action Plans. Together, these plans commit to nearly 600 environmental improvement and pollution prevention actions beginning in FY 2006. The Laboratory also met the DOE Order 450.1 requirement to have an EMS implemented by December 31, 2005.

Registration to the ISO 14001:2004 standard requires extensive management review. External audits of the system have been conducted as follows:

- Kansas City Plant Pre-Audit, September 2004 (three auditors, three days)
- NSF-ISR (an independent third-party ISO 14001 registrar) Pre-Assessment, September 2005 (two auditors, three days)

- NSF-ISR Desk Audit, November 2005 (one auditor, two days)
- NSF-ISR Readiness Review, Phase 1 Audit, January 2006 (two auditors, three days)
- NSF-ISR Certification Audit, Phase 2 Audit, March 2006 (five auditors, five days)
- NSF-ISR Surveillance Audit 1, September 2006 (two auditors, three days)
- NSF-ISR Surveillance Audit 2, April 2007 (two auditors, three days)

These audits covered most of the Divisions and all major support contractors and included interviews conducted from the Director and Deputy Director level to individual staff and students chosen at random by the auditors. The auditors concluded that the LANL EMS meets all the requirements of the ISO 14001-2004 standard with no major nonconformities and recommended that LANL maintain full certification. On April 13, 2006, LANL received full certification of its EMS to the ISO 14001-2004 standard. LANL is the first NNSA national laboratory and the first University of California-operated facility to receive this distinction.

NNSA recognized the success of the EMS management and the core teams' unique approach by giving the Laboratory the 2006 NNSA "Best in Class" Award for EMS-developed projects. The Laboratory also received the DOE Pollution Prevention STAR Award for 2006.

A second important component of the EMS is the institutional environmental stewardship and management support programs. These programs, described below, assist with the integration of job and work-specific evaluations and ensure natural and cultural resources are managed from a Laboratory-wide perspective.

a. Waste Management Program. Research programs that support the Laboratory's mission generate contaminated waste that must be properly managed to avoid risks to human health, the environment, or national security. The Laboratory generates Resource Conservation and Recovery Act regulated waste, Toxic Substances Control Act regulated waste, low-level radioactive waste, mixed low-level waste, transuranic waste, wastewater, administratively controlled waste, medical waste, New Mexico Special Waste, and solid waste. Certain wastes are also treated and/or disposed of at the Laboratory.

The Laboratory's goal is to conduct waste management operations in a manner that minimizes hazardous and nonhazardous waste generation as much as is technically and economically feasible and maintains excellence in safety, compliance, environment, health, and waste management operations. This goal is accomplished through the following:

- Ensuring a safe and healthy workplace;
- Minimizing adverse impact to the general public;
- Minimizing adverse impact to the environment; and
- Ensuring compliance with all applicable laws, standards, and regulations governing environment, safety, and health.

b. Pollution Prevention Program. The Pollution Prevention (P2) Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs, and reduce risk. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions. Specific P2 activities include the following:

- Collecting data and reporting on DOE P2 goals;
- Forecasting waste volume to identify P2 opportunities;

- Conducting P2 opportunity assessments for customer divisions;
- Funding specific waste reduction projects through the Generator Set-Aside Fund Program;
- Managing affirmative procurement efforts;
- Conducting an annual LANL P2 awards program to recognize achievements;
- Supporting sustainable design for the construction of new buildings; and
- Communicating P2 issues to the Laboratory community.

The Laboratory's P2 Program continues to be recognized for its accomplishments. The Laboratory received seven (up from five in FY 2005) national NNSA Pollution Prevention awards for Laboratory projects in FY 2006. Projects in FY 2006 yielded more than $5.2 million (up from more than $4 million in FY 2005) in savings to the Laboratory. The P2 Program was instrumental in incorporating preventive measures into the EMS, and the Laboratory received ISO 14001 certification. The pollution prevention efforts received an overall performance rating of "Good" for FY 2006. The projects collectively avoided the generation of more than 10,300 kg of hazardous waste, 680 kg of mixed low-level waste, 169 m3 of low-level waste, 55 m3 of transuranic waste, 170 m3 of industrial waste, 2200 kg of sand, and 1,500 gal. of storm water potentially contaminated with high explosives. Together the projects were responsible for the recycling of 40,000 gal. of oil, more than 1,000,000 lbs of scrap metal, 100 tons of concrete, 25,000 m3 of soil, and hundreds of m3 of furniture and equipment for reuse.

c. Environmental Restoration Programs. In mid-2006, the environmental programs were reorganized into several projects that have responsibility for different aspects of environmental restoration. The goal of these projects is to ensure that residual materials and contaminants from past Laboratory operations do not threaten human or environmental health and safety. To achieve this goal, the Laboratory is investigating and, as necessary, remediating sites contaminated by past Laboratory operations. Fieldwork at several sites was either implemented, ongoing, or completed in calendar year 2006. Much of the work under these projects is subject to the requirements in the Compliance Order on Consent (Chapter 2, Section B.1). Chapter 9 summarizes the cleanup work conducted or completed in calendar year 2006.

d. Compliance and Surveillance Programs. The Laboratory routinely collects samples of air particles and gases, water, soil, sediment, foodstuffs, and associated biota. For 2006, the Laboratory requested more than 617,000 analyses for chemical and radiochemical constituents on over 11,700 environmental samples from at least 1,888 sampling locations (Table 1-2). By far, the largest number of samples was collected to characterize or assess sites being investigated or cleaned up as part of environmental restoration efforts. The remainder of the analyses helps identify whether impacts occurred from LANL operations or whether emissions and releases are within limits. Trained personnel collect additional samples to obtain information about particular events, such as major surface-water runoff events, non-routine radiation releases, or special studies.

i. Air Resources. The Laboratory maintains a rigorous air quality compliance program for the emissions of both radionuclide and nonradionuclide air pollutants. The Laboratory operates under a number of air emissions permits issued by the New Mexico Environment Department (NMED) and approvals for construction of new facilities/operations by the US Environmental Protection Agency (EPA). These permits and approvals require pollution control devices, stack emissions monitoring, and routine reporting. This report describes these permits and reports; they are also available online at http://www.lanl.gov/environment/air/index.shtml. Proposals for new Laboratory operations and facilities are reviewed to determine the requirements for permitting, monitoring, and reporting of air emissions.

In addition to the compliance program, the Laboratory operates an extensive network of ambient air quality monitoring stations and direct penetrating radiation monitoring stations. The network includes station

Table 1-2
Approximate Numbers of Environmental Samples, Locations, and Analytes collected in 2006

Sample Type or Media	Locations	Samples	Analytes or Measurements
Ambient Air[a]	55	2,618	8,104
Stack Monitoring	29	3,173	26,485
Ground Water	195	567	105,784
Surface Water Base Flow	31	42	12,738
Surface Water Snowmelt	0	0	0
Surface Water Storm Runoff	163	969	31,048
NPDES Outfalls	17	82	1815
Sediment	61	61	5,416
Soil, Foodstuffs, and Biota	87	378	7,565
Neutron Radiation	50	200	200
Gamma Radiation	92	361	361
Environmental Restoration	1,108	3,332	418,250
Totals:	**1,888**	**11,783**	**617,766**

[a] Does not include particulate (in air) measurements made by six Tapered Element Oscillating Microbalance instruments that calculated particulate concentrations every half hour.

locations on site, in adjacent communities, and in regional locations. These stations are operated to ensure that air quality and ambient radiation doses meet EPA and DOE standards. These data are published in this report (Chapter 4) and online at http://www.lanl.gov/environment/air/index.shtml.

The Laboratory also works with and assists neighboring communities and pueblos in performing ambient air, direct penetrating radiation, and meteorological monitoring.

ii. Water Resources. The LANL Water Stewardship Program manages and protects groundwater and surface water resources (Chapters 5 and 6). The Laboratory conducts several activities to comply with the requirements of DOE Orders, NM and federal regulations, and the Consent Order.

Groundwater resource management and protection efforts at the Laboratory focus on (1) the regional aquifer underlying the plateau, (2) the perched groundwater found within canyon alluvium, and (3) the perched groundwater at intermediate depths above the regional aquifer. The objectives of the Laboratory's groundwater programs are to determine compliance with waste-discharge requirements and to evaluate any impact from Laboratory activities on groundwater resources. This program includes environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations.

To evaluate the potential environmental effects of Laboratory operations, LANL's surface water protection efforts focus on monitoring surface water and stream sediment in northern NM. The objectives of the surface water program are to address water pollution control compliance, environmental surveillance, watershed management, surface and ground water protection, drinking water quality protection, pesticide protection obligations, and public assurance needs. The Laboratory analyzes samples for parameters such as radionuclides, high explosives, metals, a wide range of organic compounds, and general chemistry.

iii. Biological Resources. The LANL biological resources program focuses on assisting Laboratory projects and programs to comply with federal and state laws and regulations, DOE Orders, and LANL directives related to biological resources. DOE/NNSA and LANL administrators determined that management of natural resources strongly benefits the Laboratory (DOE 1996). The Mitigation Action Plan for the SWEIS for Continued Operation of Los Alamos National Laboratory (DOE 1999) formalized this effort by requiring

LANL to mitigate the danger of wildfire and develop a comprehensive plan for integrated natural resources management.

The current approach to managing biological resources at LANL includes developing an institutional Biological Resources Management Plan (LANL 2006). The plan is being developed to integrate short- and long-term mission activities and compliant and effective management of LANL's biological resources. The plan addresses the following elements: site planning, landscape management (including protection of wetlands and floodplains, and integration of forest fuels treatments into other biological resource protection objectives), species management (including federally threatened or endangered species and other sensitive species), and contaminants in biota.

LANL's Emergency Management and Response Division manages wildland fire, including fuels treatment on LANL property. One of the lasting results of past wildfires in and around LANL has been a significant increase in a regional, multi-agency approach to managing biological resources. Intensive forest management has been conducted under an institutional wildfire hazard reduction project that is implemented through the Wildfire Hazard Reduction Project Plan (LANL 2005b).

iv. Soil, Foodstuffs, and Non-foodstuffs Biota Resources. The Laboratory collects surface soil, foodstuffs, and non-foodstuffs biota from the Laboratory, perimeter communities (Los Alamos, White Rock, and surrounding pueblos), and regional (background) areas to determine whether there is an impact of Laboratory operations on human health via the food chain and the environment. The Laboratory conducts these programs to comply with the requirements of DOE Orders and New Mexico and federal regulations. Samples of the various media are collected on a three-year rotating basis and analyzed for radionuclides, heavy metals, and organic chemicals to determine concentrations and distribution in soil and potential uptake by plants, animals, and humans. Radiation doses to humans and biota (Chapter 3) and changes in concentrations over time are also measured and analyzed. These data are published in this report (Chapters 7 and 8) and other Laboratory publications.

v. Cultural Resources. The Laboratory manages the diverse cultural resources according to the requirements of the National Historic Preservation Act and the other federal laws and regulations concerned with cultural resources protection. Cultural resources include archaeological sites and associated artifacts, historic buildings and associated artifacts, and traditional cultural places of importance to Native American and other ethnic groups. The act's goal is for federal agencies to act as responsible stewards of our nation's resources when their actions potentially affect historic properties. Section 106 of the act requires federal agencies to take into account the effects their projects may have on historic properties and to allow review and comment by the State Historic Preservation Office and the Advisory Council on Historic Preservation. The Section 106 regulations outline a project review process that is conducted on a project-by-project basis.

The Laboratory has adopted a Cultural Resources Management Plan (LANL 2005c) as an institutional comprehensive plan that defines the responsibilities, requirements, and methods for managing its cultural properties. The plan provides an overview of the cultural resources program, establishes a set of procedures for effective compliance with applicable historic preservation laws, addresses land-use conflicts and opportunities, ensures public awareness of DOE's cultural heritage stewardship actions at LANL, and provides a 10-year road map that summarizes and prioritizes the steps necessary to manage these resources.

2. Organizations Implementing Environmental Management

Safety, environmental protection, and compliance with ES&H laws and regulations are underlying values of all Laboratory work. The Laboratory uses ISM to create a worker-based safety and environmental compliance culture in which all workers are committed to safety and environmental protection in their daily work.

Each Laboratory organization is responsible for its own environmental management and performance. Line management provides leadership and ensures ES&H performance is within the context of the Laboratory's values and mission. Laboratory managers establish and manage ES&H initiatives, determine and communicate expectations, allocate resources, assess performance, and are held accountable for safety performance.

During the first half of 2006, the Environmental Stewardship (ENV) Division developed and managed the Laboratory programs for environmental regulatory compliance. This work was conducted in five ENV Division groups: Meteorology and Air Quality (MAQ), Water Quality and Hydrology (WQH), Solid Waste Regulatory Compliance (SWRC), Ecology (ECO), and Environmental Characterization and Remediation (ECR). The Division was responsible for communicating environmental policies to Laboratory employees and made appropriate environmental training programs available. The ENV Division groups worked with line managers to prepare and review required environmental documentation. The five groups also initiated and managed Laboratory programs for environmental assessment and were responsible for executing environmental surveillance work under the auspices of the ENV Division's Environmental Protection Program.

In mid-2006, the Laboratory environmental programs were reorganized as part of the transition to LANS, LLC. Under the new organizational structure, environmental characterization, remediation, surveillance, and waste management programs are part of the Environmental Programs (EP) Directorate. Environmental permitting is managed within the Environmental Protection Division in the Environment, Safety, Health, and Quality (ESHQ) Directorate. An organizational chart and description is available at http://www.lanl.gov/organization/.

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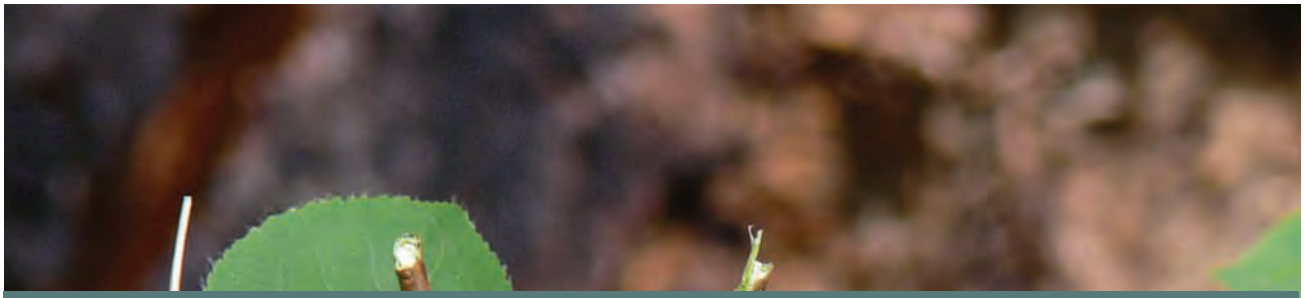

2. Compliance Summary



2. Compliance Summary

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A. INTRODUCTION

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. Laboratory policy implements US Department of Energy (DOE) requirements by directing employees to protect the environment and meet compliance requirements of applicable federal and state environmental regulations. Federal and state environmental laws address: (1) handling, transporting, releasing, and disposing of contaminants and wastes; (2) protecting ecological, archaeological, historic, atmospheric, soil, and water resources; and (3) conducting environmental impact analyses. Regulations provide specific requirements and standards to ensure maintenance of environmental quality. The US Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. DOE and its contractors are also subject to DOE-administered requirements for control of radionuclides. Table 2-1 presents the environmental permits or approvals the Laboratory operated under in 2006 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2006. The following sections summarize the Laboratory's regulatory compliance performance during 2006.

B. COMPLIANCE STATUS

The Laboratory continues to meet requirements under the Clean Water Act. None of the 126 samples collected from the Sanitary Waste System Plant's outfall and only one (a residual chlorine measurement) of 949 samples collected from industrial outfalls exceeded Clean Water Act effluent limits. Compliance with National Pollutant Discharge Elimination System (NPDES) requirements at permitted construction sites improved in 2006 to 94% overall (from 93% in 2005). The Laboratory was well below all Clean Air Act permit limits for emissions to the air.

The Laboratory continued to conduct corrective actions in accordance with the March 2005 Compliance Order on Consent (Consent Order). The NMED issued three Notices of Violation (NOVs) to LANL and DOE pursuant to the Consent Order that alleged improper disposal of cleanup debris, failure to report a release of a groundwater contaminant, and improper storage of building debris. All of the Laboratory deliverables (plans and reports) required by the Consent Order were submitted on time to NMED, though one was later deemed substantially incomplete.

Table 2-1
Environmental Permits or Approvals under which the Laboratory Operated during 2006

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Hazardous Waste Facility	Hazardous Waste Facility Permit and Mixed-Waste Storage and Treatment Permit	November 1989	November 1999**	NMED[b]
	TA-3, Building 29 Chemistry and Metallurgy Research Building Part B Permit Renewal Application, Revision 0.0	Submitted January 1999	—	NMED
	TA-50 Part B Permit Renewal Application Revision 3.0	Submitted August 2002	—	NMED
	General Part B Permit Renewal Application, Revision 2.0	Submitted August 2003	—	NMED
	TA-54 Part B Permit Renewal Application, Revision 3.0	Submitted June 2003	—	NMED
	TA-16 Part B Permit Renewal Application, Revision 4.0	Submitted June 2003	—	NMED
	TA-55 Part B Permit Application, Revision 2.0	Submitted September 2003	—	NMED
	General Part A Permit Application, Revision 5.0	Submitted April 2006	—	NMED
HSWA[c]	RCRA corrective activities	March 1990	December 1999**	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring.	March 1, 2005	September 20, 2015	NMED
CWA[d]/NPDES[e]	Outfall permit for the discharge of industrial and sanitary liquid effluents	February 1, 2001	January 31, 2005**	EPA[f]
	MSGP[g] for the discharge of stormwater from industrial activities	October 30, 2000	October 30, 2005**	EPA
	Federal Facility Compliance Agreement for storm water discharges from Solid Waste Management Units (SWMUs)	February 5, 2005	—	EPA
	Construction General Permits (19) for the discharge of stormwater from construction activities	varies	July 1, 2008*	EPA

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
CWA Sections 404/401	COE[h] Nationwide Permits (3)	varies	varies	COE/NMED
Groundwater Discharge Plan, TA-46 SWWS Plant[i]	Discharge to groundwater	January 7, 1998	January 7, 2003**	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid-Waste Treatment Facility	Discharge to groundwater	Submitted August 20, 1996	Approval pending	NMED
Groundwater Discharge Plan, Domestic Septic Systems	Discharge to groundwater	Submitted April 27, 2006	Approval pending	NMED
Air Quality Operating Permit (20.2.70 NMAC[j])	LANL air emissions Operating Permit Modification 1	April 30, 2004 June 15, 2006	April 29, 2009	NMED
Air Quality (20.2.72 NMAC)	Portable rock crusher Retired and removed from operating permit Permit number will remain active to track exempt sources at LANL	June 16, 1999 June 15, 2006	None	NMED
	TA-3 Power Plant Permit revision Permit modification	September 27, 2000 November 26, 2003 July 30, 2004	None	NMED
	Generator at TA-33	October 10, 2002	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement (CMRR)	September 16, 2005	None	NMED
	Radiological Laboratory, Utility, Office Building		None	NMED
	TA-11 Fuel/wood fire testing	March 29, 2005	Canceled January 12, 2006	NMED
	TA-16 flash pad TA-36 sled track	March 29, 2005	Canceled January 12, 2006	NMED
Air Quality (NESHAP[k])	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED
	Radiological air emissions at CMRR	July 14, 2005	None	EPA
	Radiological Laboratory, Utility, Office Building		None	EPA

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Open Burning	TA-11 Fuel/wood fire testing	December 27, 2002	Canceled March 6, 2006	NMED
	TA-14 Burn cage	December 27, 2002	Canceled March 6, 2006	NMED
	TA-16 Flash pad	December 27, 2002	Canceled March 6, 2006	NMED
	TA-36 Sled track and open burn area	December 27, 2002	Canceled March 6, 2006	NMED

[a] Resource Conservation and Recovery Act
[b] New Mexico Environment Department
[c] Hazardous and Solid Waste Amendments
[d] Clean Water Act
[e] National Pollutant Discharge Elimination System
[f] Environmental Protection Agency
[g] Multi-Sector General Permit
[h] US Army Corps of Engineers
[i] Sanitary Wastewater Systems Plant
[j] New Mexico Administrative Code
[k] National Emission Standards for Hazardous Air Pollutants

*Construction General Permit (CGP) expiration date
**Permit was administratively continued for all of 2006



Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2006

Date	Purpose	Performing Agency
4/03/06–4/12/06	Hazardous waste compliance inspection (closeout 5/9/2006)	NMED[a]
7/14/2006	PCB[b] inspection for compliance with TSCA[c] requirements	EPA[d] Region 6
10/18/2006	CGP[e] compliance inspection, TA-3 Security Perimeter Project	NMED
10/19/2006	CGP compliance inspection, TA-55 CMRR Project	NMED
2/03/06	Asbestos management inspection of building TA-59-1, response to complaint regarding respiratory protection	NMED
2/08/06	Asbestos management inspection of building TA-16-193, Standard project inspection	NMED
2/08/06	Asbestos management inspection of multiple buildings at TA-3. Standard project inspection	NMED
9/16/06	Asbestos management inspection of roofing job at TA-53 sector J, G, & F. Standard project inspection	NMED
9/18/06	Title V Operating Permit compliance inspection	NMED
10/25/06	Asbestos management inspection of ash pile at Los Alamos Airport	NMED

(No Federal Insecticide, Fungicide, and Rodenticide Act; Section 401/404; or Groundwater Discharge Plan inspections were conducted in 2006.)

[a] New Mexico Environment Department
[b] Polychlorinated biphenyls
[c] Toxic Substances Control Act
[d] Environmental Protection Agency
[e] Construction General Permit

1. Resource Conservation and Recovery Act

a. Introduction. The Laboratory produces a variety of hazardous wastes, mostly in small quantities relative to industrial facilities of comparable size. RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, establishes a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The EPA has authorized the State of New Mexico to implement the requirements of the program, which it does through the New Mexico Hazardous Waste Act and state regulations found in the New Mexico Administrative Code (NMAC) Title 20, Chapter 4, Part 1, as revised October 1, 2003 (20.4.1 NMAC). Federal and state laws regulate management of hazardous wastes based on a combination of the facility's status; large- or small-quantity generation; and the types of treatment, storage, and disposal conducted by the facility.

Certain operations may require an operating permit, called a hazardous waste facility permit, or a RCRA permit. The LANL hazardous waste facility permit expired in 1999 but was administratively continued beyond the expiration date as allowed by the permit and by 20.4.1.900 NMAC. In anticipation of the permit's expiration, and by agreement with NMED, the Laboratory submitted preliminary permit renewal applications for NMED review starting in 1996. The permit renewal applications are pending and have been revised as needed.

b. RCRA Permitting Activities. The Laboratory submitted proposed modifications to the LANL hazardous waste facility permit in 2006. These included Class I permit modifications for minor revisions to the facility inspection plan (February), the contingency plan (April, May, and December), Module III, Attachment F and Attachment G (October), and to identify LANS as the new co-operator of LANL (April). Additional

permit-related activities included the May submittal to NMED of the LANL RCRA Permit Application Unit Assessment. This assessment was conducted at the request of the NMED to clarify the history of waste management units at the Laboratory. The assessment provided a listing of all hazardous waste management units at LANL, a brief history of each unit, and their current status (active, closed, withdrawn, etc.).

New closure plans for the waste management units at Technical Areas (TAs) 16, 50, 54, and 55 were also submitted as part of the permit renewal process in September. NMED issued final approval of the closure of TA-55-PF4-B38 in January 2006. Closure certification reports were completed and submitted for the Area L 36 and 37 lead stringer shafts (September) and the TA-54 Area L treatment tanks (December).

c. Other RCRA Activities. The compliance assurance program performed Laboratory self-assessments to determine whether hazardous and mixed waste is managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. The program communicated findings from these self-assessments to waste generators, waste-management coordinators, and waste managers who help line managers implement appropriate actions to ensure continual improvement in LANL's hazardous waste program. In 2006, the Laboratory completed 1,453 self-assessments with a nonconformance rate of 3.02%.

d. RCRA Compliance Inspection. From April 3, 2006 to April 12, 2006, NMED conducted a hazardous waste compliance inspection at the Laboratory (see Table 2-2). The Laboratory received no further communications in 2006 regarding this inspection.

e. Site Treatment Plan. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the DOE and the University of California (UC), requiring compliance with the Site Treatment Plan. On June 1, 2006, LANS replaced UC as the operating contractor at LANL at which time LANS assumed responsibility for compliance with the order. The plan documents the use of off-site facilities for treating and disposing of mixed waste generated at LANL and stored for more than one year. The Laboratory met all 2006 Site Treatment Plan deadlines and milestones by treating and disposing of more than 1.2 m^3 of Site Treatment Plan low-level mixed waste.

f. Solid Waste Disposal. LANL sends sanitary solid waste (trash) and construction and demolition debris for disposal to the Los Alamos County landfill on East Jemez Road. The DOE owns the property and leases it to Los Alamos County under a special-use permit. Los Alamos County operates this landfill and is responsible for obtaining all related permits for this activity from the state. The landfill is registered with the NMED Solid Waste Bureau. Laboratory trash placed in the landfill in 2006 included 1954 metric tons of trash and 170 metric tons of construction and demolition debris. Through LANL recycling efforts, 2532 metric tons of material did not go to the landfill in 2006.

g. Compliance Order on Consent (Consent Order). The Consent Order requires LANL-wide investigation and cleanup of SWMUs and areas of concern (AOC) pursuant to stipulated procedures and schedules. (Schedules in the Consent Order may be adjusted to account for delays in NMED approvals, or to accommodate requests from DOE or its authorized contractor for time extensions.) The Consent Order applies to SWMUs and AOCs subject to RCRA and HSWA requirements. Radionuclides are regulated by DOE under the Atomic Energy Act. To avoid duplication of completed work, the Consent Order does not apply to those SWMUs and AOCs that received "no further action" decisions from EPA when it had primary regulatory authority. Following the investigation phase for subject SWMUs or AOCs, and upon NMED determination that corrective measures are needed, a corrective measure evaluation report must be prepared. After NMED authorizes a remedy, the corrective measure is implemented. After completing the remedy, a remedy completion report must be prepared and submitted to NMED for approval.

Details of the history and status of SWMUs and AOCs listed in the Consent Order may be found in the Site-Wide Environmental Impact Statement (SWEIS) for LANL and a description of the work done in 2006 may be found in Chapter 9 of this report.

All of the Laboratory deliverables (plans and reports) required by the Consent Order were submitted on time to NMED (see Tables 9-1 and 9-2 in Chapter 9 of this report). The MDA C Investigation Report, although submitted on time, was deemed substantially incomplete and the NMED assessed stipulated penalties against LANL in early 2007.

In July 2006, the NMED Hazardous Waste Bureau issued a Notice of Violation (NOV) to DOE and LANS alleging that disposal of debris from SWMU 73-002 in the Los Alamos County landfill violated the approved workplan, and, therefore, was a violation of the Consent Order. NMED proposed to assess a penalty of $88,930. After the parties met, DOE and LANS agreed to pay a penalty of $50,930 to resolve the matter.

In September 2006, NMED issued a second NOV to DOE and LANS alleging a failure to report the release of a groundwater contaminant (chromium) in accordance with the Consent Order. NMED proposed to assess a penalty of $795,620. The parties negotiated a resolution to the NOV and, without admitting the allegations, DOE and LANS agreed to pay a penalty of $251,870.

In October 2006, NMED issued a third NOV to DOE and LANS alleging three counts of improper storage of building debris that contained a small volume of listed waste. NMED proposed to assess a penalty of $402,600. After the parties met, DOE and LANS, without admitting any of the allegations, agreed to pay a penalty of $119,845 to resolve the matter.

2. Comprehensive Environmental Response, Compensation, and Liability Act

No lands were transferred from DOE to other agencies in 2006 under the Land Conveyance and Transfer Project. Environmental Baseline Survey Reports were initiated for tracts A-8-a and A-11 in anticipation of scheduled transfers in 2007. These reports contain the Comprehensive Environmental Response, Compensation, and Liability Act 120(h) information required to transfer these properties to private or municipal ownership and indicate that "no hazardous substances exist on these sites," that "all remedial action necessary to protect human health and the environment has been taken," or that certain restrictions on use are required.

3. Emergency Planning and Community Right-to-Know Act

a. Introduction. The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Executive Order 13148, *Greening the Government Through Leadership in Environmental Management*. Executive Order 13148 was superseded in January 2007 by Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*.

b. Compliance Activities. For 2006, the Laboratory submitted two annual reports to fulfill its requirements under EPCRA, as shown in Table 2-3 and described below.

Emergency Planning Notification. Title III, Sections 302–303, of EPCRA require the preparation of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees (1) of any changes at the Laboratory that might affect the local emergency plan or (2) if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2006.

Table 2-3
Compliance with Emergency Planning and Community Right-to-Know Act during 2006

Statute	Brief Description	Compliance
EPCRA Sections 302–303 Planning Notification	Requires emergency planning notification to state and local emergency planning committees.	No changes to the notification have been made since the July 30, 1999 notification and an update in 2000.
EPCRA Section 304 Release Notification	Requires reporting of releases of certain hazardous substances over specified thresholds to state and local emergency planning committees and to the National Response Center.	LANL submitted a Release Notification on August 31, 2006 for a leaking pressure vessel of anhydrous ammonia. There were no other leaks, spills, or other releases of chemicals into the environment that required EPCRA Section 304 reporting during 2006.
EPCRA Sections 311--312 Material Safety Data Sheets and Chemical Inventories	Requires facilities to provide appropriate emergency response personnel with an annual inventory and other specific information for any hazardous materials present at the facility over specified thresholds.	The presence of 36 hazardous materials stored at LANL over specified quantities in 2006 required submittal of a hazardous chemical inventory to the state emergency response commission and the Los Alamos County Fire and Police Department.
EPCRA Section 313 Annual Toxic Release Inventory	Requires all federal facilities to report total annual releases of listed toxic chemicals used in quantities above reportable thresholds.	Use of lead exceeded the reporting thresholds in 2006, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the state emergency response commission.

Emergency Release Notification. Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals into the environment, if these chemicals exceed specified reporting quantities. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. On August 31, 2006, the Laboratory submitted a release notification for a leaking pressure vessel of anhydrous ammonia. The exact quantity of ammonia that leaked from the vessel is unknown. However, the capacity of the vessel was up to 150 lb and therefore, the Laboratory assumed that the reportable quantity of 100 lb for ammonia was exceeded. There were no other leaks, spills, or other releases of chemicals into the environment that required EPCRA Section 304 reporting during 2006.

Material Safety Data Sheet/Chemical Inventory Reporting. Title III, Sections 311–312, of EPCRA require facilities to provide an annual inventory of the quantity and location of hazardous chemicals above specified thresholds present at the facility. The inventory includes hazard information and storage location for each chemical. The Laboratory submitted a report to the state emergency-response commission and the Los Alamos County fire and police departments listing 36 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2006.

Toxic Release Inventory Reporting. Executive Order 13148 requires all federal facilities to comply with Title III, Section 313, of the EPCRA. This section requires reporting of total annual releases to the environment of listed toxic chemicals that exceed activity thresholds. Beginning with reporting year 2000, new and lower chemical-activity thresholds were put in place for certain persistent, bioaccumulative, and toxic chemicals and chemical categories. The thresholds for these chemicals range from 0.1 g to 100 lb. Until this change went into effect, the lowest threshold was 10,000 lb. LANL exceeded one threshold in 2006 and therefore was required to report the uses and releases of this chemical. The reported material was lead. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-4 summarizes the reported releases for lead in 2006.

Table 2-4
Summary of 2006 Reported Releases under EPCRA Section 313

	Lead (lb)
Air Emissions	10.6
Water Discharges	2
On-Site Land Disposal	8,878
Off-Site Waste Transfers	2,178

4. Toxic Substances Control Act

Because the Laboratory's activities are research and development (R&D) rather than the manufacture of commercial chemicals, the Laboratory's main concern under the Toxic Substances Control Act (TSCA) is the regulations covering polychlorinated biphenyls (PCBs) and import/export of R&D chemical substances. The PCB regulations govern substances including, but not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills.

During 2006, the Laboratory shipped 58 containers of PCB waste off site for disposal or recycling. The quantities of waste disposed of included 105 lb (48 kg) of capacitors and 2,661 lb (1207 kg) of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 Code of Federal Regulations (CFR) 761 manifesting, record keeping, and disposal requirements. PCB wastes go to EPA-permitted disposal and treatment facilities. Light ballasts go off-site for recycling. The primary compliance document related to 40 CFR 761.180 is the annual PCB report that the Laboratory submits to EPA Region 6.

The renewal request for the Area G PCB disposal authorization was withdrawn in 2006. During 2006, EPA performed one PCB site inspection, and approximately 34 TSCA reviews were conducted on imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office.

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the manufacturing of pesticides and the protection of workers who use these chemicals. Sections of this act that apply to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the act. The New Mexico Pesticide Control Act applies to the Laboratory's licensing and certification of pesticide workers, record keeping, application of pesticides, inspection of equipment, and the storage and disposal of pesticides.

The New Mexico Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2006. The Laboratory conducted four quarterly inspections of the pesticide storage area in 2006 and found that the storage area was maintained in accordance with RCRA regulations.

Table 2-5 shows the amounts of pesticides the Laboratory used during 2006.

6. Clean Air Act

Pursuant to the federal Clean Air Act (CAA) Amendments and Title 20 of NMAC, Chapter 2, Part 70, Operating Permits (20.2.70 NMAC), LANS is authorized to operate applicable air emission sources at LANL per the terms and conditions as defined in Operating Permit No. P100-M1. The operating permit conditions mirror existing source-specific permit conditions applicable to operating requirements, record keeping,

Table 2-5
Herbicides and Pesticides used at LANL in 2006

Herbicides		Insecticides	
VELPAR L (Liquid)	177 gal	TEMPO 20 WP	23.4 oz
Roundup Pro	115 oz	MAXFOURCE ANT BAIT	6.5 oz
		TALSTAR F	11 oz
		WASP FREEZE	37 oz
		BAYGON 250 (Aerosol)	4 oz
		BAYGON 250 (Canister)	48 oz
		565 Plus XLO	22 oz
		ULD-BP-100 (Liquid)	10 oz

monitoring, and reporting. Compliance with the conditions of the Title V Operating Permit is deemed to be compliance with any applicable air requirements existing at the date of permit issuance.

As part of the Title V Operating Permit program, LANL reports emissions from sources included in the Operating Permit twice a year. These sources include multiple boilers, two steam plants, a data disintegrator, carpenter shops, three degreasers, and asphalt production. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities.

According to reporting requirements in the Title V Operating Permit's terms and conditions, the Laboratory must submit an Annual Compliance Certification report to NMED. In the 2006 Compliance Certification report, a permit deviation for the TA-60 Asphalt Plant was reported. On May 1, 2006, smoke opacity of 24% was observed at the Asphalt Plant. This is slightly above the opacity limit of 20% stated in the permit. An excess emissions report was submitted to NMED identifying the details of this deviation. LANL demonstrated full compliance with all other permit applicable terms and conditions and met all reporting requirement deadlines.

In 2006, LANL received a modification to Operating Permit No P100. This permit modification, P100-M1, was issued on June 15, 2006. The modification incorporated permit conditions from the combustion turbine New Source Review (NSR) Permit 2195B-M1, incorporated permit conditions from the data disintegrator NSR Permit 2195H, and removed the rock crusher from the Title V permit.

According to the terms and conditions of NSR air quality permit 2195B-M1, LANL started construction of a low emission combustion turbine, which will supply power to various buildings in the TA-3 area in the event of commercial power loss. The combustion turbine is expected to start operation in 2007.

Under the Title V Operating Permit program, LANL is a major source, based on the potential to emit nitrogen oxides (NO_X), carbon monoxide (CO), and volatile organic compounds (VOCs). In 2006, the TA-3 steam plant and boilers located across the Laboratory were the major contributors of NO_X, CO, and particulate matter (PM). R&D activities were responsible for most of the VOC and hazardous air pollutant emissions. Table 2-6 summarizes these data.

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LANL staff calculates air emissions using emission factors from source tests, manufacturer's data, and EPA documentation. Calculated emissions are based on actual production rates, fuel usage, and/or material throughput. To satisfy requirements set forth in Title 20 of NMAC, Chapter 2, Part 73, Notice of Intent and

Table 2-6
Calculated Actual Emissions for Regulated Pollutants Reported to NMED for Operating Permit Compliance

	Pollutants, tons					
Emission Units[a]	**NO_x**	**SO_x**	**PM**	**CO**	**VOC**	**HAPs**
Asphalt Plant	0.03	0.005	0.01	0.4	0.008	0.008
TA-21 Steam Plant	1.5	0.02	0.1	1.3	0.08	0.03
TA-3 Steam Plant	17.8	0.3	2.3	12.3	1.7	0.6
Regulated Boilers	5.1	0.03	0.5	3.6	0.3	0.1
R&D Chemical Use	NA	NA	NA	NA	10.1	4.8
Degreaser	NA	NA	NA	NA	0.02	0.02
Data Disintegrator	NA	NA	0.4	NA	NA	NA
Carpenter Shops	NA	NA	1.1	NA	NA	NA
Storage Tanks	NA	NA	NA	NA	0.007	NA
Stationary Standby Generators[b]	18.4	4.1	0.9	4.1	0.9	0.005
Miscellaneous Small Boilers	19.2	0.1	1.5	16.1	1.1	0.4
TA-33 Generator	0.09	0.01	0.003	0.07	0.002	< 0.001
TOTAL	**62.1**	**4.6**	**6.8**	**37.9**	**14.3**	**6.0**

[a] NOx = nitrogen of oxygen. SOx = Sulfur dioxide. PM = particulate matter. CO = carbon monoxide. VOC = volatile organic compounds. HAPs = hazardous air pollutants.

[b] Emissions from these source categories were reported for the first time in 2004, as required by the Title V Operating Permit. Emissions units in these categories are exempt from construction permitting and annual emission inventory reporting requirements and are not included in Figure 2-1.

Emissions Inventory Requirements (20.2.73 NMAC) and the Title V Operating Permit, LANL submits an annual Emissions Inventory Report and semi-annual Emissions Report, respectively, to NMED. Figure 2-1 depicts a five-year history of criteria pollutant emissions. Emissions for 2005 and 2006 are very similar and remain relatively constant following a sharp emissions decline in 2004.

a. New Mexico Air Quality Control Act.

i. Permits. LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to revise the operating permit application, to apply for construction permits, or to submit notifications to NMED. During 2006, the Laboratory performed approximately 190 air quality reviews and submitted an NSR air quality permit for three generators to be used at TA-33. A technical revision was also requested and received for a change in the type of furnace used in TA-55 beryllium operations. Also, as mentioned in Section 6, Clean Air Act, above, LANL received a modification to the LANL Operating Permit. LANL submitted 10 exemption notifications to NMED. The exemptions were primarily for small boilers, small generators, and storage tanks. LANL currently operates under the air permits listed in Table 2-1.

ii. Open Burning. LANL only performed open burns during the first two months of 2006. The burns were performed under both 20.2.60 and 20.2.72 NMAC regulations. LANL had four open burning permits (20.2.60 NMAC) for operational burns conducted to thermally treat or dispose of high explosives or material contaminated with high explosives and to test accident scenarios involving fire. All operational burns in 2006 were conducted within the terms specified in the permits. To document compliance with permit requirements, the Laboratory reports the results of these operations to NMED.

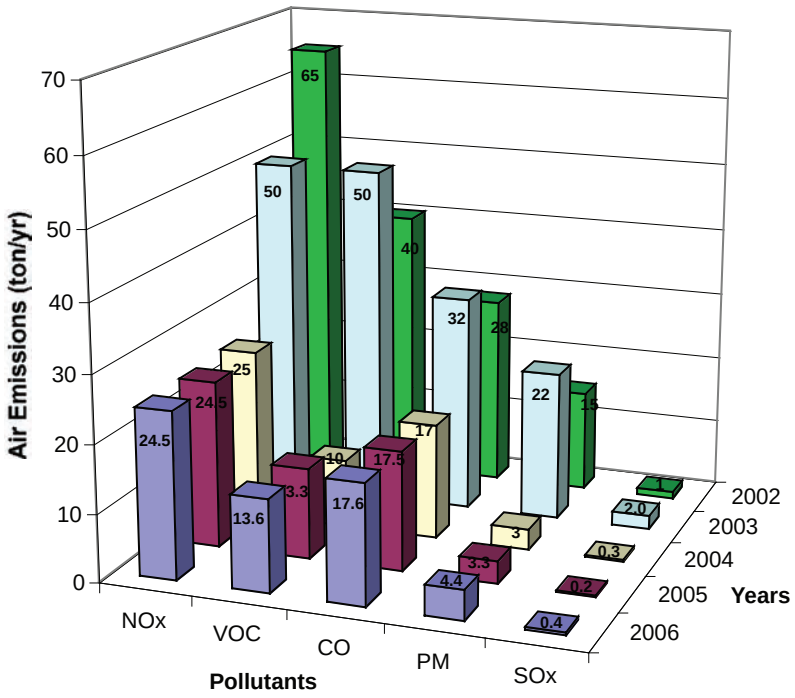

Figure 2-1. LANL Criteria Pollutant Emissions from 2002 to 2006 for Emissions Inventory Reporting.

In 2006, LANL requested the cancellation of the four open burn permits mentioned above. The DOE is developing a strategic plan for missions at its national laboratory complex. In view of these events, and as part of its transition in operations contractor, the Laboratory undertook a review of the testing and activities anticipated at the sites covered by the permits. The Laboratory completed this review and determined that, for the foreseeable future, it no longer needed to perform the types of testing and activities authorized by the permits. The cancellation of the permits was effective on March 6, 2006.

iii. Asbestos. The National Emission Standard for Hazardous Air Pollutants (NESHAP) for Asbestos requires that LANL provide advance notice to NMED for large renovation jobs that involve asbestos and for all demolition projects. The asbestos NESHAP further requires that all activities involving asbestos be conducted in a manner that mitigates visible airborne emissions and that all asbestos-containing wastes be packaged and disposed of properly.

LANL continued to perform renovation and demolition projects in accordance with the requirements of the asbestos NESHAP. Major activities in 2006 included 14 large renovation jobs and demolition projects of which NMED received advance notice. These projects, combined with other smaller activities, generated 1058.69 m^3 of asbestos waste. All asbestos wastes were properly packaged and disposed of at approved landfills.

To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly. In addition, NMED conducted five inspections during the year and identified no violations.

b. Federal Clean Air Act.

i. Ozone-Depleting Substances. Title VI of the Clean Air Act contains specific sections that establish regulations and requirements for ozone-depleting substances (ODS), such as halons and refrigerants. The

main sections applicable to the Laboratory prohibit individuals from knowingly venting an ozone-depleting substance into the atmosphere during maintenance, repair, service, or disposal of halon fire-suppression systems and air-conditioning or refrigeration equipment. All technicians who work on refrigerant systems must be EPA-certified and must use certified recovery equipment. The Laboratory is required to maintain records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants. The Laboratory's standards for refrigeration work are covered under Criterion 408, "EPA Compliance for Refrigeration Equipment," of the Operations and Maintenance manual.

The Laboratory continued to work at eliminating the use of Class 1 ODS in order to meet DOE's goal to eliminate the use of these refrigerants by 2010. In 2006, the Laboratory removed a total of 33,962 pounds of Class 1 ODS from active inventory.

ii. Radionuclides. Under Rad-NESHAP, the EPA limits the effective dose equivalent of radioactive airborne releases from a DOE facility, such as LANL, to any member of the public to 10 mrem/yr. The 2006 dose to the maximally exposed individual (MEI) (as calculated using EPA-approved methods) was 0.47 mrem. The location of the highest dose was at the Los Alamos County Airport Terminal. Operations at TA-74 during the ash pile cleanup, now completed, contributed about half of this dose; the remainder came from Laboratory stack emissions.

7. Clean Water Act

a. NPDES Industrial Point Source Outfall Self-Monitoring Program. The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the requirements for NPDES permits for point-source effluent discharges to the nation's waters. The NPDES outfall permit establishes specific chemical, physical, and biological criteria that the Laboratory's effluent must meet before it is discharged.

From January 1 through May 31, 2006, UC and the DOE/National Nuclear Security Administration (NNSA) were co-permittees of the NPDES permit covering Laboratory operations. From June 1 through December 31, 2006, LANS and the DOE/ NNSA were co-permittees. EPA Region 6 in Dallas, Texas, issues and enforces the permit. NMED certifies the EPA-issued permit and performs some compliance-evaluation inspections and monitoring for the EPA. The Laboratory's current industrial point-source NPDES permit contains 21 permitted outfalls that include one sanitary outfall and 20 industrial outfalls. To view the Laboratory's NPDES permit, go online to http://www.lanl.gov/environment/h2o/cw_npdes.shtml.

The Laboratory's long-term objectives require that outfall owners continue evaluating outfalls for possible elimination and that new construction designs and modifications to existing facilities provide for reduced or no-flow effluent discharge systems. No NPDES outfalls were deleted in 2006; however, four outfalls were eliminated and not included in the Laboratory's NPDES Permit re-application submitted to EPA on July 30, 2004. The Laboratory's new NPDES point-source permit is anticipated to be issued in 2007 and will include one sanitary outfall and 16 industrial outfalls for a total of 17 permitted outfalls (Table 2-7).

The Laboratory's NPDES outfall permit requires weekly, monthly, and quarterly sampling to demonstrate compliance with effluent quality limits. The Laboratory also collects annual water-quality samples at all outfalls. The Laboratory reports analytical results to EPA and NMED at the end of the monitoring period for each respective outfall category. During 2006, none of the 113 samples collected from the Sanitary Wastewater Systems (SWWS) Plant's outfall exceeded effluent limits; however, one of the 733 samples collected from industrial outfalls exceeded effluent limits (see discussion below). Monitoring data obtained from sampling at NPDES permitted outfalls are in data supplement Table S2-1 (on included Compact Disk) and available online at http://wqdbworld.lanl.gov/.

Table 2-7
Volume of Effluent Discharge from NPDES Permitted Outfalls in 2006

Outfall Number	TA-bldg	Description	Watershed (Canyon)	2006 Discharge (gal.)
02A129	21-357	TA-21 Steam Plant	Los Alamos	21,945,000
03A047[a]	53-[b]	LANSCE Cooling Tower	Los Alamos	0
03A048	53-963/978	LANSCE Cooling Tower	Los Alamos	19,741,000
03A049[a]	53-[b]	LANSCE Cooling Tower	Los Alamos	0
03A158	21-209	TA-21 CoolingTower	Los Alamos	483,360
051	50-1	TA-50 Radioactive Liquid Waste Treatment Facility	Mortandad	1,633,000
03A021	3-29	CMR Building Air Washers	Mortandad	553,000
03A022	3-2238	Sigma Cooling Tower	Mortandad	1,498,330
03A160	35-124	National High Magnetic Field Laboratory Cooling Tower	Mortandad	31,536,000
03A181	55-6	Plutonium Facility Cooling Tower	Mortandad	2,759,860
13S	46-347	Sanitary Wastewater Treatment Plant	Sandia	103,246,000
001	3-22	Power Plant	Sandia	9,191,000
03A024[a]	3-187	Sigma Press Cooling Tower	Sandia	0
03A027	3-2327	Strategic Computing Complex Cooling Tower	Sandia	10,764,000
03A113	53-293/952	LANSCE Cooling Tower	Sandia	423,570
03A199	3-1837	Laboratory Data Communications Center	Sandia	17,009,000
03A028	15-202	PHERMEX Cooling Tower	Water	300
03A130	11-30	TA-11 Cooling Tower	Water	1,757
03A185	15-312	DARHT Cooling Tower	Water	907,300
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	12,818
05A097[a]	11-52	TA-11 Drop Pad/HE Testing	Water	0
			2006 Total:	**221,705,295**

[a] Requested deletion from permit.

[b] Structure removed.

The following is a summary of the corrective actions taken by the Laboratory during 2006 to address the NPDES outfall permit noncompliance cited above.

TA-15-312 Outfall 03A185. On September 18, 2006, a total residual chlorine concentration of >2200 µg/L exceeded the NPDES daily maximum permit limit of 11 µg/L and the minimum quantification level (MQL) of 100 µg/L in NPDES Permit NM0028355. The noncompliance was attributed to a malfunctioning chemical feed pump and check valve that feeds the chlorine neutralizer to the cooling tower outfall discharge. The pump was fixed immediately and a new check valve was installed. The feed pump is used infrequently (several times per year when chlorine is introduced into the cooling tower basin for algae control). The pump will be inspected more frequently to ensure proper operation.

b. NPDES Sanitary Sewage Sludge Management Program. The Laboratory's TA-46 SWWS Plant is an extended-aeration, activated-sludge sanitary wastewater treatment plant. The activated-sludge treatment process requires periodic disposing of excess sludge (waste-activated sludge) from the plant's clarifiers to synthetically lined drying beds. After air-drying for a minimum of 90 days to reduce pathogens, the dry sludge

is characterized and disposed of as a New Mexico Special Waste. Monitoring data obtained from routine characterization of SWWS Plant sludge is available online at http://wqdbworld.lanl.gov/. During 2006, the SWWS Plant generated approximately 27.5 dry tons (54,971 dry lb) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material.

c. NPDES Industrial Point Source Permit Compliance Evaluation Inspection. There were no Compliance Evaluation Inspections performed in 2006.

d. NPDES Storm Water Construction Permit Program. The NPDES Construction General Permit (CGP) Program regulates storm water discharges from construction activities disturbing one or more acres, including those construction activities that are part of a larger common plan of development collectively disturbing one or more acres.

LANL and the general contractor apply individually for NPDES CGP coverage and both are permittees at most construction sites. Compliance with the NPDES CGP includes the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP) before soil disturbance can begin and site inspections once soil disturbance has commenced. A SWPPP describes the project activities, site conditions, best management practices (BMPs), and permanent control measures required for reducing pollution in storm water discharges and protecting endangered or threatened species and critical habitat. Compliance with the NPDES CGP is demonstrated through periodic inspections that document the condition of the site and identify corrective actions required to keep pollutants from moving off the construction site. Data collected from these inspections is tabulated weekly, monthly, and annually in the form of Site Inspection Compliance Reports.

During 2006, the Laboratory implemented and maintained 57 construction site SWPPPs and SWPPP addendums and performed 609 storm water inspections. The Laboratory uses a geographic information system to manage project information and generate status reports that facilitate reporting under the Director's Portfolio Reviews. The overall CGP compliance record in 2006 was 94% at all inspections compared to 93% in 2005. During the summer months, when most high-intensity precipitation events occur, the compliance record was 93% in 2006. At the end of 2006, 100% of the Laboratory's permitted sites were in compliance with the CGP.

The LANL storm water team continued to support project personnel with CGP compliance by finding new solutions to the problems associated with stabilizing disturbed landscapes. The solutions for preventing noncompliances have been incorporated into the team's Quality Assurance Improvement Performance Report. To further reduce future CGP noncompliances and to increase awareness of CGP requirements, the storm water team updated the Engineering Standards Manual, revised subcontractor document language, and briefed subcontractors on CGP requirements at pre-bid and pre-construction meetings. In addition, construction site representatives, LANL project managers, or their subcontractor technical representatives are also required to attend storm water inspections and ensure appropriate corrective measures are taken. A new form developed by the storm water team certifies that project representatives have been notified of any potential deficiencies or noncompliances immediately upon completion of an inspection. Mitigating factors can then be developed and implemented more quickly.

e. NPDES Industrial Storm Water Program. The NPDES Industrial Storm Water Permit Program regulates storm water discharges from identified regulated industrial activities (including SWMUs) and their associated facilities. These activities include metal fabrication; hazardous waste treatment, storage, and disposal; landfill operations; vehicle and equipment maintenance; recycling activities; electricity generation; and asphalt manufacturing.

UC and the DOE were co-permittees under the EPA 2000 NPDES Storm Water Multi-Sector General Permit for Industrial Activities (MSGP-2000). The MSGP-2000 expired October 30, 2005, without EPA issuing a new permit. Administrative continuance of the MSGP-2000, which requires continued compliance with the

expired permit requirements, was granted to existing permit holders. This continuance will remain in effect until a new permit is issued. There is currently no identified date for issuance of a new permit.

On December 1, 2005, EPA issued a draft MSGP. Proposed changes to the permit include increased storm water monitoring requirements, changes in benchmark monitoring parameters, increased inspection frequencies, additional SWPPP content requirements, and increased requirements for BMP selection, implementation, and maintenance.

MSGP-2000 required the development and implementation of site-specific SWPPPs, which must include identification of potential pollutants and activities and the implementation of BMPs. Permit requirements also include the monitoring of storm water discharges from permitted sites. In 2006, LANL implemented and maintained 15 SWPPPs under the MSGP-2000 requirements, covering 26 facilities and site-wide SWMUs. Compliance with the MSGP-2000 requirements for these sites is achieved primarily by implementing the following:

- Identifying potential contaminants and activities that may impact surface water quality and identifying and providing structural and non-structural controls (BMPs) to limit the impact of those contaminants.
- Developing and implementing facility-specific SWPPPs.
- Monitoring storm water runoff at facility gauging stations for industrial sector-specific benchmark parameters, and visually inspecting storm water runoff to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

f. Federal Facility Compliance Agreement/ Administrative Order. On February 3, 2005, DOE entered into a compliance agreement with EPA to protect surface water quality at the Laboratory through a FFCA. The FFCA establishes a compliance program for the regulation of storm water discharges from SWMUs and AOCs until such time as those sources are regulated by an individual storm water permit pursuant to the NPDES Permit Program. All SWMUs and certain AOCs (collectively, Sites) are covered by this agreement. On March 30, 2005, EPA issued an Administrative Order (AO) to the Laboratory that coincides with the FFCA.

The FFCA/AO establishes a schedule for monitoring and reporting requirements and requires the Laboratory to minimize erosion and the transport of pollutants or contaminants from Sites in storm water runoff. The FFCA also requires DOE and the Laboratory to comply with all requirements of the Laboratory's Multi-Sector General Permit (MSGP).

The FFCA/AO requires two types of monitoring at specified sites, pursuant to two monitoring management plans, including: 1) watershed sampling at approximately 60 automated gauging stations at various locations within the canyons pursuant to a Storm Water Monitoring Plan (SWMP), and 2) site-specific sampling at approximately 294 Sites, on a rotating basis pursuant to a SWMU SWPPP over a four year period. The purpose of storm water monitoring is to determine if there is a release or transport of contaminants into surface water that could cause or contribute to a violation of applicable surface water quality standards. If a release or transport occurs, it may be necessary to implement BMPs to reduce erosion or to re-examine, repair, or modify existing BMPs to reduce erosion. The SWMU/SWPPP must also describe an erosion control program to control and limit contamination migration and transport from Sites and to monitor the effectiveness of controls at the Sites.

In 2006, the Laboratory completed the following tasks:

(1) Submitted the annual modification of the SWPPP for SWMU/AOCs that describes watershed-scale monitoring, site-specific monitoring, and the erosion control program at SWMU/AOCs;

(2) Continued negotiations with EPA and NMED on the development of an individual permit for storm water discharges from SWMUs;

(3) Submitted all monthly water screening action level exceedance reports and quarterly status reports required by the FFCA on schedule;

(4) Completed the following fieldwork:

- Installed 42 new site-specific samplers to bring the total to 122;
- Collected 400 storm water samples at site-specific locations;
- Collected 186 storm water samples at gage locations;
- Conducted 902 inspections at 279 Sites;
- Completed maintenance of BMPs at all FFCA Sites;
- Completed 290 Annual Comprehensive Site Compliance Evaluation inspections (ACSCE).

The ACSCE inspections were conducted by qualified personnel as required under the MSGP to assess the presence of existing industrial materials, leaks and spills, offsite tracking of sediment, tracking/blowing of industrial materials, and evidence of pollutants entering into receiving waters. The annual inspections also included an evaluation of the existing structural BMPs at each Site.

g. Aboveground Storage Tank Compliance Program. The Laboratory's Aboveground Storage Tank (AST) Compliance Program is responsible for ensuring compliance with the requirements established by EPA (CWA, 40 CFR, Part 112) and NMED Petroleum Storage Tank Bureau Regulations (20.5 NMAC). During 2006, the Laboratory was in full compliance with both EPA and NMED requirements.

Spill Prevention Control and Countermeasures (SPCC) Plans fulfill the federal requirements for the AST Compliance Program, as required by the CWA (40 CFR, Part 112, Oil Pollution Prevention Regulations). Comprehensive SPCC Plans are developed to meet EPA requirements that regulate water pollution from oil spills.

EPA proposed additional extensions to compliance deadlines for meeting new regulatory requirements under the federal Clean Water Act (40 CFR, Part 112). Proposed new regulations will require the Laboratory to modify and implement its SPCC Plans by July 1, 2009. The primary modifications address AST storage capacity, inspection frequency, and integrity testing requirements. The Laboratory continued the process of completing all modifications to existing and new SPCC Plans and implementing those modifications.

On August 15, 2003, NMED implemented new regulations that combined requirements for underground storage tanks and ASTs (20.5 NMAC). The Laboratory continues to maintain and operate ASTs in compliance with 20.5 NMAC. In July 2006, the Laboratory paid annual AST registration fees of $100 per AST.

During 2006, the Laboratory continued to work on removing and decommissioning ASTs that were no longer in service. In 2006, the Laboratory continued the quarterly assessment program for AST systems to assist AST owners and operators in meeting regulatory compliance requirements and associated deadlines.

On February 21, 2002, the Laboratory notified EPA, NMED, and the National Response Center of a discharge of approximately 48,000 gallons of diesel fuel into the environment from a tank at TA-21-57. Soil removal and sampling were performed in accordance with Laboratory, state, and federal regulatory requirements to determine the extent of the leak. The Laboratory completed characterization of the release in December 2003 and is continuing to work with NMED on a path forward for mitigation efforts. In 2006, the Laboratory continued efforts to implement a Sampling and Analysis Plan to conduct additional characterization of the

TA-21-57 diesel release site to further evaluate subsurface diesel contamination. Additional characterization will provide information needed for establishing current conditions for the subsurface diesel contamination. Upon evaluation of additional characterization, the Laboratory intends to develop applicable processes for site mitigation.

On April 3, 2003, the Laboratory notified NMED of the discovery of diesel-contaminated soil near the TA-3 Power Plant AST (TA-3-26). The Laboratory completed initial characterization of the diesel-contaminated soil in April 2004 and is continuing to work with NMED on a path forward for additional characterization and mitigation efforts. In 2006, the Laboratory implemented a Sampling and Analysis Plan to conduct secondary characterization at TA-3-26. Results from secondary characterization work will help determine a path forward for corrective actions.

h. Dredge and Fill Permit Program. Section 404 of the CWA requires the Laboratory to obtain permits from the US Army Corps of Engineers to perform work within perennial, intermittent, or ephemeral watercourses. Section 401 of the CWA requires states to certify that Section 404 permits issued by the Corps will not prevent attainment of state-mandated stream standards. NMED reviews Section 404/401 joint permit applications and issues separate Section 401 certification letters which may include additional permit requirements to meet state stream standards for individual Laboratory projects. In addition, the Laboratory must comply with 10 CFR 1022, which specifies how DOE sites comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands.

During 2006, three Section 404/401 permits were issued to the Laboratory:

- Omega Road Erosion Repair Project in Los Alamos Canyon (Nationwide Permit No. 13, Bank Stabilization),
- Stream Gage Maintenance Project in Two-Mile, Canada del Buey, Pajarito, Sandia, Water, Los Alamos, and Mortandad Canyons (Nationwide Permit No. 5, Scientific Measurement Devices), and
- Stream Gage Construction Project in Ancho, Fence, Canyon de Valle, Sandia, and Los Alamos Canyons (Nationwide Permit No. 5, Scientific Measurement Devices).

In addition, LANL reviewed 745 excavation permits and 81 project profiles for potential impacts to watercourses, floodplains, or wetlands. No Floodplain/Wetland Assessments were prepared in 2006. No violations of the DOE Floodplains/Wetlands Environmental Review Requirements were recorded. NMED and the Corps of Engineers did not inspect active sites permitted under the Section 404/401 regulations during 2006.

8. Safe Drinking Water Act

Los Alamos County, as owner and operator of the Los Alamos water supply system, is responsible for compliance with the requirements of the federal Safe Drinking Water Act (SDWA) and the New Mexico Drinking Water Regulations (NMEIB 2002). The SDWA requires Los Alamos County to collect samples from various points in the water distribution systems at the Laboratory, Los Alamos County, and Bandelier National Monument to demonstrate compliance with SDWA maximum contaminant levels (MCLs). EPA has established MCLs for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The State has adopted these standards in the New Mexico Drinking Water Regulations. EPA has authorized NMED to administer and enforce federal drinking water regulations and standards in New Mexico. Information on the quality of the drinking water from the Los Alamos County Water Supply System is in the County's annual Consumer Confidence Report, available online at: http://www.lac-nm.us/.

In 2006, the Laboratory conducted additional confirmation monitoring of the Los Alamos County water supply system for quality assurance purposes. Chapter 5 presents these data.

9. Groundwater

a. Groundwater Protection Compliance Issues. Under requirements of DOE Order 450.1 the Laboratory prepared a groundwater protection management plan to protect groundwater resources in and around the Los Alamos area and ensure that all groundwater-related activities comply with the applicable federal and state regulations. The Consent Order requires the Laboratory to establish a groundwater monitoring system, conduct investigations to determine the nature and extent of contamination in the groundwater, and remediate the groundwater if necessary. Characterization wells in the intermediate and regional aquifers are shown in Figure 2-2.

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in New Mexico. Under the regulations, when required by NMED, a facility must submit a groundwater discharge plan and obtain NMED approval (or approval from the New Mexico Oil Conservation Division for energy/mineral-extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge plan.

In 2006, the Laboratory had one approved groundwater discharge plan (see Table 2-1) for the TA-46 SWWS Plant and two groundwater discharge plans pending NMED approval for the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) and the Laboratory's 14 domestic septic systems. On August 27, 2002, the Laboratory submitted a renewal application for the SWWS Plant groundwater discharge plan; NMED approval was pending at the end of 2006. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the RLWTF at TA-50. On April 27, 2006, the Laboratory submitted a groundwater discharge plan application for the discharge of domestic wastewater from 14 domestic septic systems. Approval of these two discharge plan applications were still pending at the end of 2006.

b. Compliance Activities. The Laboratory performed most groundwater compliance work in 2006 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and groundwater well construction.

In 2006, the NMED approved the Laboratory's Interim Facility-Wide Groundwater Monitoring Plan. The plan specifies that monitoring be conducted by watershed, and specifies the wells, frequency of monitoring, and analytical suites. Groundwater monitoring by watershed following this plan began in June 2006. Periodic monitoring reports on these monitoring events by watershed were submitted to NMED beginning in November 2006. Results of groundwater monitoring are presented in Chapter 5.

Sample analytical, water-level, well-construction, and other groundwater data can be reviewed online on the Laboratory's Water Quality Database website, http://wqdbworld.lanl.gov/. Periodic monitoring reports can be found on the Laboratory's Environment website, http://www.lanl.gov/environment/h2o/reports.shtml.

The Laboratory completed the groundwater investigation of Mortandad Canyon during 2006. This work was submitted to NMED in October 2006 as part of the Mortandad Canyon Investigation Report (LANL 2006a). In addition, the Laboratory submitted the Interim Measures Report for Chromium Contamination in Groundwater to NMED in November 2006 (reference). These investigations are summarized in Chapter 9.

In 2006, LANL installed six alluvial characterization wells, one intermediate characterization well, and five piezometers (Table 2-8) in Sandia Canyon as part of the Interim Measures Work Plan for Chromium

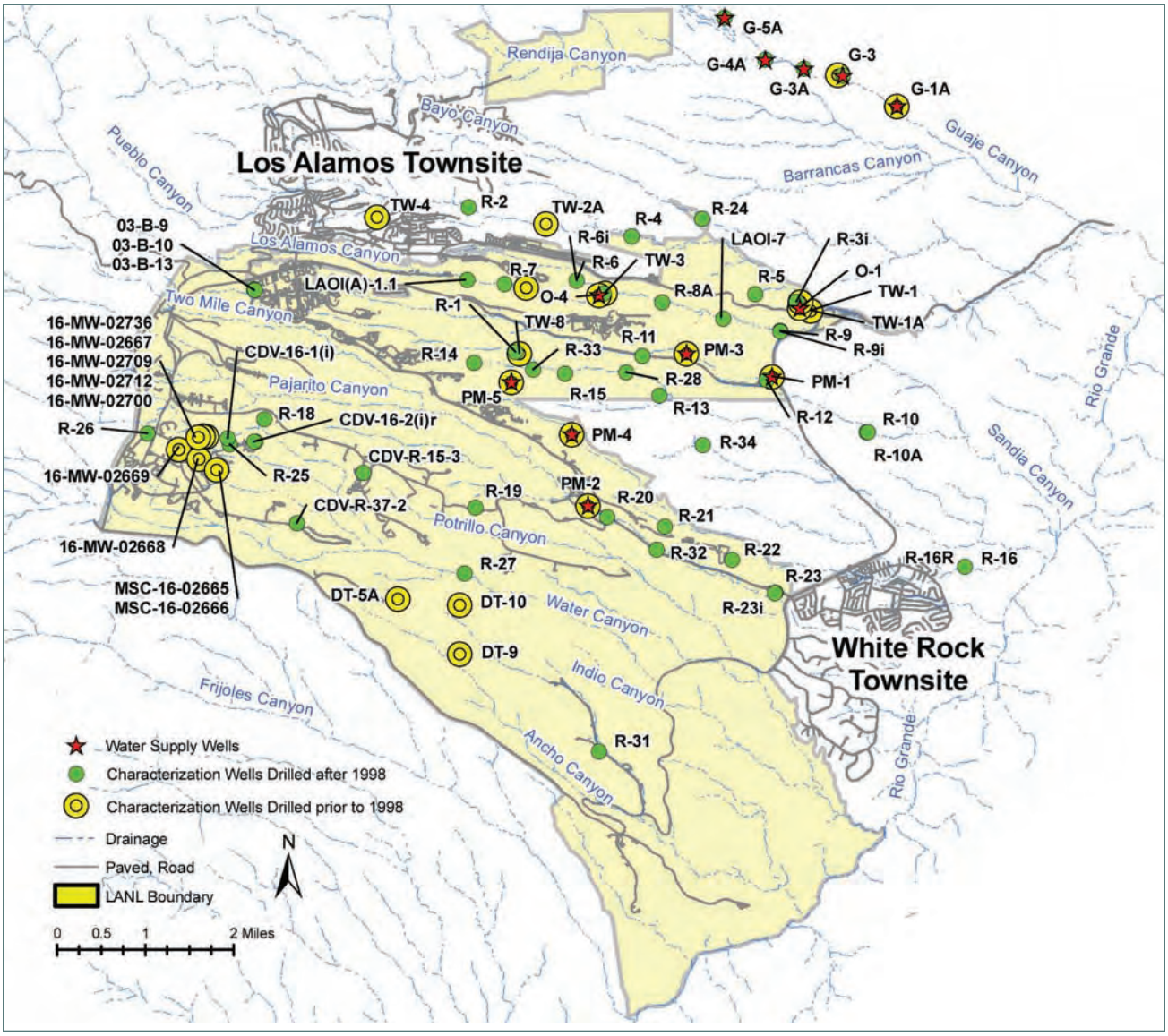

Figure 2-2. Intermediate-perched and regional aquifer characterization wells at LANL and vicinity.

Contamination in Groundwater (LANL 2006b). The alluvial wells were installed to determine the extent of alluvial saturation, determine the nature and extent of chromium contamination within the alluvial aquifer, and obtain data to calculate chromium inventory.

A total of five piezometers were installed in three separate boreholes. Piezometers SCP-1 (a), (b), and (c) were installed in a single borehole located six ft west of alluvial well SCA-4; piezometers SCP-2(a) and 2(b) were installed in separate boreholes located approximately 5 and 10 ft east of alluvial well SCA-3, respectively.

The interim measures work plan called for the drilling and sampling of six characterization boreholes to determine nature and extent of chromium in the upper vadose zone and obtain data to calculate chromium inventories. Six boreholes (SCC-1 to SCC-6) were drilled with air rotary techniques; core samples were collected at 20-ft intervals. Cuttings were collected at 5-ft intervals between the core runs. Water samples were collected from four of the borehole locations during drilling. An intermediate well, designated SCI-1, was installed in the SCC-1 borehole, located in lower Sandia Canyon, north of East Jemez Road and between the SCA-2 and SCA-3 alluvial well locations. This hole was 400 ft below ground surface (bgs)

Table 2-8
Wells and Boreholes Installed in 2006

Type [a]	Identifier	Watershed (Canyon)	Total depth (ft bgs)	Screened interval (ft bgs)	Water level (ft bgs)	Comments
I	LAOI-3.2a	Los Alamos	266.9	181.4–191	172.9	Near confluence with DP Canyon. Drilled to determine if perched water was present below 165 ft, to install a screen below the total depth of adjacent well LAOI-3.2, and to drill to 300 ft which was the original target depth of LAOI-3.2
I	SCI-1	Sandia	377.9	358.4–377.9	366.66	Lower Sandia Canyon, north of East Jemez Road and between alluvial wells SCA-2 and SCA-3.
A	SCA-1	Sandia	2.2	1.3–1.9	0.02	Hand-augered in upper canyon in wetlands near headwaters.
A	SCA-2	Sandia	19	10.3–15	14.36	Hand-augered in lower canyon on the south side of East Jemez Road. The well was bailed dry during development after removing 0.6 gallons of water.
A	SCA-3	Sandia	58.5	27.6–32	32.1	South of East Jemez Road and west of regional well R-11. Developed but no aquifer test due to the small saturated interval in the well.
A	SCA-4	Sandia	42	37–41.5	37.91	South of East Jemez Road and west of regional well R-11.
A	SCA-5	Sandia	64.9	55–64.4	57.8	Lower Sandia Canyon, north of East Jemez Road and immediately west of the firing range.
A	SCP-1(a)	Sandia	43.8	37.8–38.3	37.64	Located 6 ft west of alluvial well SCA-4. Piezometer installation in same borehole as SCP-1(b) and (c). .
A	SCP-1(b)	Sandia	43.8	39.4–39.9	37.76	Piezometer in same borehole as SCP-1(b) and (c).
A	SCP-1(c)	Sandia	43.8	41.2–41.7	37.45	Piezometer in same borehole as SCP-1(b) and (c).
A	SCP-2(a)	Sandia	45.6	44.5–45	32.04	Located 10 ft east of alluvial well SCA-3. Piezometer.
A	SCP-2(b)	Sandia	51.5	49.5–50	34.45	Located 5 ft east of alluvial well SCA-3. Piezometer.

[a] A = alluvial aquifer well; I = intermediate aquifer well.

and 9.5 ft into the Cerros del Rio basalt. Alluvial groundwater was encountered from 33.5 ft to 58 ft bgs. Intermediate-perched water was encountered in the Puye Formation at approximately 366 ft bgs. The screened interval of the intermediate well extended from 358.4 to 377.9 ft bgs. After construction of SCI-1 and during development, the contractor determined that filter pack sand was being bailed from the well. A camera survey determined that the bottom of the sump, constructed of polyvinyl chloride (PVC), had been knocked from the bottom of the well. With LANL and NMED approval, a permanent cylindrical PVC plug was placed into the bottom of the sump.

10. National Environmental Policy Act

The intent of the National Environmental Policy Act (NEPA) (42 U.S.C. 4331 et seq.) is to promote productive harmony between humans and the environment. Federal agencies such as the DOE/NNSA must consider the environmental impacts of proposed projects and ensure public participation as part of the decision-making process. The Laboratory's Risk Reduction Office devotes considerable resources to assist NNSA in compliance with the NEPA, pursuant to DOE Order O451.1B. Proposed projects and actions at LANL are reviewed to determine if there are resource impacts, and the appropriate coverage under NEPA, and these recommendations are provided to NNSA. The following NEPA analyses were prepared or reviewed in 2006.

a. New LANL Site-Wide Environmental Impact Statement. DOE NEPA implementing regulations (10 CFR Part 1021.330[d]) require a SWEIS to be reviewed at least every five years and a Supplemental Analysis performed to examine whether the SWEIS still adequately covers site operations. The local DOE site office produced a Supplement Analysis in September 2004 that was reviewed by DOE headquarters. In October 2004, DOE headquarters made the decision to expand the Supplement Analysis to a Supplemental SWEIS. In April 2005, DOE headquarters decided to convert the Supplemental SWEIS to a full SWEIS and consider three alternatives for future operations at LANL. The new SWEIS will consider operations for a period of five years, 2008–2012. The three SWEIS alternatives considered were:

The No Action Alternative: This alternative would continue operations at current levels. This alternative considers the levels of operation covered in the 1999 SWEIS Record of Decision Expanded Operations Alternative. This alternative would include updates on the operations of the 15 Key Facilities defined in the 1999 SWEIS to anticipate operational levels over the next five years and consideration of new facilities proposed for construction over this period.

The Expanded Operations Alternative: This alternative would include the No Action Alternative plus new or enhanced facilities for ongoing operations. Waste management levels would increase. The major change in this alternative would be the increase in pit production to 50 pits/year in the current TA-55 facilities.

The Reduced Operations Alternative: This alternative would include operational reductions at certain facilities while enhancing some facilities for ongoing operations. Pit production would remain at the 1999 SWEIS Record of Decision levels of 20 pits/year. The major changes considered in this alternative are the closing of LANSCE (Los Alamos Neutron Science Center) and a reduction in operations of approximately 20% for Dual-Axis Radiographic Hydrodynamic Test (DARHT) and a 20% reduction in firing site operations.

The three alternatives were analyzed and the Expanded Operations Alternative was selected as the preferred alternative. On July 7, 2006 NNSA published a Notice of Availability for the draft SWEIS and announced a 60-day public comment period. A Record of Decision on the new SWEIS is expected to be issued in late 2007 or early 2008.

b. Environmental Impact Statement for Operation of a BSL-3 Facility at LANL. In 2000, the DOE/NNSA initiated the National Environmental Policy Act (NEPA) process to prepare an Environmental Assessment (EA) for the construction and operation of a Biosafety Level-3 (BSL-3) facility. On February 23, 2002, DOE/NNSA released a final EA and associated Finding of No Significant Impact (FONSI) for the facility. The construction of the 3,200 ft^2 facility, which began in the summer of 2002, was substantially completed in the fall of 2003.

Upon further internal review, DOE determined that it was necessary to conduct additional seismic analysis because the facility was constructed on top of fill material on a slight slope. Therefore, in early 2004, DOE withdrew the portion of the FONSI that dealt with the operation of the facility and decided to prepare a separate Environmental Impact Statement (EIS) to evaluate reasonable alternatives for operation.

On November 29, 2005, DOE/NNSA published a Notice of Intent (NOI) in the Federal Register announcing its intent to prepare an EIS for the facility. The NOI stated that the public scoping period would end on December 29, 2005. Three public scoping meetings were held—one each in Los Alamos, Santa Fe, and Española, New Mexico. Because of comments received during these meetings, NNSA extended the public scoping period through January 17, 2006.

A draft EIS was prepared and submitted to NNSA for concurrence review (DOE/EIS-0388). The EIS evaluated three alternatives:

- Proposed Action Alternative: This alternative analyzed operation of the BSL-3 facility at LANL at the level permitted by Centers for Disease Control guidelines for a BSL-3 facility. BSL-2 work would also be done in parts of the facility.
- BSL-2 Alternative: This alternative analyzed operation of the facility at the level permitted for a BSL-2 facility; and
- No-Action Alternative: Under this alternative, the already constructed facility would not be operated as a biosafety facility, but would be used instead for non-BSL laboratory work.

A Notice of Availability for the approved draft EIS is expected to be published in 2007 for public review and comment.

11. Endangered Species Act

The Endangered Species Act requires federal agencies to protect populations and habitats of federally listed threatened or endangered species. The Laboratory contains potential habitat for two federally endangered species (Southwestern willow flycatcher, *Empidonax traillii extimus*, and black-footed ferret, *Mustela nigripes*), two federally threatened species (bald eagle, *Haliaeetus leucocephalus*, and Mexican spotted owl, *Strix occidentalis lucida*), and one candidate species (yellow-billed cuckoo, *Coccyzus americanus*). The Southwestern willow flycatcher and black-footed ferret have not been observed on Laboratory property. In addition, there are several federal species of concern and state-listed species potentially occurring within LANL (Table 2-9).

The Laboratory meets its requirements for threatened and endangered species protection through implementation of its Threatened and Endangered Species Habitat Management Plan and review of excavation permit requests and project profiles. During 2006, LANL reviewed 752 excavation permits and 95 project profiles for potential impacts to threatened or endangered species. The Laboratory conducted annual surveys for Mexican spotted owl, Southwestern willow flycatcher, and bald eagle. During 2006, LANL prepared biological assessments for three projects that required consultation with the US Fish and Wildlife Service regarding potential impacts on federally-listed threatened or endangered species:

- Site-Wide Environmental Impact Statement
- Effluent Reduction Ponds
- Monitoring and Maintenance of Monitoring Stations and Wells

Table 2-9
Other Sensitive Species Occurring or Potentially Occurring at LANL

Scientific Name	Common Name	Protected Status[a]	Potential to Occur[b]
Gila pandora	Rio Grande Chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains Salamander	NME, FSOC	Moderate
Falco peregrinus anatum	American Peregrine Falcon	NMT, FSOC	High
Falco peregrinus tundrius	Arctic Peregrine Falcon	NMT, FSOC	Moderate
Accipiter gentiles	Northern Goshawk	NMS, FSOC	High
Lanius ludovicianus	Loggerhead Shrike	NMS	High
Vireo vicinior	Gray Vireo	NMT	Moderate
Plegadis chihi	White-faced Ibis	S1	Moderate
Myotis ciliolabrum melanorhinus	Western Small-footed Myotis Bat	NMS	High
Myotis volans interior	Long-legged Bat	NMS	High
Euderma maculatum	Spotted Bat	NMT	High
Plecotus townsendii pallescens	Townsend's Pale Big-eared Bat	NMS, FSOC	High
Nyctinomops macrotis	Big Free-tailed Bat	NMS	High
Myotis thysanodes thysanodes	Fringed Bat	NMS	High
Myotis yumanensis yumanensis	Yuma Bat	NMS	High
Myotis evotis evotis	Long-eared Bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red Fox	NMS	Moderate
Ochotona princeps nigrescens	Goat Peak Pika	NMS, FSOC	Low
Zapus hudsonius luteus	New Mexico Meadow Jumping Mouse	NMT, FSOC	Moderate
Lilium philadelphicum var. andinum	Wood Lily	NME	High
Cypripedium calceolus var. pubescens	Greater Yellow Lady's Slipper	NME	Moderate
Speyeria Nokomis nitocris	New Mexico Silverspot Butterfly	FSOC	Moderate

NMS = New Mexico Sensitive Taxa (informal); S1 = Heritage New Mexico: Critically Imperiled in New Mexico; NMT = New Mexico Threatened; NME = New Mexico Endangered; FSOC = Federal Species of Concern.

[b] Low = No known habitat exists on LANL; Moderate = Habitat exists, though the species has not been recorded recently; High = Habitat exists and the species occurs at LANL.

12. Migratory Bird Treaty Act

Under the provisions of the Migratory Bird Treaty Act, it is unlawful "by any means or manner to pursue, hunt, take, capture [or] kill" any migratory birds except as permitted by regulations issued by the US Fish and Wildlife Service. Personnel from LANL received retraining for migratory bird protection measures at the annual New Mexico Avian Protection Workshop and continued to recommend best management practices for migratory bird protection to LANL projects during project reviews. Special emphasis was placed on protection of migratory birds on power line and pole structures.

13. Cultural Resources

The goal of the National Historic Preservation Act (NHPA) of 1990 is to have federal agencies act as responsible stewards of the nation's resources when their actions affect historic properties. NHPA Section 106

requires federal agencies to take into account the effects projects may have on historic properties and to allow for comment by the Advisory Council on Historic Preservation. Section 106 regulations outline a project review process conducted on a project-by-project basis.

In 2006, the Laboratory conducted 21 projects that required some field verification of previous survey information. In addition to the 13 new archaeological sites identified in 2006, we identified 166 historic buildings. Twenty-three archaeological sites and 65 historic buildings were determined eligible for the National Register of Historic Places.

The Laboratory began the fifth year of a multiyear program of archaeological excavation in support of the Land Conveyance and Transfer project. The DOE/NNSA is in the process of conveying to Los Alamos County approximately 2,000 acres of Laboratory lands. Thirty-nine archaeological sites have been excavated during the five field seasons, with more than 200,000 artifacts and 2,000 samples collected. Together, these sites provide new insights into past activities on the Pajarito Plateau from 5000 BC to AD 1943. From a compliance perspective, these excavations resolve the anticipated adverse effects to archaeological sites from the future development of lands to be acquired by Los Alamos County. These sites are also ancestral places to the Pueblo people and representatives from the Pueblos of San Ildefonso and Santa Clara acted as tribal consultants and monitors on the project.

In support of LANL's fiscal year 2006 decontamination and decommissioning program, the Laboratory conducted historic building assessments and other documentation work related to two proposed projects as required under the provisions of the NHPA. Buildings included in these projects are located at TAs-8, -9, -14, -15, -22, -36, -39, -40, -60, and -69. This work included field visits to historic properties (including interior and exterior inspections), digital and archival photography, and architectural documentation (using standard LANL building recording forms). Additional documentation included the production of location maps for each of the evaluated projects. Historical research was also conducted using source materials from the LANL archives and records center, historical photography, the Laboratory's public reading room, and previously conducted oral interviews.

The long-term monitoring program at the ancestral pueblo of Nake'muu was completed as part of the DARHT Facility Mitigation Action Plan (DOE 1996). Nake'muu is the only pueblo at LANL that still contains its original standing walls. During the nine-year monitoring program, the site has experienced a 0.9% displacement rate of chinking stones and 0.3% displacement of masonry blocks. Statistical analyses indicate these displacement rates are significantly correlated with annual snowfall, but not with annual rainfall or explosive tests at the DARHT facility.

Native American consultation is ongoing with respect to identifying and protecting traditional cultural properties, human remains, and sacred objects in compliance with the NHPA and Native American Graves Protection and Repatriation Act. Work for the Land Conveyance and Transfer Project included consultation with San Ildefonso and Santa Clara Pueblos for project monitoring, the implementation of a Native American Graves Protection and Repatriation Act intentional excavation agreement, identification of potential reburial locations, protection of Traditional Cultural Properties, and student internships. In fiscal year 2006, a total of 38 sets of culturally affiliated human remains and associated funerary objects or objects of cultural patrimony were repatriated to the Pueblo de San Ildefonso. These represent remains and objects variously encountered and collected from LANL property between the period of 1956 and 2005. Other projects include the Nake'muu noise vibration study, the development of a final management plan for the TA-3 University House Traditional Cultural Properties, and the Cerro Grande Rehabilitation Project.

Protection and Repatriation Act. Work for the Land Conveyance and Transfer Project included consultation with San Ildefonso and Santa Clara Pueblos for project monitoring, the implementation of a Native American Graves Protection and Repatriation Act intentional excavation agreement, identification of potential reburial

locations, protection of Traditional Cultural Properties, and student internships. In fiscal year 2006, a total of 38 sets of culturally affiliated human remains and associated funerary objects or objects of cultural patrimony were repatriated to the Pueblo de San Ildefonso. These represent remains and objects variously encountered and collected from LANL property between the period of 1956 and 2005. Other projects include the Nake'muu noise vibration study, the development of a final management plan for the TA-3 University House Traditional Cultural Properties, and the Cerro Grande Rehabilitation Project.

C. UNPLANNED RELEASES

1. Air Releases

There were two unplanned air releases during 2006.

- A smoke opacity of 24% was observed at the TA-60 Asphalt Plant on May 1, 2006. The permit limit for opacity is 20%.
- A release of ammonia equal to or in excess of the reportable quantity was reported under Section 304 of EPCRA. The reportable quantity for ammonia is 100 pounds.

2. Water releases

There were no unplanned releases of radioactive liquids in 2006. There were six unplanned releases of non-radioactive liquids in 2006:

- Approximately 300 gal. of fire suppression water into upper Sandia and Los Alamos Canyons.
- Approximately four yd^3 of clean fill sediment from storm water runoff from a construction site at TA-50 into upper Ten Site Canyon.
- Approximately 1,000 gal. of potable water from TA-54-215 into Canada Del Buey.
- Approximately 2,000 gal. of potable water into the run-on diversion channel at MDA-T and SWMU 21-0016(a)-99.
- Greater than 41,000 gal. of potable water into the diversion channel around MDA-T, into Consolidated Unit 21-016(a)-99, and into DP Canyon.
- Approximately 600 gal. of fire suppression water into upper Sandia Canyon.

The Laboratory investigated all unplanned releases of liquids as required by the NMWQCC Regulations 20.6.2.1203 NMAC. Upon cleanup, the NMED and the DOE Oversight Bureau inspected the unplanned release sites to ensure adequate cleanup. In 2006, the Laboratory was in the process of administratively closing out all releases for 2006 with the DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

D. REFERENCES

DOE 1996: "Dual-Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," United States Department of Energy report USDOE/EIS-0228 (January 1996).

LANL 1998: Water Quality and Hydrology Group, "Hydrogeologic Workplan," Final Version, Los Alamos National Laboratory (May 1998).

LANL 2006a: "Mortandad Canyon Investigation Report," Los Alamos National Laboratory document LA-UR-06-6752, ID 094160 (October 2006).

LANL 2006b: "Interim Measures Work Plan for Chromium Contamination in Groundwater," Los Alamos National Laboratory document LA-UR-06-1961, Los Alamos, New Mexico. (LANL 2006, 091987) (March 2006).

NMEIB 2002: New Mexico Environmental Improvement Board, State of New Mexico, "Drinking Water Regulations" (as amended through December 2002), found at 20.7.10 NMAC.





3. Radiological and Non-Radiological Dose Assessment



3. Radiological and Non-Radiological Dose Assessment

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A. INTRODUCTION

This chapter presents the results of the calculation of doses to the public and biota from Laboratory operations in 2006 and reports whether the doses are below specified limits. This chapter also provides a measure of the significance of environmental radioactivity in the context of its importance to humans and biota. In this respect, the human dose assessment provides a different perspective from the biota dose assessment. The calculated human dose is received near the publicly accessible Laboratory boundaries, whereas the biota dose is potentially received throughout the interior of the Los Alamos National Laboratory (LANL or the Laboratory), usually at locations rarely visited by humans. In addition, the potential risks from nonradiological materials detected during 2006 and previous years' sampling activities are summarized.

As defined by DOE Standard 1153-2002 (DOE 2002), biota are divided into plants and animals. Plants receive the highest dose because they live their whole lives in one location. Animals range over a wider area, which usually minimizes their dose. Humans receive the lowest dose because they limit their time in areas with residual contamination and do not typically eat the vegetation or drink the water in these areas. Therefore, locations with no significant human dose may have higher biota dose.

B. HUMAN DOSE ASSESSMENT

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented are calculated using standard methods specified in guidance documents (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997, 1999; NRC 1977). The "effective dose equivalent," referred to here as "dose," is calculated using radiation weighting factors and tissue weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in millirem (mrem), is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. For example, 1 mrem of direct gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium.

Federal government standards limit the dose that the public may receive from Laboratory operations. The DOE public dose limit to any individual is 100 mrem/yr (DOE 1993) received from all pathways (i.e., all ways in which people can be exposed to radiation, such as inhalation, ingestion, and direct radiation). Furthermore, doses to members of the public must be reduced to low levels consistent with a documented ALARA (as low as reasonably achievable) process and generally not exceeding a dose constraint of one-quarter of the primary dose limit, or 25 millirem in a year (DOE 1999). The dose received from airborne

emissions of radionuclides is further restricted by the US Environmental Protection Agency's (EPA's) dose standard of 10 mrem/yr (EPA 1986), also known as the RAD-NESHAP (National Emission Standards for Hazardous Air Pollutants) dose limit. These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from community drinking water supplies are limited in accordance with the Clean Water Act, either by established maximum contaminant levels (MCLs) for some radionuclides or by dose (4 mrem/yr for man-made radionuclides) (DOE 1993; EPA 2000).

2. Public Dose Calculations

a. Scope. The objective of our public dose calculations is to report incremental (above-background) doses caused by LANL operations. Therefore, we don't include dose contributions from radionuclides present in our natural environment or from radioactive fallout.

Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (or external) radiation. We calculate doses for the following cases:

(1) The entire population within 80 km of the Laboratory;

(2) The maximally exposed individual (MEI) who is not on LANL/DOE property for the airborne pathway dose only and compared to the EPA RAD-NESHAP dose limit of 10 mrem/year;

(3) The MEI not on LANL/DOE property for the all-pathways dose and compared to the DOE Order 5400.5 dose limit of 100 mrem/year;

(4) Residents in Los Alamos and White Rock.

b. General Considerations. We begin with environmental measurements of air, water, soil, foodstuffs, sediment, and non-foodstuffs biota and convert these measurements to dose using the standard methods specified above.

As discussed in Section B.4, the dose rate from naturally occurring radioactivity is approximately 400 mrem/yr (additional man-made sources of radiation such as medical/dental uses of radiation and building products such as stone walls, raise the total background dose to 470 mrem/yr on average). It is extremely difficult to measure doses from LANL that are less than 0.1% (one one-thousandth) of natural doses. As the dose rates become smaller, the estimates become less certain and less significant. Generally, we conclude that a dose rate less than 0.1 mrem/yr is essentially zero and cannot be distinguished from natural background radiation.

i. Direct Radiation Exposure. The Laboratory monitors direct radiation from gamma photons or neutrons at about 100 locations in and around LANL (Chapter 4, Section C). Direct radiation doses above natural background are measured near Technical Area (TA) 54, but not elsewhere.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source of external radiation. At distances more than one km, the decrease in radiation dose rate with increasing distance from the radiation source (inverse-square law), combined with scattering and attenuation or shielding in the air, reduces the dose to much less than 0.1 mrem/yr, which cannot be distinguished from natural background radiation. This means the only significant above-background doses from direct radiation are measured near TA-54 (section B.3.b.ii of this chapter).

To estimate the dose to the public, we combine the measurements of gamma and neutron dose with an occupancy factor of 1/16 (NCRP 1976). The direct radiation measurements reported in Chapter 4 would apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/yr). We follow standard guidance and assume continuous occupancy for residences and places of business. For all other locations, we multiply the measured dose by the 1/16 occupancy factor.

ii. Airborne Radioactivity (Inhalation Pathway). At distances more than a few hundred meters from LANL sources, the dose to the public is almost entirely from airborne radioactive material. Whenever possible, we use the direct measurements of airborne radioactivity concentrations measured by the Ambient Air Sampling Network (AIRNET) and reported in Chapter 4, Section A. Where local concentrations are too small to measure, we calculate the doses using the CAP88 model (EPA 2006), an atmospheric dispersion and dose calculation computer code that combines stack radionuclide emissions information with meteorological data to estimate where the released radioactive material went and the dose from that radioactive material. The estimation of dose for this chapter was performed using CAP88-PC Version 3.0 (EPA 2006).

In particular, some of the radionuclide emissions from the Los Alamos Neutron Science Center (LANSCE) are not measured by AIRNET. These emissions are measured at the stacks (Chapter 4, Section B) and the resulting doses are calculated with CAP88. These doses decrease substantially with distance from the stack because the radioactive half-lives are short (20 minutes or less).

iii. Water (Ingestion Pathway). The majority of radionuclides detected in groundwater samples collected from known or potential drinking water sources (i.e., Los Alamos County drinking water supply wells and natural springs) in 2006 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226. However, several radionuclides attributable to Laboratory operations were measured in samples from an on-site alluvial spring in upper Los Alamos Canyon (DP Spring), which is not a recognized drinking water source. Americium-241, plutonium-239,240, cesium-137, strontium-90, and tritium were measured in these samples at the following maximum concentrations: 0.288 pCi/L, 0.179 pCi/L, 8.32 pCi/L, 31.1 pCi/L, and 148.8 pCi/L, respectively. The maximum dose from ingesting one liter of water from this spring would be approximately 0.0065 mrem. The highest concentration of tritium detected in a Los Alamos County drinking water supply well was about 21 pCi/L in a sample collected from the Otowi-1 well located in Pueblo Canyon and is well within the range of tritium concentrations found in rain water (16 to 35 pCi/L, Holloway 1993). This concentration is far below the EPA MCL of 20,000 pCi/L and would result in a dose of less than 0.1 mrem/yr if this water were to be ingested for an entire year (assumes 730 L ingested for the year). However, this well was not used by Los Alamos County as a drinking water source during 2006.

iv. Soil (Direct Exposure Pathway). We report measurements of radionuclide concentrations in surface soil in Chapter 7. As described in Chapter 7, Section C.1, soil samples were collected on the perimeter of the Laboratory and at regional and on-site locations. No regional samples had radionuclide concentrations above the Regional Statistical Reference Levels (RSRLs). RSRLs represent background radionuclide concentrations plus three standard deviations in media, such as soil, sediment, and crops, collected or harvested in regional areas far from the influence of the Laboratory averaged over a period of five years.

Radionuclide concentrations above the RSRLs were detected in soil samples taken from perimeter locations at TA-8 (GT Site), West Airport, and Tsankawi/PM-1. At the TA-8 location, the following radionuclides were detected above RSRLs: 1) cesium-137 at 1.4 pCi/g compared to the RSRL of 0.83 pCi/g, 2) plutonium-238 at 0.0077 pCi/g compared to the RSRL of 0.0067 pCi/g, and 3) plutonium-239,240 at 0.039 pCi/g compared to the RSRL of 0.036 pCi/g. The elevated cesium-137 concentration on the perimeter of TA-8 is typical for samples taken at higher elevations, where increased rainfall results in higher concentrations of fallout radionuclides (Eisenbud et al., 1997, Whicker et al., 1982). The plutonium-238 and plutonium-239,240 concentrations are essentially indistinguishable from the RSRLs.

At the West Airport location, the plutonium-239,240 soil concentration was 0.091 pCi/g compared to the RSRL of 0.036 pCi/g. This elevated plutonium-239,240 soil concentration can be attributed to historical stack emissions from TA-21.

At the Tsankawi/PM-1 location, uranium-234 and uranium-238 soil concentrations were detected at 1.6 pCi/g compared to the RSRLs of 1.4 pCi/g. Although these concentrations are slightly elevated above the RSRLs, the ratio of the uranium-234 to uranium-238 concentrations is indicative of natural uranium and not attributed to past or present Laboratory operations.

Five on-site locations that are accessible to the public, specifically in the area of State Route 502 at TA-73, also have transuranic radionuclide concentrations above the RSRLs. The plutonium-239,240 concentrations at these locations ranged from 0.12 to 0.39 pCi/g compared to the RSRL of 0.036 pCi/g. The americium-241 concentrations at these locations ranged from 0.023 to 0.041 pCi/g compared to the RSRL of 0.019 pCi/g. The elevated transuranic radionuclide soil concentrations at these locations are also attributed to historical stack emissions from TA-21.

With the exception of the West Airport and TA-73 locations, the soil concentrations measured in 2006 are essentially indistinguishable from regional background and fallout concentrations, and the resulting dose from soil (external gamma exposure, dust inhalation, and soil ingestion) at the sample locations is less than 0.1 mrem/yr. In summary, we conclude that the LANL contribution to the dose from soil is less than 0.1 mrem/yr, and the majority of the radionuclides detected are primarily due to fallout and historical operations at the Laboratory.

v. Food (Ingestion Pathway). We report measurements of the radioactive content of foods in Chapter 8. During 2006, two wild edible plant species, common lambsquarter and amaranth, were collected on the perimeter of Pueblo de San Ildefonso within Mortandad Canyon. No other foodstuffs were collected during 2006.

The concentration of strontium-90 in the two samples of common lambsquarter and the two samples of amaranth were elevated compared with their respective RSRLs. Refer to Supplemental Data Table S8-3 for specific radionuclide concentration values. The total dose received from consuming a pound of these wild edible plants is much less than 0.1 mrem.

It should be noted that the strontium-90 levels in the common lambsquarter and amaranth samples are higher than in crops that are normally collected as part of the Laboratory's surveillance program. This specific ingestion scenario therefore serves as a worst-case example due to the elevated levels and the close proximity of the sample location to the Laboratory boundary.

