ERID-207316

Los Alamos National Laboratory

Environmental Report 2010

Los Alamos
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LA-14445-ENV

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- We approach our work as responsible stewards of our environment to achieve our mission.
- We prevent pollution by identifying and minimizing environmental risk.
- We set quantifiable objectives, monitor progress and compliance, and minimize consequences to the environment, stemming from our past, present, and future operations.
- We do not compromise the environment for personal, programmatic, or operational reasons.

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LA-14445-ENV
Issued September 2011

Los Alamos National Laboratory Environmental Report 2010

Waste and Environmental Services Division
505-667-0808

Environmental Data and Analysis Group
505-665-2917

Environmental Programs Directorate
505-606-2337

Corrective Actions Program
505-665-3388

Engineering & Technology
505-667-3460

TA-21 Closure Project
505-665-4897

Environmental Protection Division
505-667-2211

Environmental Stewardship Group
505-665-8855

Water Quality and RCRA Group
505-665-0666

Los Alamos National Laboratory Environmental Report 2010 reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) environmental organizations, as required by US Department of Energy Order 450.1, *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 LANL site and the Laboratory's major environmental programs. Chapter 2 reports the Laboratory's compliance status for 2010. 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 (air in Chapter 4; water and sediments in Chapters 5 and 6; soils in Chapter 7; foodstuffs and biota in Chapter 8; and subsurface soil vapor in Chapter 10) 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 11 provides an overview of the performance of the analytical chemistry laboratories that provide sample analyses to the Laboratory. Chapter 12 provides an overview of the health of the Rio Grande, monitoring results from the Valles Caldera and Jemez Mountains, and explains the actions taken to reduce environmental risks at the Laboratory. 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. Appendix E provides a glossary of terms, Appendix F provides acronyms and abbreviations. Appendix G provides Elemental & Chemical Nomenclature, and Appendix H provides errata for the 2009 report.

In printed copies of this report, we've also enclosed a disk with a copy of the full report in Adobe Acrobat portable document format (PDF) and detailed supplemental tables of data from 2010 in Microsoft Excel format. These files are also available for download from the web.

An on-line web survey for providing comments, suggestions, and other input on the report is available at the web address given below. Inquiries or comments regarding these annual reports may be directed to

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LANL ENVIRONMENTAL REPORT 2010

This year's report incorporates some changes to the format and content, including a change in the report name, a change in the report's organization, and a summary of two major 2011 events, the Japanese Fukushima reactor accident and the Las Conchas forest fire.

CHANGE OF REPORT NAME

Starting this year, we have changed the report name to "Los Alamos National Laboratory Environmental Report 2010." The Laboratory has published a summary report of environmental monitoring since 1969. In 1973, the report title became "Environmental Surveillance at Los Alamos during 1973," and the report maintained this title convention through the 2009 report. The term surveillance was used to encompass the full range of environmental sampling and monitoring activities.

The new name more closely aligns the report's name and purpose with the DOE Order 231.1 requirement for an annual site environmental report. The report will continue to encompass the full range of environmental sampling and monitoring activities. In addition, as the Laboratory's environmental restoration program moves into the corrective measures phase, the report will evolve to provide a more integrated look at the long-term monitoring conducted to assure that corrective measures continue to protect the environment.

REPORT ORGANIZATION

Three major changes are implemented in the 2010 report organization:

- Consolidation of DOE Order compliance performance in Chapter 2,
- Presentation of soil gas monitoring information in Chapter 10, and
- Consolidation of analytical chemistry laboratory performance in Chapter 11.

The consolidation of DOE Order compliance performance in Chapter 2 allows the reader to find a comprehensive summary of DOE Order compliance in one location.

Soil gas monitoring has been conducted at Technical Area (TA)-54 and TA-21 for a number of years. Chapter 10 presents this contaminant pathway data, which is also used in developing the Consent Order corrective measures for these TAs.

In previous reports, analytical chemistry laboratory performance information was reported in each media sampling chapter, giving the appearance that LANL has many individual analytical laboratory programs. In fact, the Laboratory has one program for procuring analytical laboratory services, verifying and validating analytical data, and assessing analytical laboratory performance. Bringing each media together into Chapter 11 allows the reader to understand the entire program.

2011 EVENTS SUMMARIZED

The Laboratory performed sampling and monitoring of two significant environmental events during the first half of 2011: Japan's Fukushima reactor accident in March and the Santa Fe National Forest Las Conchas forest fire in June and July. Preliminary environmental monitoring and assessment information from these events are presented in the 2010 report. A more detailed discussion will be presented in the 2011 Environmental Report.

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Introduction

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 36-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 feet on the flanks of the Jemez Mountains to about 6,200 feet above the Rio Grande at White Rock Canyon. Most Laboratory and Los Alamos County 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, Bandelier National Monument, the US General Services Administration, and Los Alamos County. In addition, 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 its commitment to environmental stewardship and full compliance with environmental protection laws. Part of LANL's commitment is to report on its environmental performance, and as such, this report does the following

- Characterizes LANL's environmental management, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment,
- Summarizes environmental occurrences and responses,
- Confirms compliance with environmental standards and requirements, and
- Highlights significant programs and efforts.

Environmental Monitoring

The Laboratory monitors emissions, effluents, and environmental media to meet environmental compliance requirements, determine actions to protect the environment, and monitor the long term health of the local environment. We collect data from the surrounding region to establish baseline environmental conditions in areas not influenced by LANL operations. LANL monitoring includes the radiological ambient air sampling network (AIRNET); groundwater, soil, foodstuffs, and biota (plants and animals) sampling as far away as Dixon, NM (40 direct miles away); and sediment monitoring along the Rio Grande as far upriver as Abiquiu Reservoir and downriver as Cochiti Reservoir. We also collect data on site and at the Laboratory perimeter to determine if operations are impacting LANL or neighboring properties (e.g., Pueblo and Los Alamos County lands). Perimeter monitoring also measures the highest potential impact to the public. During 2010, the Laboratory collected environmental samples from more than 4,000 locations and received more than 1.4 million analyses or measurements on these samples.