We conclude that the LANL contribution to the dose from consuming wild foodstuffs (specifically common lambsquarter and amaranth from the perimeter of Pueblo de San Ildefonso land within Mortandad Canyon) is less than 0.1 mrem/yr, which is small relative to the all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint.

vi. Release of Items. The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public. The requirements for release of such items are found in LANL 2006a. All items destined for release from known or potentially contaminated areas are screened for radioactive contamination in accordance with procedures of LANL's Health Physics Operations group. Any items with surface contamination or dose levels above the authorized release limits for uncontrolled use are not released to the public. Items from a known or potentially contaminated area that cannot be completely surveyed are also not released. The authorized release limits for items are found in LANL 2006a and are the limits in Figure IV-1 of DOE 1993 and DOE 1995. In 2006, no items were released to the public with contamination or dose levels approaching the authorized release limits. Therefore, the dose to the public from this pathway is negligible. In addition, the transfer of real property from DOE to the public is allowed if the modeled dose is no greater than 15 mrem/yr. The transfer of real property involving modeled doses greater than 15 mrem/yr requires the approval of DOE Headquarters. No real property was transferred in 2006. Refer to DOE 2000 for further information regarding this process.

3. Dose Calculations and Results

a. Population within 80 Kilometers. We used the local population distribution to calculate the dose from 2006 Laboratory operations to the population within 80 km (50 miles) of LANL. Approximately 280,000 persons live within an 80-km radius of the Laboratory. We used county population estimates provided by the University of New Mexico Bureau of Business and Economic Research (available at http://www.unm.edu/~bber/).

The collective dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL. For example, if two persons each receive three mrem, the collective dose is six person-mrem. This dose results from airborne radioactive emissions. Other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88.

The 2006 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 0.6 person-rem, which is significantly lower than the dose of 2.46 person-rem reported for 2005. Tritium contributed about 49% of the dose, and short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 50% of the dose. The decrease in the 2006 collective population dose compared to 2005 is primarily attributable to the repair of a leak at LANSCE in December 2005 and to an additional delay line installed at LANSCE in 2005. LANSCE has historically been the major contributor to the collective population dose. Until 2005, collective population doses for the past 12 years had declined from a high of about four person-rem in 1994 to less than one person-rem in 2004 (Figure 3-1). It is expected that future collective population doses will be less than one person-rem. No observable health effects in the local population are expected from this dose.

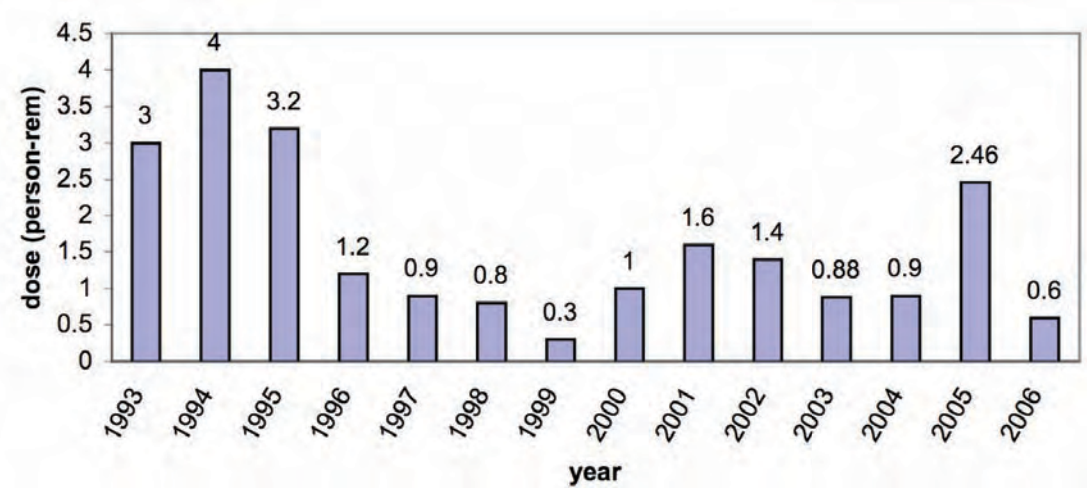

Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL.

b. Maximally Exposed Individual. The MEI is a hypothetical member of the public who, while not on DOE/LANL property, receives the greatest dose from LANL operations. For the past six years, the airborne pathway (RAD-NESHAP) and all-pathways MEI location has been at 2470 East Road, usually referred to as "East Gate." East Gate has normally been the location of greatest exposure because of its proximity to LANSCE and the prevailing wind direction. During LANSCE operations, short-lived positron emitters, such as carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

i. Airborne Pathway (RAD-NESHAP) MEI Dose. We modeled the dose at East Gate from LANSCE and from the LANL stacks using CAP88. The CAP88-modeled doses (Stavert 2007) were 0.176 mrem/yr from LANSCE and 0.20 mrem/yr from other LANL stacks. We added 0.047 mrem/yr from the radionuclides measured at the AIRNET station, though this dose is primarily from tritium, most of which was in the CAP88 modeled doses. Therefore, the total dose at East Gate was approximately 0.42 mrem/yr.

Because the LANSCE emissions for 2006 were reduced compared to an average of about two mrem/yr over the six years prior to 2006 (Figure 3-2), the location of the 2006 MEI was not as readily apparent as in the past and required more detailed calculations, as described below.

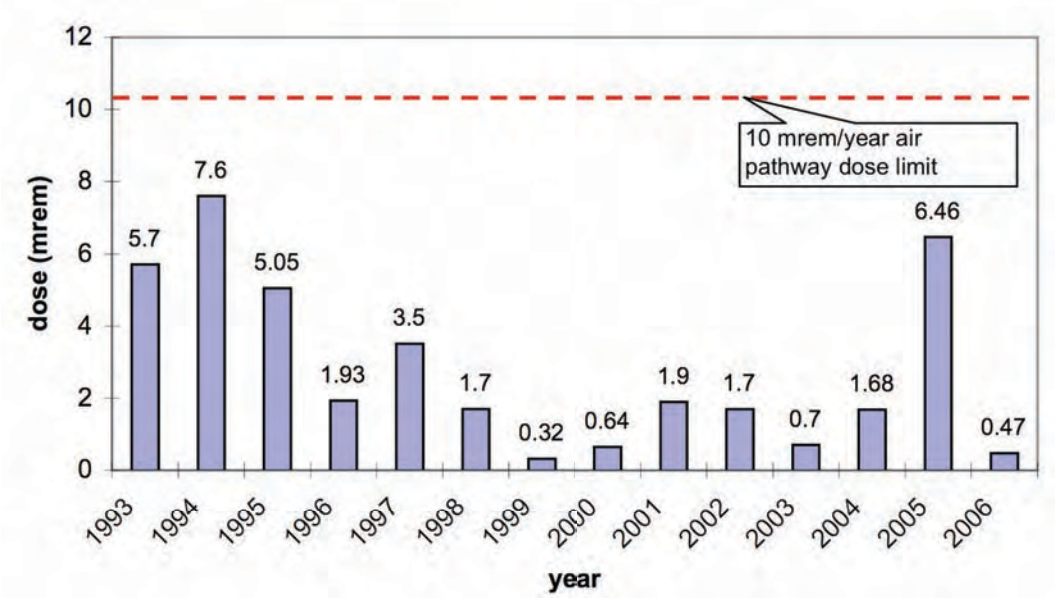

Figure 3-2. Annual airborne pathway (RAD-NESHAP) dose (mrem) to the maximally exposed individual off-site over the past 14 years.

To determine the RAD-NESHAP MEI location, we considered all compliance AIRNET station locations with an AIRNET dose greater than the AIRNET dose at East Gate (0.047 mrem/yr). The locations considered were TA-21 Area B (0.42 mrem/yr), Los Alamos Airport terminal (0.22 mrem/yr), Los Alamos County Landfill (0.10 mrem/yr), Los Alamos Inn South (0.09 mrem/yr), Crossroads Bible Church (0.05 mrem/yr), and Los Alamos Airport Road (0.05 mrem/yr).

The 0.42-mrem/yr dose measured near TA-21, Area B, was the result of remediation work at Area V, which is immediately adjacent to the TA-21 AIRNET station. The location of the maximum public dose from the Area V work is at Airport Road, where the dose is smaller than of the TA-21, Area B, dose (because the distance is greater).

The AIRNET dose at the Los Alamos County Airport terminal was larger than the dose at Airport Road. An ash pile adjacent to the terminal resulting from incinerator operations during the 1940s and 1950s was remediated, causing low levels of plutonium-239 in the ash to become airborne. The source of plutonium-239 in the ash was probably from the incineration of slightly contaminated trash. The AIRNET station at the terminal measured levels of airborne plutonium-239 from the ash pile that would result in a dose of 0.22 mrem/yr if an individual continuously breathed air at this location for a calendar year (24 hours/day and 365

days/year). Adding the dose at the terminal from all LANL stack emissions calculated by CAP88 (0.25 mrem) resulted in a total dose of 0.47 mrem/yr, which makes this the RAD-NESHAP MEI location for 2006.

ii. All-pathways MEI Dose. The location evaluated in 2006 as the potential all-pathways MEI is the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant emits neutrons. The measured neutron dose at the boundary was 20 mrem/yr. After subtracting a 2-mrem/yr neutron background dose and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose was 18/16 = 1.1 mrem/yr. A gamma photon dose was not calculated for this location because the low-energy photons emitted from the transuranic waste are absorbed in the intervening air layer between Area G and the Sacred Area. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as 0.03 mrem/16 = 0.002 mrem/yr. We added the dose derived from measurements at the AIRNET station along the northern boundary of Area G (0.18 mrem/yr) closest to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.011 mrem/yr. This results in a dose at this location of approximately 1.1 mrem/yr, which is greater than the airborne pathway MEI dose at East Gate and the Los Alamos County Airport terminal.

The airborne pathway MEI dose of 0.47 mrem/yr at the Los Alamos County Airport terminal is below the 10 mrem/yr EPA airborne emissions dose limit for the public (40 CFR 61, EPA 1986), and based on previous studies, we conclude it causes no observable health effects (HPS 1996, BEIR 1990). The all-pathways MEI dose of 1.1 mrem/yr at the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G is below the 100 mrem/yr DOE limit for all pathways and the 25 mrem/yr dose constraint (DOE 1993, DOE 1999), and, again, we conclude it causes no observable health effects.

In recent years, LANSCE has been the major contributor to the MEI dose. Future operations of the facility and associated emissions are expected to stay consistent with 2006 levels. The elevated levels in 2005 were caused by a broken valve at the inlet to the emissions controls system. An additional delay line was added in 2005 and contributed to the emissions reduction in 2006. Because stack emissions are expected to remain low, the major contributor to the air pathway MEI dose will most likely be from low levels of transuranic radionuclides in suspended wind-blown soil from environmental remediation projects.

c. Doses in Los Alamos and White Rock. We used background-corrected AIRNET data (reported in Chapter 4, Section A) and the factors in EPA guidance (EPA 1986) to calculate an annual dose at each of the perimeter AIRNET stations that represent the Los Alamos resident and the White Rock resident. To these doses, we added the contributions from LANSCE and other stacks, calculated using CAP88 for two representative locations: 5 km northwest of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

i. Los Alamos. During 2006, the Laboratory contributions to the dose at an average Los Alamos residence were 0.0078 mrem/yr from tritium and 0.0045 mrem/yr from LANSCE. Other radionuclides contributed about 0.0002 mrem/yr. This results in a total dose to an average Los Alamos resident of approximately 0.0125 mrem/yr.

ii. White Rock. During 2006, the Laboratory contributions to the dose at an average White Rock residence were 0.0091 mrem/yr from tritium and 0.0052 mrem/yr from LANSCE. Other radionuclides contributed about 0.0002 mrem/yr. This results in a total dose to an average White Rock resident of approximately 0.0145 mrem/yr.

The contributions from direct radiation, food, water, and soil are discussed in Section B.2 of this chapter; each contribution is essentially considered to be a zero dose. In summary, the total annual dose in 2006 to an average Los Alamos/White Rock resident from all pathways was about 0.01 mrem and is well below the

all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint. No observable health effects are expected from this dose (HPS 1996).

4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section, we discuss the LANL contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b).

External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from naturally occurring radionuclides. Doses from cosmic radiation range from 50 mrem/yr at lower elevations near the Rio Grande to about 90 mrem/yr in the higher elevations west of Los Alamos (Bouville et al. 988). Doses from terrestrial radiation range from about 50 to 150 mrem/yr, depending on the amounts of natural uranium, thorium, and potassium in the soil (McNaughton 2005).

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

In addition, members of the US population receive an average dose of 50 mrem/yr from medical and dental uses of radiation, 10 mrem/yr from man-made products, such as stone or adobe walls, and less than 1 mrem/yr from global fallout from nuclear-weapons tests (NCRP 1987a). Therefore, the average total annual dose from sources other than LANL is approximately 470 mrem. Refer to Figure 3-3 for a comparison of the natural radiation background (and other sources) in Los Alamos County to the US average background. The estimated LANL-attributable 2006 all-pathways MEI dose, 1.1 mrem/yr, is about 0.2% of this dose.

5. Effect to an Individual from Laboratory Operations

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem) (BEIR 1990). However, doses to the public from LANL operations are much smaller (Table 3-1). According to the 1996 Position Statement of the Health Physics Society (HPS 1996), “Below 10 rem, risks of health effects are either too small to be observed or are nonexistent.” Therefore, the doses presented in this chapter are not expected to cause observable health effects.



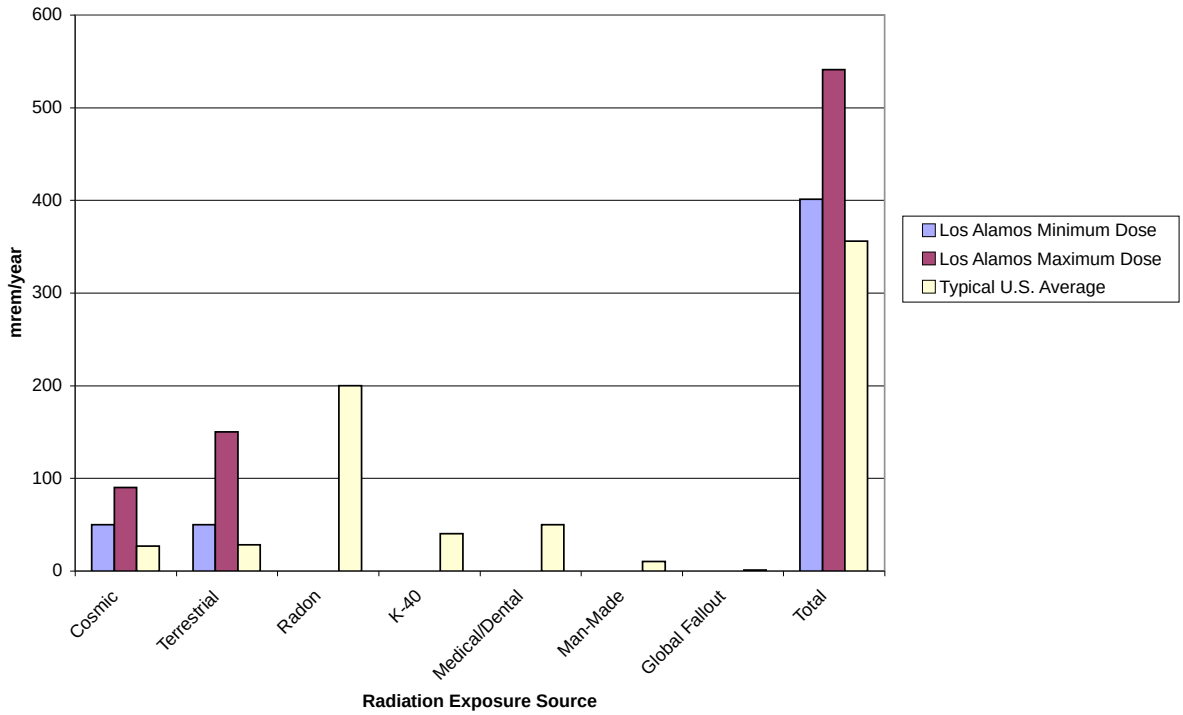

Figure 3-3 **Los Alamos County radiation background compared to average US background. Los Alamos County-specific background doses have not been determined for potassium-40, medical/dental exposures, man-made radiation, and global fallout, and are assumed to be the same as the US average in this figure.**

Table 3-1
LANL Radiological Dose for Calendar Year 2006

Pathway	Dose to Maximally Exposed Individual mrem/yr (mSv)	% of DOE 100 mrem/year Limit	Estimated Population Dose person-rem (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose person-rem (person-Sv)
Air	0.47[a] (4.7×10^{-3})	0.47%	0.6 (6×10^{-3})	NA[b]	NA
Water	<0.1 (<1.0×10^{-3})	<0.1%	0	NA	NA
Other Pathways (foodstuffs, soils)	<0.1 (<1.0×10^{-3})	<0.1%	0	NA	NA
All Pathways	1.1[c] (1.1×10^{-2})	1%	0.6 (6×10^{-3})	~280,000	~131,600[d] (~1316)

[a] This is the RAD-NESHAP MEI dose measured at the Los Alamos County Airport terminal

[b] NA = Not applicable – Pathway-specific populations are not specified, and pathway-specific background doses have not been determined, as allowed by DOE guidance

[c] This is the all-pathways MEI dose at the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G

[d] Based on 200 mrem/yr from inhalation of radon and its decay products, 70 mrem/yr from cosmic radiation, 100 mrem/yr from terrestrial radiation, 40 mrem/yr from potassium-40, 50 mrem/yr from medical and dental uses of radiation, and 10 mrem/yr from man-made products (see section B.4)

C. BIOTA DOSE ASSESSMENT

1. Biota Dose Assessment Approach

a. Overview. The biota dose assessment methods are described in detail in the DOE Standard (DOE 2002) and in the computer program RESRAD-BIOTA (http://web.ead.anl.gov/resrad/home2/biota.cfm). The DOE methods are general in nature and allow specific parameters to be adjusted according to local conditions because the calculations apply to all types of biota and all types of ecosystems. The site-specific methods used at LANL are specified in the quality assurance project plan for Biota Dose Assessment (available at http://www.lanl.gov/environment/all/qa.shtml), and McNaughton 2005 describes in detail the application of these methods to specific locations at LANL.

We calculate the dose to selected plants and animals following the guidance of DOE Standard 1153-2002 (DOE 2002) and LANL (LANL 2004a). Trees of the pine family (pinaceae) are representatives for terrestrial plants because they are radiosensitive (UNSCEAR 1996) and because their deep roots might tap into buried contamination (Foxx 1984a, b; Tierney 1987). Deer mice are representatives for terrestrial animals because of their relatively small home range, which means the maximally exposed mouse might spend a large fraction of its time in the most contaminated location. These plants and animals are common and widespread at LANL and the surrounding area. Other plants and animals (including aquatic plants and animals) may be collected and analyzed to estimate biota dose depending on availability and locations of interest.

b. Biota Dose Limits. The DOE biota dose limits (DOE 2002) are applied to biota populations rather than to individual plants and animals because it is the goal of DOE to protect populations, especially with respect to preventing the impairment of reproductive capability within the population. For animals, we use the population area for deer mice of 3 ha (30,000 m^2) (Ryti et al. 2004; LANL 2004a). We also average the dose to plants over this same area (McNaughton 2005).

The DOE dose limits to biota populations are

- Terrestrial animals: 0.1 rad/day (100 mrad/day)
- Terrestrial plants: 1 rad/day (1,000 mrad/day)
- Aquatic animals: 1 rad/day (1,000 mrad/day)

c. Methods. To ensure that the assessment is comprehensive, we begin with an initial screening (DOE 2002) that compares the maximum radionuclide concentrations in soil, sediment, and surface water with the DOE Biota Concentration Guides (BCGs). The DOE Standard (DOE 2002) states, "An important point is that exceeding the BCGs should not force a mandatory decision regarding remediation of the evaluation area, but rather is an indication that further investigation is likely necessary." If the BCGs are exceeded, a site-specific assessment is conducted that uses average concentrations and incorporates site-specific bioaccumulation factors. Following the guidance of the DOE Standard (DOE 2002), we do not include external-radiation dose from experimental facilities such as the Dual Axis Radiographic HydroTest (DARHT) facility and LANSCE. To provide further refinement of the screening process, we screen on a radionuclide-by-radionuclide basis and compare each radionuclide concentration to the appropriate BCG. If the concentration exceeds 10% of the BCG (or biota dose limit) for any one radionuclide, a full-scale screening is performed using the sum-of-the-fractions approach.

2. Biota Dose Results

Soil, sediment, vegetation (overstory and/or understory), and small mammals were collected in 2005 and 2006 from several locations. Specifically, soil and understory vegetation were collected at regional, perimeter,

and on-site locations. Overstory vegetation was collected at MDA B at TA-21. Understory vegetation was collected at MDA G at TA-54. Overstory and understory vegetation, birds, bees, and mice were collected around the DARHT facility at TA-15. Understory and overstory vegetation, sediment, and mice were collected upgradient and downgradient of the Los Alamos Canyon Weir. Understory vegetation, sediment, and mice were collected upgradient of the Pajarito Canyon Flood Retention Structure. Refer to supplemental tables for Chapters 7 and 8 for full details regarding analysis results.

All radionuclide concentrations in vegetation sampled were far below the terrestrial plant 0.1 rad/day biota dose screening level (10% of 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled were far below the terrestrial animal 0.01 rad/day biota dose screening level (10% of 0.1 rad/day dose limit). As previously mentioned in the soil pathway section (section B.2.iv.) of this chapter, certain perimeter and on-site sample locations had soil radionuclide concentrations above RSRLs attributable to historical Laboratory operations. However, none of these concentrations exceeded the limiting terrestrial animal BCG screening levels. Refer to Chapter 7 for more information. A separate analysis of biota dose was performed for Mortandad Canyon, and the results are presented below.

a. Mortandad Canyon Biota Assessment Update. New data for Mortandad Canyon are presented in the *Mortandad Canyon Investigation Report* (LANL 2006b). The portion of Mortandad Canyon from the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) outfall to well MCO-8.2 in TA-5 fails the initial BCG screening, so a site-specific biota dose assessment is required. The methods are described in detail in McNaughton 2005.

Near the TA-50 RLWTF outfall, the concentrations of cesium-137 are higher than elsewhere in the canyon (187 pCi/g) and the canyon is narrower, while in the middle reaches (M3 and M4), the concentrations are lower (72 pCi/g) and the canyon is wider. If these concentrations of cesium-137 are averaged over the standard population area of 3 ha, the resulting population doses from cesium-137 amount to three mrad/day to both terrestrial plants and animals.

The americium-241, plutonium-239, and plutonium-238 concentrations in reach M3 are 21, 18, and 8 pCi/g, respectively. These concentrations result in a dose of about 3 mrad/day to plants and 1 mrad/day to animals.

The strontium-90 concentrations in reach E1E and further down canyon are less than 10% of the cesium-137 concentrations, so the strontium-90 biota dose is much less than 1 mrad/day to both plants and animals. The tritium concentration throughout the canyon is about 1 pCi/g, which is negligible. The uranium concentration throughout the canyon is also about 1 pCi/g, which is consistent with background. Both tritium and uranium contribute a negligible dose. Thus, the total dose from the RLWTF outfall to well MCO-8.2 in TA-5 is about 7 mrad/day to plants and 5 mrad/day to animals, which are below the DOE biota dose limits.

The previous dose estimates (LANL 2004b) of 9 mrad/day for terrestrial plants and seven mrad/day for terrestrial animals were slightly conservative. The 2004 and 2006 doses to terrestrial biota in the Mortandad Canyon watershed are similar and much less than the DOE biota-dose limits of 1,000 mrad/day to terrestrial plants and 100 mrad/day to terrestrial animals.

b. Surface Waters Biota Assessment. Unfiltered surface water samples were also collected in 2006 and analyzed for radionuclides. Specifically, samples were collected in Pueblo Canyon above Acid Canyon, lower Pueblo Canyon, DP Canyon above TA-21, DP Canyon below TA-21, Los Alamos Canyon between DP Canyon and SR-4, Los Alamos Canyon at the Rio Grande, and Mortandad Canyon below Effluent Canyon. The time-weighted sums of ratios for estimated annual average surface water concentrations of radionuclides in these major canyons were below the limiting aquatic animal and riparian animal BCGs (no greater than 43%). The primary contributor to the higher sum-of-the-ratios values was radium-226, which is probably of natural origin. Refer to Chapter 6, Table 6-2, for more information regarding specific radionuclide concentrations and associated BCG ratios.

D. NON-RADIOLOGICAL DOSE ASSESSMENT

1. Overview

We have concluded that dose to members of the public and biota from LANL radiological hazards is well understood and extensively documented. We wish to place equal emphasis on the risk to members of the public and biota from non-radiological hazards present at LANL, such as heavy metals and organic compounds.

This section assesses the potential human health risk from non-radiological materials that have been released from LANL either during 2006 or during the previous 64 years of operations at LANL. Non-radiological air pollutants are regulated by the Clean Air Act, as discussed in Chapter 2, Section 6. The applicable standards for other media are summarized in Table 5-1, Table 6-1, Table 8-1, and Appendix A. Air emissions data are reported in Chapter 2, ambient air data are reported in Chapter 4, and the data for other environmental media are reported in Chapters 5 through 8. The resulting potential public health risks are summarized below.

2. Results

a. General Considerations. The emissions from LANL and the associated off-site concentrations of non-radiological contaminants in air, water, soil, and food are well below the applicable standards or risk-based concentrations (EPA 2007, NMED 2006). Nevertheless, members of the public could potentially be exposed to hazardous materials from each of the environmental media discussed in the following sections.

i. Air (Inhalation Pathway). The assessment of the ambient air impacts of high explosives testing, reported in Chapter 4, Section D.5, indicates no adverse impacts to the public. The beryllium concentrations reported in Chapter 4, Section D.6, appear to be of natural origin, except for one sample at TA-54, Area G, which is not accessible to the public.

ii. Groundwater (Ingestion). Groundwater results are reported in Chapter 5. The only Laboratory impact on a potential drinking water supply is at well Otowi-1 in Pueblo Canyon. 2006 groundwater samples from this well have an average perchlorate concentration of 1.8 µg/L, which is less than 1/10 of EPA's Drinking Water Equivalent Level of 24.5 µg/L. However, this well is not used by Los Alamos County for its drinking water supply and therefore does not present a risk to human health.

In 2005 LANL found hexavalent chromium in Mortandad Canyon regional aquifer monitoring well samples at levels above the NM groundwater standard. Hexavalent chromium has also been found in a Sandia Canyon regional aquifer well. However, hexavalent chromium has not been found in drinking water supply wells, so at present there is no health risk from ingestion of water from these wells.

iii. Surface Water and Sediment. The concentrations of chemicals in surface water and sediment are reported in Chapter 6. No potentially hazardous chemicals were detected off site, and we conclude there is no current hazard to the public from surface water and sediment exposure.

PCBs are present in the on-site sediment, especially in the upper portion of Sandia Canyon, but there is no pathway for ingestion by humans. The usual pathway to humans is ingestion of fish, but there are no fish in Sandia Canyon. More generally, there are no aquatic organisms within the LANL boundaries that are part of a food ingestion pathway to humans.

PCBs are carried in sediment by storm water runoff to the Rio Grande. However, the PCB concentrations in fish are not measurably different upstream (e.g., Abiquiu Reservoir, Rio Grande above Otowi bridge) and downstream of LANL (e.g., Cochiti Reservoir, Rio Grande below Otowi bridge).

iv. Soil. Soil concentrations are reported in Chapter 7. A few heavy metals were detected slightly above RSRLs at offsite and perimeter locations (Sportsman's Club and Two-Mile Mesa at TA-6), but were far below their soil screening levels and, therefore, do not pose a potential human health risk. One on-site location easily accessible from off site (TA-73/SR502 [west] near the Los Alamos Fire Department station) had detected semivolatile organic compounds resulting from asphalt scattered on the ground, but the concentrations detected were below residential soil screening levels and, therefore, do not pose a potential human health risk.

v. Foodstuffs (Ingestion). The concentrations of nonradioactive materials in foodstuffs are reported in Chapter 8. The data show that there are no potentially hazardous materials from LANL detected in off-site foodstuffs, so there is no potential human health risk.

vi. Potential Future Risks. The possibility of hexavalent chromium and perchlorate entering the drinking-water supply in the future is being evaluated. Our goal is to assess both present and future risk, and the models to calculate future risks are being developed.

3. Conclusion

The environmental data collected in 2006 show that at present there is no potential public-health risk from non-radiological materials released from LANL. Further discussion of risk to the public from radiological and non-radiological materials released by the Laboratory to the environment is found in Chapter 10.

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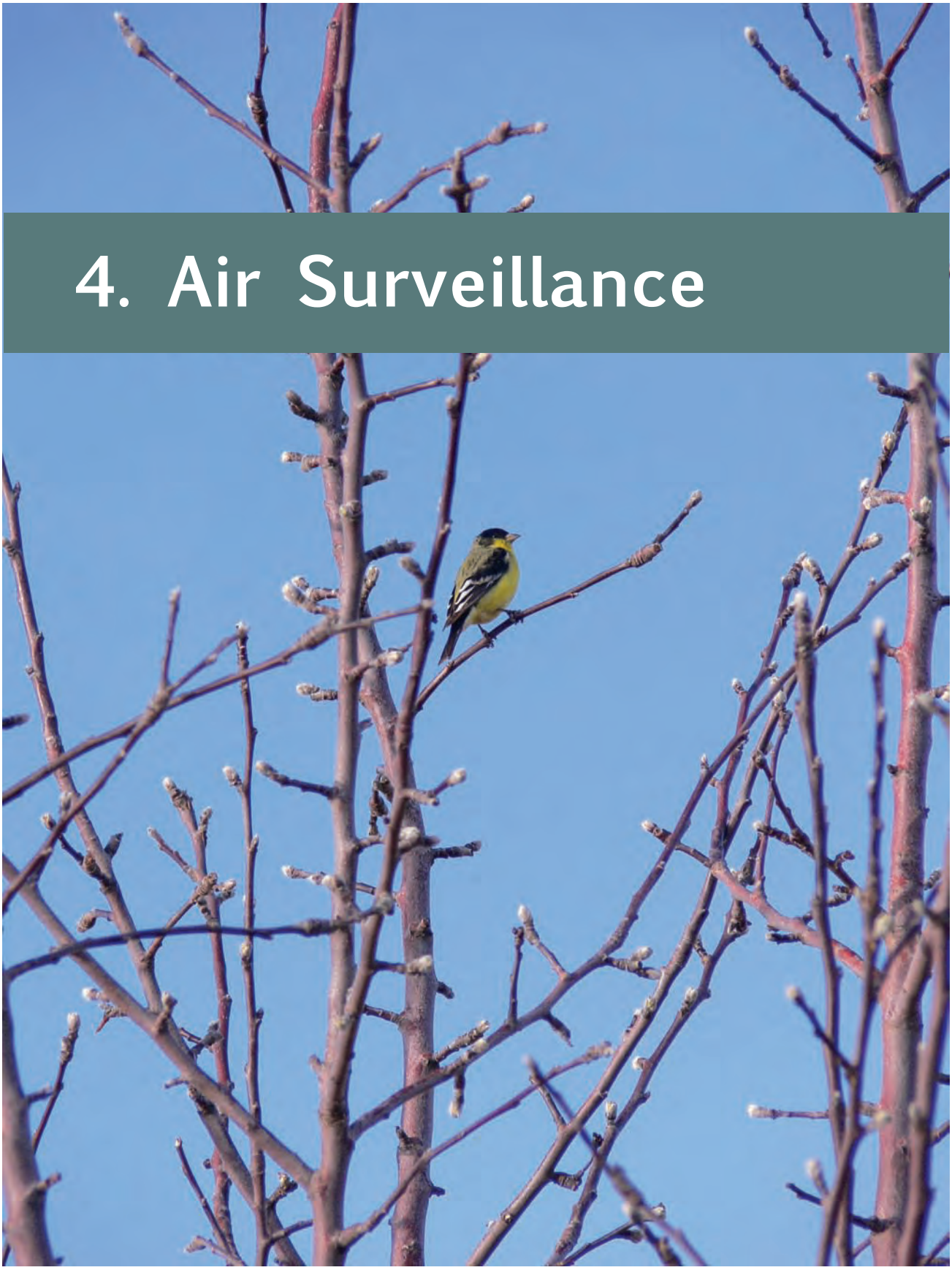
4. Air Surveillance



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A. AMBIENT AIR SAMPLING

1. Introduction

The radiological air sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides, such as plutonium, americium, uranium, tritium, and some activation products, that may be released from Los Alamos National Laboratory (LANL or the Laboratory) operations. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by LANL's air sampling program. Most of the regional airborne radioactivity comes from the following sources: (1) fallout from past atmospheric nuclear weapons tests conducted by several countries, (2) natural radioactive constituents in particulate matter, such as uranium and thorium, (3) terrestrial radon diffusion out of the earth and its subsequent decay products, and (4) material formation from interactions with cosmic radiation, such as natural tritiated water vapor produced by interactions of cosmic radiation and common atmospheric gases. Table 4-1 summarizes regional levels of radioactivity in the atmosphere for the past five years, which can be useful in interpreting current air sampling data.

Table 4-1
Average Background Concentrations of Radioactivity in the Regional[a] Atmosphere

			Annual Averages[c]				
Analyte	Units	EPA Concentration Limit[b]	2002	2003	2004	2005	2006
Alpha	fCi/m^3	NA[d]	0.8	0.8	1.1	0.9	1.0
Beta	fCi/m^3	NA	13.3	13.7	18.3	16.3	17.0
Tritium[e]	pCi/m^3	1500	-0.1	-0.1	0.1	0.1	-0.2
Pu-238	aCi/m^3	2100	0.0	-0.1	0.09	0.0	0.1
Pu-239	aCi/m^3	2000	0.3	-0.1	-0.07	0.1	0.2
Am-241	aCi/m^3	1900	0.3	-0.7	-0.47	0.1	-0.3
U-234	aCi/m^3	7700	21.7	20.9	17.4	12.4	16.6
U-235	aCi/m^3	7100	2.4	1.8	1.17	1.2	0.8
U-238	aCi/m^3	8300	21.8	20.1	17.0	13.2	16.1

[a] Data from regional air-sampling stations operated by LANL during the last 5 years (locations can vary by year).
[b] Each EPA Concentration Limit is from 10 CFR 40 and corresponds to 10 mrem/year.
[c] Gross alpha and beta annual averages are calculated from gross air concentrations. All other annual averages are calculated from net air concentrations.
[d] Not available
[e] Tritium annual averages have been corrected for the tritium lost to bound water in the silica gel.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days can increase soil entrainment, but precipitation, such as rain or snow, can wash particulate matter out of the air. Consequently, changing meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity concentrations. Forest fires can dramatically increase short-term ambient concentrations of particulate matter.

Air quality group personnel compared ambient air concentrations, as calculated from the AIRNET sample measurements, with environmental compliance standards for publicly accessible locations or with workplace exposure standards for on-site locations. We compare concentrations in areas accessible to the public with the 10-mrem annual dose equivalent concentration established by the Environmental Protection Agency (EPA) (EPA 1989). Concentrations in controlled access areas are compared with Department of Energy (DOE) Derived Air Concentrations (DACs) for workplace exposure (DOE 1988a).

2. Air Monitoring Network

During 2006, LANL operated about 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as regional, pueblo, perimeter, waste site (Technical Area [TA] 54), or other on-site locations.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures. Generally, each AIRNET sampler continuously collects particulate matter and water-vapor samples for approximately two weeks per sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates of about 0.11 m^3 per minute. These filters are analyzed for various radionuclides.

Vertically mounted canisters that contain about 135 g of silica gel, with an airflow rate of about 0.0002 m^3 per minute, are used to collect water vapor samples. We dry this silica gel in a drying oven to remove most residual water before use in the field. The gel is a desiccant that removes moisture from the sampled air. After use in the field, the gel is removed from the canister and shipped to the analytical laboratory where the moisture is distilled, condensed, and collected as a liquid. This liquid is analyzed for the presence of tritium. The AIRNET quality assurance project plan and the numerous procedures through which the plan is implemented provide details about the sample collection, sample management, chemical analysis, and data management activities.

b. Data Management. In the field, personnel recorded the sampling data on a palm-held microcomputer, including timer readings, volumetric airflow rates at the start and end of the sampling period, and comments pertaining to these data. Personnel transferred these data to an electronic table format within the AIRNET database.

c. Analytical Chemistry. A commercial laboratory analyzed each particulate-matter filter for gross alpha and gross beta activities. These filters were also grouped by region across sites, designated as "clumps," and analyzed for gamma-emitting radionuclides. Clumps usually ranged from four to nine filters. To prepare a quarterly composite for isotopic gamma analyses for each AIRNET station, half-filters from the six or seven sampling periods at each site were combined. Analysts at the laboratory dissolved these composites, separated them chemically, and then analyzed them for isotopes of americium, plutonium, and uranium using alpha spectroscopy. After a two-week collection period, water was distilled from the silica gel that had been used to collect water vapor in the field. A commercial laboratory used liquid scintillation spectrometry to analyze this distillate for tritium. All analytical procedures met the requirements of Title 40 Code of Federal Regulations (CFR) Part 61, Appendix B. The AIRNET quality assurance project plan provides a summary of the target minimum detectable activity for the biweekly and quarterly samples.

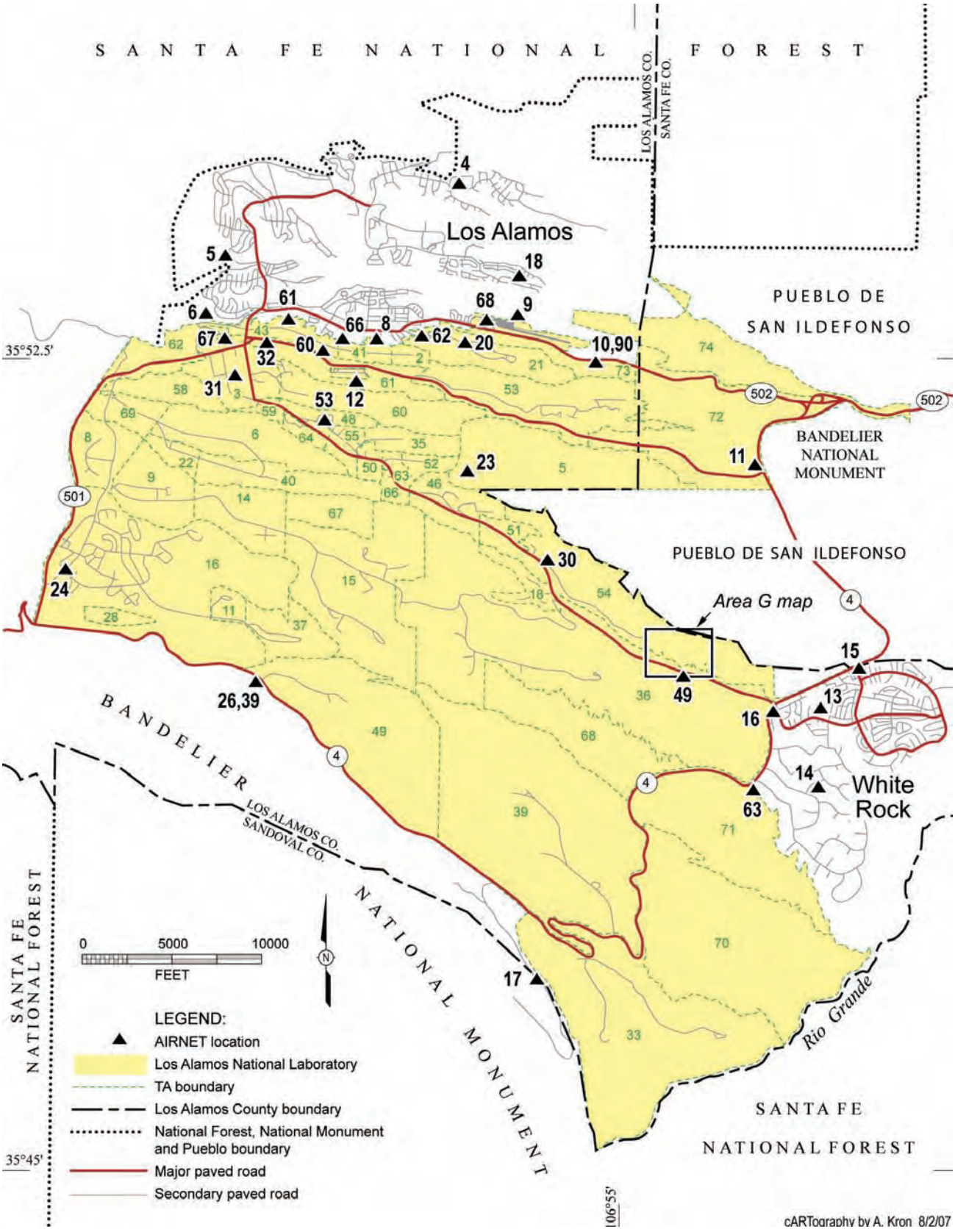

Figure 4-1. Off-site perimeter and on-site LANL AIRNET locations.

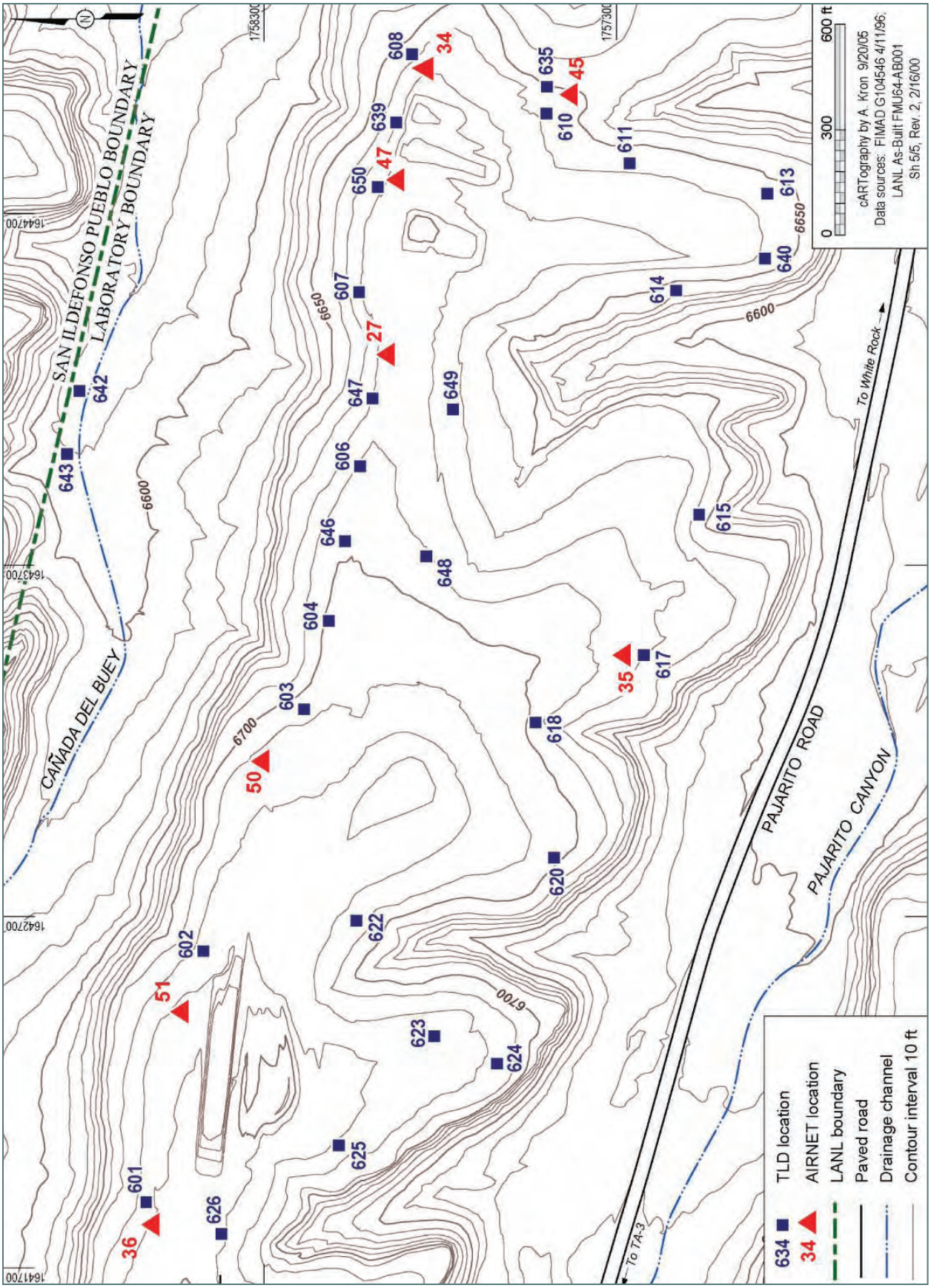

Figure 4-2. AIRNET and thermoluminescent dosimeter locations at TA-54, Area G.

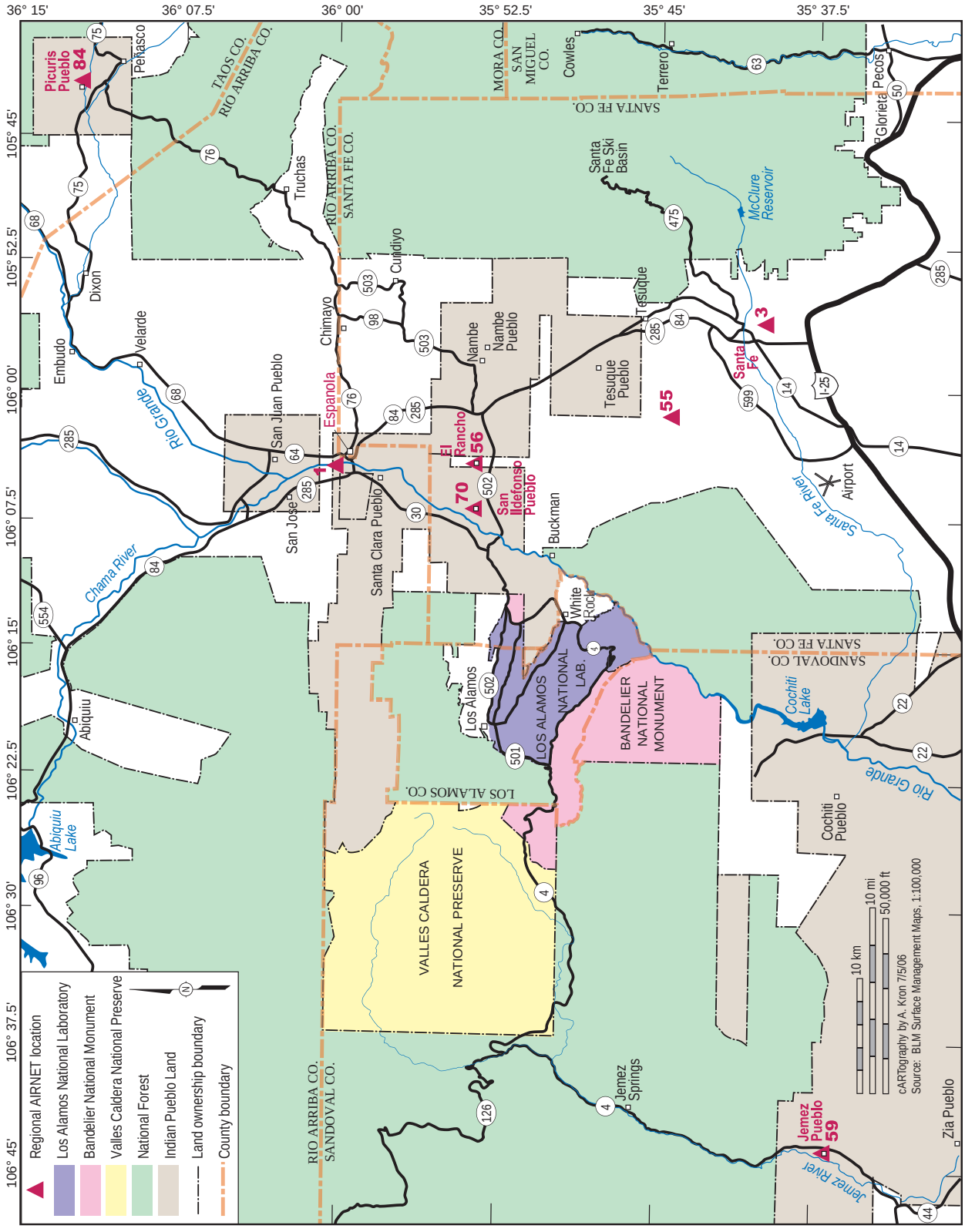

Figure 4-3. Regional and pueblo AIRNET locations.

d. Laboratory Quality Control Samples. The air sampling team and the analytical laboratories maintained a program of blank, spike, duplicate, and replicate analyses. This program provided information on the quality of the data received from analytical laboratories. These data were reviewed by technical staff to ensure the sample data met all quality assurance requirements.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations. Tables 4-2 through 4-12 summarize the 2006 ambient air concentrations calculated from the field and analytical data. In the Data Supplement, Tables S4-1 through S4-9 provide data from individual sites. The number of measurements is normally equal to the number of samples analyzed. Measurements containing measurable amounts of the material of interest are those in which the value is greater than three times the standard deviation (s = standard deviation, or sigma) of the measurement's uncertainty. The minimum detectable activities are the levels that the instrumentation could detect under ideal conditions. All AIRNET concentrations are total measurements without any type of regional background subtractions. However, the air concentrations include corrections for radioactivity from the filter material and the analytical process. The net concentrations are usually somewhat lower than the gross because small amounts of radioactivity are present in the filter material, the acids used to dissolve the filter, and the tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

Table 4-2
Airborne Long-lived Gross Alpha Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
				Mean	Interval[a]		
		>2s	>3s	(fCi/m3)	(fCi/m3)	Station	(fCi/m3)
Regional	103	103	103	1.04	±0.10	01	1.16
Pueblo	78	78	78	0.94	±0.08	70	1.00
Perimeter	668	668	668	0.86	±0.02	18	1.34
Waste Site	206	205	205	0.91	±0.08	36	1.16
n-site	166	166	166	0.82	±0.04	30	0.93

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-3
Airborne Long-lived Gross Beta Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
				Mean	Interval[a]		
		>2s	>3s	(fCi/m^3)	(fCi/m^3)	Station	(fCi/m^3)
Regional	103	103	103	17.0	±0.9	01	18.5
Pueblo	78	78	78	16.0	±0.9	70	16.8
Perimeter	668	668	668	15.5	±0.25	18	23.1
Waste Site	206	206	206	14.9	±0.5	36	15.4
On-site	166	166	166	15.0	±0.5	53	15.5

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-4
Airborne Tritium as Tritiated Water Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence Interval[a] Mean		Maximum Annual Concentration	
		>2s	>3s	(pCi/m^3)	(pCi/m^3)	Station	(pCi/m^3)
Regional[b]	102	4	0	-0.2	±0.2	03	0.1
Pueblo[b]	78	3	0	-0.1	±0.3	59	0.0
Perimeter[b]	665	231	134	3.5	±0.8	26	9.0
Waste Site[c]	204	200	195	514	±239	51	3300
On-site[c]	165	89	66	6.3	±2.5	53	11.1

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 1,500 pCi/m^3.
[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 pCi/m^3.

Table 4-5
Airborne Plutonium-238 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence Interval[a] Mean		Maximum Annual Concentration	
		>2s	>3s	(aCi/m^3)	(aCi/m^3)	Station	(aCi/m^3)
Regional[b]	15	0	0	0.1	±0.3	03	0.25
Pueblo[b]	12	0	0	-0.15	±0.2	84	0.01
Perimeter[b]	100	2	0	0.0	±0.1	44	0.6
Waste Site[c]	32	3	2	1.1	±1.3	36	3.8
On-site[c]	26	1	1	0.2	±0.3	52	0.9

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 2,100 aCi/m^3.
[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 3,000,000 aCi/m^3.

Table 4-6
Airborne Plutonium-239,240 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence Interval[a] Mean		Maximum Annual Concentration	
		>2s	>3s	(aCi/m^3)	(aCi/m^3)	Station	(aCi/m^3)
Regional[b]	14	1	0	0.2	±0.5	03	0.9
Pueblo[b]	12	2	0	0.2	±0.4	59	0.4
Perimeter[b]	100	19	7	1.8	±2.4	09	30.2
Waste Site[c]	32	16	12	190	±265	36	760
On-site[c]	26	6	6	10	±14	20	64

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 2,000 aCi/m^3.
[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3.

Table 4-7
Airborne Americium-241 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
				Mean	Interval[a]		
		>2s	>3s	(aCi/m^3)	(aCi/m^3)	Station	(aCi/m^3)
Regional[b]	15	1	0	-0.30	±0.4	56	0.01
Pueblo[b]	12	4	0	0.4	±0.4	59	0.55
Perimeter[b]	100	25	0	0.1	±0.2	14	0.9
Waste Site[c]	32	16	8	4.7	±5.7	36	21
On-site[c]	26	8	3	1.4	±1.8	20	6.2

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

[b] EPA 40 CFR Concentration Limit is 1,900 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3.

Table 4-8
Airborne Uranium-234 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
				Mean	Interval[a]		
		>2s	>3s	(aCi/m^3)	(aCi/m^3)	Station	(aCi/m^3)
Regional[b]	15	15	15	16.6	±5.1	56	21.4
Pueblo[b]	12	12	12	19.5	±9.2	59	35.3
Perimeter[b]	100	97	90	8.3	±1.7	32	29.2
Waste Site[c]	32	32	30	20.5	±10.1	51	47.7
On-site[c]	26	26	26	9.6	±3.8	20	18.7

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

[b] EPA 40 CFR Concentration Limit is 7,700 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3.

Table 4-9
Airborne Uranium-235 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
				Mean	Interval[a]		
		>2s	>3s	(aCi/m^3)	(aCi/m^3)	Station	(aCi/m^3)
Regional[b]	15	5	0	0.8	±0.7	56	1.7
Pueblo[b]	12	4	1	1.5	±1.1	59	1.6
Perimeter[b]	100	16	2	0.5	±0.2	42	1.3
Waste Site[c]	32	8	3	1.3	±0.7	51	3.9
On-site[c]	26	3	0	0.4	±0.4	49	1.2

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

[b] EPA 40 CFR Concentration Limit is 7,100 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3.

Table 4-10
Airborne Uranium-238 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
				Mean	Interval[a]		
		>2s	>3s	(aCi/m^3)	(aCi/m^3)	Station	(aCi/m^3)
Regional[b]	15	15	15	16.1	±5.0	03	19.7
Pueblo[b]	12	12	11	18.5	±7.8	59	32.0
Perimeter[b]	100	99	94	9.8	±1.6	32	31.4
Waste Site[c]	32	32	32	32.6	±30.8	51	154
On-site[c]	26	26	25	11.1	±2.6	20	15.0

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

[b] EPA 40 CFR Concentration Limit is 8,300 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3.

Table 4-11
Airborne Gamma-emitting Radionuclides Potentially Released by LANL Operations

Nuclide	Number of Biweekly Samples	Number of samples > MDA[a]	Mean Concentration (fCi/m^3)	Measured MDA as % of required MDA[b]
As-73	186	0	1.3	0.2
As-74	186	0	-0.04	0
Cd-109	186	0	-0.3	0
Co-57	186	0	0.002	0.002
Co-60	186	0	-0.009	0
Cs-134	186	0	-0.05	0
Cs-137	186	0	-0.02	0
Mn-54	186	0	-0.01	0
Na-22	186	0	0.02	1.4
Rb-83	186	0	-0.02	0
Ru-103	186	0	-0.007	0
Se-75	186	0	0.002	0.03
Zn-65	186	0	-0.05	0

[a] Minimum detectable activity.

[b] Required MDA is set so 0.5 mrem annual dose can be measured.

Table 4-12
Airborne Concentrations of Gamma-emitting Radionuclides that Occur Naturally in Measurable Quantities

Nuclide	Number of Biweekly Samples	Number of samples > MDA[a]	Mean[b] Concentration (fCi/m^3)
Be-7	186	185	86
Pb-210	186	0	32

[a] Minimum detectable activity.

[b] Measurements less than the MDA are not included in the average.

All data in this AIRNET section, whether in the tables or the text, that are expressed as a value plus or minus (±) another value represent a 95% confidence interval. Because these confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurement and analytical errors but also seasonal and spatial variations. As such, the calculated 95% confidence intervals are overestimated for the average concentrations and probably represent confidence intervals that approach 100%. All ambient concentrations are activity concentrations per cubic meter of sampled air. Some values in the tables are negative. See Appendix B for an explanation of negative values.

Air concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. Other multiples of uncertainties could be used, but 3s is consistent with the widely accepted practice of using 3s control limits for statistical quality control charts (Duncan 1986, Gilbert 1987). It also eliminates most of the false positives or detections that occur about 5% of the time at 2s, but less than 0.3% of the time at 3s.

b. Gross Alpha and Gross Beta Radioactivity. We use gross alpha and gross beta analyses primarily to (1) evaluate general radiological air quality, (2) identify potential trends, and (3) detect sampling problems. If the gross analytical results appear to be elevated, then analyses for specific radionuclides may be performed to investigate a potential problem, such as an unplanned release.

The National Council on Radiation Protection and Measurements (NCRP) estimated the national average concentration of long-lived gross alpha activity in air to be two femtocuries (fCi)/m^3. Polonium-210, a decay product of radon, and other naturally occurring radionuclides are the primary sources of alpha activity (NCRP 1975, NCRP 1987). The NCRP also estimated national average concentration levels of long-lived gross beta activity in air to be 20 fCi/m^3. The presence of lead-210 and bismuth-210, also decay products of radon, and other naturally occurring radionuclides are the primary sources of this activity.

In 2006, we collected and analyzed approximately 1,200 air samples for gross alpha and gross beta activity. The annual mean for all of the stations is about half of the NCRP's estimated average for gross alpha concentrations (Table 4-2). At least two factors contribute to these lower concentrations: (1) the use of actual sampled air volumes instead of standard temperature and pressure volumes and (2) the burial of alpha emitters in the filter that are not measured by front-face counting. Gross alpha activity is dependent on variations in natural conditions, such as atmospheric pressure, atmospheric mixing, temperature, and soil moisture.

Table 4-3 shows gross beta concentrations within and around LANL. These data show variability similar to the gross alpha concentrations. The annual average is below the NCRP-estimated national average, but the gross beta measurements include little if any lead-210 because of its low-energy beta emission. We calculate the gross beta measurements on the actual sampled air volumes instead of standard temperature and pressure volumes. The primary source of measured gross beta activity in particulate matter is the bismuth-210 in the radon-222 decay chain.

Figures 4-4 and 4-5 show the temporal variability of gross alpha and beta activities in air, respectively. Variability among sites within AIRNET is usually much less than variability over time. For example, in winter, at lower elevations around LANL, the radon may be trapped below an inversion layer, resulting in higher levels of radon near the ground and therefore higher gross alpha and beta count rates.

c. Tritium. Tritium is present in the environment primarily as the result of nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure the tritium in water (HTO or tritiated water) because the dose impact is about 14,000 times higher than if it were hydrogen gas (HT or tritium) (DOE 1988b).

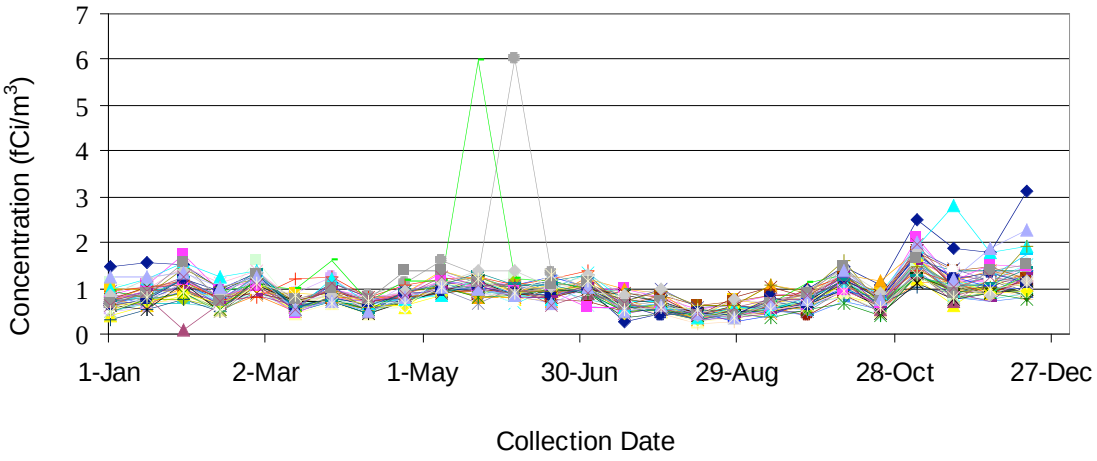

Figure 4-4. Gross alpha measurements (fCi/m³) for all sampling sites by date collected in 2006.

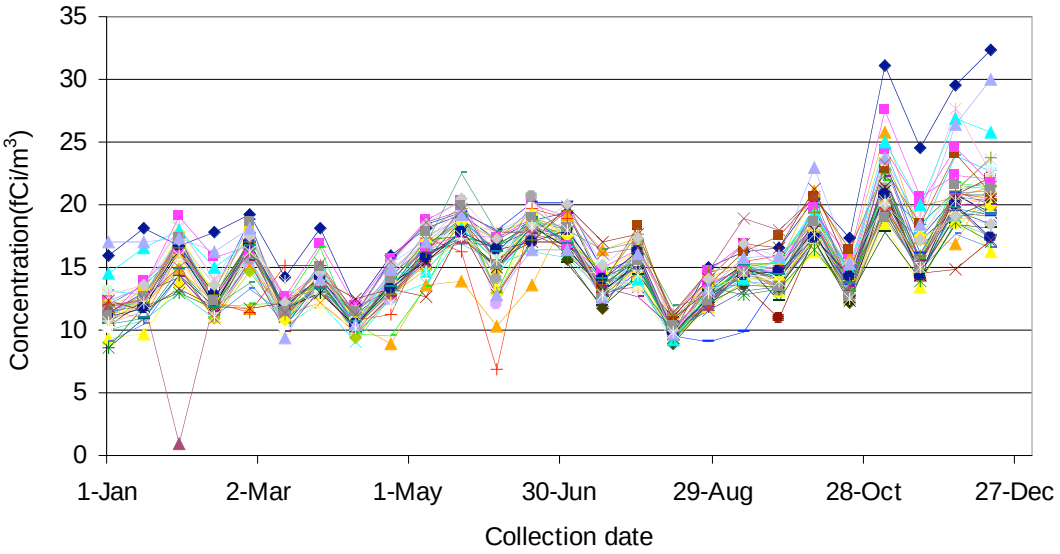

Figure 4-5. Gross beta measurements (fCi/m³) for all sampling sites by date collected in 2006.

Water-vapor concentrations in the air and tritium concentrations in the water vapor were used to calculate ambient levels of tritium. Corrections for blanks, bound water in the silica gel, and isotopic distillation effects are included in this calculation.

The annual concentrations of tritium for 2006 at the regional and pueblo stations were not significantly greater than zero (Table 4-4). The average concentration of tritium for the perimeter samplers was significantly greater than zero, as were the average concentrations for the on-site groups. The highest concentrations were measured at the TA-54 waste site in Area G. A source of elevated tritium levels at Area G was identified and moved to the tritium shafts at Area G. This waste came from decontamination and decommissioning work at TA-21. Concentrations at Area G during 2006 are not expected to continue at the same elevated levels. All annual mean concentrations at all sampling stations were well below the applicable EPA and DOE guidelines.

Figure 4-6 shows the measured stack emissions at TA-21 and also maximum and average off-site AIRNET measurements in nearby and generally downwind (east) Los Alamos. Emissions from stacks at TA-21 were stopped permanently in September 2006 as one of the TA-21 shutdown activities. The peak tritium concentrations were due to planned operational releases.

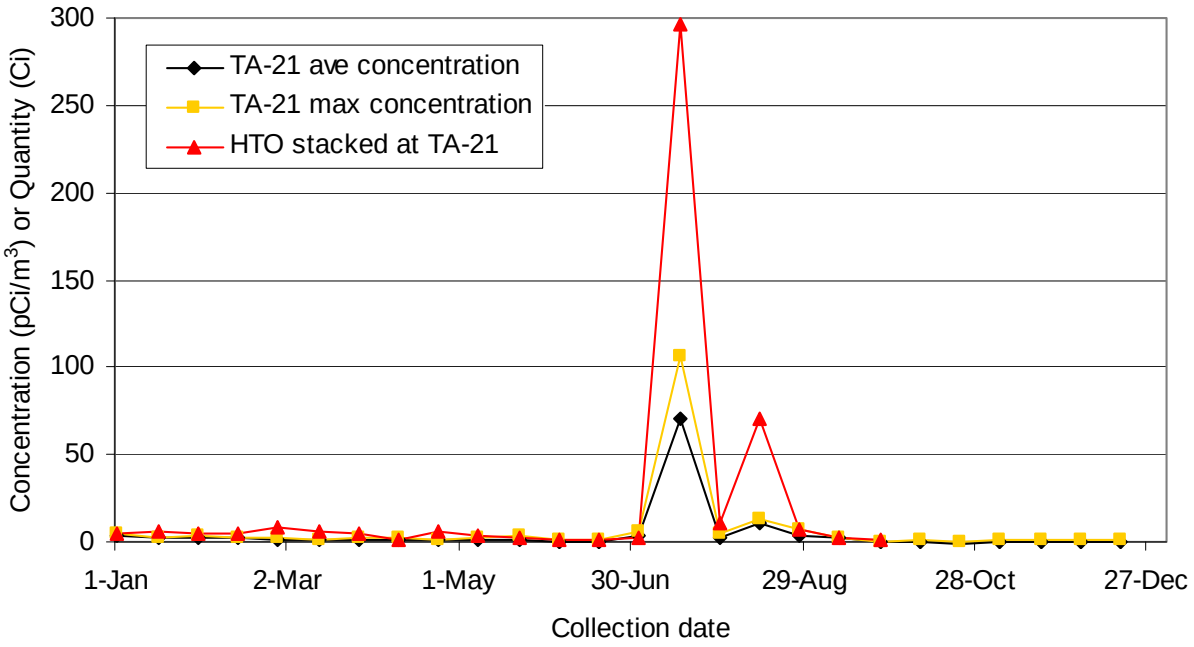

Figure 4-6. Tritium oxide stack emissions at TA-21 and ambient concentrations in east Los Alamos in 2006.

The highest off-site annual tritium concentration in 2006, 9 picocuries (pCi)/m^3 at station 26, is equivalent to about 0.6% of the EPA public dose limit of 1,500 pCi/m^3. Emissions from TA-16 seldom caused concentrations to exceed investigation levels as described in section A.5 of this chapter. (Investigation levels are set at values of five-year averages plus 3s.) We measured elevated tritium concentrations at a number of on-site stations, with the highest annual concentration (3300 pCi/m^3) at TA-54, Area G. This annual mean concentration is only about 0.016% of the DOE DAC for worker exposure of 20,000,000 pCi/m^3 and is measured at a location near a pit containing tritium-contaminated waste.

d. Plutonium. While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), this element is not naturally present in measurable quantities in the ambient air. All measurable sources in air are from plutonium research and development activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, worldwide fallout from atmospheric testing of nuclear explosives is the primary source of plutonium in ambient air.

Table 4-5 summarizes the plutonium-238 data for 2006. Three occurrences of plutonium-238 greater than 3s were measured. All were on site; the two highest were at Area G. The highest quarterly concentration was 15.5 aCi/m^3.

No detectable concentrations of plutonium-239,240 greater than 3s were found at any of the regional or pueblo samplers (Table 4-6). Seven perimeter quarterly concentrations were above their 3s uncertainties, four of which were collected at station 66 (Los Alamos Inn-South). The annual mean concentration at this location was 12 aCi/m^3, or about 1% of the EPA public dose limit. These higher ambient concentrations are

from historical activities at LANL's old main Technical Area (TA-1) that deposited plutonium on the hillside below the Los Alamos Inn. Two other perimeter concentrations above 3s were measured, at stations 9 and 68 near the Los Alamos Airport, and are due to remediation work at TA-21 and TA-73. The annual mean concentrations for these two stations were 30 and 1.3 aCi/m^3, respectively.

The on-site station at TA-21 (station 20) exceeded 3s for its quarterly concentrations for three quarters—also due to the work at TA-21. Finally, 12 quarterly concentrations at Area G exceeded 3s. All on-site and waste site concentrations were below 0.2% of the DOE DAC for workplace exposure.

e. Americium-241. As with plutonium isotopes, americium is present in very low concentrations in the environment. No detected concentrations of americium-241 were measured off-site or at the perimeter. Table 4-7 summarizes the americium-241 data. Eleven on-site quarterly samples with a concentration of americium-241 greater than 3s were measured. Most were at Area G; two were at TA-21. The highest quarterly off-site and on-site concentrations were less than 0.2% and 0.001% of public and worker limits, respectively.

f. Uranium. Three isotopes of uranium are normally found in nature: uranium-234, uranium-235, and uranium-238. In natural uranium, relative isotopic abundances are constant and well characterized. Uranium-238 and uranium-234 are essentially in radioactive equilibrium, with a measured uranium-238 to uranium-234 isotopic activity ratio of 0.993 (Walker et al., 1989). Comparisons of isotopic concentrations are used to estimate LANL contributions because known LANL emissions in the past 50 years are not of natural uranium, but enriched (EU—enriched in uranium-234 and -235) or depleted (DU—depleted of uranium-234 and -235).

All annual mean concentrations of the three uranium isotopes were below 1% of the applicable EPA and DOE guidelines (Tables 4-8 through 4-10). The highest annual uranium concentrations were at locations with high dust levels from local soil disturbances, such as dirt roads at the Los Alamos County Landfill and LANL's TA-54, Area G. The regional and pueblo groupings had higher average concentrations of uranium isotopes than the perimeter group because of increased particulate matter concentrations associated with unpaved roads, unpaved parking lots, and other soil disturbances, such as construction activities and grazing, but not any known man-made sources of uranium.

During 2006, there were two detections of DU (stations 51 and 60), as shown in Figure 4-7. Firing sites use DU in tests and so there is DU dust at the Laboratory in places. Excess uranium-238 concentrations were identified by statistically comparing the uranium-234 and uranium-238 concentrations. If the concentrations in a sample were more than 3s apart, the sample was considered to have significant concentrations of EU or DU (see Section A.6). We measured one instance of EU during 2006 (station 9) near the remediation work at TA-21. EU remaining from Manhattan era work is expected in this area.



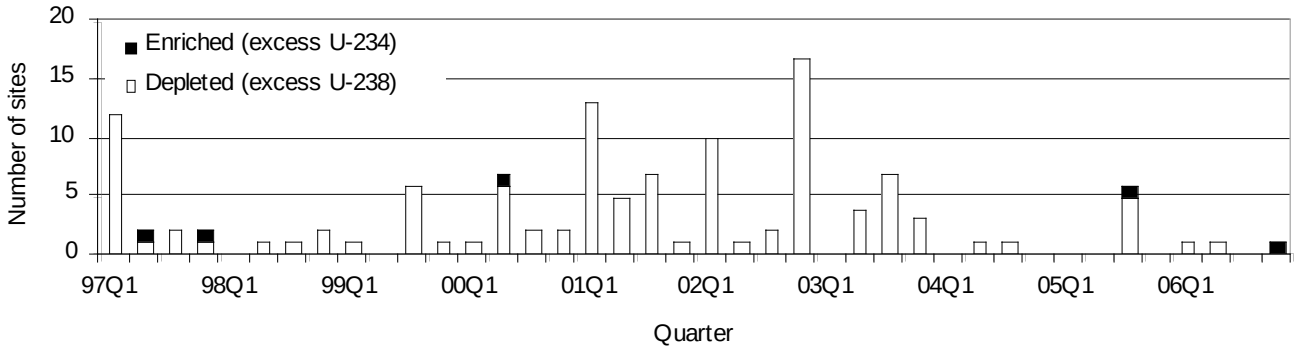

Figure 4-7. Number of sites where enriched or depleted uranium has been detected from 1997 through 2006.

g. Gamma Spectroscopy Measurements. In 2006, the air sampling team requested gamma spectroscopy measurements (Tables 4-11 and 4-12) on biweekly filters grouped across sites for a single sampling period, which are identified as "clumps." Our practice is to investigate the measurement of any analyte concentration (listed in Table 4-11) above its MDA. We do not investigate detected quantities of beryllium-7, potassium-40, and lead-210, which are natural radionuclides normally present in measurable concentrations. In 2006, beryllium-7 was routinely detected.

5. Investigation of Elevated Air Concentrations

Two action levels have been established to determine the potential occurrence of an unplanned release: "investigation" and "alert." Investigation action levels are based on historical measurements and are designed to indicate that an air concentration is higher than expected. These levels are set at values equal to a five-year rolling average plus 3s. Alert action levels are based on allowable EPA and DOE annual doses and require a more thorough, immediate follow-up.

When a measured air concentration exceeds an action level, the air quality group verifies that the calculations were done correctly and that the sampled air concentrations are representative, i.e., that no cross contamination has taken place. Next, we work with personnel from the appropriate operations to assess potential sources and possible mitigation for the elevated concentrations.

In 2006, air sampling values exceeded alert action levels on-site only. In the second quarter, the alert action levels were exceeded for plutonium-239 at two stations at Area G due to unexpected airborne releases during routine operations involving the receipt of waste from TA-21 cleanup.

Tritium alert levels were also exceeded at Area G near a pit which contained tritium-contaminated waste. Starting in May, tritium concentrations increased and peaked in the hottest months then decreased steadily towards the end of the year. This waste was subsequently moved to a shaft containing other tritium-contaminated waste.

An unexpected plutonium-239 concentration was attributed to the El Rancho station in the fourth quarter of 2006. We initiated a further investigation: a re-analysis of samples from the same time periods at the same location, as well as a suite of swipes taken on the AIRNET housing. All negative results confirm that there was no plutonium contamination at this site. The original values were rejected.

6. Long-Term Trends

a. Uranium. Even though the annual and quarterly concentrations of uranium isotopes vary, peak concentrations for all three isotopes occur during the windier second quarter of each year (Figure 4-8). For years, the uranium-238 concentrations have been consistently higher than the uranium-234 concentrations.

The samples with DU or EU were all collected on Laboratory property or within Los Alamos County. This year, one EU and two DU detections were made. Off-site concentrations of DU are comparable to, or less than, historical natural uranium concentrations. A notable increase was observed in the three years following the 2000 Cerro Grande fire when compared to the three years before (Figure 4-8). It seems the lower levels of the years prior to the fire are again the norm.

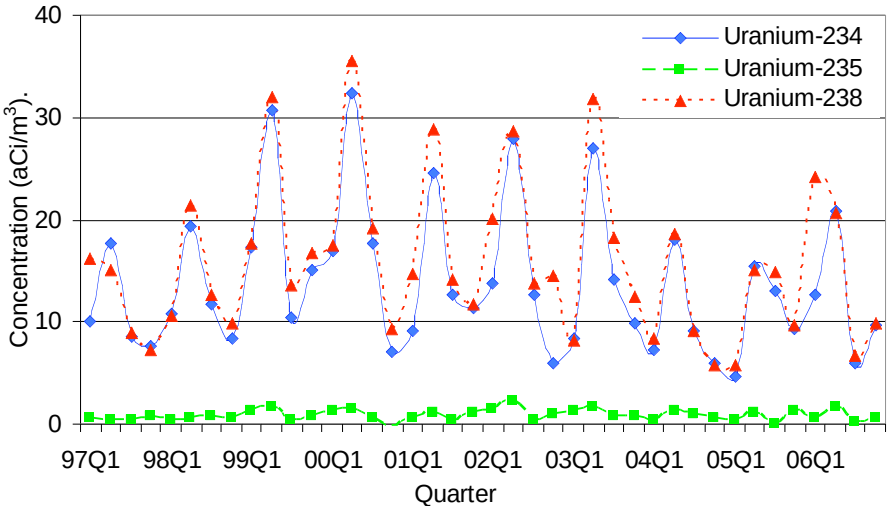

Figure 4-8. AIRNET quarterly uranium concentrations (network-wide excluding site at TA-36).



b. Plutonium and Americium. Only two quarterly measurements during the last 10 years for the regional and pueblo samples were above their 3s analytical uncertainties. However, on-site measurements of plutonium-238, plutonium-239, and americium-241 are clearly higher for the sampling stations at TA-21 and TA-54, where about one-quarter of the measurements are detected concentrations of these radionuclides. Perimeter samplers are somewhere in between, with occasional samples having detected concentrations. Figures 4-9, 4-10, and 4-11 are graphs of the annual concentrations by isotope and station location grouping. The increased concentration at the waste site (TA-54) this year is due to resuspension during operations involving the transfer of cleanup waste from TA-21 to Area G during the second quarter. The remediation activities at TA-21 are the cause for the increase in the on-site americium-241 and plutonium-239 annual averages.

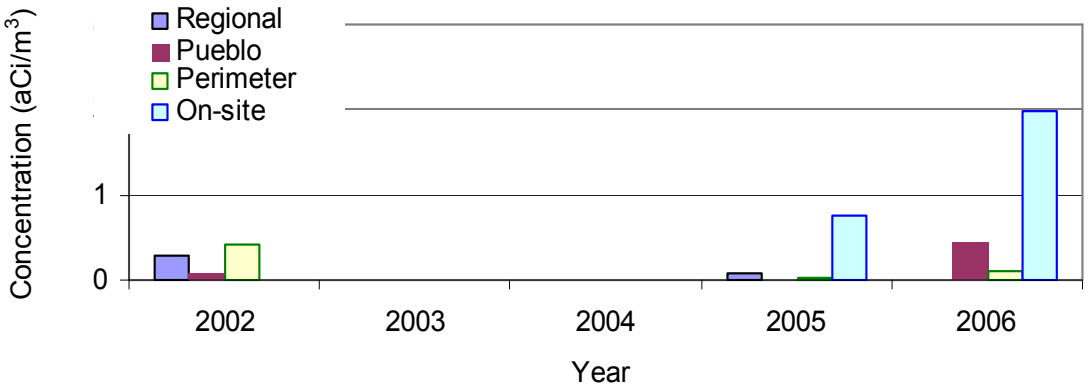

Figure 4-9. Am-241 concentration trends.

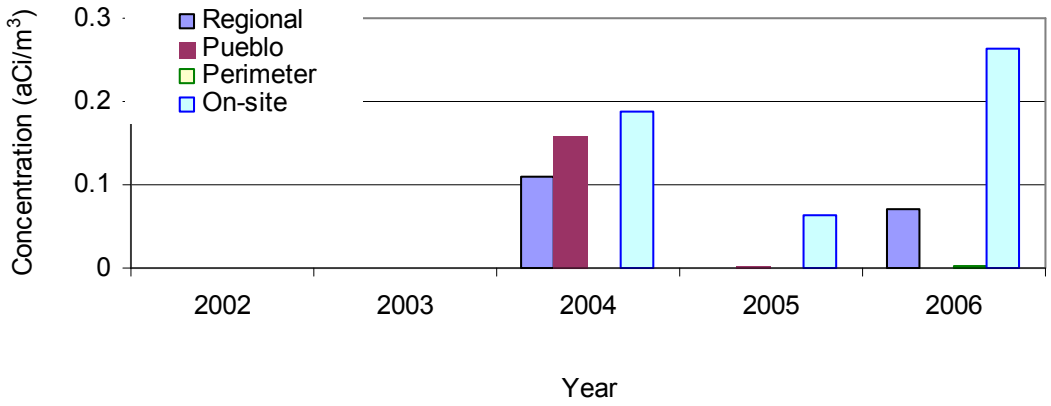

Figure 4-10. Pu-238 concentration trends.

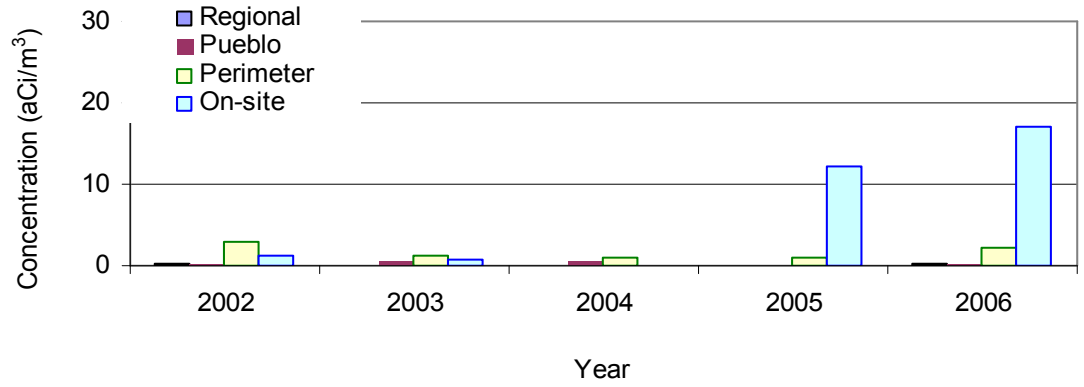

Figure 4-11. Pu-239,240 concentration trends.

Annual average concentrations of plutonium-239 and americium-241 are above zero for the TA-54, Area G, sampling stations. Concentrations at the TA-54 samplers have been low for several years, except for the soil-screening operation in 2002 (Figure 4-12) (ESP 2002) and this year's elevated plutonium-239 values. The average concentrations for the other sample location groupings vary but remain near zero, with occasional samples and/or locations having detected concentrations.

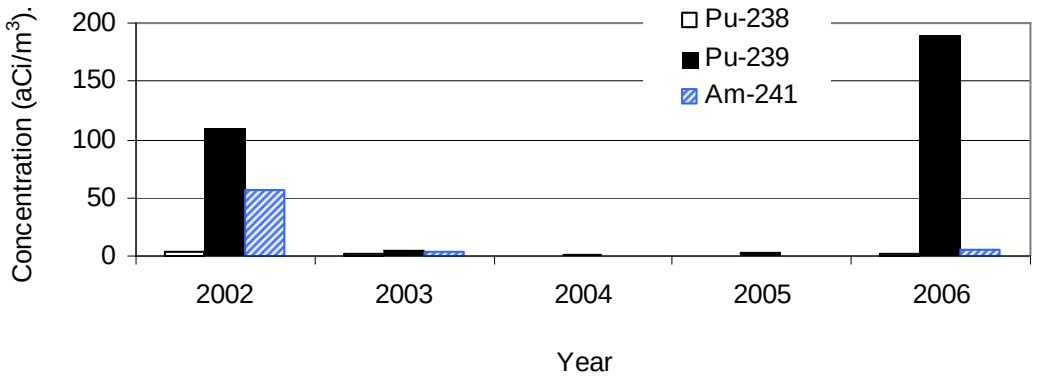

Figure 4-12. Americium and plutonium concentration trends for TA-54, Area G.

c. Tritium. Unlike other radionuclides, tritium concentrations are strongly influenced by current operations so emissions show no distinctive trends. The trend in concentrations at Area G has been down over the last five years (Figure 4-13). However, in 2006 tritiated waste near a few samplers raised the annual average. This waste has subsequently been relocated elsewhere at Area G: lower releases and doses are anticipated in the future. With the closure of two stacks at TA-21 this year, we see lower ambient tritium values nearby.

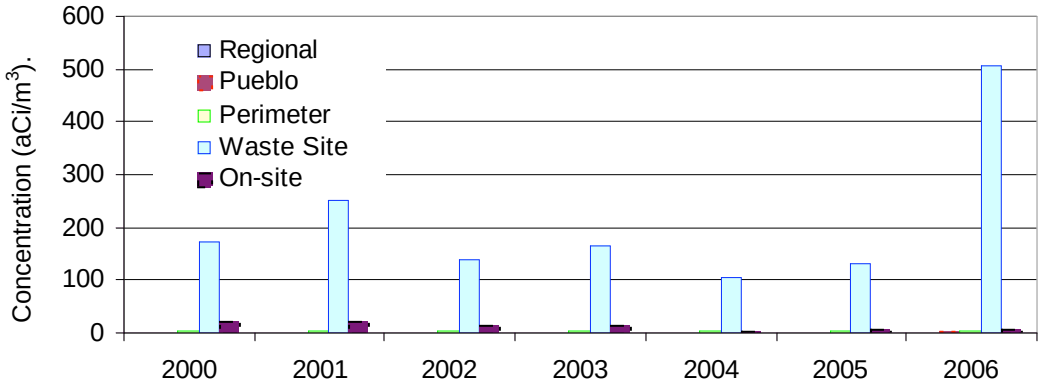

Figure 4-13. Tritium concentration trends.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may vent to the environment through a stack or other forced air release point. Members of the Rad-NESHAP team at LANL evaluate these operations to determine impacts on the public and the environment. If this evaluation shows that emissions from a stack may potentially result in a member of the public

receiving as much as 0.1 mrem in a year, LANL must sample the stack in accordance with Title 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (Rad-NESHAP) (EPA 1989). During 2006, we identified 28 stacks meeting this criterion. Where sampling is not required, emissions are estimated using engineering calculations and radionuclide materials usage information.

2. Sampling Methodology

In 2006, we continuously sampled 28 stacks for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP). For each of these emission types, LANL employs an appropriate sampling method, as described below.

Emissions of radioactive particulate matter generated by operations at facilities such as the Chemistry and Metallurgy Research Building and the TA-55 Plutonium Facility are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. These samples are collected weekly and shipped to an off-site analysis laboratory. This laboratory uses gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, the laboratory composites these samples and analyzes them to determine the cumulative activity on all the filters of radionuclides such as uranium-234, -235, and-238, plutonium-238 and -239,240 and americium-241. These isotopic data are then used to calculate emissions from each stack for the six-month period.

A charcoal cartridge samples emissions of vapors, such as bromine-82, and highly volatile compounds, such as selenium-75, generated by operations at the Los Alamos Neutron Science Center (LANSCE) and hot cell activities at the Chemistry and Metallurgy Research Building and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. This charcoal filter is mounted downstream of a glass-fiber filter (discussed above) that removes any particulates from this sample media. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the filter.

We measure tritium emissions from LANL's tritium facilities with a collection device known as a bubbler. This device enables us to determine not only the total amount of tritium released but also whether it is in the elemental (HT) or oxide (HTO) form. The bubbler pulls a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). "Bubbling" through these three vials removes essentially all HTO from the air, leaving only elemental tritium. The air is then passed through a palladium catalyst that converts the elemental tritium to HTO. The sample is then pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. Liquid scintillation counting determines the amount of HTO and HT by analyzing the ethylene glycol for the presence of tritium.

In previous years, stacks at LANSCE were monitored for tritium. After an historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling tritium following the July 2001 report period based on the low historical emissions of HTO from TA-53 and the low relative contribution of tritium to the off-site dose from TA-53 emissions. Emissions of tritium reported in 2006 from LANSCE are based on 2001 tritium generation rates.

We measure GMAP emissions from LANSCE activities using real-time monitoring data. A sample of stack air is pulled through an ionization chamber that measures the total amount of radioactivity in the sample. Gamma spectroscopy and decay curves are used to identify specific radioisotopes and the quantity of each. From these data, the total emissions of each radionuclide are calculated.

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis. Analytical methods used comply with EPA requirements (40 CFR 61, Appendix B, Method 114). See Section F in this chapter for the results of analytical quality assurance measurements. General discussions on the sampling and analysis methods for each of LANL's emissions follow.

b. Particulate Matter Emissions. We removed and replaced the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions weekly and shipped them to an off-site analytical laboratory. Prior to shipping, each sample was screened with a hand-held instrument to determine if there were any unusually high levels of alpha or beta radioactivity. The laboratory performed analyses for the presence of alpha and beta radioactivity after the sample had been allowed to decay for approximately one week (to allow short-lived radon progeny to decay). In addition to alpha and beta analyses, the laboratory performed gamma spectroscopy analysis to identify specific isotopes in the sample.

The glass-fiber filters were composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We used the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compared the results of the isotopic analysis with gross activity measurements to ensure that the requested analyses (e.g., uranium-234, -235, and -238; and plutonium-238 and -239,240, etc.) identified all significant activity in the composites.

For particulate filters from the LANSCE accelerator facility, the analytical laboratory only performs gamma spectroscopy analyses based on the anticipated suite of emissions from this facility. Again, hand-screening is performed the day of change-out prior to shipment to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions. We removed and replaced the charcoal canisters installed at facilities with the potential for significant vaporous activation products emissions weekly, and then shipped the samples to the off-site analytical laboratory, where gamma spectroscopy identified and quantified the presence of vaporous radioactive isotopes.

d. Tritium Emissions. Tritium bubbler samples, used to sample facilities with the potential for significant elemental and oxide tritium emissions, were collected and transported to LANL's Health Physics Analytical Laboratory on a weekly basis. The Health Physics Analytical Laboratory added an aliquot of each sample to a liquid scintillation cocktail and determined the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions. Continuous monitoring was used, rather than off-line analysis, to record and report GMAP emissions for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-line. The GMAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total GMAP emissions were measured with the ionization chamber. The real-time current this ionization chamber measured was recorded on a strip chart, and the total amount of charge collected in the chamber over the entire beam operating cycle was integrated on a daily basis. The gamma spectroscopy system analyzed the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determined the relative composition of the emissions. Decay curves were typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes were made at LANSCE, new decay curves and energy spectra were recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2006 totaled approximately 1,290 Ci. Of this total, tritium emissions comprised approximately 893 Ci, and air activation products from LANSCE stacks contributed nearly 398 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium, were less than 0.00002 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 2.3 Ci, which is about a 100-fold increase from 2005. Increased hot cell activities at TA-48 accounted for the increase, though this amount has a very small dose impact.

Table 4-13
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2006 (Ci)

TA-Bldg	H-3[a]	Am-241	Pu[b]	U[c]	Th[d]	P/VAP[e]	GMAP[f]	Sr-90[g]
TA-03-029		1.44E-07	1.21E-06	1.70E-05	1.20E-06	1.31E-04		2.91E-08
TA-03-102			3.01E-10	1.76E-09				
TA-16-205	3.40E+02							
TA-21-155	5.68E+01							
TA-21-209	4.48E+02							
TA-48-001						2.31E+00		
TA-50-069		2.61E-10	2.37E-09					
TA-53-003	2.74E+00						8.02E+00	
TA-53-007	5.93E+00					9.91E-03	5.47E+02	
TA-55-004	4.02E+01			2.61E-08	9.33E-09			8.88E-09
Total[h]	8.93E+02	1.44E-07	1.21E-06	1.70E-05	1.21E-06	2.32E+00	5.55E+02[l]	3.80E-08

NOTE: Some buildings have more than one sampled stack.
[a] Includes both gaseous and oxide forms of tritium.
[b] Includes Pu-238, Pu-239, and Pu-240.
[c] Includes U-234, U-235, and U-238. Does NOT include radioactive progeny of U-238.
[d] Includes Th-228, Th-230, and Th-232.
[e] P/VAP–Particulate/vapor activation products (with measured radionuclides and short-lived radioactive progeny).
[f] GMAP–Gaseous mixed activation products.
[g] Strontium-90 values include yttrium-90 short-lived radioactive progeny.
[h] Some differences may occur because of rounding.
[l] Total for GMAP includes 314 curies released from diffuse sources at TA-53.

Table 4-13 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-14 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-15 presents the half-lives of the radionuclides typically emitted by LANL operations. During 2006, the LANSCE facility (TA-53) non-point source emissions of activated air comprised approximately 530 Ci of carbon-11 and 22 Ci of argon-41.

Table 4-14
Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2006 (Ci)

TA-Building	Nuclide	Emission
TA-48-0001	As-73	7.86E-07
TA-48-0001	Br-76	4.79E-04
TA-48-0001	Br-77	1.44E-04
TA-48-0001	Br-82	4.43E-06
TA-48-0001	Ga-68	3.75E-03
TA-48-0001	Ge-68	3.75E-03
TA-48-0001	Kr-79	2.3E+00
TA-48-0001	Se-75	1.2E-05
TA-48-0001	V-48	1.17E-08
TA-53-0003	C-11	8.02E+00
TA-53-0007	Ar-41	1.42E+01
TA-53-0007	As-73	4.07E-05
TA-53-0007	Be-7	9.19E-07
TA-53-0007	Br-76	2.32E-03
TA-53-0007	Br-77	2.99E-04
TA-53-0007	Br-82	2.81E-03
TA-53-0007	C-10	1.72E-01
TA-53-0007	C-11	1.84E+02
TA-53-0007	Hg-197	4.36E-03
TA-53-0007	Hg-197m	4.36E-03
TA-53-0007	N-13	1.37E+01
TA-53-0007	Na-24	1.14E-06
TA-53-0007	O-14	3.53E+01
TA-53-0007	O-15	2.01E+01
TA-53-0007	Os-191	5.29E-05
TA-53-0007	Se-75	2.49E-05

Table 4-15
Radionuclide Half-Lives

Nuclide	Half-Life
H-3	12.3 yr
Be-7	53.4 d
C-10	19.3 s
C-11	20.5 min
N-13	10.0 min
N-16	7.13 s
O-14	70.6 s
O-15	122.2 s
Na-22	2.6 yr
Na-24	14.96 h
P-32	14.3 d
K-40	1,277,000,000 yr
Ar-41	1.83 h
Mn-54	312.7 d
Co-56	78.8 d
Co-57	270.9 d
Co-58	70.8 d
Co-60	5.3 yr
As-72	26 h
As-73	80.3 d
As-74	17.78 d
Br-76	16 h
Br-77	2.4 d
Br-82	1.47 d
Se-75	119.8 d
Sr-85	64.8 d
Sr-89	50.6 d
Sr-90	28.6 yr
I-131	8 d
Cs-134	2.06 yr
Cs-137	30.2 yr
Os-183	13 h
Os-185	93.6 d
Os-191	15.4 d
Hg-193	3.8 h
Hg-195	9.5 h
Hg-195m	1.67 d
Hg-197	2.67 d
Hg-197m	23.8 h
U-234	244,500 yr
U-235	703,800,000 yr
U-238	4,468,000,000 yr
Pu-238	87.7 yr
Pu-239	24,131 yr
Pu-240	6,569 yr
Pu-241	14.4 yr
Am-241	432 yr

5. Long-Term Trends

Figures 4-14 through 4-17 present radioactive emissions from sampled LANL stacks. These figures illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady since 2000, varying slightly each year but staying in the low-microcurie range. Tritium emissions showed a slight increase in 2006 due to ongoing source removal activities at two tritium facilities at TA-21. In 2006, emissions of GMAP returned to a low level, following a one-year elevation in 2005 described below.

Site-wide tritium emissions are staying low due to the consolidation of most tritium operations at TA-16. In 2006, source removal activities were completed at TA-21-155 and TA-21-209. Continued emissions from these facilities result from off-gassing of contaminated equipment remaining in the building. Following removal of the majority of the tritium source term, monitoring continued until we had a clear grasp of the emissions potential from these two stacks. At the end of September 2006, monitoring activities at these two stacks ceased. Until these stacks are fully decommissioned and torn down, future emissions from these stacks will be reported as part of LANL's non-monitored source program. These future emissions will be calculated based on emissions rates measured in the summer and early fall of 2006.

In 2006, LANSCE operated in the same configuration as 2002–2005, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center, causing the majority of radioactive air emissions. Operations to the 1L Target took place from April through December.

The emissions control system at the LANSCE 1L Target is a "delay line," which retains the short-lived activation products for a short time before release out the stack. This time interval allows decay of the short-lived radionuclides to non-radioactive components. A cracked valve in the inlet of this delay system caused greatly elevated emissions in 2005, relative to previous years. Additional delay line sections were installed in May and November of 2005 and the defective valve was fixed in late 2005. The additional delay line contributed to the relatively low emissions in 2006. In all years, emissions were below all regulatory limits. Figure 4-18 shows the individual contribution of each of these emission types to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. Bear in mind that this plot does not directly relate to off-site dose because some radionuclides have a higher dose impact per curie released than others. GMAP and tritium remain the highest contributors to the total curies released. These gas-phase nuclides are not easily removed from an exhaust stack air stream by standard control techniques, such as filtration. GMAP and tritium emissions continue to fluctuate as the major emissions type; tritium cleanup operations and LANSCE operations vary from year to year. GMAP emissions are normally the greatest source of off-site dose from the airborne pathway because of the close proximity of the LANSCE facility to the LANL site boundary.

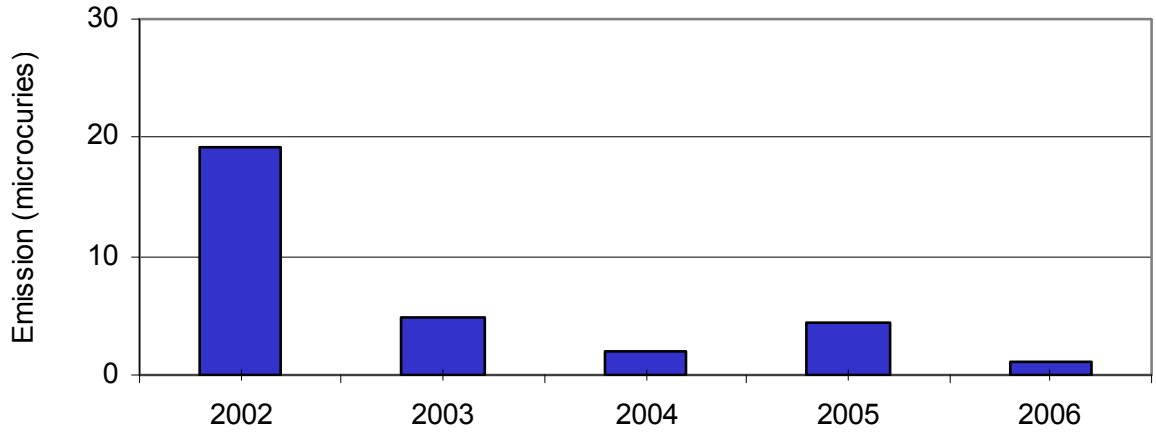

Figure 4-14. Plutonium emissions from sampled LANL stacks.

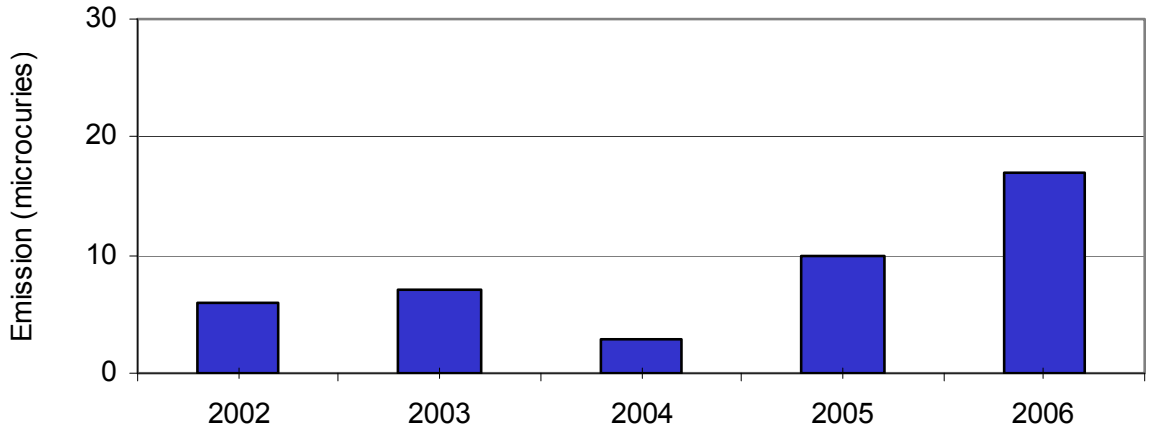

Figure 4-15. Uranium emissions from sampled LANL stacks.

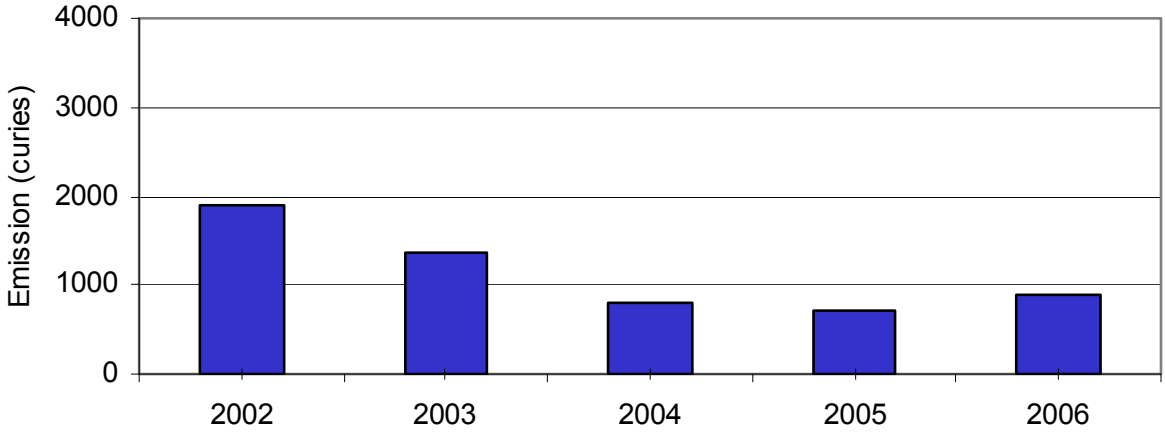

Figure 4-16. Tritium emissions from sampled LANL stacks.

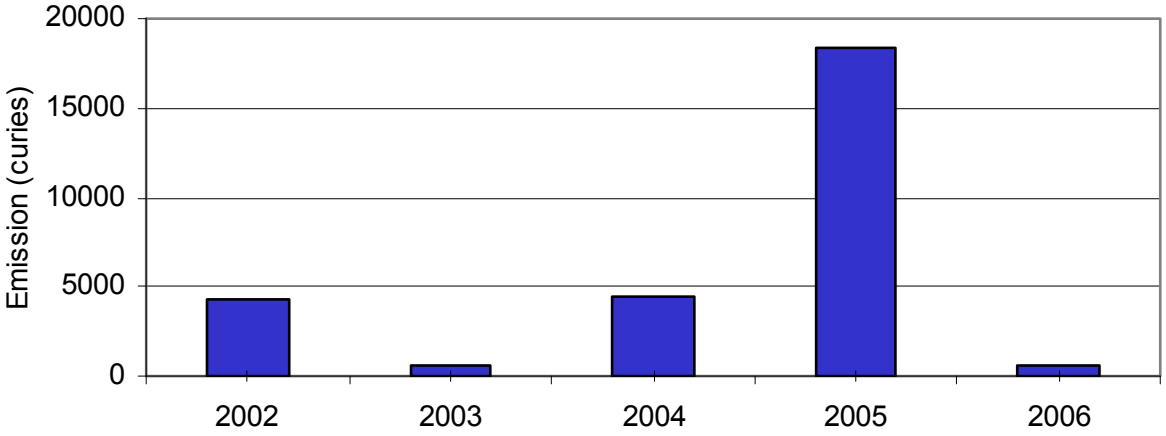

Figure 4-17. GMAP emissions from sampled LANL stacks.

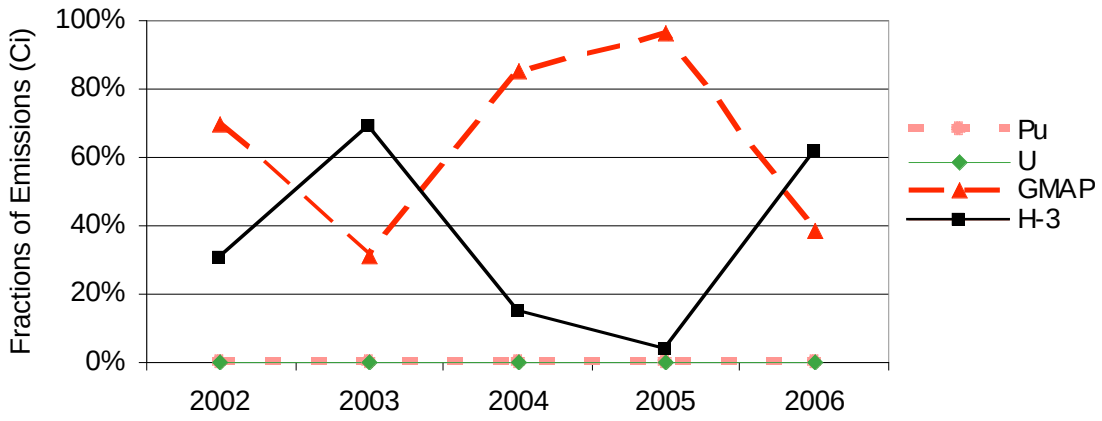

Figure 4-18. Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP.

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM

1. Introduction

We monitor gamma and neutron radiation in the environment—that is, outside of the workplace—according to the criteria specified in McNaughton et al. (2000). Naturally occurring radiation originates from terrestrial and cosmic sources. It is extremely difficult to distinguish man-made sources from the natural background because the natural radiation doses are generally much larger than those from man-made sources. The dose rate from natural terrestrial and cosmic sources measured by the dosimeters (does not include radon and internal sources) varies from approximately 100 to 200 mrem/yr.

2. Monitoring Network

a. Dosimeter Locations. In an attempt to distinguish any impact from LANL operations on the public, we located 90 thermoluminescent dosimeter (TLD) stations around LANL and in the surrounding communities (Figures 4-2 and 4-19).

b. Neutron Dosimeters. We monitor potential neutron doses with 50 albedo TLD stations near known or suspected sources of neutrons (mostly at or near TA-54). Albedo dosimeters are sensitive to neutrons and use a hydrogenous material that causes neutron backscatter to simulate the human body.



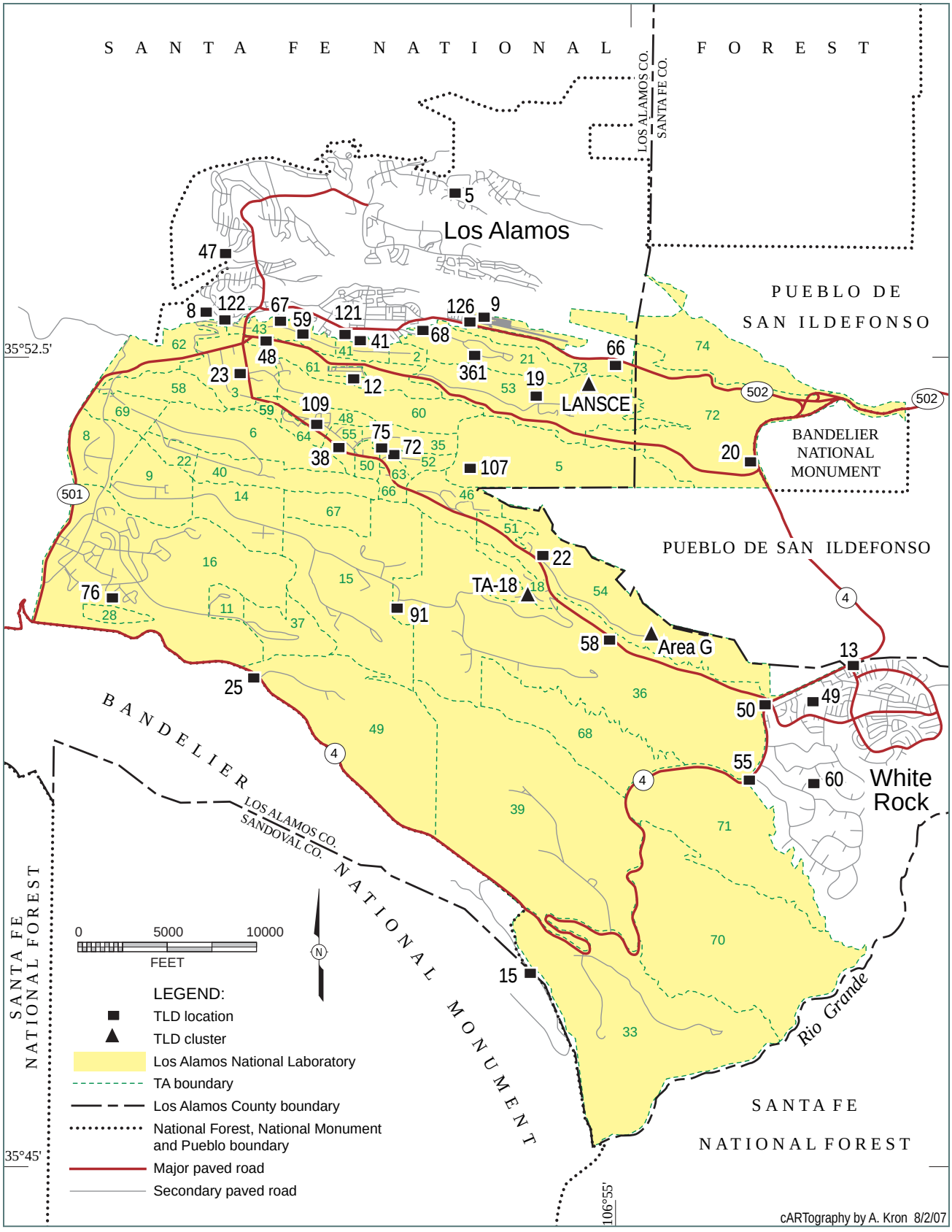

Figure 4-19. Off-site perimeter and on-site LANL TLD locations.

c. Neutron Background. Natural cosmic rays result in a neutron background dose of approximately 10 mrem/yr. However the neutron dosimeters record a dose of approximately 2 mrem/yr because the environmental dosimeters are calibrated with a D_2O-moderated neutron source with a different energy spectrum from cosmic-ray neutrons. Therefore, a neutron reading of 2 mrem/yr indicates a normal background reading.

3. Quality Assurance

The calibration laboratory at LANL's Health Physics Measurements Group (RP-2) calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited the dosimeters that RP-2 provides, and RP-2 provides quailty assurance for the dosimeters. The uncertainty in the TLD data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall 1s uncertainty is similar to previous data and is 8%.

4. Results

The annual dose equivalents at all stations except those at or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Supplemental Data Table S4-10. The only location with a measurable contribution from LANL operations is near TA-54, Area G. Figure 4-2 shows the locations of the stations at TA-54, Area G, which is a temporary storage area for transuranic waste awaiting shipment to the Waste Isolation Pilot Plant.

South of the line of TLDs from #601 to #608, Area G is a controlled-access area, so these data are not representative of a potential public dose. However, TLDs #642 and #643 are close to the boundary of the Pueblo de San Ildefonso Sacred Area, which is accessible to members of the Pueblo. Furthermore, TLD #134 is deployed by Pueblo staff within the boundaries of the Sacred Area.

After subtracting background, the annual doses measured by TLDs #134, #642, and #643 were 18 mrem, 14 mrem, and 14 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Canada del Buey and are partially shielded by the rim of the canyon. These are the doses that would be received by a person who is at the location of the TLDs 24 hours per day and 365 days per year. As discussed in Chapter 3, the public dose near TLD #134 is calculated as 18/16 = 1.1 mrem.

TLD #133 is located several hundred meters further from Area G and measures nothing above the cosmic-ray background. This is expected because of the distance and the shielding provided by the air.

Annual doses of 18 mrem and 10 mrem were measured by TLDs #651 and #652, which are located along Pajarito Road, south of Area G. This section of Pajarito Road is controlled limiting public access.

D. NONRADIOACTIVE AMBIENT AIR MONITORING

1. Introduction

During 2006, we continued a reduced version of the Non-Radiological Air Sampling Network (NonRadNet) implemented in 2001. Currently, the objectives of NonRadNet are to conduct monitoring to develop a database of typical background levels of selected nonradiological species in the communities nearest LANL and to measure LANL's potential contribution to nonradiological air pollution in the surrounding communities. The program consists of six ambient particulate matter monitoring units at three locations plus selected AIRNET samples, which are analyzed for the nonradiological constituents aluminum, calcium, and beryllium.

2. Air-Monitoring Network

During 2006, ambient particulate matter monitoring continued at three locations—one in White Rock and two in Los Alamos. The White Rock sampling location is at the White Rock Fire Station (at AIRNET station 15). One Los Alamos station is at the Los Alamos Medical Center (at AIRNET station 61) and the other is near 48th Street (AIRNET station 6). Both of these latter locations lie between TA-3 and the population center of the Los Alamos town site. Two monitors are operated at each location: one for particles with diameters of 10 micrometers (μm) or less (PM-10) and another for particles with diameters of 2.5 μm or less (PM-2.5).

3. Sampling Procedures, Data Management, and Quality Assurance

A tapered-element oscillating microbalance ambient particulate monitor, fitted with either PM-10 or PM-2.5 sample inlets, measures continuously PM-10 and PM-2.5 concentrations. The microbalance has an oscillating ceramic "finger" with a filter that collects particles. The added mass of the particles changes the resonant frequency of the oscillator. The change in frequency is measured; an associated mass of accumulated particulate matter is recorded and saved. The data are later downloaded to a database. Personnel use these data as an indicator of natural dust loading in the atmosphere. The sampled air volumes are calculated and the ambient air concentrations derived.

4. Ambient Air Concentrations

a. Particulate matter. We achieved an overall data collection efficiency exceeding 90% for 2006. Annual averages and 24-hour maxima for both particle sizes at the three locations are shown in Table 4-16. The annual average for PM-10 is about 13 μg/m^3 at all locations; the annual average for PM-2.5 is about 7 μg/m^3. These annual averages are well below EPA standards (see Table 4-16). The 24-hour maxima for both PM-2.5 and PM-10 at all three locations are also much less than EPA standards.

Table 4-16
PM-2.5 and PM-10 Concentration Data Summary for 2006 (μg/m^3)

Station Location	Constituent	Maximum 24 hour (g/m^3)	Annual Average (g/m^3)
48th Street, Los Alamos	PM-10	42	12
	PM-2.5	15	6
Los Alamos Medical Center	PM-10	54	14
	PM-2.5	17	7
White Rock Fire Station	PM-10	64	15
	PM-2.5	16	7
EPA Standard	PM-10	<150	<50[a]
	PM-2.5	<65	<15[a]

[a] EPA 40 CFR Part 50

5. Detonation and Burning of Explosives

LANL tests explosives by detonating them at firing sites operated by the Dynamic and Energetic Materials Division and the Hydrodynamic Experiments Division. LANL maintains records that include the type of explosives used and other material expended at each site. Table S4-11 (in the Data Supplement) summarizes the amounts of expended materials for the last five years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2006, LANL burned roughly 6,100 pounds of high explosives.

An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicates no adverse air quality impacts. The quantities of materials detonated during 2006 were less than the amounts for which impacts are analyzed in the DOE (1999) report.

6. Beryllium Sampling

The State of New Mexico has no ambient-air-quality standard for beryllium. For comparison purposes, we use the NESHAP standard of 10 ng/m^3 (40 CFR Part 61). Beryllium air concentrations for 2006 are very similar to those measured in recent years.

During 2006, we analyzed quarterly composite samples from 23 sites for beryllium, aluminum, and calcium (see Table S4-12 in the Data Supplement). These sites are located near potential beryllium sources at LANL or in nearby communities. Beryllium and aluminum concentrations in soil occur in a fairly constant ratio: note the linear dependence in Figure 4-20 (correlation coefficient = 0.92). Non-natural occurrences of beryllium would appear far to the right of the straight line. The red triangle with a beryllium concentration of 0.14 ng/m^3 (from Area G station 36) seems to have a slightly elevated beryllium concentration. However, this and all other values are less than 2% of the NESHAP standard and are therefore considered of no health concern. We believe all the other measured beryllium concentrations are of a natural origin and represent resuspended soil and dust.

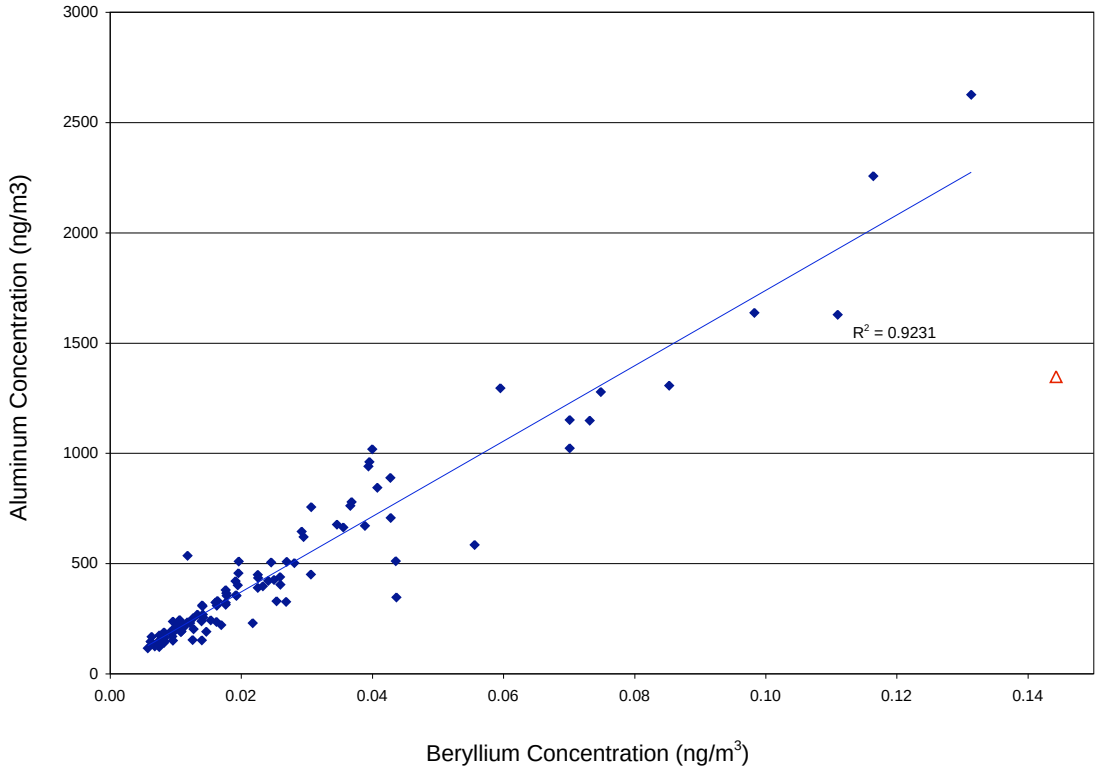

Figure 4-20. Correlation between aluminum and beryllium concentrations in AIRNET samples.

E. METEOROLOGICAL MONITORING

1. Introduction

Data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. To accommodate the broad demands for weather data at the Laboratory, the meteorology team measures a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dew point, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Rishel et al. 2003) provides details of the meteorological monitoring program. An electronic copy of the "Meteorological Monitoring Plan" is available online at http://www.weather.lanl.gov/.

2. Monitoring Network

A network of seven towers gathers meteorological data at the Laboratory (Figure 4-21). Four of the towers are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), two are in canyons (TA-41 in Los Alamos Canyon and MDCN in Mortandad Canyon), and one is on top of Pajarito Mountain (PJMT). The TA-6 tower is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is located adjacent to the TA-6 meteorological tower. Precipitation is also measured in North Community (NCOM) of the Los Alamos town site.

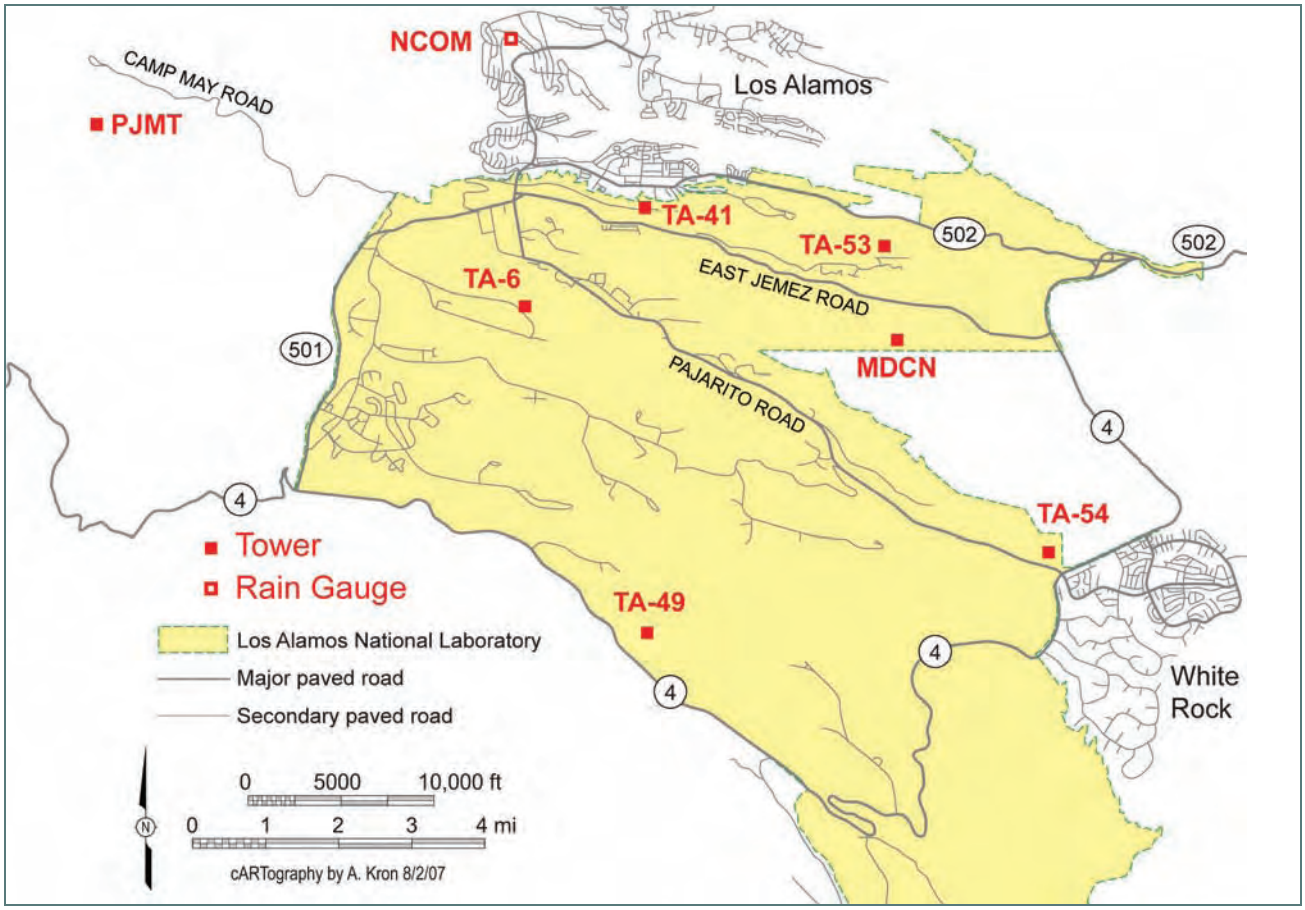

Figure 4-21. Location of meteorological monitoring towers and rain gauges.

3. Sampling Procedures, Data Management, and Quality Assurance

We place instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid wake effects (from trees and structures) on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers. The multiple levels provide a vertical profile of conditions important in assessing boundary layer flow and stability conditions. The multiple levels also provide redundant measurements that support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar-heating effects.

Data loggers at the tower sites sample most of the meteorological variables at 0.33 hertz (Hz), store the data, average the samples over a 15-min period, and transmit the data to a Hewlett-Packard workstation located at the Meteorology Lab (TA-59) by telephone or cell phone. The workstation automatically edits measurements that fall outside of realistic ranges. Time-series plots of the data are also generated for a meteorologist's data-quality review. Daily statistics of certain meteorological variables (e.g., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. During the past 50 years, a similar once-daily set of statistics has been telephoned to the National Weather Service. Observers log cloud type and percentage cloud cover three times daily.

All meteorological instruments are annually refurbished and calibrated during an internal audit/inspection. Field instruments are replaced with backup instruments, and the replaced instruments are checked to verify that they remained in calibration while in service. All instrument calibrations are traceable to the National Institute of Standards and Technology. An external audit is typically performed once every two to three years. The most recent audit was an "assist visit" by the DOE Meteorological Coordinating Council in August of 2006. The report can be requested at http://www.weather.lanl.gov/.

4. Climatology

Los Alamos has a temperate, semiarid mountain climate. Atmospheric moisture levels are low, and clear skies are present about 75% of the time. These conditions lead to high solar heating during the day and strong long-wave radiative cooling at night. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized here are from analyses of historical meteorological databases maintained by the meteorology team and following Bowen (1990 and 1992).

The years from 1971 to 2000 represents the time period over which the climatological standard normal is defined. The standard should be 1961-1990, according to the World Meteorological Organization, until 2021 when 1991–2020 will become the standard, and so on every 30 years (WMO 1984). In practice, however, normals are computed every decade, and so 1971–2000 is generally used. Our averages are calculated according to this widely followed practice.

December and January are the coldest months. The majority (90%) of minimum temperatures during December and January range from 4˚F to 31˚F. Minimum temperatures are usually reached shortly before sunrise. 90% of maximum temperatures, which are usually reached in mid-afternoon, range from 25˚F to 55˚F. The record low temperature of -18˚F was recorded on January 13, 1963. The Sangre de Cristo Mountains to the east of the Rio Grande valley act as a barrier to wintertime arctic air masses that descend into the central US, making the occurrence of local subzero temperatures rare. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. 90% of minimum temperatures during these months range from 45˚F to 61˚F. 90% of maximum temperatures range from 67˚F to 89˚F. The record high temperature of 95˚F was recorded on June 29, 1998.

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.95 in. The average annual snowfall is 58.7 in. Winter precipitation in Los Alamos is often caused by storms approaching from the Pacific Ocean. Large snowfalls may occur locally as a result of orographic lifting of the storms by the high terrain. The record single-day snowfall is about 39 in., which occurred between 11 a.m. January 15, 1987, and 11 a.m. the next day. The record single-season snowfall is 153 in. set in 1986–87.

Precipitation in July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in mid September. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

The complex topography of Los Alamos influences local wind patterns, notable in the absence of large-scale disturbances. Often a distinct diurnal cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow upslope along the ground. This is called anabatic flow. During the night, cool air that forms close to the ground tends to flow downslope and is known as katabatic flow. As the daytime anabatic breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerlies of the Pajarito Plateau. Nighttime katabatic flow enhances the local westerly winds. Flow in the east-west-oriented canyons of the Pajarito Plateau is generally aligned with the canyons, so canyon winds are usually from the west at night as katabatic flow and from the east during the day.

5. 2006 in Perspective

Figure 4-22 presents a graphical summary of Los Alamos weather for 2006. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared to monthly normals (averages during the 1971–2000 time period).

The year 2006 was warmer and dryer than normal. The average annual temperature in 2006 of 49.6˚F exceeded the normal annual average of 47.9˚F by 1.7˚F. The total precipitation in 2006 of 16.62 in. was 12% below normal (18.95 in.). January, February, April, May, and June were particularly warm months, while September was clearly cooler than normal. The year began very dry as drought conditions that returned in late 2005 continued through May 2006. The late June monsoon start was early, but the rains ebbed in mid July. The monsoon returned in force during August with double the average rainfall amount for the month, as was the case the previous year. Autumn recorded average rainfall amounts but 2006 ended on a high note as December saw twice as much snow as usual with a massive two-day storm during the final week. The strong year-end surge in precipitation was not enough to cover the debt from the first half of the year, however, and 2006 ended with below average precipitation, albeit with hope for a snowy winter.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-23 shows the historical record of temperatures in Los Alamos from 1926 through 2006. The annual average temperature is not the average temperature per se, but rather the mid-point between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-23. Every year since 1998 has been warmer than the 1971–2000 normal. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it can be seen that the warm spell during the past decade is not as extreme as the warm spell during the early-to-mid 1950s. On the other hand, the current warming trend is longer-lived.

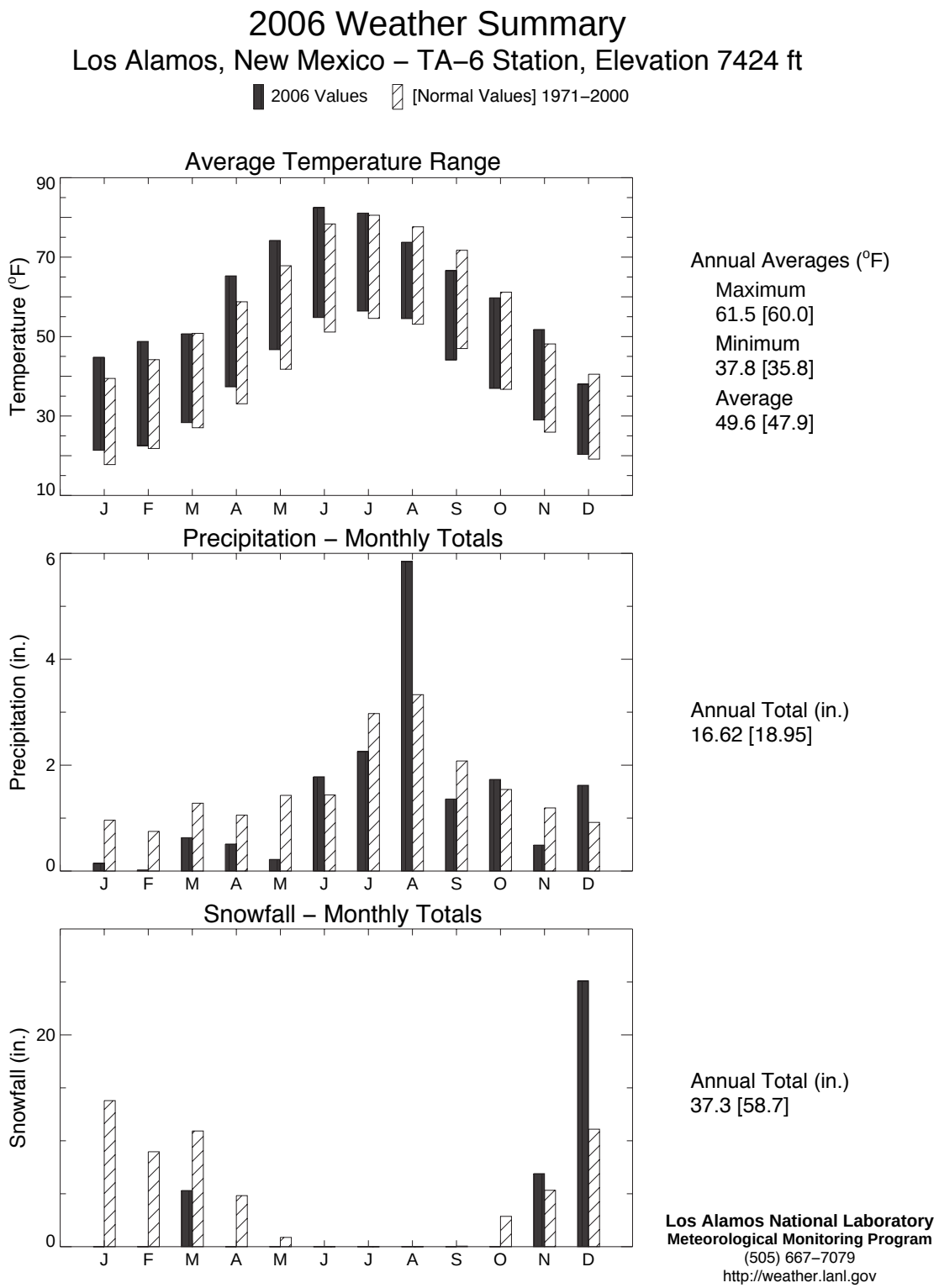

Figure 4-22. Weather summary for Los Alamos in 2006 at TA-6 station, elevation 7,424 ft. Numbers in brackets are 30-year averages, and non-bracketed numbers are 2006 figures.

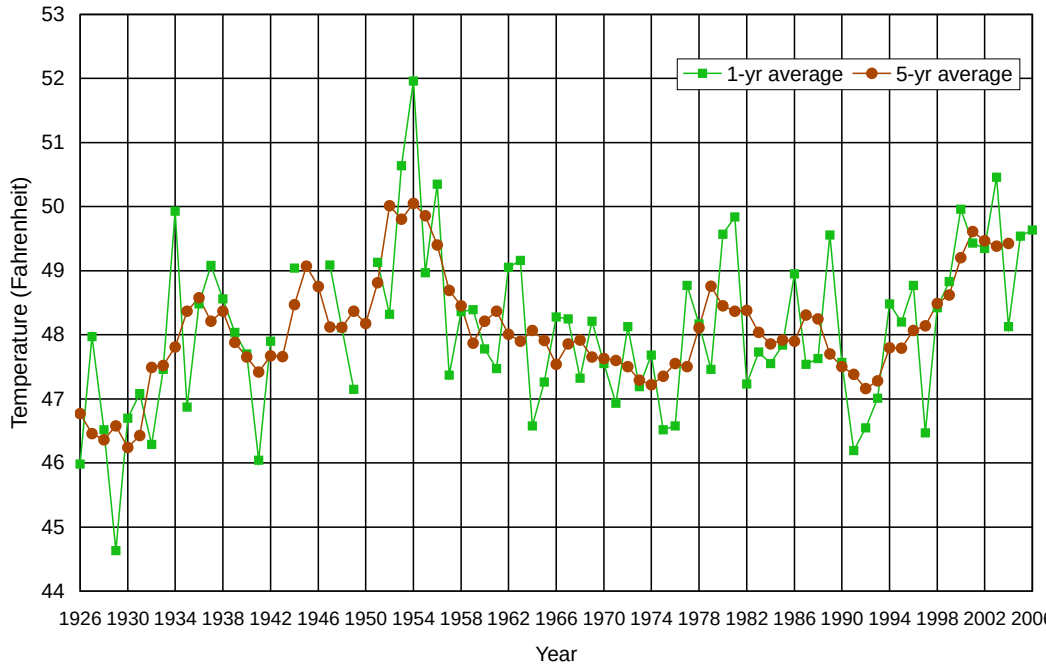

Figure 4-23. Temperature history for Los Alamos.

Figure 4-24 shows the historical record of the annually summed total precipitation. The drought appears to have ended in 2003, and 2004 and 2005 brought surplus precipitation to help restore normal conditions. The moist trend did not continue in 2006, but the nearly 17 inches are clearly not far off the normal of about 19 inches. As with the historical temperature profile, the five-year running mean is also shown. The five-year average indicates not only that the recent drought is behind us, but that it was the most severe drought on record in Los Alamos.

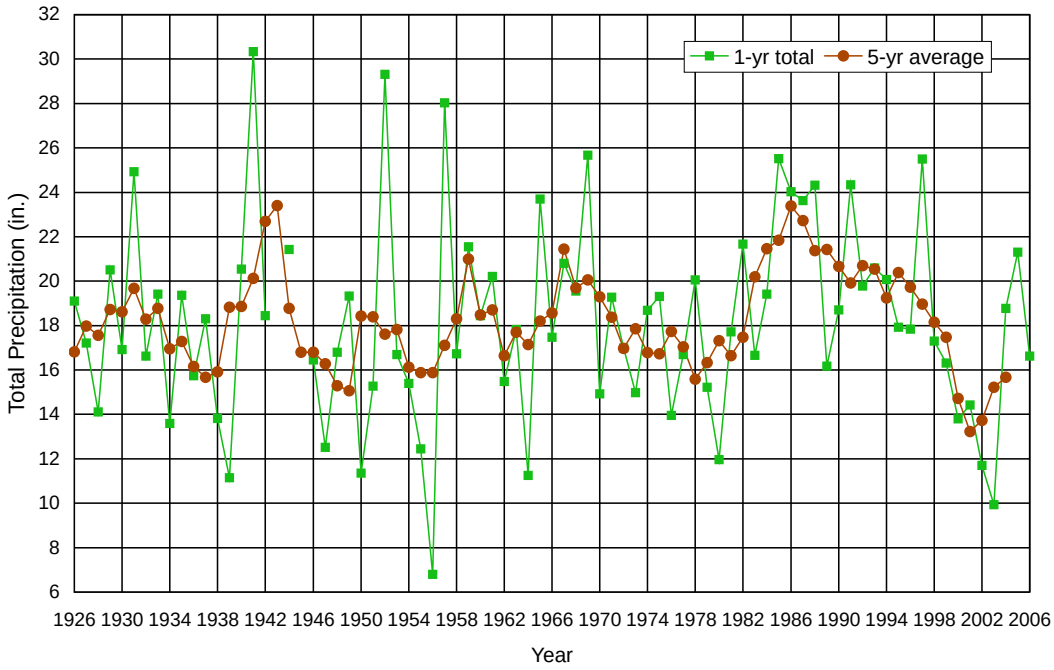

Figure 4-24. Total precipitation history for Los Alamos.

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-25. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are from the south at TA-6 almost 14% of the time during days in 2006. Winds are from the north slightly more than 2% of the time during the day. Wind roses also show the distribution of wind speed. About 8% of the time, for example, winds at TA-6 are from the south and range from about 6 to 11 mph. Winds from the south at TA-6 exceed 17 mph only a fraction of 1% of the time.

The wind roses are based on 15-minute-averaged wind observations for 2006 at the four Pajarito Plateau towers and the Pajarito Mountain tower. Interestingly, wind roses from different years are almost identical, indicating that wind patterns are constant when averaged over a year.

Daytime winds measured by the four Pajarito Plateau towers are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope katabatic flow of cooled mountain air.

Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest, reflecting the prevailing westerly winds. The thick, red barbs of the Pajarito Mountain roses reveal that winds there are much faster than on the Pajarito Plateau and are faster at night than during the day. Curiously, however, winds on the Pajarito Plateau are faster during the day than at night. This is due to vertical mixing that is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface, resulting in slower wind aloft and faster wind at the surface. At night, there is little mixing so wind aloft remains fast and wind at the surface receives little boosting from aloft.

F. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

During 2006, the air quality organization revised approximately 12 procedures to reflect the constant improvements in the processes; no plans required revisions. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that processes perform satisfactorily. All current quality-related documents are available online at http://www.lanl.gov/environment/air/qa.shtml.

2. Field Sampling Quality Assurance

a. Methods. Overall quality of this portion of the program is maintained through the rigorous use of documented procedures that govern all aspects of the sample-collection program.

Particulate and water-vapor samples are (1) collected from commercially available media of known performance, (2) collected under common chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors, and (3) prepared in a secure and radiologically clean laboratory for shipment. The samples are then delivered to internal and external analytical laboratories under full chain-of-custody, including secure FedEx shipment, to all external vendors and tracked at all stages of their collection and analysis through the AIRNET and RADAIR relational databases.

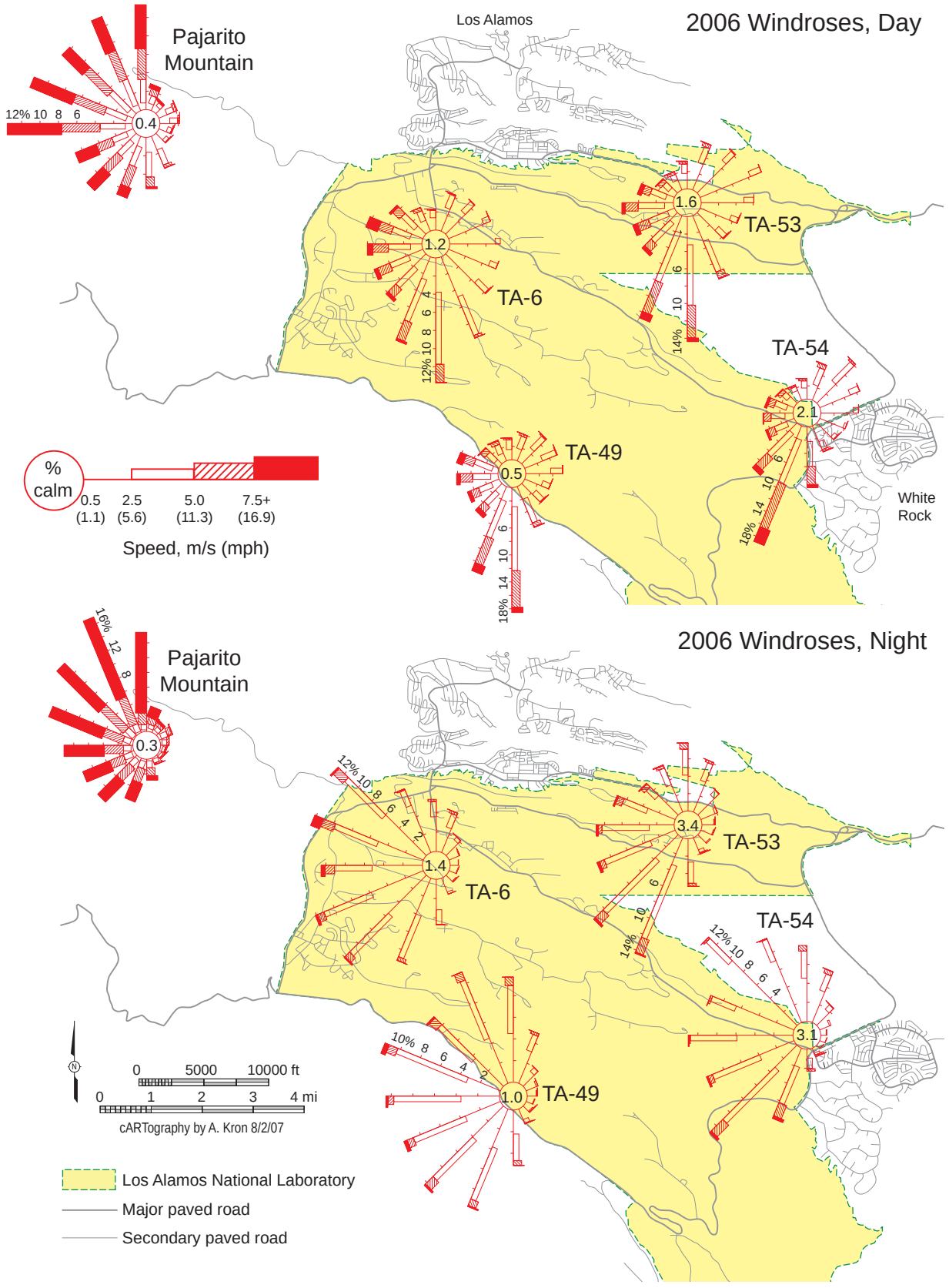

Figure 4-25. Daytime and nighttime wind roses, 2006.

Field-sampling completeness is assessed every time the analytical laboratory returns the AIRNET biweekly gross alpha/beta data. RADAIR field-sampling completeness is evaluated each week upon receipt of the gross alpha/beta and tritium bubbler data. All these calculations are performed for each ambient-air and stack-sampling site and are included in the quality-assessment memo that is prepared by stack monitoring staff to evaluate every data group received from a supplier.

b. Results Field data completeness for AIRNET and stacks was 100%. Sample run time was greater than 98.6% for AIRNET and 99.7% for stacks.

3. Analytical Laboratory Quality Assessment

a. Methods. Specific statements of work are written to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified our program objectives. These statements of work are sent to potentially qualified suppliers who undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry-laboratory assessors. Statement of work specifications, professional judgment, and quality-system performance at each laboratory, including recent past performance on nationally conducted performance-evaluation programs, are primarily used to award contracts for specific types of radiochemical and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. We submit independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned by email in an electronic data deliverable of specified format and content. The analytical laboratory also submits a full paper set of records that serves as the legally binding copy of the data. Each set of samples contains all the internal QA/QC data the analytical laboratory generates during each phase of chemical analysis, including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable. The electronic data are uploaded into either the AIRNET or RADAIR databases and immediately subjected to a variety of quality and consistency checks. Analytical completeness is calculated, tracking and trending of all blank and control-sample data is performed, and all are documented in the quality-assessment memo mentioned in the field-sampling section. All parts of the data-management process are tracked electronically in each database, and periodic reports to management are prepared.

b. Results. Analytical data completeness was 99.61% for AIRNET filters, 99.02% for AIRNET silica gel, and 99.9% for stacks. The overall results of the quality monitoring in 2006 indicate that all analytical laboratories maintained the same high level of control that has been observed in the past several years.

4. Analytical Laboratory Assessments

During 2006, one internal and one external laboratory performed all chemical analyses reported for AIRNET and RADAIR samples. Paragon Analytics, Inc., Fort Collins, Colorado, provided the following analyses:

- Biweekly gross alpha, gross beta, and gamma analyses of filters for AIRNET.
- Biweekly analyses for tritium in AIRNET silica gel.
- Weekly gross alpha, gross beta, gamma, and stable beryllium analyses on stack samples.
- Quarterly analyses for alpha-emitting isotopes (americium, plutonium, and uranium) and stable beryllium, calcium, and aluminum on AIRNET quarterly composite samples.
- Semester analyses of composites of stack filters for gross alpha, gross beta, americium-241, gamma-emitting isotopes, lead-210, polonium-210, plutonium isotopes, strontium-90, thorium isotopes, and uranium isotopes.

The Laboratory's on-site Health Physics Analytical Laboratory (HSR-4) performed instrumental analyses of tritium in stack emissions.

Paragon Analytics was assessed during 2006 and the laboratory was found to provide very high quality work in compliance with all LANL requirements. This laboratory has consistently performed well. The laboratory participated in national performance-evaluation studies during 2005 and the study sponsors judged the analytical laboratory to have acceptable performance for all analytes attempted in all air sample matrices.

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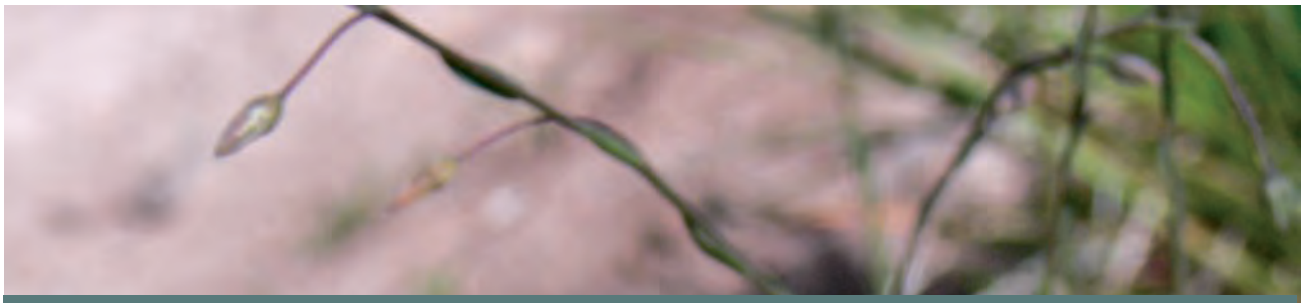

5. Groundwater Monitoring



5. Groundwater Monitoring

contributing authors:
David B. Rogers and Bart J. Vanden Plas

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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality on the Pajarito Plateau and in the surrounding area. The Laboratory conducts groundwater monitoring and characterization programs to comply with the requirements of the Department of Energy (DOE) Orders and New Mexico (NM) and federal regulations. The objectives of the Laboratory's Water Stewardship Project are to determine compliance with waste discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources. This program addresses regulatory compliance, environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations (LANL 1996, 1998).

Because of the Laboratory's semiarid, mountainside setting, significant groundwater is found only at depths of more than several hundred ft. The Los Alamos County public water supply comes from supply wells that draw water from the regional aquifer, found at depths of 600 to 1,200 ft. Groundwater protection efforts at the Laboratory focus on (1) the regional aquifer underlying the area and include (2) the shallow perched groundwater found within canyon alluvium and (3) the perched groundwater at intermediate depths above the regional aquifer.

To comply with the requirements of the NMED Compliance Order on Consent (Consent Order), LANL significantly expanded the number of monitored groundwater locations during 2005. Groundwater monitoring conducted during 2006 was carried out according to the first Interim Sitewide Monitoring Plan approved by NMED under the Consent Order (LANL 2006). LANL's Water Stewardship Project collected groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

B. HYDROGEOLOGIC SETTING

The following sections describe the hydrogeologic setting of the Laboratory and include a summary of groundwater contaminant sources and distribution. Additional detail can be found in LANL (2005), which summarizes results of investigations conducted under the Hydrogeologic Workplan from 1998 through 2004.

1. Geologic Setting

Los Alamos National Laboratory is located in northern NM on the Pajarito Plateau, which extends eastward from the Sierra de los Valles, the eastern range of the Jemez Mountains (Figure 5-1).

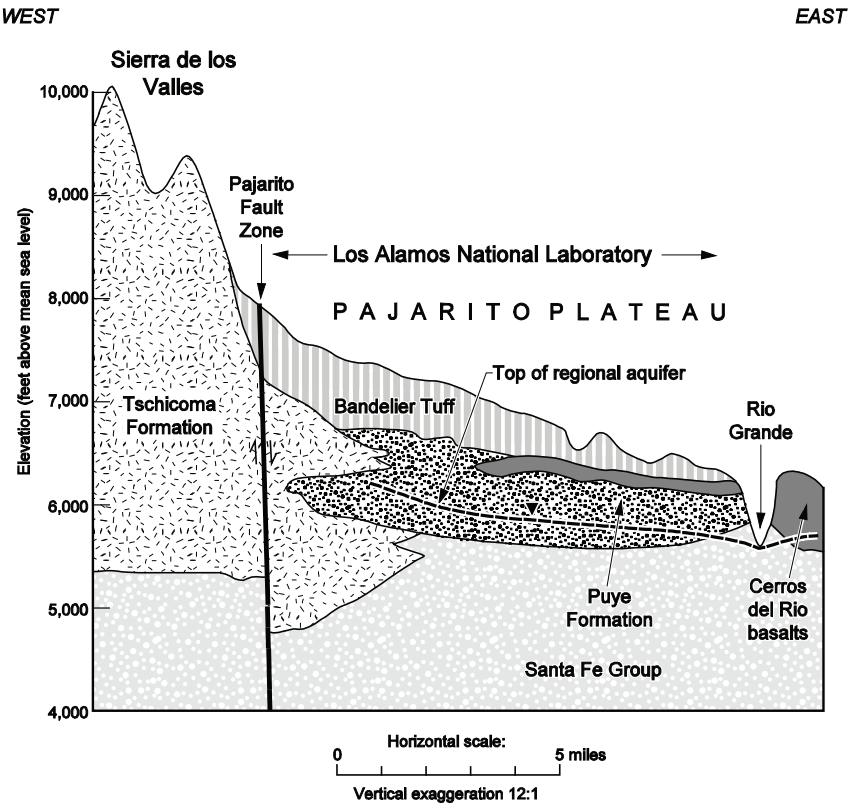


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau.

The Rio Grande borders the Laboratory on the east. Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from volcanic ashfall deposits and pyroclastic flows that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1,000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains (Figure 5-1). The Puye Formation conglomerate underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows interfinger with the Puye Formation conglomerate beneath the Laboratory. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

2. Groundwater Occurrence

Due to its location on a semiarid mountainside, the Laboratory lies atop a thick zone of mainly unsaturated rock, with the principal aquifer found 600 to 1,200 ft below the ground surface. Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater is retained above less permeable layers and is separated from underlying groundwater by unsaturated rock.

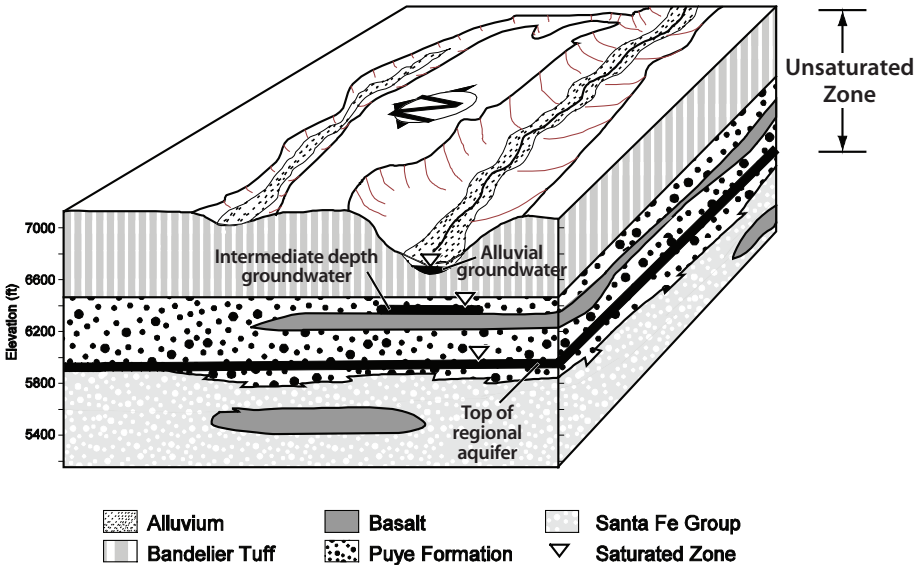


Figure 5-2. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) zones of intermediate-depth perched groundwater whose location is controlled by availability of recharge and by subsurface changes in rock type and permeability, and (3) the regional aquifer beneath the Pajarito Plateau. The regional aquifer extends throughout the neighboring Española Basin.

Stream runoff may be supplemented or maintained by Laboratory discharges. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. Streams have filled some parts of canyon bottoms with alluvium up to 100 ft thick. In wet canyons, runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rocks, maintaining shallow bodies of perched groundwater within the alluvium. Evapotranspiration and infiltration into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and within the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. Intermediate groundwater occurrence is controlled by availability of recharge and variations in permeability of the rocks underlying the plateau. Depths of the intermediate perched groundwater vary: approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched water occurs in volcanics on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from a gallery in Water Canyon. Intermediate perched water also occurs in the southwest portion of the Laboratory just east of the Sierra de los Valles. A number of intermediate springs, fed by local recharge, discharge from mesa edges along canyons. Other intermediate groundwater is found in the Bandelier Tuff at a depth of approximately 700 ft. The source of this deeper perched water may be infiltration from streams that discharge from canyons along the mountain front, or underflow of recharge from the Sierra de los Valles.

The regional aquifer of the Los Alamos area occurs at a depth of 1,200 ft along the western edge of the plateau and 600 ft along the eastern edge (Figures 5-1 and 5-3). The regional aquifer lies about 1,000 ft

beneath the mesa tops in the central part of the plateau. This is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer flows generally east or southeast toward the Rio Grande. Groundwater model studies indicate that underflow of groundwater from the Sierra de los Valles is the main source of regional aquifer recharge (LANL 2005). Groundwater velocities vary spatially but are typically 30 ft/yr.

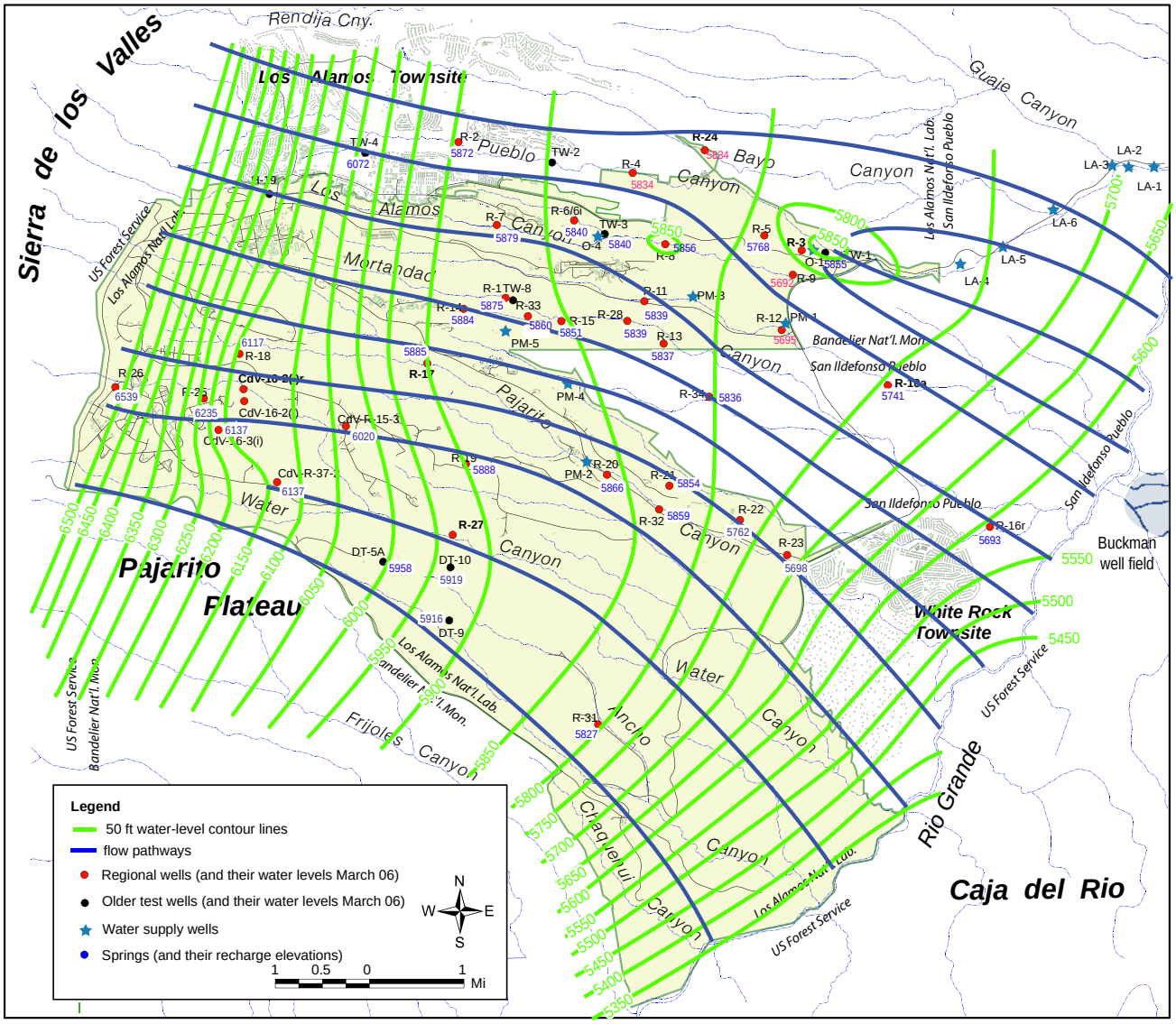


Figure 5-3. Contour map of average water table elevations in March 2006 for the regional aquifer (LANL 2007a).

The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation, part of the Santa Fe Group (Figure 5-1). Underneath the central and western part of the plateau the aquifer rises farther into the Cerros del Rio basalt and the lower part of the Puye Formation.

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 620 ft of unsaturated tuff, basalt, and sediments with generally low (<10%) moisture content. Water lost by downward seepage from alluvial and intermediate groundwater zones travels through the underlying rock by

unsaturated flow. This percolation is a source of certain contaminants, mobile in water, which may reach the regional aquifer within a few decades. The limited extent of the alluvial and intermediate groundwater bodies, along with the dry rock that underlies them, limits their volumetric contribution to recharge reaching the regional aquifer.

3. Overview of Groundwater Quality

Since the 1940s, liquid effluent disposal by the Laboratory has affected water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. Liquid effluent disposal is also the primary means by which Laboratory contaminants have affected the quality of deep groundwater, including intermediate perched zones and the regional aquifer. Where Laboratory contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location beneath a mesa-top site where large amounts of liquid effluent have been discharged.

The discharge of effluents to canyons or mesa-top locations in the Laboratory's semiarid setting initiates or increases downward percolation of water. Even under unsaturated flow conditions, this percolation may move significant amounts of water and contaminants to the regional aquifer within a few decades. The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so recharge from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced.

Drainages that received liquid radioactive effluents include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize radioactive effluent discharge history at the Laboratory.

Because of releases of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems (SWWS) Plant, Sandia Canyon has received the largest liquid discharge volumes of any canyon in recent decades. Water Canyon and its tributary Cañon de Valle have received effluents produced by high explosives (HE) processing and experimentation (Glatzmaier 1993; Martin 1993).

Over the years, Los Alamos County has operated three sanitary treatment plants in Pueblo Canyon (ESP 1981). Only the Bayo sanitary treatment plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

Liquid effluent disposal at the Laboratory has impacted the quality of alluvial groundwater in several canyons. Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 17) and the volume of water released (by more than 80%). For 1993 to 1997, total estimated average flow was 1,300 M gal/yr; flow decreased to 230 M gal/yr for 1998 to 2005 (Rogers 2006). The quality of the remaining discharges has been improved through treatment process improvements so that the discharges meet applicable standards.

Liquid effluent discharges have affected intermediate perched groundwater and the regional aquifer to a lesser degree. The intermediate groundwater in various locations shows localized radioactive (tritium), organic (RDX, chlorinated solvents, dioxane[1,4-]), and inorganic (hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate) contamination from Laboratory operations.

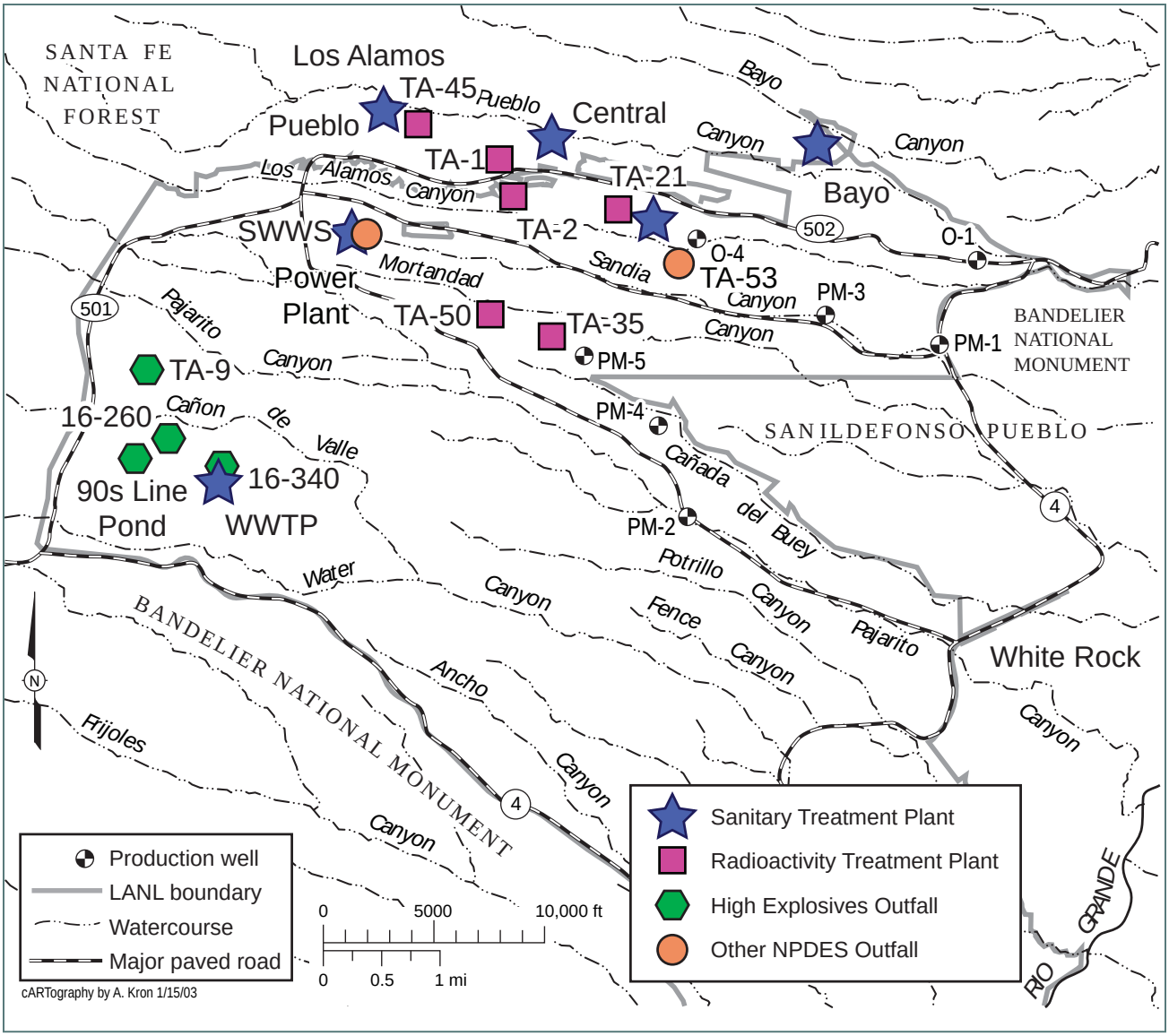


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. Most outfalls shown are inactive.

Figure 5-5 summarizes regional groundwater quality issues at the Laboratory. In 2006, the high explosives compound Royal Demolition Explosive (RDX) was detected in the regional aquifer for the first time at Pajarito Canyon well R-18. RDX is listed as a toxic pollutant in the New Mexico groundwater regulations (NMWQCC 2002). The concentration was near the detection limit and at 2% of the EPA 10^{-5} excess cancer risk tap water screening level. RDX was not found in samples taken during 2005 from this well. Earlier detection of RDX in the regional aquifer at R-25 (to the south of R-18) was probably due to cross-contamination from shallower well screens caused by well construction delays. The Laboratory is investigating these issues in cooperation with the New Mexico Environment Department (NMED).

Hexavalent chromium and nitrate have been found in several regional monitoring wells. Hexavalent chromium is above the NM groundwater standard in one regional aquifer well and at 60% of that standard

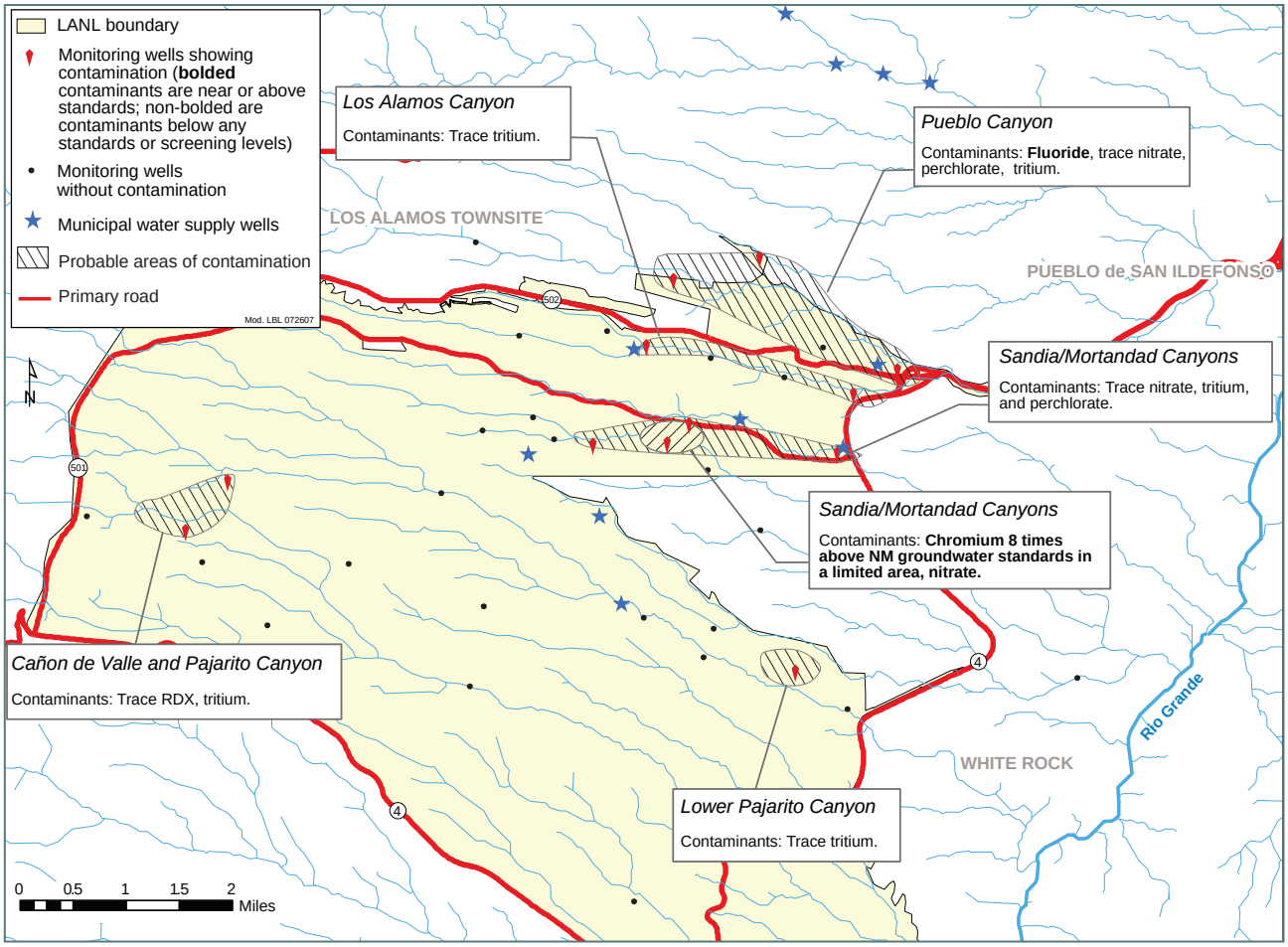


Figure 5-5. Summary of regional aquifer groundwater quality issues at Los Alamos National Laboratory.

in another. Nitrate (as nitrogen) reaches 50% of the NM groundwater standard in two regional aquifer monitoring wells and fluoride is at 50% of the standard in one well. Traces of tritium and perchlorate are also found in the regional aquifer.

With one exception, drinking water wells in the Los Alamos area have not been adversely impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate is found at concentrations that average 1/10th of the Environmental Protection Agency's (EPA's) Drinking Water Equivalent Level of 24.5 µg/L. This well is not used by Los Alamos County for water supply. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water requirements.

Certain chemical constituents are good indicators of the possible presence of Laboratory effluents in groundwater. These chemical constituents are described as being chemically conservative, that is, their concentrations are usually not affected by chemical reactions. Examples of these conservative chemical constituents found in past LANL effluents include perchlorate, tritium, hexavalent chromium, and, to a lesser extent, nitrate. Nitrate is often conservative but its concentration may be affected by bacterial activity. Groundwater that has background concentrations of perchlorate, tritium, hexavalent chromium, and nitrate is likely to be unaffected by LANL discharges.

C. GROUNDWATER STANDARDS

We apply regulatory standards and risk levels in evaluating groundwater samples as described in Table 5-1. For water supply wells, which draw water from the regional aquifer, we compare concentrations of radionuclides in samples to (1) the derived concentration guides (DCGs) for ingested water calculated from DOE's 4-mrem drinking water dose limit and (2) the EPA maximum concentration levels (MCLs). For radioactivity in groundwater other than drinking water, there are NM groundwater standards for uranium and radium. For risk-based screening of other radioactivity, groundwater samples from sources other than water supply wells may be compared with DOE's 4-mrem drinking water DCGs and with EPA MCLs. The DCGs for the 100-mrem public dose limit apply as effluent release guidelines. Where used in this chapter for such comparison purposes, in assessing water samples from sources other than water supply wells, these DCGs and MCLs are referred to as *screening levels*.

The NM drinking water regulations and EPA MCLs apply as regulatory standards to nonradioactive constituents in water supply samples. They may be used as risk-based screening levels for other groundwater samples. The New Mexico Water Quality Control Commission (NMWQCC) groundwater standards (NMWQCC 2002) apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples. NMWQCC (2002) specifies how to determine standards for the toxic pollutants listed in the NMWQCC groundwater standards, if they have no other state or federal standard. Accordingly, we screen results for these compounds at a risk level of 10^{-5} for cancer-causing substances or a hazard index of one (HI = 1) for non-cancer-causing substances. A HI of one or less indicates that no (noncancer) adverse human health effects are expected to occur. We used the EPA Region 6 tap water screening levels to screen these toxic pollutant compounds (http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm). For cancer-causing substances, the Region 6 tap water screening levels are at a risk level of 10^{-6}, so we use 10 times these values to screen at a risk level of 10^{-5}.

Groundwater is a source of flow to springs and other surface water that neighboring tribal members and wildlife use. The standards for groundwater or NMWQCC's surface water standards (NMWQCC 2000), including the wildlife habitat standards, also apply to this water (see Chapter 6).

D. MONITORING NETWORK

In 2005, the Laboratory and the NMED signed the Consent Order, which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory annually submit an Interim Facility Groundwater Monitoring Plan (Interim Plan) to the department for its approval. The first Interim Plan was approved in June 2006 (LANL 2006). Groundwater monitoring in 2006 was conducted by the Laboratory according to the Interim Plan.

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: the regional aquifer, perched alluvial groundwater in the bottom of some canyons, and localized intermediate-depth perched groundwater systems (Figures 5-6, 5-7, 5-8, 5-9, and 5-10). The springs and wells are described by Purtymun (1995), LANL (2005), and (for new wells) individual well completion reports.

To document the potential impact of Laboratory operations on Pueblo de San Ildefonso land, the DOE signed a memorandum of understanding in 1987 with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on pueblo land. Groundwater monitoring stations at Pueblo de San Ildefonso are shown in Figure 5-10 and mainly sample the regional aquifer. Basalt Spring, Los Alamos Spring, GU-0.01 Spring, and Pine Rock Spring are intermediate groundwater sampling points, and wells LLAO-1B and LLAO-4 sample alluvial groundwater. Figure 5-10 also shows the location of three City of Santa Fe wells monitored by the Laboratory.

Table 5-1
Application of Standards to LANL Groundwater Monitoring Data

Constituent	Sample Location	Standard or DCG	Risk-Based Screening Level	Reference	Location	Notes
Radionuclides	Water supply wells	DOE 4-mrem Derived Concentration Guides, EPA MCLs		DOE Order 5400.5, 40 CFR 141-143	On site and off site	A 4-mrem/year dose rate limit and EPA MCLs apply to drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem Derived Concentration Guides		DOE Order 5400.5	On site	DOE public dose limit is 100 mrem/yr, applies to effluent discharges
Radionuclides	Other groundwater samples		4-mrem Derived Concentration Guides, EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On site and off site	A 4-mrem/year dose rate limit and EPA MCLs are for comparison because they apply only to drinking water systems
Non-radionuclides	Water supply wells	EPA MCLs, NM groundwater standards, EPA 10^{-5}, and HI = 1 risk levels for NM toxic pollutants with no standard		40 CFR 141-143, 20.6.2 NM Administrative Code	On site and off site	EPA MCLs apply to drinking water systems. Use EPA Region 6 table for 10^{-5} and HI = 1 risk values
Non-radionuclides	Other groundwater samples	NM groundwater standards, EPA 10^{-5} and HI = 1 risk levels for NM toxic pollutants with no standard	EPA MCLs	40 CFR 141-143, 20.6.2 NM Administrative Code	On site and off site	NMED regulations protect all groundwater. EPA MCLs are for comparison because they apply only to drinking water systems. Use EPA Region 6 table for 10^{-5} and HI = 1 risk values



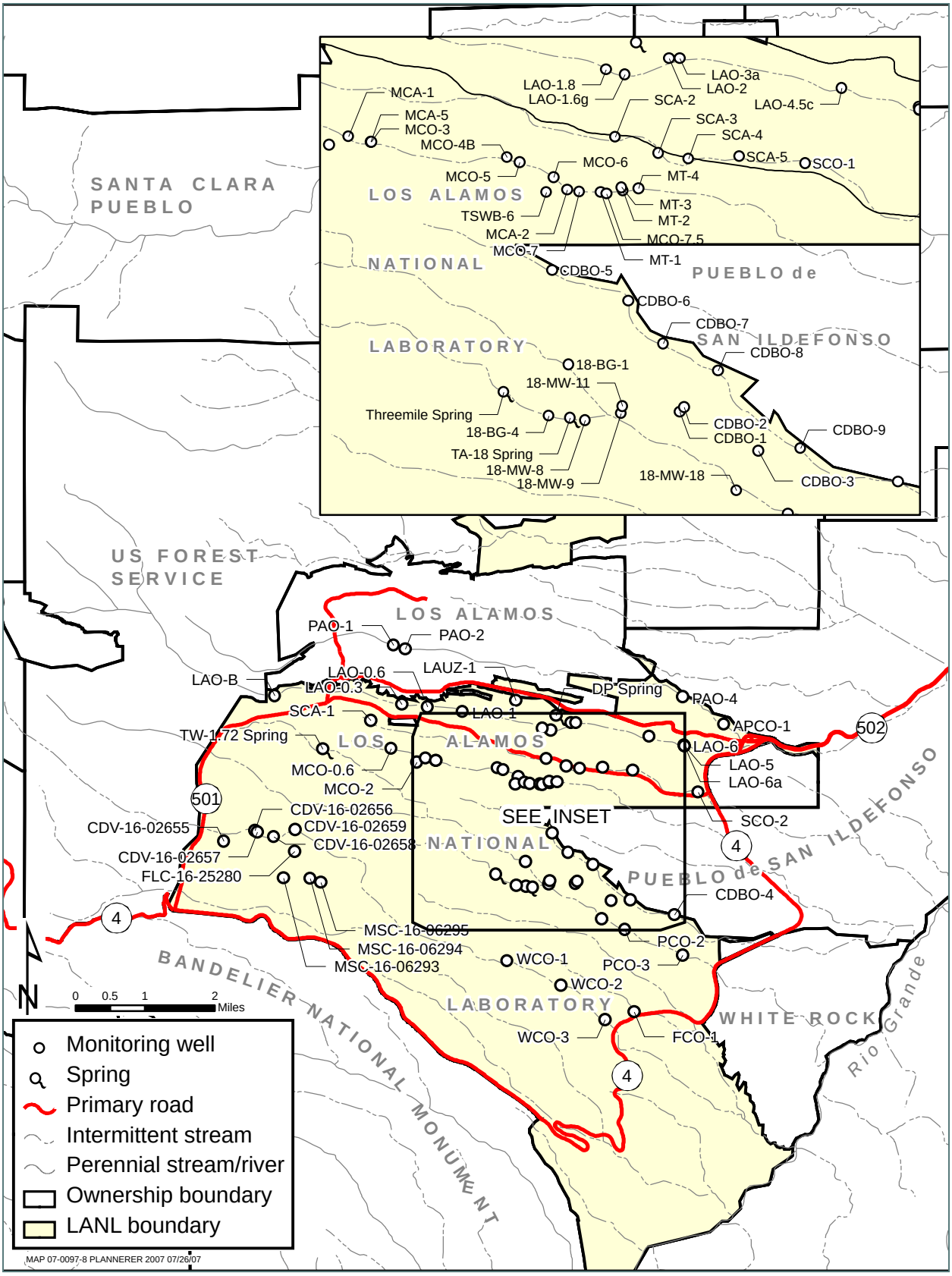


Figure 5-6. Springs and wells used for alluvial groundwater monitoring.

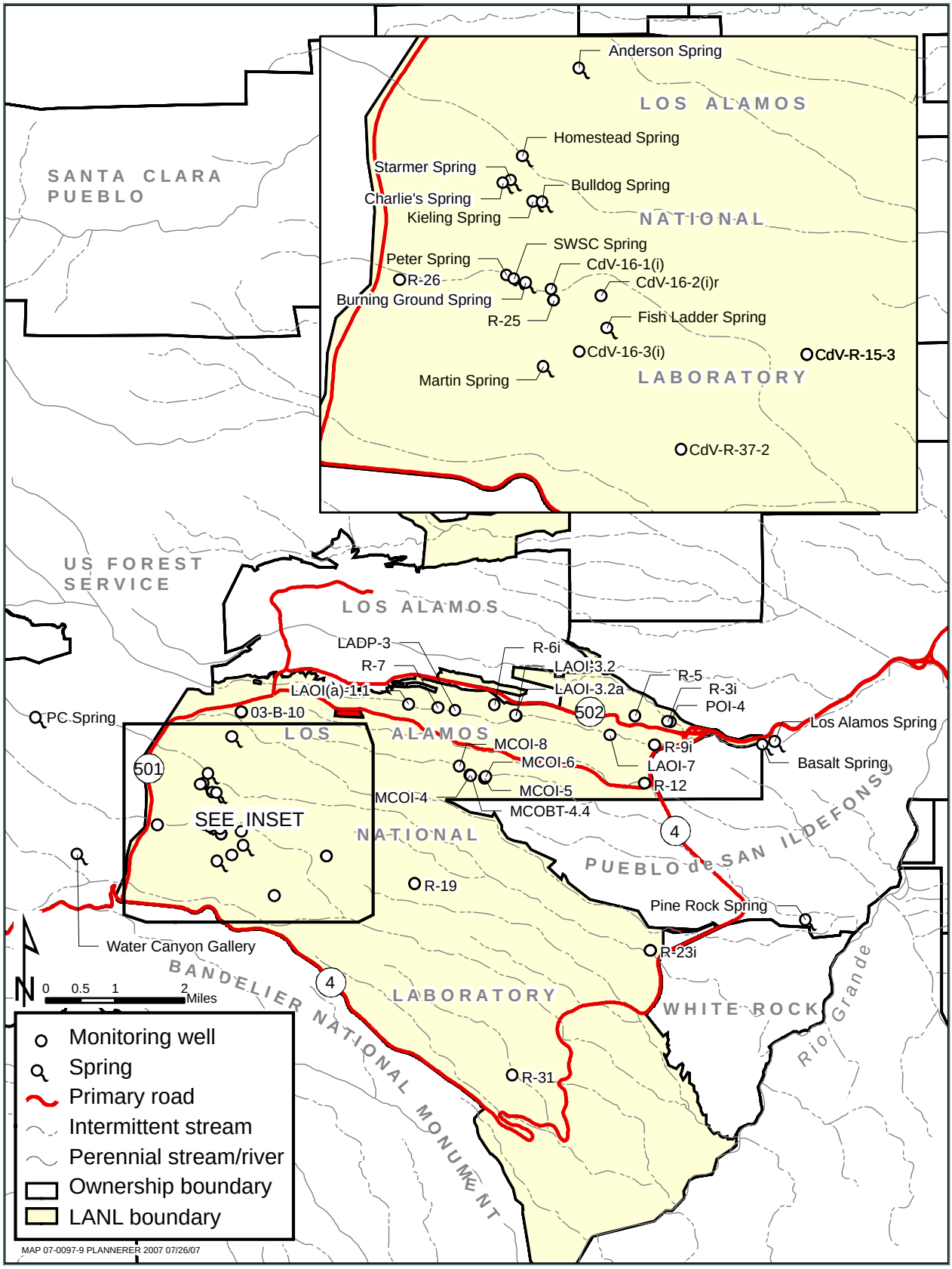


Figure 5-7. Springs and wells used for intermediate perched zone monitoring.

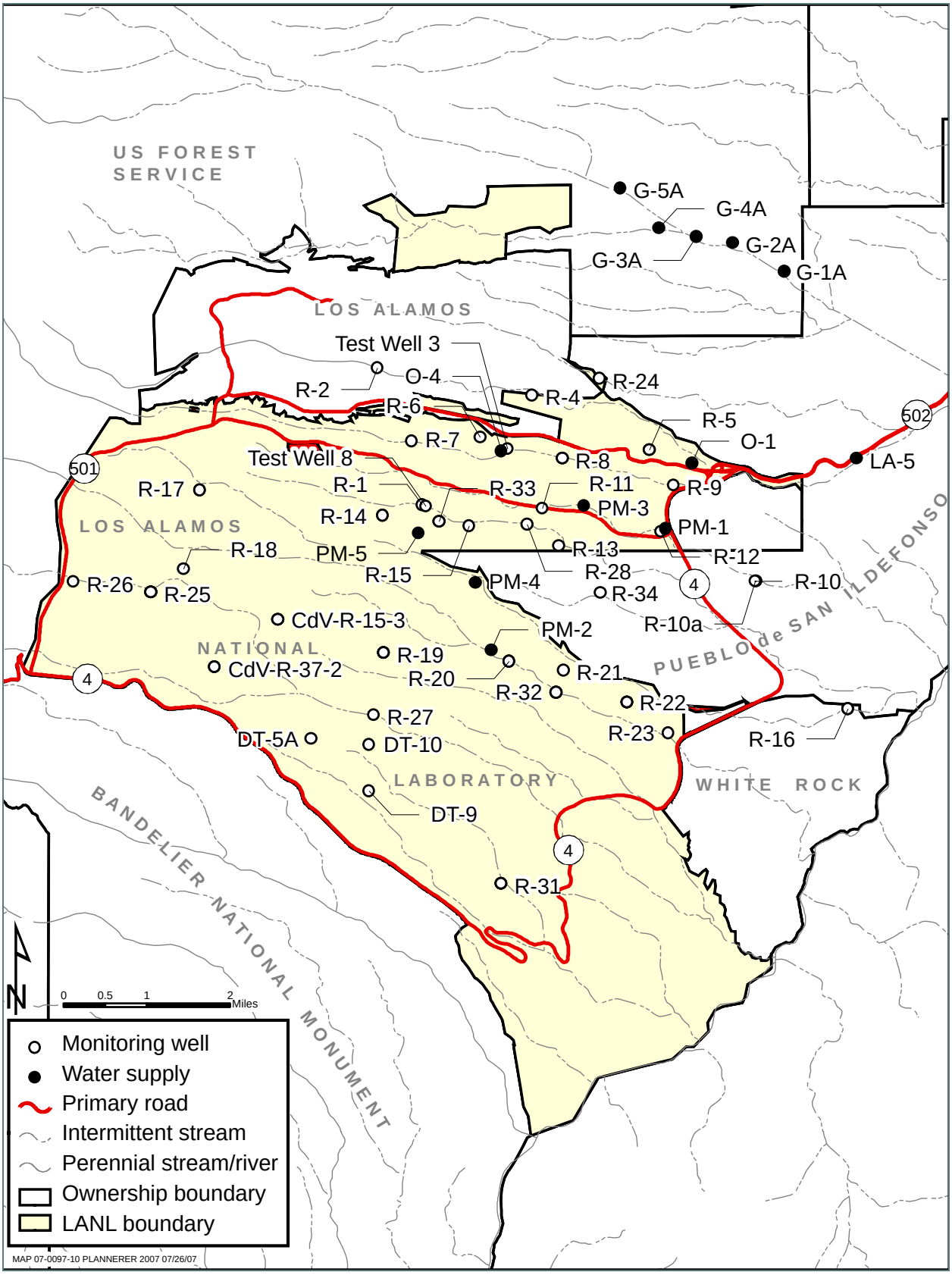


Figure 5-8. Wells used for regional aquifer monitoring.

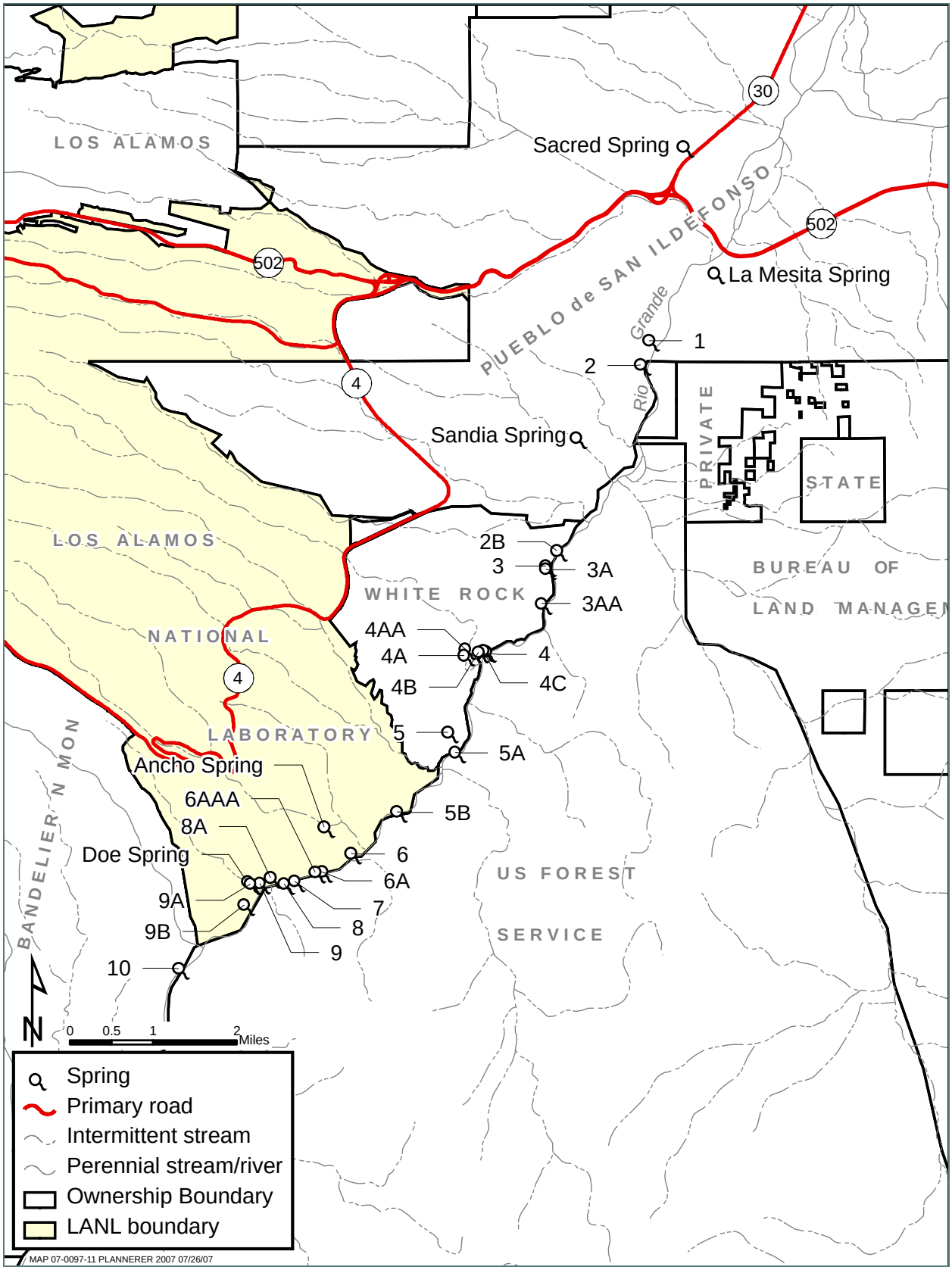


Figure 5-9. Springs used for regional aquifer monitoring.

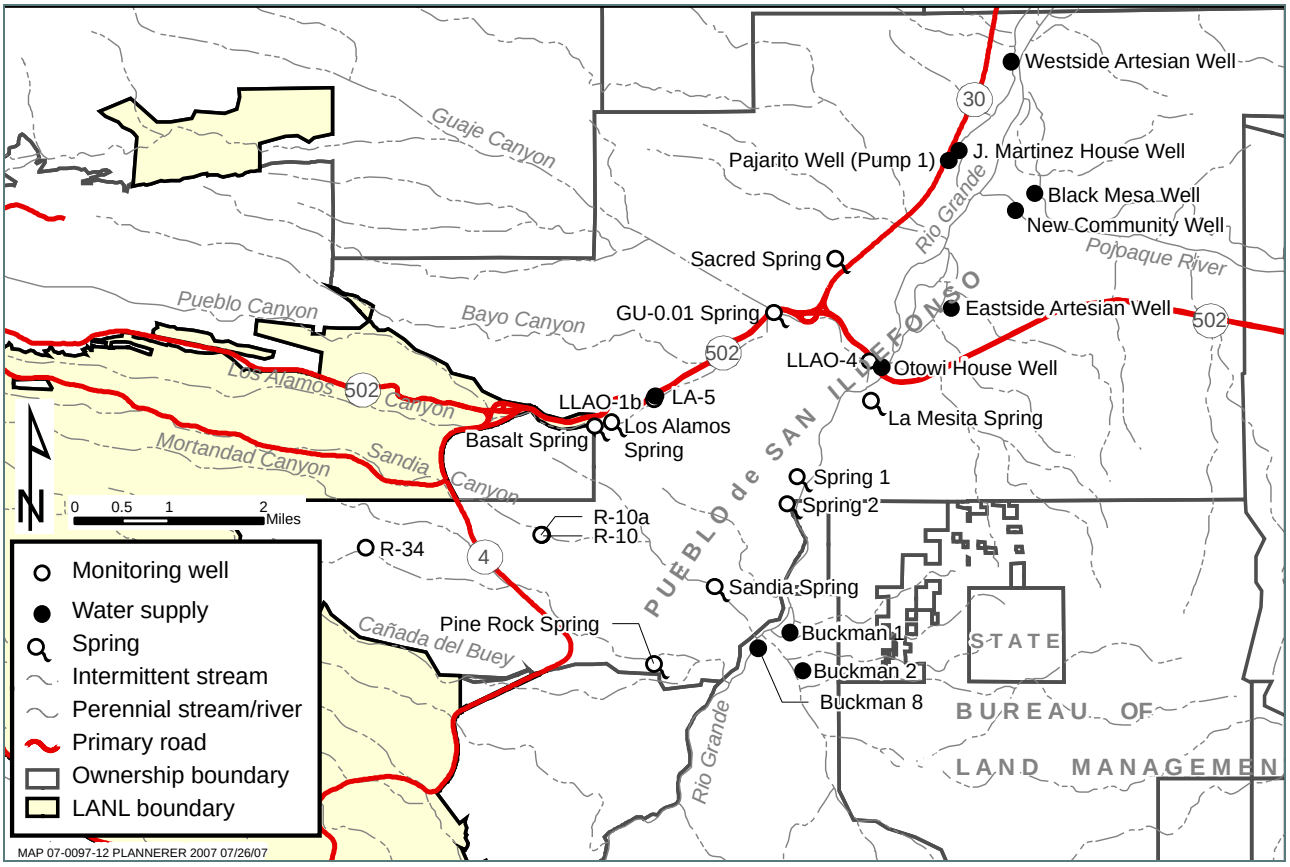


Figure 5-10. Springs and wells used for groundwater monitoring at the City of Santa Fe Buckman well field and on Pueblo de San Ildefonso.