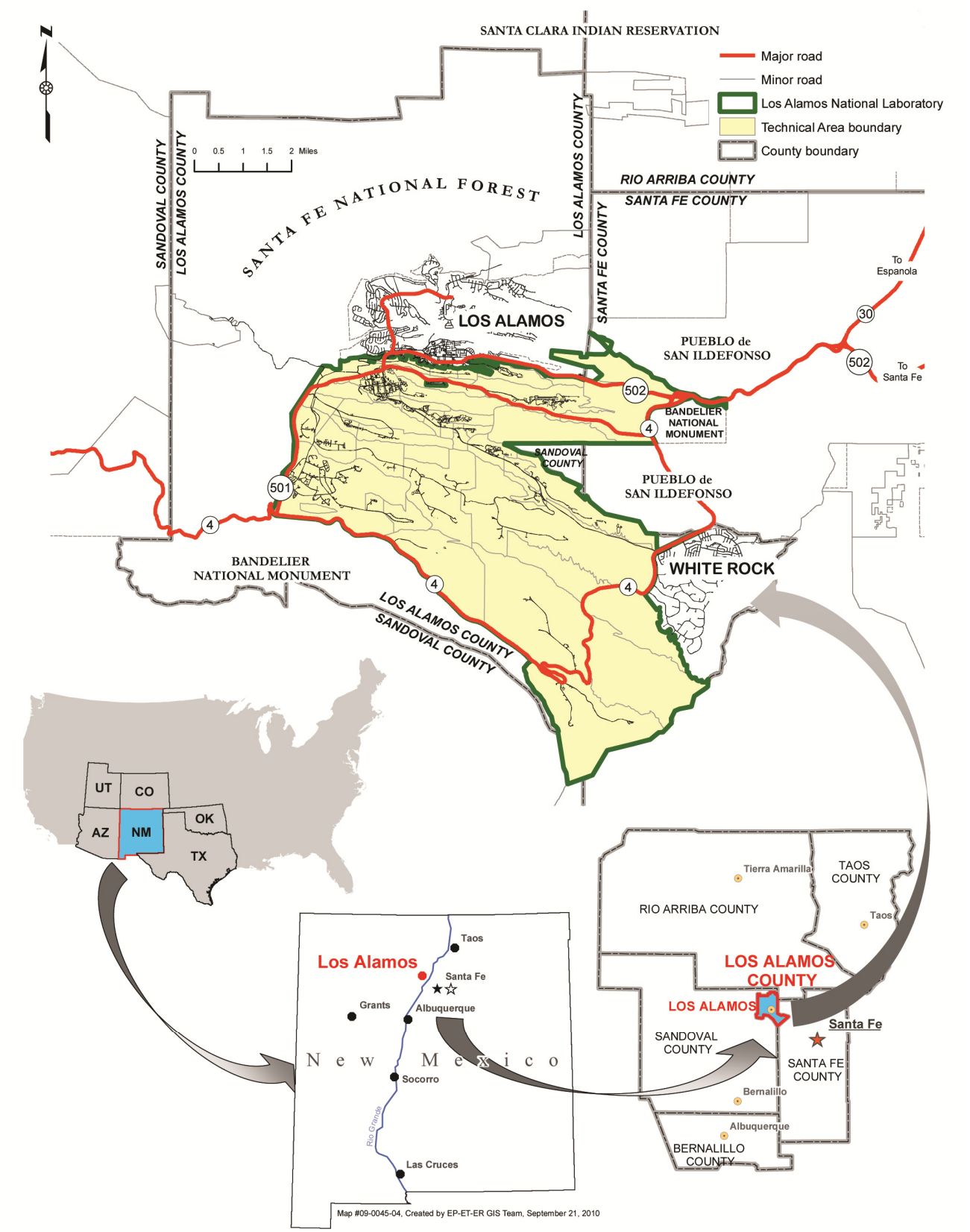

Figure ES-1 Regional location of Los Alamos National Laboratory

Environmental Protection Programs

The Department of Energy (DOE) has established a series of Orders directing each DOE site to implement sound stewardship practices that are protective of natural and cultural resources. These Orders require the implementation of an Environmental Management System (EMS), a Site Sustainability Plan, Radiation Protection of the Public, and Radioactive Waste Management.

As part of its commitment to protect the environment and improve its environmental performance, LANL continued the implementation of its EMS pursuant to DOE Order 450.1A and the international standard ISO14000-2004. The EMS is a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals. Three audits of the LANL EMS occurred in 2010; no significant corrective actions were identified.

- LANL met six high-level environmental stewardship goals
- LANL met six of seven waste reduction goals.
- LANL won six NNSA Pollution Prevention Awards
- LANL published the first Site Sustainability Plan for energy, water, and transportation

LANL met six high-level environmental stewardship commitments during fiscal year (FY) 10.

- Increase public outreach events for environmental projects
- Maintain 98% and higher successful environmental program self-inspections
- Ensure compliant implementation of waste and air quality permits
- Improve transuranic (TRU) waste shipments to the Waste Isolation Pilot Plant (WIPP)
- Complete funded New Mexico Environment Department's (NMED's) Compliance Order on Consent (Consent Order) deliverables
- Implement a program for assuring that wastes are managed prior to employee departure from LANL and a chemical pharmacy that allows chemical users to purchase the exact amount of chemicals required to reduce chemical waste generation.

LANL FY10 waste generation was reduced over FY09 in all waste categories with the exception of routine hazardous waste.

The Pollution Prevention Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risk to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions. LANL was awarded six NNSA awards in 2010:

- Video Teleconferencing Cuts Travel Costs and Reduces Greenhouse Gas Emissions
- Sustainable Projects for a Sustainable Future
- Sigma Electroplating Discharge Reduction
- Integration of Site Sustainability Plan Goals and LANL's EMS
- New Plutonium Removal Technique Means Less Waste
- LANL Algal Biofuels Consortium Development Team

LANL published the first Site Sustainability Plan in 2010. This plan sets energy, transportation, and water stewardship goals to assure that LANL can maintain its mission activities in a sustainable manner. During FY10, the Laboratory met milestones for the Sanitary Effluent Reclamation Facility (SERF) expansion, purchased renewable energy credits, reduced fleet petroleum consumption, and installed water and electricity metering at individual buildings.

The Laboratory met all DOE public and biota dose limits, As Low As Reasonably Achievable (ALARA) assessments, and clearance of real and personal property requirements during 2010.

DOE approved Laboratory operations to generate, treat, or dispose of radioactive waste during 2010. LANL generated, processed, and disposed of approximately 25,000 m^3 of low-level waste during 2010; approximately 10% was buried at Technical Area (TA)-54, Area G, and the remaining wastes were shipped off site for disposal. The Laboratory shipped 723 m^3 of TRU waste to WIPP during calendar year 2010 (Figure ES-2). DOE and LANL have set 2015 as the goal to complete the shipment of all stored TRU waste from Los Alamos to WIPP.

Figure ES-2 TRU waste shipping profile

Compliance with State and Federal Regulations

The Environmental Protection Agency (EPA) and NMED regulate Laboratory operations under various environmental statutes (e.g. Clean Air Act, Clean Water Act, etc.) through operating permits, construction approvals, and the DOE/NMED Consent Order. These permits are designed by the regulatory agencies to allow Laboratory operations to be conducted while assuring that the public, air, land, soils, water, and biota are protected. The Laboratory's compliance performance is an assessment of our protection of the environment. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations for 2010.

- NMED renewed the LANL RCRA Hazardous Waste Facility Permit.
- EPA issued the Individual Permit for storm water discharges from Solid Waste Management Units (SWMUS) and Areas of Concern (AOCs).

NMED renewed the Laboratory's RCRA Hazardous Waste Facility Permit in November 2010 and the EPA issued the Individual Permit for storm water discharges from Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs). The Laboratory submitted Groundwater Discharge Permit applications to NMED for the TA-46 Sanitary Waste Water System and the Domestic Septic Tank/Leachfield Systems in 2010.

Compliance Order on Consent

The March 2005 Consent Order between LANL, DOE, and NMED is the principal regulatory driver for LANL's environmental restoration programs. The Consent Order contains requirements for investigation and cleanup of SWMUs and AOCs 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 2010. The projects wrote and/or revised 22 work plans and 37 reports and submitted them to NMED. A total of 220 documents or reports were submitted to NMED. LANL installed two groundwater monitoring wells (with three screens) in the perched/intermediate aquifer and 12 groundwater monitoring wells (with 20 screens) in the regional aquifer to support Consent Order characterization and remediation activities.

- The Consent Order governs the Laboratory's environmental restoration. It specifies actions that the Laboratory must complete to characterize and remediate contaminated sites.
- The Laboratory met all 2010 Consent Order deliverables.