Water quality monitoring results are given in accompanying supplemental data tables (on included compact disk), which include results for several boreholes. The water quality results from borehole samples are for screening purposes and used to guide further investigation. Borehole samples cannot be used to accurately evaluate aquifer conditions because they are a mixture of high-turbidity water affected by drilling fluids and a large portion of the borehole. Following well installation, well development is used to remove aquifer and drilling materials from the well before sampling.

LANL conducts a regular program of water level measurements for monitoring wells. A summary of groundwater level measurements for 2006 is given in Allen et al. (2007).

1. Regional Aquifer and Intermediate Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. Wells recently constructed under the Hydrogeologic Workplan (LANL 1998) are intended for additional groundwater characterization efforts and to extend the Laboratory's groundwater monitoring system. Several of these wells were added to the monitoring well network beginning in 2002. New wells completed in 2006 are described in Chapter 2, section B.9.b.

In the 1950s and 1960s, the Laboratory located the first eight regional aquifer monitoring wells where they might detect contaminants infiltrating from areas of effluent disposal or underground weapons-testing operations. Newer characterization wells have been installed beginning in 1998. Some of these newer wells penetrate down to 600 ft or more into the regional aquifer, and several have multiple sampling ports within

intermediate perched zones and the regional aquifer. A column on the supplemental data tables identifies the groundwater zones sampled by different ports of these wells and gives the depth of the port or top of the well screen.

The Laboratory collects samples from 12 Los Alamos County water supply wells in three well fields that produce water for the Laboratory and the community. The water supply wells are screened up to lengths of 1,600 ft within the regional aquifer, and the wells draw samples that integrate water over a large depth range. Los Alamos County owns and operates these wells. The County is responsible for demonstrating that the supply system meets Safe Drinking Water Act requirements. This chapter reports on supplemental sampling of those wells by the Laboratory.

Additional regional aquifer samples come from wells located on Pueblo de San Ildefonso and from the Buckman well field operated by the City of Santa Fe.

We sample numerous springs near the Rio Grande because they represent natural discharge from the regional aquifer (Purtymun et al., 1980). Sampling the springs allows us to detect possible discharge of contaminated groundwater from underneath the Laboratory into the Rio Grande.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, we use shallow wells and some springs to sample perched alluvial groundwater in several canyons. In any given year, some of these alluvial observation wells may be dry, and water samples cannot be obtained. Some observation wells in Water, Fence, and Sandia Canyons have been dry most often since their installation in 1989. All but one of the wells in Cañada del Buey are generally dry.

3. Well Sampling Issues

In some LANL characterization wells, the use of fluids to assist well drilling has affected the chemistry of groundwater samples. From 1998 through 2006, over 40 new wells were drilled for hydrogeologic characterization beneath the Pajarito Plateau as part of the Laboratory's Hydrogeologic Workplan (LANL 1998) or as part of corrective measures. Of the new wells, some have screens in perched intermediate zones, most have screens in the regional aquifer, and a few have screens in both perched intermediate zones and the regional aquifer. Concerns about the reliability or representativeness of the groundwater quality data obtained from these wells stem from the potential for residual drilling fluids and additives to mask the present and future detection of contaminants.

New wells undergo extensive well development to reduce the turbidity of water samples and to remove drilling fluids from the rock formations. Effects of drilling fluid on water quality appear to linger longer in multiple completion wells than in single completion wells because the latter can be developed more vigorously. Well screens installed in lower permeability zones are also difficult to develop. The quality of water samples from single screen wells may also be better because they can be purged when sampled.

Most Pajarito Plateau groundwater is under chemically oxidizing conditions, meaning that free oxygen is dissolved in the water. Addition of organic matter in drilling fluids into the aquifer near a well stimulates bacterial activity, which reduces available oxygen and changes the chemical behavior of several constituents found in groundwater and adjacent aquifer material. With reducing conditions (absence of oxygen), the solubility of metals such as manganese and iron increases, and they are dissolved from the surface of minerals that make up the aquifer's rock framework or possibly from well fittings. Several other chemical constituents may also increase or decrease in concentration as a result of the mainly temporary effect of the drilling fluids on the region near the well (Bitner 2004, ERSP 2005).

The Well Screen Analysis Report (LANL 2007b) provided a geochemical evaluation of 80 screens in 42 wells that had been completed and sampled as of December 2006. The report concluded the following:

- The most common drilling artifact is the presence of reducing conditions.
- Single-screen wells show the least impact from residual drilling fluids.
- The majority of the screens in multiple-screen wells are impacted by residual drilling fluids.
- However, nearly all multiple-screen wells have at least one screen interval rated as good or very good for measuring water quality.
- A vast majority of the screens were able to detect strontium, barium, and zinc. Fewer were able to detect uranium.
- 46% of the screens detected the presence of residual organics from drilling fluids. Organics with a high organic-carbon partition coefficient would not be detected reliably in the presence of residual organic drilling fluids.
- 45% of the screens detected the presence of various stages of reducing conditions.
- Tritium and RDX can be detected reliably in all screens. Strontium-90 can be detected in 91% of the wells. Percentages of detection range from 46% to 76% for other potential contaminants, with the exception of TNT, which could only be detected 31% of the time. The capability of detecting potential contaminants was higher for single-screen wells.

As a result of the first well screen assessment conducted in 2005 (ERSP 2005), LANL began a pilot study to rehabilitate wells R-12, R-16, and R-20. During late summer-autumn of 2006, the sampling systems were removed from these wells and they were purged extensively and jetted. A more aggressive hydropulse system was used in R-20. Preliminary results of the pilot rehabilitation produced were reported in the Pilot Well Rehabilitation Study Summary Report (LANL 2007c).

E. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables present groundwater monitoring data for 2006. Columns on the data tables identify the groundwater zones sampled—whether alluvial, intermediate, or regional; the latter includes water supply wells—or indicate if the location is a spring. For wells with several sampling ports, the depth and groundwater zone sampled for each port appear in the table. For single-screen wells, the depth of screen top is given. Springs have a depth of 0 ft, and wells with unknown depth list a value of –1. Supplemental Data Table S5-1 provides definitions for sample description codes used in the data tables.

Table S5-2 lists the results of radiochemical analyses of groundwater samples for 2006. The table also gives the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results from analyses done by the University of Miami.

Table S5-4 lists radionuclides detected in groundwater samples, as reported by the analytical laboratory. For most radionuclide measurements, we report a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (which indicates that the result is a nondetect). The analytical laboratory reports as detected a result that is greater than the measurement-specific MDA. University of Miami tritium data do not have laboratory qualifiers; in that case, a result is reported as detected when analytical results are greater than three times the reported (one-sigma) uncertainty.

Data with qualifier codes other than X or U are shown in Table S5-4 to provide additional information on analytical results; in some cases, for example, the analyte was found in the laboratory blank, or there were other analytical issues. The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7). After we receive the analytical laboratory data packages, the packages receive secondary validation by an independent contractor, Analytical Quality Associates (AQA). The reviews by AQA include verifying that holding times were met, that all documentation is present, and that analytical laboratory quality control measures were applied, documented, and kept within contract requirements.

Because uranium, gross alpha, and gross beta are usually detected in water samples and to focus on the higher measurements, Table S5-4 only includes occurrences of these measurements above threshold values (all of the results are included in Table S5-2). We selected threshold levels of 5 µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta, which are lower than the respective EPA MCLs or screening levels (30 µg/L for uranium, 15 pCi/L for gross alpha, and 50 pCi/L for gross beta). The right-hand columns of Table S5-4 compare results to the standards shown on the table.

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2006. Table S5-9 lists groundwater perchlorate results. We analyzed samples for perchlorate using two methods. This table includes all perchlorate results determined by the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method (now EPA 6850 Modified, formerly SW-846:8321A[M]) and all detections by the ion chromatography (IC) method (EPA:314.0). The method detection limit (MDL) for the IC method is 4 µg/L; the LC/MS/MS method MDL is 0.05 µg/L or larger if the sample had higher concentrations and was analyzed using sample dilution. We use both methods because LC/MS/MS by SW-846 6850 (or EPA 6850 Modified) for perchlorate has not yet been officially promulgated by the EPA. The results of trace metal analyses appear in Table S5-10.

As part of the rehabilitation pilot study, three wells (R-12, R-20, and R-16) underwent redevelopment and testing during 2006 to improve sample quality. Results for those tests and accompanying sampling are covered in a separate report (LANL 2007c) but are not included here.

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross the Laboratory. The accompanying maps depict the location of groundwater contaminants. The maps provide a spatial context for distribution of groundwater contamination. Rather than showing data for 2006 alone, the maps represent a synthesis of the last several years of groundwater data collected for Laboratory groundwater monitoring and characterization programs.

The contaminant distribution maps show contaminant locations extrapolated beyond the area covered by monitoring wells. This extrapolation takes into account the location of contaminant sources and direction of groundwater flow. Question marks on the maps indicate where contaminant extent is inferred but not confirmed by monitoring coverage. For alluvial groundwater in canyons, the extent of contamination lateral to the canyon is not to scale; contaminated groundwater is confined to the canyon bottom alluvium and is quite narrow at the map scale.

1. Organic Chemicals in Groundwater

In 2006, we analyzed samples from selected springs and monitoring wells for organic constituents. Table S5-11 summarizes stations sampled and organic chemical suites for which samples were analyzed. These samples were analyzed for some or all of the following organic chemical suites: volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, diesel-range organics (DROs), and HEs. The Quality Assurance (QA) Section of this chapter (Section H) covers analytes and analytical methods. Many of the possible organic detections that the analytical laboratory reported were

rejected because the compounds were either detected in method blanks (that is, they were introduced during laboratory analysis) or were detected in field quality control (QC) samples, including equipment, field, and trip blanks. Equipment blanks use distilled water with which sampling equipment is rinsed before sampling to check for organic contamination acquired during sampling. Trip blanks accompany samples during sample preparation, transportation, and shipment to determine if organic contamination occurs. Table S5-12 shows organic compounds detected in 2006 and results from field QC samples.

A large number of groundwater samples were analyzed for dioxins and furans in 2006. Only two of these compounds have screening levels or regulatory standards. These values are about the same magnitude as the detection limits. The method is quite sensitive and these compounds were found near the detection limit in a large number of samples. See the QA Section for more discussion on this topic.

a. Organic Sample Quality Control Program. Because of the sensitive nature of organic chemical sampling and analysis, a carefully designed field and analytical laboratory quality control program is essential for evaluating the presence of organic constituents in environmental samples. Organic analytes may be detected in field quality control samples such as field blanks or equipment blanks, indicating that they are not truly present in associated groundwater samples. These analytes may be present in the quality control samples because of inadvertent contamination of sampling or analytical laboratory equipment by organic constituents that come from other sources.

Most analytical methods require the analysis of laboratory-prepared method blanks or instrument blanks with each batch of samples. Target organic chemicals that are detected in these blanks indicate contamination from the sampling or analytical environments. Certain organic compounds used in analytical laboratories are frequently detected in laboratory blanks, that is, contamination introduced by the analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993). Numerous field, trip, and equipment blanks collected during this reporting period contained toluene, acetone, butanone[2-], and hexanone[2-], which indicates inadvertent sample contamination in either the field or analytical laboratory.

2. Radioactivity in Groundwater

In 2006, other than for naturally occurring radionuclides (for example, radium-226 and uranium-234), no water supply radioactivity analyte activity or concentration value exceeded the 4-mrem DOE DCGs applicable to drinking water. One regional aquifer result exceeded a 4-mrem DOE DCG, but that standard is mentioned for comparison purposes as it is not applicable to the sample: this was the result for neptunium-237 in monitoring well R-27, located in Water Canyon. The preponderance of nondetections for neptunium-237 in samples collected on that date indicates that the detected result is a false positive. No other regional aquifer radioactivity results were greater than regulatory standards.

Otherwise, the main radioactive element detected in the regional aquifer is naturally occurring uranium, found in springs and wells throughout the Rio Grande Valley. The large gross alpha values found in samples from these springs and wells result from the decay of naturally occurring uranium in the water. Other naturally occurring radioactivity in groundwater samples comes from members of the uranium-235, uranium-238, and thorium-232 decay chains. Potassium-40 is also a source of natural radioactivity.

For well and spring samples from intermediate perched groundwater, other than for naturally occurring radionuclides, no results exceeded the 4-mrem DOE DCG screening levels (Table 5-1). Three wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 25% to 60% of the EPA MCL (screening level) of 20,000 pCi/L. Pine Rock Spring on Pueblo de San Ildefonso had a uranium concentration of 32 µg/L (above the NM groundwater standard of 30 µg/L) and related gross alpha of 29 pCi/L. The high uranium value may be due to dissolution of uranium from the bedrock by sanitary effluent, which

is used to water athletic fields at nearby Overlook Park (Teerlink 2007). This is because the effluent represents additional water passing through the rock and sanitary effluent dissolves uranium from the bedrock.

Pajarito Canyon intermediate monitoring well R-23i at 534 ft had one gross alpha value of 17 pCi/L in an unfiltered sample; while there is no applicable groundwater standard, for comparison purposes, the MCL is 15 pCi/L. This sample had an extraordinarily high turbidity of 785 NTU (nephelometric turbidity units); the higher than usual gross alpha, gross beta, and uranium values for this sample probably reflect natural radioactivity of aquifer material incorporated in the sample.

There are no applicable groundwater standards for radioactivity from a DOE (LANL) source in perched alluvial groundwater, however, for comparison purposes, results for the following constituents were near or exceeded the 4-mrem DOE DCGs: plutonium-239,240 in Pueblo Canyon; and strontium-90 from alluvial groundwater in Mortandad and DP/Los Alamos Canyons. Again, for comparison purposes in the absence of applicable groundwater standards, the maximum strontium-90 values in alluvial groundwater from Mortandad and DP/Los Alamos Canyon were above the EPA MCL of 8 pCi/L (Figure 5-11).

While there are no applicable groundwater standards, for comparison purposes, total LANL-derived radioactivity exceeded the 4 mrem DOE DCG in alluvial groundwater samples from Pueblo Canyon (plutonium-239,240 and americium-241 in PAO-2 and APCO-1), Los Alamos Canyon (plutonium-239,240, americium-241, and strontium-90 in DP Spring and well LAUZ-1), and Mortandad Canyon (tritium, plutonium-238, plutonium-239,240 americium-241, and strontium-90 in wells MCO-4B and MCO-6) (Figure 5-12). While there are no applicable groundwater standards, for comparison purposes, the highest total radioactivity in 2006 was found in MCO-4B, above the 4 mrem DCG. These high radioactivity values are not directly related to turbidity, which, in these wells is both relatively high and also variable with time. While there are no applicable groundwater standards, for comparison purposes, gross beta values in some samples from alluvial wells in Mortandad and DP/Los Alamos Canyon exceeded the EPA 50 pCi/L drinking water screening level. The gross beta activity in these wells likely is due to presence of strontium-90.

3. Perchlorate in Groundwater

During the last decade, the EPA recognized the potential for perchlorate toxicity at concentrations in the µg/L range. Based on a new toxicity assessment by the National Academy of Sciences, the EPA set a Drinking Water Equivalent Level of 24.5 µg/L for perchlorate in 2006. The March 2005 NMED Order on Consent for LANL mandates a 4 µg/L screening level for perchlorate. Several studies indicate that perchlorate occurs naturally in groundwater of arid regions due to atmospheric deposition and other sources. Plummer et al. (2006) found perchlorate concentrations ranging from 0.12 µg/L to 1.8 µg/L in samples of north-central NM groundwater that have ages predating anthropogenic influence and that are not affected by industrial perchlorate sources. Perchlorate concentrations in Mortandad Canyon groundwater are much above background as a result of past effluent discharges. Otherwise perchlorate concentrations are near the values found by Plummer et al. (2006).



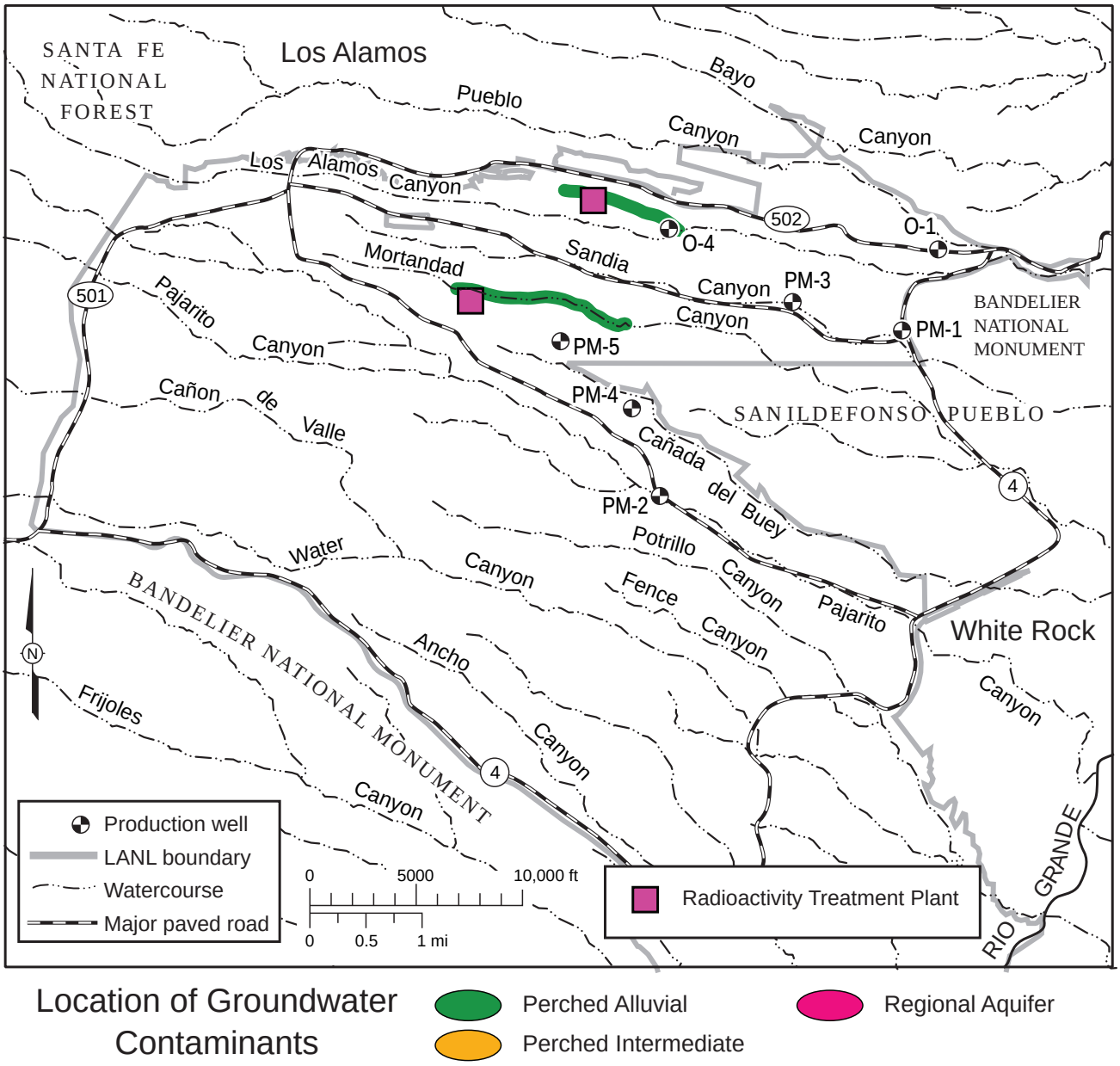


Figure 5-11. **Location of groundwater contaminated by Sr-90: while there is no applicable groundwater standard, for comparison purposes, the area indicated has Sr-90 activity above the 8 pCi/L EPA MCL. Different colors indicate the affected groundwater zones. Along canyons, the extent of alluvial groundwater contamination lateral to the canyon is not to scale; contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.**

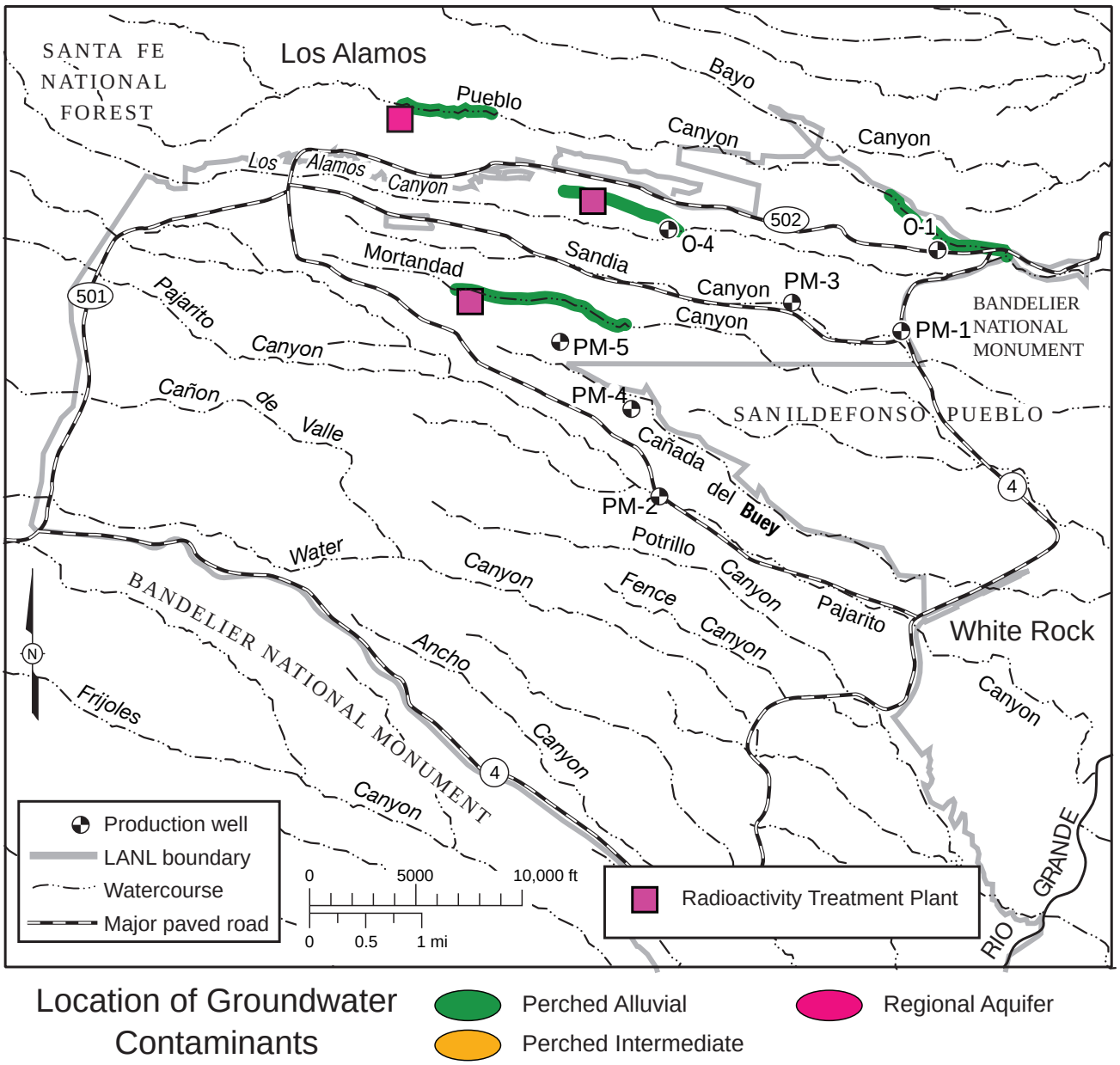


Figure 5-12. Location of groundwater contaminated by radioactivity: while there is no applicable groundwater standard, for comparison purposes, samples from the area indicated have the sum of Sr-90, Pu-238, Pu-239,240, and Am-241 above the 4-mrem DOE DCG. Different colors indicate the affected groundwater zones.

4. Metals in Groundwater

In 2005 LANL found hexavalent chromium in Mortandad Canyon regional aquifer monitoring well samples at levels above the NM groundwater standard and in intermediate-depth groundwater at levels just below the NM groundwater standard. Hexavalent chromium has also been found in a Sandia Canyon regional aquifer well as discussed below. In alluvial groundwater beneath Cañon de Valle, barium occurs at concentrations above the NM groundwater standard. Molybdenum concentrations have been near the NM groundwater

standard (for irrigation use) in Los Alamos Canyon alluvial groundwater for over a decade. Other metals occur in groundwater at concentrations near or above regulatory standards. This may be because of issues related to well sampling and well construction, rather than being from LANL releases.

In addition to the effect of drilling fluids, well samples may have relatively high turbidity. The presence in water samples of residual aquifer or soil material leads to detection of metals such as aluminum, iron, and manganese, which are primary constituents of the silicate and other minerals that make up the aquifer framework. These effects of turbidity on water quality are also seen in many samples from alluvial wells and springs (in the case of springs, because they incorporate surrounding soil material).

The older LANL test wells have steel casings and galvanized metal well fittings that are subject to rust and metal flaking. Over time and with wear, corrosion, and work on the wells, water samples have shown increasing content of metals like iron, lead, manganese, and zinc.

In 2005, a number of groundwater samples had selenium results that exceed the NM Livestock Watering Standard of 5 µg/L. All but one of these results were analyzed using SW-846:6010B, which has a nominal detection limit of 6 µg/L. In 2006, selenium samples were analyzed with SW-846:6020, which has a detection limit of 2.5 µg/L; selenium was not detected in any groundwater sample in 2006.

F. GROUNDWATER SAMPLING RESULTS BY WATERSHED

1. Guaje Canyon (includes Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities (Table 5-2). The Guaje well field, located northeast of the Laboratory, contains five water supply wells. No tritium was detected in low-detection-limit (1 pCi/L) analysis of samples from these wells (Table S5-3). Groundwater with such tritium activity below approximately 1.6 pCi/L is probably old and isolated from surface recharge. The age of such groundwater is more than 3,000 years, but large dating uncertainties may be associated with small tritium activities (Blake et al., 1995). Rendija and Barrancas Canyons have seen little past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

Table 5-2
Summary of Groundwater Contamination in Guaje Canyon
(includes Rendija and Barrancas Canyons)

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
Guaje, Rendija, and Barrancas Canyons	Minor dry sources	None, alluvial groundwater only in upper Guaje Canyon	No intermediate groundwater	Natural arsenic above MCL

Perchlorate was found in each of the five wells in the Guaje well field at concentrations ranging from 0.31 to 0.41 µg/L, which is consistent with background levels and prior findings. G-1A and G-2A both had arsenic at about 83% of to above the EPA MCL of 10 µg/L. This naturally-occurring arsenic has been found in this well field at such levels during its entire history.

2. Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyons)

Bayo Canyon contained a now-decommissioned firing site. The canyon has only ephemeral surface water, and no known alluvial or intermediate groundwater (Table 5-3).

Table 5-3
Summary of Groundwater Contamination in Los Alamos Canyon
(includes Bayo, Acid, Pueblo, and DP Canyons)

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Bayo Canyon	Minor past dry and liquid sources	No alluvial groundwater	No intermediate groundwater	None
Pueblo and Acid Canyons	Multiple past effluent discharges, current sanitary effluent	Plutonium-239,240, arsenic	Nitrate at 50% of NM GW Std., fluoride at 70% of NM GW Std.	Fluoride at 50% of NM GW Std., trace perchlorate and nitrate
Los Alamos and DP Canyons	Multiple past effluent discharges	Strontium-90, fluoride at 65% of NM GW Std.	None	None
Lower Los Alamos Canyon	Multiple past effluent discharges	Nitrate above NM GW Std.	Nitrate above NM GW Std.	None

Pueblo Canyon receives effluent from Los Alamos County's Bayo Sewage Treatment Plant. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity is found in current groundwater samples. Tritium and perchlorate results from regional aquifer groundwater in this canyon, though below standards, indicate the lingering influence of past discharges from radioactive wastewater outfalls in Acid Canyon. High nitrate concentrations found in alluvial and intermediate groundwater may be due to sanitary effluent from the Los Alamos County Bayo Sewage Treatment Plant.

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at Technical Area (TA)-1 (1942–1945) and until 1993 from nuclear reactors at TA-2. From 1952 to 1986, a liquid-waste treatment plant discharged effluent containing radionuclides from the former plutonium-processing facility at TA-21 into DP Canyon, a tributary to Los Alamos Canyon. Los Alamos Canyon also received radionuclides and metals in discharges from the sanitary sewage lagoons and cooling towers at the Los Alamos Neutron Science Center (LANSCE) at TA-53. Except for strontium-90, contaminant concentrations in shallow groundwater have decreased dramatically over the years.

a. Pueblo Canyon. Low-detection-limit tritium results for supply well O-1 in 2006 were about 21 pCi/L; values have fallen by a factor of two since the end of 2004. The tritium level indicates the diluted presence of past tritium-bearing surface water recharge in the regional aquifer. Four O-1 samples showed perchlorate at an average of 1.8 µg/L; perchlorate concentrations have also fallen, from an average of 2.7 µg/L in 2004. O-1 had an above-background nitrate as nitrogen concentration of 0.9 mg/L in 2006 (compared to an MCL of 10 mg/L); the nitrate concentration in 2005 was 1.4 mg/L.

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, shows low-detection-limit tritium values indicative of past discharges. The values range up to 58 pCi/L. Tritium was not detected in samples from R-2, located between the outfall site and R-4, or farther downstream in R-5.

Regional aquifer nitrate and perchlorate values are also near background at R-2. R-4 and R-5 showed nitrate (as nitrogen) at up to 20% of the 10-mg/L NM groundwater standard. R-4 samples contained fluoride at 50% of the 1.6 mg/L NM groundwater standard (Figure 5-13); fluoride values in samples from this well have been steady since 2005. Perchlorate was at background in R-2, and at the highest concentration for these wells, of 4 µg/L, in R-4. Father downstream, R-5 had a perchlorate concentration of 1.2 µg/L.

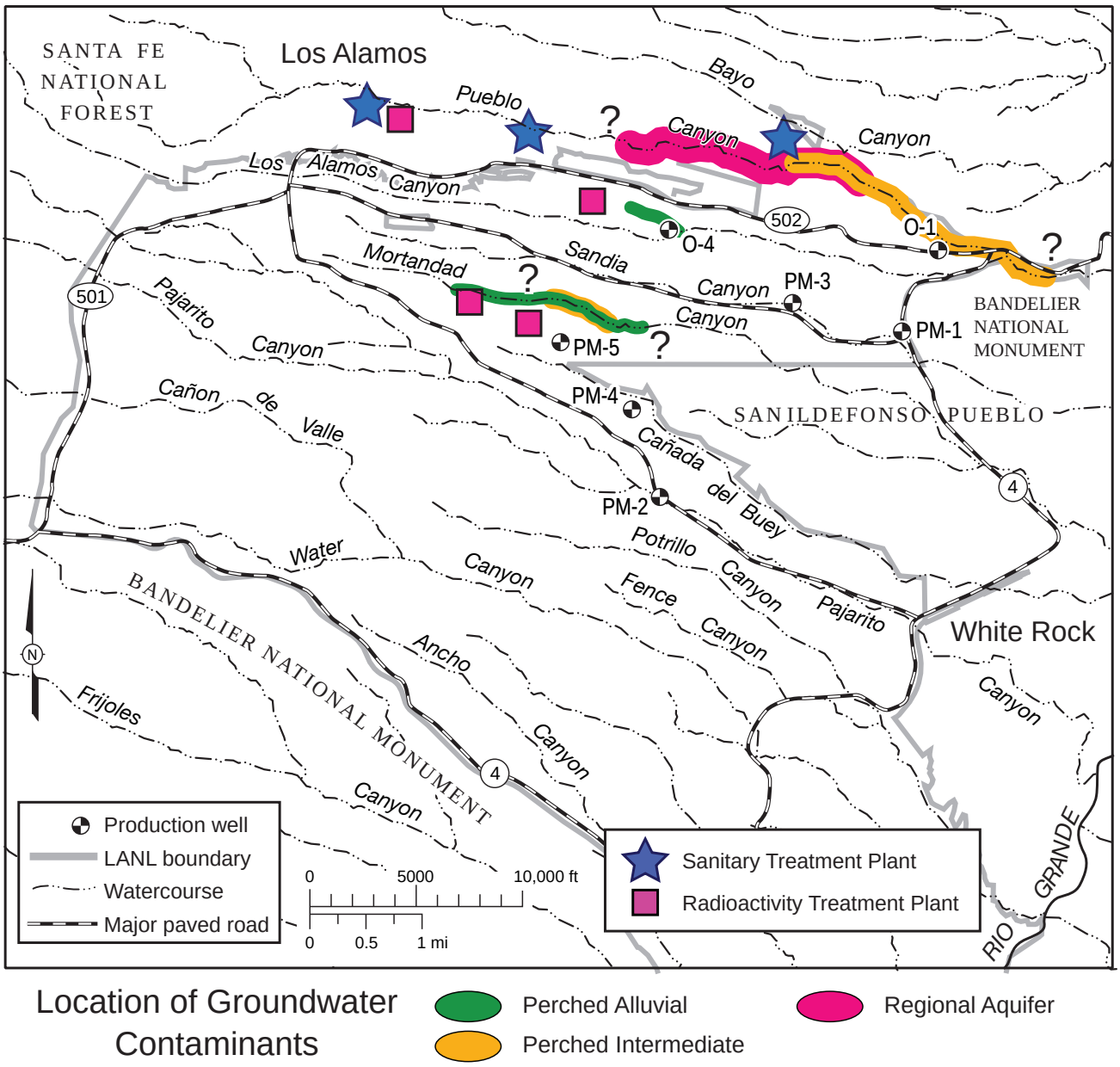


Figure 5-13. Location of groundwater containing fluoride above one half of the 1.6 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

A sample from Pueblo Canyon intermediate well R-3i had a uranium concentration of 7.8 µg/L, above levels in background wells. The higher uranium may result from dissolution of uranium from surrounding bedrock by sanitary or other effluent (Teerlink 2007). Low-detection-limit tritium values in intermediate wells ranged from nondetection in R-5 to 21 pCi/L in POI-4 and 74 pCi/L in R-3i. R-5 showed 1.1 mg/L of fluoride in the intermediate zone at 66% of the NM groundwater standard, which is similar to prior data (Figure 5-13). POI-4 had 5 mg/L of nitrate (as nitrogen) or 50% of the 10 mg/L NM groundwater standard (Figure 5-14). This is the highest nitrate value measured to date in this well; prior values have ranged from 3 mg/L to 4 mg/L; nearby intermediate-depth wells have also shown values in this range. Perchlorate values from the intermediate zone were nondetection or near background values, except for a result of 1.65 µg/L from R-5. A sample from R-3i had diesel range organics just above the detection limit; however, the analytical laboratory found that it had incorrectly determined the MDL for this analyte.

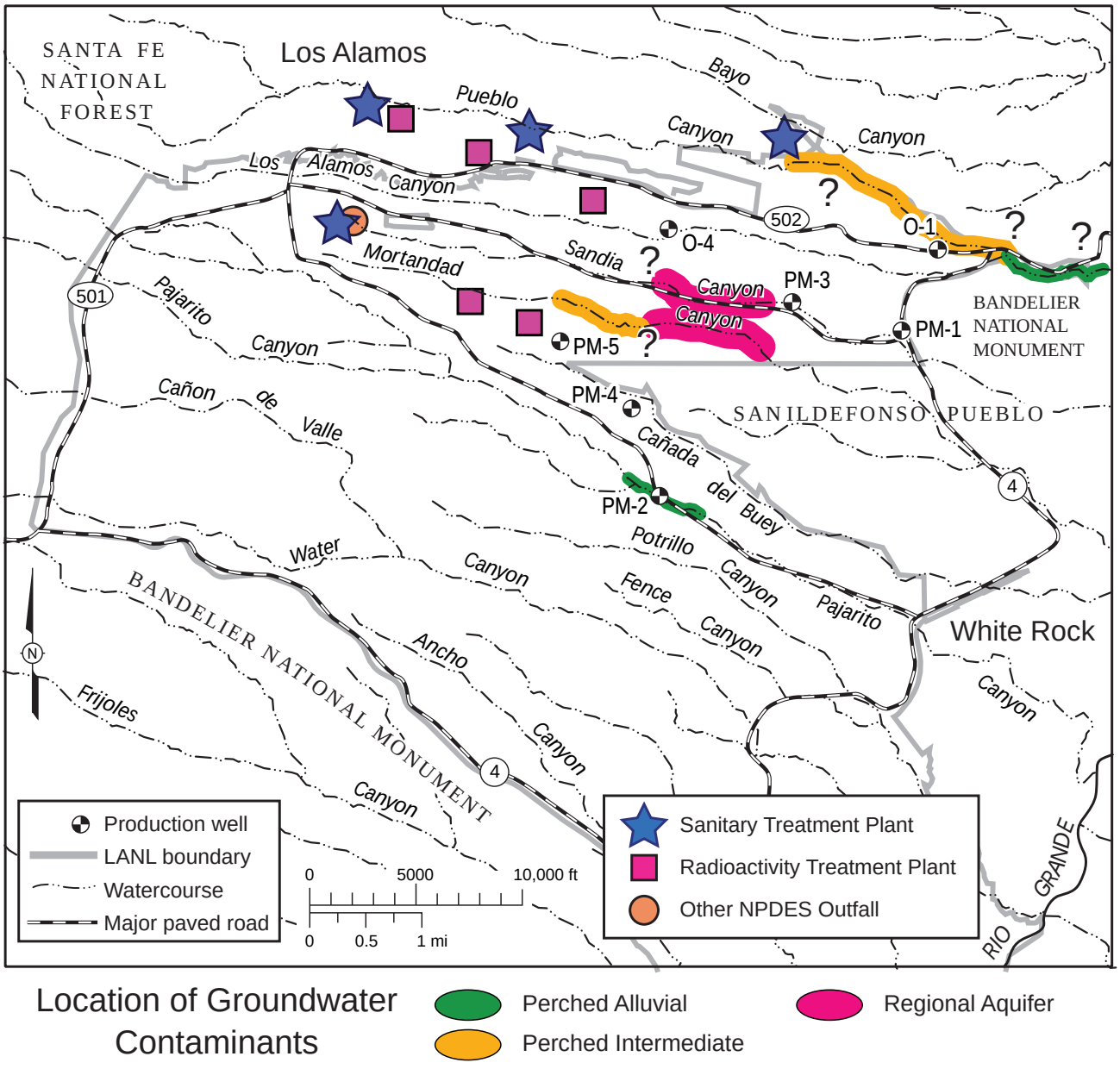


Figure 5-14. Location of groundwater containing nitrate (as nitrogen) above one half of the 10 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones.

On several days in August 2006 (including August 7, 8, and 25) large rainstorms caused significant runoff in Pueblo Canyon. All of the alluvial wells were flooded and PAO-3 was washed away. Several of these wells were sampled immediately after flooding (on August 8 and 10). The sample quality indicates that the wells were impacted by being submerged; apparently surface sediment was forced down along the well casing. This sediment could have carried radioactive and other chemical constituents into the well screens. The filtered and unfiltered aluminum values in APCO-1 are the highest (by a factor of 10) observed in that well to date. The turbidity value for this sampling event was high– 85 NTU, higher than the prior high of 19 NTU and the more usual 5 NTU. Aluminum values in PAO-1, sampled two days later than APCO-1, are also much higher than most prior values (except for those measured in 2005). Turbidity in PAO-1 was 10 NTU, similar to one prior value; therefore, the elevated aluminum in PAO-1 is apparently not related to turbidity in this instance. Alternatively, turbidity may have varied considerably during purging and sampling.

All four sampled alluvial wells in Pueblo Canyon had strontium-90 at values ranging from 6% to 19% of the 8-pCi/L EPA MCL screening level. Three wells had detectable plutonium-239,240 as in prior years. The unfiltered plutonium-239,240 result for APCO-1 (1.5 pCi/L) exceeds the prior highest result by a factor of 10; there is no applicable groundwater standard for this sample, however, for comparison purposes, the 4 mrem DOE DCG is 1.2 pCi/L. Again, for comparison purposes in absence of an applicable groundwater standard, an unfiltered plutonium-239,240 result in PAO-2 (1.17 pCi/L) is just below the 4 mrem DOE DCG (Figure 5-12). The filtered results for plutonium-239,240 in these groundwater samples are much lower (0.0691 pCi/L and 0.271 pCi/L, respectively). The elevated results for unfiltered plutonium-239,240 may also be attributed to elevated turbidity and entry of surface sediment into the well screen, resulting from the August 2006 flooding.

b. Los Alamos Canyon. Low values of tritium were found in a few regional aquifer wells in Los Alamos Canyon, indicating a small contribution from recent recharge. Values in Test Well 3 and R-9 were 15 pCi/L and 11 pCi/L, respectively, while results from other wells were nondetections. The perchlorate concentration in R-9 was 0.98 µg/L, while other regional aquifer and supply wells in Los Alamos Canyon were at background, that is, below 0.6 µg/L. Several of the newer regional aquifer wells had high levels in samples of aluminum, iron, and manganese due to drilling fluid or turbidity effects.

Isopropyl benzene was found for the first time just above the detection limit in R-9. This compound has been found in several other wells and apparently is derived from decomposition of residual drilling materials. Because of a leaking fuel tank found at TA-21 during 2002, supply well O-4 was sampled four times during 2005 for diesel range organics; none were detected.

Samples from intermediate wells LAOI(a)-1.1 and LAOI-7 had detections of americium-241 and plutonium-238, respectively. However, these detections were near the MDA and not repeated in other samples, indicating that the results are false positives. Basalt Spring, which is fed by intermediate groundwater, is in lower Los Alamos Canyon on Pueblo de San Ildefonso land. A filtered sample contained strontium-90 just above the detection limit, as in some prior years. No strontium-90 was detected in the unfiltered sample. The latter result would be expected to be higher, so the filtered result may be a false positive or strontium-90 could be present near the detection limit.

Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained 4,300 pCi/L, 1,000 pCi/L, 3,180 pCi/L and 1,200 pCi/L of tritium, respectively. These moderate values indicate a residual impact of past effluent; the wells lie downstream from the former radioactive liquid waste discharge in DP Canyon. Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 also had 10 µg/L, 3 µg/L, 5 µg/L, and 0.9 µg/L of perchlorate, respectively.

Alluvial groundwater in DP and Los Alamos Canyons continues to show strontium-90; although there is no applicable groundwater standard, for comparison purposes, the values range up to and above the 8-pCi/L EPA MCL (Figure 5-11). Also for comparison purposes in absence of an applicable groundwater standard, the

strontium-90 values in DP Spring and well LAUZ-1 were respectively 78% of and above the 4-mrem DOE DCG (Figure 5-12). As in past years, several other LANL-derived radionuclides (plutonium, americium) were found in alluvial groundwater but at values well below the 4-mrem DCG screening levels. Tritium levels in alluvial groundwater in these two canyons have fallen sharply since the cessation of discharges. Tritium was present in 2006 samples at values between 31 pCi/L to 160 pCi/L.

In lower Los Alamos Canyon on Pueblo de San Ildefonso land, an unfiltered sample in LLAO-1b showed plutonium-239,240 well above the detection limit but at 15% of the 4-mrem DCG screening level. This was the first detection of plutonium-239,240 in the well. The sample was collected on August 9 after the first day of flooding that month. As described above, the flooding apparently forced surface sediments carrying radionuclides into the well screens.

Samples from DP Spring and LAO-2 in DP Canyon had fluoride concentrations at up to 65% of the NM groundwater standard (Figure 5-13). The fluoride is likely a residual of past effluent discharges into the canyon. The filtered and unfiltered nitrate (as nitrogen) results from samples at LLAO-1b were respectively 6.1 mg/L and 9.7 mg/L (Figure 5-14). The latter value is the highest measured in the well and is 97% of the NM groundwater standard. The source of nitrate may be releases into Pueblo Canyon from the Los Alamos County sanitary treatment plant. The nitrate (as nitrogen) concentration at nearby Basalt Spring was 91% of the standard.

Metals concentrations in alluvial wells in Los Alamos Canyon showed the effect of turbidity, with relatively high values of aluminum and iron. In Los Alamos Canyon, molybdenum in LAO-2 and LAO-3a has dropped to 30% of the NM groundwater standard, which is for irrigation use (Figure 5-15). The molybdenum came from cooling towers at TA-53 (LANSCE). Use of sodium molybdate was discontinued in June 2002. Molybdenum concentrations in Los Alamos Canyon alluvial groundwater have been quite variable in recent years, perhaps because of large variation in stream flow caused by drought conditions.

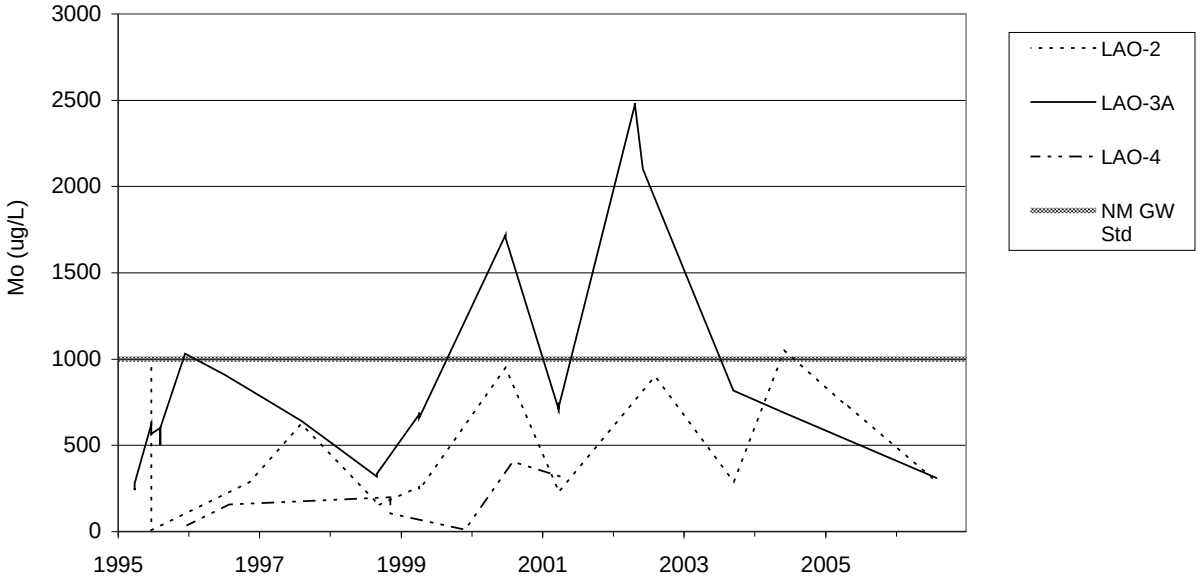


Figure 5-15. Molybdenum concentration histories in Los Alamos Canyon alluvial groundwater compared with the NM groundwater standard.

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives the largest liquid discharges of any canyon at the Laboratory from the cooling tower at the TA-3 power plant (Table 5-4). Treated effluents from the TA-46 SWWS Plant have been routed to Sandia Canyon since 1992. Chromate was used to treat cooling water at the power plant until 1972 (ESP 1973). These discharges are tentatively identified as the source for hexavalent chromium concentrations discovered in the regional aquifer beneath Sandia and Mortandad Canyons that are above the NM groundwater standard (Figure 5-16). Sandia and Mortandad Canyons lie close together, and water infiltrating beneath Sandia Canyon may have been diverted to the south by southwesterly dipping basalts prior to reaching the regional aquifer (ERSP 2006). In October 2006, chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon were 29 µg/L or 59% of the groundwater standard; other analyses show the chromium is in the hexavalent form.

Table 5-4
Summary of Groundwater Contamination in Sandia Canyon

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Sandia Canyon	Multiple liquid discharges	Arsenic	None	Hexavalent chromium at 59% of NM GW std., nitrate at 50% of NM GW std.

Samples from supply wells PM-1 and PM-3 showed no tritium using the method with a 1 pCi/L detection limit. Tritium activities in regional wells R-11 and R-12 were 11 pCi/L and 38 pCi/L respectively. Nitrate (as nitrogen) in R-11 was 51% of the NM groundwater standard, apparently due to past Laboratory sanitary effluent releases (Figure 5-14).

In Sandia Canyon, perchlorate values at supply wells PM-1 and PM-3 ranged from 0.40 to 0.45 µg/L, similar to prior results and within background. Perchlorate results were 0.1 µg/L in R-12 and averaged 0.73 µg/L in samples from R-11. The R-11 values are slightly above background. Organic compounds detected in well samples appear to result from inadvertent low-level contamination during analysis or sampling.

Tritium activities in intermediate groundwater samples from two screens at R-12 were 121 pCi/L and 14 pCi/L, decreasing with depth. Perchlorate was not detected in these samples.

Two new alluvial wells (SCA-1 and SCA-5) were sampled in Sandia Canyon. A set of samples from SCA-1 produced a nitrate result of 6 mg/L in one sample (60% of the NM groundwater standard), but nitrate was not detected in the other (Figure 5-14). It appears that a field preservation error caused the higher value.

A PCB, aroclor-1260, was found in the first sample from Sandia Canyon alluvial well SCA-1 at 6% of the NM groundwater standard. PCBs are present in sediment and runoff samples in this canyon. The turbidity in the sample from this 1.5-ft-deep well was 93 NTU.

4. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon has a small drainage area that heads at TA-3. This drainage area receives inflow from natural precipitation and a number of National Pollutant Discharge Elimination System (NPDES) outfalls, including one from the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35 (Table 5-5).

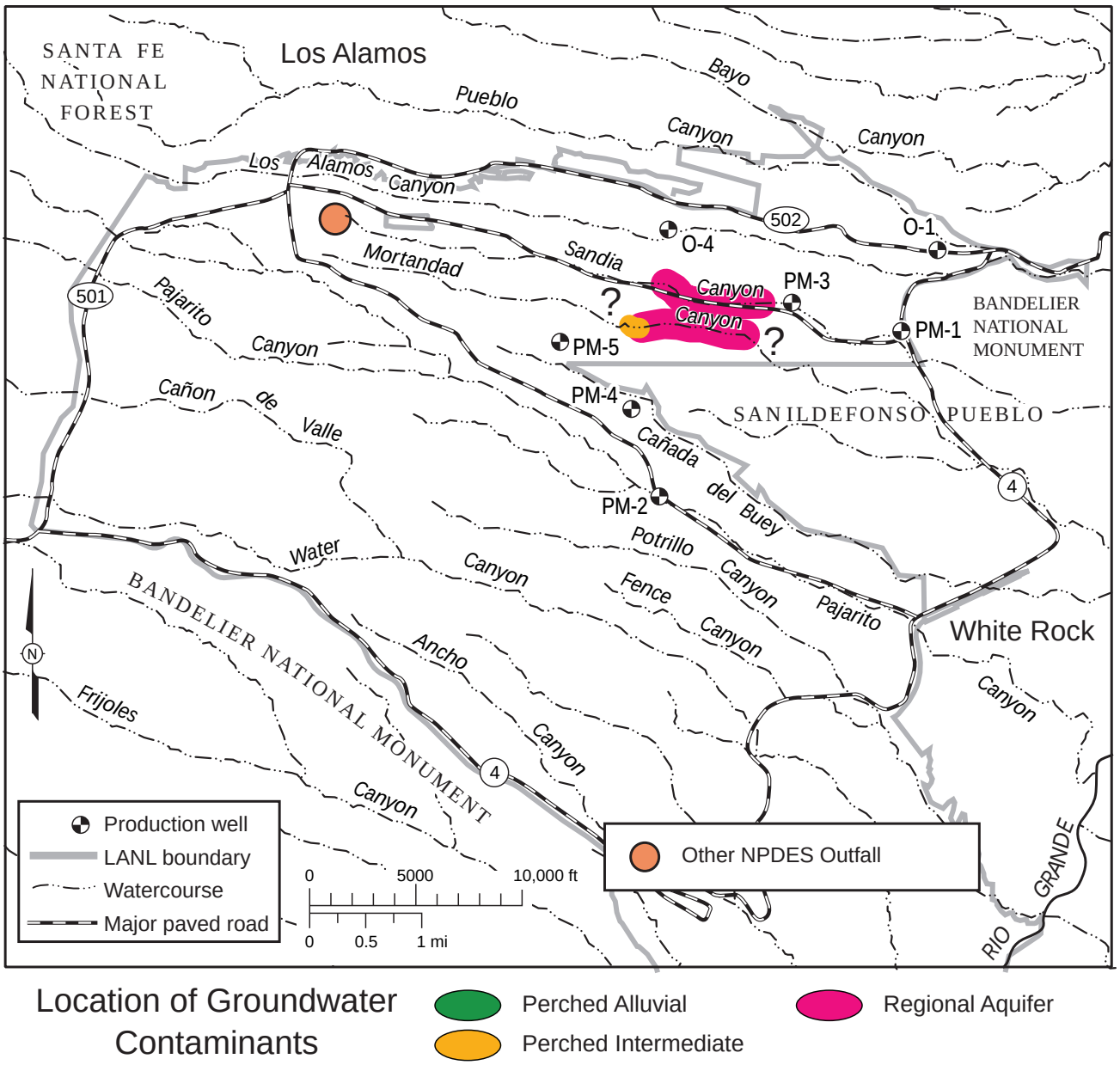


Figure 5-16. **Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard. Different colors indicate the affected groundwater zones.**



Table 5-5
Summary of Groundwater Contamination in Mortandad Canyon
(includes Ten Site Canyon and Cañada del Buey)

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
Mortandad and Ten Site Canyons	Multiple past and current effluent discharges	Chloride and fluoride above NM GW stds., strontium-90, perchlorate	Uranium, hexavalent chromium, nitrate, and fluoride above NM GW stds., tritium, perchlorate, bis(2-ethylhexyl)phthalate, dioxane[1,4-]	Hexavalent chromium above and nitrate at 45% of NM GW stds., trace perchlorate
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two observation wells have ever contained water. Because treated effluent from the Laboratory's SWWS facility at TA-46 may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture-monitoring holes was installed during 1992 within the upper and middle reaches of the drainage. Past discharges included accidental releases from experimental reactors and laboratories at TA-46.

a. 2006 Radioactive Liquid Waste Treatment Facility Discharges. Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2004 through 2006 appear in Supplemental Data Table S5-13. Table S5-13 shows mean annual levels in effluent for each radionuclide and the ratio of this to the 100-mrem DOE DCG for public dose. Figures 5-17 and 5-18 show the relationship of RLWTF average annual radionuclide activities and selected general inorganic concentrations (fluoride, nitrate, perchlorate) in discharges to DOE DCGs or NM groundwater standards since 1996. The 2006 discharges from the RLWTF met all DOE, EPA, and NM requirements. Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, for the last seven years the RLWTF has met all DOE radiological discharge standards and all NPDES requirements, and for all but two weeks in 2003, the RLWTF has voluntarily met NM groundwater standards for fluoride, nitrate, and total dissolved solids (TDS). Two weekly composite samples exceeded the fluoride standard in 2003.

During 2006, the nitrate + nitrite (as nitrogen) concentrations of all effluent discharges from the RLWTF were less than the NM groundwater standard for nitrate (as nitrogen) of 10 mg/L, as has been the case since 2000 (Figure 5-19). The average 2006 effluent total nitrate + nitrite (as nitrogen) concentration was 1.62 mg/L. In 2006, the highest nitrate concentration in a Mortandad Canyon base flow grab sample taken below the outfall in Effluent Canyon was 3.5 mg/L.

The fluoride concentration in the discharge has also declined over the last few years (Figure 5-20). The 2006 effluent fluoride concentration (average value of 0.08 mg/L) was below the NM groundwater standard of 1.6 mg/L. In 2006, the fluoride concentration in Mortandad Canyon at the surface water station Mortandad below Effluent Canyon was 0.38 mg/L.

A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002; no perchlorate has been detected in the effluent after this date (Figure 5-21). For 2006, no perchlorate was detected in effluent samples.

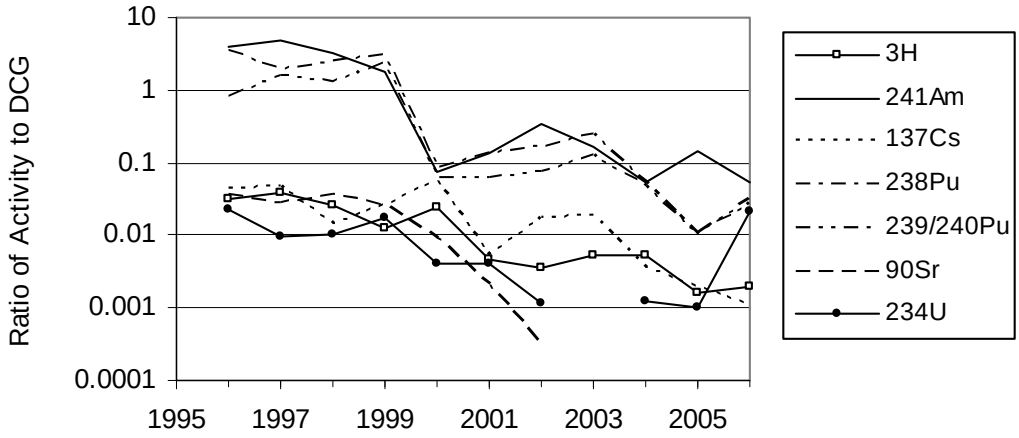


Figure 5-17. Ratio of 1996–2006 average annual radionuclide activity in RLWTF discharges to the 100-mrem public dose DOE DCGs.

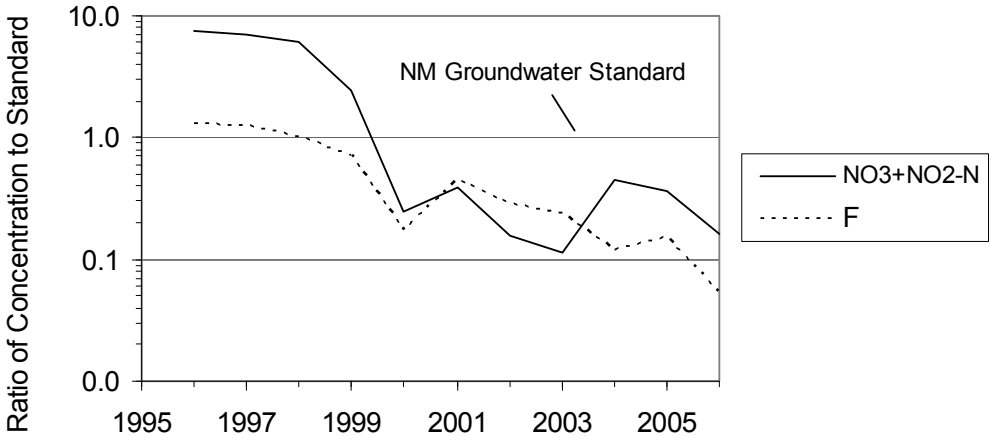


Figure 5-18. Ratio of 1996–2006 average annual mineral concentration in RLWTF discharges to the NM groundwater standards.

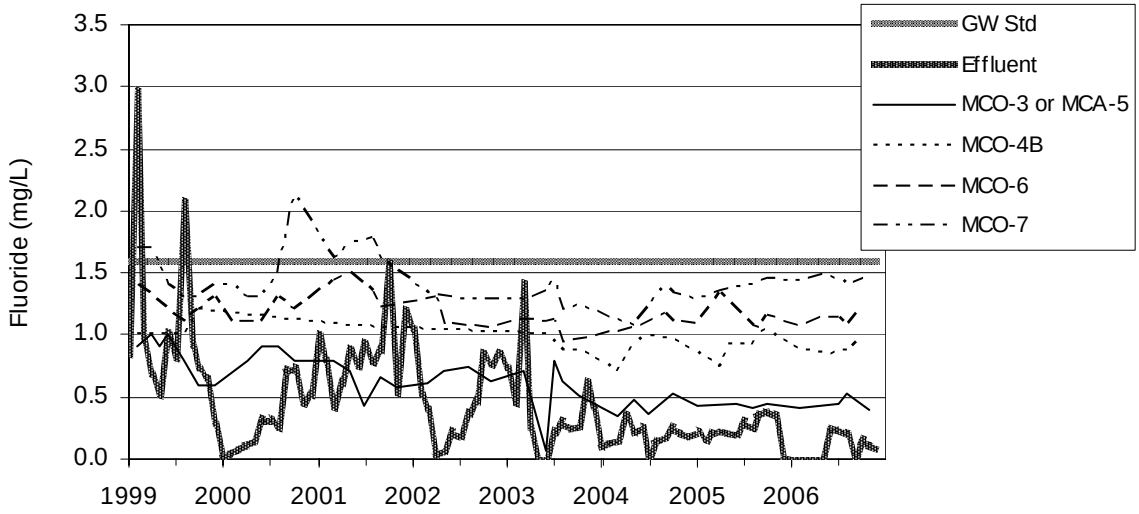


Figure 5-19. Nitrate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2006, compared to the NM groundwater standard.

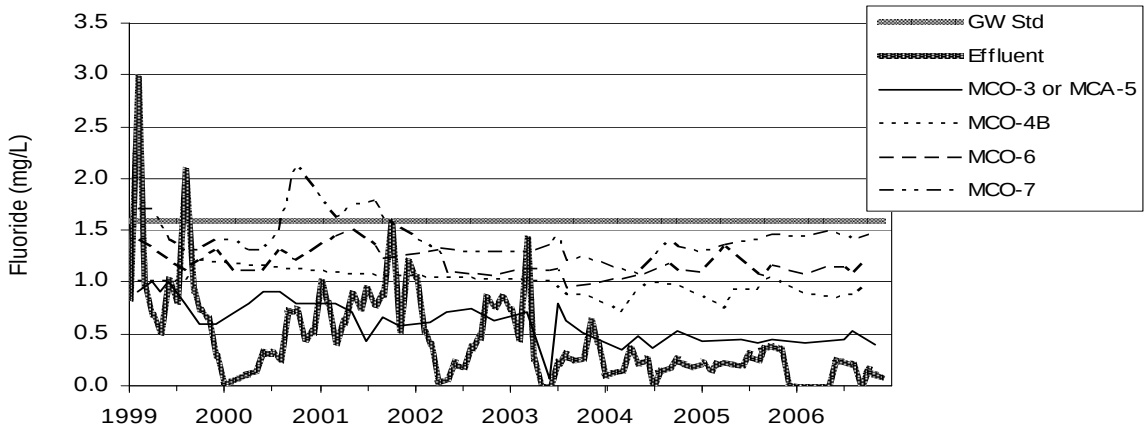


Figure 5-20. Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2006, compared to the NM groundwater standard.

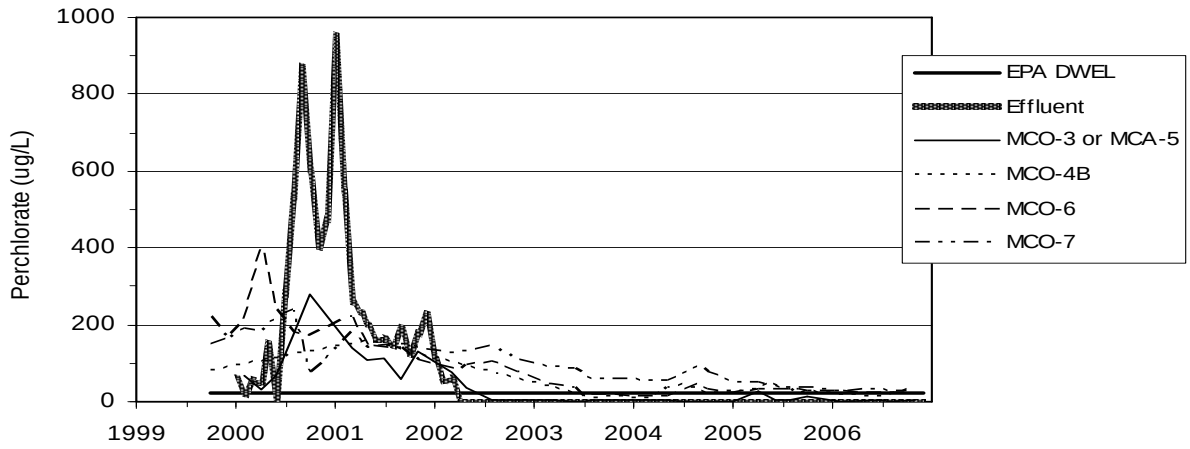


Figure 5-21. Perchlorate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2006; there is no applicable groundwater standard so for comparison purposes results are shown relative to EPA's Drinking Water Equivalent Level of 24.5 µg/L.

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer. The regional aquifer beneath Mortandad Canyon shows impact from past LANL discharges; intermediate groundwater shows a generally larger effect. In 2006, sampling at regional aquifer monitoring well R-28 in Mortandad Canyon continued to show contamination by hexavalent chromium above the NM groundwater standard of 50 µg/L (Figure 5-16). The Laboratory began investigation of this issue in cooperation with NMED and identified past cooling tower discharges in Sandia Canyon as the likely source (ERSP 2006). MCOI-6, an intermediate groundwater well in Mortandad Canyon, consistently showed filtered chromium just below the NM groundwater standard.

Between 2000 and 2005, R-15 tritium showed an increase from 2 pCi/L to 29.6 pCi/L (Figure 5-22). Since May 2005 the tritium activity of well samples has been relatively stable at about 29.7 pCi/L. The recent higher values indicate some contribution of recent recharge to the regional aquifer at R-15. However, these values are below the EPA MCL screening level of 20,000 pCi/L. A corresponding increase occurred for perchlorate (from less than 5 µg/L to 7 µg/L) but not nitrate (Figure 5-23). As with tritium, perchlorate concentrations have been fairly stable since June 2004, at about 6.4 µg/L. The earlier perchlorate data have a MDL of 4 µg/L giving lower precision for that period.

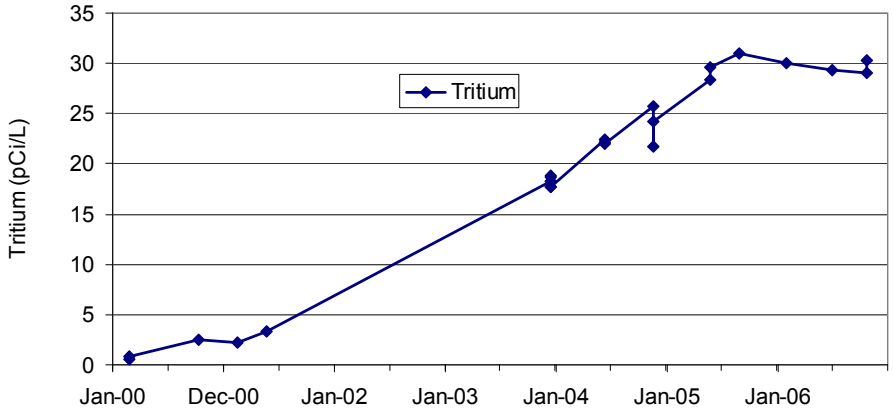


Figure 5-22. Tritium history in Mortandad Canyon regional aquifer well R-15.

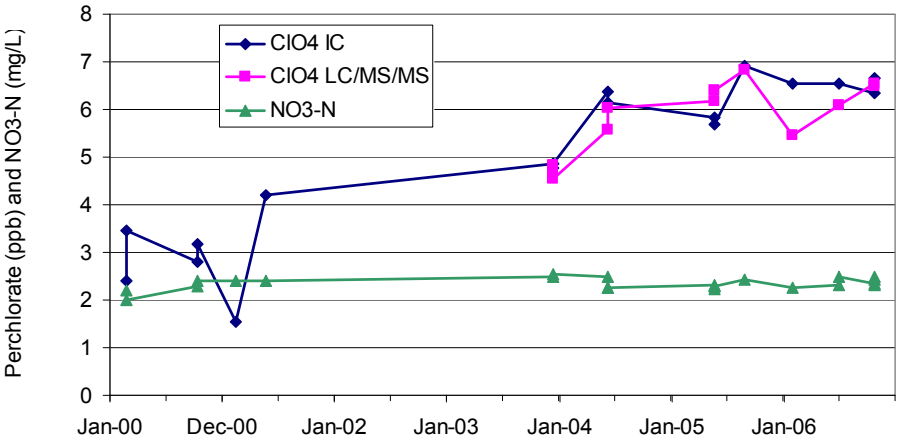


Figure 5-23. Perchlorate and nitrate histories in Mortandad Canyon regional aquifer well R-15.

R-28 has tritium values averaging 184 pCi/L and perchlorate concentrations in the range of 1 µg/L; these results along with the chromium levels indicate impact of LANL effluents. Nitrate (as nitrogen) concentrations in samples from R-28 were 45% of the NM groundwater standard of 10 mg/L in 2006 (Figure 5-14). Test Well 8 had tritium values of 3.0 pCi/L and 15.7 pCi/L and perchlorate concentrations averaging 0.26 µg/L. No other regional aquifer well in Mortandad Canyon had repeatable low-detection limit tritium detections, and other perchlorate values were below 0.5 µg/L. Filtered and total chromium results in R-28 have been above 400 µg/L and have been confirmed as hexavalent chromium by separate analysis.

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with some compounds near or exceeding regulatory standards. Three wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 25% to 60% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-24). Tritium has a short half life of about 12.4 years, so these values will decline rapidly because the tritium activity in effluent has decreased. Pine Rock Spring on Pueblo de San Ildefonso had a uranium concentration of 32 µg/L (above the NM groundwater standard of 30 µg/L) and related gross alpha of 29 pCi/L. These values may be caused by dissolution of uranium from the bedrock by sanitary effluent used to water athletic fields at nearby Overlook Park (Teerlink 2007). The tritium activity in this spring was 30 pCi/L.

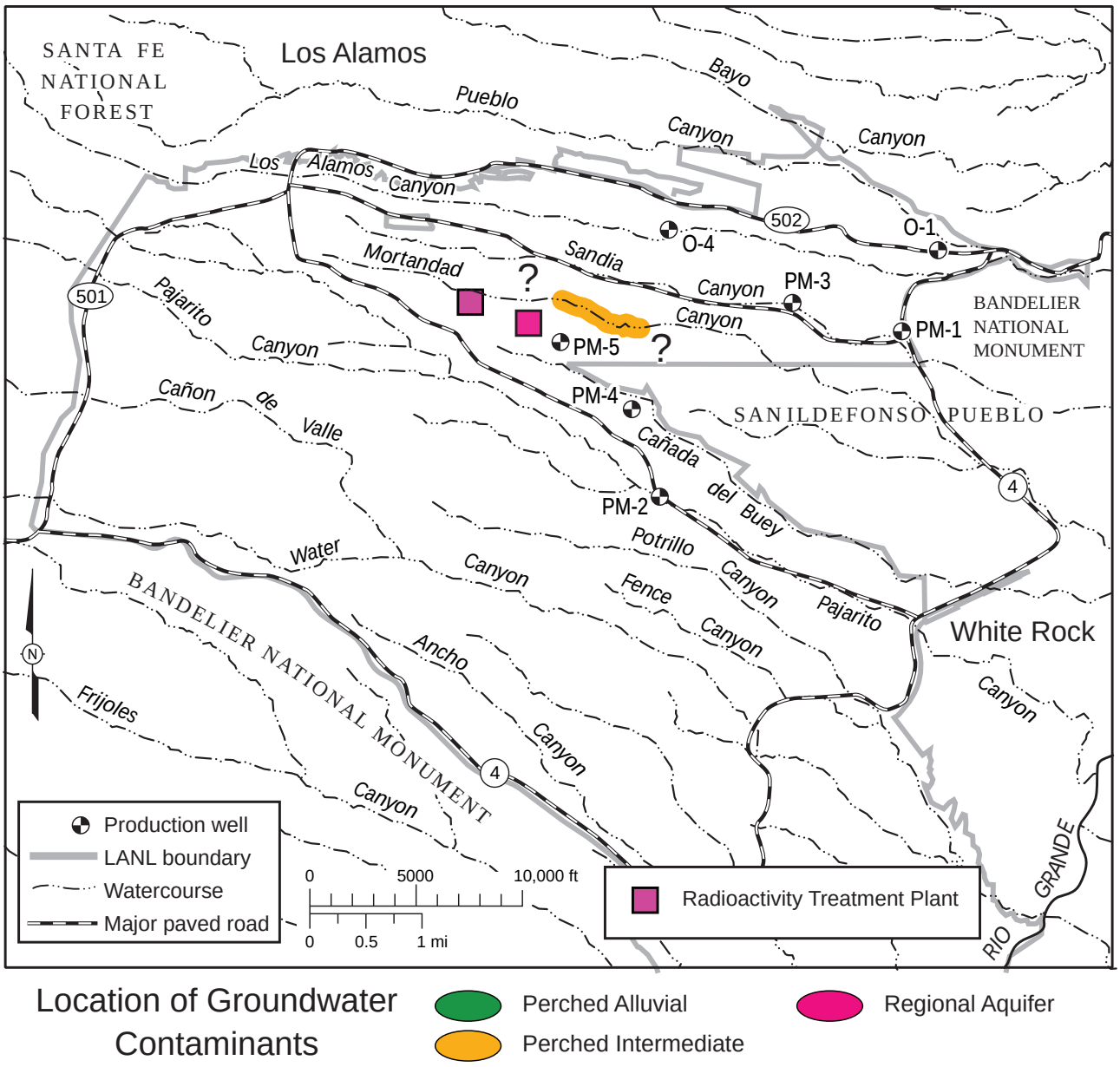


Figure 5-24. Location of groundwater contaminated by tritium: while there is no applicable groundwater standard, for comparison purposes, the area indicated has tritium activity above one-half of the 20,000 pCi/L EPA MCL. Different colors indicate the affected groundwater zones.

Nitrate (as nitrogen) concentrations in two of the intermediate wells (MCOI-4 and MCOI-6) ranged from 14 mg/L to 20 mg/L, above the NM groundwater standard of 10 mg/L (Figure 5-14). The nitrate (as nitrogen) concentration in MCOI-5 was 5.5 mg/L. Perchlorate was not detected in the well farthest upstream (MCOI-8) but in three other wells ranged from 110 µg/L to 190 µg/L (Figure 5-25); while there is no applicable groundwater standard, for comparison purposes, the EPA's Drinking Water Equivalent Level is 24.5 µg/L. The fluoride concentration in MCOI-8, however, was above the 1.6 mg/L NM groundwater standard (Figure 5-13). At Pine Rock Spring, the fluoride, nitrate (as nitrogen), and total dissolved solids were respectively 56%, 90%, and 58% of the NM groundwater standards.

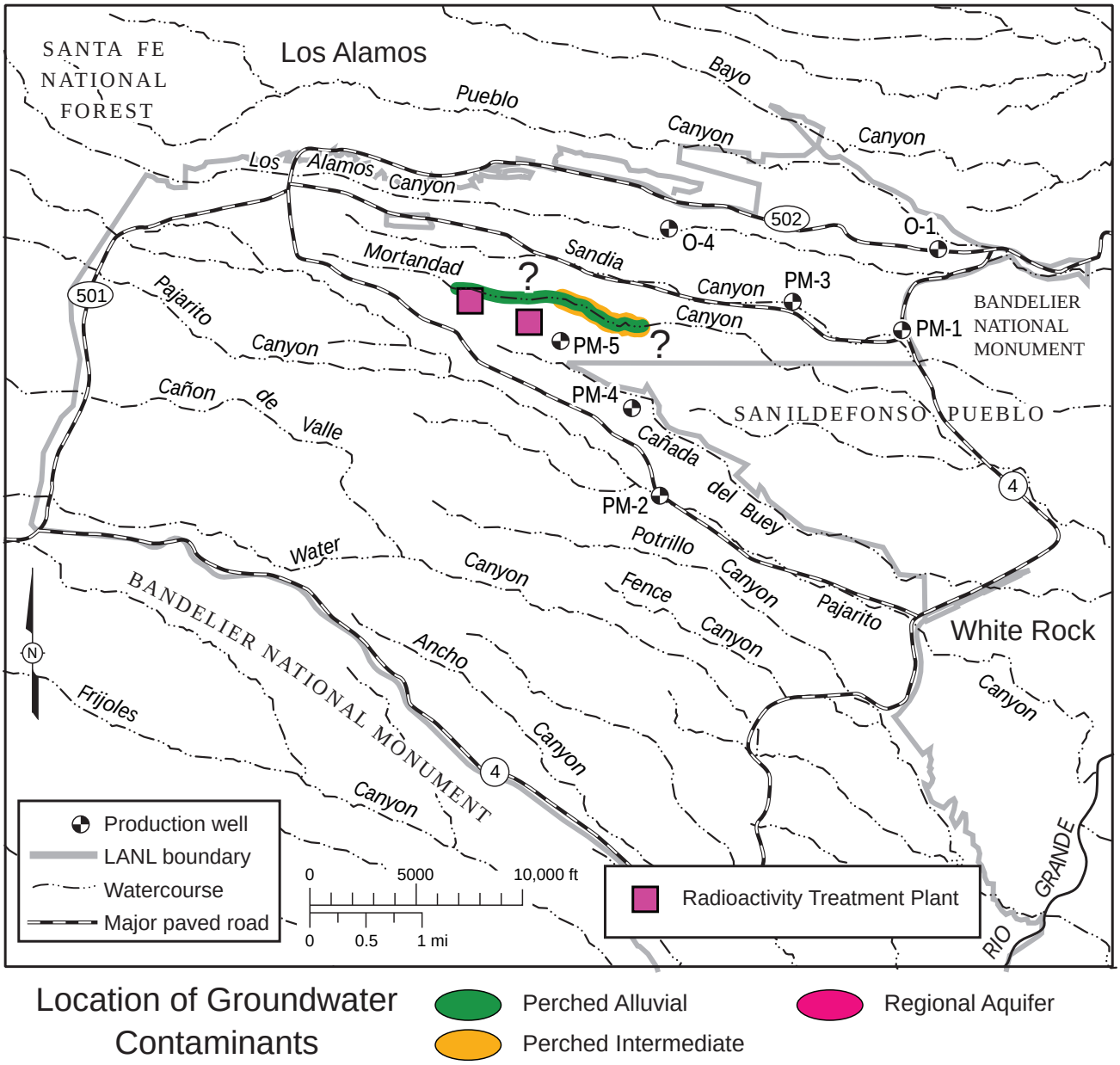


Figure 5-25. Location of groundwater contaminated by perchlorate; there is no applicable groundwater standard, but for comparison purposes, the concentrations in the areas indicated are above the 24.5 µg/L EPA Drinking Water Equivalent Level. Different colors indicate the affected groundwater zones.

Chromium was detected in three of the newest intermediate-depth wells: MCOI-8, MCOI-5, and MCOI-6. In MCOI-8 and MCOI-5 the filtered values are much lower than the unfiltered values, leading to the conclusion that the chromium comes from aquifer or well materials, rather than the groundwater. Elevated total nickel concentrations in MCOI-5 and MCOI-8 support a conclusion that metal corrosion or aquifer material are the chromium source in this well. Because these wells have little water, they must be sampled with a bailer, which produces very turbid samples (turbidities of 31 NTU for MCOI-8 and 1 NTU to 17 NTU for MCOI-5). On the other hand, MCOI-6 has sufficient water to allow use of a pump and produces lower turbidity samples (1.3 NTU to 4.9 NTU). Both filtered and unfiltered chromium values in MCOI-6 are near or slightly above

50 µg/L (the NM groundwater standard). Analysis in 2006 confirms that this chromium is predominantly in the form of hexavalent chromium. MCOI-5 also had filtered nickel at 28% of the NM groundwater standard (for irrigation use) of 200 µg/L.

In 2005 the organic compound dioxane[1,4-] was detected in two intermediate wells in Mortandad Canyon. There is no applicable groundwater standard for dioxane[1,4-], however, for comparison purposes, the EPA Region 6 dioxane[1,4-] 10^{-5} risk value is 61 µg/L. All 2005 detected analytical results were below or slightly above the practical quantitation limit (PQL) of 50 µg/L (the MDL is 20 µg/L) for the volatile organic method SW-846:8260B. In 2006, samples were analyzed using a more sensitive semivolatile organic method SW-846:8270C which has a practical quantitation limit (PQL) of 10 µg/L (the MDL is 1 µg/L). In 2006, dioxane was detected in MCOI-4, MCOI-5, and MCOI-6 at concentrations of 28 µg/L, 9 µg/L, and 24 µg/L, respectively. The highest result, in MCOI-4, was 45% of the EPA Region 6 tap water screening level.

Bis(2-ethylhexyl)phthalate was detected in duplicate samples taken in June and October from MCOI-6; there is no applicable groundwater standard for this compound, but for comparison purposes the concentrations were above the 6 µg/L EPA MCL. The source of this compound at this well is not known. Bis(2-ethylhexyl)phthalate is a plasticizer and common field or analytical laboratory contaminant. However, the compound has been found in four of five samples from MCOI-6 at concentrations ranging from 2 µg /L to 12 µg/L. This compound was also found in a June sample from MCOI-4 at 16 µg/L.

c. Alluvial Groundwater. Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest just below the TA-50 RLWTF outfall at well MCA-5 and decrease down the canyon. Most radionuclides are adsorbed to sediment closer to the outfall and subsequently move with sediment rather than in groundwater. There are no applicable groundwater standards for these radionuclides, but for comparison purposes, since the early 1990s, radionuclide levels have not exceeded the 100-mrem DOE DCGs for public dose (applicable to effluent discharges). The levels of strontium-90 (which is not as strongly adsorbed) and gross beta in these wells are high; these constituents have no applicable groundwater standard, but for comparison purposes, usually exceed their respective EPA MCL or screening level in many of the wells. In past years, the levels of strontium-90, plutonium-238, plutonium-239,240, and americium-241 in alluvial groundwater exceeded the 4-mrem DOE DCG screening levels; also given for comparison purposes as there are no applicable groundwater standards for these radionuclides.

There are no applicable groundwater standards for most radioactivity in alluvial groundwater, however, for comparison purposes, in 2006, total LANL-derived radioactivity exceeded the 4 mrem DOE DCG in Mortandad Canyon alluvial groundwater samples from wells MCO-4B and MCO-6 (Figure 5-12). For comparison purposes in absence of an applicable groundwater standard, for radioactivity from a DOE source, results for the strontium-90 were near or exceeded the 4-mrem DOE DCG in MCO-4B. Again for comparison purposes in absence of an applicable groundwater standard, the levels of strontium-90 also exceeded the EPA MCL (Figure 5-11). Gross beta values (probably reflecting strontium-90 activity) in samples from most alluvial wells were high; there is no applicable groundwater standard, but for comparison purposes the results were near or exceeded the EPA 50 pCi/L drinking water screening level.

As shown in Figures 5-19 and 5-20, the nitrate (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 are below the NM groundwater standards. Under the groundwater discharge plan application for the RLWTF, the Laboratory collected additional quarterly samples for nitrate, fluoride, perchlorate, and total dissolved solids during 2006 from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7. Nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L (Figure 5-19), and fluoride concentrations were below the NM groundwater standard of 1.6 mg/L (Figure 5-20). MCO-3 had a maximum nitrate (as nitrogen) at about 39% of the NM groundwater standard. All of the alluvial groundwater samples taken below the RLWTF outfall had fluoride concentrations above 60% of the NM groundwater

standard, with some above the standard (Figure 5-13). Two downstream wells (MT-3 and MCO-7.5) had fluoride values exceeding the standard, a result of past effluent discharge.

Chloride and TDS concentrations in MCO-0.6 were above the NM groundwater standards (which are intended for domestic water supply). This alluvial well is located upstream from the RLWTF outfall, rarely has water, can seldom be sampled, and represents a small saturated thickness. TDS was also 84% of the NM groundwater standard (intended for domestic water supply) at MCO-2 in Effluent Canyon. This well is also shallow with little saturated thickness.

RLWTF outfall had high perchlorate concentrations (Figures 5-21 and 5-25). There is no applicable groundwater standard for high perchlorate, but for comparison purposes, the 2006 concentrations at some wells were above the EPA's Drinking Water Equivalent Level of 24.5 µg/L. Alluvial groundwater concentrations of perchlorate have dropped, especially near the outfall, following the removal of perchlorate from RLWTF effluent in March 2002. Nonetheless, the perchlorate concentrations generally increase downstream, with maximum 2006 concentrations at various wells of 3.8 µg/L at MCO-3 (nearest the outfall), 30.6 µg/L at MCO-4B, 27 µg/L at MCO-6, and 32 µg/L at MCO-7. This shows that effluent quality improvement has had the largest effect on groundwater quality near the outfall, and affects groundwater quality farther downstream more slowly.

The July barium results in MCO-0.6 are 70% of the NM groundwater standard and are twice the highest prior value (though data are sparse). In October sampling, the filtered cobalt result was 25.4 µg/L (which was 51% of the NM groundwater standard intended for irrigation use). This was nearly twice the previous high, out of three total samples. This well is shallow with little (and stagnant) water and samples have high turbidity.

d. Long-Term Radioactivity Trends. Figures 5-26 through 5-30 depict long-term trends of radionuclide concentrations in surface water and shallow perched alluvial groundwater in Mortandad Canyon downstream from the RLWTF outfall at TA-50. The surface water samples are from the monitoring station "Mortandad below Effluent Canyon", a short distance downstream from the outfall. Radioactivity levels at this station vary daily depending how soon individual samples are collected after a release from the RLWTF and on the composition of a release. These samples also vary in response to changing amounts of runoff from other sources in the drainage.

The alluvial groundwater samples shown in figures 5-26 through 5-30 are from observation well MCO-6 in the middle reach of the canyon. Groundwater radioactivity at MCO-6 is more stable than surface water sampled at station Mortandad below Effluent Canyon because it is farther from the outfall and because groundwater responds more slowly to variations in runoff water quality. Because of its strong adsorption to sediments, cesium-137 is not usually detected in groundwater samples, though it was detected in 2005 at alluvial well MCA-5, nearest the outfall.

Chemical reactions such as adsorption do not delay tritium transport, so tritium activity is relatively uniform throughout the alluvial groundwater. Average annual tritium activity in the RLWTF effluent dropped below the EPA MCL screening level (20,000 pCi/L) in 2001, and tritium activity has dropped in surface water and alluvial groundwater since then. Tritium activities in Mortandad Canyon alluvial groundwater have been below the MCL screening level since 2001 (Figure 5-26).



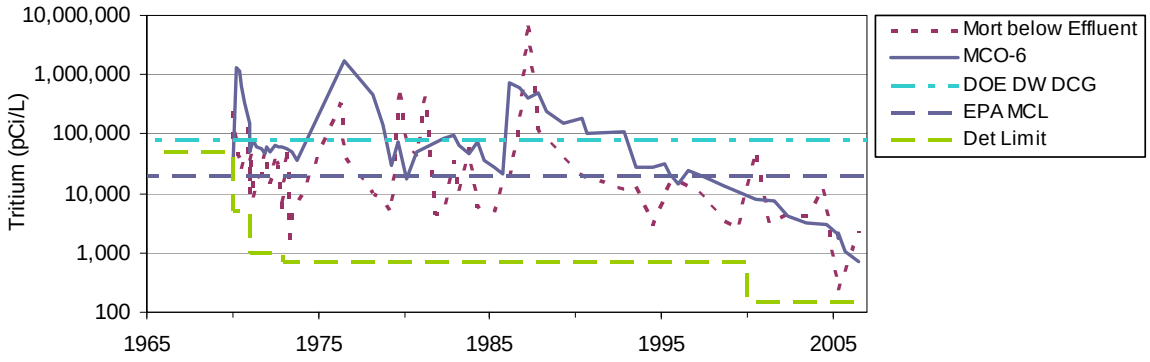


Figure 5-26. **Tritium activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for tritium so the DOE DCG and EPA MCL are shown for comparison purposes.**

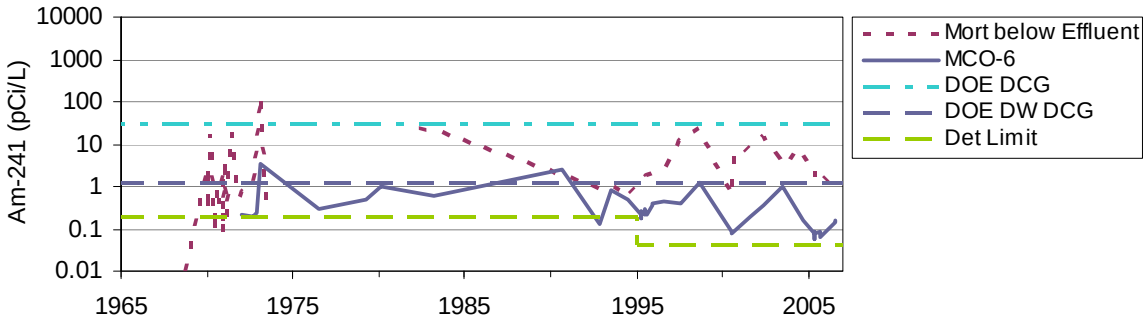


Figure 5-27. **Americium-241 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for americium-241 so the DOE DCG is shown for comparison purposes.**

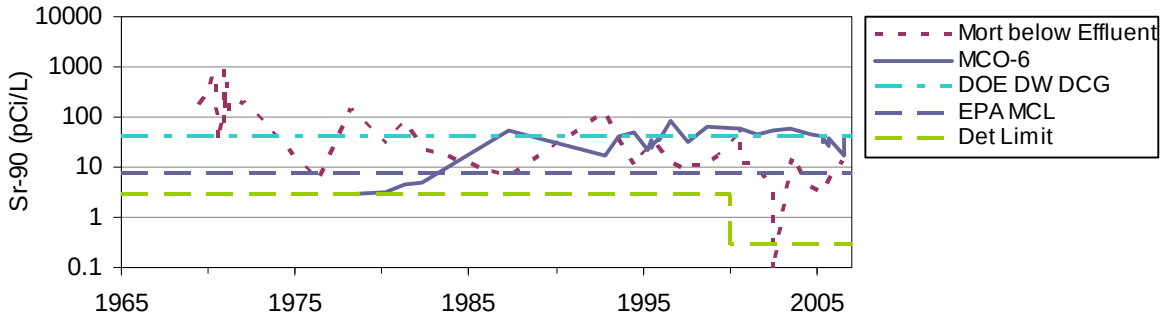


Figure 5-28. **Strontium-90 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for strontium-90 so the DOE DCG and EPA MCL are shown for comparison purposes.**

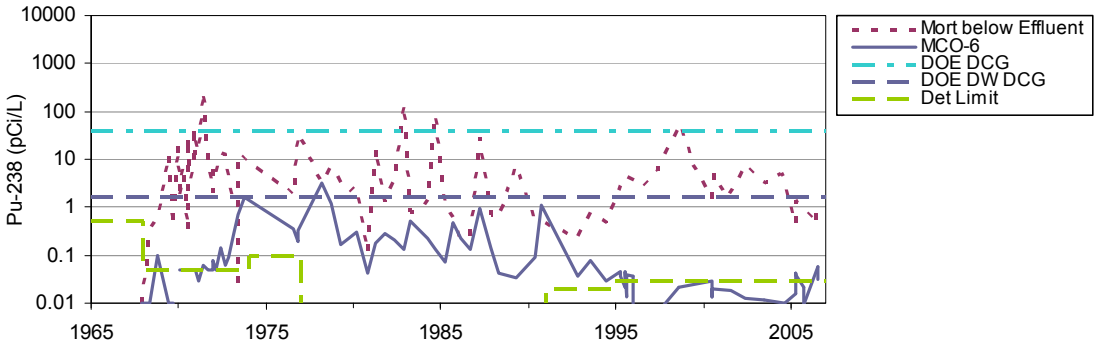


Figure 5-29. Plutonium-238 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for plutonium-238 so the DOE DCG is shown for comparison purposes.

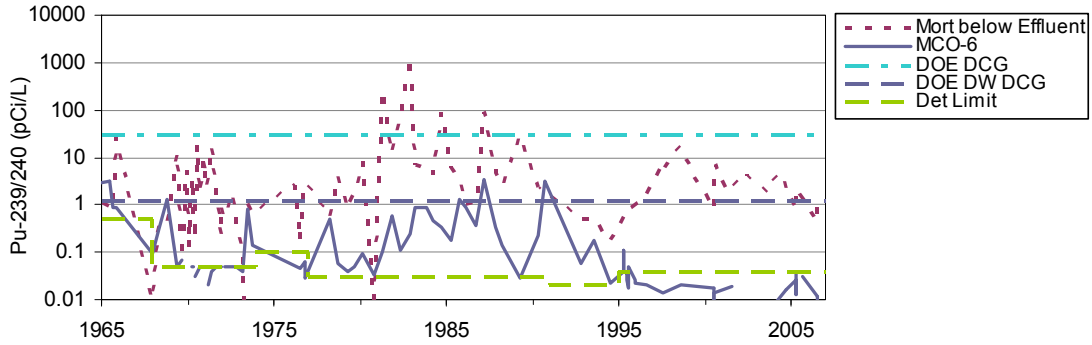


Figure 5-30. Plutonium-239,240 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for plutonium-239,240 so the DOE DCG is shown for comparison purposes.

Before 1990, americium-241 activity was not measured regularly at monitoring stations in Mortandad Canyon. For most years prior to 1999, the americium-241 activity of RLWTF discharges exceeded the 100-mrem DOE DCG for public dose of 30 pCi/L (Figure 5-27). There are no applicable groundwater or surface water standards for americium-241; for comparison purposes, over the last few years, americium-241 in surface water nearest the outfall has been just below the 100-mrem DOE DCG, whereas in the groundwater nearest the outfall it is closer to the 4-mrem DCG screening level. Americium-241 in alluvial groundwater downstream at MCO-6 has been below the 4-mrem DOE DCG screening level since the early 1970s. This is true for alluvial wells closer to the outfall than MCO-6 only since the early 1990s.

In 2006, strontium-90 was detected in surface water at Mortandad below Effluent Canyon and in all alluvial groundwater observation wells down to MCO-7 (Figure 5-28). There are no applicable groundwater or surface water standards for strontium-90; for comparison purposes, the strontium-90 activities in the upstream wells remain at values in the range of the 4-mrem DOE DCG screening level (40 pCi/L) and the EPA MCL screening level (8 pCi/L). It appears that strontium-90 has been retained by cation exchange on sediment within the upstream portion of the alluvium. The level of strontium-90 has risen gradually at downstream wells MCO-5 and MCO-6 during the last 20 years, suggesting that the mass of the radionuclide is moving slowly downstream.

Both plutonium isotopes were detected in surface water at Mortandad below Effluent Canyon and at some alluvial wells in 2006 (Figures 5-29 and 5-30). There are no applicable groundwater or surface water standards for plutonium isotopes; however, for comparison purposes, both isotopes have been historically detected at Mortandad below Effluent Canyon and at MCO-3 (now MCA-5) at levels near the 100-mrem DOE public dose DCGs (30 pCi/L for plutonium-239,240 and 40 pCi/L for plutonium-238), but the levels have decreased during the past few years. Values at other alluvial observation wells, except for MCO-4 and MCO-7.5, were near the detection limit in the 1990s. Plutonium has, in general, been detected in all alluvial observation wells in Mortandad Canyon but appears to be decreasing in activity at downstream locations.

e. Cañada del Buey. Water supply wells PM-4 and PM-5 are on the mesa top just south of Cañada del Buey. PM-4 operates as a backup well and in any year may have fewer sample events. No tritium was detected in samples from these two wells. Analyses for perchlorate in samples from PM-4 and PM-5 had an average concentration of 0.34 μg/L, similar to earlier results. No HE compounds were detected in samples from these wells.

Alluvial well CDBO-6 in Cañada del Buey was sampled twice in 2006 with no constituents near regulatory standards or screening levels.

5. Pajarito Canyon (Includes Twomile and Threemile Canyons)

Pajarito Canyon has a drainage that extends into the Sierra de los Valles, west of the Laboratory. In lower Pajarito Canyon near the eastern Laboratory boundary, saturated alluvium occurs but does not extend beyond that boundary. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-9 (Table 5-6). Some firing sites border portions of tributaries Twomile and Threemile canyons. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at TA-18. Waste management areas, used for disposal of organic solvents and low-level radioactive waste, occupy the mesa north of the lower part of the canyon. A small contaminated body of shallow intermediate groundwater occurs behind a former Laboratory warehouse location at TA-3, where the Laboratory disposed of waste materials.