Table ES-1

Environmental Permits or Approvals under which the Laboratory Operated during 2010

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Permit	Hazardous Waste Facility Permit: Permitted hazardous waste storage units: TAs-3, -50, -54, and -55	November 1989, renewed November 2010	December 2020	NMED[b]
	40 CFR 265 Standards: Interim Status hazardous waste storage and treatment facilities: TAs-14, -16, -36, -39, and -54. Permit applications to be submitted to NMED.	Post-1980 hazardous waste units; Post-1991 mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring; revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised June 18, 2008	September 20, 2015	NMED
CWA[d]/NPDES[e]	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012	EPA[f]
	MSGP[g] for the discharge of storm water from industrial activities	September 29, 2008	September 29, 2013	EPA
	NPDES Individual Permit for storm water discharges from SWMUs and AOCs	November 1, 2010	March 31, 2014	EPA
	Construction General Permits (17) for the discharge of storm water from construction activities	June 30, 2008	July 31, 2011 (proposed extension until January 31, 2012)	EPA
CWA Sections 404/401	COE[h] Nationwide Permits (four)	NA	NA	COE/NMED
Groundwater Discharge Permit , TA-46 SWWS[i] Plant	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998 Renewal application submitted on July 2, 2010	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 Tank/Leachfield Systems	Discharge to groundwater	Submitted April 27, 2006 Application resubmitted on June 25, 2010	Approval pending	NMED

Table ES-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC[j])	LANL air emissions Renewal 1	August 7, 2009	August 7, 2014	NMED
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	Retired and removed from operating permit	June 15, 2006		
	Permit number will remain active to track exempt sources at LANL			
	TA-3 Power Plant	September 27, 2000	None	NMED
	Permit revision	November 26, 2003		
	Permit modification 1, Revision 1	July 30, 2004		
	Permit modification 1, Revision 2	March 5, 2009		
	1600-kW generator at TA-33	October 10, 2002	None	NMED
	Permit revision	May 28, 2008	None	NMED
	Two 20-kW generators and one 225-kW generator at TA-33	August 8, 2007	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Permit revision	September 12, 2006	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement (CMRR), Radiological Laboratory, Utility, Office Building (RLUOB)	September 16, 2005	None	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

[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

* Permit was administratively continued though 2010

The status of Consent Order investigations and remediations is presented in Figure ES-3. For those aggregate areas presented as complete, all investigation activities have been completed, and no additional field sampling campaigns, investigation reports, or corrective measures activities are anticipated. Aggregate areas listed as in progress include sites or areas where field sampling campaigns or corrective measure activities are currently being conducted, or investigation reports are being prepared or finalized. Aggregate areas listed as pending include sites or areas where work plan preparation and field sampling campaigns have not yet started. As of December 2010, scheduled investigation activities are complete at six aggregate areas, are in progress at 21 aggregate areas, and are pending at two aggregate areas. NMED granted Certificates of Completion for 34 SWMUs and AOCs in 2010.

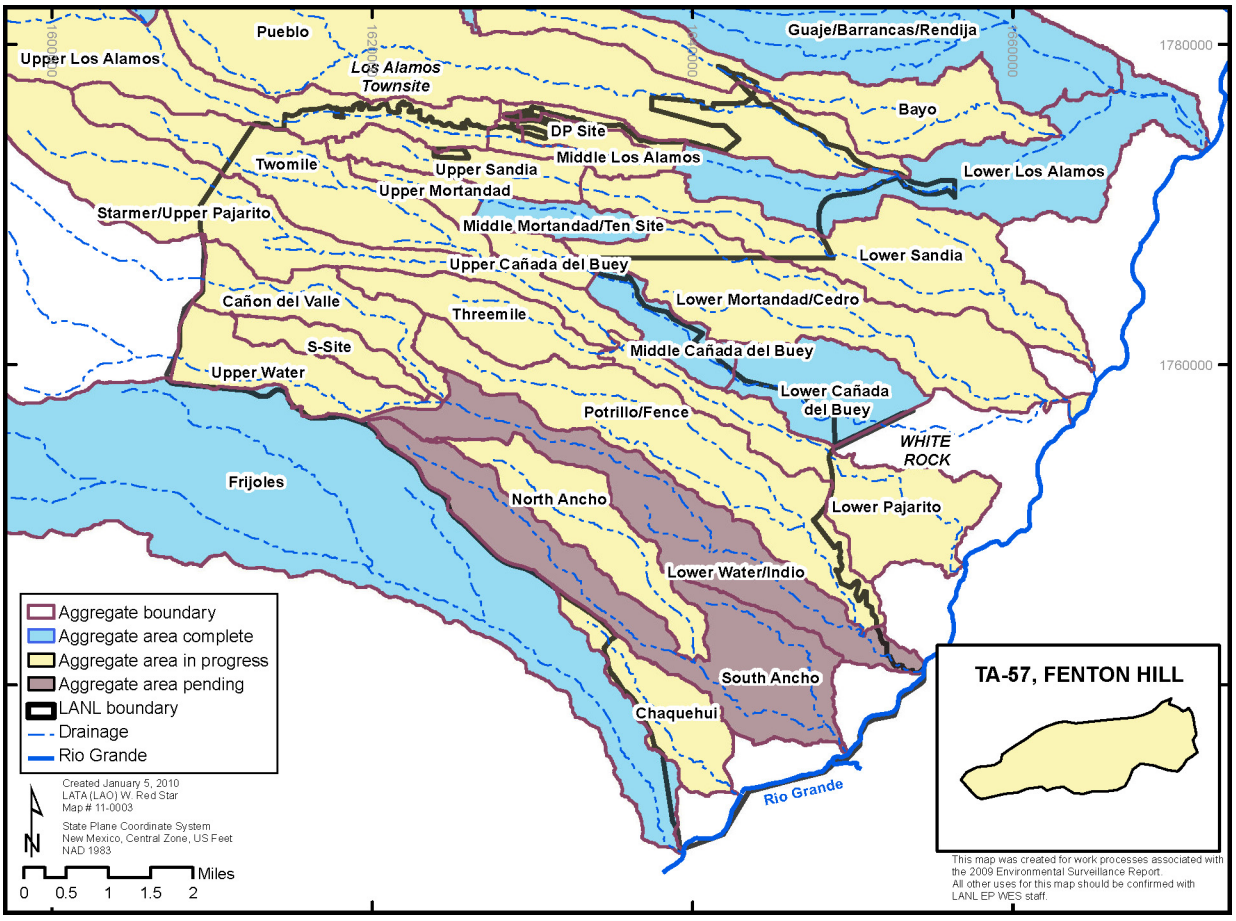

Figure ES-3 Aggregate areas as defined for the NMED Consent Order and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending.

In November 2010, EPA Region 6 issued an Individual Permit (IP) that authorizes discharges of storm water from certain Potential Release Sites (PRSs), SWMUs, and AOCs at the Laboratory. The sites listed in the IP are associated with historical LANL operations dating back to the Manhattan Project era of the 1940s. The IP lists 405 permitted sites that must be managed to prevent the transport of contaminants off site via storm water runoff.

Site-specific storm water control measures that reflect best industry practice considering their technological availability, economic achievability and practicability are required for each of the 405 permitted sites to minimize or eliminate discharges of pollutants. These controls are referred to as Best Management Practices (BMPs).

The local storm water drainage around sites (called Site Monitoring Areas [SMAs]) has been hydrologically analyzed, and sampling locations have been identified to most effectively sample runoff from sites.