Table 5-6
Summary of Groundwater Contamination in Pajarito Canyon
(Includes Twomile and Threemile Canyons)

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Pajarito, Twomile, and Threemile Canyons	Major dry sources, past major but minor present liquid sources	Chloride above and nitrate at 50% of NM GW stds.	Dichloroethene[1,1-] and trichloroethane[1,1,1-] above NM GW stds., RDX above EPA excess cancer risk level, trichloroethene, dichloroethane[1,1-], dioxane[1,4-]	Trace RDX

In 2006, tritium was not detected by the low-detection-limit method (MDA about 1 pCi/L) in the one sample from supply well PM-2. Four perchlorate analyses had an average concentration of 0.30 μg/L, similar to prior data.

In regional aquifer well R-18, strontium-90 was found in a filtered sample but not in the paired unfiltered sample or in the filtered or unfiltered field duplicate. As well, there are no strontium-90 detects in prior samples. The lack of consistency for this apparent detection between paired samples and prior samples indicates that this result is an analytical artifact.

Regional aquifer well R-22 lies just east of MDA G, the low-level radioactive waste management facility. In 2006, R-22 showed tritium at 2–3 pCi/L in the uppermost of five regional aquifer ports. This result is consistent with previous sampling observations. Tritium was also found at 9 pCi/L in the deepest port, consistent with earlier results. Over the past year, R-18 tritium values have jumped around from nondetect to 7 pCi/L; results for the last three samples have been mainly nondetect. In R-23, perchlorate was found at 0.47 µg/L, which is near background. Otherwise, in regional aquifer samples from Pajarito Canyon, tritium was not detected or was at about 1 pCi/L, and perchlorate was at background values.

RDX was detected at Pajarito Canyon regional well R-18 near the detection limit and at 2% of the EPA 10^{-5} excess cancer risk tap water screening level. RDX is listed as a toxic pollutant in the New Mexico groundwater regulations (NMWQCC 2002). RDX was detected in samples taken in August and December 2006, but not in two samples taken in 2005. The compound 2,6-Diamino-4-nitrotoluene (a breakdown product of RDX) was also detected in the December sample from R-18, but it was not found in August 2006, the only other time it was analyzed.

One-time organic compound detections occurred in several wells in this watershed. Total xylenes were found in a number of groundwater samples collected around the Laboratory in 2006, particularly during two periods of late August and October. Of the 13 detections, one was rejected in validation and six occurred in equipment, field, or trip blanks. In October, two samples from R-17 found total xylene near the detection limit. During this period, xylene[1,3-]+xylene[1,4-] was found in equipment and trip blanks and samples at R-23i, samples from two depths at R-17, a sample at R-1 (Mortandad Canyon), and a field blank at R-20.

One R-22 sample contained two pesticides, also near the detection limit. For a set of samples collected during late August, three locations (18-BG-1, 18-MW-11, and R-22 at 1,273 ft in the regional aquifer) had samples that contained one or more of the pesticides DDD[4,4'-], DDE[4,4'-], and DDT[4,4'-]. None of the locations have prior detections of pesticides, and the results are likely due to analytical laboratory contamination.

Seven springs were sampled in the Upper Pajarito Canyon drainage. The springs are fed by intermediate-depth groundwater from within adjacent mesas. PC Spring lies west of LANL in the Sierra de los Valles, so likely reflects background conditions. These intermediate springs mainly issue along canyon sides above adjacent streams. Plutonium-239,240 was detected in two of five samples from Homestead Spring in Pajarito Canyon—a field blank and unfiltered field duplicate—but was not detected in the filtered field duplicate and the other unfiltered and filtered samples. Thus, the results appear to be false positives.

Tritium and strontium-90 were found at low levels in two shallow intermediate wells (03-B-10 and 03-B-13) that monitor SWMU 03-010a behind a former warehouse at TA-3. Several intermediate springs in Upper Pajarito Canyon and intermediate well R-23i in Lower Pajarito Canyon had low-detection-limit tritium activities in the range of 30 pCi/L to 90 pCi/L.

August samples from 03-B-10 and 03-B-13 had TDS results of about 550 mg/L, about 60% of the groundwater standard (intended for domestic water supply). The TDS results from samples for these wells during the remainder of the year were about half these values.

Most of the intermediate wells and springs in Pajarito Canyon had perchlorate concentrations below 0.55 µg/L. The highest values of 0.8 µg/L were found at Bulldog Spring. Filtered iron in samples from six of the springs ranged from 60% of to above the NM groundwater standard (for domestic water supply) of 1,000 µg/L. The iron may be present in colloidal form that passes through the filter.

Samples from several of the intermediate groundwater springs in Upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. As in earlier samples, RDX was detected at Bulldog Spring at 75% of the EPA 10^{-5} excess cancer risk tap water screening level (Figure 5-31).

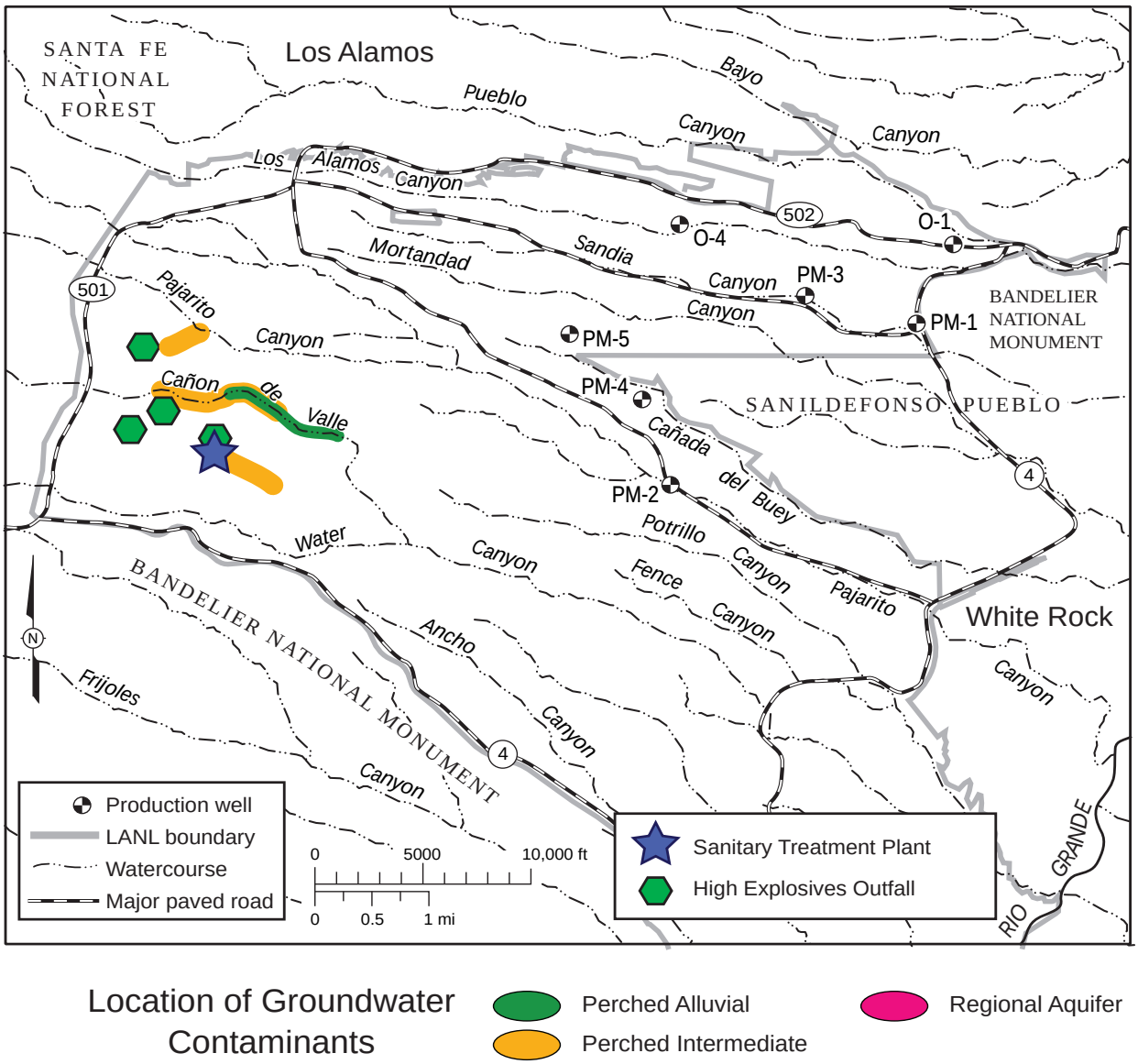


Figure 5-31. Location of groundwater containing RDX above one half of the EPA Region 6 10^{-5} excess cancer risk tap water screening level of 6.1 µg/L. Different colors indicate the affected groundwater zones.

Samples in 2006 from SWMU 03-010a intermediate groundwater wells 03-B-10 and 03-B-13 contained several organic compounds including four chlorinated solvents. Several compounds were at concentrations exceeding NM groundwater standards. This SWMU is under investigation according to a plan approved by NMED and these compounds are some of the contaminants of concern identified in the investigation. In 2006, samples were analyzed for the first time for dioxane[1,4-] and it was found at up to 142 µg/L, above the EPA 10^{-5} excess cancer tap water screening level. Other compounds found in the wells were chloroform, trichloroethene, dichloroethane[1,1-], dichloroethene[1,1-], and trichloroethane[1,1,1-]. The concentrations of the latter two of these compounds were above NM groundwater standards in some of the samples.

Strontium-90 was detected in PCO-3 (0.65 pCi/L or 8% of the MCL screening level). Strontium-90 has been detected in this well at such values three times since 2001. However, strontium-90 has not been detected in all samples taken, even at a given sampling event and this inconsistency casts some doubt on the presence of strontium-90 in the groundwater. Alluvial well samples in lower Pajarito Canyon also contained 60 pCi/L to 80 pCi/L of tritium.

August samples showed nitrate (as nitrogen) at 60% of the NM groundwater standard in alluvial well 18-MW-9 (Figure 5-14). Prior data are not available for this location. In December samples, the nitrate level was 20% of the standard.

Chloride and TDS values from alluvial well PCO-3 in lower Pajarito Canyon are, respectively, just above or just below the NM groundwater standard (intended for domestic water supply). The values in this well have fluctuated widely, with current results in the middle of the range. The well has little water and has not been sampled often. Alluvial groundwater perchlorate concentrations had a maximum value of 0.57 µg/L at 18-MW-9.

As described in the previous section, pesticides were detected in samples from 18-BG-1 and 18-MW-11. None of the locations where pesticides were found during the August sampling event have prior pesticide detections, and the results are likely due to analytical laboratory contamination.

6. Water Canyon (Includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon and Cañon de Valle (a tributary) pass through the southern portion of LANL where the Laboratory conducts explosives development and testing. In the past, the Laboratory released wastewater into both canyons from several HE-processing sites in TA-16 and TA-9 (Table 5-7). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. Alluvial groundwater in Cañon de Valle shows barium above 1 mg/L, the NM groundwater standard (Figure 5-32), and RDX above 6.1 µg/L, an EPA risk-based tap water screening level that corresponds to a 10^{-5} excess cancer risk (Figure 5-31). Intermediate perched groundwater in this area also shows RDX at concentrations above 6.1 µg/L. The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for testing of weapons system components. These three small canyons have surface water only in response to precipitation events, and no known alluvial or intermediate groundwater.

In 2006, neptunium-237 was detected in one sample from regional aquifer monitoring well R-27. There is no applicable groundwater standard for neptunium-237, but for comparison purposes, the activity exceeded the 4-mrem DOE DCG. On July 1, 2006 four samples collected from this well were analyzed for radioactivity, a filtered and unfiltered sample and field duplicate. In the filtered field duplicate, the analytical laboratory reported detection of neptunium-237 at a level slightly above the detection limit. This is the only detection of neptunium-237 in the six samples collected from this well in 2006 and early 2007. The preponderance of nondetections indicates that the detected result was a false positive.

No tritium was detected in any of three regional aquifer monitoring wells sampled within this watershed. Perchlorate was either not detected or values were below 0.31 µg/L and thus within the background range.

The main metals found in well samples at high values relative to standards were iron and manganese. The occurrence of these high metals concentrations results from reducing conditions caused by drilling fluid impact (ERSP 2005).

Table 5-7
Summary of Groundwater Contamination in Water Canyon
(Includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Cañon de Valle	Multiple dry and past effluent sources	Barium above NM GW std, RDX above EPA excess cancer risk level, tetrachloroethene, trichloroethene	Boron above and barium at 65% of NM GW stds., RDX above EPA excess cancer risk level, trace tetrachloroethene, trichloroethene	None
Water Canyon	Multiple dry and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None
Potrillo, Fence, and Indio Canyons	Minor dry sources	No alluvial groundwater	No intermediate groundwater	None

Isopropylbenzene was again detected in CdV-R-37-2 at 1,200 ft. This compound may be a temporary result of drilling fluids used. Trichloro-1,2,2-trifluoroethane[1,1,2-] was also found at this port but in only one of several samples. This compound is also known as freon 113. It may show up as a false positive when running a mass spectrometer. In 2005 trichloro-1,2,2-trifluoroethane[1,1,2-] was found in most field trip blanks and samples from this and a nearby well, suggesting some source of sample contamination or analyte misidentification.

For intermediate groundwater samples from upper Cañon de Valle, tritium activities ranged from 7 pCi/L to 66 pCi/L for wells and 60 pCi/L to 130 pCi/L for springs and are consistent with earlier sampling results. Perchlorate in intermediate-depth wells was either not detected or close to background, with the highest value of 0.49 µg/L. For springs flowing from intermediate perched zones, perchlorate values ranged up to 0.74 µg/L, slightly above background.

Boron was found in samples from Martin Spring and other nearby springs at concentrations above the NM groundwater standard (for irrigation use), a reflection of past effluents. Barium was found in a sample from Peter Spring at 66% of the NM groundwater standard (Figure 5-32).

Intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX (Figure 5-31) was present at the highest levels compared to risk levels; above the 6.1 µg/L EPA 10^{-5} excess cancer risk tap water screening level in springs and wells. The chlorinated solvents tetrachloroethene (also known as tetrachloroethylene, perchloroethylene, or PERC) and trichloroethene (or trichloroethylene or TCE) continue to be found in Burning Ground and Martin Springs. The highest values were in Burning Ground Spring at 8% and 2% of the respective NM groundwater standards which are 20 µg/L and 100 µg/L. Tetrachloroethene was also found in two wells, with the highest values at 624 ft in CdV-16-1(i) at about 5% of the NM groundwater standard.

Cañon de Valle alluvial well CDV-16-02657 had uranium at up to 34% of the 30 µg/L NM groundwater standard, consistent with levels previously seen in that well. Tritium was found in many alluvial wells in Cañon de Valle and Martin Spring Canyon at activities ranging from 70 pCi/L to 155 pCi/L. Alluvial

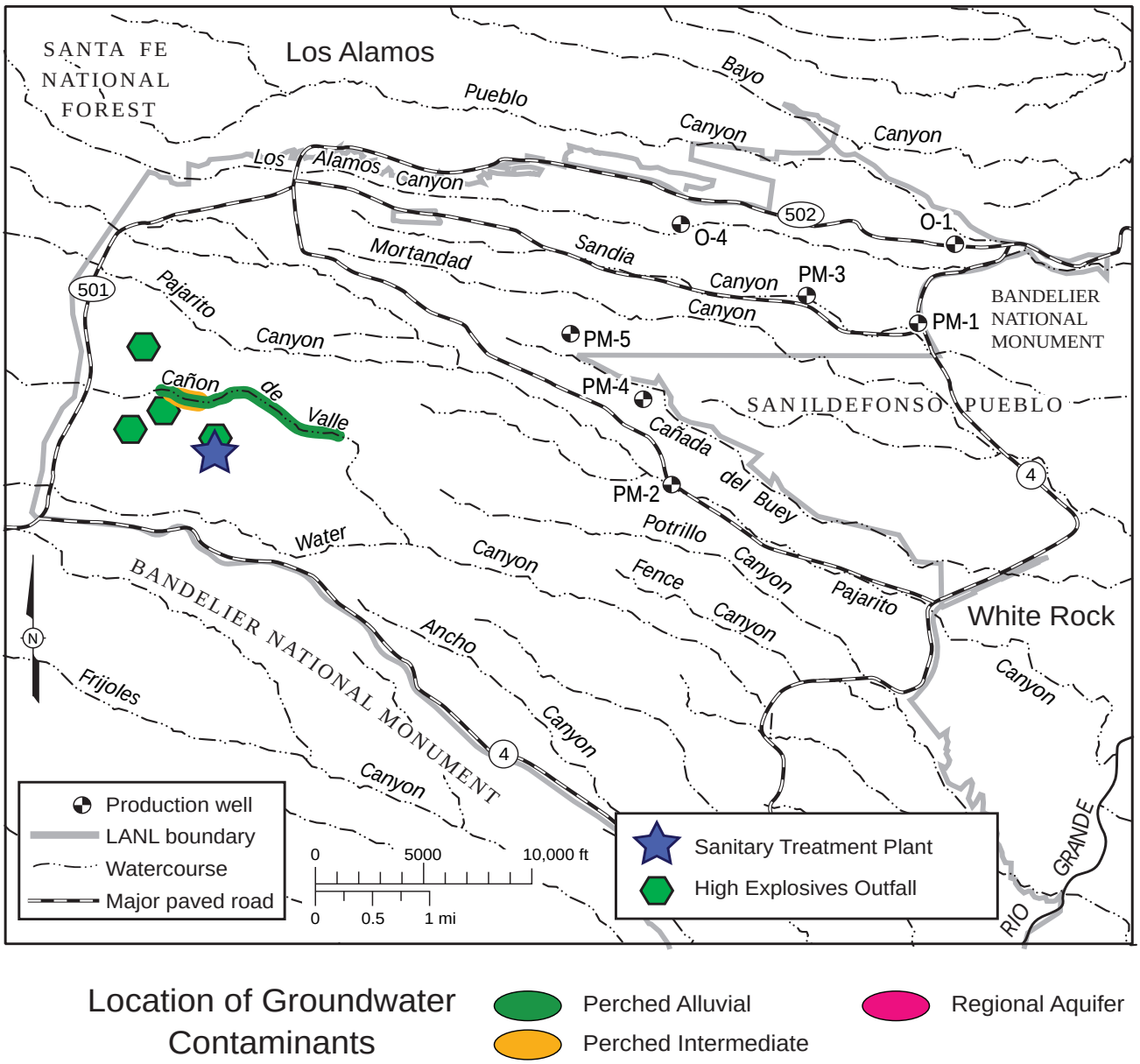


Figure 5-32. Location of groundwater containing barium above one half of the NM groundwater standard of 1 mg/L. Different colors indicate the affected groundwater zones.

wells CDV-16-02656 and CDV-16-02659 showed the highest perchlorate values for this area, just above background at 0.88 µg/L. Perchlorate results for these wells were variable and results for two other alluvial wells were nondetections.

Barium, present due to past high explosives wastewater discharges, exceeded the NM groundwater standard in numerous alluvial wells in Cañon de Valle (Figure 5-32). Aluminum, iron, and manganese related to sample turbidity also exceeded NM groundwater standards (for domestic water supply or irrigation use) in alluvial groundwater samples in Cañon de Valle.

Alluvial well samples contained several HE compounds. As with intermediate perched groundwater, RDX was present at the highest levels compared to risk levels, some above the 6.1 µg/L EPA 10^{-5} excess cancer risk level (Figure 5-31). Some RDX values in 2005 were also above the risk level.

Tetrachloroethene and trichloroethene were found in alluvial well CDV-2658 at 13% and 3% of the respective NM groundwater standards which are 20 µg/L and 100 µg/L. These compounds are commonly found in groundwater in Cañon de Valle.

7. Ancho Canyon

Area AB at TA-49 was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved insufficient HEs and fissionable material to produce a nuclear reaction. The canyons in the watershed are mainly dry with little alluvial and no known intermediate groundwater (Table 5-8). In 1960, the US Geological Survey drilled three deep wells (Test Wells DT-5A, DT-9, and DT-10) to monitor regional aquifer water quality. Another well, R-31, lies downstream from firing sites at TA-39. Tritium was detected only in the shallowest regional aquifer port of R-31 at 0.6 pCi/L. Perchlorate values were either in the range for background or were nondetections. Iron and manganese concentrations are high in the upper two ports of R-31 due to persistent effects of drilling fluids.

Table 5-8
Summary of Groundwater Contamination in Ancho Canyon

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Ancho Canyon	Minor dry sources and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None

8. White Rock Canyon Springs

The springs that issue along the Rio Grande in White Rock Canyon represent the principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al., 1980). The White Rock Canyon springs serve as boundary monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande (Table 5-9). A few springs such as Spring 2B appear to represent discharge of perched groundwater; that spring is supplied by municipal sanitary effluent discharge or irrigation with effluent of athletic fields near White Rock.

Table 5-9
Summary of Groundwater Contamination in White Rock Canyon Springs

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
White Rock Canyon: Springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, uranium, trace tritium

Other than tritium, the only radionuclide detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring. As in past years, the concentration was nearly 10 µg/L, or 32% of the NM groundwater

standard. Naturally occurring uranium is commonly detected in this and a few other nearby wells and springs. White Rock Spring tritium values are similar to prior results. The new result at 31 pCi/L for Spring 4B is slightly lower than earlier results of 45 pCi/L. The result of 11 pCi/L in Sacred Spring is the first value above 1 pCi/L in that location.

Results for White Rock Spring perchlorate samples collected in 2006 are consistent with prior data; concentrations are below background results observed in extensive sampling of NM groundwater by Plummer et al. (2006). The highest value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso at a concentration of 0.71 µg/L. This spring has also had high nitrate and uranium values; it is not located near any apparent sources of contamination. Several of the springs in the Spring 4 series had perchlorate values of 0.5 to 0.6 µg/L, the highest concentrations for springs on the west side of the Rio Grande.

Spring 2 samples had fluoride concentrations at 73% of the NM groundwater standard of 1.6 mg/L. The fluoride occurs naturally in groundwater near the Rio Grande and in the Española Basin.

A PCB compound (aroclor-1254) was detected in Spring 3, with no evidence of analytical laboratory contamination, though the analytical laboratory cannot rule out preparation lab contamination. The concentration is 7% of the NM groundwater standard and is an estimated value (J qualified). At this location there are no prior PCB detections. As well, there are only three aroclor detections in prior spring samples, with two in the past seven years, so sampling or analytical laboratory contamination is a likely explanation for the Spring 3 result. In 2005, a detection of the PCB compound aroclor-1262 occurred in the Spring 1 sample.

Nearly every White Rock spring sample contained acetone (all below 4 µg/L) and toluene (all below 1 µg/L). Methylene chloride, acetone, butanone[2-], and hexanone[2-] were found in the field blanks and some of these compounds were found in field trip blanks. Acetone was found in the field blanks at 30 µg/L and 40 µg/L but either not detected in associated spring samples or found at much lower levels. No toluene was found in the trip blanks. These results suggest possible field sample contamination.

9. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near and east of the Rio Grande. Other Pueblo de San Ildefonso wells and springs were covered in prior sections. The groundwater data for these wells and springs indicate the widespread presence of naturally occurring uranium at levels approaching the NM groundwater standard of 30 µg/L. These measurements are consistent with previous samples. Naturally occurring uranium concentrations near or exceeding the NM groundwater standard are prevalent in well water throughout the Pojoaque area and Pueblo de San Ildefonso. The high gross alpha readings for these wells are related to naturally occurring uranium.

Eastside Artesian and Westside Artesian wells have levels of sodium, chloride, fluoride, and total dissolved solids near or above NM groundwater standards or EPA health advisory levels. Westside Artesian well is not used as a drinking water source. Perchlorate concentrations in these wells ranged from nondetect to 0.5 µg/L.

The boron value in the Westside Artesian well was above the NM groundwater standard of 750 µg/L (for irrigation use), similar to the values of past years. Several of the wells had arsenic concentrations that were 60% to 85% of the 10 µg/L EPA MCL. These findings are also similar to results from past years.

A large number of PAH (polycyclic aromatic hydrocarbon) compounds (semivolatile organic compounds including benzo(a)pyrene, for example) were found in a sample from LA-5. The compounds were only found in the field duplicate but not the companion sample, indicating an analytical laboratory contamination source. Also, the presence of the compound chloronapthalene suggests contamination from the analytical laboratory spike sample.

10. Buckman Well Field

In 2006, we sampled three wells in the City of Santa Fe's Buckman Field (Table 5-10). The detection of plutonium-238 in Buckman well No. 1 is likely an artifact of analysis. From 2001 through 2006, plutonium-238 was analyzed in 19 samples from wells in the Buckman Field. The 2006 result is the only detection and the result is close to the MDA supporting the conclusion that it is an analytical outlier. As in past samples, these wells, particularly Buckman well No. 2, contain high uranium relative to the NM groundwater standard of 30 µg/L. The gross alpha levels in these wells are attributable to the presence of uranium.

Table 5-10
Summary of Groundwater Contamination in White Rock Canyon Wells

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: Pueblo de San Ildefonso and Buckman Wellfield	None	No alluvial groundwater	No intermediate groundwater	Natural fluoride, chloride, arsenic, boron, uranium

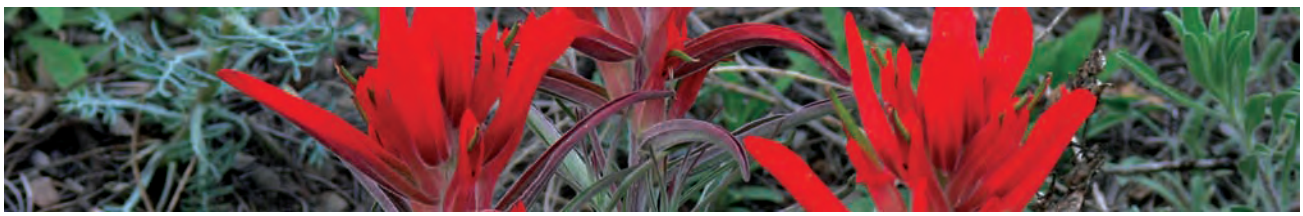
Generally, no tritium is detected in these wells at a detection limit of about 1 pCi/L, and this was the case with the 2006 samples. Perchlorate concentrations in the Buckman wells ranged from 0.24 µg/L to 0.33 µg/L, within the range of naturally occurring values. Two of the wells had arsenic concentrations near the 10 µg/L EPA MCL.

G. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SOIL SAMPLE ANALYSES

1. Introduction

Environmental sampling personnel conducted QA activities in 2006 in accordance with DOE Order 414.1A, which prescribes a risk-based, graded approach to QA. To maximize effective resource use, this process promotes the selective application of QA and management controls based on the risk associated with each activity.

The water quality database (http://wqdbworld.lanl.gov/) contains all the surface water, groundwater, and sediment analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results are inconsistent with prior data, we investigate the laboratory records, and the sample may be reanalyzed or the location resampled. Both the initial sample and the follow-up sample analyses are kept in the database and are available to the public. In some cases, comments are appended to the records to indicate existence of recognized analytical issues. The primary documentation of analytical issues for data from a given year is provided in this report.



In 2006, the majority of the collected data were of high quality. The analytical laboratories flagged 7% of the data for potential data use issues; two thirds of these flags were because the results were between the quantitation and detection limits. The remaining approximately 2% of the results were flagged by the laboratory for potential data quality reasons. After data validation by AQA, 97% were of sufficient quality for use. Overall, 21% of the accepted results were qualified for data quality reasons, including holding time violations, potential cross contamination, instrument calibration, and other reasons.

There are several interrelated components of the quality assurance efforts in the groundwater and surface water programs:

- Ensuring the quality and consistency of work processes at LANL used to collect and ship samples and to assess and validate data.
- Use of quality control (QC) samples to measure the quality of sample collection processes and analytical results.
- Qualification and performance assessment of analytical laboratories.
- Validation of data packages
- Review of analytical results
- Audits and assessments of program and analytical laboratories

The methods and results for each of these components of the quality program are discussed in the following subsections.

2. Procedures for Work Processes

a. Methods. All sampling, data reviews, and data package validations were conducted using standard operating procedures that are part of a comprehensive QA program. The quality program and procedures may be viewed at http://www.lanl.gov/environment/all/qa.shtml. Completed chain-of-custody forms serve as an analytical request form and include the requester or owner, sample number, program code, date and time of sample collection, total number of bottles, list of analytes to be measured, and bottle sizes and preservatives for each analysis required.

b. Results. Field quality assurance procedures and the quality plan documents were revised in 2006, but the revisions were not implemented until after the end of the 2006 sampling for most of the affected documents. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that processes perform satisfactorily.

See Supplemental Tables S5-14, S5-15, and S5-16 for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples during 2006.

3. Quality Control for Samples and Analytical Results

a. Methods. We submit quality control samples along with environmental samples so that we can detect possible field or analytical laboratory contamination and track analytical laboratory performance. Differences in analytical results between field duplicate samples, for example, may indicate that the samples were not uniform or that there was significant variation in analyses. Detection of analytes in deionized water field blanks could indicate contamination of our deionized water source or sample bottles or contamination from the analytical laboratory. We evaluate the results from QC samples along with the environmental sample results in order to understand whether the results truly represent environmental measurements.

The required analytical laboratory batch QC is defined by the analytical method, the analytical statement of work (SOW), and generally accepted laboratory practices. The laboratory batch QC is used in the data-validation process to evaluate the quality of individual analytical results, to evaluate the appropriateness of the analytical methodologies, and to measure the routine performance of the analytical laboratory.

In addition to batch QC performed by laboratories, we submitted field QC samples to test the overall sampling and analytical laboratory process and to spot-check for analytical problems. These samples included equipment blanks, field blanks (deionized water), performance evaluation blanks (deionized water), and field trip blanks (described below). Duplicate analyses of select samples were also conducted at the laboratory.

Equipment and Field Blanks: Equipment and field blanks were submitted for metals, organic, general inorganic, and radiochemistry analyses to monitor for contamination during sampling and decontamination of equipment. Contamination in the equipment and field blanks could be from either field contamination or contamination after sample collection. Any contamination in equipment or field blanks was reviewed to determine if a cause could be found.

Performance Evaluation Blanks: Performance evaluation blanks are deionized water (DI) blanks submitted as regular samples, without any indication that they are QC samples. They go through the same analytical process as the regular field samples. The DI blanks are measured with the same background contributions from reagents and biases as the regular samples, give an estimate of background and systematic analytical errors, and aid in the determination of false detections in associated environmental samples.

Field Trip Blanks: Trip blanks are a special case of performance evaluation blanks applicable to volatile organic compound measurements. They are kept with the samples from collection to analysis. Field trip blanks are used to help identify volatile organic compound cross contamination that may occur during sample handling, shipping, and storage, or at the analytical laboratory.

Field Duplicates: Field duplicates are split samples that provide information about field variation of sample results as well as analytical laboratory variation. Field duplicates can indicate sampling techniques with poor reproducibility.

b. Results. The nitrate results for five samples at four groundwater and surface water locations (Sandia below Wetlands, R-23i, Sandia below Wetlands, and South Fork of Sandia Canyon at E122) sampled between July 28, 2006, and September 18, 2006, were reported at levels over 500 mg/L. Review of these samples found that the nitrate values were not supported by the total dissolved solids determination or the historical data for the sites, where these data were available. Additional testing at the laboratory on containers still available indicated that the high levels of nitrate were not found in unpreserved samples. The high nitrate values in these samples therefore, were likely from the incorrect use of nitric acid preservative in the field in place of the method-specified sulfuric acid preservative. In those cases where it appeared that an error was made, the data were marked rejected during data validation due to the possibility of a field sampling error. This issue also occurred in 2005.

In some cases, sample results for filtered and unfiltered sample results are compared to see if the results for each are consistent with historical results, as well as with each other. There were several instances where the filtered and unfiltered results indicated that there might have been a problem with how the sample containers were labeled in the field. In these cases, results for inorganic analytes were higher in the filtered sample when compared to the unfiltered sample collected at the same time from the same location. In each case, the samples were examined at the laboratory to determine if it was possible to tell if the samples were filtered or unfiltered. In those cases where it appeared that an error was made, the data were marked rejected during data validation due to the possibility of a field sampling error.

4. Qualification and Performance Assessment of Analytical Laboratories

a. Methods. The Laboratory is responsible for acquiring analytical services that support monitoring activities. The SOW for analytical services follows the National Nuclear Security Administration Service Center's Analytical Management Program's Model Statement of Work (Model SOW). The SOW provides contract analytical laboratories the general QA guidelines specified in the Model SOW and also includes specific requirements and guidelines for analyzing surface water, groundwater, and sediment samples.

Laboratories undergo a pre-award assessment to evaluate their ability to perform the needed analyses.

LANL requires most analytical laboratories to participate in independent national performance evaluation programs. These programs measure each laboratory's performance when analyzing analytes in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP) and other pertinent programs as available for the analytical methods conducted under contract with LANL. For 2006, General Engineering Laboratories (GEL) and Severn-Trent Los Angeles (STSL) participated in both MAPEP and proficiency testing offered by Environmental Resource Associates, but STSL did not provide any water analyses for the covered analytes. STLA, Paradigm, and ALTA Analytical Laboratory did not participate in either of these programs.

b. Results. To provide access to additional laboratories and meet the requirements of the NMED Consent Order, analytical laboratory contracts were combined with the contracts within the LANL Environmental Programs Directorate under control of the Sample Management Office (SMO). Three additional laboratories were added to address specific needs created by the Order and by the chromium issue.

- To address the need for polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDDs and PCDFs), GEL subcontracted with Paradigm Analytical Laboratories. Due to performance problems with Paradigm Analytical Laboratories on the PCDDs and PCDFs analysis, the SMO transferred the work to ALTA Analytical Lab.
- To address the need for analysis of the biodegradation products of Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), Severn-Trent Laboratories was selected to do the analysis for mononitroso-RDX (MNX), dinitroso-RDX (DNX), and trinitroso-RDX (TNX) due to their previous experience with this method. The method development was conducted at the direction of the SMO for the Environmental Restoration Program and the first analyses conducted in 2001. The first analyses for the Water Stewardship Program were conducted in 2006.
- To address concerns about hexavalent chromium first reported in 2006, STLA was selected to conduct the hexavalent chromium analysis by EPA Method SW-846:7191.

GEL participated in many different performance evaluation studies that addressed a majority of the parameters for which they conduct analysis. There are no performance evaluation programs for the specialty analyses conducted at STLA (chromium-VI), ALTA (dioxins and furans), Paradigm (dioxins and furans), and Severn-Trent Saint Louis (STSL) (RDX breakdown products). Therefore, performance on groundwater samples at STLA, ALTA, Paradigm, and STSL was not assessed through performance evaluation programs.

Results for the applicable performance evaluation programs at GEL are given in Table 5-11 for water and soil samples (soil PE sample results are applicable to sediment samples). Only results that were found deficient are discussed. The majority of results was found sufficient; these results are not included.

5. Validation of Data Packages

a. Methods. We verify that analytical data used to support monitoring activities are defensible and of known quality. Analytical data packages sent to us by the analytical laboratories undergo a rigorous review and validation process following the guidelines set in the DOE-AL Model standard operating procedure for data validation, which includes review of the data quality and the documentation's correctness and completeness. Tables S5-5, S5-6, and S5-7 in the Data Supplement list qualifier and validation flag codes that accompany 2006 sediment and water data. When documentation or contract-compliance problems are identified during data validation, the analytical services laboratory is contacted and attempts are made to resolve or clarify the problem.

Table 5-11
Results of Performance Evaluations at GEL Laboratories

Evaluation	Analytes Affected	Results and Actions Taken
ERA Rad-63	Gross beta by EPA 900.0 and SW9310	Result was less than the acceptable range (Reported value 29.5 pCi/L; acceptance limits, 30.4–47.8 pCi/L).
ERA WS-112	Vanadium by EPA 200.8 and SW6020	Result was less than the acceptable range (Reported value 782 µg/L; acceptance limits, 891–1,090 µg/L).
ERA WS-114	Copper by EPA 200.8	Result was less than the acceptable range (Reported value 590 µg/L; acceptance limits, 614–750 µg/L).
	Vanadium by EPA 200.8	Result was less than acceptable range (Reported value 329 µg/L; acceptance limits, 401–490 µg/L).
	Zinc by EPA 200.8	Result was less than the acceptable range (Reported value 424 µg/L; acceptance limits, 425–519 µg/L).
		The serial dilution had a high recover for Cu, V, and Zn, indicating a matrix effect. If the laboratory had reported the 5X dilution, each of these results would have been acceptable. GEL reported acceptable results for these analytes in the following PT study, WS-117.
ERA WS-120	Mercury by EPA 245.1/245.2 and SW846 7470A	Result was greater than the acceptable range (Reported value 26.7 µg/L; acceptance limits, 1.91–3.55 µg/L). A dilution error occurred causing a 10X bias to the reported value.
	Nitrite + Nitrate as N by EPA 353.1	Result was less than the acceptable range (Reported value 6.09 mg/L; acceptance limits, 7.16–8.76 mg/L). Although the batch QC results were all acceptable, causing the performance sample results to be reported, instrument instability problems have resulted in the purchase of a new analytical nstrument to resolve instability issues.
	Uranium by EPA 200.7 and SW846 6010B	Uranium is not typically reported by inductively coupled plasma (ICP) analyses. The U results by ICP-mass spectrometry (MS) for this PT study were acceptable. No further corrective action is required.
	Vanadium by EPA 200.8 and SW846 6020	Result was greater than the acceptable range (Reported value 800 µg/L; acceptance limits, 609–745 µg/L). This analyte is not typically reported by ICP-MS. The vanadium results by ICP for this PT were acceptable. No further corrective action is required.

Table 5-11 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
ERA WP-138	2,3,4,6-Tetrachlorophenol by SW846 8270C and EPA 625	Result was less than the reporting limit of 10 µg/L (Reported value <10 µg/L; acceptance limits, 4.52–61.5 µg/L). A database problem caused upload of an incorrect target list. If the proper list had been used, an acceptable value of 34.4 µg/L would have been reported. No further corrective action was reported by the laboratory.
	Nitrite + Nitrate as N by EPA 353.1	Result was less than the acceptable range (Reported value 16.9 mg/L; acceptance limits, 18.2 – 25.9 mg/L). Although the batch QC results were all acceptable, causing the PT sample results to be reported, instrument instability problems have resulted in the purchase of a new RFA instrument to resolve instability issues.
	Titanium by EPA 200.8 and SW846 6020	Result was less than the acceptable range (Reported value 199 µg/L; acceptance limits, 214–280 µg/L). This analyte is not typically reported by ICP-MS. No further corrective action is required.
ERA WS-122	Turbidity by EPA 180.1/SM 2130 B	Result was greater than the acceptable range (Reported value 3.96 NTU; acceptance limits, 3.98 – 5.42 NTU).
MAPEP-16	Endosulfan II by SW846 8081A	Laboratory reported a false positive. The sample chromatogram revealed possible contamination in the retention time area for Endosulfan II.
MAPEP-15	Strontium-90 (mixed analyte soil standard)	Result was greater than the acceptable range (Reported value 209.7 Bq/kg; acceptance limits, 220.0–408.7 Bq/kg). GEL did not report a corrective action for this failure.

All other water and sediment analytes not shown in the table were acceptable.

b. Results. Analytical Quality Associates, Inc. (AQA) validated all of the 2006 data packages. Individual validation memos were issued for each analytical fraction for each data report. The average report had five data validation memos. AQA issued a number of nonconformance reports (NCRs) for Data Validation Memos that had to be reissued. Most of the NCRs were written in response to problems concerning minor documentation and typographical errors on individual memos. These reports were corrected and reissued. Associated sample results were generally not affected.

In 2006, documentation or contract-compliance problems required the largest analytical services provider, GEL, to issue package-specific NCRs. Most of the NCRs written in response to these problems concerned requests for clarification on data results and missing pages in data packages. GEL reissued corrected documents for all of the reports containing missing documentation or erroneous data. All NCRs were successfully closed except as noted in the following section.

6. Review of Analytical Results

a. Methods. Radiological Data: Negative values are sometimes reported in radiological measurements. Negative numbers occur because radiochemistry counting instrument backgrounds are subtracted from sample readings to obtain net counts. Because of slight background fluctuations, individual values for samples containing little or no activity can be positive or negative numbers. Although negative values do not represent a physical reality, removing negative values would introduce a positive bias to a data set, so we report them as they are received from the analytical laboratory as required by the "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991). Also see Appendix B.

The precision of radiological analytical results is reported as one standard deviation (one sigma) of the total propagated uncertainty. For most radionuclide measurements, we report a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (indicating nondetect). University of Miami tritium data do not have laboratory qualifiers; in that case, a detected result is reported when analytical results are greater than three times the reported (one-sigma) uncertainty.

Nonradiological Data: For organic compounds and some general inorganic chemistry (that is, major anions, cations, and nutrients) parameters, the nondetections are reported at the Practical Quantitation Limit (PQL). For the metals and the rest of the general inorganic chemicals, nondetections are reported at the MDL. Data between the MDL and PQL are qualified as estimated by the analytical laboratory. The analytical laboratory reports nonradiological results below the MDL as nondetections.

Detection-Limit Issues: The SOW requires that analytical laboratories verify their calculated MDLs empirically. Federal regulations prescribe a process for determining analytical laboratory detection limits which uses standards based on deionized water. For analysis of environmental samples, these detection limits may not be achievable. The additional constituents present in natural water samples may lead to matrix interference in the analytical process, which decreases the method sensitivity. Comparing results from these analyses with a detection limit based on deionized water will lead to additional false positive results for environmental samples. Empirical determination of detection limits using natural sample matrices produces a detection limit that is achievable for these samples.

b. Results. In addition to data validation, results are reviewed to assess the need for actions. In some cases, the data review identifies issues with data quality that require action to determine the overall quality of the reported results. Issues with data quality identified either through validation or data review are addressed in this section.

For example, there was an RDX interference found by GEL in the HE analyses by EPA SW-846 Method 8330, conducted during 2006. GEL investigated the interference and was not able to find a definitive cause. All affected data were identified during the corrective action process and appropriately qualified during data validation. As a result, most of the groundwater data for the last quarter of 2006 were analyzed following EPA SW-846 Method 8321 to avoid the problems with Method 8330.

GEL experienced difficulty with the calibration for the compound 1,4-dioxane by the volatile organic EPA SW-846 Method 8260 (MDL 20 µg/L). This resulted in the majority of the 1,4-dioxane results being rejected in validation. There were problems with blank contamination as well. To provide better results, 1,4-dioxane was added to the analyte list for EPA SW-846 Method 8270 (MDL 1 µg/L).

Diesel range organics (DRO) were analyzed more extensively to address waste characterization criteria. GEL reported a significant number of detections for DRO in areas where DRO was not expected or likely to be present. Investigation into this issue revealed that GEL was not using an appropriate detection limit for this analysis. The detection limit issue is still under investigation and will be resolved in 2007.

GEL subcontracted with Paradigm Analytical Laboratory to provide PCDD and PCDF analysis by EPA Method SW-846: 8290, as required by the Consent Order. The Paradigm results indicated very low-level detections at a majority of the groundwater locations sampled (detections reported at 34 of 36 groundwater locations). To correct the problem of false positive detections, LANL changed to ALTA Analytical Laboratory. ALTA showed a lower rate of detection (detections reported at four of 13 locations) but still at a higher rate than expected for PCDDs and PCDFs in groundwater. These detections of PCDDs and PCDFs in groundwater have occurred inconsistently in individual samples and their related duplicate samples. In addition, these compounds have been detected inconsistently between sample rounds for the same locations. Paradigm has also reported contamination in some of the method blanks associated with these samples, but the detection of

PCDDs and PCDFs in the method blanks and samples has not been consistent. This pattern of inconsistent detections of PCDDs and PCDFs in groundwater has continued into 2007, and LANL is investigating this issue.

There were 21 detections of Xylene[1,3-]+Xylene[1,4-] in 2006 evenly split between groundwater samples and blanks. All of the detections were below PQL. GEL was asked to investigate possible low-level contamination by Xylene[1,3-]+Xylene[1,4-]. GEL reported that there was no evidence of pervasive contamination in the laboratory. The data were qualified following the data validation procedure requirements. There were seven results with associated blank contamination that were qualified as non-detects, 13 results were reported as detections less than the PQL, and one result was rejected because of carryover contamination in the laboratory.

There were detections of 4,4'-DDT and or its breakdown products in three wells in 2006. These were the first samples collected for pesticides at these three locations. All detects were below the PQL and were not confirmed in subsequent samples collected from these locations. The analytical laboratory and data validation subcontractor indicated that the data were acceptable as reported for both the detections and the subsequent non-detections reported. Therefore, both sets of results are reported in the database.

There were four detections of PCBs reported in 2006 groundwater samples. Three of these detections were below the PQL and were marked as estimated (with the J qualifier) by the laboratory. This simply means that the results are valid detections but are near the MDL. Reanalyses of these samples were not conducted because the holding time had expired and reanalysis of samples at this level would not have produced useful data to determine detect status for these low levels. There was also a detection of Aroclor-1242 at a concentration of 4.5 µg/L in a sample from R-12 at 810.8 ft. This sample was re-extracted and reanalyzed after the 7-day extraction holding time had expired, but within two months of sampling, and was found to have non-detectable levels of Aroclor-1242 in the sample (result reported as less than 0.143 ug/L). While this result was rejected due to the holding time violation based on National Functional Guidelines (EPA 2001), other guidance in the Clean Water Act (40 CFR Parts 122 and 136) provides for a one-year holding time for PCBs in water. Therefore, it is unlikely that the high levels of Aroclor-1242 reported in the first analysis would have been lost in the sample over the time interval in question due to the stability of PCBs.

There were a series of volatile organic compounds detected in well R-20 at various depths including toluene, naphthalene, isopropylbenzene, acetone, and tetrachloroethene. Investigation into the detections of toluene indicated that there were problems with the well involving the packer system used and that this system might have contributed to the contamination detected at the well. Review of the data by AQA and GEL did not indicate any data quality problems with the analyses provided by GEL. Sampling conducted after addressing some of the possible problems with the field equipment were inconclusive, with detections of acetone in both samples and associated equipment and field trip blanks. The naphthalene, isopropylbenzene, and tetrachloroethene were not detected in the samples or blanks during the subsequent sampling rounds.

There were several detections of plutonium-239/240 that may be false positives. The results are greater than the minimum detectable activity (MDA) and less than three times the sample-specific uncertainty. A thorough review of the data reported by the laboratory was conducted by GEL, AQA, and LANL and no specific cause has been identified. However, a review of plutonium-239,240 data for the past few years shows that the analytical laboratory is reporting much lower MDAs with their results in 2006. Additional investigations into this issue are ongoing.

7. Audits and Assessments of Program and Analytical Laboratories

a. Methods. In addition to routine review of data packages, analytical laboratory oversight includes audits, site visits, and conference calls to review general laboratory quality practices. Problems identified during

these processes normally require the laboratory to take a formal corrective action. Audits are conducted at least every three years for laboratories contracted by the SMO for environmental sample analysis.

b. Results. GEL and Severn-Trent St. Louis receive an audit on an annual basis due to the large amount of work they perform for the programs at LANL.

In December 2006, AQA conducted a Data Package Assessment (DPA) at GEL. This assessment included data package completeness, documentation of the analytical work, instrument calibration and calibration checks, method quality control, secondary reviews and QA oversight, sample receiving and custody, holding times, use of appropriate methods, calculation review, and sample preparation. Ancillary records reviewed in support of the assessment include analyst proficiency training, standards preparation and traceability, calibrations not included in the data package, holding blanks, electronic files, laboratory performance evaluation samples, and any non-conformances and corrective actions associated with the report. Additionally, contractual compliance with the DOE-AL Model SOW and LANL SOW was reviewed.

This data package assessment included data packages for organic, radiochemical, and general inorganic analyses. All the files were retrieved quickly and contained all the required documentation except as noted in the audit report. There were 12 items submitted for corrective action listed in the data package audit report. One of these items relates to the corrective action for the RDX interference discussed in Section 6b. Of the remaining issues, two did not relate to LANL groundwater data and the other 9 issues were for contractual or documentation issues that did not adversely impact the data reported by GEL during 2006.

Data package assessments were not conducted at STSL, STLA, ALTA, or Paradigm in 2006.

There were no internal program audits or assessments performed in 2006 for the Water Stewardship Program.

8. Department of Energy Contract Analytical Program Audits

a. Methods. The Office of Environmental Management at DOE Headquarters (HQ-EM) mandated participation in the Department of Energy Contract Analytical Program (DOECAP; https://doecap.oro.doe.gov/). DOECAP is a consolidated, uniform audit program for conducting annual audits of commercial laboratories to eliminate audit redundancy by involving all DOE program line organizations and field elements, provide a pool of trained auditors sufficient to support consolidated audits, standardize terms and conditions of existing and proposed contracts to allow acceptance of consolidated audit results, and interface with state and federal regulatory agencies, as well as other industry standard-setting groups, such as the National Environmental Laboratory Accreditation Conference. LANL requires participation in DOECAP for all major analytical providers. Smaller or specialty providers are audited following the LANL Environmental Characterization & Remediation (ECR) QA Program.

DOECAP audits result findings and observations when there are items of concern that need to be addressed in the audit report. The DOECAP Policies and Practices document defines the following findings and observations:

- A Priority I finding shall only be issued for a significant item of concern, or significant deficiency regarding key management/programmatic control(s), which in and of itself represents a concern of sufficient magnitude to potentially render the audited facility unacceptable to provide services to the DOE if not resolved via immediate and/or expedited corrective action(s).
- A Priority II finding shall be issued to document a deficiency which in and of itself does not represent a concern of sufficient magnitude to render the audited facility unacceptable to provide services to the DOE.

- An observation provides the DOECAP mechanism for identifying and tracking a deficiency of an isolated nature or lesser significance than that warranting issuance of a Priority II finding, as well an opportunity for improvement, identified during a DOECAP audit.

b. Results. The following DOECAP audits were conducted at facilities providing water and sediment data to the Water Stewardship Program:

- STSL DOECAP: This audit occurred on April 5–7, 2006. Four Priority II (PII) findings from 2005 remain open. There were 14 new PII findings and 22 new observations, of which 10 findings and 14 observations were for operations unrelated to LANL samples. The corrective action plan has been approved and is available on the DOECAP website.
- GEL DOECAP: This audit occurred on May 9–12, 2006. All Priority II (PII) findings from 2005 were closed. There were seven new PII findings and 10 new observations. All findings and all but one observation directly affect data processes for LANL data. The final audit report is available on the DOECAP website.

DOECAP did not conduct audits of STLA, ALTA, or Paradigm in 2006.

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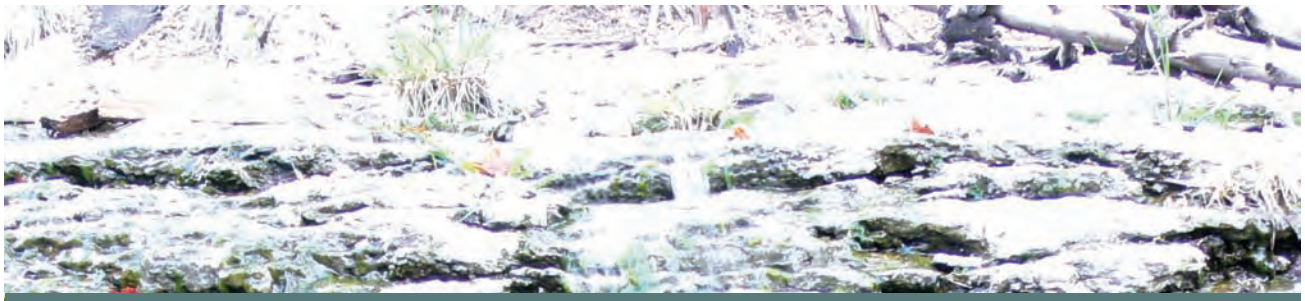

6. Watershed Monitoring



6. Watershed Monitoring

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A. INTRODUCTION

The Laboratory monitors the quality of surface water and stream sediment throughout northern New Mexico (NM) to evaluate the potential environmental effects of Laboratory operations. The Laboratory analyzes samples for several parameters, including radionuclides, explosive compounds, inorganic chemicals, a wide range of organic compounds, and general chemistry of surface water. In this chapter, the effects of Laboratory operations are evaluated over time. Additionally, the sampling results are compared with criteria established to protect human health and the aquatic environment.

In addition to monitoring to assess the radiological impacts from the Laboratory, LANL also monitors stream sediment, surface water, and storm water for the nonradiological impacts. The nonradiological monitoring and assessments are done in conformance with agreements with federal and state regulatory agencies. The agreements require a widespread monitoring of both perennial and ephemeral stream flows for an extensive list of constituents. As a result, increased sampling of base flow has resulted from the Compliance Order on Consent (the Consent Order), discussed in Chapter 2. Additionally, increased sampling of storm runoff and snowmelt has resulted from the Federal Facility Compliance Agreement (FFCA) and Administrative Order (AO) (EPA 2005a, b). Sampling is conducted at dozens of locations. The total surface water monitoring effort has yielded a substantial amount of water quality data. The principal focus of this chapter is on environmental conditions in the canyon floors, or watercourses, with limited references to individual sites.

B. HYDROLOGIC SETTING

Watersheds that drain Laboratory property are dry for most of the year. No perennial surface water extends completely across Laboratory land in any canyon. The canyons consist of over 85 miles of watercourses located within the Laboratory and immediately upstream of the Laboratory within Los Alamos Canyon. Of the 85 miles of watercourse, approximately two miles are naturally perennial, and approximately three miles are perennial waters created by effluent.

The remaining 80 or more miles of watercourse are dry for varying lengths of time. The driest segments may flow in response only to local precipitation or snowmelt, and the streambed is always above the water table. The flow in these streams is ephemeral. Other streams may sometimes have the water table higher than the streambed and/or extensive snowmelt in the watershed and are said to be intermittent. Intermittent streams

may flow for several weeks to a year or longer. To aid in water quality interpretation, we divide stream flow into three types or matrices. Each of the three flow types might be sampled at a single location within a time span of as little as a week, depending on weather conditions. At times, the flow might represent a combination of several of these flow types.

The three types are

- Base flow—persistent stream flow, but not necessarily perennial water. (This stream flow is present for periods of weeks or longer. The water source may be effluent discharge or shallow groundwater that discharges in canyons.)
- Snowmelt—flowing water present because of melting snow. (This type of water often may be present for a week or more and in some years may not be present at all.)
- Storm water runoff—flowing water present in response to rainfall. (These flow events are generally very short lived, with flows lasting from less than an hour to—rarely—several days.)

Because base flow is present for extended periods of time, it is available for potentially longer-term exposures, such as wildlife watering. Storm water runoff or snowmelt may provide a short-term water source for wildlife. Storm water is capable of moving Laboratory-derived constituents off-site and possibly into the Rio Grande.

None of the streams within Laboratory boundaries average more than one cubic ft per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs. By comparison, flow in the Rio Grande commonly averages approximately 800 to 1,000 cfs. Although most of the watercourses at LANL are dry throughout the year, occasional floods can redistribute sediment in a streambed to locations downstream. Streamflow in 2006 on the Pajarito Plateau was record setting and dominated by large rainfall events in August. Total precipitation for the month was approximately six inches which is nearly double the long-term average. Snowmelt for the year was negligible. The total storm runoff volume in 2006 of 168 ac-ft was measured at downstream gages in the watersheds crossing LANL lands. This runoff measurement was the second largest since 1995 and was attributable to large runoff events on August 8 and 25.

The August 8 storm was centered over the community of Los Alamos and produced the largest peak runoff event of record in Pueblo Canyon at 1930 cfs (Romero et al. 2007). The storm delivered approximately two inches of rainfall in one hour, which corresponds to between a 50 and 100 year return interval (NOAA 2006). Flow volumes in lower Pueblo Canyon were 25% larger than that of the other LANL canyons combined. The August 25 storm was centered over the central part of the Laboratory and produced a peak runoff of 628 cfs in Two Mile Canyon. The storm produced 2.15 inches of precipitation in three hours, approaching the intensity for a 100-year rainfall event. As a result of the two storms, new peak discharges were recorded at more than 20 stream gages across the Laboratory.

Hydrologic conditions in all LANL canyons and in upper Pueblo Canyon have recovered to near pre-fire levels. However, recovery after the fire has been somewhat counteracted in Pueblo Canyon by urbanization adjacent to the upper reaches. The increased pavement and roofs shed more local precipitation into the canyon. The increased runoff within Pueblo Canyon is discussed in more detail in Section G.2.

C. SURFACE WATER AND SEDIMENT STANDARDS

Table 6-1 summarizes the standards used to evaluate the monitoring data. The suite of standards varies, depending on the stream flow conditions and established or potential uses. To evaluate Laboratory impacts, we compare analytical results for surface water and sediment samples with regulatory water quality criteria or with risk-based screening levels.

Table 6-1
Application of Surface Water Standards and Sediment Screening Values to Monitoring Data

Medium	Standard	Risk- or Dose-Based Screening Level	Reference	Location	Notes
Surface water					
Radionuclides	State water quality standards for surface water (New Mexico Water Quality Control Commission, NMWQCC, 2005)	Biota Concentration Guides (BCGs) NM Radiation Protection Regulations	DOE Technical Standard 20.3.4 NMAC	On-site and off-site	Surface water is present sporadically or are not available for long-term access and do not provide persistent drinking water. The actual exposure pathway is to plants/animals, and not to humans. BCGs based on 1 rad/day exposure limit for aquatic animals and terrestrial plants, and 0.1 rad/day for terrestrial animals. Comparison with radionuclide criteria based on time-weighted average over the year per DOE Order 5400.5 and 20.3.4 NMAC.
			20.6.4 NMAC	On-site and off-site	Based on the protection of livestock watering for Ra-226 + Ra-228, tritium, and gross alpha radiation. NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, compare single sample results with numeric criteria.
Nonradionuclides	State water quality standards for surface water		20.6.4 NMAC	On-site ephemeral, intermittent streams	Single sample results are compared with numeric water quality criteria corresponding to livestock watering, wildlife habitat, and limited aquatic life standards (including acute aquatic life and human health criteria for persistent pollutants).
				On-site perennial streams	Single sample results are compared with numeric water quality criteria corresponding to livestock watering, Wildlife Habitat, and coldwater aquatic life standards (including chronic aquatic life and human health criteria). For screening purposes, single sample results are compared with 1.5 times the chronic aquatic life criteria (NMED 2006a).
				Off-site	Single sample results are compared with numeric water quality criteria corresponding to designated uses contained in NMWQCC water quality standards.
	State water quality standards for ground water		20.6.2 NMAC	On-site and off-site	Single sample result comparisons with groundwater quality criteria are used to determine potential for stream flows to impact underlying bodies.

Table 6-1 (continued)

Medium	Standard	Risk- or Dose-Based Screening Level	Reference	Location	Notes
Sediment					
Radionuclides	None	Human health screening levels	LANL	On-site and off-site	Screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public; comparisons are made for recreational or industrial exposure parameters; based on a dose rate limit of 15 mrem/year (LANL 2005). Recreational levels are appropriate for Laboratory lands because of public access. There are no residential uses of LANL lands and residential use is impractical at most locations (e.g., many canyon bottoms).
		Biota concentration guides	DOE technical standard	On-site and off-site	Dose limit to biota same as for surface water. Individual results compared to BCGs.
		Background	LANL (1998) or McLin (2004)		Results from Pajarito Plateau stations are compared to plateau-specific background levels (LANL 1998). Results from regional stations are compared to background levels specific to the major rivers within the Rio Grande drainage system (McLin 2004).
Nonradionuclides	None	Human health screening levels	NMED, EPA Region 6, or LANL	On-site and off-site	Recreational or industrial screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public.
		Background	LANL (1998) or McLin (2004)		Results from Pajarito Plateau stations are compared to plateau-specific background levels (LANL 1998). Results from regional stations are compared to background levels specific to the major rivers within the Rio Grande drainage system (McLin 2004).



1. Applicable New Mexico Surface Water Standards

The NM Water Quality Control Commission (NMWQCC) establishes surface water standards for waters of the state in Standards for Interstate and Intrastate Surface Waters (NMWQCC 2005). Certain watercourses may be 'classified' and have segment-specific designated uses. A designated use may be an attainable or an existing use (e.g., livestock watering, aquatic life) for the surface water. Nonclassified surface water is described as ephemeral, intermittent, or perennial, each of which also has corresponding designated uses. The designated uses for surface water are associated with use-specific water quality criteria, including numeric criteria.

Significant changes were made in the NMWQCC stream standards that became effective July 17, 2005. The most significant change, with respect to surface water monitoring at the Laboratory, is the classification of all surface water with segment-specific designated uses within the Laboratory boundary. Four segments, with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact, are classified as perennial (Figure 6-1). The remaining segments, with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact, are classified as ephemeral or intermittent.

The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. While direct use of the surface water is minimal within the Laboratory, stream flow may extend beyond the LANL boundaries where the potential is greater for more direct use of the water. Stream flows may extend onto Pueblo de San Ildefonso tribal land. Spring water may be used traditionally and ceremonially by San Ildefonso tribal members, and uses may include ingestion or direct contact.

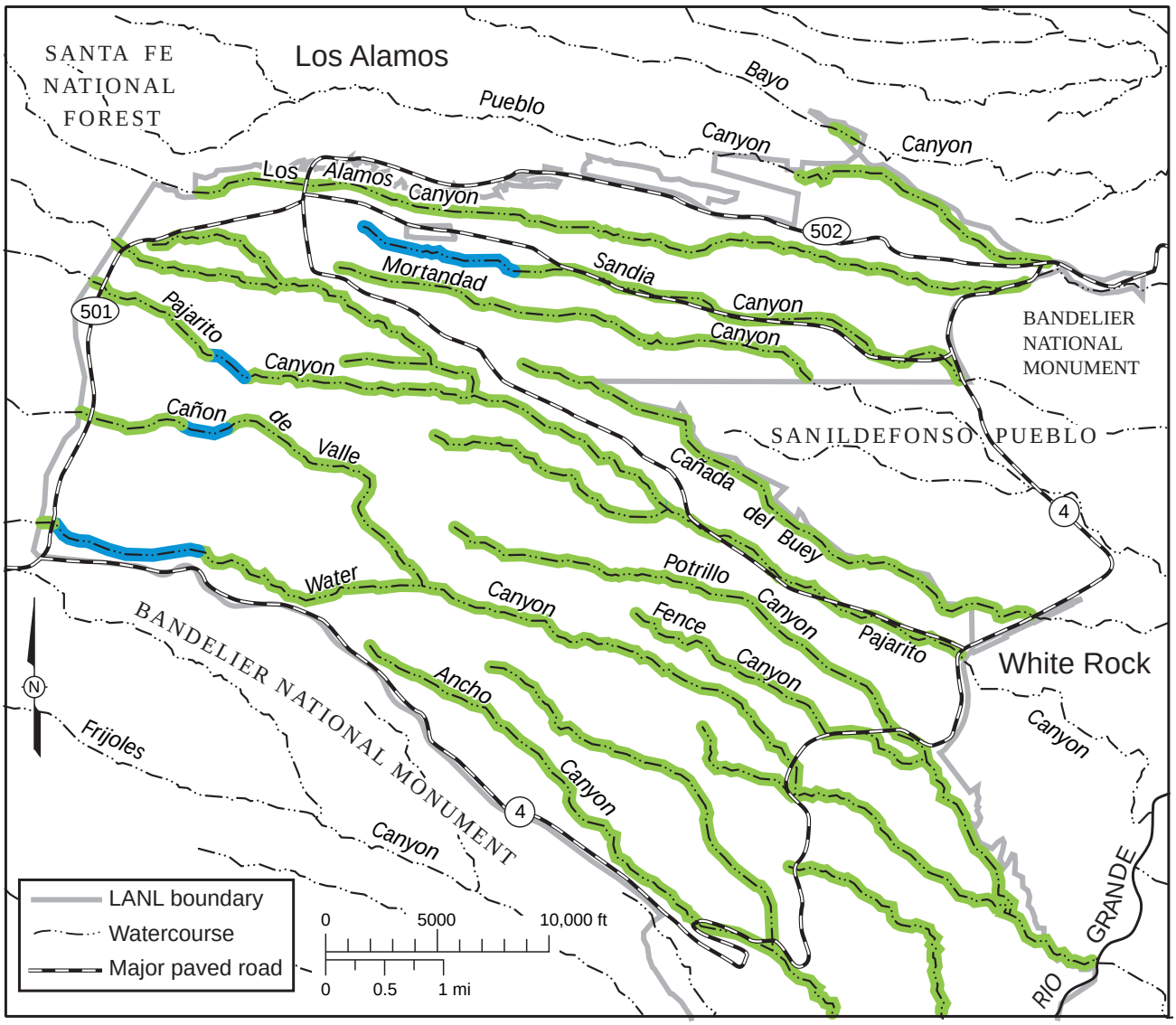
2. Radionuclides in Surface Water

DOE Order 5400.5 prescribes total dose limits associated with exposure to radionuclides in environmental media. There are no drinking water systems on the Pajarito Plateau that rely on surface water supplies because of the limited extent of stream flow. The emphasis of our radiological assessment of surface water is, therefore, on potential exposures to aquatic organisms and terrestrial plants and animals, rather than to humans. For protection of biota population, we compare concentrations of radionuclides in surface water with the US Department of Energy (DOE) Biota Concentration Guides (BCGs) (DOE 2002). Comparison of water quality results to BCGs is done based on annual flow-weighted radionuclide content of the water rather than on individual samples.

Surface water analytical results are also compared with the NMWQCC water quality standard for protection of livestock watering use, which is a designated use for surface water within the Laboratory boundary (NMWQCC 2005). NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, we compare single sample results with numeric criteria for radium-226 + radium-228 and tritium, as discussed in Section 3.

3. Nonradioactive Constituents in Surface Water

Surface water concentrations of nonradioactive constituents are also compared with the NMWQCC (2005) numeric water quality criteria that correspond to the designated uses for the stream. All surface water within the Laboratory boundary have the designated uses of livestock watering and wildlife habitat. For classified ephemeral and intermittent watercourses, the limited aquatic life use applies, along with the acute (short-term) aquatic life criteria and the human health criteria for persistent pollutants. The NMWQCC human health criteria are based on the US Environmental Protection Agency (EPA) criteria for "consumption of organisms only." Within the classified perennial waters, the coldwater-designated use applies, together with both the acute and chronic (long-term) aquatic life criteria and the human health criteria for toxic pollutants, including persistent and carcinogenic pollutants. Hardness-dependent aquatic life numeric criteria are calculated using a water hardness value of 100 mg $CaCO_3$/L.



Stream Type Designated Uses

Perennial (NM 20.6.4.126): Coldwater Aquatic Life, Livestock Watering, Wildlife Habitat, Secondary Contact Ephemeral and Intermittent (20.6.4.128): Limited Aquatic Life, Livestock Watering, Wildlife Habitat, Secondary Contact

Perennial

Ephemeral and Intermittent

Figure 6-1. Designated stream segments and uses at Los Alamos National Laboratory.

For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life, the Laboratory uses the protocol employed by the NMED for assessing standards attainment in waters of the state (NMED 2006a). For designated perennial stream segments, single sample results are compared with the chronic screening level that is 1.5 times the chronic aquatic life criterion. Surface water quality results are lastly compared with the NMWQCC groundwater standards to evaluate the potential for stream flows to impact underlying groundwater bodies (NMWQCC 2002).

4. Sediment

Sediment analytical results are compared to screening levels to identify concentrations that may require further assessment. The Laboratory's Environment Remediation and Support Services Division uses residential, industrial, construction worker, or recreational screening action levels (SALs) to identify radionuclide activity levels of interest (LANL 2005). Comparisons with SALs are used to readily distinguish the areas with the most potential concern: concentrations below the SALs are not of concern to public health, whereas concentrations greater than the SALs would trigger more detailed investigations. Residential uses do not occur on Laboratory land. Recreation is the dominant use in most areas of the Laboratory watercourses. Concentrations of nonradioactive compounds in sediment are compared with recreational or industrial soil-screening levels developed by NMED (2006b), EPA Region 6 (EPA 2007), or LANL (2007). All of these screening levels are conservative (protective) because they are calculated based on the assumption that humans will be exposed to the chemicals or radionuclides for extended periods of time, which is not the case on LANL property. For sediment stations located on the Pajarito Plateau, sediment data are also compared with established plateau-specific background levels of metals or background activities of radionuclides that are naturally occurring or result from atmospheric fallout (LANL 1998) and sources other than LANL. Data from regional sediment stations are compared to background levels established for the major drainages of the area, the Rio Grande, Rio Chama, and Jemez River (McLin 2004).

D. SAMPLING LOCATIONS AND DATA ANALYSIS METHODS

1. Regional Monitoring Locations

Regional base flow and sediment sampling stations (Figure 6-2) are located in northern NM. Samples from regional stations reflect background concentrations and provide a basis for evaluating Laboratory impacts to the Rio Grande drainage system. Regional sediment samples were obtained from stations on the Rio Grande and the Jemez River, from Abiquiu Reservoir on the Rio Chama, and from Cochiti Reservoir on the Rio Grande. Sampling stations in the Rio Grande drainage system are located up to approximately 60 km upstream of the Laboratory.

2. On-Site and Perimeter Monitoring Locations

Surface water and sediment are sampled in all major canyons that cross current or former Laboratory lands. Stream sediment is sampled to evaluate the accumulation of undissolved contaminants in the aquatic environment (DOE 1991). Surface water samples are collected across the Pajarito Plateau within and near the Laboratory, with particular emphasis placed on monitoring at the Laboratory boundaries. We collect base-flow grab samples from locations where effluent discharges or natural springs maintain stream flow (Figure 6-3).

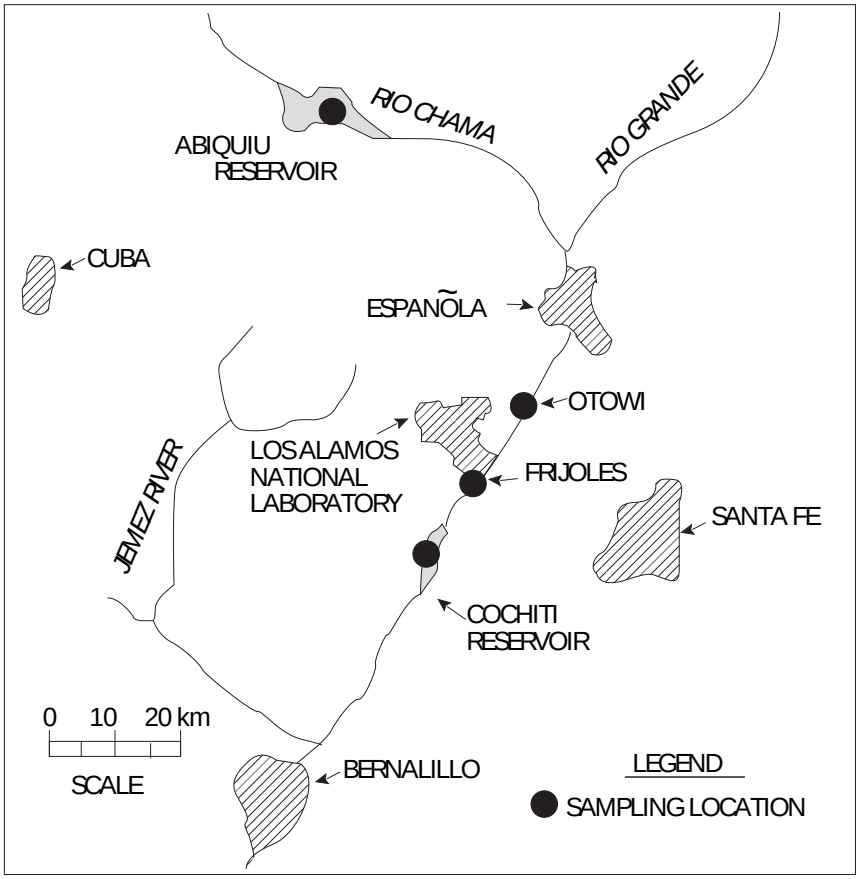


Figure 6-2. Regional base flow and sediment-sampling locations.

Storm water runoff samples in watercourses are collected at stream-gaging stations using automated samplers (Figure 6-4). Many gaging stations are located where drainages cross the Laboratory's boundaries. Storm water runoff is also sampled at many mesa-top sites which allows the Laboratory to evaluate runoff from specific Laboratory activities (Figure 6-5). These sites usually have negligible runoff from other sources.

Sediment stations on the Pajarito Plateau (Figure 6-6) are located within approximately four km of Laboratory boundaries, with the majority located within Laboratory boundaries. Many of the sediment-sampling stations on the Pajarito Plateau are located within canyons to monitor sediment contamination in the active channel related to past and/or present effluent discharges. Three major canyons were extensively characterized in 2006 (Pueblo, Los Alamos, and Mortandad Canyons) that have experienced past or present liquid radioactive releases; samples are collected from above the Laboratory to their confluence with the Rio Grande.

Sediment from drainages was collected downstream of two material disposal areas (MDAs), MDA G and MDA AB. Material Disposal Area G at Technical Area (TA)-54 is an active waste storage and disposal area. Sampling stations were established outside its perimeter fence in 1982 (Figure 6-7) to monitor possible transport of radionuclides from the area. MDA AB at TA-49 was the site of underground nuclear weapons testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved high explosives (HEs) and fissionable material. We established stations in 1972 to monitor surface sediment in drainages adjacent to MDA AB (Figure 6-8).

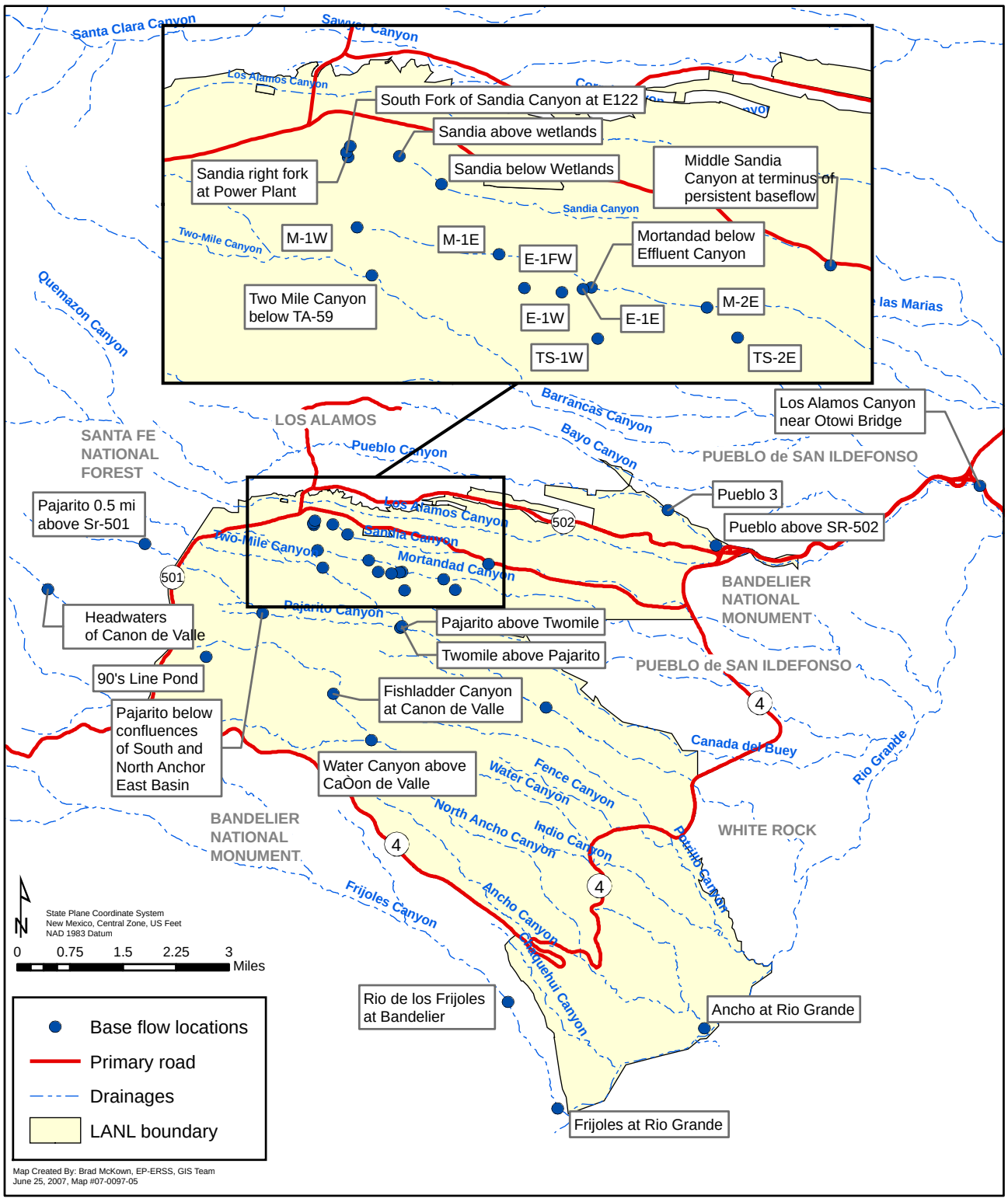


Figure 6-3. Base flow sampling locations in the vicinity of Los Alamos National Laboratory.

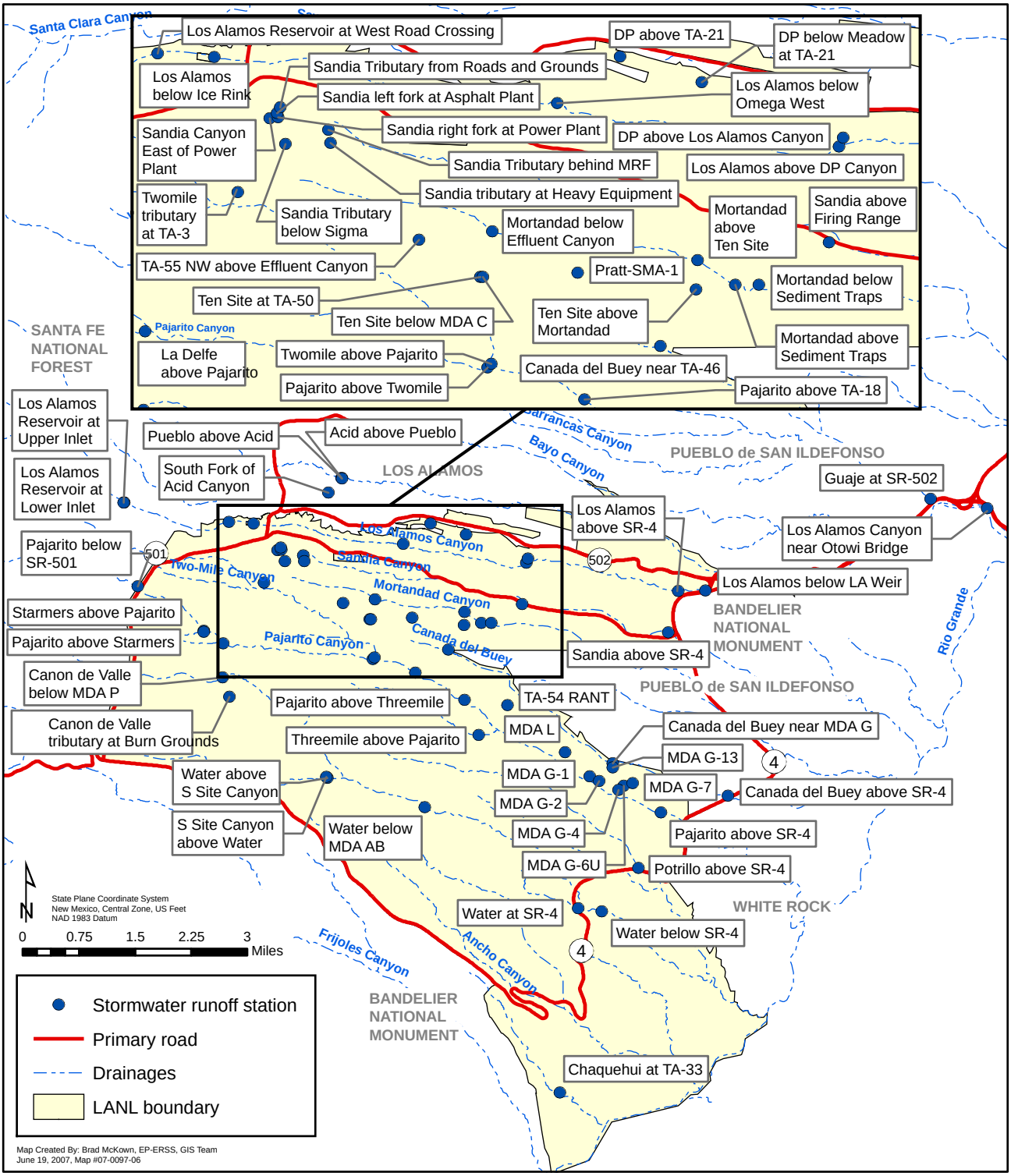


Figure 6-4. Storm water runoff sampling (gage) stations in the vicinity of Los Alamos National Laboratory.

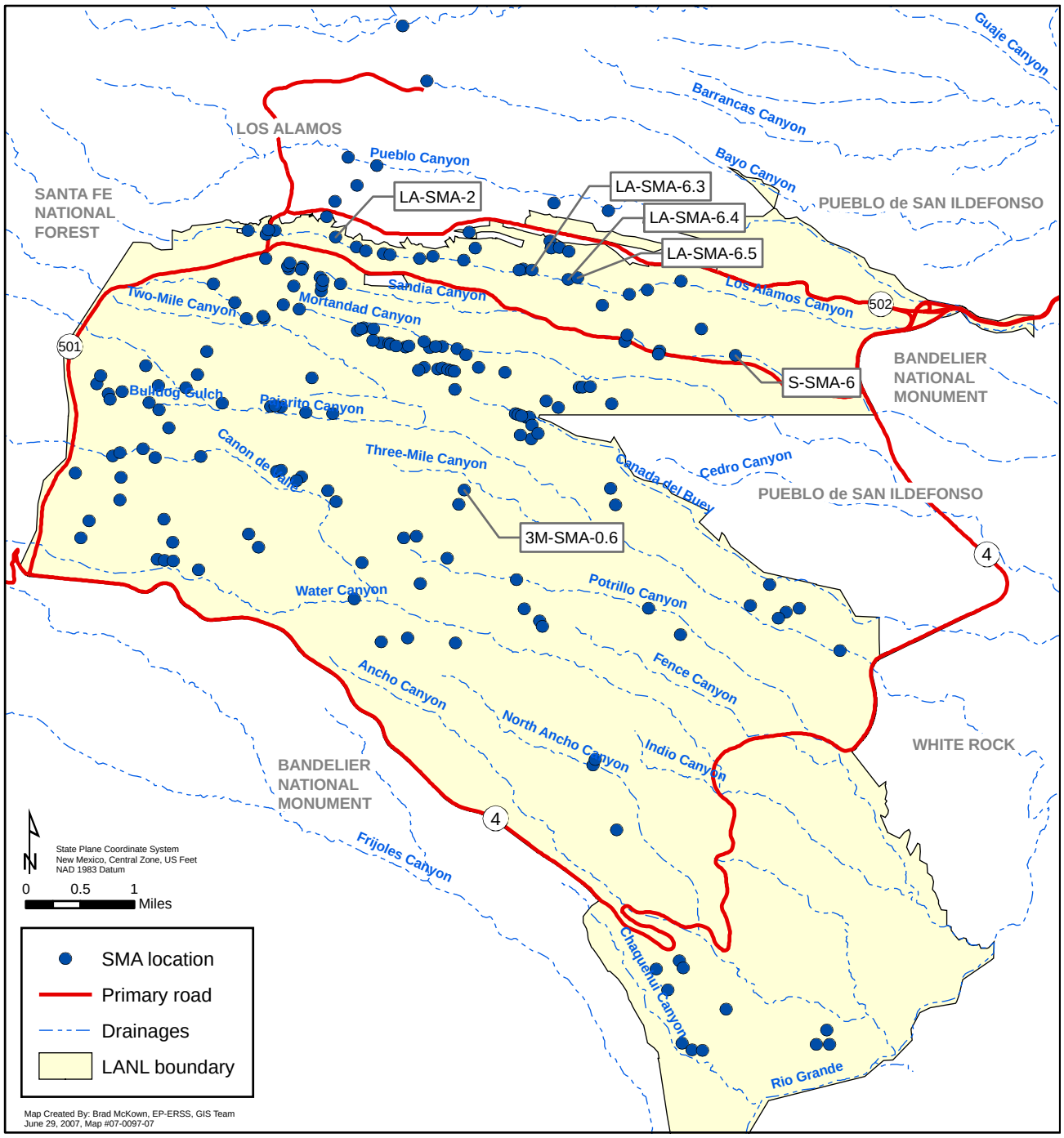


Figure 6-5. Site-specific storm water runoff sampling stations in 2006 in the vicinity of Los Alamos National Laboratory.

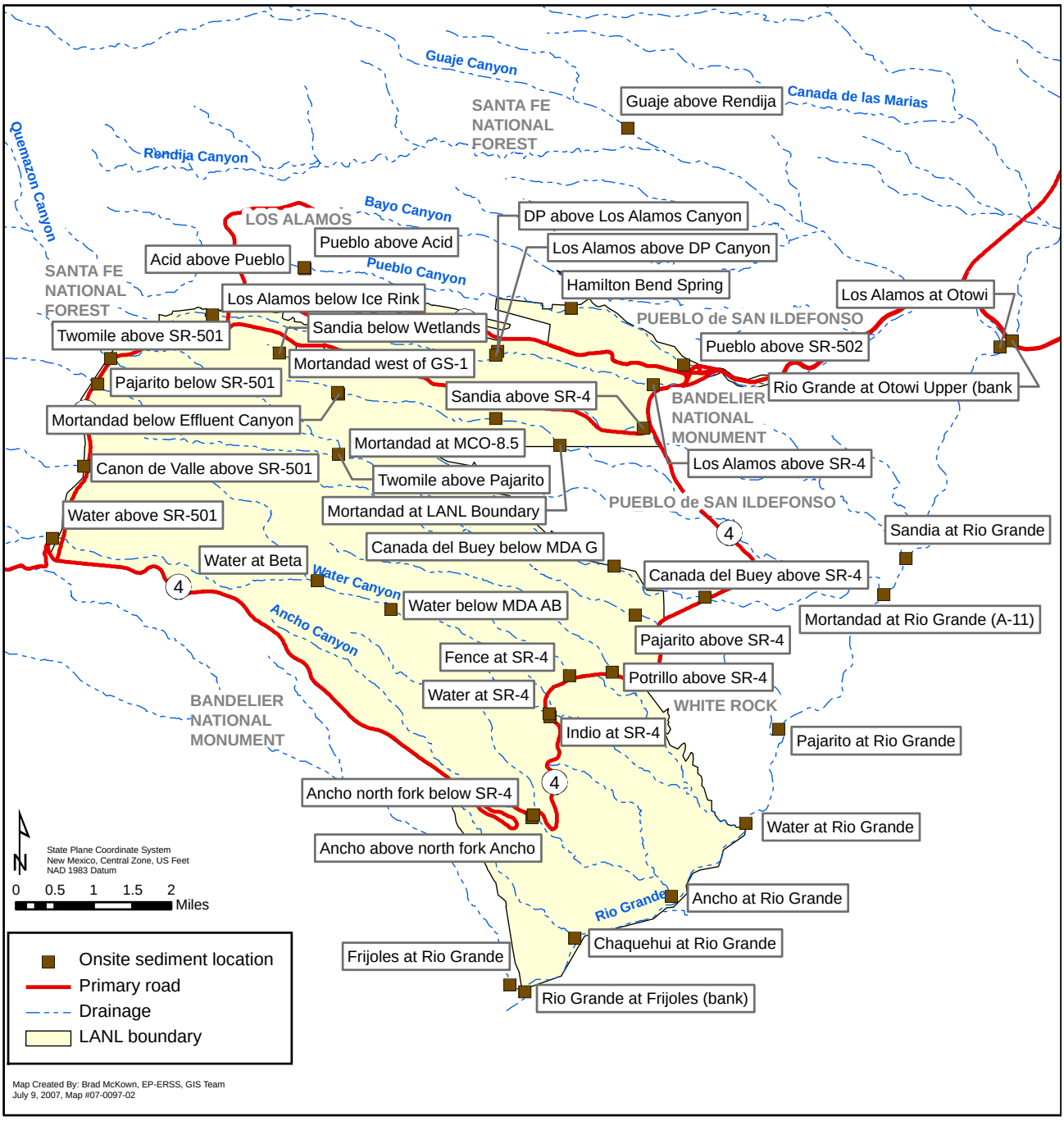


Figure 6-6. **Sediment sampling locations in the vicinity of Los Alamos National Laboratory. Material disposal areas with multiple sampling locations are shown in Figures 6-7 and 6-8.**

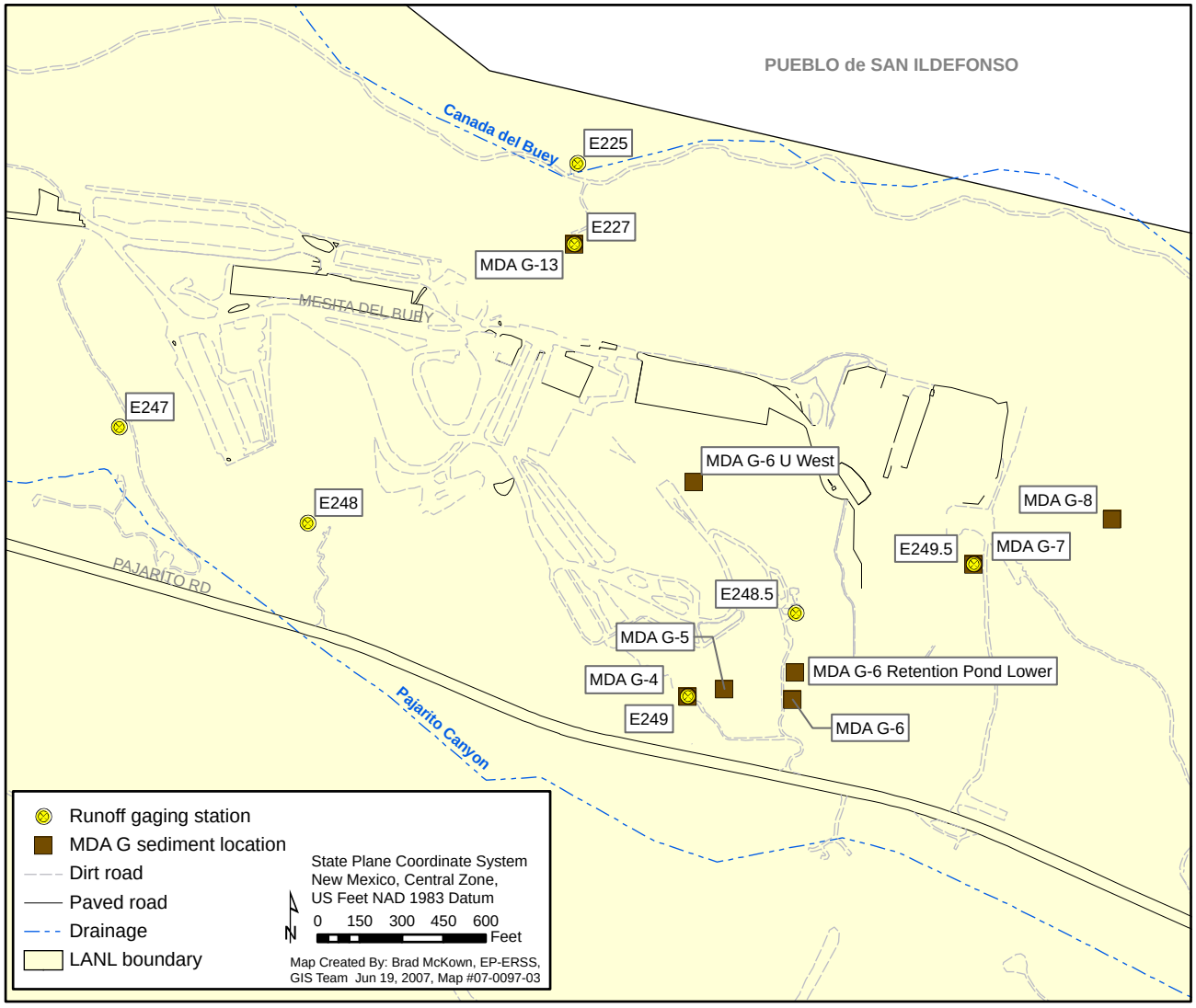


Figure 6-7. Sediment and storm water runoff sampling stations at TA-54, MDA L, and MDA G.

Additionally, surface water and sediment were sampled at several locations on Pueblo de San Ildefonso lands. DOE entered into a Memorandum of Understanding with the Pueblo de San Ildefonso and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on pueblo land. The watershed drainages that pass through LANL onto Pueblo lands are Los Alamos/Pueblo, Sandia, Mortandad, and Cañada del Buey Canyons.

3. Sampling and Analysis Procedures

Our procedures for sampling and analysis depend on the type of stream flow and location. We collect grab samples of base flow and snowmelt runoff from free-flowing streams near the bank. We filter and preserve grab samples in the field. The storm runoff (gage) stations, located mostly in canyon bottoms, are equipped with automated samplers that are activated at the start of significant flow events. Typically, the automated samplers collect water from the first 30 minutes of the runoff event to sample the first flush of storm water. This is the third year that the first flush has been sampled and it is a significant change from previous years.

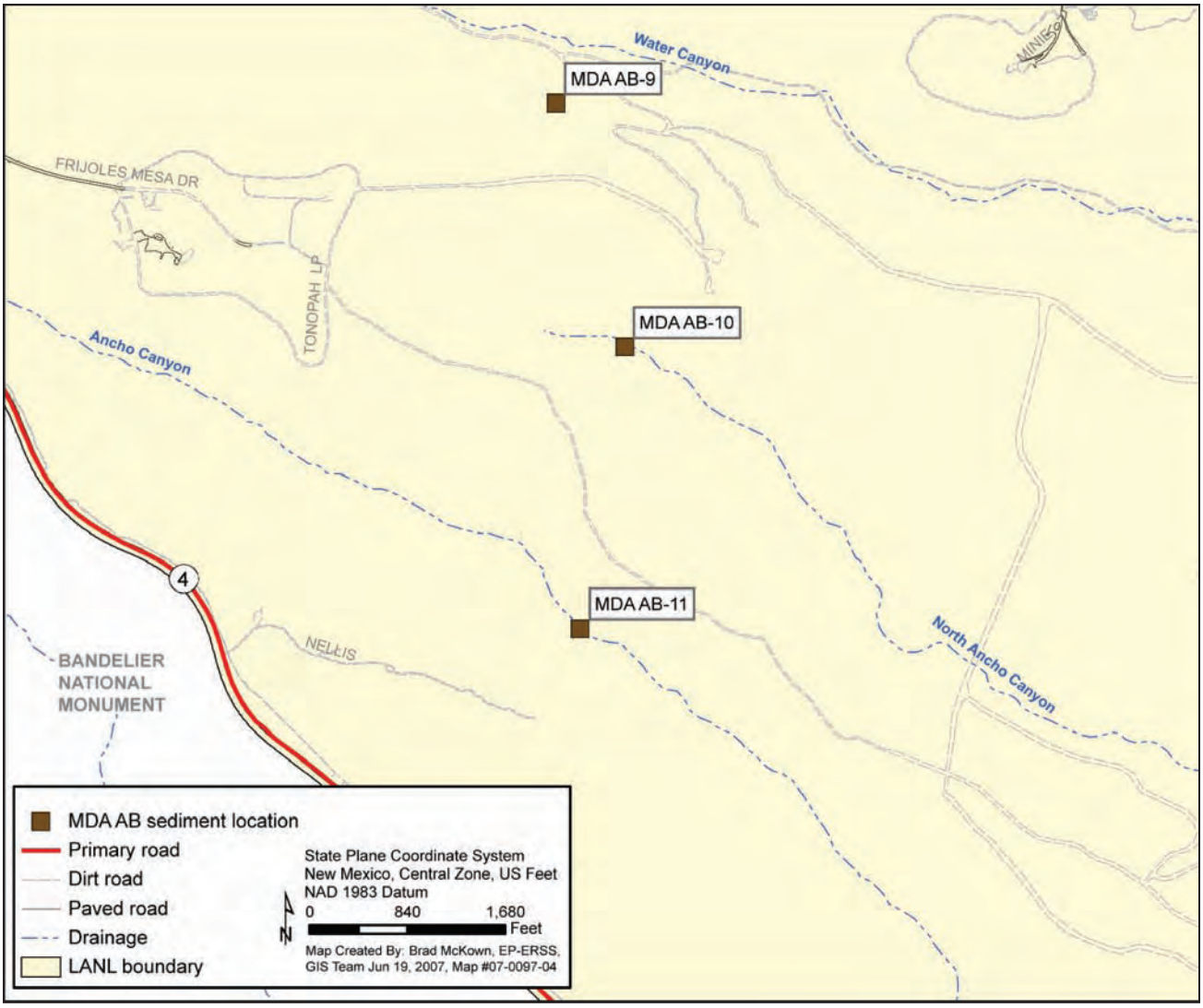


Figure 6-8. Sediment sampling stations at Area AB, TA-49.

Previously, samples were collected over a two-hour period. Higher concentrations are expected in the first flush compared to the average concentration during a flow event, so the post-2004 data are not directly comparable to data from previous years.

Storm water runoff samples from mesa tops are collected with buried single-stage runoff samplers. Individual storm runoff sample bottles are filtered and preserved at LANL. Base flow and snow melt samples are filtered and preserved in the field; storm flow samples are filtered and preserved in LANL's storm water operations facility, because filtering highly sediment-laden waters in the field is difficult. Samples are then shipped to the commercial analytical laboratory as is, without compositing or splitting. Sediment samples are collected from the edge of the main channels of flowing streams. To collect samples from the beds of intermittently flowing streams, a disposable scoop is used to collect fine-textured sediment across the main channel to a depth of 20 mm.

E. WATERSHED SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables on the included compact disk present all the 2006 watershed-related surface water and sediment analytical results. In the tables, radiological results are presented in sequence for each of these media, followed by the results for major chemical quality analytes, metals, and organic compounds.

Surface water and sediment samples are analyzed for gross alpha, gross beta, and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, uranium isotopes, and tritium, cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22). Table S6-1 in the Data Supplement lists the results of radiochemical analyses of surface water for 2006. The table also lists the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity, where available. Uranium is analyzed by isotopic methods. For most radionuclide measurements, a detection is an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier codes of X or U (indicating nondetect). Trace-level tritium measurement results for surface water samples are presented in Table S6-2. The results of radiochemical analyses of sediment appear in Table S6-3.

Concentrations of major chemical constituents in surface water are listed in Table S6-4. Table S6-5 and S6-6 present results of metals analyses for surface water and sediment, respectively.

The scope and results of organic analyses are presented in Tables S6-7 through S6-10. Table S6-7 presents the number and type of organic analyses performed on surface water samples, and Table S6-8 presents results for any organic chemical detected in surface water. Similarly, Tables S6-9 and S6-10 present summaries of organic analyses of stream sediment.

Qualifier codes are shown in some tables to provide additional information on analytical results that are not detections: in some cases, for example, the analyte was found in the laboratory blank, or there were other analytical issues. The tables show two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7).

The overall quality of most surface water in the Los Alamos area is good, with low levels of dissolved solutes. Of the more than 100 analytes measured in sediment and surface water within the Laboratory, most are at concentrations far below regulatory standards or risk-based levels. However, nearly every major watershed indicates some effect from Laboratory operations, often for just a few analytes. In the following sections, we first present a Laboratory-wide overview on surface water and sediment quality, and then the key findings are discussed in more detail on a watershed-by-watershed basis.

The contaminant distribution maps show contaminant locations extrapolated beyond the area covered by sampling stations. This extrapolation takes into account the location of contaminant sources and stream flow within each watershed. Question marks on the maps indicate where contaminant extent is inferred, but not confirmed by monitoring coverage. The extent of contamination lateral to the canyon is not to scale: much of the contamination is limited to the canyon bottom alluvium and is quite narrow at the map scale.

1. Radioactivity in Surface Water and Sediment

In 2006, there were no new locations with radiological contamination, and levels of radioactivity were within ranges measured in recent years. Other than for naturally occurring radionuclides (for example, radium-226), none of the radionuclide activities or concentrations were greater than applicable DOE standards or guidelines.

Approximately 8 of 10 surface water samples in 2006 contained gross alpha activity greater than the NM regulatory standard of 15 pCi/L for livestock watering. However, the vast majority of the alpha activity is due to natural sediment and soil from uncontaminated areas carried in storm water runoff, and Laboratory impacts are relatively small.

Decay of naturally occurring isotopes in sediment is a source of gross alpha activity, which is supported by the strong correlation between gross alpha and suspended sediment concentrations (SSC) shown in Figure 6-9. The relationship between gross alpha activity and SSC in stations within LANL is identical to stations upstream of LANL, with the exception of Mortandad Canyon. Mortandad Canyon receives effluent from a radioactive liquid waste treatment plant for radioactive materials. Therefore the elevation above the upper 95% confidence level for background stations shown in Figure 6-9 could be attributed to anthropogenic sources in storm water runoff.

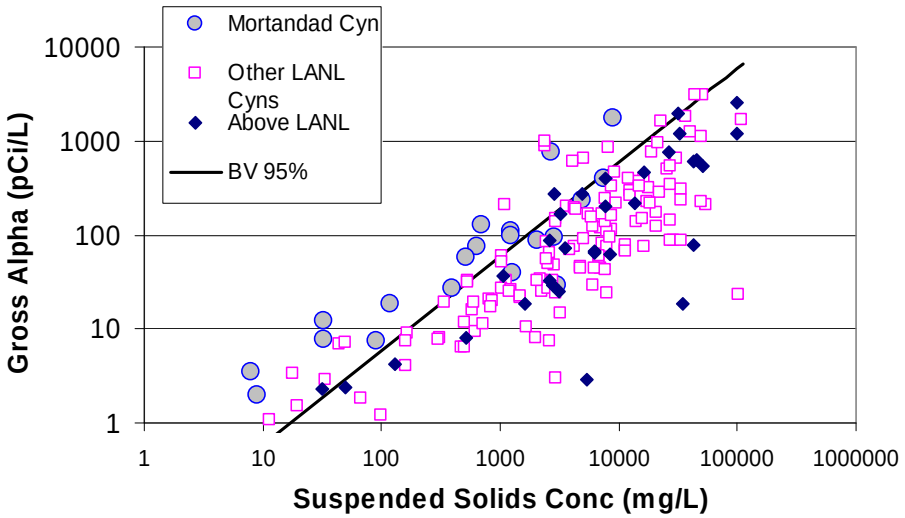


Figure 6-9. Relationship between gross alpha particle activity and suspended solids concentrations in surface water, 2000 - 2006. The line represents the upper 95th percentile level of activities that would arise naturally from background stream sediment (McDonald et al., 2003).

Gross alpha activities measured across the Pajarito Plateau have declined substantially since the 2000 Cerro Grande fire as stream flows are reduced with recovery in the burned areas (Figure 6-10), which has resulted in reduced concentrations of suspended solids.

Gross alpha radioactivity is a general screening measurement of limited value in assessing radiological hazards because specific alpha emitters in the water cannot be identified or quantified. Therefore, gross alpha results are not discussed in detail in this report. Instead, specific individual radionuclides identified in LANL waste streams (Watkins and Del Signore 2005) or known to be associated with the nuclear industry (Langmuir 1997) are analyzed. A listing of gross alpha concentrations measured in surface water is provided in Supplemental Table S6-1.

Table 6-2 compares the annual average concentrations of specific radionuclides in surface water at Los Alamos against the DOE's BCGs. In order to compare surface water sample data with the DOE BCGs, we calculated the time-weighted average annual radioactivity in waters, focusing on the wetter stream segments.

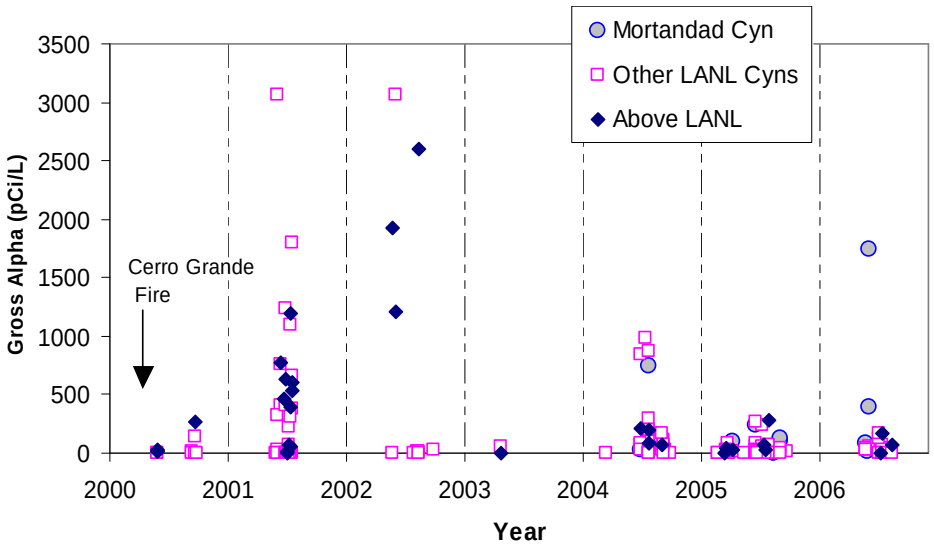


Figure 6-10. Time trends in total gross alpha activity in surface water.

Time-weighted average concentrations were calculated for the individual radionuclides of primary concern on the landscape at Los Alamos: americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, tritium, and uranium isotopes. Concentrations measured during base flow periods and during storm runoff periods were weighted proportionally after reviewing stream flow records (Romero et al., 2007) to distinguish the flow regimes; periods with no flow were assigned concentrations of zero.

This approach is consistent with DOE guidance (DOE 2003). For waters containing more than one radionuclide, a ratio for each radionuclide is calculated by dividing the concentration of each radionuclide by its particular BCG. To be consistent with DOE Order 5400.5, the sum of the ratios should not exceed 1.0 (DOE 1990). Because the calculations are often based on limited sample sets and hydrologic interpretation, these results should be viewed as approximations.

The time weighted annualized concentrations, and sum of ratios, for unfiltered surface water in the major canyons were well below the BCGs. Table 6-2 shows that concentrations of all of the individual isotopes were less than 5 percent of their respective BCGs, except for radium-226 at 40 percent of the BCG. When the mixtures of isotopes are considered, the largest sums of the ratios were found in the Los Alamos Canyon drainage system at between 25 to 43 percent of the standard.

Approximately 95 percent of the calculated potential radiological dose to biota is attributable to radium-226. Although radium-226 is probably of natural origin, it is of concern because it has the most stringent BCG for all the radionuclides monitored. The BCG was established to protect riparian animals that ingest radium-226 in calcium-deficient waters. However, surface water at Los Alamos is calcium-abundant and the resultant dose from radium-226 is considerably less than calculated as the calcium interferes with the uptake of radium-226.

2. Metals in Surface Water and Sediment

In 2006, all metals concentrations in sediment were below screening levels for recreational and residential uses. In surface water, the vast majority of results were below the most stringent applicable state stream standards, other than for metals of natural origin (for example, aluminum.)

The NM Surface Water Quality Standards (NMWQCC 2005) vary across the Laboratory depending on the designated uses for a particular stream segment, as discussed in Section C.3. To evaluate how 2006

Table 6-2
Estimated Annual Average Unfiltered Surface Water Concentrations of Radionuclides in Selected Canyons with the Biota Concentration Guides

Radionuclide	BCGs[a] (pCi/L)	Pueblo above Acid	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon between DP and SR-4	LA Canyon at Rio Grande	Mortandad Canyon below Effluent Canyon	Max percent of BCG[a]
Am-241	400		0.01	0.1	0.5	0.01	9	2%
Cs-137[b]	20,000	0.1	0.2	2	2	0.3	33	0.2%
H-3	300,000,000		43	21	7	26	294	<0.01%
Pu-238	200		0.001	0.01	0.04	0.01	5	2%
Pu-239,240	200	0.01	0.3	0.1	0.5	0.04	7	4%
Sr-90	300	0.1	0.01	12	0.8	0.4	4	1%
U-234	200	0.3	0.4	0.6	1.3	1.5	2	1%
U-235,236	200	0.01	0.01	0.02	0.1	0.1	2	0.1%
U-238	200	0.4	1.0	0.4	1.3	1.4	0.1	1%
Ra-226	4	0.2	0.9	0.2	0.9	1.6	0.2	40%
Sum of ratios to BCGs		0.05	0.06	0.05	0.25	0.43	0.15	

[a] BCG = DOE Biota Concentration Guides (DOE 1992)

[b] The BCG for Cs is a site-specific modified BCG from McNaughton 2005

Blank cells indicate no analytical laboratory detection in 2006



monitoring results compare to the state standards, the applicable standards were compared to results for each specific location. During 2006, 580 sampling events were conducted at 169 locations. The monitoring included 86 site-specific (mesa top or hillside) sites and 79 watercourse (canyon floor) sites on the Pajarito Plateau. The testing program varied by watershed but surface water samples typically were tested for more than 100 analytes.

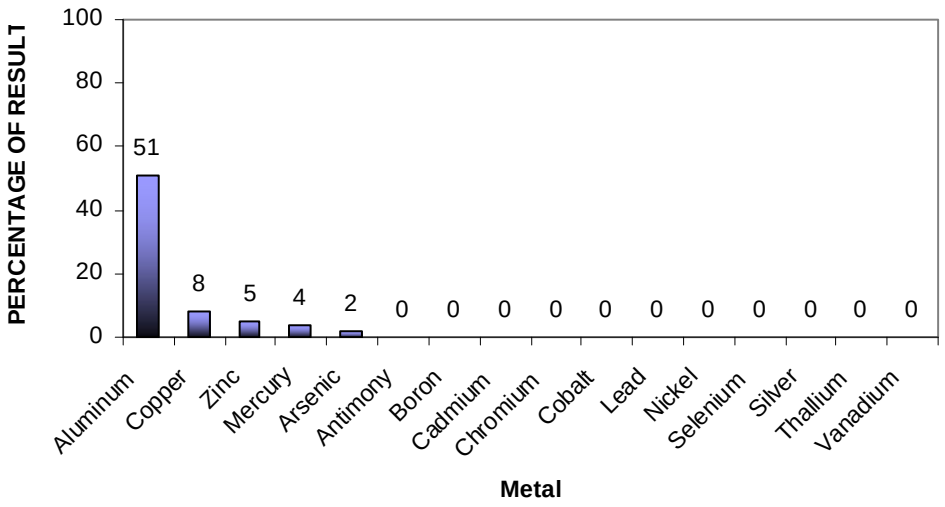


Figure 6-11. Frequency of metals results from watercourse stations above the most-restrictive NM stream standards.

About 50 percent of surface water samples contained concentrations of dissolved aluminum higher than the acute aquatic life standard (Figure 6-11). Aluminum is a natural component of soil and not derived from Laboratory operations in any significant quantity. In the slightly alkaline waters at Los Alamos, aluminum rarely occurs in solution in natural water at concentrations greater than a few tens to hundreds of micrograms per liter (Hem 1986). Consequently, a large majority of these results greater than the standard are probably due to the presence of particulate aluminum (colloids) that pass through the filter, rather than being dissolved in the water column which is the basis of the standard. No other metal was present at concentrations greater than the standard in more than 10 percent of the samples. The metals data indicate a minimal overall impact from the Laboratory, although a few localized areas appear to contain elevated copper (Figure 6-12), mercury, and zinc concentrations.

Following the Cerro Grande fire, numerous watercourses across the Laboratory were identified as water-quality impaired with total recoverable selenium concentrations above the NM wildlife habitat standard and added to the federal Clean Water Act §303(d) list (NMWQCC 2004). Selenium concentrations have progressively declined since the fire (Figure 6-13) and no values greater than the wildlife habitat standard of 5 µg/L were measured in 2006. The water quality trends indicate that the elevated selenium concentrations were due to natural sources, probably the ash from the fire. These data indicate that drainages near the Laboratory are no longer impaired with elevated selenium concentrations.

3. Organic Compounds in Surface Water or Sediment

The concentrations of organic compounds were analyzed in approximately 50 watercourse surface water stations and 50 active channel sediment stations. PCBs were generally found in two canyons above regulatory standards and are the principal class of organic compounds detected. Figure 6-14 shows where PCBs have recently been detected in surface water. In sediment, none of the organic compounds were detected at concentrations greater than recreational or residential soil screening levels.

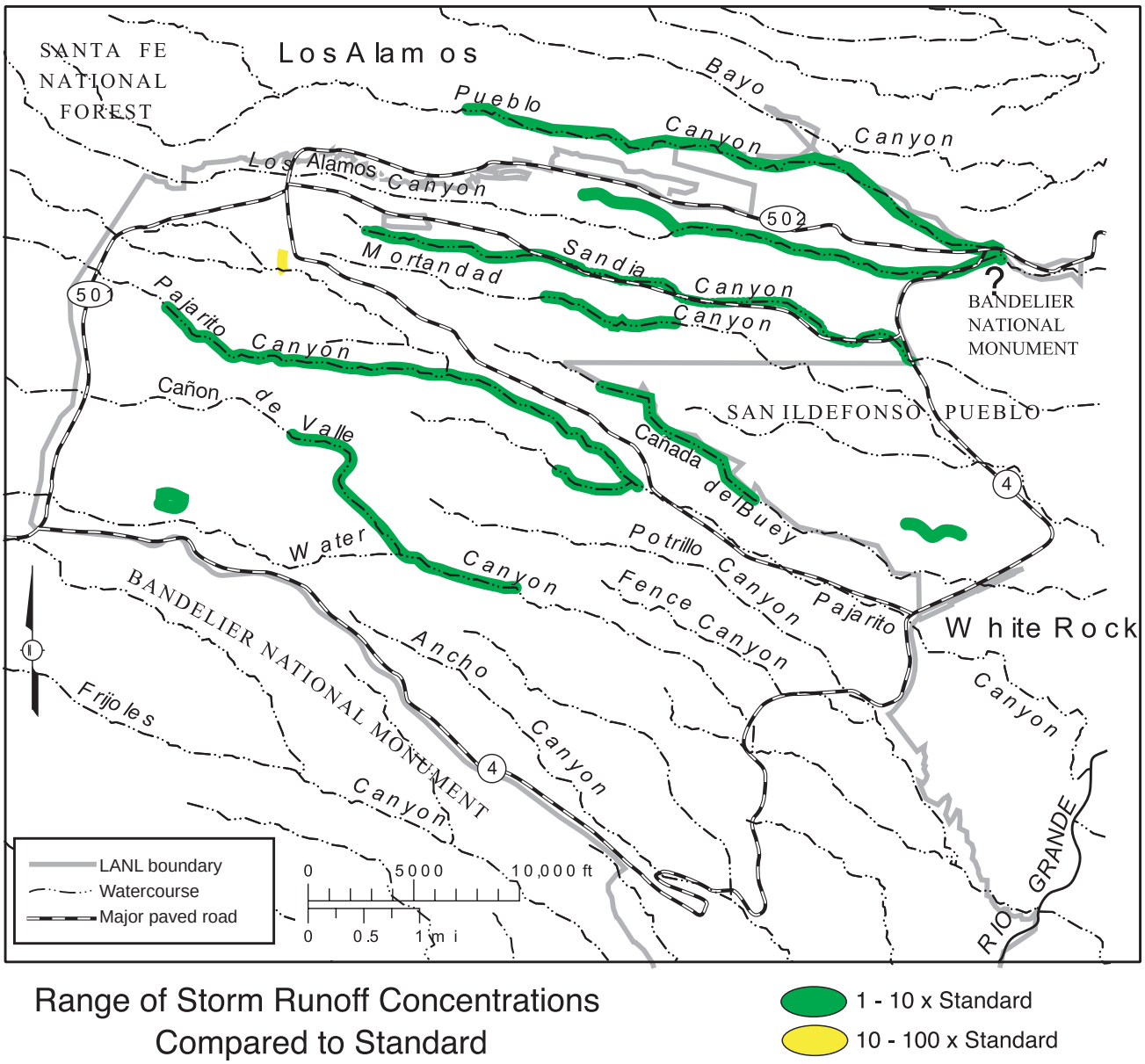


Figure 6-12. Location of surface water with levels of dissolved copper greater than stream standards.

The types of organic compounds analyzed for varied depending on the location and typically included the following suites: pesticides/PCBs, explosives compounds, volatile organics compounds, and semi-volatile organics compounds. On average, more than 70 different organic compounds were assessed at each site. PCBs were the only class of organic compounds that were definitively detected at concentrations greater than the NM water quality standards and are likely Laboratory-derived in part.

Surface water was analyzed for PCBs in 14 watercourses and detected in 6. Consistent with previous years, multiple PCB detections were reported in Sandia and Los Alamos Canyons. Sandia Canyon accounted for about half of the detections and Los Alamos Canyon an additional one-third. The PCB human health standards protect people from ingesting contamination through aquatic life consumption. The main sources of PCBs on Laboratory lands are likely predominantly from past spills and leaks of transformers, rather than current effluent discharges.

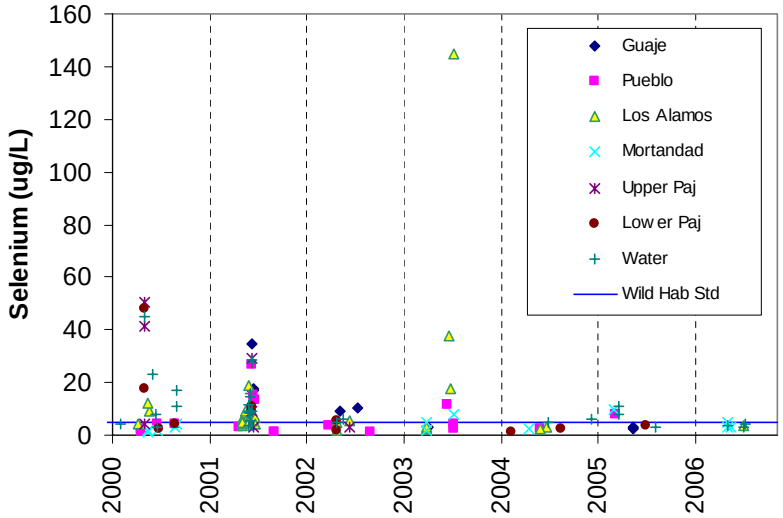


Figure 6-13. Trends in total recoverable selenium concentrations in surface water.

F. IMPACTS TO THE RIO GRANDE

Laboratory impacts to the Rio Grande were assessed in 2006 by comparing contaminant concentrations in sediment at locations upstream and downstream of LANL. River sediment was collected from the active channel of the river at the Otowi gage (upstream of LANL) and at the confluence with Frijoles Canyon in Bandelier National Monument (downstream). Additionally, samples of bottom sediment were collected at three separate locations each in Abiquiu Reservoir (upstream) and in Cochiti Reservoir (downstream), and analyzed for radioactivity and metals. Samples of Cochiti Reservoir bottom sediment were also analyzed for organic compounds.

All measurements of radioactivity in the Rio Grande and in Cochiti Reservoir were orders of magnitude below recreational or residential screening levels. In river sediment, no appreciable differences in radioactivity were measured above and below the Laboratory. Plutonium-239,240 concentrations were below analytical detection limits in the Rio Grande at both Frijoles and Otowi stations.

Plutonium-239,240 concentrations in bottom sediment from Cochiti Reservoir were comparable to those measured in 2005— near or slightly elevated above regional fallout levels (Figure 6-15). Though the 2006 sampling of Cochiti Reservoir was performed within one month following the August 8 record flood in Pueblo Canyon, plutonium-239,240 concentrations were not appreciably different than those measured since 2000. Metals concentrations in Rio Grande and Cochiti Reservoir bottom sediment were consistent with previous measurements. For example, 2006 Cochiti Reservoir mercury concentrations were within the ranges measured upstream at Abiquiu Reservoir (Figure 6-16), and below national median concentrations measured in reservoir studies across the country (Gillom et al. 1997).

No detections were found in Cochiti Reservoir sediment of pesticides, PCBs, semi-volatile organic analytes, or high explosive compounds. The pesticides DDE and DDT were detected in sediment collected at the Rio Grande at Frijoles station. These compounds have been historically detected in water samples taken from Frijoles creek and are not from Laboratory sources.

Natural stream flow and sediment loading in the Rio Grande is quite large compared to those from Los Alamos area streams. These factors reduce the possibility of identifying significant impacts from the

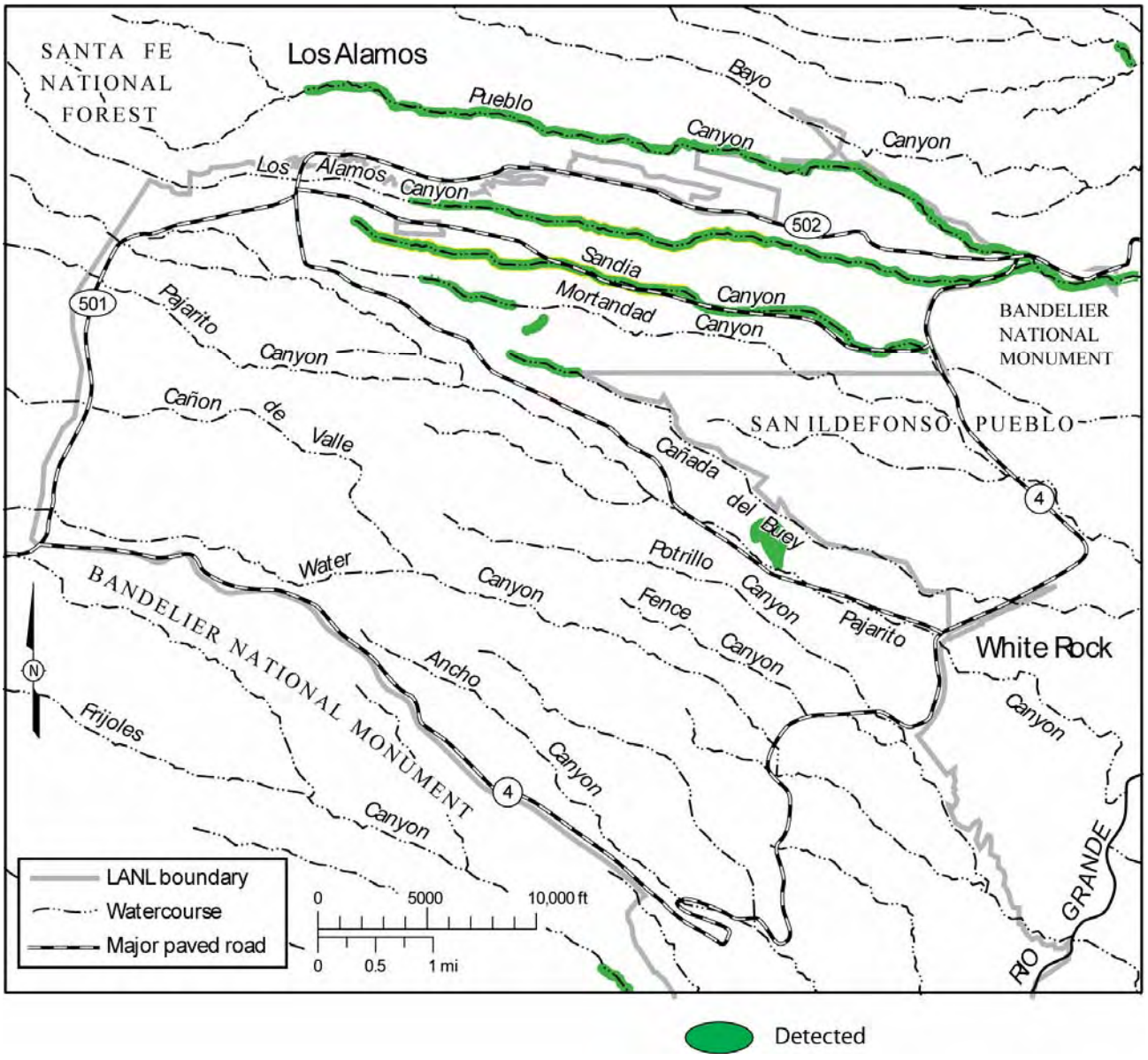


Figure 6-14. Location of surface water with detected PCBs.

Laboratory in the Rio Grande. A hydrographic comparison of 2006 flows in Los Alamos area canyons to flows in the Rio Grande is shown in Figure 6-17. Water flow in the Rio Grande at the Otowi gage was commonly a thousand times larger than that for all of the Los Alamos area canyons combined. Los Alamos area flows exceeded 10 cfs only on August 8 and 25. Similarly, the annual budget of suspended sediment and bed sediment passing the Otowi gage station were calculated to be 1,000 and 100 times that contributed by Los Alamos Canyon (Graf 1997). Large inputs of sediment from undeveloped parts of the Rio Grande watershed dilute the anthropogenic inputs from urban, industrial, and agricultural areas (Wilson and Van Metre 2000).

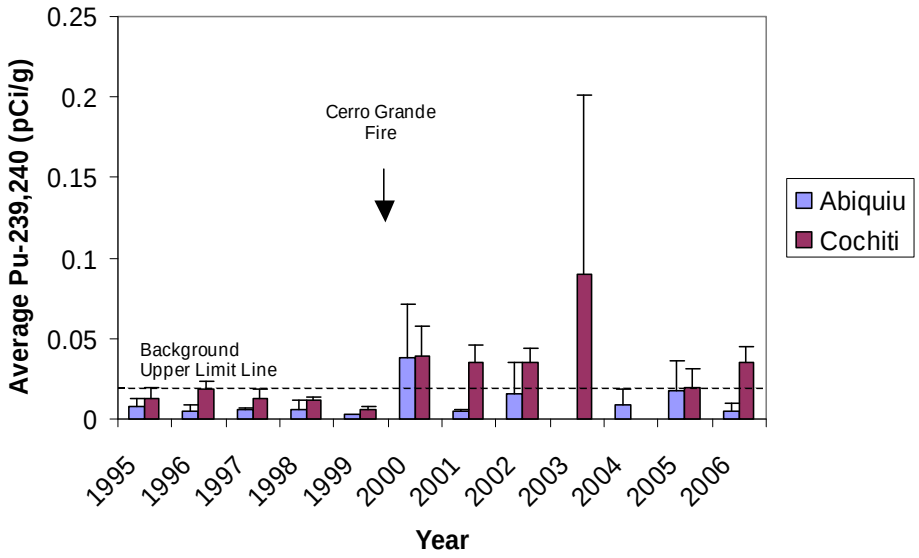


Figure 6-15. Plutonium-239,240 concentration (mean ±1 standard deviation) trends in Abiquiu and Cochiti Reservoir bottom sediment, 1995-2006.

G. CANYON-SPECIFIC CONTAMINATION

1. Guaje Canyon (includes Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities. Concentrations of metals, organic chemicals, and radionuclides in Guaje Canyon storm water were below NM and DOE standards. Active channel sediment contained background ranges of metals and radionuclides (LANL 1998).

2. Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyon)

Los Alamos Canyon has a large drainage that heads in the Sierra de los Valles. The Laboratory has used the land in the Los Alamos Canyon watershed continuously since the mid-1940s, with operations conducted at some time in all of the sub-drainages. Each of the canyons draining the watershed also receives urban runoff from the Los Alamos town site, and lower Pueblo Canyon receives treated sanitary municipal wastewater.



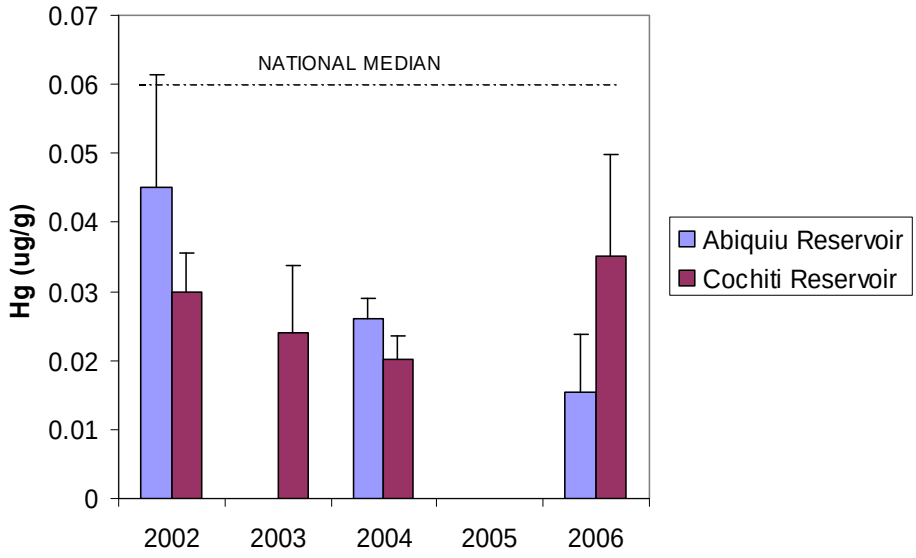


Figure 6-16. **Median mercury concentration (± IQR) trends in Abiquiu and Cochiti Reservoirs bottom sediment, 2002 –2006. National median value is from the US Geological Survey (Gilliom et al. 1997).**

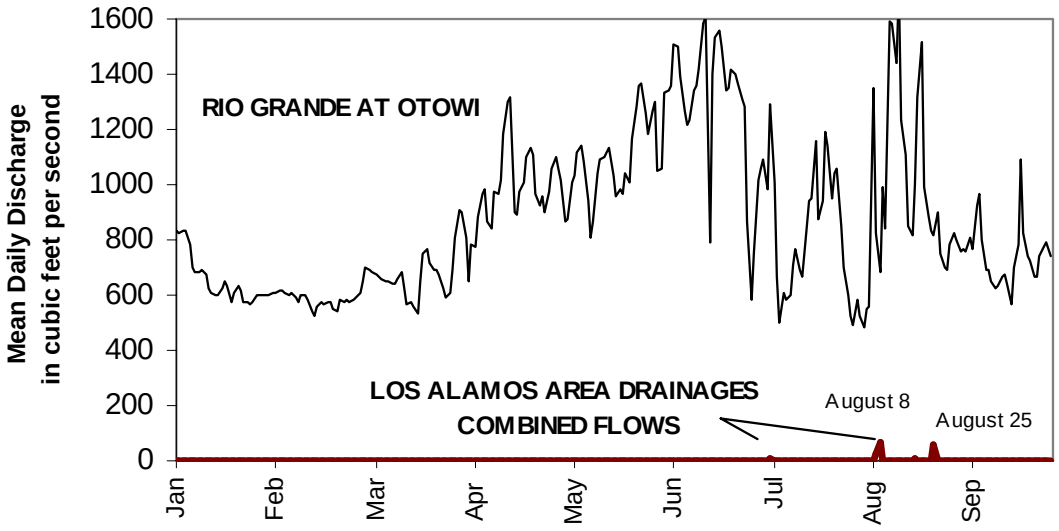


Figure 6-17. **Discharge from Los Alamos drainages in comparison to discharge at the Rio Grande at Otowi streamflow gaging station.**

Past release of radioactive liquid effluents into Pueblo (via tributary Acid Canyon), DP, and Los Alamos Canyons has introduced americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, and tritium, among other radionuclides, into the canyon. Many of these radionuclides bind to stream sediment and persist at levels several orders of magnitude above worldwide fallout levels. Elevated levels of radioactivity can be found in those canyons in both surface water and sediment. Plutonium has moved down Pueblo Canyon, through Los Alamos Canyon, off-site across Pueblo de San Ildefonso lands, and to the Rio Grande near the Otowi Bridge (Graf 1997; Reneau et al., 1998). Plutonium-239,240 from historic Acid Canyon discharges has been traced in stream sediment more than 55 km to lower Cochiti Reservoir (Gallaher and

Efurd 2002). Several contaminated sediment removal efforts have been conducted in Acid Canyon. In 2005, additional stabilization of sediment was performed in Pueblo Canyon to retard transport downstream. The installation of 3,000 linear feet of jute matting along channel banks that contained elevated radionuclide concentrations, and the planting of 3,000 willow plants to provide additional stream bank support, was completed in 2005 (PPWP 2005).

Most of the contaminant load in the Los Alamos Canyon drainage system is associated with sediment. None of the radionuclide, metal, or organic compound concentrations in sediment exceeded recreational or residential screening levels in 2006 samples. Nonetheless, concerns arise when the sediment is moved downstream and has the potential to enter the Rio Grande, depending on the runoff passing through the drainage. Because total runoff in 2005 and 2006 increased from previous years, downstream transport also increased. However, as noted earlier, no appreciable changes in contaminant concentrations have been detected in the Rio Grande sediment following these wet years.

Hillside sampling stations in middle Los Alamos canyon in 2006 contained elevated concentrations of radionuclides, mercury, and PCBs, consistent with past years. The highest concentrations were measured in storm runoff from channels below the Manhattan Project-era plutonium research buildings at TA-1 (station LA-SMA-2 and –4) and DP site at TA-21 (LA-SMA-6.3 and –6.5). Concentrations measured in the canyon floor were considerably lower than at these hillside sites. Still, mercury and PCBs were detected at concentrations above NM human health standards throughout the watershed and extending to the confluence with the Rio Grande near Otowi.

Because radionuclides, mercury, and PCBs are associated with sediment, rather than dissolved in the water column, the impact these individual hillside sites have on the watershed can be tracked by examining changes in the suspended contaminant concentrations. Figures 6-18 and 6-19 shows the plutonium-239,240

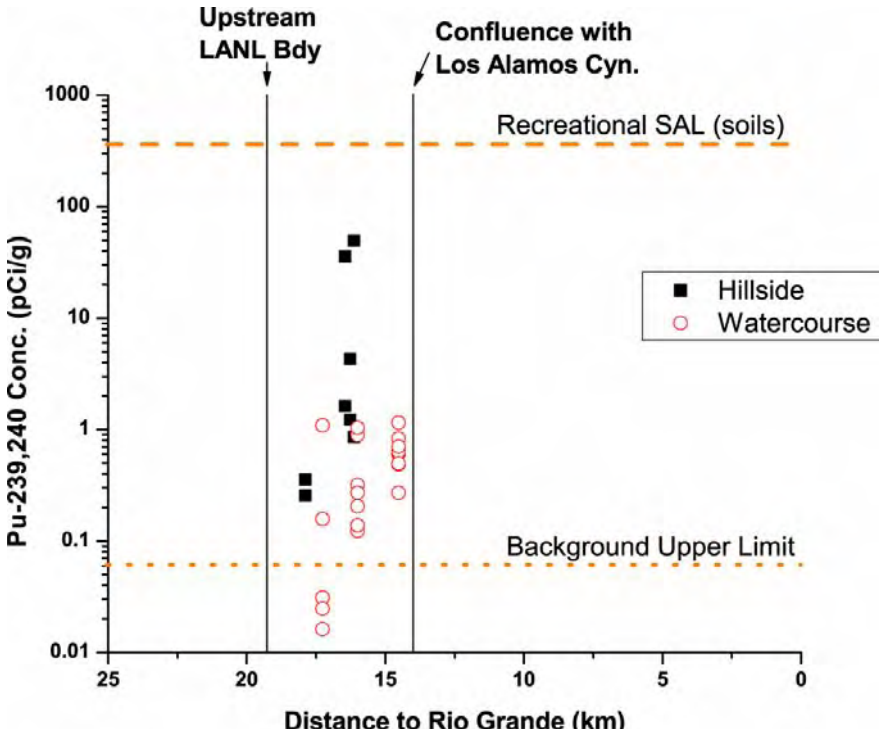


Figure 6-18. Plutonium-239,240 concentration spatial trends in DP Canyon suspended sediment, 2004–2005.

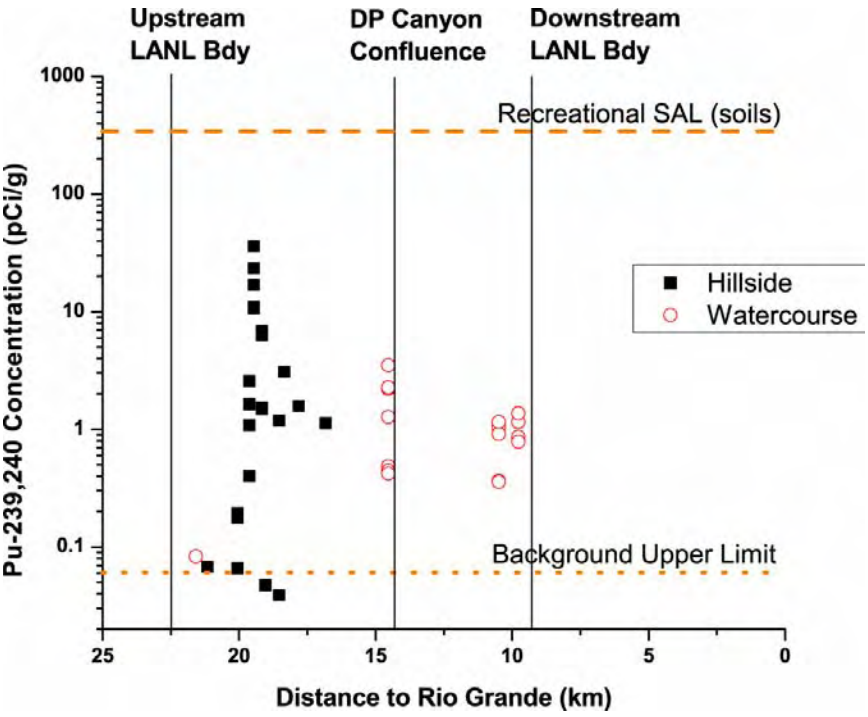


Figure 6-19. **Plutonium-239,240 concentration spatial trends in Los Alamos Canyon suspended sediment, 2004–2005.**

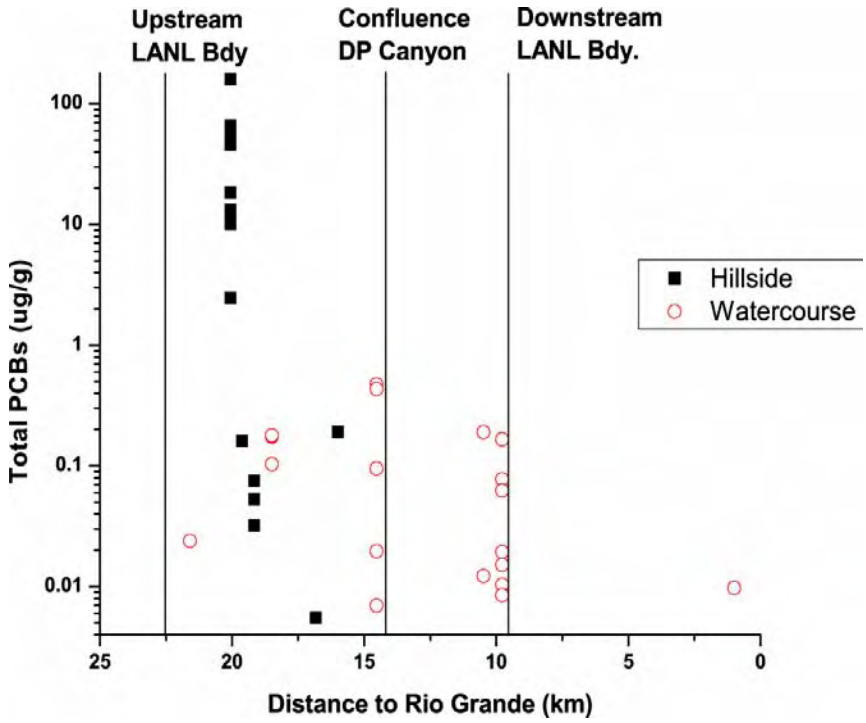


Figure 6-20. **Total PCBs concentration spatial trends in Los Alamos Canyon suspended sediment, 2004–2005.**

concentrations calculated in suspended sediment at various locations within DP and Los Alamos Canyons, respectively. Stations located below a specific suspected release site are labeled as "Hillside" stations. Stations located in the canyon bottom (stream gage sites) are labeled as "Watershed". The graphs show that plutonium-239,240 concentrations at the hillside sites have been measured at near 60 pCi/g. Concentrations in the canyon floor are above-background but substantially lower than at the hillside sites, averaging approximately 1 pCi/g. The plots indicate that there is relatively small variation in suspended plutonium concentrations in the canyon floors, compared to the contributing hillsides. A plot for total PCBs shows a similar pattern (Figure 6-20).

The dioxin 2,3,7,8-TCDD was detected in a base flow sample in lower Pueblo Canyon. As discussed in Chapter 5, this result is highly uncertain and additional research must be performed to establish any confidence in the detection. The reported concentration is indistinguishable from the typical analytical detection limit, and it was not detected in a separate sample collected on the same date in the immediate vicinity (Pueblo 3 vs Pueblo above State Road 502).

Since the Cerro Grande fire, there has been substantial reduction in the amount of sediment in middle Los Alamos Canyon carried beyond the Laboratory's eastern boundary. It is estimated that the low-head weir has captured more than half of the suspended sediment load since its installation in late 2000. The reduction in sediment transport has occurred through a reduction in stream flow velocity in the weir basin, and an associated settling of suspended sediment.

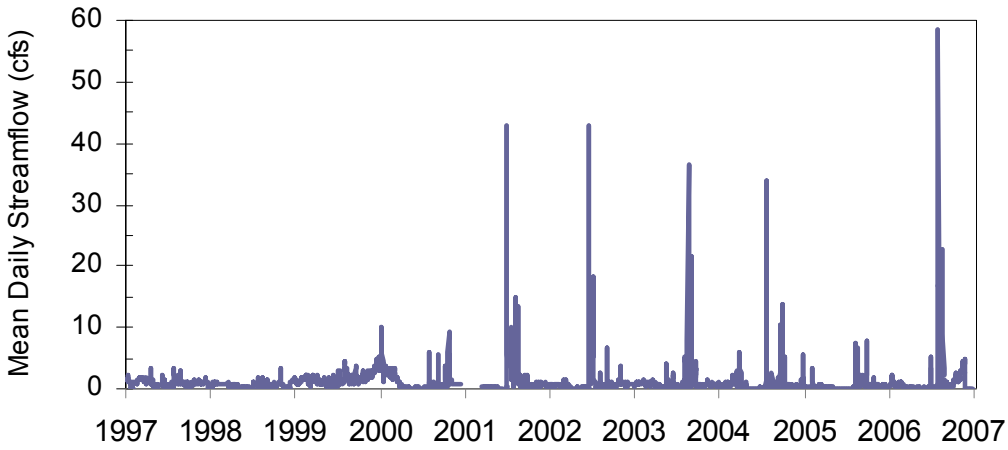


Figure 6-21. Mean daily discharge (cfs) at stream gage E060, lower Pueblo Canyon near State Road 502.

In contrast to middle Los Alamos Canyon, stream flow in Pueblo Canyon has recently become more dynamic and flashy (Figure 6-21). In the five years before the Cerro Grande fire, mean daily discharges rarely exceeded 4 cfs. Since 2000, daily discharges greater than 10 cfs occurred several times per year. There are multiple probable causes for the hydrologic changes in Pueblo Canyon:

- The lack of vegetation cover after the fire allowed for increased runoff from the hills above Los Alamos.
- Increased urban development in the upper portion of the canyon, with increased roof area and more efficient drainage systems. The increased pavement and roofs shed more local precipitation into the canyon.
- Re-engineering of a drainage culvert at the toe of the earthen bridge across upper Pueblo Canyon. Before the fire, stream flows from the upper portion of the canyon were highly restricted from passing into the lower canyon by the presence of a relatively small (18-inch) culvert at the base of the earthen

embankment. After the fire, the culvert was replaced with an 8-foot diameter culvert, and later enlarged to 12-feet. Flows from the upper canyon now readily pass to the lower canyon.

- The large, near-100 year rainfall events that hit the Los Alamos townsite area on July 2, 2001 and August 8, 2006.

Analysis of rainfall/runoff responses indicate that the hills draining into upper Pueblo Canyon recovered from the fire substantially by the end of 2004. Consequently, it is likely that the combination of increased urbanization and the larger culvert remain principal factors in the sustained alteration of Pueblo Canyon hydrology. When compared to other canyon systems on the Laboratory, Pueblo Canyon yields approximately 10 times the amount of runoff, per given drainage area and rainfall amount during the years 2003 through 2006 (Figure 6-22).

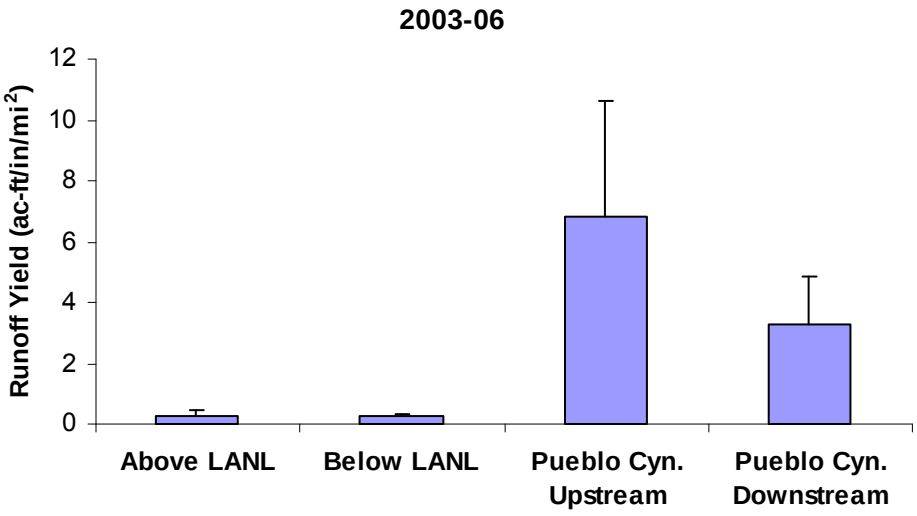


Figure 6-22. Average (±1 standard deviation) summer runoff yields for 2003 through 2006. The yields indicate how efficiently rainfall is shed from the landscape, after adjusting for the contributing drainage area and amount of local rainfall.

The importance of the alteration of Pueblo Canyon hydrology relates to the potential for downstream movement of legacy-contaminated sediment stored within the canyon floor. A few large runoff events can carry a substantial fraction of the entire sediment load for the year.

Long-term radionuclide trend plots for Pueblo and Los Alamos Canyons channel sediment are presented in Figures 6-23 through 26. Most stations show no appreciable change compared to previous years. An increase in plutonium-239,240 concentration was seen in lower Los Alamos Canyon (at Otowi) sediment near the confluence with the Rio Grande, to a level approximately 10 times greater than recently recorded measurements. However, the plutonium-239,240 concentration at the Otowi site is well below recreational or residential screening levels. Because the lower Los Alamos Canyon (Otowi) sample was collected August 14, it is likely that the increase reflects downstream transport of Pueblo Canyon sediment from the August 8 large runoff event. The impact of the August 8 runoff event on Pueblo Canyon sediment can not be described because sampling was conducted before the event. Thus the August 8 storm effects are not reflected in the long-term radionuclide plots for Pueblo Canyon.

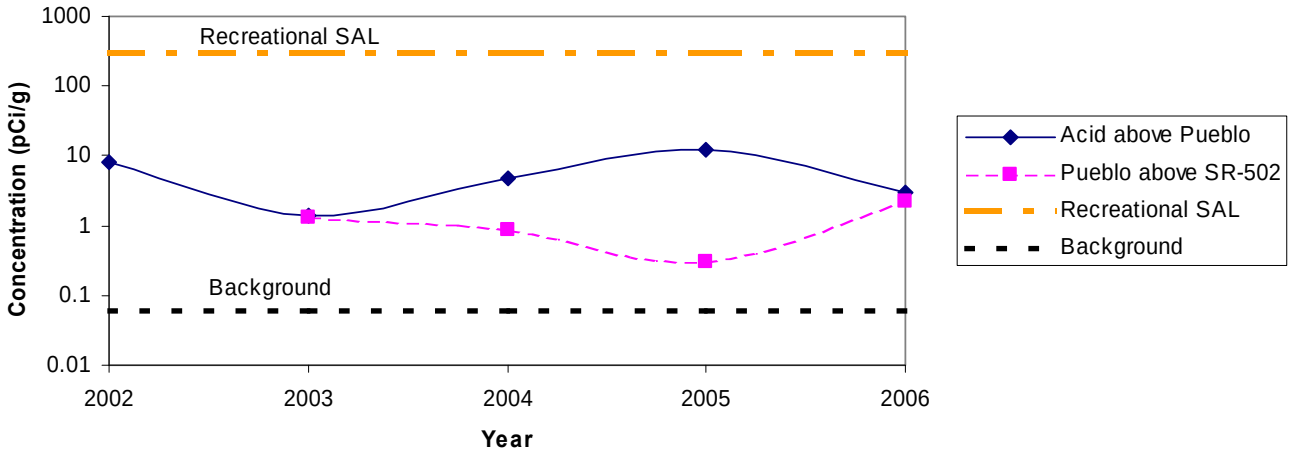


Figure 6-23. Long-term plutonium-239,240 trends in Pueblo Canyon sediment.

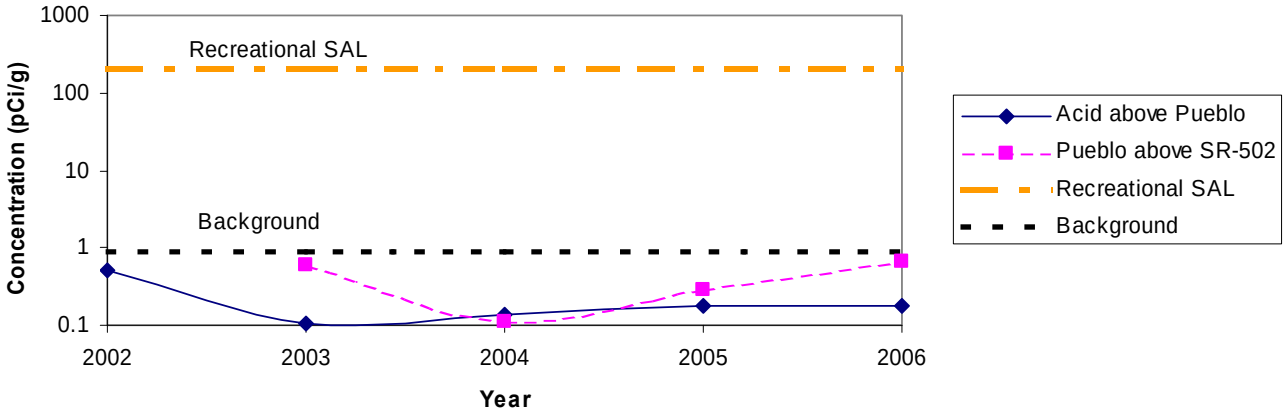


Figure 6-24. Long-term cesium-137 trends in Pueblo Canyon sediment.

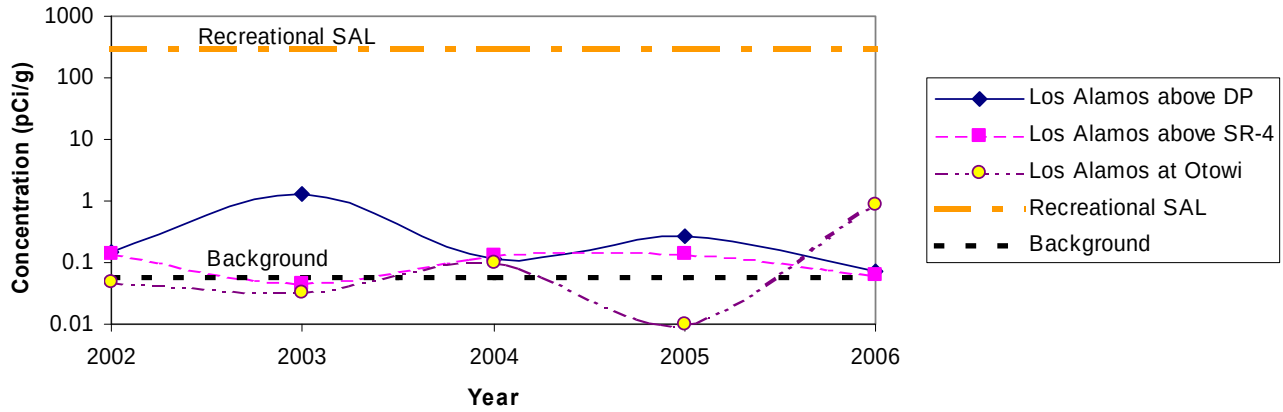


Figure 6-25. Long-term plutonium-239,240 trends in Los Alamos Canyon sediment.

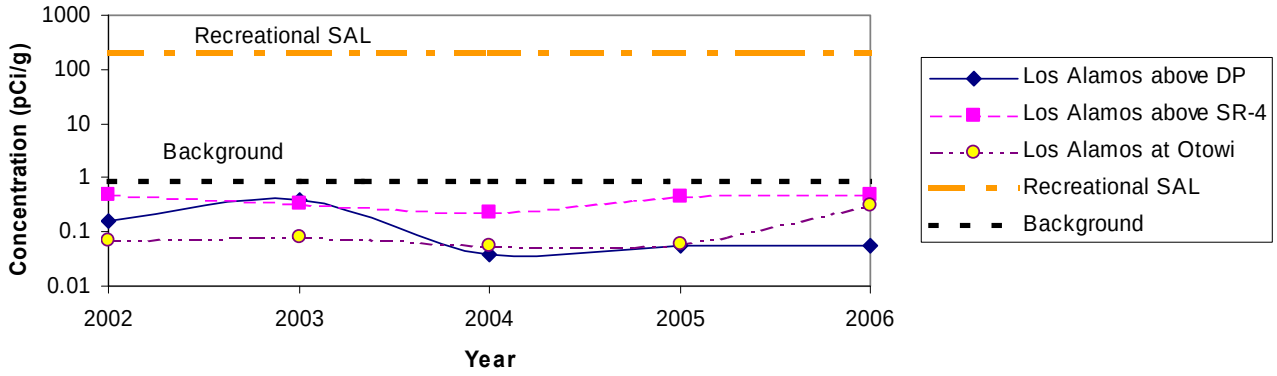


Figure 6-26. Long-term cesium-137 trends in Los Alamos Canyon sediment.

3. Sandia Canyon

Sandia Canyon heads on the Pajarito Plateau within the Laboratory's TA-3 area and has a total drainage area of about 5.5 mi^2. This relatively small drainage extends eastward across the central part of the Laboratory and crosses Pueblo de San Ildefonso land before joining the Rio Grande. Effluent discharges primarily from power plant blowdown create perennial flow conditions along a 2-mile reach below TA-3. Only two days of runoff was recorded at the Laboratory boundary in 2006 (Romero et al., 2007). Monitoring results have consistently shown minimal off-site contamination from the Laboratory in Sandia Canyon.

PCBs were detected throughout the watershed from near the Laboratory's main technical area at TA-3 to the LANL downstream boundary at SR-4. Unlike the Los Alamos Canyon watershed, however, there is minimal off-site stream flow in Sandia Canyon. While most detection were in storm water samples, three base flow samples collected near the Sandia Canyon wetlands also detected PCBs. Surface water samples near the wetlands contain the highest PCB concentrations in suspended sediment (Figure 6-27), and appear to be higher than at the site-specific hillside monitoring stations in Sandia Canyon. The human health standard is intended to protect people from ingesting contamination through fish consumption, but there are no fish in Sandia Canyon. Further, flows from the canyon have little probability of reaching the Rio Grande. In addition to PCBs at watercourse sampling stations, PCBs were reported at two site-specific monitoring stations in upper Sandia Canyon, particularly at station S-SMA-6.

Sediment samples collected in the upper portion of Sandia Canyon contained PCB concentrations at 1% the recreational soil screening level. Downstream sediment concentrations of PCBs decline quickly and usually are not detected at the downstream boundary.

Above-background concentrations of chromium, copper, lead, mercury, silver, and zinc in surface water and sediment are found along an approximately two-mile segment of Sandia Canyon below TA-3. Storm water runoff occasionally contains concentrations above regulatory standards. Unlike previous years, results in 2006 found none of these metals above NM water quality standards in storm water.

4. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon heads on the Pajarito Plateau near the main Laboratory complex at TA-3. The canyon crosses Pueblo de San Ildefonso land before joining the Rio Grande.

The annual time-weighted average concentrations of americium-241, plutonium-238, and plutonim-239,240 are well below the BCGs in unfiltered surface water collected below Effluent Canyon (Table 6-2). When the

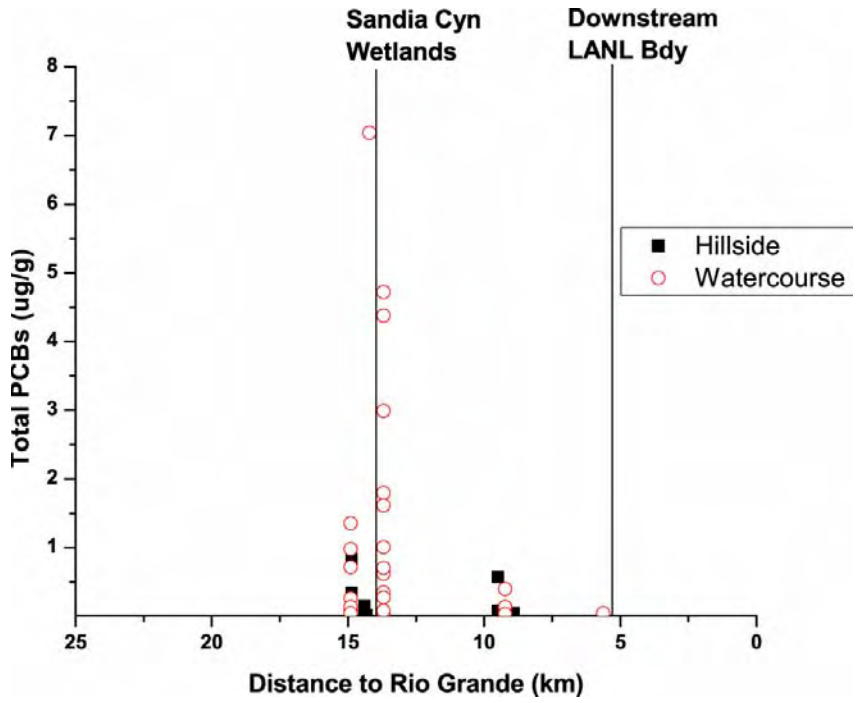


Figure 6-27. Spatial trends of PCB concentrations in Sandia Canyon suspended sediment.

mixture of radionuclides is considered (see discussion in D.4), the surface water in Mortandad Canyon below Effluent Canyon was at 15% of the BCGs.

Radioactivity concentrations in sediment just below the RLWTF have not changed appreciably in the past decade. Concentrations in Mortandad Canyon at the LANL boundary are less than DOE's allowable discharge limits and within background levels (LANL 1998).

Stream sediment in Mortandad Canyon downstream of Effluent Canyon as far as the sediment traps, and downstream to near well MCO-8.5, contains above background concentrations of plutonium-238, plutonium-239,240, and cesium-137 (Figures 6-28 and 6-29). Cesium-137 concentrations in active channel sediment upstream of the sediment traps were 5% of the recreational SAL (LANL 2005) (Figure 6-29), and gradually trending downward over time. The sediment traps are located approximately two miles upstream of the Laboratory's eastern boundary. Despite the history of releases into the Mortandad Canyon watershed, radioactivity in sediment at the Laboratory's eastern boundary for the past two years was within background levels. Americium-241, cesium-137, and plutonium-239,240 concentrations in sediment at the boundary are orders of magnitude lower than at upstream stations closer to the RLWTF discharge. The rarity of stream flow within Mortandad Canyon for two miles upstream of the Laboratory boundary is the main reason for the lower sediment radioactivity in downstream sediment.

In 2006, approximately 50 surface water samples were collected from watercourse and hillside sites and analyzed for PCBs within Mortandad Canyon and its tributaries: Cañada del Buey, Ten Site Canyon, and Pratt Canyon. Only two samples contained detected concentrations of PCBs, both in middle Mortandad Canyon. These results indicate that PCB concentrations in the drainage are relatively small but are occasionally detected.

The dioxin 2,3,7,8-TCDD was detected in two base flow samples in Mortandad Canyon. As discussed with regard to Pueblo Canyon, these results are highly uncertain and additional investigation is needed to establish confidence in the detections.

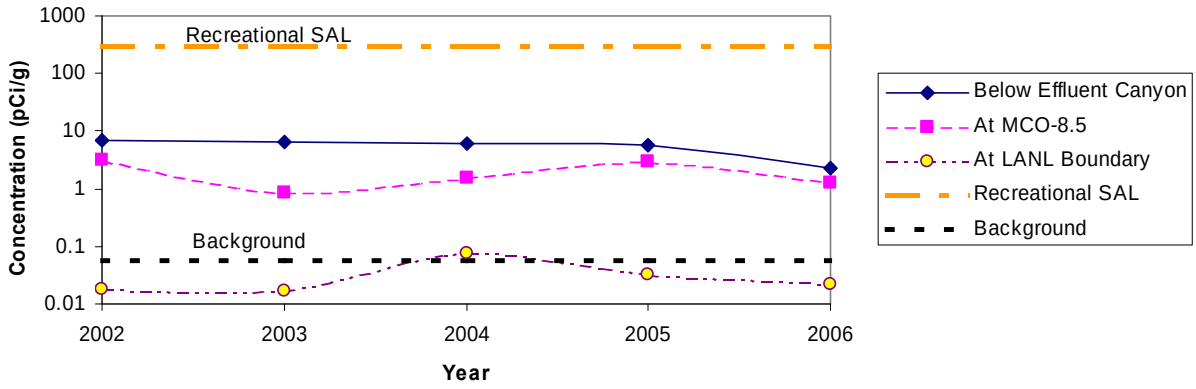


Figure 6-28. Long-term plutonium-239,240 trends in Mortandad Canyon sediment.

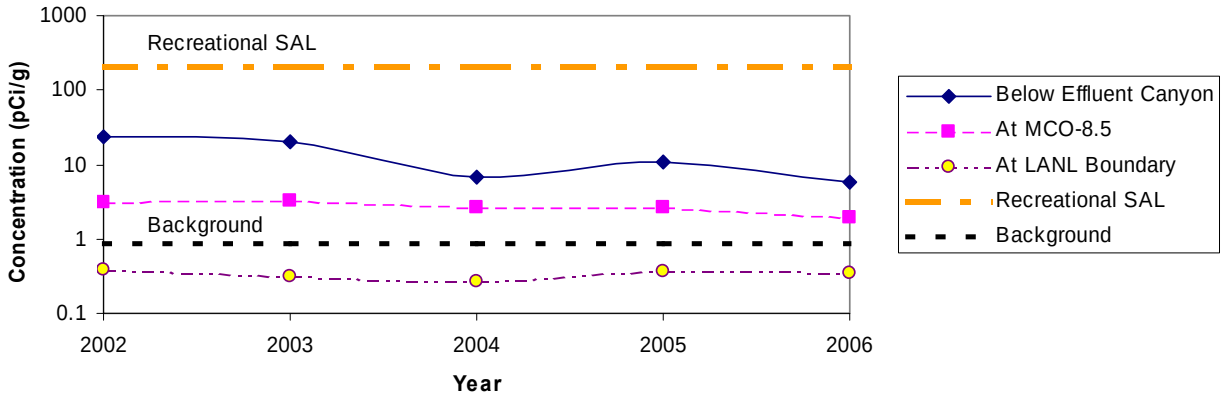


Figure 6-29. Long-term cesium-137 trends in Mortandad Canyon sediment.

Radioactivity in sediment around MDA G and in Cañada del Buey was generally consistent in 2006 with previous years. All results are well below the recreational and residential SALs. No significant trends are evident.

5. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads on the flanks of the Sierra de los Valles on US Forest Service lands. The canyon crosses the central part of the Laboratory before entering Los Alamos County lands near White Rock.

Consistent with past years, americium-241, plutonium-238, and plutonium-239,240 concentrations were greater than background in sediment samples from channels draining MDA G. Concentrations of these radionuclides were commonly 5 to 10 times background. All of the radionuclides were at concentrations below recreational and residential SALs.

Concentrations of copper and zinc greater than standards were detected at the Twomile tributary at TA-3 station. That station monitors drainage from a large paved area and the Laboratory's main machine shop. These results are consistent with previous years.

In Three Mile Canyon, elevated concentrations of uranium-238 were detected in three samples collected below a high explosive firing site (station 3M-SMA-0.6) (Figure 6-5). The samples indicate the presence of depleted uranium, as activity ratios of uranium-238 to uranium-234 were not unity.

In 2006, no PCBs were detected in 18 storm runoff samples from stations along the Pajarito Canyon edge of MDA G.

6. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon heads on the flanks of the Sierra de los Valles on US Forest Service land and extends across the Laboratory to the Rio Grande. Water Canyon and its tributary Cañon de Valle pass through the southern portion of the Laboratory where explosives development and testing take place. Elevated concentrations of barium, HMX, and RDX have previously been measured in sediment and surface water. RDX is principally detected only within Cañon de Valle. As shown in Figure 6-30, RDX is rarely detected below the confluence with Water Canyon; since 2004, only 1 of 18 storm runoff samples from Water Canyon contained detectable levels of RDX. This area is being investigated under a RCRA corrective measures evaluation.

Area AB at TA-49 was the site of underground nuclear-weapons testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). These tests involved HEs and fissionable material insufficient to produce a nuclear reaction. Area AB drains into Ancho and Water Canyons. Legacy surface contamination is responsible for above-background fallout concentrations of plutonium-238 and –239,240 and americium-241 present in the sediment downstream of this site. No above-background plutonium-238 or –239,240 concentrations extend more than about 100 yards beyond Area AB.

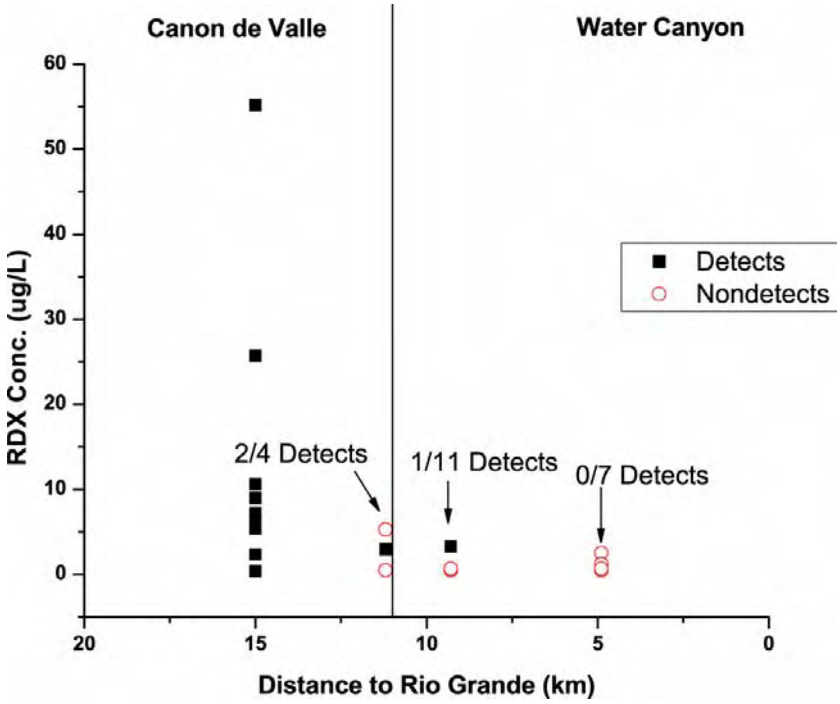


Figure 6-30. RDX spatial trends in Cañon de Valle and Water Canyon surface water, 2004-2006. Data from watercourse stations only.

H. QUALITY ASSURANCE

To process watershed samples, we used the same quality assurance (QA) protocols and analytical laboratories described in Chapter 5. QA performance for the year is also described in Chapter 5.

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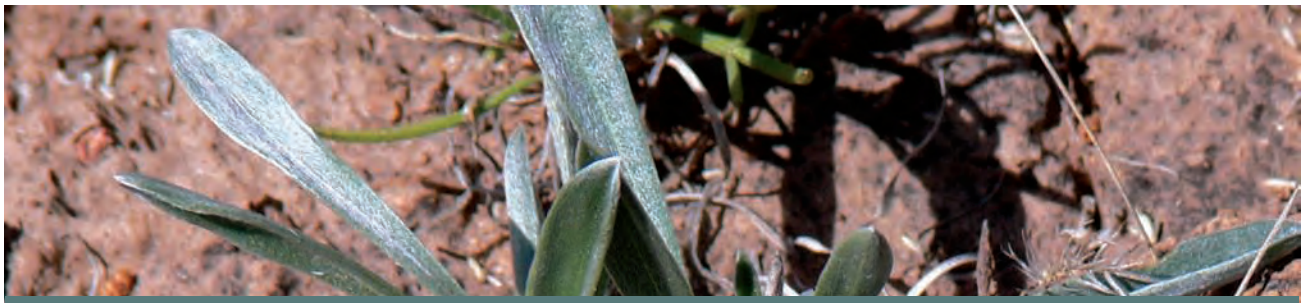

7. Soil Monitoring



7. Soil Monitoring

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A. INTRODUCTION

A soil sampling and analysis program offers the most direct means of determining the concentration, distribution, and long-term trends of radionuclides and other chemicals around nuclear facilities (DOE 1991). The soil characterization program provides information about potential pathways (e.g., soil ingestion, food ingestion, re-suspension into the air, and groundwater contamination) that may deliver radioactive materials or chemicals to humans.

The overall soil surveillance program at Los Alamos National Laboratory (LANL or the Laboratory) consists of

(1) An institutional component that monitors soil within and around the perimeter of LANL in accordance with US Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993); and

(2) A facility component that monitors soil (and sediment) within and around the perimeter of the Laboratory's

- Principal radioactive waste disposal area (Area G) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and
- Principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) in accordance with the Mitigation Action Plan (DOE 1996).

The objectives of LANL's soil surveillance program are to determine the following:

(1) Radionuclide and nonradionuclide (inorganic and organic chemicals) concentrations in soil collected from potentially impacted areas (Laboratory-wide and facility-specific);

(2) Trends over time (i.e., whether radionuclide and nonradionuclide concentrations are increasing or decreasing over time); and

(3) The committed effective dose equivalent potentially received by surrounding area residents (see Chapter 3 for the potential radiation doses that individuals may receive from exposure to soil).

B. SOIL COMPARISON LEVELS

To evaluate Laboratory impacts from radionuclides and nonradionuclides, we first compare the analytical results of soil samples collected from the Laboratory's on-site and perimeter areas with regional background levels (RSRLs). Where the results exceed these background levels, we then compare the concentrations with the screening levels (SLs) and, finally, if needed, with the appropriate standard. A description of the levels and/or the standard used to evaluate the results of radionuclides and nonradionuclides in soil are as follows, and an overall summary can be found in Table 7-1.

- Regional Statistical Reference Levels: RSRLs are the upper-level background concentration (mean plus three standard deviations = 99% confidence level) for radionuclides and nonradionuclides calculated from soil data collected from regional locations away from the influence of the Laboratory over at least the last five sampling periods. RSRLs, which represent natural and fallout sources, are calculated as data becomes available and can be found in the supplemental data tables of this report.
- Screening Levels: SLs for radionuclides are set below the DOE single-pathway dose limit of 25 mrem/yr so that potential concerns may be identified in advance of major problems, i.e., a "yellow flag." If a radionuclide exceeds the SL, then we investigate the reason. LANL's Environment and Remediation Support Services Division developed SLs to identify chemicals of potential concern on the basis of a 15-mrem/yr protective dose limit for a residential scenario (LANL 2005) using the residual radioactive (RESRAD) computer model (Yu et al. 1995). We compared nonradionuclides to the New Mexico Environment Department (NMED) soil screening levels that are set at a 10^{-5} risk level for carcinogens or a hazard quotient (HQ) of 1 for non-carcinogens (NMED 2006). The SLs for a residential scenario were used for soil collected from perimeter areas and SLs for an occupational scenario were used for soil collected from Laboratory areas.
- Standard: If an SL for a radionuclide is exceeded, then a dose to a person is calculated using RESRAD and all of the measured radionuclide concentrations available from supplemental data Table S7-1. The calculated dose is based on a residential scenario with soil ingestion, inhalation of suspended dust, external irradiation, and ingestion of homegrown fruits and vegetables as the exposure pathways. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis we used can be found in Fresquez et al. 1996. This calculated dose is compared to the 25-mrem/yr DOE dose constraint (DOE 1993; DOE 1999c).

Table 7-1
Application of Soil Standards and Other Reference Levels to LANL Monitoring Data

Constituent	Sample Location	Standard	Screening Level	Background Level
Radionuclides	Perimeter, On-site, Area G, and DARHT	25 mrem	15 mrem (residential)	RSRL/BSRL[a]
Nonradionuclides	Perimeter		10^{-5} risk (residential) or HQ = 1	RSRL
	DARHT, On-site, Area G		10^{-5} risk (occupational) or HQ = 1	RSRL/BSRL[a]

[a] Baseline Statistical Reference Levels (BSRL) and a discussion of these levels can be found in Section D.3.



C. INSTITUTIONAL MONITORING

1. Monitoring Network

Surface soil samples are collected from 17 on-site, 11 perimeter, and six regional (background) locations on a triennial basis (every third year) (Figure 7-1). Areas sampled at LANL are not from contaminated areas referred to as solid waste management units (SWMUs) or areas of concern (AOCs). Instead, the majority of on-site soil sampling stations are located on mesa tops close to and, if possible, downwind from major facilities or operations at LANL in an effort to assess soil that may have been contaminated from stack emissions and fugitive dust (the re-suspension of dust from SWMUs/AOCs and active firing sites).

Samples were collected from Technical Area (TA)-16 (S-Site), TA-21 (DP-Site), near TA-33, north of TA-50/35 at TA-60, TA-51, west of TA-53, east of TA-53, east of TA-54, Potrillo Drive at TA-36, near Test Well DT-9 at TA-49, R Site Road east at TA-15, and Two-Mile Mesa at TA-06. This year we collected five additional soil samples from along the south side of State Road (SR) 502 within the TA-73 boundary—these points are downwind of TA-21 (the former plutonium processing facility) and associated SWMUs/AOCs including Material Disposal Areas (MDAs) A, B, and T.

The 11 perimeter stations, located within 2.5 mi of the Laboratory, were sampled to determine the soil conditions of the inhabited areas to the north (North Mesa, Sportsman's Club, Quemazon Trail, west airport, and east airport) and east of the Laboratory (White Rock, San Ildefonso, Otowi, and Tsankawi/PM-1). Additional samples were collected west of US Forest Service property (across from TA-8) and south on Bandelier National Monument property (near TA-49) to provide comprehensive coverage.

Soil samples from on-site and perimeter stations are compared with soil samples collected from regional locations in northern New Mexico that surround the Laboratory in all major directions and where radionuclides, metals, and organic chemicals are mostly from natural sources or worldwide fallout events. These areas are located near Ojo Sarco, Dixon, Borrego Mesa (near Santa Cruz dam) to the northeast; Rowe Mesa (near Pecos) to the southeast; Youngsville to the northwest; and Jemez to the southwest. All locations are at similar elevations to LANL, are more than 20 mi away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations as required by the DOE (DOE 1991).

At all sites, soil surface samples were collected with a stainless steel soil ring 4 in. in diameter pushed 2 in. deep at the center and corners of a 33 ft x 33 ft square area. The five samples per site were combined and mixed thoroughly in a large Ziploc® bag to form a composite sample. Composite samples were placed in pre-labeled 500 mL polyethylene bottles, fitted with chain-of-custody tape, and placed into individual Ziploc® bags. All samples were handled and shipped under full chain-of-custody procedures to Paragon Analytics Inc., for analysis. Samples were analyzed for tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, and uranium-238. The soil samples were also analyzed for 23 target analyte list (TAL) inorganic chemicals, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), and high explosives (HE). The results from these sample analyses are presented in supplemental Tables S7-1 to Table S7-3. (Note: We report on the analyses of vegetation collected from these same sites in Chapter 8, Section B.3.)



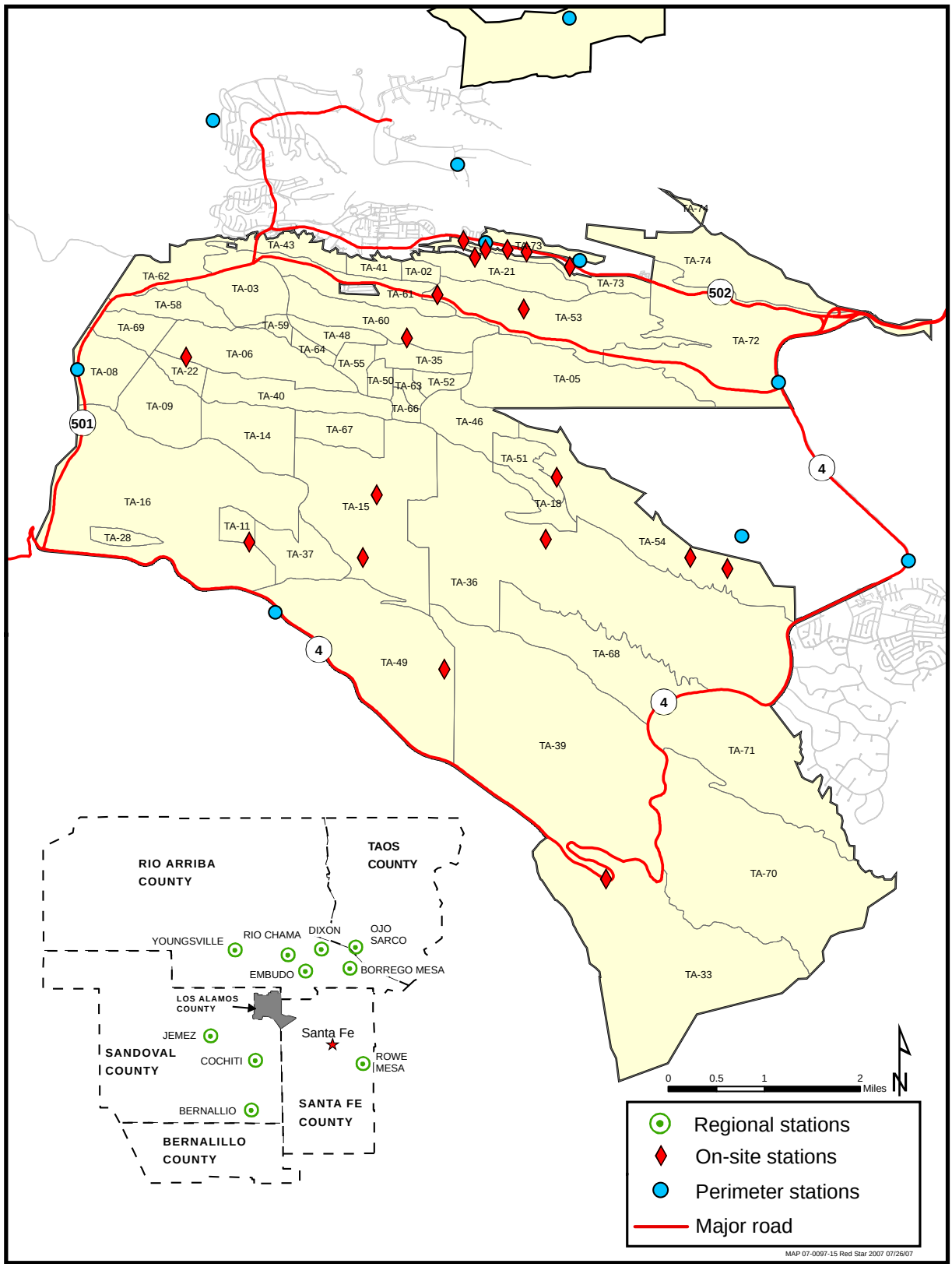

Figure 7-1. On-site Laboratory, perimeter, and off-site regional soil sampling locations.

2. Radionuclide Analytical Results

All of the radionuclide (activity) concentrations in soil collected from on-site and perimeter areas in 2006 were low (pCi range), and most were either not detected or below RSRLs (Table S7-1). A nondetected value is one in which the result is lower than three times the counting uncertainty and is not significantly ($\alpha = 0.01$, or 99% confidence level) different from zero (Keith 1991, Corely et al. 1981).

The few detected radionuclides above RSRLs in soil collected from perimeter areas included cesium-137 and plutonium-239,240 at the TA-8 location (GT Site), plutonium-239,240 at the west airport location, and uranium-234 and -238 at the Tsankawi/PM-1 location. All of the radionuclide concentrations in these samples were slightly above the RSRLs and were below residential SLs and do not pose a potential unacceptable dose to the public. The uranium in soil at the Tsankawi/PM-1 location was naturally occurring as the distribution of uranium-234 and uranium-238 were at equilibrium.

With respect to the detected radionuclides in soil collected from the on-site areas, there were two general locations within the Laboratory that contained amounts of plutonium-239,240 and americium-241 above RSRLs. One of these areas, based on the locations sampled at TA-21 (DP-Site) and along SR 502 at TA-73, included the northern part of the Laboratory downwind of the former plutonium processing facility (and/or its associated SWMUs/AOCs) at TA-21. Although the concentrations of plutonium-239,240 and americium-241 in soil from these areas were above RSRLs, they were still within the range of concentrations reported in previous years, are not increasing over time (Figures 7-2 and 7-3) (Fresquez et al. 1998), and are far below residential SLs. Thus, the levels of plutonium and americium detected in soil samples, particularly along the Laboratory's northern perimeter, do not pose a potential unacceptable dose to the public.

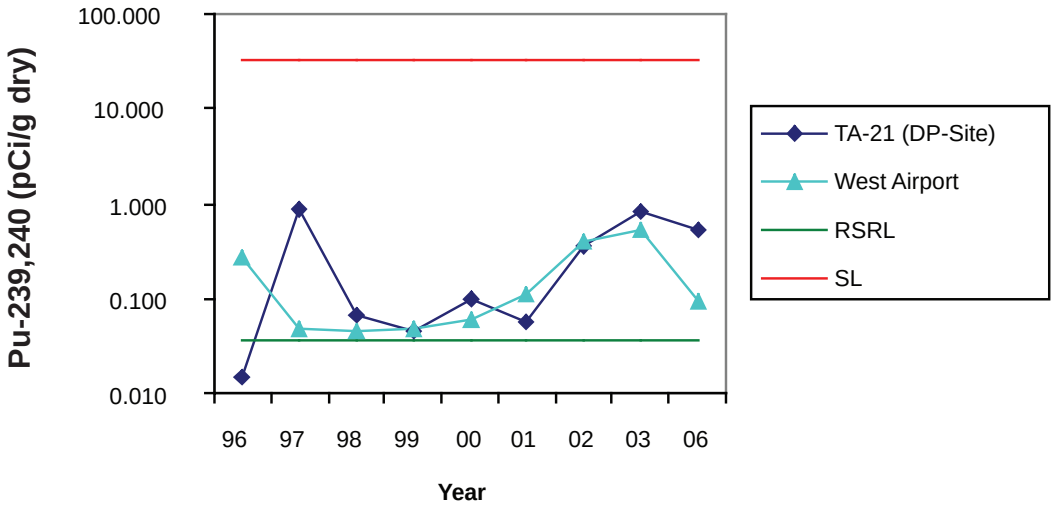

Figure 7-2. Plutonium-239,240 concentrations in soil samples collected from the west airport and TA-21 (DP-Site) stations from 1996 through 2006 as compared with the regional statistical reference level (RSRL) and the screening level (SL).

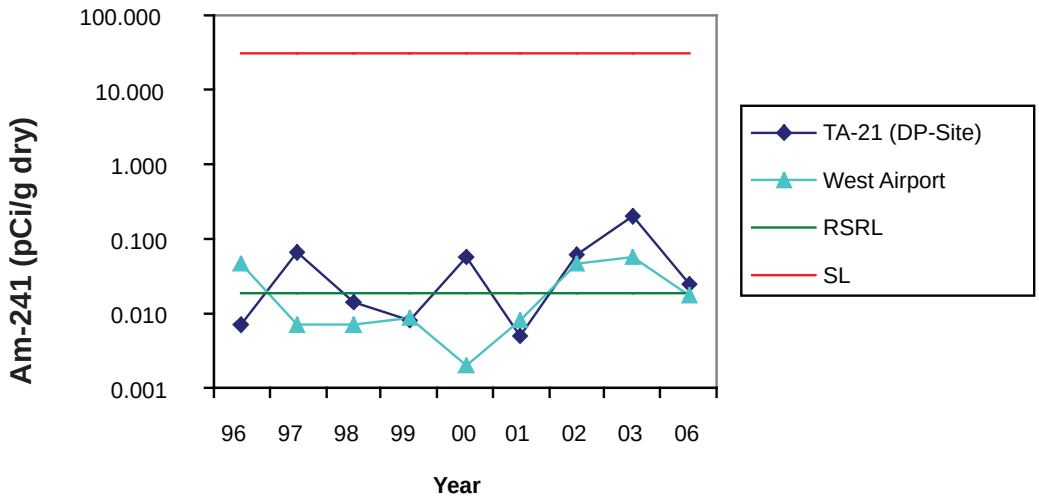

Figure 7-3. Americium-241 concentrations in soil samples collected from the west airport and TA-21 (DP-Site) stations from 1996 through 2006 as compared with the regional statistical reference level (RSRL) and the screening level (SL).

The other area with elevated plutonium-239,240 and americium-241 levels was located near the eastern side of the Laboratory downwind of Area G at TA-54. A more detailed description of the sampling of potential contaminants occurring around the perimeter of this site can be found in Section D.1 of this chapter.

3. Nonradionuclide Analytical Results: Trace and Abundant Elements

Supplemental data Table S7-2 shows the results of the inorganic chemical analyses in surface soil collected from perimeter, on-site, and regional background areas in 2006. Nearly all of the inorganic chemical concentrations from on-site and perimeter areas were below RSRLs. The few heavy metals above the RSRLs included mercury (0.046 mg/kg vs. RSRL of 0.039 mg/kg dry) at the Sportsman's Club location north of LANL and thallium (0.31 mg/kg dry vs. RSRL of 0.25 mg/kg dry) at the Two-Mile Mesa location at TA-06. The concentrations detected are slightly above the RSRLs and far below the appropriate SLs and do not pose a potential hazard to human health.

4. Nonradionuclide Analytical Results: PCBs, HE, and SVOCs

All PCBs, HE, and nearly all SVOCs in soil from perimeter and on-site locations were below detection limits (supplemental data Table S7-3). Only one site showed some detected SVOCs. This site, TA-73/SR 502 (west), is located on the south side of SR 502 and east of the Los Alamos Fire Department and an inspection of the site showed considerable amounts of asphalt scattered throughout the sampling area. Asphalt, a petroleum-based product, contains a host of polyaromatic hydrocarbons (PAHs), but the amounts detected were below the occupational SLs and do not pose a potential risk to human health.



D. FACILITY MONITORING

1. Monitoring Network for Area G at TA-54

The Laboratory conducts facility-specific soil monitoring on an annual basis at Area G (Lopez 2002). Area G is a 63-acre radioactive waste processing area located on the east end of Mesa del Buey at TA-54 (Figure 7-4). Area G was established in 1957 and is the Laboratory's primary radioactive solid waste burial and storage site (Hansen et al. 1980, Soholt 1990). Tritium, plutonium, americium, uranium, and a variety of fission and activation products are the main radionuclides in waste materials disposed of at Area G (DOE 1979). Monitoring at Area G includes the collection and analysis of air, sediment, surface water runoff, soil, vegetation, and small mammals for contaminants. Section D.2, below, reports on the 21 soil surface samples collected in 2006 at designated locations around the perimeter of Area G at TA-54. Three of these locations around the northwestern corner of Area G (locations 58-01, 15-01, and 54-01) were sampled again after elevated levels of plutonium-239,240 and tritium were detected at an air monitoring (AIRNET) station located north of Pit 38 in May and July, respectively. Apparently, the radionuclides in question were from soil material from TA-21, and the container bags holding the waste soil may have ruptured during their placement in the pit.

Other samples from Area G included four collected along a transect, starting from the northeast portion of Area G to the Pueblo de San Ildefonso fence line in a northeasterly direction (the primary wind direction). (Note: The Pueblo de San Ildefonso fence line is approximately 150 ft north of the LANL/pueblo boundary line.) These samples were collected at approximately the 160-, 500-, 800-, and 930-ft distance from Area G.

The soil (grab) samples were collected from the 0- to 6-in. depth with disposable polystyrene scoops. Samples for analysis of radionuclides (tritium; plutonium-238; plutonium-239,240; americium-241; uranium-234; uranium-235; and uranium-238) and inorganic chemicals (TAL metals) were placed into 500-mL poly bottles, and samples for PCB analysis were placed into 500-mL amber glass bottles. All sample bottles were secured with chain-of-custody tape, placed into individual Ziploc® bags, cooled to approximately 4ºC, and submitted to Paragon Analytics, Inc. The results from these samples are presented in supplemental Tables S7-4 to S7-7. (Note: We report on the analyses of vegetation collected at Area G in Chapter 8, Section 4.a.)

2. Radionuclide and Nonradionuclide Analytical Results for Area G

a. Perimeter Results. With respect to the 21 soil samples collected around the perimeter of Area G in March 2006, concentrations of tritium were detected above the RSRL of 0.86 pCi/mL in 13 of the 21 samples (Table S7-4) (Fresquez 2007b). The highest tritium concentrations (104 pCi/mL and 690 pCi/mL) were collected in the southern portion of Area G where the tritium shafts are located and are similar to concentrations detected in past years at these locations (Fresquez et al. 2004a, Fresquez and Lopez 2004, Fresquez et al. 2005). Also, tritium concentrations in soil at these locations compare well with the vegetation data collected on the south side of Area G (see Chapter 8, Section 4.a). Although tritium is consistently detected above the RSRL in soil samples in the southern portion of Area G, the concentrations are far below the residential SL of 5,400 pCi/mL, and the migration of tritium from the Area G boundary, at least at surface and subsurface depths, is not extensive. In a recent study at Area G, for example, tree samples were collected along a transect starting from the southern portion at various distances (approximately 33, 165, 330, 490, and 660 ft) from the perimeter fence line (Fresquez et al. 2003). Results showed that the concentrations of tritium in trees collected nearest the perimeter boundary (33 to 53 ft) were higher than the RSRL for vegetation. From there, the concentrations of tritium in trees decreased greatly with distance, and at about 330 ft away, the concentrations were similar to the RSRL.

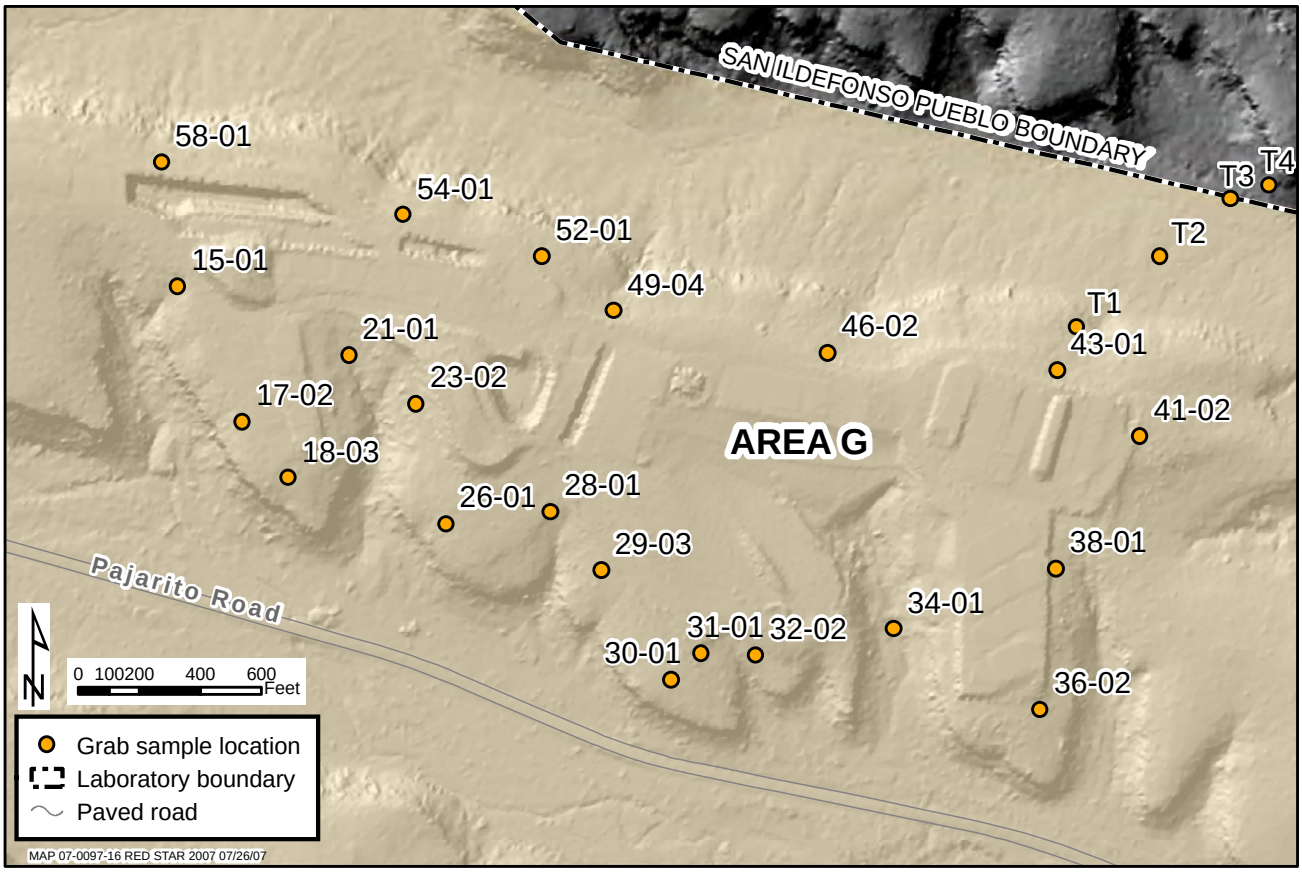

Figure 7-4. Sample locations of soil at Area G.