Stormwater is monitored from these SMAs to determine the effectiveness of the controls. When target action levels (TALs) which are based on New Mexico water quality standards, are exceeded, corrective actions are required. In 2010, the Laboratory completed the following tasks:

- Development of a Site Discharge Pollution Prevention Plan (SDPPP) for SWMU/AOCs that describes three main objectives: identification of pollutant sources, description of control measures and monitoring that determines the effectiveness of controls at all regulated SWMU/AOCs
- Fieldwork:
  - ❖ Completed more than 1,000 rain event inspections conducted on all 250 SMAs
  - ❖ Conducted BMP maintenance during inspection at 140 SMAs
  - ❖ Conducted BMP installation at 205 SMAs
  - ❖ Maintained 45 gauge stations for storm event sampling in support of environmental surveillance and Los Alamos/Pueblo canyon monitoring
  - ❖ Decommissioned/removed sampler and equipment at 45 previous Federal Facilities Compliance Agreement (FFCA) locations

Unplanned Releases

There were no unplanned airborne releases and no unplanned releases of radioactive liquids from LANL in 2010. There were 23 spills or releases of non-radioactive liquids, most of which were potable water, hydraulic fluid, or domestic wastewater. Other liquids included re-use water, steam condensate, and sanitary wastewater. LANL reported all liquid releases to NMED; the releases will be administratively closed upon final inspection.

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-4 shows doses to the hypothetical maximally exposed individual (MEI) via the air pathway over the last 10 years at an off-site location; this location was at LA Inn South in 2010. The annual dose to the MEI for the airborne pathway was approximately 0.33 mrem, similar to the previous four years, and well under the regulatory limit of 10 mrem (Figure ES-4). During 2010, the population within 80 km of LANL received a collective dose of about 0.22 person-rem, down from 0.57 person-rem in 2009. The doses received in 2010 from LANL operations by an average Los Alamos residence and an average White Rock residence were less than 0.1 mrem at each location. The maximum all-pathways dose, composed almost entirely of direct radiation from waste stored at TA-54, Area G, could result in an exposure of 0.9 mrem per year to a hypothetical individual in the adjacent sacred area of Pueblo de San Ildefonso. Doses were also calculated for members of the public who hike on LANL property or areas previously impacted by LANL effluents: Acid Canyon, Pueblo Canyon, lower Ancho Canyon, and along the Rio Grande. All doses were calculated to be less than 0.1 mrem.

- ❖ Radiation dose in 2010 to the MEI was similar to the very low-level dose calculated in 2009.
- ❖ The location of the hypothetical MEI for airborne radionuclides was determined to be at the LA Inn South in downtown Los Alamos. This location received low levels of radiation from resuspension of contaminated soils in Los Alamos Canyon.

Table ES-2
Sources of Radiological Doses

Source	Recipient	Dose	Location	Trends
Background (includes human-made sources)	Humans	~700 mrem/yr*	Not applicable	Not applicable
Air	Humans	0.33 mrem/yr	LA Inn South in downtown Los Alamos	Similar to very low level in previous four years
Direct radiation	Humans	0.9 mrem/yr	LANL-San Ildefonso boundary	Similar to previous years
Food	Humans	< 0.1 mrem/yr	All sites	Steady
Drinking water	Humans	< 0.1 mrem/yr	All sites	Steady
All	Terrestrial animals	< 0.01 rad/day	All sites	Steady
All	Terrestrial plants	< 0.1 rad/day	All sites	Steady

* Increased from previous years due to new information about average medical doses.

Biota Dose

The DOE biota dose limits are intended to protect populations of plants and animals, especially with respect to preventing the impairment of reproductive capability within the biota population. All radionuclide concentrations in vegetation sampled were far below the 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) (Table ES-2).

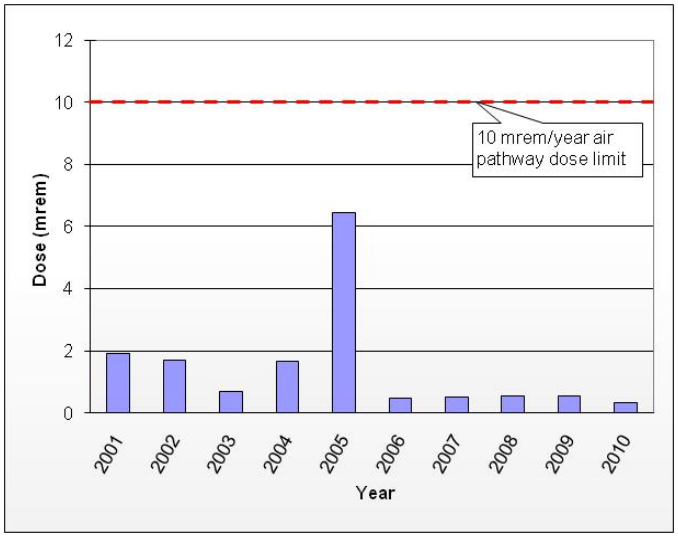

Figure ES-4 **Annual airborne pathway dose (mrem) to the off-site MEI over the past 10 years. The 2010 location of the calculated MEI is at the southern edge of the Los Alamos townsite, on the edge of Los Alamos Canyon.**

Radiological Air Emissions

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, (3) tritium, and (4) gaseous air activation products (radioactive elements created by the Los Alamos Neutron Science Center [LANSCE] particle accelerator beam). In addition, the Laboratory collects 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 isotopes of plutonium, americium, uranium, and tritium.

LANL monitored 28 stacks for emissions of radioactive material to the ambient air in 2010. Total stack emissions during 2010 were approximately 298 curies (Ci), a decrease from 800 Ci in 2009, Short-lived air activation products from LANSCE stacks and diffuse emissions contributed 211 Ci of the total. Most of the curies from LANSCE are from very short-lived radionuclides that decay significantly before reaching the LANL site boundary. Tritium emissions composed about 87 Ci of the total. Combined airborne emissions of other radionuclides, such as plutonium, uranium, americium, and thorium, were less than 0.000020 Ci and emissions of particulate/vapor activation products were 0.016 Ci.

- As in previous years, there were no detections of radionuclides above background at Pueblo de San Ildefonso and regional locations.
- The largest off-site ambient air measurements of radionuclides occurred adjacent to the environmental restoration work at TA-21, MDA B. These concentrations were less than 9% of the EPA 10-mrem public dose limit.

Radionuclide concentrations in ambient air samples in 2010 were generally comparable with concentrations in prior years. As in past years, the AIRNET system detected slightly elevated radionuclides from known areas of contamination and active environmental remediation sites. At regional locations away from Los Alamos, all air sample measurements were consistent with background levels. Annual mean radionuclide concentrations at all LANL perimeter stations were less than 9% of the EPA dose limit for the public. Measurable amounts of tritium were reported at a number of on-site locations and at perimeter locations. The highest off-site tritium concentration was 0.2% of the EPA public dose limit. The highest on-site tritium measurement (less than 3% of the DOE limit for worker exposure) was made at Area G near disposal shafts containing tritium-contaminated waste. Environmental restoration work at TA-21, material disposal area (MDA) B, produced higher plutonium-239/240 concentrations at perimeter locations and at decontamination and demolition (D&D) locations during 2010 than in previous years. Maximum concentrations were less than 9% of the EPA dose limit for the public. The maximum annual uranium concentrations were from natural uranium at locations with high dust levels from local soil disturbances. There were three detections of enriched uranium (near the environmental restoration work at TA-21, MDA B) and two likely detections of depleted uranium (which has lower radioactivity than natural uranium).

Non-Radiological Air Emissions and Air Quality

LANL demonstrated full compliance with all Clean Air Act monitoring and reporting requirements. Emissions of criteria pollutants (nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter, volatile organic compounds, and hazardous air pollutants) were similar to the previous five years. The TA-3 power plant and boilers located across the Laboratory were the major contributors of nitrogen oxides, carbon monoxide, and particulate matter. Science research and development activities were responsible for most of the volatile organic compound and hazardous air pollutant emissions. In 2010, LANL provided the second greenhouse gas emissions report to NMED, as required by state regulation. The 2009 emissions of carbon dioxide (reported in 2010) were approximately 56,426 metric tons of carbon dioxide equivalents from the combustion of fossil fuels. During 2010, LANL removed more than 5,900 pounds of ozone-depleting refrigerants from the active inventory.

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 one Los Alamos location. The annual averages at both locations for PM-10 was about 13 micrograms (μg)/m^3 and about 6 μg/m^3 for PM-2.5 and were mostly caused by natural dust and wildfire smoke. In addition, the 24-hour maxima for both PM-10 and PM-2.5 at both locations did not exceed 40% and 55% of the respective EPA standards.

The Laboratory analyzed air filter samples from 38 sites for beryllium, aluminum, and calcium. These sites are located near potential beryllium sources at LANL and in nearby communities. All concentrations measured this year were at or below 2% of the National Emission Standards for Hazardous Air Pollutants standard of 10 ng/m^3 and were similar to those of recent years. Past studies closely correlated beryllium concentrations with aluminum concentrations, which indicates that all measurements of beryllium are from naturally occurring beryllium in re-suspended dust. Aluminum and calcium are used to evaluate elevated uranium measurements and no unusual concentrations were measured.

Groundwater Monitoring

Groundwater at the Laboratory occurs as a regional aquifer (water-bearing rock capable of yielding significant quantities of water to wells and springs) at depths ranging from 600 to 1,200 feet 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-5). 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.

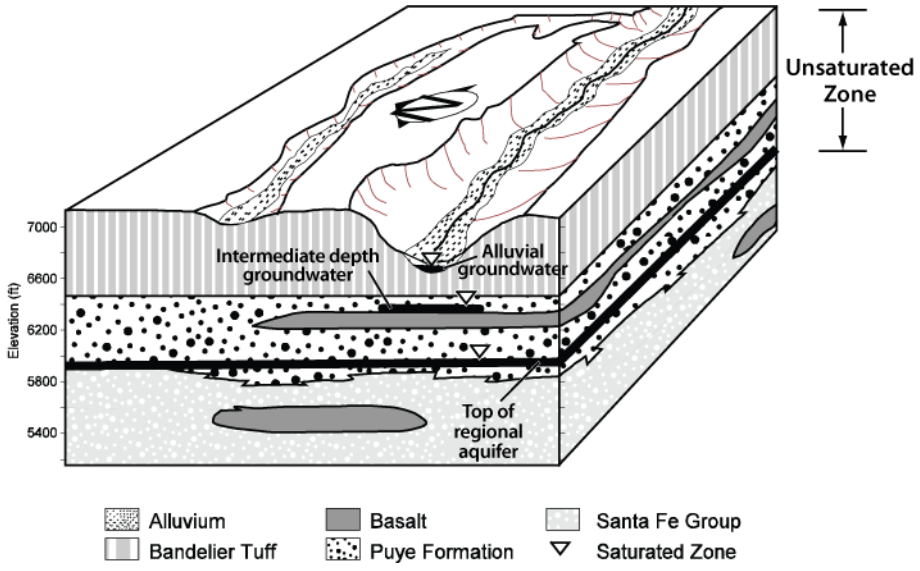

Figure ES-5 Three modes of groundwater occurrence

In 2010, LANL installed two perched intermediate groundwater monitoring wells and 12 regional aquifer monitoring wells. Eight regional wells were installed to monitor for potential contamination from MDAs in TA-54 and to support Corrective Measures Evaluation (CME) reports for MDAs at TA-54. Two regional wells were installed downgradient of TA-49 and MDA-AB. One regional well was installed east of TA-74 to monitor for potential contamination near the municipal production well Otowi 1. One regional well was installed in Mortandad Canyon as part of the ongoing chromium investigation. One intermediate well was installed as a hydrologic test well to support the TA-16 260 Outfall corrective measures implementation.

The Laboratory has changed groundwater quality through liquid effluent disposal, with the greatest impact on alluvial groundwater. Laboratory contaminants have also affected the intermediate perched zones and the regional aquifer. 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 and impacts on the regional aquifer are reduced.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 12 active) and the volume of water released (by 80%). From 1993 to 1997, total estimated average release was 1,300 million (M) gal./yr. Flow decreased to 230 M gal./yr from 1998 to 2005 and was 141 M gal./yr in 2010. Major upgrades to the TA-50 Radioactive Liquid Waste Facility (RLWTF) in 1999 through 2002 brought effluents into compliance with standards for radionuclides and constituents regulated under NPDES and NM groundwater discharge permits. Alluvial groundwater quality in Mortandad Canyon has improved due to these project improvements. The Laboratory uses federal and state drinking water and human health standards as "screening levels" to evaluate concentrations in all groundwater, even though many of these standards only apply to drinking water.

Where Laboratory contaminants are found in deep groundwater, the setting is either a canyon where alluvial groundwater is usually present (because of natural runoff or Laboratory effluents) or a location where large amounts of liquid effluent have been discharged (e.g., Mortandad Canyon and upper Sandia Canyon). During 2010, LANL received and evaluated 153,000 analytical results for groundwater samples from wells and springs. Table ES-3 summarizes contaminants detected in portions of the groundwater system.

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

Chemical	On-Site	Off-Site	Significance	Trends
Chromium	Regional aquifer in Mortandad Canyon, intermediate groundwater in Mortandad and Sandia Canyons	No	Found in regional aquifer above groundwater standards; not affecting drinking water supply wells; source eliminated in 1972.	Increasing in Mortandad intermediate groundwater. Fairly steady over five years at other locations in Mortandad and Sandia canyons' intermediate and regional groundwater
Nitrate	Intermediate groundwater in Pueblo and Mortandad canyons, and regional groundwater in Sandia Canyon and Mortandad Canyon	Pueblo and Los Alamos Canyons	In Pueblo Canyon, may be due to Los Alamos County's Sewage Treatment Plant; otherwise due to past effluent discharges. TA-50 RLWTF effluents have met discharge limits since 2000.	Generally variable in Pueblo, steady in Sandia, decreasing in Mortandad Canyon
Perchlorate	Alluvial, intermediate, and regional groundwater in Mortandad Canyon; intermediate in Los Alamos Canyon; regional aquifer in Pueblo Canyon	Pueblo Canyon	Reflects past outfall discharges that have ceased	Decreasing in Mortandad Canyon alluvial groundwater due to effluent quality improvement; increasing at one location in the regional aquifer in Mortandad Canyon
Dioxane[1,4-]	Intermediate groundwater in Los Alamos, Mortandad, and Pajarito Canyons	No	Not used as drinking water supply; limited in extent	Fairly steady or decreasing concentrations over five years in Los Alamos and Mortandad; seasonal variation in Pajarito
Trichloroethane [1,1,1-]; dichloroethene[1,1-]	Intermediate groundwater near main warehouse	No	Not used as drinking water supply; limited in extent	Seasonally variable, undergoing corrective action
RDX	Alluvial and intermediate groundwater in Cañon de Valle, intermediate groundwater in Pajarito Canyon	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations. In the regional aquifer in Pajarito Canyon, values are below standards, but increasing at one location.
Barium	Alluvial groundwater in Cañon de Valle and Pajarito and Mortandad Canyons	No	Not used as drinking water supply; limited in extent	Generally stable in Cañon de Valle, in others likely due to cation-exchange caused by road salt
Boron	Intermediate groundwater in Cañon de Valle	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Tetrachloroethene, trichloroethene	Alluvial and intermediate groundwater in Cañon de Valle	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Strontium-90	Alluvial groundwater in Los Alamos and Mortandad canyons	No	Not used as a drinking water supply; has not penetrated to deeper groundwater. TA-50 RLWTF effluent discharges decreased since 2000.	Mainly fixed in location; some decrease due to effluent quality improvement
Fluoride	Alluvial groundwater in Los Alamos and Mortandad canyons. Intermediate groundwater in Pueblo and Los Alamos canyons. Regional aquifer in Pueblo Canyon	Pueblo Canyon	Result of past effluent releases; not affecting drinking water supply wells	In alluvium, slow decrease in concentration due to effluent quality improvement