Many of the soil samples collected at Area G, particularly around the perimeter of the northern, northeastern, and eastern sections, contained detected concentrations of americium-241 (10 out of 21 samples), plutonium-238 (eight out of 21 samples), and plutonium-239,240 (nine out of 21 samples) above RSRLs (Table S7-4). The highest concentrations of americium-241 (1.2 pCi/g dry) and plutonium-239,240 (5 pCi/g dry) were detected in a soil sample (location 38-01) located on the perimeter of the eastern side of Area G near the Transuranic Waste Inspection Project (TWISP) domes. All concentrations were below residential SLs and do not pose a potential unacceptable dose to human health.

Three additional soil samples were collected in October around the northwestern section of Area G after elevated tritium and plutonium-239,240 concentrations were detected in air samples earlier in the year. The concentrations of tritium in all three soil samples were higher than concentrations of tritium recorded in March. In particular, location 15-01 contained tritium, americium-241, plutonium-238, and plutonium-239,240 two to nearly six times higher than previous results. However, all concentrations of radionuclides were far below residential SLs and do not pose a potential unacceptable dose to humans.

Most of the inorganic chemicals detected in soil near the perimeter of Area G were below RSRLs (478 out of 483 measurements) (Table S7-5). The only heavy metals detected above the RSRL were zinc (120 mg/kg dry compared to the RSRL of 69 mg/kg dry in one sample located at site 21-01 just east of the mixed waste dome) and antimony (0.39 mg/kg dry compared with the RSRL of 0.27 mg/kg dry in one sample at location 38-01 just east of the TWISP domes). All concentrations of these heavy metals were far below the industrial/occupational SLs and do not pose a potential hazard to human health.

Only one soil sample of 21 samples collected contained PCBs—these detections were found at location 26-01, which is on the south side of Area G. Aroclor-1254 and Aroclor-1260 in this one soil sample were detected at concentrations of 0.067 and 0.094 mg/kg dry, respectively. These levels are far below the industrial/occupational SL of 8.3 mg/kg dry.

With reference to concentration trends over time (1996–2006), Figures 7-5 and 7-6 show the concentrations of tritium and plutonium-239,240 in soil from areas that have had the highest amounts detected year after year. The results for tritium at locations 29-03 and 31-01 show an increase in concentrations that peak in 2002 and then decrease to those commonly observed in recent years (Figure 7-5). The plutonium-239,240 concentrations, which are located mostly on the northeastern part (locations # 41-02 and 43-01), are not increasing over time and are below the SL (Figure 7-6).

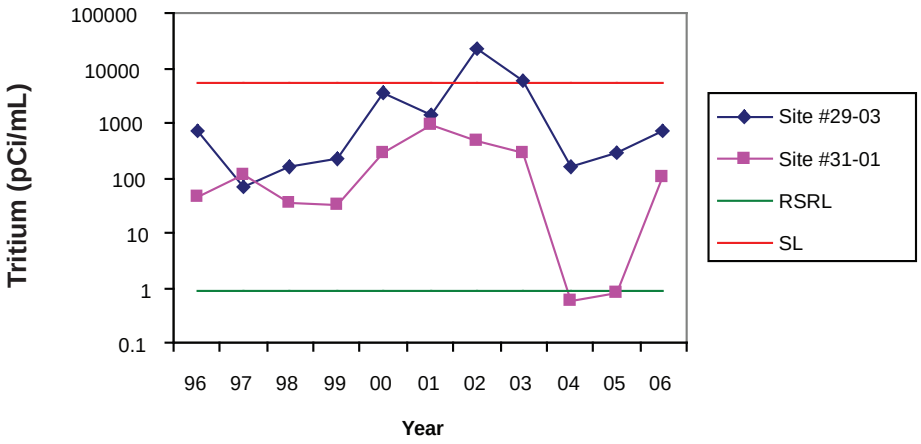

Figure 7-5. Tritium in surface soil collected from the southern portions of Area G at TA-54 from 1996 to 2006 as compared with the regional statistical reference level (RSRL) and screening level (SL).

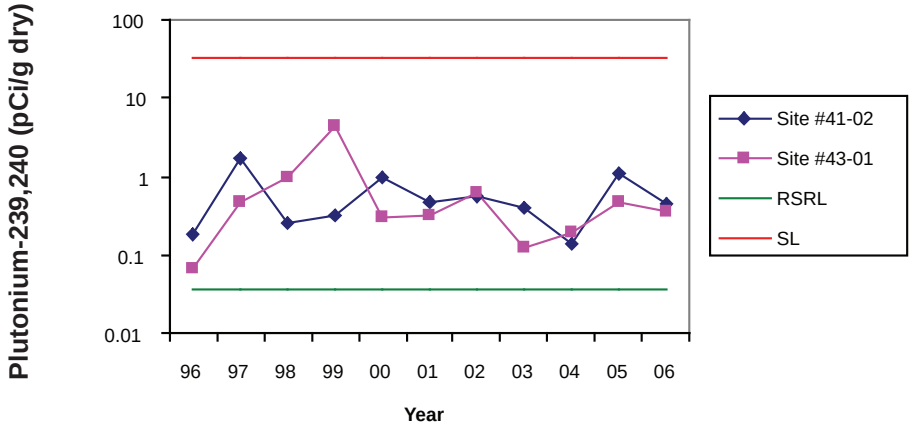

Figure 7-6. Plutonium-239,240 in surface soil collected from the northeastern portions of Area G at TA-54 from 1996 to 2006 as compared with the regional statistical reference level (RSRL) and screening level (SL).

b. Transect Results from Area G to the Pueblo de San Ildefonso Boundary. Concentrations of americium-241, plutonium-238, and plutonium-239,240 in most of the soil samples collected along a transect starting from the northeast portion of Area G and extending to the Pueblo de San Ildefonso fence line were above the RSRLs (Table S7-6). All concentrations are far below the residential SLs, and concentrations of all radionuclides decrease to RSRLs within a relatively short distance from the Pueblo fence line. Soil samples collected from 1996 through 2006 as part of the institutional monitoring program (see Section C.1, above) about 800 ft northeast of the Pueblo de San Ildefonso fence line (the "San Ildefonso" site) show that most samples (nine out of 11) contained plutonium-239,240 concentrations below the RSRL (Fresquez, 2005a and Table S7-1). Although uranium-234 and uranium-238 concentrations were slightly above the RSRLs in the soil sample collected near the fence line, the levels of these isotopes closer to Area G were below the RSRLs, and the distribution of uranium-234 and uranium-238 indicates that the uranium is naturally occurring.

All inorganic chemicals, including all heavy metals, in soil samples collected along a transect from Area G to the Pueblo de San Ildefonso fence line were below the RSRLs (Table S7-7). No PCBs were detected in any of the soil samples collected from the transect.

3. Monitoring Network for DARHT at TA-15

The Laboratory conducts facility-specific soil and sediment monitoring on an annual basis at DARHT (Nyhan et al. 2001). Approximately 20 acres in size, DARHT is located at R-Site (TA-15) at the Laboratory's southwestern end. Activities at DARHT include the utilization of very intense X-rays to radiograph a full-scale non-nuclear mock-up of a nuclear weapon's primary during the late stages of the explosively driven implosion of the device (DOE 1995). Possible contaminants include radionuclides, beryllium, and heavy metals.

Soil samples are collected around the perimeter of the DARHT facility at a 0- to 2-in. depth on the north, east, south, and west sides (Figure 7-7). An additional soil sample is collected on the north side near the firing point. Sediment samples are collected at a 0- to 6-in. depth on the north, east, south, and southwest sides. All samples are placed into 500-mL poly bottles, fitted with chain-of-custody tape, and submitted to Paragon Analytics, Inc., under strict chain-of-custody procedures for the analysis of tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; uranium-238; and for TAL metals. (Note: We report on the analyses of vegetation, small mammals, birds, and bees collected around the DARHT facility in Chapter 8, Section 4.b.)

We compared the radionuclide and nonradionuclide results in soil and sediment from the DARHT sampling to both RSRLs and baseline statistical reference levels (BSRLs). BSRLs are the concentrations of radionuclides and nonradionuclides (mean plus three standard deviations) in soil and sediment collected from around the DARHT facility (1996 through 1999) before the start up of operations (Fresquez et al. 2001), as per the DARHT Mitigation Action Plan (DOE 1996). The use of both reference levels is employed because the BSRLs for some elements may be biased as a result of changes in (pre- and post-) sampling locations and the change in analytical techniques. A comparison of BSRLs with RSRLs, for example, has shown that some baseline radionuclides, like cesium-137, may be biased low and some inorganic chemicals, like silver, may be biased high. Also, some TAL metals that have been analyzed recently have no baselines at all. To accommodate parking spaces and storage areas within the DARHT complex after operations began, soil sampling locations were moved from within the fenced perimeter boundary (<100 ft from the facility) to sites located outside the perimeter fence boundary (>300 ft from the facility). This may have affected the concentrations of some radionuclides, particularly cesium-137, because the pre-operation samples were collected in mostly disturbed soil and the post-operation samples are collected in mostly undisturbed soil.

Higher amounts of fallout radionuclides would be expected in the undisturbed soil rather than the disturbed soil because of the mixing associated with disturbed soil. Also, the change in analytical techniques may have

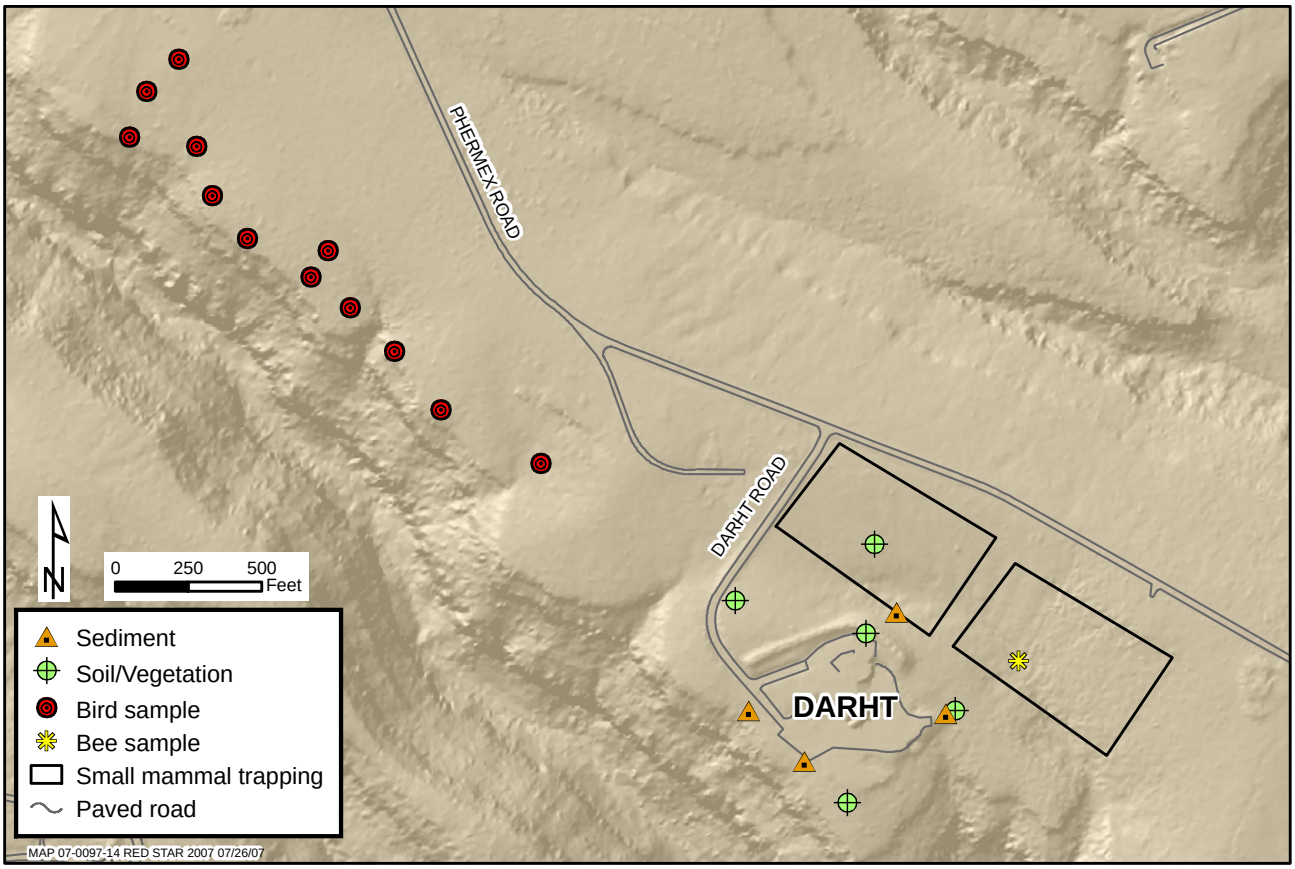

Figure 7-7. Sample locations of soil, sediment, vegetation, bees, and birds at DARHT.

improved the reporting levels of some elements, namely that of silver. The use of inductively coupled plasma mass spectrometry instrumentation to analyze post operation samples, for example, significantly decreased the detection limits of silver from 2 to 0.2 mg/kg.

4. Radionuclide and Nonradionuclide Analytical Results for DARHT

Most of the soil and sediment collected from within and around the perimeter of the DARHT facility contained concentrations of radionuclides and nonradionuclides that were either not detected or below BSRLs and/or RSRLs (Table S7-8 and Table S7-9). The very few radionuclide and inorganic chemicals detected above both the statistical reference levels were uranium-238 and beryllium in the soil sample collected nearest the firing point. Whereas the beryllium concentration was slightly above the BSRL (Figure 7-8), the concentration of uranium-238 was approximately an order of magnitude above the BSRL and appears to be increasing over time (Figure 7-9). Also, the distribution of uranium-234 to uranium-238 shows that the uranium in this soil sample was depleted uranium. Depleted uranium, a metal used as a substitute for the enriched uranium in weapon components tested at LANL, has also been detected in vegetation (Fresquez 2004), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2007a) around the DARHT facility in previous years.

Although the concentrations of uranium-238 and beryllium in the soil sample collected near the firing point were above BSRLs, the levels were still far below residential and occupational SLs respectively, and do not pose a potential unacceptable dose or hazard to human health. Moreover, the concentrations of these elements are not elevated past the perimeter fence line.

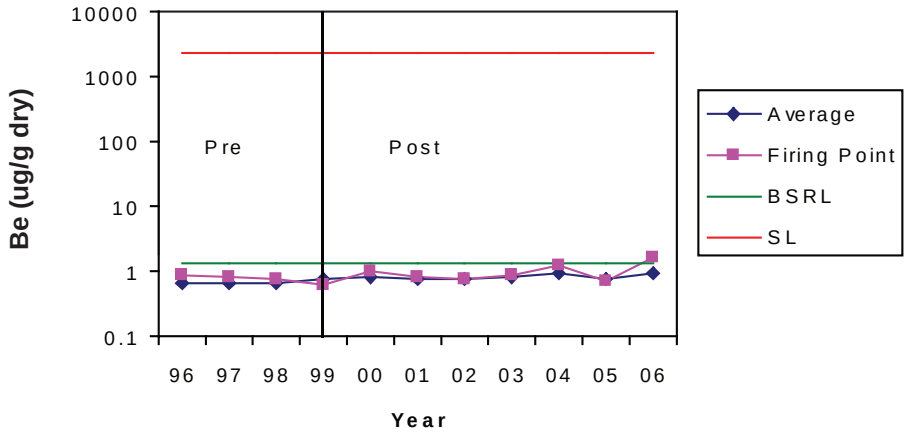

Figure 7-8. **Beryllium concentrations in soil collected within (near the firing point) and around (n = 4) the DARHT facility at TA-15 from 1996-1999 (pre-operation) to 2000-2006 (post-operation) as compared with the baseline statistical reference level (BSRL) and screening level (SL).**

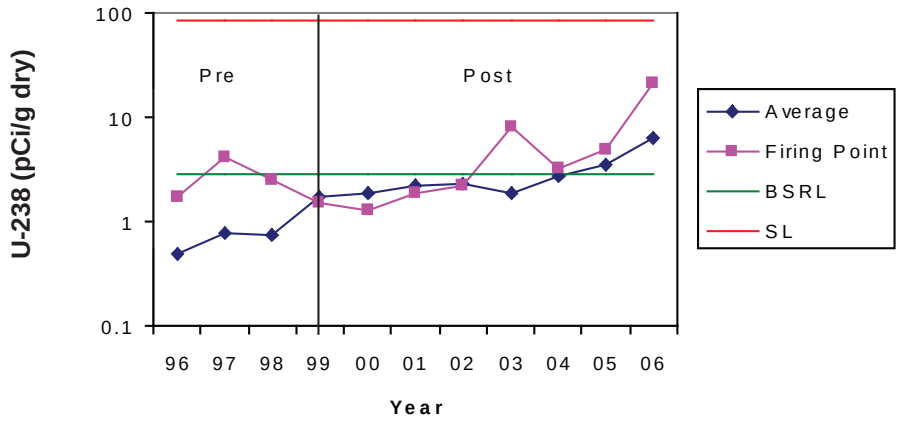

Figure 7-9. **Uranium-238 concentrations in soil collected within (near the firing point) and around (n = 4) the DARHT facility at TA-15 from 1996-1999 (pre-operation) to 2000-2006 (post-operation) as compared with the regional statistical reference level (BSRL) and screening level (SL).**

E. SPECIAL MONITORING STUDIES

1. Los Alamos Canyon Weir and Pajarito Flood Control Structure

Two special monitoring studies of sediment were conducted at the Los Alamos Canyon Weir and the Pajarito Canyon Flood Control Structure. The Los Alamos Canyon Weir is located at the northeastern boundary of LANL within TA-72 near the junction of NM State Road 4 and NM State Road 502. The Pajarito Canyon Flood Control Structure is located downstream of the confluence of Two-Mile and Pajarito Canyons at TA-18. Sediment samples along with vegetation and small mammals were collected behind (upstream of) the

structures to assess potential impacts to the biota as a result of potentially contaminated surface water runoff and sediment. Because sediment was collected and analyzed in support of the biota monitoring, the results are presented in Chapter 8, Section C.1 and C.2.

2. Beryllium in Surface Soil Collected Within and Around LANL: 1992-2006

A summary of beryllium concentrations in soil collected from all of the on-site and perimeter areas identified in Section C.1 from 1992 to 2006 was made and reported in Fresquez 2007c. Results show that the concentrations of beryllium from on-site (n = 153) and perimeter (n = 111) areas over the years ranged from 0.27 to 1.8 mg/kg (mean = 0.72 mg/kg) and from 0.20 to 1.3 mg/kg (mean = 0.65 mg/kg), respectively (Table S7-10). Most (97%) of the beryllium concentrations from LANL areas were below the RSRL of 1.2 mg/kg, and the few values that were above the RSRL were far below the industrial/occupational SL of 2,250 mg/kg. Mean beryllium concentration in soil from around Area G was 0.57 mg/kg and from DARHT was 0.78 mg/kg; both below the RSRL. There are no significant ($\alpha = 0.05$) increasing trends in beryllium concentrations in any of the samples from on-site or perimeter sites over time.

F. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND NONFOODSTUFFS BIOTA MONITORING PROGRAM

1. Quality Assurance Program Development

The soil sampling team conducts soil, foodstuffs, and nonfoodstuffs biota (SFB) sampling according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the LANL Quality Assurance Project Plan for the Soil, Foodstuffs, and Biota Monitoring Project and in the following LANL standard operating procedures:

- Produce Sampling
- Fish Sampling
- Game Animal Sampling
- Processing and Submitting Samples
- Soil Sampling
- Chain-of-Custody Data for Soil, Foodstuffs, and Biota Samples
- Sampling Soil and Vegetation at Facility Sites
- Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota

These procedures, which are available on the LANL web (http://www.lanl.gov/environment/all/qa.shtml), ensure that the collection, processing, and chemical analysis of samples, the validation and verification of data, and the tabulation of analytical results are conducted in a consistent manner from year to year. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

2. Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of carefully documented procedures, listed above, that govern all aspects of the sample-collection program.

The team collects all samples under strict chain-of-custody procedures, which minimize the chances of data transcription errors. We hand-deliver samples to the LANL Sample Management Office where they are directly shipped to an external analytical laboratory under full chain-of-custody. The LANL project leader tracks all samples and upon delivery of data back from the laboratory via electronic and hard copy means, a LANL chemist assesses the completeness of the field sample process along with other variables. A quality assessment document is created and attached to the data packet and provided to the LANL project leader.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified the program objectives. These statements of work are sent to potentially qualified analytical laboratories, which undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality-system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical, inorganic chemical, and organic chemical analyses.

Each analytical laboratory conducts chain-of-custody and analytical processes under its own quality plans and analytical procedures. Each laboratory returns data by e-mail in an electronic data deliverable with a specified format and content. The analytical laboratory also submits a full set of paper records that serves as the legal copy of the data. Each set of samples contains all the internal quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, method blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and immediately subjected to a variety of quality and consistency checks. Analytical completeness is determined, tracking and trending of all blank and control-sample data is performed, and all the data are included in the quality assessment memo mentioned in the field sampling section. We track all parts of the data-management process electronically and prepare periodic reports to management.

4. Field Data Quality Assessment Results

Field data completeness for SFB in 2006 was 100%.

5. Analytical Data Quality Assessment Results

Analytical data completeness for all SFB sampling programs was >95%. We track, trend, and report all quality control data in specific quality evaluation memos that we submit to project staff along with each set of analytical data received from our chemistry laboratories. The overall results of the 2006 quality program indicate that all analytical laboratories maintained the same high level of control that has been observed in the past several years.

6. Analytical Laboratory Assessments

During 2006, two external laboratories performed all chemical analyses reported for SFB samples:

- Paragon Analytics, Inc., Fort Collins, Colorado, provided radiological, trace element, and organic chemical analysis of soil and sediment.
- Severn Trent Laboratories, St. Louis, Missouri, provided radionuclide and inorganic chemical analyses in vegetation, bees, and small mammals.

We performed an assessment of Paragon Analytics, Inc., during 2004. The laboratory participated in national performance-evaluation studies during 2004 and 2005. The detailed results of these performance evaluations are included in the assessment report. Overall, the study sponsors judged the analytical laboratory to have acceptable performance for almost all analytes attempted in all matrices.

7. Program Audits

In 2005, we hosted a data quality assessment and evaluation to evaluate whether the procedures in various programs are being implemented as written. The auditors (Time Solutions 2) were external quality assurance professional experts (ISO 9000 and 14000 certified) and examined all aspects of the SFB program as it relates to procedures. While it was noted that improvements have been made to the SFB program since the last audit (completed by auditors external to the sampling group but internal to LANL), several observations were made to improve processes. These observations include keeping procedures up-to-date and meeting internal commitments made in our quality assurance plans. Since the quality assessment, we have implemented all recommendations resulting from the observations.

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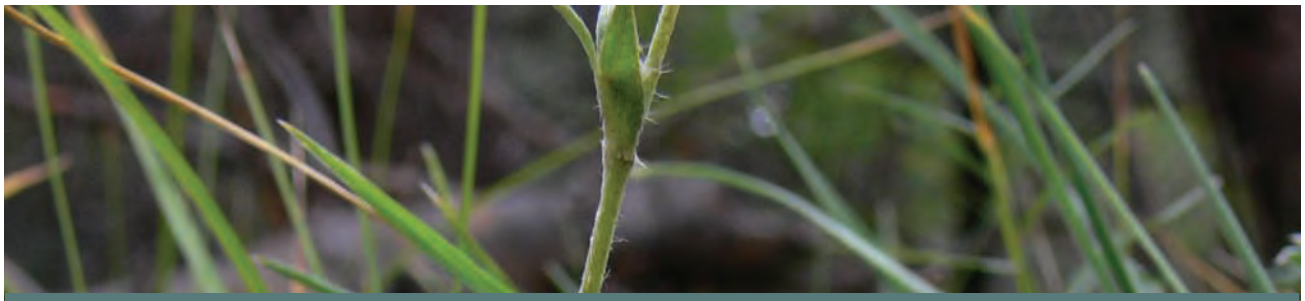

8. Foodstuffs and Biota Monitoring



8. Foodstuffs and Biota Monitoring

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A. FOODSTUFFS BIOTA MONITORING

1. Introduction

A wide variety of wild and domestic edible vegetables, fruits, grains, and animal products are harvested in the area surrounding the Los Alamos National Laboratory (LANL or the Laboratory). Ingestion of foodstuffs constitutes an important exposure pathway by which radionuclides (Whicker and Schultz 1982) and nonradionuclides (inorganic and organic chemicals) (Gough et al. 1979) may be transferred to humans. Over the years, we have collected a variety of foodstuff samples (e.g., vegetables, grains, fruits, fish, milk, eggs, honey, herbal teas, mushrooms, piñon nuts, domestic ungulates, and small and large game animals) from the surrounding area and communities to determine whether Laboratory operations have impacted human health via the food chain. US Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate this monitoring program, and the guidance for assessing impacts to foodstuffs is presented in the DOE's guidance for environmental surveillance (DOE 1991).

The objectives of the program are as follows:

(1) Measure radioactive and nonradioactive concentrations in foodstuffs from on-site (within LANL property) and perimeter areas, and compare these results with regional (background) areas;

(2) Determine concentration trends over time; and

(3) Provide data used to estimate dose and risk from the consumption of the foodstuffs (see Chapter 3 for dose and risk estimates to individuals from the ingestion of foodstuffs).

In general, major foodstuffs like food crops and fish are collected on a triennial basis. The next full-scale assessment for crops (and milk) is scheduled for 2007. (Note: Fish were collected in 2005.) This year, we focused on the collection and analysis of radionuclides and inorganic chemicals in two wild edible plants, common lambsquarters and pigweed amaranth, collected from Mortandad Canyon on Pueblo de San Ildefonso land.

2. Foodstuffs Comparison Levels

To evaluate potential Laboratory impacts on foodstuffs plants from radionuclides and nonradionuclides, we first compared analytical results with regional statistical reference levels (RSRLs). Where the levels exceeded RSRLs, we then compared the concentrations to screening levels (SLs) and standards, if available.

A description of the levels and/or the standard used to evaluate the results of radionuclides and nonradionuclides in foodstuffs plants are as follows, and an overall summary can be found in Table 8-1.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations = 99% confidence level) calculated from foodstuffs data collected from regional locations away from the influence of the Laboratory (>9 miles away) (DOE 1991) over at least the last five sampling periods. RSRLs represent natural and fallout sources, are calculated as data becomes available, and can be found in the supplemental data tables S8-1 and S8-2 of this report.
- Screening levels (SLs): SLs are set below federal regulations so that potential concerns may be identified in advance of major problems, i.e., a "yellow flag." If a constituent exceeds an SL, the reason for that increase is thoroughly investigated. For radionuclides, the dose assessment team at the Laboratory developed SLs on the basis of a conservative 1 mrem protective annual dose limit (this is 4% of the 25 mrem/yr DOE single-pathway constraint (DOE 1999). We are not aware of any specific SLs for most inorganic chemicals in foodstuff plants (FDA 2000), but comparisons were made to toxicity values (TV) obtained from the literature.
- Standard: Based on the concentrations of radionuclides in foodstuffs, we calculate a dose to a person (Chapter 3). We compare this dose with the 25-mrem/yr DOE single-pathway dose constraint (DOE 1999). There are no standards for inorganic chemicals in foodstuff plants.

Table 8-1
Standards and Other Reference Levels Applied to Foodstuffs

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Foodstuffs Plants	25 mrem/yr	1.0 mrem/yr	RSRLs
Nonradionuclides (Inorganic Chemicals)	On-site and perimeter	Foodstuffs Plants		TVs	RSRLs

3. Wild Edible Plants

a. Monitoring Network. For several years, we have collected wild food plants within Mortandad Canyon on the eastern side of LANL on Pueblo de San Ildefonso land. Mortandad Canyon has been the primary release area of treated liquid radioactive waste from the Laboratory (Gallaher et al. 1997), and radionuclides have been detected in biota in the upper reaches of Mortandad Canyon on Laboratory property closer to the source (Bennett et al. 1996). Subsequently, samples of edible plant foods were collected on Pueblo de San Ildefonso land as near to the LANL fence line as possible and have included piñon nuts and Navajo Tea (Fresquez and Gonzales 2000); prickly pear fruit (Fresquez et al. 2001a, Fresquez et al. 2002); and common purslane, acorns, and common lambsquarters (Fresquez et al. 2005a, 2006). This year, in addition to common lambsquarters (*Chenopodium sp.*), we collected pigweed amaranth (*Amaranth sp.*) from both Mortandad Canyon and from background locations. Pigweed amaranth seed is used for baking and for cereal type porridge and the greens are eaten like those of common lambsquarters (TNM 2004). Two samples of each crop were collected approximately 16 to 160 ft from the LANL fence line. Samples were analyzed for tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, and uranium-238. Also, 23 target analyte list (TAL) metals were analyzed.

b. Radionuclide and Nonradionuclide Analytical Results. Most (activity) concentrations of radionuclides in two wild food plants, common lambsquarters and pigweed amaranth, collected within Mortandad Canyon on Pueblo de San Ildefonso land, either were not detected or were below the RSRLs (Table S8-1). A nondetected value is one in which the result is lower than three times the counting uncertainty and is not significantly ($\alpha = 0.01$) different from zero (Keith 1991, Corely et al. 1981).

The only radionuclide detected above the RSRL in both common lambsquarters and pigweed amaranth was strontium-90 (Figure 8-1.) Strontium-90 concentrations in these plants are similar to other wild food plants collected from this same location in previous years. The higher strontium-90 concentrations in plants from Mortandad Canyon as compared with background plants are not related to elevated strontium-90 levels in the soil; the concentrations of strontium-90 in soil from Mortandad Canyon on Pueblo de San Ildefonso land are similar to RSRLs (Figure 8-2) (Fresquez et al. 2006). Instead, the higher levels of strontium-90 in plants from Mortandad Canyon may be related to the lower calcium content in the soil (Figure 8-3). Lower calcium concentrations in soil are usually reflected by higher strontium-90 levels in plant tissues because both elements are chemically similar and the plants do not differentiate between the two (Whicker and Schultz 1982). The highest strontium-90 concentration in common lambsquarters (0.36 pCi/g dry) and pigweed amaranth (0.22 pCi/g dry) in Mortandad Canyon are still below the SL of 1 pCi/g dry (i.e., <1 mrem/yr) and do not pose a potential unacceptable dose to humans who ingest these plants.

All inorganic chemical concentrations in common lambsquarters and pigweed amaranth samples collected from within Mortandad Canyon on Pueblo de San Ildefonso land were either below the reporting limits (i.e., they were not detected) or below RSRLs (supplemental data Table S8-2).

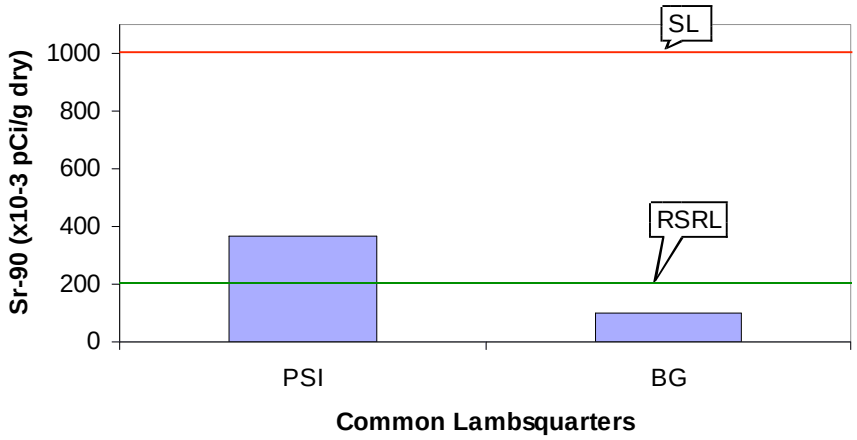

Figure 8-1. **The highest strontium-90 concentration in common lambsquarters collected within Mortandad Canyon on Pueblo de San Ildefonso (PSI) land as compared with a background sample (BG), the regional statistical reference level (RSRL), and screening level (SL).**

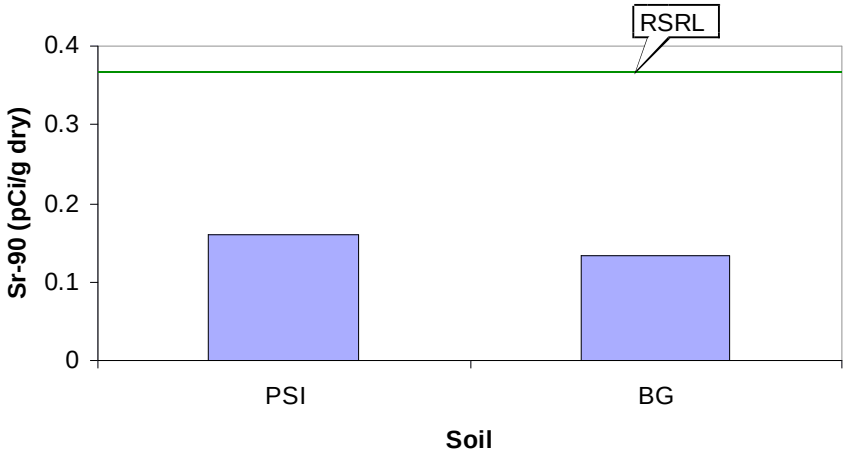

Figure 8-2. **The average strontium-90 concentrations in soil collected from Mortandad Canyon on Pueblo de San Ildefonso (PSI) land as compared with background (BG) and the regional statistical reference level (RSRL).**

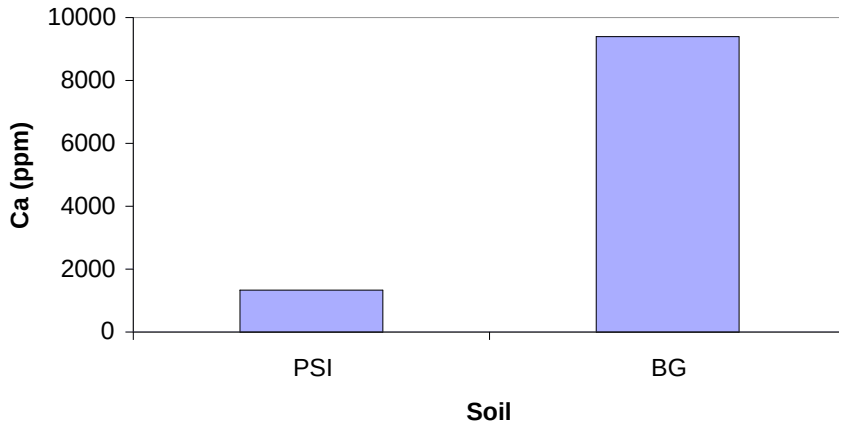

Figure 8-3. **The average calcium concentrations in soil collected from Mortandad Canyon on Pueblo de San Ildefonso (PSI) land as compared with background (BG).**

B. NONFOODSTUFFS BIOTA MONITORING

1. Introduction

DOE Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate the monitoring of nonfoodstuffs biota for the protection of ecosystems. Although monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, site-wide vegetation monitoring started in 1994. Presently, in addition to vegetation, we also monitor small mammals, amphibians, reptiles, birds, and bees within and around LANL on a systematic basis or for special studies.

The three objectives of the nonfoodstuffs biota program are to determine

(1) Radionuclide and nonradionuclide concentrations in biota from on-site (LANL property) and perimeter areas, and compare these results to regional (background) areas,

(2) Determine concentration trends over time, and

(3) Estimate potential dose to plants and animals.

Chapter 3 includes the results of the 2006 biota dose assessments at LANL.

2. Nonfoodstuffs Biota Comparison Levels

To evaluate whether there are Laboratory impacts from radionuclides and nonradionuclides in nonfoodstuffs biota, we first compared the analytical results of biota samples collected from on-site and perimeter areas with RSRLs. If the levels exceed RSRLs, we compare the concentrations with SLs, if available, and then to standards, if available. A discussion of these comparison levels is as follows and a summarization can be found in Table 8-2:

- Regional background levels: RSRLs are the upper-level background concentrations (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from nonfoodstuffs biota data collected from regional locations away from the influence of the Laboratory (>9 miles away) (DOE 1991) over the past five sampling periods. RSRLs represent natural and fallout sources, are calculated annually, and can be found in the supplemental data tables S8-3 through S8-25 of this report.
- Screening levels: SLs are set below federal regulatory standards so that potential concerns may be identified in advance of potential ecological health problems—a "yellow flag." If a constituent exceeds an SL, then the reason for that exceedance is thoroughly investigated. For radionuclides in nonfoodstuffs biota, SLs were set at 10% of the standard by the dose assessment team at the Laboratory to identify the potential contaminants of concern (McNaughton 2006). Nonradionuclides are compared with TVs obtained from the literature.
- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1 rad/d DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/d for terrestrial animals (DOE 2002).

Table 8-2
Standards and Other Reference Levels Applied to Nonfoodstuffs Biota

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1 rad/d	0.1 rad/d	BSRLs[a]
	On-site and perimeter	Terrestrial animals	0.1 rad/d	0.01 rad/d	RSRLs
	DARHT	Terrestrial animals	0.1 rad/d	0.01 rad/d	BSRLs
Nonradionuclides	On-site and perimeter	Biota		TVs	RSRLs
	DARHT	Biota		TVs	BSRLs

[a] Baseline Statistical Reference Levels (BSRL) and a discussion of these levels can be found in Section 4.b.i.

3. Institutional Monitoring

Native understory vegetation are collected on a triennial basis at the same time and at the same locations (17 on-site, 11 perimeter, and six regional locations) as the soil sampling program described in Chapter 7, Section C.1 (Figure 7-1). Previous understory sampling occurred in 1998 (Gonzales et al. 2000) and in 2003 (Fresquez and Gonzales 2004). In 2006, samples were submitted to Severn Trent Laboratories, Inc., under full chain-of-custody procedures for the analysis of tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and TAL metals.

a. Radionuclide and Nonradionulclide Results of Native Vegetation. Most activity concentrations of radionuclides in native understory plants collected from both on-site and perimeter areas were either not detected or below RSRLs (Table S8-3). The very few detected radionuclides in vegetation from on-site and perimeter areas that were higher than RSRLs included strontium-90 and plutonium-238 in a sample collected east of Area G at TA-54; cesium-137 in a sample collected east of White Rock; tritium in a sample collected along State Road 502 at Technical Area (TA)-73; and plutonium-239,240 in a sample collected west of the former plutonium processing facility at TA-21. All of these detected concentrations were below SLs and do not result in adverse effects to the vegetation.

The results of the inorganic chemical analysis in native vegetation from on-site and perimeter areas as compared with RSRLs are presented in Table S8-4. Most inorganic chemicals in native vegetation from on-site and perimeter areas were below RSRLs. The few inorganic chemicals in native vegetation from on-site and perimeter areas above RSRLs included mostly zinc and cadmium. While all of the concentrations of zinc in native vegetation from perimeter and on-site locations were slightly above the RSRL, the amount of cadmium in a plant sample east of TA-54 at Area G was detected in higher concentrations than the RSRL (1.2 mg/kg dry vs. the RSRL of 0.63 mg/kg dry). The concentration of cadmium in this plant sample was below the SL of 3.0 mg/kg dry (Allaway 1968) and not a significant hazard to the plant(s).

4. Facility Monitoring

a. Area G at TA-54.

i. Monitoring Network. The Laboratory conducts facility-specific vegetation monitoring on an annual basis at Area G (Lopez 2002). A description of the area and the types of waste disposed of at Area G is presented in Chapter 7 Section D.1. This year, two understory vegetation samples—one from the southern area of Area G (location G-29-03) and one from the northeastern area of Area G (location G-43-01)—were collected. Historically, the southern area has had tritium activity and the northeastern area has had plutonium activity compared with other areas around the perimeter of Area G (Fresquez and Lopez 2004, Fresquez et al. 2004, 2005b). Plant understory samples were analyzed for tritium, cesium-137, strontium-90, americium-241, plutonium isotopes, uranium isotopes, and TAL metals.

ii. Vegetation Results for Area G. Tritium concentrations from understory vegetation sample location G-29-03 collected from the southern perimeter of Area G near the tritium shafts was above the RSRL (511 pCi/mL vs. the RSRL of 0.56 pCi/mL) (Table S8-5). Similarly, the vegetation sample collected near the northeastern corner of Area G (location G-43-01) had a plutonium-239,240 concentration higher than the RSRL (0.32 pCi/g ash vs the RSRL of 0.017 pCi/g ash). All tritium and plutonium-239,240 concentrations above the RSRLs were below the SL of 0.1 rad/day for terrestrial understory plants (e.g., <345,000 pCi/mL for tritium and <578 pCi/g ash for plutonium isotopes). These data correlate very well with the soil data (Chapter 7, section D.2) and are similar to previous years (Figures 8-4 and 8-5).

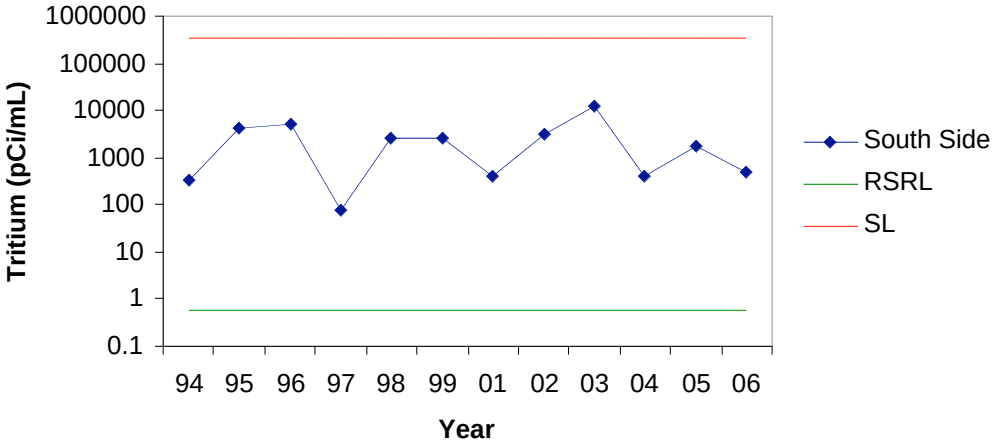

Figure 8-4. **Tritium in understory vegetation collected from the south side (see Figure 7-4 for location information associated with G-29-03) outside of Area G at TA-54 from 1994 through 2006 compared with the regional statistical reference levels (RSRL) and screening level (SL).**

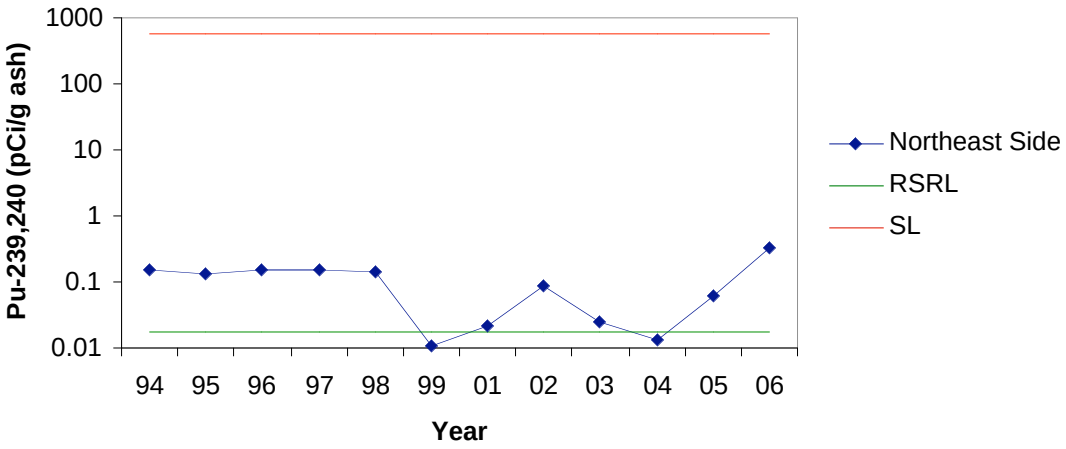

Figure 8-5. **Plutonium-239,240 in understory vegetation collected from a selected location (see Figure 7-4 for location information associated with G-43-01) outside of Area G at TA-54 from 1994 through 2006 compared with the regional statistical reference levels (RSRL) and screening level (SL).**

All concentrations of inorganic chemicals, with the exception of zinc in both vegetation samples, were either not detected or below the RSRLs (Table S8-6). The highest zinc concentration was detected in a vegetation sample from location G-43-01(93 mg/kg dry vs. the RSRL of 50 mg/kg dry). Nevertheless, the concentration of zinc was below the SL (400 mg/kg dry) (Chapman 1966) and is not a significant concern.

b. DARHT at TA-15

i. Monitoring Network. The Laboratory conducts facility-specific biota monitoring on an annual basis at DARHT (Nyhan et al. 2001). In 2006, the biota samples collected at DARHT included vegetation, small mammals, birds, and bees (Figure 7-7).

Overstory and understory vegetation samples are collected near the same four locations as the soil samples collected on the north, south, west, and east sides of the complex (see Chapter 7, Section D.2. or Figure 7-7 for sample locations). We used snap traps to collect samples of deer mice (*Peromyscus* spp.) from two sample grids located on the north and northeast side of the DARHT facility. We conducted bird sampling using mist net traps—setting 12 mist capture nets starting from about 200 ft to 1,600 ft outward from the west side of the DARHT facility. Spacing of the nets was about 150 ft from one another. In addition, we set mist nets in Jemez Springs and Nambé to capture birds for background comparisons. Finally, we collected honey bees from five hives located just northeast of the DARHT facility.

All biota samples were submitted to Severn Trent Laboratories, Inc., and analyzed for concentrations of tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; uranium-238; and TAL metals. Results of the vegetation, small mammals, birds, and bee samples were compared with either RSRLs or baseline statistical reference levels (BSRLs). BSRLs are the upper-limit baseline data established over a four-year period (1996–1999) prior to the start-up of DARHT operations in 2000. The BSRLs, at the three sigma level, are based on data from Fresquez et al. (2001b) for vegetation, Bennett et al. (2001) for small mammals, and Haarmann (2001) for bees. BSRLs for birds are not available. The bird samples collected in 2006 from DARHT were compared to bird samples collected from regional background (RSRLs) areas and can be found in the present data. Also, RSRLs were used in other media where BSRLs were not available.

ii. Vegetation Results at DARHT. All radionuclide concentrations, with the exception of uranium-238 in vegetation collected from around the DARHT facility, were either not detected or below BSRLs (Table S8-7). The highest concentrations of uranium-238 were detected in overstory vegetation collected from the north and east sides of the complex and the distribution of uranium-234 to uranium-238 was consistent with that of depleted uranium. Depleted uranium, a metal used as a substitute for the enriched uranium in weapon components tested at LANL, has also been detected in soil (Fresquez 2004), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) at DARHT in previous years. All concentrations of uranium-238 in vegetation at DARHT were below the SL (<889 pCi/g ash) and do not pose a potential unacceptable dose to the plants.

A plot of uranium-238 concentrations in understory vegetation over the past 11 years shows that the levels are steady and mostly below the BSRL (Figure 8-6). Conversely, the levels of uranium-238 in overstory vegetation are higher than the understory vegetation, are above the BSRL in recent samples, and are significantly ($\alpha = 0.05$) increasing over time, especially since operations began in 2000 on the eastern side. Concentrations of uranium-238 in overstory vegetation at DARHT will be closely monitored over time.

A comparison of the 23 TAL metals in vegetation collected from around the DARHT facility with the BSRLs (or RSRLs when BSRL data was not available) show that most were either not detected or below statistical levels (Table S8-8). The only inorganic chemical detected above either of the reference levels was arsenic in one overstory plant sample collected on the south side of the DARHT facility. The detected arsenic concentration (2.3 mg/kg vs the BSRL of 0.35 mg/kg) was within the range of 2.1 mg/kg to 8.2 mg/kg considered toxic to plants (Gough et al. 1979). It is not clear why this tree sample contained an elevated concentration of arsenic as the amounts of arsenic in all other vegetation samples in the area around the DARHT grounds showed no other arsenic detections. Also, the arsenic concentrations in the soil and sediment samples collected in this vicinity were at background levels (Table S7-5). We will continue to monitor the vegetation at this location for arsenic in the future.

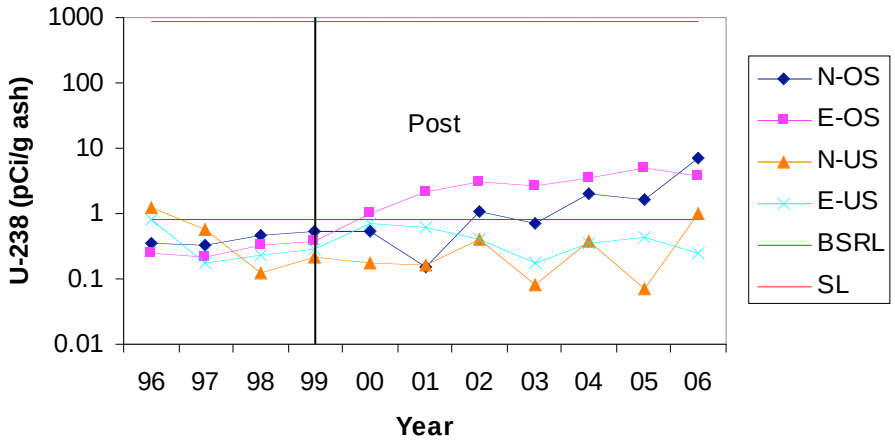

Figure 8-6. **Uranium-238 in overstory (OS) and understory (US) vegetation collected from the north (N) and east (E) side of the DARHT facility at TA-15 from 1996 (pre-operational) through 2006 (post-operational) compared with the baseline statistical reference levels (BSRL), and the screening level (SL).**

iii. Small Mammal Results at DARHT. With the exception of uranium-234 in the whole body of mice collected downwind of DARHT, radionuclides were either not detected or below BSRLs (Table S8-9) (Fresquez 2007). The highest level of uranium-234 (0.55 pCi/g vs the BSRL of 0.28 pCi/g ash), however, was far below the SL and does not pose a hazard to the mice. The distribution of uranium-234 and uranium-238 indicate that the uranium in mice was depleted uranium.

iv. Bird Results at DARHT. All radionuclides in bird samples collected west of the DARHT facility were either not detected or below the RSRLs (Table S8-10). In contrast, there were many inorganic chemicals detected above RSRLs in one (spotted towhee sample) of the two bird samples collected west of the DARHT facility (Table S8-11). The inorganic chemicals above the RSRLs in the one spotted towhee sample included aluminum, barium, beryllium, iron, manganese, vanadium, arsenic, lead, and silver. It is not clear why only one of the two bird samples collected near the DARHT facility contained inorganic chemical concentrations above RSRLs because there is no evidence of these metals being elevated around the DARHT facility. Instead, the source of metals in birds may be from surface waters from Canon de Valle, a tributary just below the bird collection points near DARHT. For example, base flow and storm water runoff within Canon de Valle contain silver (by two to three times) above the NM acute aquatic life standards. Past discharges from photography laboratories are cited as the probable source of the silver.

v. Bee Results from DARHT. Most concentrations of radionuclides (Table S8-12) and all nonradionuclides (Table S8-13) in bees sampled from four hives located northeast of the DARHT facility were below the BSRLs. The only radionuclide concentrations above the BSRLs were for uranium-234 and uranium-238 in three of the four bee samples. The distribution of these isotopes showed that one of these samples contained depleted uranium. All concentrations of uranium-234 and uranium-238 were below the SL of 0.01 rad/day and, therefore, do not contribute significant doses to the bees.

C. SPECIAL STUDIES OF NONFOODSTUFFS BIOTA

1. Characterization of Biotic and Abiotic Media Upstream of the Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure

In May 2000, a prescribed burn at Bandelier National Monument went out of control and burned nearly 50,000 acres of federal and pueblo land, including approximately 7,500 acres on LANL property. Because the Cerro Grande Fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increased sediment (and potential contaminant) transport from LANL to off-site locations. As a preventive measure, the U.S. Army Corps of Engineers constructed two large erosion control structures to control storm water runoff and sediment from burned areas. These structures consist of (1) a low-head, rock-filled gabion weir that lies across the stream bed in Los Alamos Canyon near the junction of State Roads 4 and 502, and (2) a large cement flood retention structure located downstream of the confluence of Two-Mile and Pajarito Canyons.

As part of the Special Environmental Analysis of actions taken in response to the Cerro Grande Fire at LANL (DOE 2000), the DOE identified various mitigation measures that must be implemented under the Mitigation Action Plan as an extension of the fire suppression, erosion, and flood control actions. One of the tasks identified in the Mitigation Action Plan Section 2.1.7, "Mitigation Action for Soil, Surface and Ground Water, and Biota," mandates the monitoring of soil, surface water, groundwater, and biota at areas of silt or water retention behind (upstream) flood control structures, within silt retention basins, and within sediment traps to determine if there has been an increase in contaminant concentrations in these areas. To this end, we collected samples of sediment (0- to 6-in. depth), native grasses and forbs (unwashed), and deer mice (*Peromyscus sp.*) in the areas behind the Los Alamos Canyon Weir (LACW) in 2005 (Fresquez 2006a, Fresquez 2006b) and 2006 and behind the Pajarito Canyon Flood Retention Structure in 2006. Samples were analyzed for some or all of the following constituents: radionuclides, TAL metals, HE, SVOCs, and PCBs. The following two sections report the 2006 results.

a. The Los Alamos Canyon Weir. Cesium-137, plutonium-238, plutonium-239,240, and americium-241 (Table S8-14); silver, mercury, and lead (Table S8-15); and Aroclor-1260 (Table S8-16) in sediment upstream of the Los Alamos Canyon weir were detected at higher concentrations than the RSRLs. Also, strontium-90, plutonium-239,240, americium-241 (Table S8-17) and lead (Table S8-18) in overstory plants and plutonium-239,240, americium-241, uranium-234 and uranium-238 in whole body mice collected upstream of the LACW were at higher concentrations than RSRLs. These concentrations in 2006 were higher than reported in 2005. All constituents in these media, however, were below SLs and do not pose a potential unacceptable dose to humans or to the other biota sampled. These results are consistent with the human health risk assessment and the baseline ecological risk assessment conducted as part of the Los Alamos/Pueblo Canyons Investigation (LANL 2004).

b. The Pajarito Canyon Flood Retention Structure. Results of radionuclide and nonradionuclide analysis of sediment, vegetation, and small mammal samples collected upstream of the Pajarito Canyon Flood Retention Structure are presented in Table S8-20 through Table S8-25. In general, sediment concentrations of cesium-137, plutonium-239,240, uranium-234, uranium-238, copper, cadmium, silver, mercury, and Aroclor-1254 were above RSRLs; vegetation had concentrations of uranium-234, uranium-238, lead, and silver above RSRLs; and the small mammals had concentrations of plutonium isotopes, americium-241, uranium-234, and uranium-238 above RSRLs. All concentrations of radionuclides and nonradionuclides in all media, however, were below SLs and do not pose a potential unacceptable dose to human health or to the other biota sampled.

2. Radionuclide Concentrations in Trees Growing Along the North Side of MDA B

Four composite samples were collected from trees growing along the north perimeter fence line of MDA B (Figure 8-7). Samples consisted of tree shoot tips collected from every tree growing along a 100-yard section starting from the east end. Samples were submitted to Severn Trent Laboratories, Inc., and analyzed for tritium, strontium-90, cesium-137, plutonium-238, plutonium-239,240, americium-241, uranium-234, uranium-235, uranium-238, and TAL metals. The results of the radionuclide analysis show that most isotopes were either not detected or below RSRLs (Supplemental Data Table S8-26). The few radionuclides above RSRLs—cesium-137 in one sample and plutonium-239,240 in another sample—were below the 0.1 rad/day SL used to assess the dose to the trees. As for the heavy metals, chromium and nickel in one sample and zinc and lead in another sample were above RSRLs; differences between MDA B trees and regional trees were small. All elements were below SLs and do not pose a significant risk to the trees.

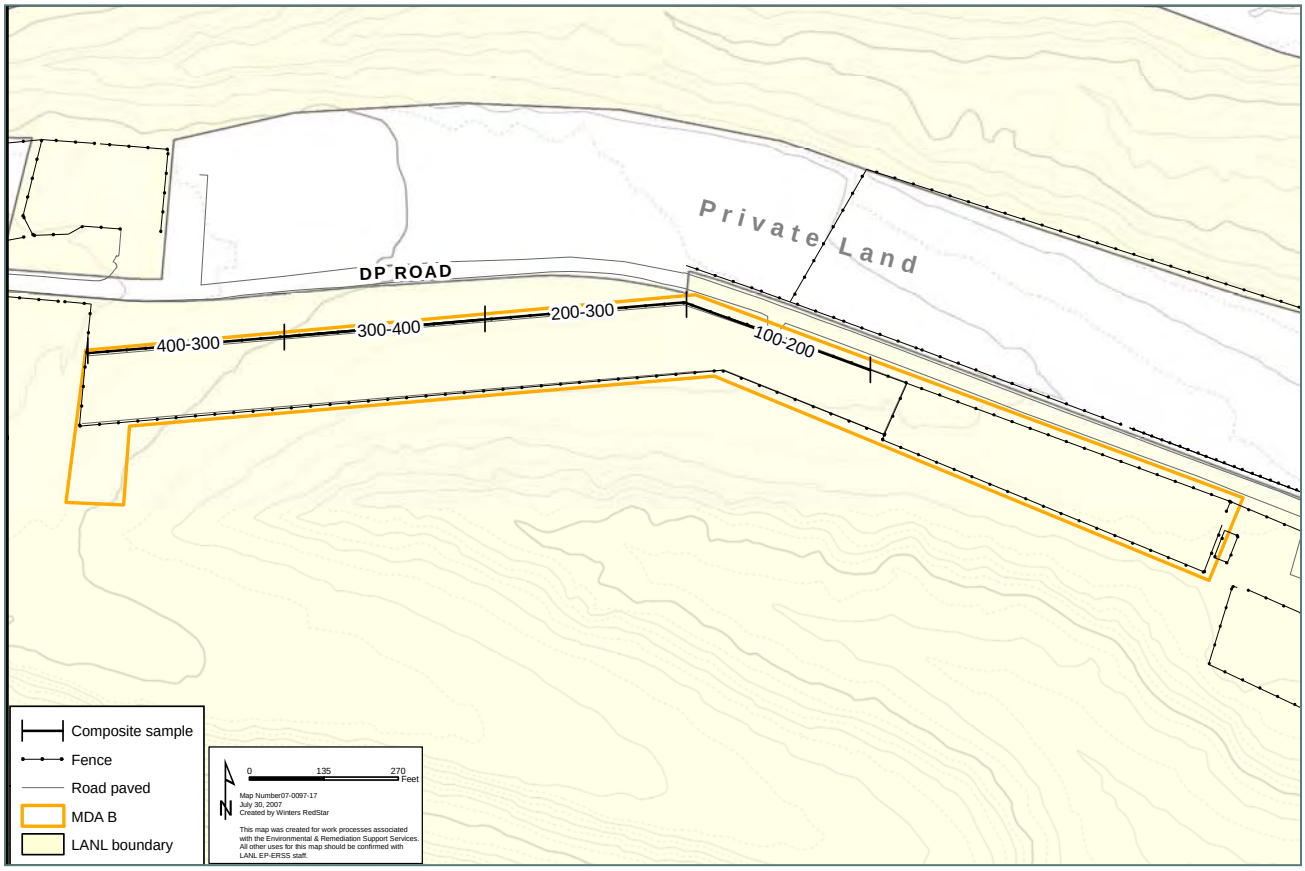

Figure 8-7. Location of composite tree samples collected near MDA B.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS AND NONFOODSTUFFS BIOTA PROGRAM

This program uses the same quality assurance (QA) protocols and analytical laboratories as described in Chapter 7.

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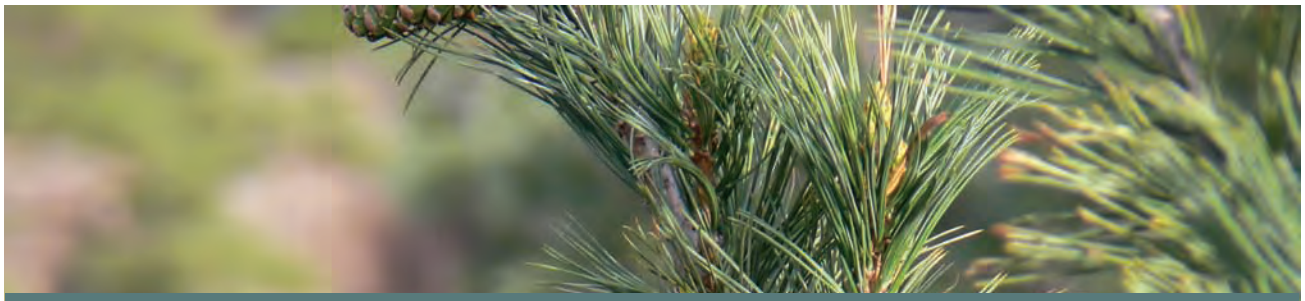

9. Environmental Restoration



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A. INTRODUCTION

The Environmental Programs (EP) Directorate at Los Alamos National Laboratory (LANL or the Laboratory) is leading the Laboratory's participation in a national US Department of Energy (DOE) effort to clean up sites and facilities formerly involved in weapons research and development. The EP Directorate's goal is to ensure past operations do not threaten human or environmental health and safety in and around Los Alamos County. To achieve this goal, the Laboratory is investigating sites potentially contaminated by past operations; the sites under investigation are designated as consolidated units, solid waste management units (SWMUs), or areas of concern (AOCs).

The New Mexico Environment Department (NMED) regulates the cleanup of hazardous wastes and hazardous constituents under the New Mexico Hazardous Waste Act. Corrective actions for the releases of hazardous waste and hazardous constituents at the Laboratory are subject to the March 1, 2005 Compliance Order on Consent (the Consent Order). The Consent Order was issued pursuant to the NM Hazardous Waste Act (NM Statutes Annotated [NMSA] 1978, § 74-4-10) and the NM Solid Waste Act (NMSA 1978, §74-9-36[D]).

The DOE regulates the cleanup of radioactive contamination. Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." DOE is implementing corrective actions pursuant to the Atomic Energy Act for releases of radionuclides in conjunction with the activities required under the Consent Order.

1. 2006 Projects

Environmental restoration work is managed under three projects that encompass sites (consolidated units, SWMUs, and AOCs) slated for investigation and/or remediation. The projects collect, manage, and report environmental data, and utilize the data to support site decisions. Each of these projects is briefly described below.

a. Corrective Action Project. This project includes the investigation and possible remediation of consolidated units, SWMUs, and AOCs intermixed with active Laboratory operations as well as consolidated units, SWMUs, or AOCs located within the Los Alamos townsite (property currently owned by private citizens, businesses, or Los Alamos County) and on property administered by the US Forest Service (USFS), the National Park Service, and the DOE.

b. Water Stewardship Project. This project includes the canyons investigations, the groundwater monitoring program (implemented through the Interim Facility-Wide Groundwater Monitoring Plan [LANL 2006k]), storm water monitoring, the minimization of erosion, and the transport of contaminants from sites by storm water runoff.

c. Technical Area (TA)-21 Closure Project. This project includes the investigation and the implementation of corrective actions for Material Disposal Areas (MDAs) A, B, T, U, and V and a broad category of environmental sites (e.g., septic systems, outfalls, disposal areas, a polychlorinated biphenyl [PCB] container storage area, drum storage areas, and a historical waste treatment laboratory) referred to as the Delta Prime (DP) Site Aggregate Area at TA-21.

In addition to the sites investigated and/or remediated under the EP Directorate projects described above, several consolidated units, SWMUs, and AOCs were managed in 2006 under the direct supervision of the DOE Los Alamos Site Office. The work at these sites involved investigation and remediation activities at Consolidated Unit 73-002-99 and four interim measures conducted at SWMUs 03-010(a) and 03-001(e). In addition, engineered covers were constructed as the final remedies for SWMUs 73-001(a) and 73-001(d) (the Airport Landfill and Debris Disposal Area, respectively).

2. Work Plans and Reports

The projects wrote and/or revised 16 work plans and 14 reports and submitted them to NMED during 2006. The work plans propose investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregates, canyons, and watersheds. The data, which are presented in remedy completion or investigation reports, are used to determine if the nature and extent of contamination is defined and to determine the potential risks to human health and the environment posed by contaminants. Depending on the data and the assessment results, sites may require additional investigation, remediation, monitoring, or no further action.

Tables 9-1 and 9-2 summarize the work plans and reports submitted and approved in 2006, the work plans and reports submitted prior to 2006 but approved in 2006, and the work plans and reports submitted in 2006 but not yet approved. Table 9-3 summarizes the 28 SWMUs and AOCs that have been completed and for which NMED granted Certificates of Completion under the Consent Order through 2006. The remainder of this section presents summaries of the investigations for which activities were started, continued, and/or completed in 2006 and those investigations for which reports were submitted in 2006. Figure 9-1 shows the locations where significant environmental characterization or remediation work was performed.

Table 9-1
Work Plans Submitted and/or Approved in 2006

Document Title	Date Submitted	Date Approved	Status
Work Plan for the North Canyons	9/21/01	8/17/06[a]	Work plan activities started in 2006 and continuing in 2007
Investigation Work Plan for Middle Los Alamos Canyon Aggregate Area	12/22/2005	n/a[b]	Revised the investigation work plan
Investigation Work Plan for Middle Los Alamos Canyon Aggregate Area, Revision 1	5/3/2006	5/30/2006[a]	Scheduled to start in 2007
Investigation Work Plan for Guaje, Barrancas, Rendija Canyons Aggregate Areas	7/22/2005	1/5/2006[a]	Investigation activities started in 2006 and will be completed in 2007
Revisions to DP Site Aggregate Area Investigation Work Plan	7/29/2005	n/a	Work plan activities completed for five sites; investigation activities continuing in 2007

Table 9-1 (continued)

Document Title	Date Submitted	Date Approved	Status
Supplemental Investigation Work Plan for DP Site Aggregate Area at Technical Area 21	4/4/2006	n/a	Work plan activities completed for five sites; investigation activities continuing in 2007
Accelerated Corrective Action Work Plan for the Investigation and Remediation of Area of Concern 16-024(v) and Solid Waste Management Units 16-026(r) and 16-013(f) at Technical Area 16	1/20/2006	3/20/2006[a]	Work plan activities completed
Corrective Measures Evaluation Plan for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54	3/10/2006	—[c]	Deferred until investigation activities completed
Investigation/Remediation Work Plan for Material Disposal Area B, Solid Waste Management Unit 21-015, at Technical Area 21	3/27/2006	n/a	Work plan revised
Investigation/Remediation Work Plan for Material Disposal Area B, Solid Waste Management Unit 21-015, at Technical Area 21, Revision 1	10/23/2006	—	Under review in 2006
Investigation Work Plan for Chromium Contamination in Groundwater	3/31/2006	5/5/2006[a]	Work plan activities completed
Accelerated Corrective Action Work Plan for the Investigation and Remediation of SWMU 61-002	4/20/2006	5/2/2006[a]	Work plan activities completed
Investigation Work Plan for Upper Los Alamos Canyon Aggregate	4/28/2006	11/6/2006	Scheduled to start in 2008
Historical Investigation Report for Upper Los Alamos Canyon Aggregate	4/28/2006	n/a	n/a
Corrective Measures Evaluation Plan for Material Disposal Area G at Technical Area 54	5/3/2006	—	Deferred until investigation activities completed
Pajarito Canyon Biota Investigation Work Plan	8/1/2006	—	Under review in 2006
Work Plan for Supplemental Sampling at Material Disposal Area G, Consolidated Unit 54-013(b)-99	9/26/2006	11/13/2006	Scheduled to start in 2007
Investigation Work Plan for South Canyons	9/28/2006	—	Under review in 2006
Historical Investigation Report for South Canyons	9/28/2006	n/a	n/a
Cañon de Valle Aggregate Area Investigation Work Plan	9/29/2006	—	Under review in 2006
Historical Investigation Report for Cañon de Valle Aggregate Area	9/29/2006	n/a	n/a
Supplemental Investigation Work Plan for Sampling at Material Disposal Area L, Solid Waste Management Unit 54-006	10/27/2006	11/13/2006[a]	Scheduled to start in 2007
Sampling and Analysis Plan for Impoundments B, C, and D at Material Disposal Area L, Solid Waste Management Unit 54-006, Revision 1	10/27/2006	11/13/2006[a]	Scheduled to start in 2007

[a] Work plans approved with modifications and/or directions.

[b] n/a = Not applicable.

[c] "—" = Approval not received in 2006.

Table 9-2
Reports Submitted and/or Approved in 2006

Document Title	Date Submitted	Date Approved	Status
Voluntary Corrective Action Completion Report for SWMU 16-016(c)-99, Revision 1	11/26/2003	1/10/2006	Work completed
Voluntary Corrective Action Completion Report using Soil Vapor Extraction System (AOC 00-027)	6/3/2005	8/30/2006	Work completed
Corrective Measure Study Report for SWMU 16-021(c)-99, Revision 1	6/15/2005	n/a[a]	Final decision remedy selection rendered by NMED in 2006
Remedy Completion Report for former TA-19	7/29/2005	6/27/2006	Work completed
TA-53 Surface Impoundments [SWMU 53-002(a)-99 and AOC 53-008] Investigation Report, Revision 1	9/8/2005	7/25/2006	Work completed
Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54	9/8/2005	n/a	Additional sampling required; supplemental work plan submitted and approved in 2006 (see Table 9-1)
MDA L Investigation Report	9/13/2005	n/a	Additional sampling required
Investigation Report for Mortandad/Ten Site Canyons Aggregate Area	9/30/2005	n/a	Remediation and additional sampling required; revised investigation report due in 2007
Los Alamos and Pueblo Canyons Supplemental Investigation Report (revised risk assessment)	12/15/2005	—[b]	Provided additional information; under review in 2006
Remedy Completion Report for AOC 03-001(i) and SWMUs 03-029 and 61-002	12/15/2005	9/13/2006	Additional sampling and/or remediation required for SWMU 61-002
Investigation Report for the TA-16-340 Complex	1/31/2006	10/25/2006[c]	Additional sampling required
Investigation Report for Material Disposal Area U, Consolidated Unit 21-017(a)-99, at Technical Area 21	2/6/2006	n/a	Directed to revise report
Investigation Report for Material Disposal Area U, Consolidated Unit 21-017(a)-99, at Technical Area 21, Revision 1	9/8/2006	9/28/2006	Work completed
Investigation Report for Solid Waste Management Units 03-010(a) and 03-001(e) at Technical Area 3	4/20/2006	—	Additional investigation required; four interim measures implemented in 2006
Remedy Completion Report for the Investigation and Remediation of Solid Waste Management Unit 33-013	3/2/2006	8/30/2006	Work completed
Investigation Report for Material Disposal Area L, Revision 1	3/10/2006	—	Additional sampling required; supplemental work plan and a sampling and analysis plan submitted and approved in 2006 (see Table 9-1)
Summary of Pajarito Canyon Phase 1 Sediment Investigations	3/22/2006	n/a	Phase 2 sampling conducted
Investigation Report for Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99	8/31/2006	11/29/2006[c]	Additional sampling and other activities required

Table 9-2 (continued)

Document Title	Date Submitted	Date Approved	Status
Investigation Report for Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21	9/18/2006	—	Under review in 2006
Mortandad Canyon Investigation Report	10/27/2006	—	Under review in 2006
Investigation Report for Consolidated Unit 21-018(a)-99, Material Disposal Area V, at Technical Area 21	10/31/2006	n/a	Additional sampling and revised investigation report to be submitted in 2007
Investigation Report for Material Disposal Area A, Solid Waste Management Unit 21-014, at Technical Area 21	11/9/2006	—	Under review in 2006
Interim Measures Investigation Report for Chromium Contamination in Groundwater	11/30/2006	12/27/2006[c]	Additional investigation activities required
Investigation Report for Solid Waste Management Unit 50-009, Material Disposal Area C, at Technical Area 50	12/6/2006	—	Required sampling to be completed in 2007

[a] n/a = Not applicable.

[b] "—" = Approval not received in 2006.

[c] Reports approved with modifications and/or directions.



Table 9-3
SWMUs and AOCs Granted Certificates of Completion in 2006

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
SWMU 16-006(e)		X	1/10/2006
SWMU 16-010(a)		X	1/10/2006
SWMU 16-016(c)		X	1/10/2006
SWMU 0-030(a)		X	2/23/2006
SWMU 0-030(b)		X	2/23/2006
SWMU 0-030(l)		X	2/23/2006
SWMU 0-030(m)		X	2/23/2006
SWMU 0-033(a)		X	2/23/2006
SWMU 0-033(b)		X	2/23/2006
AOC 0-004		X	2/23/2006
AOC 0-010(a)		X	2/23/2006
AOC 0-010(b)		X	2/23/2006
AOC 0-029(a)		X	2/23/2006
AOC 0-029(b)		X	2/23/2006
AOC 0-029(c)		X	2/23/2006
SWMU 19-001		X	6/27/2006
SWMU 19-002		X	6/27/2006
SWMU 19-003		X	6/27/2006
AOC C-19-001		X	6/27/2006
SWMU 33-013	X		8/30/2006
SWMU 21-017(a)	X		9/28/2006
SWMU 21-017(b)	X		9/28/2006
SWMU 21-017(c)	X		9/28/2006
SWMU 53-002(a)	X		9/13/2006
SWMU 53-002(b)	X		9/13/2006
AOC 3-001(i)	X		10/13/2006
AOC 0-030(k)		X	12/6/2006
AOC 0-034(a)		X	12/6/2006



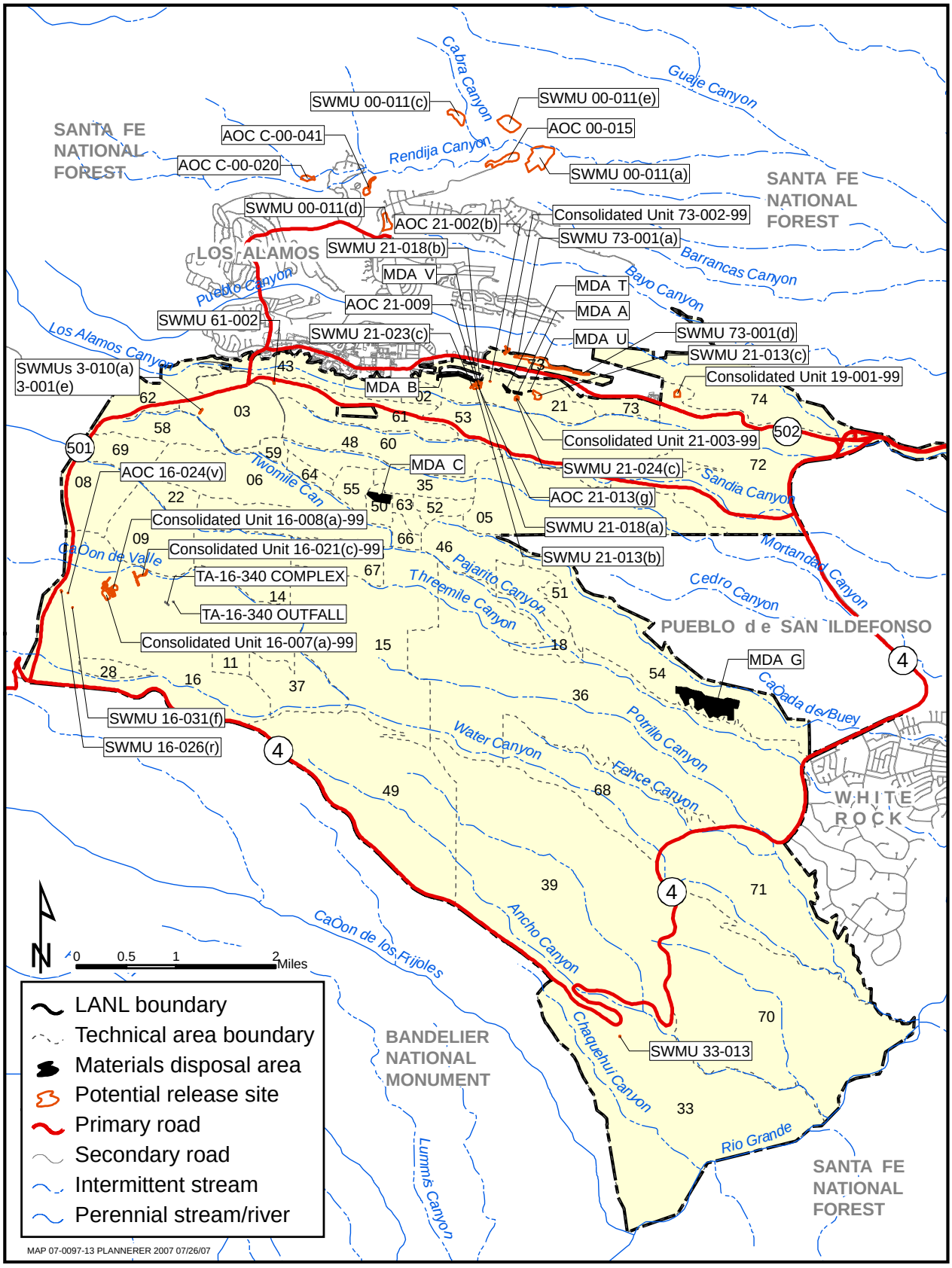

Figure 9-1. Location of MDAs and other SWMUs or AOCs where remediation and/or characterization work was performed in 2006.

B. CORRECTIVE ACTION PROJECT

The Laboratory and DOE conducted the following investigations and activities in 2006:

- Remedy completion report for SWMU 33-013 was submitted and approved.
- Additional samples were collected and results submitted for Consolidated Unit 19-001-99 and approved.
- Accelerated corrective action work plan for SWMU 61-002 was approved and the investigation and remediation were completed.
- Investigation activities were conducted and an investigation report for MDA C was submitted; required additional sampling to be completed.
- Investigation work plan for Guaje, Barrancas, Rendija Canyons Aggregate Area was approved with modifications and sampling activities were commenced.
- Field investigations for the Pueblo Canyon Aggregate Area were started and completed.
- The accelerated corrective action work plan for AOC 16-024(v) and SWMUs 16-026(r) and 16-031(f) was submitted and approved with modifications. The investigation and remediation activities were completed.
- Investigation report for the TA-16-340 Complex was submitted and approved with additional sampling required.
- Field investigations were commenced for Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line).
- Investigation report for groundwater associated with Consolidated Unit 16-021(c)-99 (260 Outfall) was submitted and approved with direction.
- Additional information and reports including periodic monitoring reports for MDAs H, L, and G were submitted.
- Investigation and remediation activities continued at Consolidated Unit 73-002-99.
- Interim measures conducted at SWMUs 03-010(a) and 03-001(e).
- Final remedy construction for the TA-73 Airport Landfill, SWMUs 73-001(a) and 73-001(d).

The following sections summarize the investigations started, continued, and/or completed in 2006.

1. SWMU 33-013

a. Site Description and History. SWMU 33-013 was an uncovered surface storage area for items awaiting disposal. The storage area was approximately 50 ft x 50 ft and was located on the asphalt surface inside the northeast corner of the fence surrounding the former TA-33 tritium facility (Building 33-86). Materials stored at SWMU 33-013 included vacuum pumps, drums containing oil contaminated with tritium and possibly with metals and solvents, and dumpsters of miscellaneous materials. The storage activities were discontinued in 1989.

b. Remediation and Sampling Activities. The Laboratory conducted investigation and remediation activities at SWMU 33-013 in accordance with the approved work plan (LANL 2005c; NMED 2005d). Field activities were completed in 2005 and the report was submitted to NMED in 2006. The *Remedy Completion Report for the Investigation and Remediation of Solid Waste Management Unit 33-013* (LANL 2006d) presents a complete description of the field activities, data review, and risk assessments for this site. Remediation

activities included the excavation and removal of base course, an asphalt pad, and soil potentially contaminated by storage activities. The activities resulted in a total excavated area of approximately 51 ft x 53 ft x 2 ft deep and approximately 540 yd^3 of soil and base course removed. Twenty confirmation samples were collected from 10 locations following the remediation of SWMU 33-013.

The excavation was backfilled with clean fill and base course. The fill was compacted and contoured to keep storm water from running off the pad site onto the surrounding mesa. No reseeding of the area was required.

c. Conclusions and Recommendations. The human health and ecological risk assessments determined that contaminant concentrations are below NMED and DOE target levels. The nature and extent of contamination at SWMU 33-013 is defined, and there is no potential unacceptable risk/dose under the industrial and construction worker scenarios or to ecological receptors.

NMED reviewed and subsequently approved the report. NMED determined that the requirements of the Consent Order have been satisfied for this SWMU and issued a Certificate of Completion for "Corrective Action Complete with Controls" for SWMU 33-013 (NMED 2006g). The controls require that the land occupied by SWMU 33-013 remain under industrial use. The Laboratory assumes responsibility for the controls specified for the site by NMED.

2. Consolidated Unit 19-001-99

a. Site Description and History. Consolidated Unit 19-001-99 (comprised of a septic system [SWMU 19-001], surface disposal area [SWMU 19-002], sewer drainline and outfall [SWMU 19-003], and potential soil contamination beneath buildings [AOC C-19-001]) is located on Los Alamos Mesa east of the Los Alamos County Airport and the East Gate industrial park. The site was used to conduct spontaneous-fission experiments and to store radioactive source material. It includes access to and a portion of Camp Hamilton Trail, a public recreational hiking trail.

b. Remediation and Sampling Activities. The Laboratory conducted an accelerated cleanup at Consolidated Unit 19-001-99 (LANL 2004a; NMED 2004b) in 2005. A complete description of the field activities, data review, and risk assessments for this site is presented in the *Remedy Completion Report for the Investigation and Remediation of Consolidated Unit 19-001-99* (LANL 2005g). Because the initial characterization sampling did not define the extent of inorganic chemicals for this consolidated unit, additional samples were collected from mesa top locations. The results were submitted to NMED in 2006.

c. Conclusions and Recommendations. The additional sampling did not detect cobalt and chromium above background levels at depth. Based on the results of all of the characterization activities at Consolidated Unit 19-001-99, the nature and extent of contamination is defined. The risk assessment presented in the original remedy completion report (LANL 2005g) showed no potential unacceptable risk under a residential scenario and no potential risk to ecological receptors.

NMED determined that the requirements of the Consent Order have been satisfied for the three SWMUs and one AOC that make up this consolidated unit. NMED issued Certificates of Completion for "Corrective Action Complete without Controls" for SWMUs 19-001, 19-002, and 19-003, and AOC C-19-001 (NMED 2006e). Corrective action complete without controls was granted because the sites have no potential unacceptable risk to human receptors under a residential land-use scenario.

3. SWMU 61-002

a. Site Description and History. SWMU 61-002 is a former storage area located east of the Radio Repair Shop on the south side of Jemez Road. The SWMU was historically used to store capacitors, transformers,

oil-filled containers, and unmarked containers. Before 1985, used oil contaminated with PCBs was stored in containers within the fenced area. The area was also used to store large spools of wire and cable.

b. Remediation and Sampling Activities. The Laboratory conducted corrective action activities at AOC 03-001(i) and SWMUs 03-029 and 61-002 because these sites were in the path of the security perimeter road and would be inaccessible after construction. A complete description of the field activities, data review, and risk assessments for this site is presented in the *Remedy Completion Report for the Investigation and Remediation of Area of Concern 03-001(i) and Solid Waste Management Units 03-029 and 61-002* (LANL 2005j).

During the 2005 investigation of SWMU 61-002, the Laboratory discovered an area of petroleum-contaminated soil and buried fuel lines in the northwest portion of the SWMU. The Laboratory submitted a work plan describing the approach for additional investigation activities at SWMU 61-002 to NMED (LANL 2006h), which approved the work plan with modifications (NMED 2006c).

Additional sampling was necessary to complete the characterization of the extent of the petroleum contamination and boreholes were drilled within and around the area to determine the lateral and vertical extent.

c. Conclusions and Recommendations. The Laboratory completed additional fieldwork at SWMU 61-002 in 2006 and submitted a remedy completion report to NMED in 2007 describing all the activities conducted in 2005 and 2006 and presenting the results.

4. MDA C

a. Site Description and History. MDA C, an inactive 11.8-acre landfill, is located within TA-50 at the head of Ten Site Canyon. MDA C consists of seven disposal pits and 108 shafts; the depths of the pits range from 12 to 25 ft and the shafts range from 10 to 25 ft below the original ground surface. Ten shafts in Shaft Group 3 (Shafts 98–107) are lined with 12-in.-thick concrete, while the rest of the pits and shafts are unlined. MDA C operated from May 1948 to April 1974 but received waste only intermittently from 1968 until it was decommissioned in 1974. Wastes disposed of at MDA C consisted of liquids, solids, and containerized gases generated from a broad range of nuclear energy research and development activities conducted at the Laboratory. These wastes included uncontaminated classified materials, metals, hazardous materials, and radioactively contaminated materials.

b. Remediation and Sampling Activities. Investigation activities at MDA C began in 2005 and concluded in 2006 according to the approved MDA C investigation work plan (LANL 2005i; NMED 2005b; NMED 2005k). A complete description of the field activities, data review, and risk assessments for this site is presented in the *Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50* (LANL 2006u). LANL conducted previous investigation work at MDA C in 1993, 1995, 1996, and 2004.

Thirty-three boreholes were drilled during the 2005–2006 subsurface investigation at MDA C. An additional three boreholes were drilled to collect paired core and pore-gas samples for the purpose of correlating volatile organic compound (VOC) concentrations in tuff with VOC concentrations in pore-gas. One borehole was drilled to a depth of 620 ft below ground surface (bgs) to define the vertical extent of contamination as well as to determine the nature and depth of fracture zones and any possible perched saturation zones. The remaining boreholes ranged in depth from 90 ft to 300 ft bgs. Subsurface core samples were collected from a minimum of five depths in each borehole. Additional samples were collected at fracture zones or zones of elevated moisture content.

c. Conclusions and Recommendations. Inorganic, organic, and radionuclide contaminants were identified at MDA C. MDA C was evaluated for potential risk and dose to human health under an industrial scenario. The

total excess cancer risk, hazard index (HI), and total dose were less than NMED and DOE target levels. We conducted an ecological risk screening assessment and found no potential risk to ecological receptors at MDA C.

Additional characterization activities at MDA C are necessary. The Laboratory will drill four vertical boreholes between Pits 1 through 4 in 2007. Additional surface samples will be collected to confirm the results of the screening-level data for inorganic chemicals and to define the nature and extent of potential contamination. The Laboratory will continue to monitor pore-gas at MDA C.

Following review of the investigation report by NMED, the Laboratory developed and submitted a Phase 2 investigation work plan. In the work plan, we proposed several existing boreholes be advanced deeper into the Otowi Member of the Bandelier Tuff and new boreholes be drilled to confirm the vertical extent of VOC pore-gas contamination.

5. Guaje/Barrancas/Rendija Canyons Aggregate Area

a. Site Description and History. The Guaje/Barrancas/Rendija Canyons Aggregate Area consists of the following seven sites:

- SWMU 00-011(a) is a 28.5-acre former mortar impact area used in the mid to late 1940s and located on General Services Administration (GSA) land east of the Sportsmen's Club in Rendija Canyon.
- SWMU 00-011(c) is a possible mortar impact area approximately 10 acres in size used in the 1940s and located on GSA and public land managed by the USFS in a tributary of Rendija Canyon north of the Sportsmen's Club.
- SWMU 00-011(d) is a former bazooka firing area approximately five acres in size used in the mid to late 1940s and largely located on Los Alamos County land, except for a small section on private property, in a small north-trending tributary of Bayo Canyon northeast of the intersection of San Ildefonso Road and Diamond Drive.
- SWMU 00-011(e) is a former ammunition impact area approximately 14 acres in size used in the mid to late 1940s and located on GSA and USFS land in a tributary of Rendija Canyon north-northeast of the Sportsmen's Club.
- AOC C-00-020 is a 30-acre possible mortar impact area used in the early 1940s located along the north valley wall of Rendija Canyon. Most of the site lies within the Santa Fe National Forest, except for a small area on the southeastern edge that is private property.
- AOC C-00-041 was the site of a former asphalt batch plant, which operated from the late 1940s to 1958. It is located in a 50- by 600-ft portion of a side slope and drainage channel that flows into Rendija Canyon on USFS land.
- AOC 00-015 is the Sportsmen's Club small-arms firing range, an active range approximately 30 acres in size located on GSA land in Rendija Canyon. The Club is leased to a nonprofit group from DOE. Operations started in 1966 and consist of several firing ranges built and operated by the Sportsmen's Club. The investigation of AOC 00-015 is deferred until the site is no longer active.

b. Remediation and Sampling Activities. NMED approved the Guaje/Barrancas/Rendija Canyons Aggregate Area investigation work plan with modifications (LANL 2005f; NMED 2006a). The Laboratory started field investigations in 2006 based on the approved work plan. Munitions and explosives surveys were completed at the sites to verify similar surveys conducted in the early 1990s. Both munitions and explosives of concern and geophysical surveys will be used to identify and remove any remaining mortar, small arms ammunition, or munitions debris from former impact/firing areas: SWMUs 00-011(a), 00-011(d), and 00-011(e). Although the Laboratory did not find any munitions and explosives of concern or munitions debris in previous surveys at

SWMU 00-011(c) and AOC C-00-020, new surveys will be conducted for verification. If no evidence is found during the prescribed surveys, these two sites will not be characterized further. Soil samples will be collected at sites with past and current munitions and explosives of concern and munitions debris recovery.

c. Conclusions and Recommendations. The Laboratory completed investigation activities and submitted the investigation report to NMED in 2007.

6. Pueblo Canyon Aggregate Area

a. Site Description and History. The Pueblo Canyon Aggregate Area consists of 45 SWMUs and AOCs, which are located within the Pueblo Canyon watershed or on the mesa top and discharged directly to the watershed. The sites include wastewater treatment plants, septic systems, outfalls and drainages, landfills, underground storage tanks, and manholes located in Pueblo Canyon or on former Laboratory property, which is now part of the Los Alamos townsite. In the approved work plan, the Laboratory proposed the investigation of 20 SWMUs/AOCs by the Corrective Action Project. DOE is investigating 11 SWMUs/AOCs, located at the Los Alamos County Airport, which will be reported on separately. Fourteen SWMUs/AOCs were not included because they either have been approved by EPA or have been approved or are pending approval by NMED.

b. Remediation and Sampling Activities. The Laboratory started and completed investigations in 2006 based on the approved work plan with modifications (LANL 2005d; NMED 2005h). The objectives of the investigations were to determine the nature and extent of contamination at the SWMUs and AOCs, provide site characterization data for evaluating potential corrective actions, and conduct characterization/confirmatory sampling. Investigation activities included the removal of septic tank structures and lines where permissible. Characterization/confirmation activities consisted of surface and shallow subsurface sampling, the drilling of angled and/or vertical boreholes, and subsequent sampling of core from the boreholes.

c. Conclusions and Recommendations. The Laboratory will present results of the investigation in the Pueblo Canyon Aggregate Area Investigation Report in 2008.

7. AOC 16-024(v) and SWMUs 16-026(r) and 16-031(f)

a. Site Description and History. AOC 16-024(v) and SWMUs 16-024(r) and 16-031(f) are located on a mesa top of the Pajarito Plateau in the western portion of TA-16.

AOC 16-024(v) is the location of a former high explosive (HE) storage magazine constructed in 1944 and located approximately 100 ft east of the TA-16 steam plant. The structure was used as an HE magazine until 1946 and then used for general storage until it was removed in 1968.

SWMU 16-026(r) is an inactive drainline and outfall from the oil-water separator at fire station #5. The fire station was built in 1952 and remains in use. The outfall area where the oil-water separator overflow line formerly discharged is an unpaved area approximately 70 ft south of the fire station. Currently, the oil-water separator and discharge line are inactive and the floor drains are rerouted to the sanitary sewer.

SWMU 16-031(f) is the former outfall from a decommissioned drinking water chlorination station. The building was constructed in 1944, was stripped of all usable equipment in 1953 when the new chlorination station was brought online, and was removed in 1992. The station was used to disinfect potable water using chlorine gas. Based on the nature of activities at SWMU 16-031(f) no release of hazardous waste or hazardous constituents is known or expected to have occurred.

b. Remediation and Sampling Activities. The Laboratory conducted an accelerated cleanup at AOC 16-024(v) and SWMU 16-024(r). The cleanups were conducted because AOC 16-024(v) and SWMU 16-

024(r) are located in areas that may be excavated for the installation of new utilities and will be inaccessible following construction activities. Characterization or remediation activities were not conducted at SWMU 16-031(f). The work plan (LANL 2006b) was submitted and approved (NMED 2006b) in 2006. The investigation and remediation activities were started and concluded in accordance with the approved work plan in 2006. Investigation activities at AOC 16-024(v) and SWMU 16-024(r) included collection of samples and removal of contaminated soil.

c. Conclusions and Recommendations. The Laboratory reported the results of the investigations in a remedy completion report, which was submitted to NMED in early 2007.

8. TA-16-340 Complex

a. Site Description and History. The TA-16-340 Complex is located near the eastern end of the TA-16 mesa, close to the head of Fishladder Canyon, and consists of Consolidated Unit 13-003(a)-99, the septic system associated with the western area of the P-Site Firing Site; Consolidated Unit 16-003(n)-99, the sump and drainline for former Building 16-342; SWMU 16-003(o), the sumps and drainlines for former Building 16-340; and SWMUs 16-029(f) and 16-026(j2), the sump and drainline for former Building 16-345.

The TA-16-340 Complex operated from 1952 to 1999 and processed and produced large quantities of plastic-bonded explosives. The plastic-bonded explosives were produced by slurrying HE and solvents together with inert binders. HE and solvent-contaminated washwater were routed to six sumps associated with Building 16-340 and to the single sump and outfall associated with Building 16-342. Historically, discharges from these sumps were routed to the Building 16-340 and 16-342 outfalls, respectively.

b. Remediation and Sampling Activities. Field investigations were completed in 2005 based on the approved work plan (LANL 2004c; NMED 2004a). A complete description of the field activities, data review, and risk assessments for this site is presented in the *Investigation Report for the TA-16-340 Complex Consolidated Units 13-003(a)-99 and 16-003(n)-99 and Solid Waste Management Units 16-003(o), 16-026(j2), and 16-029(f)* (LANL 2006a). The Laboratory conducted the initial investigation fieldwork at the TA-16-340 Complex in 1995. The investigation included the sampling of surface soil and sediment, subsurface soil, and subsurface tuff. Surface water samples were also collected at the Fishladder Seep and at the confluence of Fishladder Canyon and Cañon de Valle.

The frame, foundation, and infrastructure for Buildings 16-340, 16-342, and 16-345 were demolished and removed in 2006. Eight sumps, two manholes, and approximately 850 ft of interconnecting drainline were removed. The Laboratory removed approximately 100 yd^3 of contaminated soil from areas associated with removed fixtures and structures. The Laboratory collected 239 soil, fill, tuff, and sediment samples from the TA-16-340 Complex. Additional field activities included two intermediate-depth boreholes (200 ft bgs), two shallow boreholes (approximately 12 ft bgs), and three shallow alluvial groundwater monitoring wells installed in Fishladder Canyon. Surface water samples and pore-gas samples (two rounds) were also collected.

c. Conclusions and Recommendations. We identified inorganic chemicals and organic chemicals as contaminants in soil, sediment, and tuff but identified no radionuclides as contaminants. We detected several organic chemicals (including research department explosive or RDX [also known as hexahydro-1,3,5-trinitro-1,3,5-triazine]) and inorganic chemicals (including barium) above surface water standards or screening levels. We detected three inorganic chemicals above groundwater standards or screening levels. Several of these inorganic chemicals were sporadically detected above standards, primarily in earlier sampling rounds. Some of the inorganic chemicals likely represent naturally occurring material. We detected several VOCs sporadically in the pore-gas samples.