Table ES-3 (continued)

Chemical	On-Site	Off-Site	Significance	Trends
Chloride, total dissolved solids	Alluvial groundwater in Pueblo, Los Alamos, Sandia, Mortandad, Pajarito canyons, intermediate groundwater near TA-3 main warehouse	Pueblo Canyon	Due to road salt in snowmelt runoff	Values generally highest in winter or spring samples
Fluoride, uranium, nitrate, total dissolved solids	No	Pine Rock Spring, Pueblo de San Ildefonso	Water quality apparently affected by irrigation with sanitary effluent at Overlook Park	Steady over several years

The Laboratory has detected hexavalent chromium in several regional aquifer monitoring wells: at up to 20 times above the NM groundwater standard in Mortandad Canyon and at 50% of the standard in nearby Sandia Canyon. Samples from an intermediate well in Sandia Canyon contain chromium at 10 times the standard and support a path for the chromium contamination from beneath Sandia Canyon southward to the regional aquifer below Mortandad Canyon. The Phase II Investigation Report for Sandia Canyon will be submitted to NMED in 2012; Corrective Measures Evaluations will be developed following NMED approval of this report.

- LANL continues to investigate the hexavalent chromium found at up to 20 times the NM groundwater standard in the regional aquifer under Mortandad Canyon and nearby Sandia Canyon. One new regional well north of the LANL/Pueblo de San Ildefonso boundary measured chromium above the NM groundwater standard.
- One regional well was installed in Mortandad Canyon as part of the ongoing chromium investigation.

Concentrations of chloride above one half of groundwater standards are present in alluvial groundwater in Pueblo, Los Alamos, Sandia, Mortandad, and Pajarito canyons, and in the intermediate groundwater near TA-3 main warehouse. The source is runoff from road salting during the winter months.

Nitrate was up to 60% of the NM groundwater standard in Sandia Canyon and Mortandad Canyon regional aquifer monitoring wells. Intermediate groundwater concentrations of nitrate have decreased below the groundwater standard in Mortandad Canyon. Intermediate groundwater concentrations of nitrate are about 50% of the groundwater standard in Pueblo and Lower Los Alamos canyons.

Perchlorate is detected in most groundwater samples analyzed across northern NM. Naturally occurring perchlorate concentrations range from about 0.1 µg/L to 1.8 µg/L. One unused drinking water well in the Los Alamos area has been impacted by past Laboratory discharges of perchlorate. During 2010, perchlorate concentrations in Well O-1 in Pueblo Canyon dropped to 1.3 µg/L. Perchlorate is above the 4 µg/L Consent Order screening level at a nearby regional aquifer Pueblo Canyon well, but below the EPA interim health advisory of 15 µg/L. Perchlorate concentrations in Mortandad intermediate groundwater wells are above the EPA screening level but have been decreasing over the past five years. Concentrations are also above the Consent Order screening level in the regional aquifer below Mortandad Canyon and have increased over the past four years.

Following well rehabilitation activities in 2008, trichloroethene was detected at 1,147 feet in Pajarito Canyon regional aquifer monitoring well R-20. Trichloroethene detections have continued for five consecutive sample events through the end of 2010. The concentrations have dropped from 60% to less than 20% of the 5 µg/L EPA screening level in 2010. The source has not been determined.

- Beginning in late 2008, trichloroethene was detected in Pajarito Canyon regional aquifer monitoring well R-20 for five consecutive sample events through the end of 2010. The concentrations have decreased from 60% to less than 20% of the 5 µg/L EPA screening level.

The intermediate groundwater in various locations shows localized levels of tritium, organic chemicals (RDX, chlorinated solvents, dioxane[1,4-]), and inorganic chemicals (hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate) from Laboratory operations. A series of actions began in 2009 to implement corrective measures for high explosives and barium at the 260 Outfall at TA-16, including soil removal and installing a permeable reactive barrier. Monitoring of the effectiveness of corrective measures will be reported in the 2011 environmental report,

The total radionuclide activity from LANL discharges exceeded the dose limit that is applicable to drinking water (4 mrem/yr) only in the alluvial groundwater in portions of Mortandad and DP/Los Alamos canyons. This is mainly due to the presence of strontium-90. Because strontium-90 bonds tightly to sediments, the contamination is not moving downward from the alluvial system. In addition, the TA-50 RLWTF discharges have been less than the 100 mrem/yr DOE public dose limits since the mid 1990s.

The Laboratory monitors springs in White Rock canyon as a principal discharge of regional aquifer groundwater that flows underneath the Laboratory. Naturally occurring levels of uranium, perchlorate, and arsenic are present in some springs. Similar results are found in samples from Pueblo de San Ildefonso wells.

Laboratory surveillance monitoring of the Los Alamos County drinking water system and the Santa Fe Buckman well field demonstrate no impact from LANL contaminants.

Watershed Monitoring

Watersheds that drain LANL property are dry for most of the year. Of the more than 80 miles of watercourse, approximately three miles are naturally perennial and approximately four miles are perennial water created by effluent discharges (most notably in upper Sandia Canyon). Snowmelt runoff originating in the Jemez Mountains can extend across the Laboratory to the Rio Grande. Storm water runoff transporting sediment can leave the Laboratory boundary, but is short-lived. The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water.

- The overall quality of most surface water within the Los Alamos area is very good.
- Of the more than 100 analytes measured in watersheds across LANL, 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.

None of the streams within the Laboratory boundary average more than one cubic foot 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. The largest flows in 2010 occurred on August 16, with a total estimated mean daily flow of 25 cfs entering the Rio Grande from the Los Alamos Canyon watershed. By comparison, the average daily flow in the Rio Grande at Otowi Bridge on August 16 was 1,060 cfs.

Snowmelt runoff, estimated to be 185 acre-feet (ac-ft), crossed the eastern Laboratory boundary in Los Alamos Canyon continuously in April and May. Total storm water runoff at downstream gages in the canyons leaving the Laboratory is estimated at about 42 ac-ft, approximately 92% of this occurring in Los Alamos and Pueblo Canyons and 7% in Cañada del Buey above White Rock. In addition, approximately 4 acre-feet of effluent released from the Los Alamos County wastewater treatment plant is estimated to have passed the eastern LANL boundary in Pueblo Canyon.

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 standards and screening levels. However, nearly every major watershed indicates some effect from Laboratory operations, often for just a few analytes. Table ES-4 lists the locations of Laboratory-impacted surface water. All radionuclide levels are well below applicable guidelines or standards.

Table ES-4
LANL Impacts on Surface Water that Result in Values Near or Above Screening Levels

LANL Impact	On-Site	Off-Site	Significance	Trends
Specific radionuclides (e.g., Pu-239/240, Sr-90, and Cs-137)	No	No	No LANL-derived radionuclides exceeded DOE biota concentration guides or derived concentration guidelines in 2010	Steady
Gross alpha radioactivity	Pueblo, Los Alamos, Sandia, Mortandad, Pajarito, and Water Canyons.	Yes, including canyons not affected by LANL	56% of storm water results from 2010 greater than New Mexico Water Quality Control Commission (NMWQCC) standards. Major source is naturally occurring radioactivity in sediments, except in Mortandad, Pueblo, and Los Alamos Canyons where there are LANL contributions	Steady
Chromium	Mortandad Canyon	No	Single result above standard	Steady
Copper	Mortandad and Sandia Canyons	No	Copper was elevated in 2010 at a few sites that receive runoff from developed areas, including TA-3 and the Los Alamos town site	Steady
Mercury	Los Alamos Canyon	No	Two results above standard	Steady
Zinc	Los Alamos and Sandia Canyons	No	Zinc was above standards at two locations with small drainage areas receiving runoff from paved roads and other developed areas	
Polychlorinated biphenyls (PCBs)	Los Alamos, Mortandad, and Sandia Canyons	Yes, including canyons not affected by LANL	Above standards. PCBs have been released by historic LANL discharges and from runoff from developed areas, including the Los Alamos town site. PCBs are also found in background areas on Santa Fe National Forest land, resulting from regional atmospheric fallout	Steady

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 during short periods of intense flow. In some cases, sediment contamination is present from Laboratory operations conducted more than 50 years ago. However, all measured sediment contaminant levels are below screening levels for recreational uses.

Consistent with previous years, many surface water samples in 2010 had gross alpha radiation greater than the surface water standard of 15 pCi/L for livestock watering. Laboratory impacts are relatively small and the majority of the alpha radiation in surface water on the plateau is due to the decay of naturally occurring isotopes in sediment and soil carried in storm water runoff from uncontaminated areas. This is supported by the generally positive correlation between gross alpha radiation and suspended sediment in non-filtered surface water samples.

Highest concentrations of radionuclides from Laboratory sources were measured in surface water samples from Acid, DP, Los Alamos, and Mortandad canyons downstream from facilities that have released radioactive effluents. Concentrations are highest near historic discharges points and directly above the Los Alamos Canyon weir; concentrations decrease below the Los Alamos Canyon weir. Concentrations were similar to previous years, and no values exceeded the DOE biota concentrations guides.

Eight radionuclides in sediment were detected above background concentrations in 2010: americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, uranium-235, and uranium-238. The maximum values for seven radionuclides were found in the Mortandad Canyon stream channel or in the Los Alamos Canyon sediment retention basins. The highest plutonium-239/240

- The highest concentrations of LANL-derived radionuclides in surface water samples were measured in Acid, DP, Los Alamos, and Mortandad Canyons. All measurements are consistent with previous years and are below screening levels.
- The highest concentrations of radionuclides in sediment were obtained from several locations in Acid, Los Alamos, and Mortandad canyons below present and former outfalls. Results and are consistent with previous years.

result occurred in the Acid Canyon stream channel below historic discharges from TA-1 and TA-45, consistent with previous years.

Seven inorganic chemicals from Laboratory sources, including runoff from developed areas, were detected above NMWQCC standards: arsenic, cadmium, chromium, copper, mercury, selenium, and zinc. The concentrations above standards resulted from 5% or less of the total number samples. Arsenic, cadmium, copper and zinc are only above standards in drainages that receive runoff from developed areas, including TA-3 and the Los Alamos town site.

Metals and other inorganic chemicals are found in sediments at concentrations above typical background levels in 3% to 16% of samples collected during 2010. These constituents partially represent historic discharges from Laboratory outfalls in Los Alamos, Sandia, and Mortandad canyons. Runoff from developed areas at the Laboratory and the Los Alamos town site also contribute to sediment concentrations of cadmium, copper, lead, manganese, selenium, and zinc. Some of the results also represent naturally elevated concentrations.

High explosives were detected in surface water samples from Cañon de Valle, downstream from a high explosive machining facility at TA-16. Concentrations were less than standards. These results are consistent with previous years. Corrective measures were implemented to address this high explosive contamination in 2009 and 2010.

PCBs were detected above the human health and wildlife standards in surface water in Los Alamos, Sandia, Mortandad, and Pajarito canyons. These results are consistent with previous years. PCBs were also measured above the screening level in runoff from developed areas, including the Los Alamos town site, and in background areas, such as Cañada de los Latas north of Los Alamos. The PCBs in background areas are derived from regional atmospheric fallout. In 2010, LANL constructed two grade control structures in DP and Pueblo Canyons to stabilize sediments in place and reduce the transport of PCBs in storm water in Los Alamos and Pueblo Canyons. Monitoring results show no measurable levels of PCBs from LANL in the Rio Grande.

- PCBs are measured in storm water in Los Alamos, Sandia, Mortandad, and Pajarito canyons above standards. PCBs are also detected above standards in runoff from the Los Alamos town site and in background areas, the latter derived from regional atmospheric fallout.
- LANL completed sediment control projects in Pueblo and DP canyons in 2010 to reduce the transport of contaminated sediments.
- The flux of LANL-contaminated sediments into the Rio Grande is small.

We obtained PCB congener data from sediment samples in Laboratory canyons and along the Rio Grande during 2010. Consistent with data from 2009, the mixtures of PCB congeners upriver and downriver from LANL sources are essentially identical, but different than the PCB signature in LANL canyons. These congener data, therefore, show no measureable evidence of LANL contributions to PCBs along the Rio Grande. The PCB data from the Rio Grande were also combined with data on suspended sediment flux to estimate PCB flux in the river above LANL drainages. A preliminary estimate of PCB flux from Los Alamos Canyon is about 0.003 to 0.005 kg/yr, or 1% to 3% of the flux in the Rio Grande.

Soil Monitoring

LANL conducts large-scale soil sampling within and around the perimeter of LANL every three years. The most recent comprehensive soil survey was conducted in 2009. In general, results confirmed the results from previous sampling events and show on-site and perimeter areas contained radionuclides at very low (activity) concentrations, and most were either not detected or below regional statistical reference levels (RSRLs) (equal to the average plus three standard deviations). The few samples with radionuclide concentrations above the RSRLs were collected near known or expected areas of contamination. These samples are below industrial screening levels and thus do not pose a potential unacceptable dose to the public.

We also annually collect soil samples from two locations on the Pueblo de San Ildefonso land downwind of TA-54, Area G. Radionuclides and metals in the 2010 soil samples were below background or near background and were consistent with levels measured in previous years.

- Concentrations of radionuclides in soil samples from TA-54, Area G, are above background and less than industrial screening levels.
- Uranium concentrations in soils at DARHT have decreased since the Laboratory began conducting high explosives test shots in containment vessels in 2007.

The annual samples from around the perimeter of Area G contained above-background concentrations of tritium, americium-241, plutonium-238, and plutonium-239/240 at levels similar to those found in previous years. The highest levels of tritium around Area G were detected at the southern end, and the highest levels of the americium and plutonium were detected around the northern, northeastern, and eastern sections. Although americium-241, plutonium-238, and plutonium-239/240 in soil along the northern, northeastern, and eastern sections of Area G are slightly elevated, all levels are well below residential screening levels used to trigger investigations and decrease rapidly with distance from Area G.

The Laboratory began using containment vessels for high explosives testing in 2007 at the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility. Soil concentrations of uranium-238 near the firing point showed significantly lower levels than measured prior to 2009, and the concentrations are well below industrial screening levels. High explosives were not detected in any samples around DARHT.