The total excess cancer risks for Consolidated Units 13-003(a)-99 and 16-003(n)-99 and SWMUs 16-026(j2) and 16-029(f) were below the NMED target level for an industrial scenario. For SWMU 16-003(o), the

total excess cancer risk was above the NMED target level for an industrial scenario. The HIs were less than the NMED target level for all consolidated units and SWMUs for an industrial scenario. The evaluation of contaminant concentrations overestimates the potential risk to ecological receptors.

To address the potential risk and extent issues, the Laboratory will conduct additional soil-removal actions and sampling. The alluvial groundwater monitoring wells will be inspected for the presence of water on a quarterly basis and sampled if groundwater is present.

Following review of the investigation report, NMED agreed that additional sampling is required to complete the investigation of the TA-16-340 Complex. LANL will submit a separate investigation report to NMED.

9. Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line)

a. Site Description and History. TA-16 is located in the southwest corner of the Laboratory and covers approximately 2,410 acres (3.8 mi^2). Consolidated Units 16-007(a)-99 (the 30s Line) and 16-008(a)-99 (the 90s Line) are located near the western end of TA-16. These consolidated units consist of former HE processing buildings, former materials storage buildings, production facilities, sumps, drainlines, and outfall systems (drainages) that were associated with the 30s and 90s Lines. Historically, the 30s and 90s Lines were used for HE-processing operations, including electroplating and machining. The settling ponds were used to store wastewater generated in the nearby buildings during HE-processing operations. All the ponds were/are unlined and likely received wastes contaminated with HE and barium and, possibly, uranium, organic cleaning agents, and machining oils.

Consolidated Unit 16-007(a)-99 operated from 1944 to the early 1950s and Consolidated Unit 16-008(a)-99 operated from 1950 to 1970. The 90s Line pond is all that remains of the 30s and 90s Line production facilities. Buildings associated with the discharge to the 30s Line ponds were destroyed by burning. The buildings associated with the discharge to the 90s Line pond were decommissioned. Decommissioning activities included the demolition of buildings and the removal of sumps, blast shields, drainlines, earthen berms, and asphalt roadways.

b. Remediation and Sampling Activities. NMED approved the investigation work plan that addressed the HE ponds areas, which include Consolidated Units 16-007(a)-99 (the 30s Line) settling ponds and 16-008(a)-99 (the 90s Line) at TA-16 (S-Site) (LANL 2005b; NMED 2005g). LANL started field investigations in 2006. Boreholes will be drilled at the 30s and 90s Line ponds and in areas associated with former structures and discharge areas. Samples will be collected during the installation of several types of borings: shallow hollow-stem auger (~15 ft bgs), intermediate-depth (~150 ft bgs), and shallow hand-augered or power-augered (~5 ft bgs).

c. Conclusions and Recommendations. We have planned the investigation activities to be concluded in 2007 and the report is scheduled to be submitted to NMED in late 2007.

10. Consolidated Unit 16-021(c)-99 (260 Outfall) Groundwater Investigation

a. Site Description and History. Building 16-260, located on the north side of TA-16, has been used for HE processing and machining since 1951. Wastewater from machining operations contained dissolved HE and may have contained entrained HE cuttings. At Building 16-260, wastewater treatment consisted of routing the water to 13 settling sumps for recovery of any entrained HE cuttings. From 1951 through 1996, the water from these sumps was discharged to the 260 Outfall, which drained into Cañon de Valle.

As a result of the discharge, both the 260 Outfall and the drainage channel from the outfall were contaminated with HE and barium. The sumps and drainlines of this facility are designated as SWMU 16-003(k), and the

260 Outfall and drainage are designated as SWMU 16-021(c), and comprise Consolidated Unit 16-021(c)-99. SWMU 16-021(c) consists of three portions: an upper drainage channel fed directly by the 260 Outfall, a former settling pond, and a lower drainage channel leading to Cañon de Valle.

b. Remediation and Sampling Activities. Previous Resource Conservation and Recovery Act facility investigations (RFIs) of the former 260 Outfall [Consolidated Unit 16-021(c)-99] found that the outfall and drainage into Cañon de Valle and the canyon are contaminated with HE and barium (LANL 1996; LANL 1998b; LANL 2003). As a result, LANL conducted an investigation to determine whether 260 Outfall discharges affected the intermediate and regional groundwater. A complete description of the field activities, data review, and risk assessments for this site are presented in the *Investigation Report for Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99* (LANL 2006l).

The Laboratory installed two regional groundwater wells (wells CdV-R-15-3 and CdV-R-37-2) as part of the investigation. Other regional wells used in this investigation include wells R-18, R-19, R-25, R-26, and R-27, which were installed as part of the Laboratory's hydrogeologic work plan (LANL 1998a), and three existing municipal wells (PM-2, PM-4, and PM-5). The Laboratory installed four intermediate groundwater wells to characterize the hydrogeology of the intermediate zone between the alluvial and regional groundwater horizons—wells CdV-16-1(i), CdV-16-2(i), CdV-16-2(i)r, and CdV-16-3(i)—the last of which was completed as a boring only. Groundwater samples were of two types: boring samples collected during installation of boreholes and well samples collected (usually quarterly) from completed wells.

c. Conclusions and Recommendations. The groundwater analytical results show that the 260 Outfall discharges have affected intermediate and regional groundwater quality in limited areas, primarily by the introduction of RDX and 2,4,6-trinitrotoluene (TNT).

The intermediate groundwater samples had concentrations (less than 80 µg/L) of HE within the area defined by wells R-25, CdV-16-1(i), and CdV-16-2(i)r. In well CdV-16-1(i), RDX exceeded the EPA Region 6 tap water screening limit of 0.61 µg/L (not an applicable standard, for comparison purposes only) (EPA 2005).

For regional groundwater samples, results from well R-25 showed two types of HE, RDX and TNT, above EPA Region 6 tap water screening limits (0.61 and 2.2 µg/L, respectively) (EPA 2005). Concentrations of HE found in regional groundwater well R-25 do not extend to nearby wells located approximately 1.5 mi downgradient from R-25 (wells CdV-R-15-3 and CdV-R-37-2). HE was not detected in well CdV-R-15-3. HE and HE-breakdown products were detected at concentrations below screening limits in two downgradient regional monitoring wells (wells CdV-R-37-2 and R-19) but at low frequencies (approximately one detection in 50 samples collected). We detected RDX once in well R-19 during 2000 but at a concentration less than the tap water screening limit; RDX was not detected in any other LANL wells. Analytical data for HE (1998–2005) in municipal wells PM-2, PM-4, and PM-5 indicated single HE detections in PM-2 (RDX at 0.12 µg/L and 2,6-diamino-6-nitrotoluene at 0.3 µg/L) out of approximately 25 rounds of sampling.

Barium, a chemical of potential concern for the Cañon de Valle alluvial system, was not detected in intermediate or regional groundwater at levels above the NM Water Quality Control Commission groundwater standard (1000 µg/L). We detected tritium in five wells at concentrations well below the NM drinking water standard of 20,000 pCi/L.

The NMED reviewed the investigation report and issued an approval that includes direction and required actions (NMED 2006i). Prior to developing a corrective measures evaluation for this site, the Laboratory will complete a comprehensive assessment of each well or well screen intersecting intermediate and regional groundwater at TA-16. The Laboratory will also conduct an evaluation of each of the wells to determine if the wells are in the optimal locations for use in detection or compliance monitoring. A report summarizing the results of the well assessment will be submitted to NMED.

11. Consolidated Unit 73-002-99 (Airport Ashpile)

a. Site Description and History. Consolidated Unit 73-002-99 is located at the Los Alamos County Airport on the eastern end of the Los Alamos townsite. One portion of the site is located on the mesa top at the edge of Pueblo Canyon, and the other is located on the slope of Pueblo Canyon. Consolidated Unit 73-002-99 consists of four inactive SWMUs and one inactive AOC and includes the following:

- SWMU 73-002, a former waste incinerator, located in Building 73-02, and the ash surface disposal area located on the canyon slope north of the former waste incinerator building. The Laboratory operated the incinerator from 1947 to 1948 to destroy classified Laboratory documents, after which time it was used to burn municipal trash. The surface disposal area is located on the canyon-slope portion of the site and is presently open space accessible to the public.
- AOC 73-003, a former steam-cleaning facility (former Structure 00-1123) for garbage trucks, cans, and dumpsters used to collect municipal waste from the Los Alamos townsite. The Laboratory used the steam-cleaning facility from 1949 to 1970 and demolished it in 1971. The site is now overlain by the asphalt parking lot of the Los Alamos County Airport.
- SWMU 73-004(a), a former septic system (septic tank, drainline, and outfall) that received sanitary waste from toilets and showers in the incinerator building (Building 73-02). The inlet drainline and septic tank were removed in 1996. The mesa top portion is presently paved and is used as a parking lot for the Los Alamos County Airport. The canyon-slope portion of the site is presently open space and is accessible to the public.
- SWMU 73-004(b), a former septic system (septic tank, drainline, and outfall) that received wash water from the steam-cleaning facility (AOC 73-003). The mesa top portion is presently paved and is used as a parking lot for the Los Alamos County Airport. The canyon-slope portion of the site is presently open space and is accessible to the public.
- SWMU 73-006, two former drainlines that discharged to Pueblo Canyon from floor drains in the incinerator building (Building 73-02). The drains are presumed to have handled wash water and to have operated concurrently with the incinerator. The drainlines discharged directly onto the ash disposal area (SWMU 73-002).

b. Remediation and Sampling Activities. The primary objective of this investigation is to complete characterization of Consolidated Unit 73-002-99. Work was conducted in accordance with the approved investigation work plan (ITSI 2005; NMED 2005j).

The investigation activities specified in the approved work plan (ITSI 2005; NMED 2005j) were surface and shallow subsurface sampling, including sampling to define the nature and extent of contamination and confirmation sampling following remediation. Nature and extent sampling at SWMU 73-002 focused on the drainages below the former ash pile because runoff is the primary mechanism for the transport of contaminants from the site. For the mesa top SWMUs and AOC, the Laboratory conducted nature and extent drilling and sampling to augment previous sampling data and to complete the characterization of these sites.

The primary objective of the corrective action at SWMU 73-002 was to remove ash and associated debris from the disposal area on the south slope of Pueblo Canyon below the former incinerator. The Laboratory removed ash and associated debris from the canyon slope using several methods, including hand-picking, mechanical excavation, and vacuuming. The Laboratory performed field screening of the soil and tuff underlying the ash pile to guide waste removal and to aid in collecting soil and tuff samples to verify that cleanup levels had been achieved. The Laboratory performed confirmation sampling within the footprint of the former ash pile to verify that cleanup levels were met.

c. Conclusions and Recommendations. Remediation of contaminated soil and tuff at SWMUs 73-002, 73-004(b), and 73-006 continued into 2007. Additional sampling (confirmation and characterization) was also conducted in 2007 at these SWMUs to define the extent of contamination and to confirm that the cleanup goals were met. An investigation report for Consolidated Unit 73-002-99 was submitted in 2007.

12. SWMUs 03-010(a) and 03-001(e)

a. Site Description and History. SWMUs 03-010(a) and 03-001(e) are located within TA-3 next to the general warehouse (Building 03-0030). SWMU 03-010(a) is located about 30 ft west of Building 03-0030 and SWMU 03-001(e) is immediately adjacent to the western edge of Building 03-0030. Both SWMUs are operationally inactive.

SWMU 03-010(a) was a surface disposal site for vacuum-pump oil containing mercury and radionuclides, generated from a vacuum repair shop located in Building 03-0030 (LANL 1995). During the 1950s, it is estimated that the Laboratory discarded more than 100 lbs of mercury-contaminated vacuum-pump oil onto the canyon edge (LANL 1993).

SWMU 03-001(e) was an active storage area for vacuum-pump repair waste from 1957 to 1992. The Laboratory stored waste oil in drums on the ground and the drums periodically overflowed (LANL 1995).

b. Remediation and Sampling Activities. Several investigations of SWMU 03-010(a) have occurred over the past decade or so. The 2005 investigation of SWMUs 03-010(a) and 03-001(e) sought to establish the source of shallow groundwater, the nature and extent of groundwater contamination, the lateral extent of shallow groundwater, the hydraulic gradient, and groundwater flow rates. A complete description of the field activities, data review, and risk assessments are presented in the *Investigation Report for Solid Waste Management Units 03-010(a) and 03-001(e) at Technical Area 3* (DOE 2006).

Data collected from wells drilled during the 2005 investigation show the intermediate groundwater at Building 03-0030 is confined and the primary recharge source for the groundwater is in the immediate area of SWMU 03-001(e). However, additional data were needed to better define the source as well as to evaluate longer-term response actions of the Building 03-0030 intermediate groundwater body.

The Laboratory conducted four interim-measure activities at SWMUs 03-010(a) and 03-001(e) in 2006. The objective of the interim-measure activities is to obtain sufficient information to determine an effective control for the groundwater recharge system, thereby supporting a final remedy for the site. The four interim measures are as follows:

- Installation of pressure transducers in select monitoring wells to evaluate water-level changes over time in wells B-9, B-10, and B-13;
- Quarterly monitoring of the 2005 investigation wells (B-9, B-10, and B-13);
- A groundwater tracer study to identify the source(s) of groundwater recharge at the site; and
- Stable isotope characterization of the Building 03-0030 condensate water to determine if it may be the primary source for groundwater recharge.

c. Conclusions and Recommendations. We interpreted water-level measurements to indicate that wells B-10 and B-13 share a similar hydraulic connection to the recharge source(s). Well B-9 is either not as well hydraulically connected to the recharge source(s) when compared to wells B-10 and B-13 or is potentially not connected at all.

Quarterly groundwater sampling of wells B-9, B-10, and B-13 began on June 2006, as part of the perched-groundwater investigation of SWMUs 03-010(a) and 03-001(e). Lead was detected in filtered water samples at concentrations of 20 µg/L in well B-13 and 18.4 µg/L in well B-10, which are above the EPA maximum contaminant level (MCL) of 15 µg/L (LANL 2007) (used for comparison purposes only). Samples showed trichloroethane[1,1,1-] in well B-10 at a concentration of 94 µg/L and dichloroethene[1,1-] in well B-13 at a concentration of 5.39 µg/L, which are above the NM groundwater standards of 60 µg/L and 5 µg/L, respectively. Other organic chemicals detected included diesel range organics, trichloroethene, dioxane[1,4-], and chloroform at concentrations below standards or tap water screening levels (LANL 2007). Radionuclides detected included tritium, strontium-90, cesium-137, and plutonium-239 in either one or both wells B-10 and B-13 below standards or dose limits.

The tracer study results indicate the north-south and east-west drainages are not the sources of recharge to intermediate groundwater at SWMUs 03-010(a) and 03-001(e), but point to the building roof as a recharge source. Specifically, the results indicate the recharge to the groundwater is through the southern roof drain system.

The stable isotope data from the groundwater and condensate samples indicate a precipitation source for the perched groundwater. In addition, the results of the video-logging of the culvert leading from the roof drains on the southern half of the building show a significant break near the building foundation. This break may be the pathway that allows precipitation from the roof drains to recharge the perched groundwater.

The Laboratory plans to repair the culvert in 2007 and to continue sampling wells on a quarterly basis.

13. Airport Landfill

a. Site Description and History. SWMUs 73-001(a) and 73-001(d) are associated with TA-73 and are currently part of the Los Alamos County Airport.

SWMU 73-001(a) is a former landfill north of the airport runway and is approximately 12 acres in size. The Laboratory and Los Alamos townsite used the area as a landfill beginning in 1943. The Laboratory deposited sanitary waste and the townsite deposited municipal wastes into the landfill. Los Alamos County assumed operation of the landfill in 1965 and operated the landfill until it was closed in 1973.

SWMU 73-001(d) is a former landfill debris disposal area operated by the Laboratory from 1984 to 1986 and consisted of two roughly parallel trenches excavated to a depth of 35 ft. The Laboratory used the site in 1984 to bury debris excavated from the western portion of SWMU 73-001(a) and from SWMUs 73-001(b and c). The Laboratory covered the debris disposal area with soil in 1986 and reseeded it.

b. Remediation and Sampling Activities. The final remedy has been constructed for SWMUs 73-001(a) and 73-001(d), also referred to as the Airport Landfill and the Debris Disposal Area, respectively. The principal features of the work completed as part of the final remedy include the following:

- Regraded and compacted the main landfill surface as well as the north and east slopes
- Constructed five concrete hangar pads on the main landfill surface
- Constructed a MatCon asphalt cap on the main landfill surface
- Constructed a gas collection system beneath the MatCon surface
- Constructed a storm water collection system
- Constructed a lower concrete retaining wall and an upper mechanically stabilized earth wall at the toe of the east slope

- Constructed a low-permeability soil/geocomposite/vegetated soil cover on the upper east slope and the north slope
- Placement of additional cover soil, regarding, and revegetation of the Debris Disposal Area.

c. Conclusions and Recommendations. A description of the field activities, as-built drawings and specifications, and other associated information was presented in a remedy completion report submitted to NMED in 2007.

C. WATER STEWARDSHIP PROJECT

The Laboratory conducted the following investigations and activities in 2006:

- The Laboratory's work plan for investigations in Barrancas, Bayo, Guaje, and Rendija Canyons (North Canyons) was approved and Phase 1 field investigations of potentially contaminated sediment deposits were performed.
- Summary of Phase 1 sediment investigations in Pajarito Canyon was submitted and Phase 2 sediment investigations were conducted.
- Investigation report of the Mortandad Canyon watershed was submitted.
- Interim measures work plan for investigating chromium contamination in groundwater was submitted and approved. A work plan for installing regional well R-35 was submitted and approved. Interim measure field activities were completed and an interim measures investigation report was submitted and approved.
- The work plan for investigations in South Canyons was submitted.
- The Pajarito Canyon Biota Investigation Work Plan was submitted.
- Additional information and reports were submitted, including periodic monitoring reports, well completion reports, General Facility Information 2006, Interim Facility-Wide Groundwater Monitoring Plan, Revision 1, and Groundwater Background Investigation Report, Revision 1.

The following section includes brief summaries of the LANL investigation activities started, continued, or completed in 2006.

1. North Canyons

a. Site Description and History. The Bayo, Barrancas, Rendija, and Guaje Canyons systems are referred to as the "north canyons systems." These canyons head in the northern part of the Pajarito Plateau north of the Laboratory and are addressed by one work plan because of similarities common to all four canyons.

Bayo Canyon is located north of Pueblo Canyon and extends across Los Alamos County land, and Pueblo de San Ildefonso land to its confluence with Los Alamos Canyon. The Laboratory used former TA-10, which was located in middle Bayo Canyon, from 1943 to 1961 as a firing site to conduct experiments that used high explosives and radioactive materials. The Laboratory decontaminated and decommissioned the TA-10 site in 1963 and released the land to Los Alamos County in 1967. SWMUs and AOCs associated with TA-10 within the Bayo Canyon Aggregate Area will be addressed in the corresponding investigation work plan.

Barrancas Canyon is located north of Bayo Canyon and extends across Los Alamos County land, USFS land, Laboratory property, and San Ildefonso Pueblo land to its confluence with Guaje Canyon. No historical or current Laboratory structures or sites are present in Barrancas Canyon, although there is a potential for

dispersion of material from former TA-10 firing sites into the Barrancas Canyon watershed. Barrancas Canyon is undeveloped and the portion of the canyon on Los Alamos County and USFS land is open for recreational use by the public.

Rendija Canyon is located north of the Los Alamos townsite and extends across USFS land, private land, Los Alamos County land, and GSA land to its confluence with Guaje Canyon. Several SWMUs/AOCs are located within the watershed. Rendija Canyon is entirely open for recreational use and includes the site of the Los Alamos Sportsmen's Club, a sport-shooting range. Portions of Rendija Canyon along the north side of the Los Alamos townsite are residential areas.

Guaje Canyon is located north of Rendija Canyon and Barrancas Canyon and extends across USFS land and San Ildefonso Pueblo land to the confluence with Los Alamos Canyon. The Guaje well field in lower Guaje Canyon has been a major source of drinking water for Los Alamos since 1951.

b. Remediation and Sampling Activities. The Laboratory performed Phase 1 field investigations of sediment deposits in Barrancas, Bayo, Guaje, and Rendija Canyons following the *Work Plan for the North Canyons* (LANL 2001), as modified by agreements with the NMED (LANL 2005e; NMED 2005j; LANL 2006n). Field investigations included detailed geomorphic mapping, associated geomorphic characterization, and sediment sampling of 10 reaches specified in the work plan. Sediment sampling was also conducted in 2000 as part of post-Cerro Grande fire sediment characterization activities in one background reach in Guaje Canyon and in two reaches in Rendija Canyon.

c. Conclusions and Recommendations. We collected samples of post-fire sediment within or downcanyon from the Cerro Grande burn area. The presence of Cerro Grande ash in these samples complicates the process of identifying contaminants because ash contains elevated levels of many inorganic chemicals and radionuclides that exceed background values. Maximum concentrations of several inorganic chemicals and radionuclides in post-fire samples were obtained from the background reach, illustrating the effect of ash as a source. Some of the concentrations we detected may also represent naturally elevated background concentrations or may result from runoff from roads or residential areas and not releases from SWMUs or AOCs.

Comparison of the analytical results from north canyons sediment samples with analytical results from SWMUs and AOCs indicate releases from these sites have had little effect on concentrations in sediment in the north canyons.

Based on the Phase 1 sampling results, we proposed no additional sediment characterization prior to preparing the north canyons investigation report. The goals of the sediment sampling and analysis plan presented in the work plan (LANL 2001) and in subsequent agreements with NMED (LANL 2005e; NMED 2005j; LANL 2006n) have been met with the Phase 1 data. This recommendation is pending NMED approval.

2. Pajarito Canyon

a. Site Description and History. Pajarito Canyon is located in the central part of the Laboratory. The canyon heads in the Santa Fe National Forest west of the Laboratory boundary and empties into the Rio Grande in White Rock Canyon. The main channel is approximately 14.8 miles long and the watershed area is approximately 8 mi^2. In addition, Twomile Canyon and Threemile Canyon are major tributaries that join Pajarito Canyon and have watershed areas of 3.1 mi^2 and 1.7 mi^2, respectively. Sites within the Pajarito Canyon watershed are located at TAs 3, 8, 9, 12, 15, 18, 23, 27, 48, 54, 55, 59, 64, and 69.

b. Remediation and Sampling Activities. The Laboratory conducted a Phase 2 field investigation of sediment deposits in the Pajarito Canyon watershed in 2006 according to the NMED-modified Pajarito

Canyon Phase 1 summary report (LANL 2006e; NMED 2006j). Sediment samples were collected from 18 reaches in the Pajarito Canyon watershed in 2006. Prior to sampling, field investigations included detailed geomorphic mapping and associated geomorphic characterization.

c. Conclusions and Recommendations. One reach had maximum concentrations of several contaminants exceeding residential soil screening levels (SSLs). Additional sampling and analyses are proposed for this reach to improve concentration estimates. The proposed Phase 3 investigation, under NMED review, is focused on contaminants that contribute to potential carcinogenic, noncarcinogenic, and ecological risk for this reach.

In the Phase 2 sediment results in a reach downcanyon of releases from an incinerator ash pond, we detected dioxins and furans at concentrations greater than in the upcanyon reach. Therefore, proposed Phase 3 sampling and analysis will include dioxin and furan analyses in the next downcanyon reach and also will include all contaminants that contribute to potential risk in upcanyon reaches.

After we conducted Phase 2 sampling, the largest flood on record in the Pajarito Canyon watershed occurred on August 25, 2006. Because of the potential for remobilization and transport of contaminants, our proposed Phase 3 sampling and analysis will evaluate the concentrations of contaminants in August 2006 flood deposits in the impoundment above the flood retention structure and in downcanyon reaches. The recommendations for Phase 3 sampling are pending NMED approval.

3. Mortandad Canyon

a. Site Description and History. The investigation encompassed Mortandad, Effluent, and Ten Site Canyons, and an unnamed tributary canyon that heads in TA-5. This area is collectively referred to as the Mortandad Canyon watershed. Mortandad Canyon is located in the north-central part of the Laboratory and extends for approximately 10 mi from Diamond Drive in TA-3 east-southeast to the Rio Grande. Mortandad Canyon has a total watershed area (excluding Cañada del Buey) of about 6.0 mi^2. Primary tributary drainages on Laboratory land are Effluent Canyon, which heads in TA-48, and Ten Site Canyon, which heads in TA-50. Cañada del Buey, a major tributary of Mortandad Canyon, joins with Mortandad Canyon upstream of the Rio Grande and has a watershed area of 4.3 mi^2, will be the subject future investigations and reported on under the Sandia Canyon and Cañada del Buey investigations. The Mortandad Canyon watershed reported on here includes that portion west of State Road 4, which has a drainage area of 3.3 mi^2 of which 60% is on Laboratory land and 40% is on Pueblo de San Ildefonso land. Technical areas in the watershed include TAs 3, 4, 5, 35, 42, 48, 50, 52, 55, 60, and 63.

b. Remediation and Sampling Activities. The *Mortandad Canyon Investigation Report* (LANL 2006r) presents the results of investigations conducted from 1998 through 2005 of sediment, surface water, groundwater, and biota potentially impacted by SWMUs and AOCs located in the Mortandad Canyon watershed. Sediment investigations included geomorphic mapping, associated geomorphic characterization, and sediment sampling in 27 investigation reaches within the watershed. Surface water investigations included sampling of persistent water at nine locations in Effluent, Ten Site, and Mortandad Canyons. Groundwater investigations included installing nine alluvial wells, eight perched intermediate groundwater wells and boreholes, and seven regional groundwater wells within the watershed. Groundwater investigations also included surface and subsurface geophysical surveys, installation of piezometers, water level measurements, vector probe and flux meter analyses, and analyses of core samples and vadose zone pore water.

The Laboratory conducted a baseline ecological risk assessment to evaluate the potential for adverse effects to terrestrial and aquatic receptors and two threatened and endangered species: the Mexican spotted owl and the southwestern willow flycatcher. Ecological effects data were collected using small mammal trapping arrays, a

cavity nesting bird monitoring network, seedling germination tests, earthworm mortality and growth tests, and sediment and water toxicity tests. Concentrations of contaminants within insects, eggs, and small mammals were also measured. The Laboratory augmented the lines of evidence with breeding bird surveys, plant surveys, habitat analyses, and spatial modeling of wildlife exposure.

c. Conclusions and Recommendations. We identified contaminants in sediment, surface water, and groundwater within the watershed. The contaminants came from a variety of sources, including Laboratory SWMUs and AOCs, runoff from developed areas, and naturally occurring soil, sediment, and bedrock. Contaminant concentrations in sediment, surface water, and alluvial groundwater have generally decreased over time, indicating the initial SWMU and AOC sources are no longer major contributors to contamination. In contrast, contaminant concentrations in deeper perched intermediate and regional groundwater have increased over time, indicating the migration of mobile constituents from the alluvial zone into the vadose zone and into deeper zones of saturation.

The human health risk assessments indicated that under a recreational scenario (the current and reasonably foreseeable future land use in the canyons), no areas in the watershed had hazards and risks above NMED target levels in sediment and water. However, the radionuclide dose for one area in Effluent Canyon downcanyon from the TA-50 Radioactive Liquid Waste Treatment Facility outfall exceeded DOE's target dose for sediment; the target dose in water was not exceeded.

Although some chemicals of potential ecological concern were identified, the ecological risk assessment indicated no adverse effects to terrestrial and aquatic receptors in the Mortandad Canyon watershed.

Because of Effluent Canyon's relative inaccessibility, we proposed no remedial action to reduce the potential radiation dose to recreational users of the canyon. The reach is a short, steep, and rocky area that has no developed trail and is unlikely to be used in the same manner as normally assumed under a trail user land-use scenario. The area is posted as a soil contamination area stating that "access is restricted to workers on official business," discouraging recreational use.

Potential future changes in the vadose zone contamination and concentrations of contaminants in perched intermediate and regional groundwater are not well understood and a corrective measure evaluation is necessary to assess the need for corrective actions. A more detailed evaluation of chromium contamination in groundwater is summarized in *Interim Measures Investigation Report for Chromium Contamination in Groundwater* (LANL 2006t). Groundwater monitoring in the Mortandad Canyon watershed will continue and is described in the *Interim Facility-Wide Groundwater Monitoring Plan* (LANL 2006k).

4. Interim Measures Investigation of Chromium Contamination in Groundwater

a. Site Description and History. Several types of historical anthropogenic chromium sources are present in the Sandia, Los Alamos, and Mortandad watersheds. These sources include facilities for electroplating and photoprocessing and the use of chromate as a corrosion inhibitor in cooling tower systems. The highest chromium usage was as a corrosion inhibitor; most likely the largest amounts were used in the cooling tower blowdown for the TA-3 power plant at the head of Sandia Canyon. The blowdown was released as effluent and was discharged into upper Sandia Canyon. The cooling towers at the Omega West Reactor (TA-2) in Los Alamos Canyon also used high amounts of chromate. Chromium has also been discharged from TA-48 into Mortandad Canyon and may have been used in other smaller scale cooling systems at the Laboratory. The Laboratory stopped using chromate in the cooling tower systems in 1972.

b. Remediation and Sampling Activities. We detected chromium contamination in groundwater beneath Laboratory land. In 2006, the Laboratory submitted and NMED approved with modifications the *Interim Measures Work Plan for Chromium Contamination in Groundwater* (LANL 2006f; NMED 2006d). NMED's

approval with modification required the installation of a regional groundwater well (well R-35). The Laboratory also submitted and NMED approved a work plan for well R-35 (LANL 2006j, NMED 2006f). The Laboratory presented a complete description of the field activities and results of the interim measures investigation in the *Interim Measures Investigation Report for Chromium Contamination in Groundwater* (LANL 2006t), which was submitted to NMED in 2006.

The chromium groundwater investigations focus on characterizing the nature and extent of chromium in surface water, alluvial groundwater, the vadose zone, and perched intermediate groundwater in and beneath the Los Alamos, Sandia, and Mortandad watersheds. For these areas, the Laboratory also evaluated regional groundwater data. The data are used to evaluate spatial and temporal trends in chromium contamination at a multiple watershed scale, including variations in contaminant concentration at increasing distance from the source areas and as a function of time since chromium releases were halted.

The investigation activities include the following:

- Quarterly sampling of surface water, alluvial groundwater, perched intermediate ground water, and regional groundwater in Sandia and Mortandad Canyons,
- Investigation of surface water and alluvial groundwater infiltration in Sandia Canyon by using gauging station data and installing two piezometer sets,
- Determination of chromium distributions in the upper vadose zone of lower Sandia Canyon by drilling six new core holes,
- Determination of chromium distributions in the upper vadose zone from archival cores from Los Alamos, Sandia, Mortandad, and Ten Site Canyons,
- Determination of water quality and the extent of alluvial saturation in lower Sandia Canyon by installing five alluvial wells,
- Rehabilitation of regional well R-12 to serve as a monitoring site in Sandia Canyon, and
- Evaluation of seasonal water level variations in monitoring wells due to supply well production.

An investigation of background concentrations for total dissolved chromium and chromium(VI) was not necessary because sufficient data has already been collected.

c. Conclusions and Recommendations. Sampling data from regional groundwater monitoring wells and surrounding production wells show that only wells R-11 and R-28 contain clear evidence of Laboratory-derived chromium contamination; dissolved chromium concentrations are above groundwater standards in well R-28 and are approaching groundwater standards in well R-11. Other regional groundwater monitoring wells (e.g., well R-15) contained dissolved chromium concentrations slightly elevated above background.

The results of the interim measures investigation indicate that a significant portion of the mass of chromium is retained in the alluvium, especially in the Sandia Canyon wetland. The predominant zone of infiltration into the vadose zone occurs in the middle reaches of Sandia Canyon. However, the chromium does not remain in the vadose zone but is flushed through it into the regional aquifer.

The LANL report recommends that the interim measure phase of this investigation be concluded with the report and subsequent work be conducted under the Sandia Canyon and Cañada del Buey work plan. Additional data and wells are needed to define the extent of chromium and its impact on the regional aquifer. Installation of regional wells R-35a and R-35b will provide further information for the assessment of potential impacts to water supply well PM-3 (drilling plan for these wells was approved by NMED in 2006). In the

data collection under the modified work plan, the Laboratory will focus on characterization of the nature and extent of all contaminants (not just limited to chromium and related contaminants) sufficient to support risk assessments and remedy selection.

NMED reviewed the interim measures report and issued a notice of approval (NMED 2006l). The Laboratory is directed to submit a subsequent work plan to further investigate the present-day spatial distribution and mass of chromium in the near surface sediment and alluvium and to develop a numerical model to guide future investigation and potential remediation of the chromium contamination in the regional aquifer. The requirements will be incorporated into an addendum to the work plan for Sandia Canyon and Cañada del Buey and submitted to NMED in early 2007.

D. TA-21 CLOSURE PROJECT

Investigations and activities conducted in 2006 included the following:

- The investigation report for MDA U was submitted, revised, and approved.
- The investigation and remediation of MDA V were concluded and an investigation report was submitted.
- The investigation at MDA A was concluded and an investigation report was submitted.
- The investigation at MDA T was concluded and an investigation report was submitted.
- Investigation activities for five sites in the DP Site Aggregate Area were concluded.

The following sections summarize the investigations started, continued, and completed in 2006.

1. MDA U

a. Site Description and History. MDA U, located in the northeastern section of the DP Mesa within TA-21, consists of four SWMUs consolidated into 21-017(a)-99: SWMUs 21-017(a), 21-017(b), 21-017(c), and 21-022 (f). The Laboratory addressed SWMU 21-022(f) in conjunction with the DP Site Aggregate Area investigation (LANL 2004f) and did not investigate it with the other three SWMUs at MDA U.

The Laboratory operated MDA U from 1948 to 1968 as a subsurface disposal site for radioactively contaminated liquid wastes. Liquid effluent was discharged to the MDA U absorption beds from several buildings. In addition, the Laboratory disposed of oil from precipitrons (air filters) at MDA U. The western absorption bed received water from a cooling tower until approximately 1976.

b. Remediation and Sampling Activities. The Laboratory completed field investigations at MDA U in 2005 based on the approved work plan (LANL 2004d; NMED 2005a). A complete description of the field activities, data review, and risk assessments for these sites are presented in the *Investigation Report for Material Disposal Area U, Consolidated Unit 21-017(a)-99 at Technical Area 21* (LANL 2006c). In addition to the 2005 sampling activities, the Laboratory used previous RFI sampling results to characterize MDA U. The RFIs included 1992 DP Mesa-wide surface soil sampling, 1994 surface soil and sediment sampling, 1998 surface soil, subsurface tuff, subsurface pore-gas, and absorption bed sampling, and 2001 surface soil and absorption bed sampling.

Recent site characterization activities included drilling and sampling nine boreholes for chemical and geotechnical characterization of soil, tuff, and pore-gas. Nine surface samples (one from each borehole location before drilling began) and 46 subsurface samples were collected. Subsurface pore-gas samples from two depth intervals were collected from each of the nine boreholes.

c. Conclusions and Recommendations. We identified inorganic, organic, and radionuclide contaminants at MDA U. The nature and extent of contamination was defined and the human health risk screening assessments indicated no potential risk or dose under the industrial and construction worker scenarios. The HIs and the total excess cancer risks did not exceed NMED's target levels and the total doses did not exceed DOE's target dose. An ecological risk screening assessment for MDA U indicated no potential risk to ecological receptors.

After NMED reviewed the report, the Laboratory revised it (LANL 2006o), and NMED subsequently approved it (NMED 2006h). NMED determined that the requirements of the Consent Order have been satisfied for SWMUs 21-017(a), 21-017(b), and 21-017(c) and issued a Certificate of Completion for "Corrective Action Complete with Controls" (NMED 2006h; NMED 2006k). The controls require that the land use remain industrial and that the construction of structures at MDA U be prohibited unless it is shown that vapor intrusion does not pose a risk to human health.

2. MDA V

a. Site Description and History. Consolidated Unit 21-018(a)-99 is a 0.88-acre fenced area located on the south side of DP Road west of the TA-21 main gate. The consolidated unit is comprised of four SWMUs and one AOC, as described below:

- SWMU 21-018(a) (MDA V) received radioactive liquid waste derived from the TA-21 laundry facility (SWMU 21-018[b]) and was designed to enhance the infiltration of liquids into the tuff bedrock. The Laboratory constructed the absorption beds in 1945 and operated them until 1961.
- SWMU 21-018(b), the former laundry facility, was located south of DP Road, immediately west of the security fence that encloses TA-21 facilities to the east. The Laboratory operated the laundry facility from 1945 to 1961 for washing personal protective clothing and other reusable cloth items used in research and production operations involving radioactive materials at TA-21. The Laboratory estimated the laundry facility generated approximately 2 million gallons of effluent annually, which was discharged to MDA V.
- SWMU 21-023(c), a former septic system that consisted of a tank, inlet and outlet lines, and an outfall, served a waste treatment laboratory. The septic tank was located immediately west of the MDA V absorption beds and was 3.5 ft wide × 7 ft long × 5.8 ft deep. The outlet line was a 4-in. vitrified clay pipe that surfaced 40 ft southwest of the tank, approximately 30 ft from the canyon edge above BV Canyon. The Laboratory put the septic system into service in 1948 and removed it in 1965.
- SWMU 21-013(b) and AOC 21-013(g) are surface debris disposal sites located immediately south of MDA V on the south-facing slope above BV Canyon. It is not known how long these sites received building debris; however, they did not receive wastes later than 1994.

b. Remediation and Sampling Activities. The Laboratory began investigation activities at MDA V in 2005 and concluded the investigation in 2006, in accordance with the approved MDA V investigation work plan (LANL 2004e; NMED 2004c). A complete description of the field activities, the data review, and the risk assessments for these sites is presented in the *Investigation Report for Consolidated Unit 21-018(a)-99, Material Disposal Area V, at Technical Area 21* (LANL 2006r). In addition to the 2005–2006 sampling, the Laboratory used previous investigation results from 1992 to 2000 to characterize Consolidated Unit 21-018(a)-99.

For the remediation activities at SWMUs 21-018(a) and 21-018(b) in 2005–2006, the Laboratory removed the three absorption beds and all associated distribution lines. The excavated volume of absorption bed material totaled approximately 10,900 yd^3. For remediation activities at the surface debris disposal sites, SWMU 21-013(b) and AOC 21-013(g), the Laboratory removed concrete, asphalt, and metallic debris from the sites. The

Laboratory removed approximately 1,100 yd^3 of concrete and small amounts of asphalt and metal debris from the slope and stabilized the slope. At the septic system, SWMU 21-023(c), remediation activities included removing contaminated sediment from the outfall, with approximately 11 yd^3 of material removed from the area.

After excavating and removing the absorption bed material and septic system, the Laboratory collected shallow subsurface and borehole confirmation samples.

Twelve boreholes were drilled in and around MDA V, SWMU 21-018(a), to depths ranging from 40 to 380 ft bgs. Three boreholes were advanced to 40 ft bgs within the footprint of the former laundry facility, SWMU 21-018(b). Shallow subsurface samples were also collected from 2 to 10 ft bgs to characterize the base of shallow structures at the former laundry facility. A total of 1,160 linear ft were drilled and samples of core and pore-gas were collected from all boreholes.

At SWMU 21-023(c), samples were collected from beneath the former septic system inlet line, beneath the former septic system outlet line, the outfall, the outfall drainage, Consolidated Unit 21-027(d)-99, and in BV Canyon, upgradient and downgradient of SWMU 21-023(c). Confirmation samples were collected from eight locations where contaminated material was removed.

Following debris removal activities at SWMU 21-013(b) and AOC 21-013(g) a total of 89 samples were collected from 45 locations. Based on these analytical results, three additional locations were excavated.

c. Conclusions and Recommendations. We identified inorganic, organic, and radionuclide contaminants at MDA V. The nature and extent of contamination is defined for this consolidated unit. The human health risk screening assessments indicated no potential risks or doses under a residential scenario. The HIs and the total excess cancer risks did not exceed NMED's target levels and the total doses did not exceed DOE's target dose. The ecological risk screening assessment indicated no potential risk to ecological receptors.

We remediated Consolidated Unit 21-018(a)-99 by removing infrastructure and environmental media with concentrations of contaminants exceeding residential screening action levels (SALs) for radionuclides or residential SSLs for inorganic and organic chemicals. Currently, the site is located within an industrial area under Laboratory control and is expected to remain so for the foreseeable future. However, because the site may be transferred out of institutional control in the future, we remediated the consolidated unit to or below residential SALs and SSLs.

The report was reviewed by NMED and revised to include additional sampling results and other information requested by NMED. A revised investigation report was submitted to NMED in 2007.

3. MDA A

a. Site Description and History. MDA A is comprised of a 1.25-acre, fenced, and radiologically controlled area situated on the eastern end of DP Mesa between DP Canyon to the north and Los Alamos Canyon to the south. The Laboratory used MDA A between 1945 and 1978 to store solid and liquid wastes.

MDA A currently contains the following features:

- Two 50,000-gal. cylindrical steel storage tanks (referred to as the General's Tanks) are buried at the western end of MDA A. The tanks received waste solutions containing plutonium-239/240 and americium-241 from 1947 to 1974. Liquid waste was removed from the tanks in 1975 and 1976, but an unknown volume of sludge remains in the bottom of the tanks.

- Two 4-ft diameter, 65-ft deep vertical shafts located south of the General's Tanks. The shafts were intended to clarify rinse water generated by cleaning cement paste from a transfer hose between the pug mill and the General's Tanks. However, the General's Tanks were never filled with cement paste and the shafts were never used. The shafts were constructed in 1975 and filled with soil in 1977.
- Two eastern disposal pits were excavated to receive radioactive solid waste from DP East in 1945. The pits are approximately 18 ft wide, 125 ft long, and 12.5 ft deep. In 1946, crushed Bandelier Tuff was used to backfill and cover the pits.
- One central pit was excavated in the center of MDA A to receive and store TA-21 decontamination and decommissioning debris potentially contaminated with radionuclides. Asphalt was also disposed of in this pit. The pit was originally 40 ft wide, 150 ft long, and 22 ft deep but was later enlarged to measure 172 ft long by 134 ft wide. This pit received waste from 1969 to 1977. The pit was decommissioned in 1978 and a soil cover (crushed tuff) was placed over the pit.
- Several hundred 55-gal. drums containing iodide waste were stored on the surface at the eastern end of MDA A. These drums contained sodium hydroxide solution and stable iodine. The drum storage area was used from the late 1940s until 1960.

b. Remediation and Sampling Activities. The Laboratory began investigation activities at MDA A and concluded them in 2006, according to the approved MDA A investigation work plan (LANL 2005a; LANL 2006g; NMED 2005f). A complete description of the field activities, data review, and risk assessments for this site were presented in the *Investigation Report for Material Disposal Area A, Solid Waste Management Unit 21-014, at Technical Area 21* (LANL 2006s). As part of earlier investigations in 1992 and 1994, the Laboratory had collected surface and shallow-subsurface soil samples in the areas outside the MDA A fence line, both immediately surrounding and downslope from the facility to the north.

Sixteen boreholes, some angled, were drilled and sampled in 2006 to characterize potential contamination beneath MDA A. In addition to collecting surface and subsurface samples, the Laboratory sampled pore-gas from each core interval in each borehole. A total of 72 pore-gas samples were collected. Sixteen surface and shallow-subsurface locations were sampled on the DP Canyon slope north of MDA A in drainages and other areas of sediment deposition to evaluate potential downslope migration of contaminants from MDA A

c. Conclusions and Recommendations. We identified inorganic, organic, and radionuclide contaminants at MDA A and on the DP Canyon slope. The nature and extent of potential contaminants at MDA A and on the DP Canyon slope is defined. The human health risk screening assessments indicated no potential risks or doses under the industrial and recreational scenarios. The HIs and the total excess cancer risks did not exceed NMED's target levels and the total doses did not exceed DOE's target dose. The total estimated excess cancer risk under the construction worker scenario for MDA A was below the NMED target risk level. The construction worker HI for MDA A was above the NMED target level because of manganese. However, the manganese exposure concentration was similar to background. The construction worker HI without manganese is below the NMED target level. The total dose for a construction worker is below the DOE target dose limit. There is no potential unacceptable risk to ecological receptors.

Following review of the investigation report, NMED requested additional drilling and sampling for pore-gas. The evaluation will include the collection of tritium and VOC pore-gas samples from 15 ft bgs to 115 ft bgs. In addition, a second round of vapor-phase VOCs and tritium pore-gas samples will be collected from previously sampled depths in four boreholes. After the evaluation of the new pore-gas sampling results, including potential impacts to groundwater, a determination will be made as to whether a long-term vapor monitoring plan is needed for MDA A.

4. MDA T

a. Site Description and History. MDA T, Consolidated Unit 21-016(a)-99, is an area of approximately 2.2 acres located within TA-21 on DP Mesa. MDA T includes 25 SWMUs and AOCs associated with decommissioned radioactive liquid waste treatment facilities and various storage areas. The SWMUs and AOCs include inactive absorption beds, a retrievable waste storage area, asphalt-lined disposal shafts, sumps, acid holding tanks, acid sumps, effluent holding tanks, sodium hydroxide storage tank, an americium raffinate storage tank, acid valve pit manholes, underground steel tanks, a septic tank, grit chamber or settling tank, and airborne releases from incinerators used to burn waste oils and organics after testing (oil spills from the incinerators are known to have occurred). Also included are eight AOCs that are not part of Consolidated Unit 21-016(a)-99 but are within the footprint of the consolidated unit. These sites consist of four unintentional releases or one-time spills and four former storage and treatment tanks. The SWMUs and AOCs associated with MDA T were operational from 1945–1986. The Laboratory discharged approximately 18.3 million gallons of wastewater to the MDA T absorption beds between 1945 and 1967.

b. Remediation and Sampling Activities. The RFI activity at MDA T began in 1992 and included surface and near-surface sampling to evaluate contamination resulting from airborne stack emissions. Surface sampling was performed in 1993 and 1994 and included a small drainage leading into DP Canyon. An investigation was conducted in 1996–1997, which included the drilling of boreholes in and around MDA T, to define the nature and extent of subsurface contamination. Recent investigation activities at MDA T began in 2005 and concluded in 2006 according to the approved MDA T investigation work plan (LANL 2004b; NMED 2005e). A complete description of the field activities, data review, and risk assessments for this site is presented in the *Investigation Report for Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21* (LANL 2006m).

In 2006, surface and shallow-subsurface samples were collected north of MDA T on the DP Canyon slope. A total of 25 samples were collected from 14 locations. Nine surface and shallow-subsurface samples were also collected from within MDA T. Thirty-two boreholes (shallow, 30–40 ft bgs; intermediate, up to 100 ft; and deep, up to 380 ft) were drilled and sampled (including pore-gas) to characterize the subsurface beneath MDA T associated with the absorption beds, shafts, and the Retrievable Waste Storage Area; Building 21-035; and Building 21-257.

c. Conclusions and Recommendations. Based on the investigation results, the nature and extent of contaminants at MDA T and on the DP Canyon slope is defined. There is no potential unacceptable dose or risk under the industrial and recreational scenarios and no potential risk to ecological receptors. The total excess cancer risk and HI under the construction worker scenario were also below NMED target levels. However, the dose for the construction worker was above the DOE target level as a result of cesium-137 activity in a single sample. Potential for exposure must be assessed and precautions must be taken during demolition activities in the vicinity of Building 21-257 to protect workers from elevated cesium-137 levels.

Following NMED review of the investigation report, we developed and submitted a Phase 2 investigation work plan. The work plan describes additional sampling activities to be conducted within the consolidated unit as well as on the DP Canyon slope. These activities will include surface and near-surface as well as subsurface sampling. We will submit a Phase 2 investigation report that presents all results, including the additional sample data, and revisions of any analyses and assessments (e.g., risk assessment) that change as a result of the supplemental investigation.

5. DP Site Aggregate Area

a. Site Description and History. The DP Site Aggregate Area consists of SWMUs and AOCs located throughout TA-21. TA-21 is located on DP Mesa on the northern boundary of LANL and is immediately east-southeast of the Los Alamos townsite.

The DP Site Aggregate Area sites addressed by 2006 field activities included the following:

- SWMU 21-013(c) was a surface disposal area located northeast of the high-temperature chemistry building (Building 21-209); the dates of operation are unknown.
- Consolidated Unit 21-003-99 consists of SWMUs 21-003 and 21-013(f) and was a PCB container storage area from 1978 to 1989. SWMU 21-003 was a PCB-container storage area inside Building 21-61, including the area immediately outside and east of the building. SWMU 21-013(f) was possibly a surface disposal area and is located within the boundaries of SWMU 21-003.
- SWMU 21-024(c) was a septic system installed to route sewage from Buildings 21-54 and 21-61 in the late 1940s and operated until 1966.
- SWMU 21-009 was a waste treatment laboratory constructed in 1948 and decommissioned in 1965.
- AOC 21-002(b) was a drum storage area built southeast of Building 21-31 used for drum storage; the contents of the drums are not known. The area was decommissioned in 1966.

b. Remediation and Sampling Activities. NMED approved the *Investigation Work Plan for Delta Prime Site Aggregate Area at Technical Area 21* with modifications (LANL 2004f; NMED 2005c). In addition, the Laboratory submitted revisions to the approved work plan to NMED in 2005 (LANL 2005h) and submitted a supplemental investigation work plan in 2006 (LANL 2006i). The Laboratory started and concluded field investigations for five sites in 2006 based on the approved work plan (LANL 2004f; NMED 2005c). Results of previous investigations were used to determine whether additional data were needed. Surface and subsurface soil samples were collected from numerous locations at all the sites.

c. Conclusions and Recommendations. The Laboratory will report the results of the characterization of the DP Site Aggregate Area investigation sites in an investigation report in 2007.

E. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

The EP Directorate's quality assurance objectives are to perform work in a quality manner while minimizing potential hazards to the environment, public, or workers. All work is performed by using approved instructions, procedures, and other appropriate means that implement regulatory or contractual requirements for technical standards, administrative controls, and other hazard controls. The Quality Management Plan establishes the principles, requirements, and practices necessary to implement an effective quality assurance program.

The use of a graded approach determines the scope, depth, and rigor of implementing the quality assurance criteria for a specific activity. Activities are managed through systems that are commensurate with the quality requirements, risk, and hazards involved in the activity. Such a selective approach allows the Laboratory to apply extensive controls to certain elements of activities and limited controls to others. The control measures applied to any particular activity are covered in documents such as procedures, statements of work, project-specific work plans, and procurement contracts associated with the activity.

2. Field Sampling Quality Assurance

Overall quality is maintained through the rigorous use of carefully documented procedures that govern all aspects of the sample collection activities.

Soil, water, vapor, and biota samples are (1) collected under common EPA chain-of-custody procedures using field notebooks and sample collection logs and (2) prepared and stored in certified pre-clean sampling containers in a secure and clean area for shipment. Samples are delivered to analytical laboratories under full chain-of-custody, including secure FedEx shipment to all external vendors, and tracked at all stages of their collection and analysis.

3. Analytical Laboratory Quality Assessment

The Laboratory writes specific statements of work to govern the acquisition and delivery of analytical chemistry services after the Data Quality Objective process defines the project needs. These statements of work are sent to potentially qualified suppliers who are National Environmental Laboratory Accreditation Conference (NELAC)-certified for a pre-award assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical, organic chemical, and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. The analytical laboratory also submits a full set of hard copy records that serves as the legally binding copy of the data. Each set of samples contains all the internal quality assurance/quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and verified and validated according to its corresponding variety of quality and consistency checks. All parts of the data-management process are tracked electronically, and periodic reports to management are prepared.

4. Analytical Laboratory Assessments

The EP Directorate has eight contracts with external analytical laboratories. The laboratories are audited as long as they keep their NELAC and DOE Contract Audit Program certifications. During 2006, five external laboratory audits were performed; St. Louis Severn Trent, Assaigi, Paragon Analytics, Inc., University of Miami, and Huffman Laboratories. All laboratories participated in national performance-evaluation studies during 2006 and the results are included in the assessment report. Overall, the study sponsors judged the analytical laboratories to have acceptable performance for almost all analytes attempted in all matrices.

5. Program Audits and Assessments

The Laboratory's Performance Assurance Division–Operations Support and the Facilities Division performed internal audits of the Sample Management Office (SMO). The Performance Assurance audit found no issues, while the Facilities audit required postings for radioactivity and quarterly radiological surveys of the SMO.

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10. Environmental Risk and Hazard Reduction



10. Environmental Risk and Hazard Reduction

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A. INTRODUCTION

The Los Alamos National Laboratory (LANL or the Laboratory) is committed to evaluating and reducing hazards and risk or dose to humans and the environment from past and current Laboratory operations. These risks or doses (hereafter referred to as risk) may exist from the potential for unintentional releases, migration through the environment, or exposure of people to the hazard. Over the years, the Laboratory has decreased its release of materials into the environment and has reduced the amount of legacy contamination present. This is accomplished by assessing institutional processes, reducing sources, substituting chemicals in operations, recycling materials, and estimating the current, present-day risks as well as prospective risks, where appropriate. A few examples of these actions include the reduction in outfalls (from plant and process discharges) and air emissions, changes to effluent treatment processes at the Radioactive Liquid Waste Treatment Facility at Technical Area (TA) 50, the elimination of chromate in cooling towers, and the removal of contaminated material and waste at sites such as Material Disposal Area (MDA) P and Area G. These efforts throughout the Laboratory have significantly reduced or eliminated potential exposure and risk to workers, the public, and the environment.

This chapter describes how relative risks are estimated, some of the efforts the Laboratory is taking to reduce these risks, and how the environmental surveillance program monitors for new hazards. Detailed methods and results from the environmental surveillance program are discussed in the previous chapters of this report and specific examples of how monitoring has helped reduce risk are provided later in this chapter.

B. ESTIMATION OF RISK

Risk is evaluated either as current (present-day) risk or prospective risk (defined by the US Environmental Protection Agency [EPA] as "the future risks of a stressor not yet released into the environment or of future conditions resulting from an existing stressor"). The stressor (also known as a hazard) could be a radionuclide, a chemical, or a combination for which the potential risk is evaluated based on protective assumptions under a reasonable exposure scenario(s), safety analysis, or model.

The terminology used in describing the current risks is that a potential unacceptable risk is present or not. The "acceptable" nature is determined by target levels dictated by the regulatory authorities (NM Environment Department [NMED] or US Department of Energy [DOE]) and are equal to or less than 10^{-5} (1 in 100,000) probability of cancer, a hazard index equal to 1.0 or less for noncancer causing chemicals (indicates that no [noncancer] adverse human health effects are expected to occur), and a dose of 15 mrem/yr or less for radionuclides. In keeping with the policy of maintaining all dose and risk as low as reasonably achievable, the Laboratory strives to reduce risk/dose to below these target levels whenever possible. For the maximally

exposed individual (MEI) reported in Chapter 3 of this report, the calculated cancer risk from the estimated dose in 2006 is approximately 3×10^{-7} (3 in 10,000,000 chance of cancer).

To analyze current and prospective risk, LANL uses environmental data, computer evaluation tools, and computer models. A computer program called RACER (http://www.racteam.com/LANLRisk/RACERDatabase.htm or http://www.racteam.com/RACERatLANL.htm) is in development by the Risk Assessment Corporation (http://www.racteam.com/) in consultation with LANL and the NMED. The RACER tool will analyze collected environmental data to help estimate risk for a variety of exposure scenarios, such as recreational or residential uses. Models such as the residual radioactivity (RESRAD) model (http://web.ead.anl.gov/resrad/), Hotspot (http://www.llnl.gov/nhi/hotspot/), and CAP88 (http://www.epa.gov/radiation/assessment/CAP88/index.html) are used to evaluate risk based on material inventory buried or stored at a site or in transport (e.g., from the surface to the regional aquifer).

Prospective risk is also used to aid in the evaluation of remediation and corrective measure options. Probabilistic models account for physical system uncertainties within the context of the decisions under consideration. Prospective risk methods can identify the additional data needed to determine the optimal decision, thus guiding data collection operations.

C. EXAMPLES OF RISK AND HAZARD REDUCTION

The Laboratory is committed to reducing hazards and the associated risk to people and the environment. Current risk depends on the amount of hazardous material that actually reaches a receptor, whereas prospective risk depends on the amount of hazardous material and the probability of *exposure* in the future. It is often given as a range of concentrations and risks (expressed as a dose) rather than a single number or set of numbers due to the uncertainties associated with predicting future concentrations and exposures. Buried hazardous material buried may have little or no exposure under current conditions but may have an increased probability of exposure over time. In addition, if the material is brought to the surface either now or in the future, the potential for exposure and risk increases substantially.

The following are examples where current or past Laboratory operations have resulted in the storage of large quantities of wastes or the release of contaminants to the environment. These sites are being addressed by the Laboratory to reduce the potential and current hazards to humans and the environment.

1. TA-54 Area G and MDA G

The transuranic waste disposition program expedites the disposal of legacy transuranic waste to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM, and ensures appropriate facilities and equipment are available to facilitate disposal of current and future transuranic wastes. Area G at TA-54 stores substantial amounts of radioactively contaminated waste and other contaminated materials in above-ground storage. MDA G at TA-54 is a subsurface disposal site containing potentially hazardous and radioactive wastes from operational activities and wastes from environmental restoration and demolition activities at the Laboratory. MDA G was also used for the retrievable storage of transuranic (TRU) waste. Most of the TRU waste will eventually be transported to permanent storage at WIPP.

As discussed in Chapter 3, the dose to the all-pathway MEI results from neutrons emitted from the TRU waste at Area G (1.1 mrem in 2006). The primary method to reduce both the current and prospective risk at Area G is to steadily reduce the inventory of transuranic waste by transporting drums of radioactive material to WIPP. During 2006, the shipping rate was more than five times that of previous years. Of the approximately 130,000 plutonium equivalent curies (PE-Ci) of radioactive materials in secure above-ground storage at Area G, the Laboratory shipped approximately 12,081 PE-Ci in 2,976 barrels to WIPP in 2006. Additionally, 294 drums



Laboratory shipped approximately 12,081 PE-Ci in 2,976 barrels to WIPP in 2006. Additionally, 294 drums of neutron sources, recovered by the Off-Site Source Recovery Program, were transported to WIPP. The shipping strategy in 2007 and 2008 will shift from an emphasis on shipping specific high-activity drums to maximize the PE-Ci of TRU waste shipped to WIPP and removed from LANL. Starting in 2009, TRU waste that was buried in retrievable forms in MDA G will be excavated and shipped to WIPP. All temporarily-stored radioactive wastes are scheduled to be removed by late 2013 (Figure 10-1).

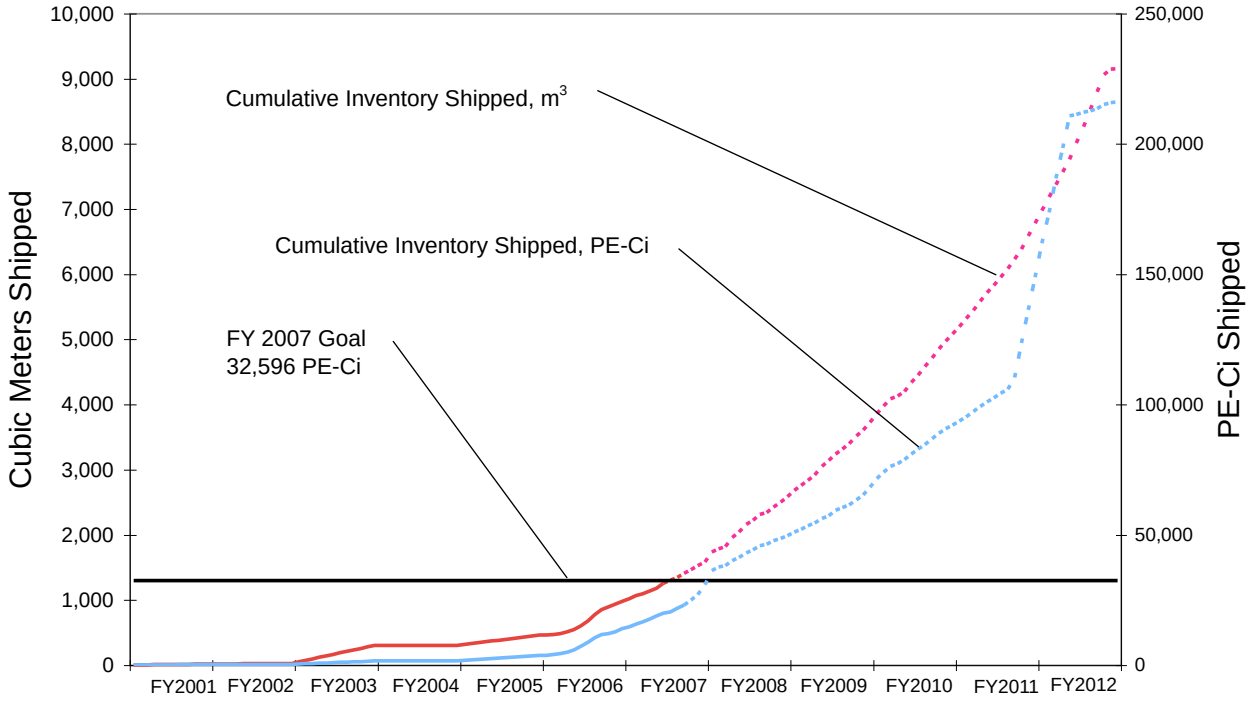

Figure 10-1. Graph showing goals for shipment of waste volume and activity at Area G.

2. TA-21

TA-21 is the site of the Laboratory's original plutonium processing facility, a tritium processing and handling facility, and several MDAs. This site has several MDAs and other solid waste management units (SWMUs) and areas of concern related to past operations. The inventories of hazardous and radioactive material at the MDAs are not well characterized because there are few records of waste disposal during the 1940s and the Manhattan Project. MDAs V and U have been remediated, MDAs A and T will undergo corrective measures evaluations to determine the appropriate corrective actions, and MDA B is scheduled to be remediated. In addition, the other sites at TA-21 are being characterized or remediated as part of the DP Site Aggregate Area investigation.

3. Groundwater

As discussed in detail in Chapter 5 (Groundwater Monitoring), Laboratory-derived impacts to groundwater have been found in some monitoring wells. At present, there is no measurable LANL-derived contamination in the supplied drinking water but there may be a prospective risk because of the potential for contamination to migrate to the drinking water supply wells in the future. Throughout 2006, efforts were under way to evaluate groundwater quality and augment the current monitoring network to ensure monitoring activities will detect contamination in groundwater before it can affect the drinking water.

4. LANSCE Emissions Reduction

Radioactive gases from the Los Alamos Neutron Science Center (LANSCE) at TA-53 have traditionally been the source of the highest radiation dose to the public from Laboratory facilities. As described in Chapter 4, emissions from LANSCE were substantially lower in 2006 than in 2005 and the lowest since 1999. Emissions in 2005 were abnormally high because of a cracked valve, but the replacement of the valve and the addition of more delay line (used to slow and allow decay of short-lived radionuclides) in 2005 resulted in greatly reduced emissions in 2006. Emissions are expected to remain low in 2007 and beyond.

5. Environmental Characterization and Restoration

The objective of the environmental investigation and cleanup activities at the Laboratory is to identify and characterize releases (the nature of the contamination), the location and extent of the contamination, whether it requires remediation (poses a potential unacceptable risk), and what type of remediation is appropriate. Over the past few years, the Laboratory has been conducting corrective action activities under the March 1, 2005 Compliance Order on Consent, which specifies requirements and goals to be met.

In the past several years, the Laboratory has determined where contamination is present and in many cases has reduced the legacy contamination. Where contamination is present, the risk is quantified to determine whether it is unacceptable with respect to human health and the environment. Table 9-3 lists the sites for which corrective actions were completed and approved in 2006.

Remediation has been completed at TA-73, which contained landfills, septic systems, an incinerator and surface disposal area, and other miscellaneous sites. This TA is currently part of or adjacent to the Los Alamos County Airport. The landfills and associated sites were addressed in 2006 as part of a corrective measure, which included the construction of an engineered cover. During the 1940s and early 1950s, ash and debris from incinerator operations were disposed of on the north-facing slope (known as the Airport Ashpile) of Pueblo Canyon. The disturbance of this site during the cleanup activities in 2006 contributed a portion of the calculated dose (0.47 mrem) at the adjacent airport terminal and resulted in this location becoming the site of the air pathway MEI for 2006 (see Chapter 3). The remediation of this site, which also included the removal of septic systems, drainlines, and outfalls in the vicinity of the ash pile, reduced the risk and dose to acceptable levels under a residential scenario.

Other major remediation activities were conducted in 2006 at MDA V at TA-21 where three absorption beds and other contaminated soil and tuff were excavated. In addition, other smaller sites around the Laboratory (individual SWMUs and areas of concern) were successfully investigated and, in some cases, remediated while other sites continue to be investigated. Investigations of groundwater contamination are continuing at several locations to determine the extent and potential for movement of contaminants.

Previous risk reduction successes include the cleanup of the MDA P landfill at TA-16; the removal of contaminated media from the 260 Outfall at TA-16; a voluntary corrective measure to remove contaminated material in DP Canyon at SWMU 21-011(k); and the removal of contaminated sludge, soil, and tuff from three lagoons at TA-53.

D. MONITORING FOR POTENTIAL EXPOSURES AND RISKS

LANL's environmental surveillance program identifies possible environmental hazards and impacts. Monitoring can detect and identify environmental impacts from hazardous and radioactive materials and data from monitoring can be used to help with mitigation of any impacts. To this end, each pathway by which an individual may be exposed is monitored. The sensitivity of environmental surveillance measurements allows for the detection of contaminants during cleanup or normal operations at near and remote locations. Additional monitoring may be conducted in places where there is an increased potential for environmental releases. In some cases, immediate actions are warranted because of monitoring results.

After sites have been remediated, long-term monitoring may be required as part of the chosen remediation solution. Such monitoring will eventually become part of the existing environmental surveillance programs and will fulfill requirements for a long-term environmental stewardship program as required by DOE.

The following subsections provide examples of findings by the environmental surveillance program that reduced or indicated the presence of LANL hazards.

1. Air Monitoring

As described in Chapter 2, LANL rigorously controls and monitors stack emissions, as required by the Clean Air Act. During 2006, the stack emissions were small and the measured concentrations and activities were less than 1% of the Clean Air Act standards.

In addition to stack emissions, other possible emissions are monitored using the AIRNET system (Chapter 4). During 2006, the AIRNET system detected several cases of emissions that were not from stacks, as described below.

- Area G is monitored by eight AIRNET stations. During 2006, as in previous years, the AIRNET data revealed plutonium emissions above background. LANL has taken steps to minimize these emissions, for example by wetting the surface at Area G when necessary and minimizing work during windy conditions.
- Unexpected elevated tritium concentrations were detected at three AIRNET stations at Area G, and the source of the tritium was traced to a tritium storage tank that had been removed during the decommissioning of the tritium facilities at TA-21. Although the emissions were not a health hazard, even for individuals close to the tank, the tank has been removed and buried in order to keep the dose as low as possible.
- An AIRNET station at TA-21 detected airborne plutonium-239 concentrations significantly greater than background during the remediation of MDA V. To monitor future work operations at TA-21, six additional AIRNET stations were installed approximately every 300 ft along DP Road and three additional stations were installed along State Road 502.
- The AIRNET station next to the Los Alamos Airport terminal measured elevated plutonium-239 concentrations near the airport during the cleanup operations at the adjacent ash pile within TA-73. These measurements were used to determine that the nearby airport terminal was the location of the air pathway MEI for 2006.
- Above-background plutonium has been detected for many years within the Los Alamos Townsite at AIRNET Station 66 near former TA-1. During the original Manhattan Project in the 1940s, the plutonium was discharged on the steep hillside of Los Alamos Canyon and is often resuspended by winds. An additional AIRNET station was installed nearby to collect more data before making a decision on future actions to keep the public dose as low as reasonably achievable.

2. Radiation Monitoring

Gamma and neutron radiation is monitored by the direct penetrating radiation monitoring network (DPRNET) described in Chapter 4.

The largest source of direct radiation is Area G at TA-54 and is monitored at 33 stations, all of which measure above-background intensities of neutron radiation. As discussed in Chapter 3, the all-pathway MEI is at the northern boundary of TA-54 and results primarily from neutrons. The neutron radiation is being reduced by removing the sources from Area G.

Though high radiation levels are not expected from TA-21 during the upcoming cleanup at that site, four new DPRNET stations have been installed along DP Road and State Road 502, between the potential sources at TA-21 and the public areas to the north and west.

NEWNET is a radiation monitor that displays radiation levels at 15-minute intervals in near real time. On December 12, 13, and 14, 2006, the NEWNET station at East Gate detected unexpected radiation, which was quickly traced to a source at LANSCE (traced to a flow condition of the target cooling water at the Isotope Production Facility). Prompt action by the LANSCE facility staff eliminated the emissions and kept the total dose to members of the public to a very low level (estimated at less than 0.03 mrem).

3. Soil, Foodstuff, and Biota Monitoring

Monitoring of soil, foodstuff, and non-foodstuff biota is an important indication of the health of the environment. Soil and sediment monitoring has established a baseline of known concentrations in selected areas on Laboratory property, in surrounding areas, and regionally. Comparison of known concentrations with future results may indicate movement of contaminants, for example in the flood retention structures that collect sediment transported downstream.

Collection and analysis of foodstuff (crops, game animals, fish, honey, milk, etc.) from the region provides confidence that no unexpected contamination has reached off-site locations. The program has identified since the 1990s that PCB and mercury levels in some types of fish both upstream and downstream in the Rio Grande are above EPA and NMED fish advisory levels.

Biota monitoring is a non-invasive method of detecting underground materials. The roots of some plants and trees penetrate into subsurface contamination and may bring contaminated material to the surface. For example, vegetation samples collected annually at MDA G demonstrate low concentrations of isotopic plutonium (approximately 1 pCi/g or less) in the soil toward the north and east of the area (Chapter 8). Tree samples indicate an area of underground tritium along the south fence of MDA G. At MDA B, tree samples from 2006 along the northern fence showed above-background plutonium-239 concentrations and cesium-137 concentrations which indicate radioactive materials are within reach of the roots. Also, measurements of chamisa within the fenced area of Bayo Canyon indicate underground concentrations on the order of 1,000 pCi/g near the southwest corner (Fresquez et al. 1995).

4. Water Monitoring

The Los Alamos County water supply system contains no detected LANL-derived contaminants so the current risk from contaminants in drinking water is less than 10^{-6}. At present, the major thrust of the water monitoring program, being developed in cooperation with the NMED, is directed toward estimating the prospective risk of contamination that may enter the drinking water in the future. One such activity is modeling to estimate the possibility of contaminants migrating from the surface through the vadose zone to the aquifer. Data show that plutonium, uranium, cesium, and strontium are tightly bound to the soil matrix and so will not migrate

in measurable amounts. Tritium is more mobile, but its migration is slower compared with its approximately 12-year radioactive half-life, so the concentrations of tritium in drinking water will remain far below drinking water standards. Thus, migration of radionuclides is not likely to be a problem, so attention is focused on migration of chemicals such as perchlorate, chromium, and high explosive residues.

Numerous additional monitoring wells have been drilled over the past several years and more are planned for 2007. These new wells will provide a better picture of the location and movement of contamination in the aquifer.

E. REFERENCES

DOE 1994: DOE-HDBK-3010-94 "Airborne Release Fractions/Rates, and Respirable Fractions for NonReactor Nuclear Facilities" (1994) (http://www.orau.gov/DDSC/dose/doehandbook.pdf)

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Fresquez et al 1995: Fresquez, P.R., T.S. Foxx, and L. Naranjo. "Strontium concentrations in chamisa (*Chrysothamnus nauseosus*) shrub plants growing in a former liquid waste disposal area in Bayo Canyon," Los Alamos National Laboratory report LA-13050-MS (1995)



Appendix A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, or foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 450.1, "Environmental Protection Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1A, "Environmental Safety and Health Reporting."

Radiation Standards. DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the EPA dose factors from Federal Guidance Report No. 13 (EPA 1999). The dose factors EPA adopted are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard for the public (NCRP 1987). Table A-1 lists currently applicable radiation protection standards, now referred to as public dose limits, for operations at the Laboratory. DOE's comprehensive public dose limit for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem per year. For one specific activity or pathway, DOE guidance specifies a "dose constraint" of 25 mrem per year (DOE 1999.) The public dose limits and the DOE occupational dose limits are based on recommendations in ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure. External dose factors were obtained from Federal Guidance Report No. 12 (EPA 1993).

Radionuclide concentrations in water are compared with DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for water are those concentrations in water that if consumed at a maximum rate of 730 liters per year, would give a dose of 100 mrem per year. Table A-2 shows the DCGs. For comparison with drinking-water systems, the DCGs are multiplied by 0.04 to correspond with the EPA limit of 4 mrem per year.

In addition to DOE standards, in 1985 and 1989, the EPA established the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 CFR 61, Subpart H. This regulation states that emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. DOE has adopted this dose limit (Table A-1). This dose is calculated at the location of a residence, school, business, or office. In addition, the regulation requires monitoring of all release points that can produce a dose of 0.1 mrem to a member of the public.

Table A-1
DOE Dose Limits for External and Internal Exposures

Exposure pathway	Dose Equivalent[a] at Point of Maximum Probable Exposure
Exposure of Any Member of the Public[b]	
All Pathways	100 mrem/yr[c]
One Specific Pathway (dose constraint)	25 mrem/yr[d]
Air Pathway Only[e]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem/yr (TEDE)[f]
Nonstochastic Effects	
Lens of eye	15 rem/yr
Extremity	50 rem/yr
Skin of the whole body	50 rem/yr
Skin of the whole body	50 rem/yr
Embryo/Fetus of Declared Pregnant Worker	0.5 rem/gestation period

[a] Refer to Glossary for definition.

[b] In keeping with DOE policy, exposures must be limited to as small a fraction of the respective annual dose limits as practicable. DOE's public dose limit applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from DOE Order 5400.5 (DOE 1990). Limits for occupational exposure are taken from 10 CFR 835, Occupational Radiation Protection.

[c] Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem per year.

[d] Guidance (DOE 1999.)

[e] This level is from EPA's regulations issued under the Clean Air Act (40 CFR 61, Subpart H) (EPA 1989a).

[f] Refer to Glossary for definition.

Table A-2
DOE's Derived Concentration Guides for Water[a]

Nuclide	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)[b]
^{3}H	2,000,000	80,000
^{7}Be	1,000,000	40,000
^{89}Sr	20,000	800
^{90}Sr	1,000	40
^{137}Cs	3,000	120
^{234}U	500	20
^{235}U	600	24
^{238}U	600	24
^{238}Pu	40	1.6
^{239}Pu	30	1.2
^{240}Pu	30	1.2
^{241}Am	30	1.2

[a] Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990). Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.

[b] Drinking water DCGs are 4% of the DCGs for non-drinking water.

Table A-3
National (40 CFR 50) and New Mexico (20.2.3 NMAC) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total Suspended Particulates	Annual	µg/m3	60		
	30 days	µg/m3	90		
	7 days	µg/m3	110		
	24 hours	µg/m3	150		
PM-10[a]	Annual	µg/m3		50	50
	24 hours	µg/m3		150	150
PM-2.5[b]	Annual	µg/m3		15	15
	24 hours	µg/m3		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	µg/m3		1.5	1.5

[a] Particles ≤10 µm in diameter.

[b] Particles ≤2.5 µm in diameter.

Nonradioactive Air Quality Standards. Table A-3 shows federal and state ambient air quality standards for nonradioactive pollutants.

National Pollutant Discharge Elimination System. The types of monitoring required under National Pollutant Discharge Elimination System (NPDES) and the limits established for sanitary and industrial outfalls can be found at *http://www.lanl.gov/environment/h2o/index.shtml*.

Drinking Water Standards. For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (NMEIB 1995). To view the New Mexico Drinking Regulations go to *http://www.nmenv.state.nm.us/Common/regs_idx.html*. EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Appendix A

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards. Concentrations of radionuclides in surface water samples may be compared with either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995) (http://www.nmenv.state.nm.us/NMED_regs/swqb/20_6_4_nmac.pdf). The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

Organic Analysis of Surface and Groundwaters: Methods and Analytes. Organic analyses of surface waters, groundwaters, and sediments are made using SW-846 methods. The specific compounds analyzed in each suite are listed in the supplemental tables for Chapters 5 and 6.



REFERENCES

DOE 2003a: US Department of Energy, "Environmental Protection Program," US Department of Energy Order 450.1 (January 15, 2003).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

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DOE 2003b: US Department of Energy, "Environment, Safety, and Health Reporting," US Department of Energy Order 231.1A (August 19, 2003).

EPA 1988: US Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors For Inhalation, Submersion And Ingestion, Federal Guidance Report No. 11," EPA-520/1-88-020 (September 1988).

EPA 1989a: US Environmental Protection Agency, "40CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," Federal Register 54, 51 653-51 715 (December 15, 1989).

EPA 1989b: US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," Code of Federal Regulations, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

EPA 1993: US Environmental Protection Agency, "External Exposure to Radionuclides in Air, Water, and Soil," Federal Guidance Report No. 12, EPA 402-R-93-081 (September 1993).

EPA 1999: US Environmental Protection Agency, "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," Federal Guidance Report No. 13, EPA 402-R-90-001 (September 1999).

ICRP 1988: International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, and 3, and their supplements, Annals of the ICRP 2(3/4) -8(4) (1979-1982), and Publication 30, Part 4, 19(4) (1988).

NCRP 1987: National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

NMEIB 1995: New Mexico Environmental Improvement Board, "New Mexico Drinking Water Regulations," (as amended through January 1995).

NMWQCC 1995: New Mexico Water Quality Control Commission, "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," Section 3-101.K (as amended through January 23, 1995).

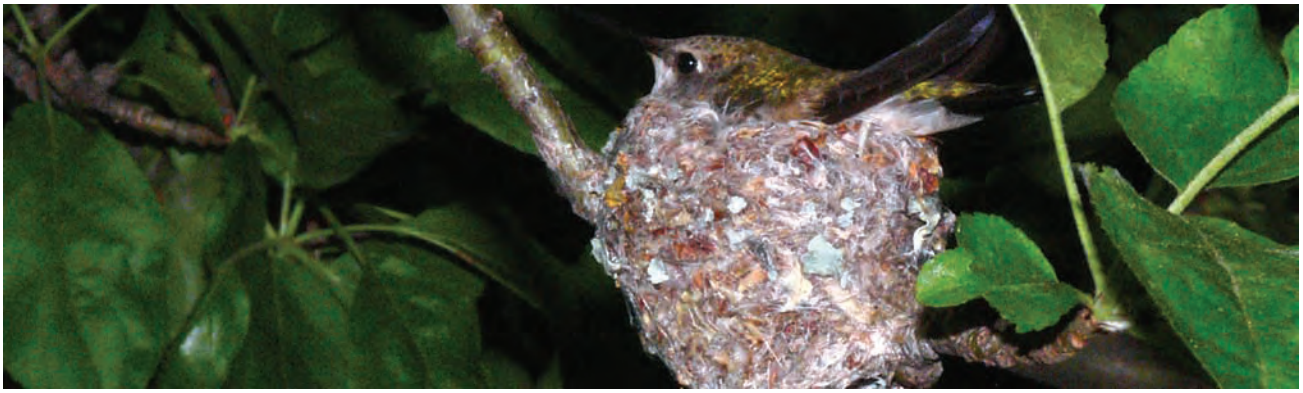
Appendix B

UNITS OF MEASUREMENT

Throughout this report the US Customary (English) system of measurement has generally been used because those are the units in which most data and measurements are collected or measured. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively. Table B-1 presents conversion factors for converting US Customary Units into SI units.

Table B-1
Approximate Conversion Factors for Selected US Customary Units

Multiply US Customary units	by	to Obtain SI (Metric) Unit
Fahrenheit (°F)	5/9 - 32	Celsius (°C)
inches (in.)	2.54	centimeters (cm)
cubic feet (ft^3)	0.028	cubic meters (m^3)
acres (ac)	.4047	hectares (ha)
ounces (oz)	28.3	grams (g)
pounds (lb)	0.453	kilograms (kg)
miles (mi)	1.61	kilometers (km)
gallons (gal.)	3.785	liters (L)
feet (ft)	0.305	meters (m)
parts per million (ppm)	1	micrograms per gram (µg/g)
parts per million (ppm)	1	milligrams per liter (mg/L)
square miles (mi^2)	2.59	square kilometers (km^2)
picocurie (pCi)	37	millibecquerel (mBq)
rad	0.01	gray (Gy)
millirem (mrem)	0.01	millisievert (mSv)



Appendix B

Table B-2 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^{3}, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the **right** of its present location. The number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the **left** of its present location. The result would be 0.00002.

Table B-2
Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
mega	1 000 000 or 10^{6}	M
kilo	1 000 or 10^{3}	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	µ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a



Table B-3 presents abbreviations for common measurements.

Table B-3
Common Measurement Abbreviations and Measurement Symbols

Symbol	Abbreviation
aCi	attocurie
Bq	becquerel
Btu	British thermal unit
Ci	curie
cm^3/s	cubic centimeters per second
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot or feet
ft^3/min	cubic feet per minute
ft^3/s	cubic feet per second
kg	kilogram
kg/h	kilogram per hour
m^3/s	cubic meter per second
µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$µg/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
mCi	millicurie
mg	milligram
mR	milliroentgen
mrad	millirad
mrem	millirem
mSv	millisievert
nCi	nanocurie
nCi/dry g	nanocurie per dry gram
nCi/L	nanocurie per liter
ng/m^3	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m^3	picogram per cubic meter
PM_{10}	small particulate matter (less than 10 µm diameter)

Table B-3 (continued)

Symbol	Abbreviation
$PM_{2.5}$	small particulate matter (less than 2.5 µm diameter)
R	roentgen
s, SD, or σ	standard deviation
sq ft (ft^2)	square feet
>	greater than
<	less than
≥	greater than or equal to
≤	less than or equal to
±	plus or minus
~	approximately

Data Handling of Radiochemical Samples

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 numbers. 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 values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1*s*) for the station and group means.

REFERENCE

Gilbert 1975: R. O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Battelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

Appendix C

DESCRIPTION OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-3. The main programs conducted at each of the areas are listed in this Appendix.

TA-0

The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos town site and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos town site.

TA-2, Omega Site

Omega West Reactor, an 8-MW nuclear research reactor, was located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor was decontaminated and decommissioned in 2002.

TA-3, Core Area

The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space.

TA-5, Beta Site

This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Twomile Mesa Site

The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

TA-8, GT Site (or Anchor Site West)

This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x-ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East

At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site

Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and



observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site

This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

TA-15, R Site

This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x-rays), a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for weapons development testing. It is also the site where DARHT (the dual-axis radiographic hydrotest facility) is located. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.

TA-16, S Site

Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. TA-16 is the site of the Weapons Engineering Tritium Facility for tritium handled in gloveboxes. Development and testing of high explosives, plastics, and adhesives and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site

This is a nuclear facility that studied both static and dynamic behavior of multiplying assemblies of nuclear materials. Near-critical experiments were conducted by remote control using low-power reactors called critical assemblies. The special nuclear materials at this site have been relocated to the Nevada Test Site.

TA-21, DP Site

This site has two primary research areas: DP West and DP East. DP West has been in the D&D program since 1992, and six buildings have been demolished. The programs conducted at DP West, primarily in inorganic and biochemistry, were relocated during 1997, and the remainder of the site was scheduled for D&D in future years. DP East was a tritium research site.

TA-22, TD Site

This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-28, Magazine Area A

This is an explosives storage area.

TA-33, HP Site

An old, high-pressure, tritium-handling facility located here is being phased out. An intelligence technology group and the National Radio Astronomy Observatory's Very Large Baseline Array Telescope are located at this site.

TA-35, Ten Site

Work here includes nuclear safeguards research and development that are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy physics, tritium fabrication, metallurgy, ceramic technology, and chemical plating.

TA-36, Kappa Site

Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C

This is an explosives storage area.

TA-39, Ancho Canyon Site

The behavior of nonnuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation state measurements, and pulsed-power systems design.

TA-40, DF Site

This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.

TA-41, W Site

Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

TA-43, Health Research Laboratory

This site is adjacent to the Los Alamos Medical Center in the town site. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics. The Department of Energy Los Alamos Area Office is also located within TA-43.

TA-46, WA Site

Activities include applied photochemistry research including the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater System Facility is located at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site

Laboratory scientists and technicians perform research and development activities at this site on a wide range of chemical processes including nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

TA-49, Frijoles Mesa Site

This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility is located here.

TA-50, Waste Management Site

This site is divided into two facility management units, which include managing the industrial liquid and radioactive liquid waste received from Laboratory technical areas and activities that are part of the waste treatment technology effort.

TA-51, Environmental Research Site

Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are performed at this site.

TA-52, Reactor Development Site

A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.

TA-53, Los Alamos Neutron Science Center

The Los Alamos Neutron Science Center, including the linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility, is located at this TA. Also located at TA-53 are the

Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator, and research and development activities in accelerator technology and high-power microwaves.

TA-54, Waste Disposal Site
This site is divided into two facility management units for the radioactive solid and hazardous chemical waste management and disposal operations and activities that are part of the waste treatment technology effort; includes Area G.

TA-55, Plutonium Facility Site
Processing of plutonium and research on plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site
This site is located about 28 miles west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains and was the location of the Laboratory's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. The high elevation and remoteness of the site make Fenton Hill a choice location for astrophysics experiments. A gamma ray observatory is located at the site.

TA-58
This site is reserved for multiuse experimental sciences requiring close functional ties to programs currently located at TA-3.

TA-59, Occupational Health Site
Occupational health and safety and environmental management activities are conducted at this site. Emergency management offices are also located here.

TA-60, Sigma Mesa
This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.

TA-61, East Jemez Road
This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.

TA-62
This site is reserved for multiuse experimental science, public and corporate interface, and environmental research and buffer zones.

TA-63
This is a major growth area at the Laboratory with expanding environmental and waste management functions and facilities. This area contains physical support facilities operated by KSL Services.

TA-64
This is the site of the Central Guard Facility and headquarters for the Laboratory Hazardous Materials Response Team.

TA-66
This site is used for industrial partnership activities.

TA-67
This is a dynamic testing area that contains significant archeological sites.

TA-68
This is a dynamic testing area that contains archeological and environmental study areas.

TA-69
This undeveloped TA serves as an environmental buffer for the dynamic testing area.

TA-70
This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-71
This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-72
This is the site of the Protective Forces Training Facility.

TA-73
This area is the Los Alamos Airport.

TA-74, Otowi Tract
This large area, bordering the Pueblo de San Ildefonso on the east, is isolated from most of the Laboratory and contains significant concentrations of archeological sites and an endangered species breeding area. This site also contains Laboratory water wells and future well fields.



Appendix D

RELATED WEB SITES

For more information on environmental topics at Los Alamos National Laboratory, access the following Web sites:

http://www.lanl.gov/environment/all/esr.shtml	Environmental Surveillance reports and supplemental data tables
http://www.lanl.gov/	Los Alamos National Laboratory web site
http://www.doeal.gov/laso/default.aspx	DOE/NNSA Los Alamos Site Office web site
http://www.energy.gov/	Department of Energy web site
http://www.lanl.gov/environment/air/index.shtml	LANL's air quality pages
http://www.lanl.gov/environment/h2o/index.shtml	LANL's water quality pages
http://www.lanl.gov/environment/waste/index.shtml	LANL's waste pages
http://www.lanl.gov/environment/eco/index.shtml	LANL's ecology pages
http://www.lanl.gov/environment/risk/index.shtml	LANL's risk reduction pages
http://www.lanl.gov/environment/cleanup/index.shtml	LANL's clean-up pages



Glossary

activation products	Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.
albedo dosimeters	Albedo dosimeters are used to measure neutrons. They use a neutron-sensitive polyethylene phantom to capture neutron backscatter to simulate the human body.
alpha particle	A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
ambient air	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
AOC	Area of concern.
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
artesian well	A well in which the water rises above the top of the water-bearing bed.
background radiation	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.
beta particle	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
biota	The types of animal and plant life found in an area.
blank sample	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

CAA Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.

CFR Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the *Federal Register*.

contamination (1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

controlled area Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

Ci Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.

cosmic radiation High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

CWA Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.

DOE US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. Los Alamos National Laboratory is managed by the NNSA, an agency within the DOE.

dose A term denoting the quantity of radiation energy absorbed.

- ***absorbed dose*** The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
- ***dose equivalent*** The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

EDE Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to 100 × 0.12 = 12 mrem.

maximum individual dose The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.

population dose The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. See definitiion of person-rem.

whole body dose A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).

EA Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.

effluent A liquid waste discharged to the environment.

EIS Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

emission A gaseous waste discharged to the environment.

environmental compliance The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.

environmental monitoring The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.

environmental surveillance The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.

EPA Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.

ephemeral A surface water that flows only in direct response to precipitation or snowmelt in the immediate locality.

exposure A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)

external radiation Radiation originating from a source outside the body.

gamma radiation Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.

gross alpha The total amount of measured alpha activity without identification of specific radionuclides.

gross beta The total amount of measured beta activity without identification of specific radionuclides.

groundwater Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.

half-life, radioactive The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (1/2 × 1/2), after three half-lives, one-eighth (1/2 × 1/2 × 1/2), and so on.

hazardous waste Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.

hydrology The science dealing with the properties, distribution, and circulation of natural water systems.

internal radiation Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.

ionizing radiation Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.

isotopes Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.

- long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
- short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

MCL Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.

MDA Material disposal area.

MEI Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.

mixed waste Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).

mrem Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.

NEPA National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.

NESHAP National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.

NNSA National Nuclear Security Agency. An agency within the DOE that is responsible for national security through the military application of nuclear energy.

nonhazardous waste Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.

NPDES National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.

nuclide A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.

outfall The location where wastewater is released from a point source into a receiving body of water.

PCB Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976.

PDL Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).

PE Curie Plutonium equivalent curie. One PE curie is the quantity of transuranic material that has the same radiation inhalation hazard as one curie of Pu-239. The PE curie is described in Appendix B of http://www.wipp.energy.gov/library/wac/CH-WAC.pdf.

perched groundwater A groundwater body above a slow-permeability rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.

perennial A surface water that flows continuously throughout the year.

person-rem A quantity used to describe the radiological dose to a population. Population doses are calculated according to sectors, and all people in a sector are assumed to get the same dose. The number of person-rem is calculated by summing the modeled dose to all receptors in all sectors. Therefore, person-rem is the sum of the number of people times the dose they receive. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)

pH A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.

piezometer A small diameter water well used to measure the hydraulic head (pressure) of groundwater in aquifers.

pollution Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).

point source An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.

ppb Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or µg/kg.

ppm Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as µg/g or mg/kg.

QA Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

rad Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body.
1 rad = 1,000 millirad (mrad)

radionuclide An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RESRAD A computer modeling code designed to model radionuclide transport in the environment.

RCRA Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

release Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation.

rem = rad × quality factor
1 rem = 1,000 millirem (mrem)

SAL Screening Action Limit. A defined contaminant level that if exceeded in a sample requires further action.

SARA Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is known as the Emergency Planning and Community Right-to-Know Act of 1986.

saturated zone Rock or soil where the pores are completely filled with water, and no air is present.

SWMU Solid waste management unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).

terrestrial radiation Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.

TLD Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.

TRU Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.

TSCA Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this act for controlling substances found to be detrimental to human health or to the environment.

tuff Rock formed from compacted volcanic ash fragments.

unsaturated zone See vadose zone in this glossary.

UST Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.

vadose zone The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.

water table The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.

watershed The region draining into a river, a river system, or a body of water.

wetland A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.

wind rose A diagram that shows the frequency and intensity of wind from different directions at a particular place.

worldwide fallout Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

Acronyms and Abbreviations

AIRNET	Ambient Air Monitoring Network
AOC	area of concern
AQA	Analytical Quality Associates
BCG	Biota Concentration Guides
BSRL	baseline statistical reference level
CFR	Code of Federal Regulations
CGP	Construction General Permit
CMR	Chemistry and Metallurgy Research (LANL building)
CWA	Clean Water Act
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
DOE	Department of Energy
DRO	diesel-range organic compound
DU	depleted uranium
EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
EU	enriched uranium
FY	fiscal year
GEL	General Engineering Laboratory
GMAP	gaseous mixed air activation products
HE	high-explosive
HMX	cyclotetramethylenetetranitramine
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
ISM	Integrated Safety Management (LANL)
LANL	Los Alamos National Laboratory (or the Laboratory)
LANSCE	Los Alamos Neutron Science Center (TA-53)
LASO	Los Alamos Site Office (DOE)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	material disposal area
MDL	method detection limit
MEI	maximally exposed individual
NCRP	National Council on Radiation Protection
NELAC	National Environmental Laboratory Accreditation Conference
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
P2	Pollution Prevention Program
PCB	polychlorinated biphenyls
PM	particulate matter
ppb	parts per billion
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite) (also Royal Demolition Explosive)
RLWTF	Radioactive Liquid Waste Treatment Facility
RSRL	regional statistical reference level
SAL	screening action level
SL	screening level
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SWEIS	Site-Wide Environmental Impact Statement
SWPP	Storm Water Prevention Plan
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act

Elemental and Chemical Nomenclature

Actinium	**Ac**
Aluminum	**Al**
Americium	**Am**
Argon	**Ar**
Antimony	**Sb**
Arsenic	**As**
Astatine	**At**
Barium	**Ba**
Berkelium	**Bk**
Beryllium	**Be**
Bicarbonate	**HCO_3**
Bismuth	**Bi**
Boron	**B**
Bromine	**Br**
Cadmium	**Cd**
Calcium	**Ca**
Californium	**Cf**
Carbon	**C**
Cerium	**Ce**
Cesium	**Cs**
Chlorine	**Cl**
Chromium	**Cr**
Cobalt	**Co**
Copper	**Cu**
Curium	**Cm**
Cyanide	**CN**
Carbonate	**CO_3**
Dysprosium	**Dy**
Einsteinium	**Es**
Erbium	**Er**
Europium	**Eu**
Fermium	**Fm**
Fluorine	**F**
Francium	**Fr**
Gadolinium	**Gd**
Gallium	**Ga**
Germanium	**Ge**
Gold	**Au**
Hafnium	**Hf**
Helium	**He**
Holmium	**Ho**
Hydrogen	**H**
Hydrogen oxide	**H_2O**
Indium	**In**
Iodine	**I**
Iridium	**Ir**
Iron	**Fe**
Krypton	**Kr**
Lanthanum	**La**
Lawrencium	**Lr (Lw)**
Lead	**Pb**
Lithium	**Li**
Lithium fluoride	**LiF**
Lutetium	**Lu**
Magnesium	**Mg**
Manganese	**Mn**
Mendelevium	**Md**
Mercury	**Hg**
Molybdenum	**Mo**
Neodymium	**Nd**
Neon	**Ne**
Neptunium	**Np**
Nickel	**Ni**
Niobium	**Nb**
Nitrate (as Nitrogen)	**NO_3-N**
Nitrite (as Nitrogen)	**NO_2-N**
Nitrogen	**N**
Nitrogen dioxide	**NO_2**
Nobelium	**No**
Osmium	**Os**
Oxygen	**O**
Palladium	**Pd**
Phosphorus	**P**
Phosphate (as Phosphorus)	**PO_4-P**
Platinum	**Pt**
Plutonium	**Pu**
Polonium	**Po**
Potassium	**K**
Praseodymium	**Pr**
Promethium	**Pm**
Protactinium	**Pa**
Radium	**Ra**
Radon	**Rn**
Rhenium	**Re**
Rhodium	**Rh**
Rubidium	**Rb**
Ruthenium	**Ru**
Samarium	**Sm**
Scandium	**Sc**
Selenium	**Se**
Silicon	**Si**
Silver	**Ag**
Sodium	**Na**
Strontium	**Sr**
Sulfate	**SO_4**
Sulfite	**SO_3**
Sulfur	**S**
Tantalum	**Ta**
Technetium	**Tc**
Tellurium	**Te**
Terbium	**Tb**
Thallium	**Tl**
Thorium	**Th**
Thulium	**Tm**
Tin	**Sn**
Titanium	**Ti**
Tritiated water	**HTO**
Tritium	**^3H**
Tungsten	**W**
Uranium	**U**
Vanadium	**V**
Xenon	**Xe**
Ytterbium	**Yb**
Yttrium	**Y**
Zinc	**Zn**
Zirconium	**Zr**

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