In 2008, the NMED collected five soil samples from high-elevation areas (11,099 to 12,476 ft) in New Mexico and Colorado and provided them to LANL to determin the origin of the detected concentrations of cesium and plutonium activity. In the four samples from New Mexico, approximately 75% of the radionuclides were from global fallout from large thermonuclear atmospheric tests conducted by the United States and the former Soviet Union, and 25% of the radionuclides were from regional fallout from much smaller atmospheric nuclear tests conducted at the Nevada Test Site (NTS). No measurable contribution to the plutonium concentration from LANL operations could be detected.

Foodstuffs Monitoring

In 2010, we collected 107 fruit and vegetable samples from on-site, perimeter (including crops irrigated with Rio Grande waters), and regional background locations. In general, all radionuclides in all produce samples were very low and primarily not detected or below the RSRLs. The highest tritium concentrations were found in fruit samples from on-site locations near tritium processing and waste operations at TA-21 and TA-54, Area G. Results were similar in past years.

Goat milk from perimeter and regional locations was sampled and analyzed. No radionuclides that we analyzed for were detected, similar to previous years.

Chicken eggs from perimeter and regional locations were sampled and analyzed. No radionuclides that we analyzed for were detected or similar to RSRLs.

Honey from bee hives located at on-site, perimeter, and regional locations were sampled and analyzed. Radionuclides, with the exception of tritium at TA-54, were either not detected or similar to RSRLs. Tritium in honey from TA-54 is from Area G operations and is not sold or consumed by the public; it is solely maintained as an experimental hive and shows that honey bees can be used as effective environmental monitors.

Crayfish were collected from the Rio Grande in one reach above LANL and in another reach downstream of the confluence of Los Alamos Canyon and the Rio Grande; the goal was to increase the number of samples and analyses available for evaluation. All concentrations of inorganic and metal constituents in the edible portions of the crayfish in the downstream reach were similar to the crayfish sampled in the reach above LANL.

Two elk were killed in vehicle accidents on Laboratory property in 2010; one within TA-36 and another within TA-54. Muscle and bone tissues from the animals were collected for analysis. Uranium concentrations were above RSRLs, but far below screening levels. Other radionuclides, inorganic constituents, and PCBs were either not detected or below RSRLs, in agreement with previous years' results. Two road-kill deer were analyzed: one from TA-46 and one from State Road 4 on Pueblo de San Ildefonso property. All radionuclide concentrations in muscle and bone were similar to those collected from regional background locations.

Biota Monitoring

No wide-scale monitoring of biota was conducted in 2010. Sampling in 2009 and in previous years shows that, in general, all concentrations of radionuclides and inorganic constituents in vegetation are very low and indistinguishable from regional background levels.

At TA-54, Area G, all radionuclides, with the exception of tritium, in native overstory vegetation (branches and needles) were either not detected or below the RSRLs. Tritium is detected above RSRLs in vegetation collected on the south side of TA-54, Area G, near tritium waste disposal shafts. Results are well below screening levels and similar to previous years.

- Vegetation at Area G contained elevated levels of radionuclides near known sources but far below screening levels.
- Biota samples at DARHT contained depleted uranium, but the levels were lower than previous years because of new contained testing measures.
- Biota samples collected above the Los Alamos Canyon Weir contained slightly elevated levels of some radionuclides and PCBs, but the concentrations were far below screening levels.

In vegetation around the DARHT facility, concentrations of radionuclides and metals were either not detected or below RSRLS. Uranium concentrations are lower than in previous years because high explosives testing is now conducted in metal vessels instead of in the open. Concentrations of radionuclides in mice at DARHT were not elevated with the exception of uranium. Uranium concentrations were slightly above baseline levels. The isotopic distribution of uranium isotopes indicates that the type of uranium is depleted uranium, released in historic open-air high explosives tests. Bees contained slightly higher levels of aluminum, copper, vanadium, and lead than RSRLs, but the concentrations were far below ecological screening levels.

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2010 were compared with samples collected in 1999 (preoperational phase). The purpose of the bird monitoring project is to determine the general ecological stress levels around the vicinity of DARHT that may be associated with facility operations (e.g., noise, disturbance, traffic, etc.). The number of birds, number of bird species, diversity, and evenness (distribution) collected in 2010 are similar to those collected before the start-up of operations at DARHT in 1999. In general, there are a large number of birds and types of birds located in the vicinity of the DARHT complex (see Figure ES-6).

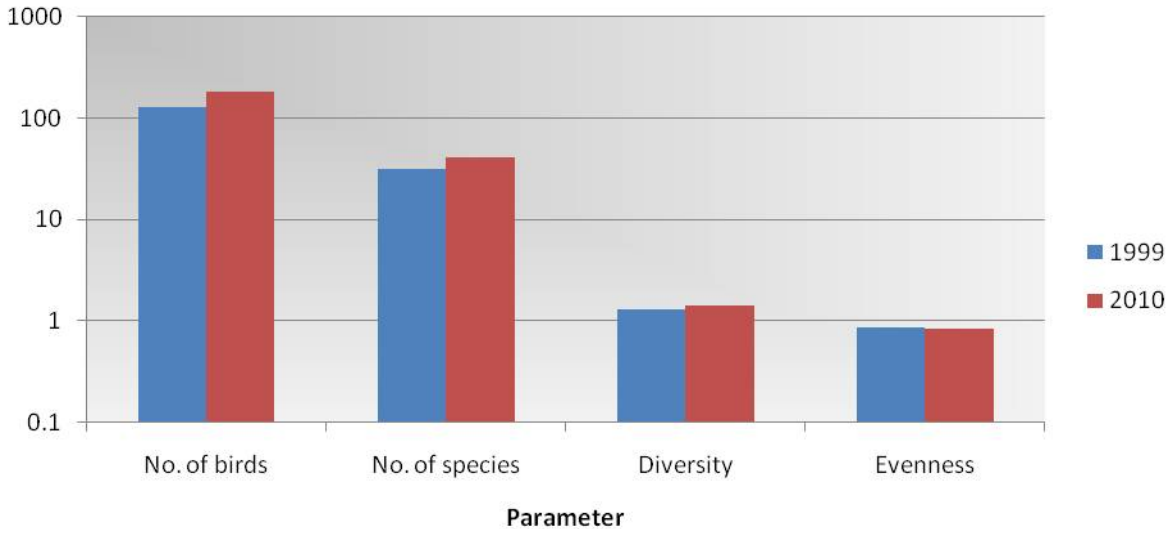

Figure ES-6 Populations, number of species, diversity, and evenness of birds occurring before (1999) and during (2010) operations at DARHT. Note the logarithmic scale on the vertical axis.

Special studies were conducted in 2010 to follow up on two Laboratory projects constructed following the 2000 Cerro Grande fire: Los Alamos Canyon weir and Pajarito Canyon Flood Control Retention Structure (FCRS). The weir was constructed to reduce the transport of contaminated sediments off site and the FCRS was constructed to protect Laboratory facilities downstream from post-fire flash flooding. Native vegetation and field mice were monitored for radionuclides, PCBs, organics, and inorganics. With a few exceptions, all contaminant concentrations in vegetation and field mice were not detected or below RSRLs. For the few contaminants above RSRLs, values were far below screening levels.

Environmental Restoration Program

Corrective actions proposed and/or conducted at LANL in 2010 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. The investigation activities are designed to characterize solid waste management units (SWMUs), areas of concern (AOCs), consolidated units, aggregate areas, canyons, 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 drain lines), excavation of contaminated media, and confirmatory sampling. These activities define the nature and extent of contamination and determine the potential risks and doses to human health and the environment.

- Characterization and cleanup of sites contaminated or potentially contaminated by past LANL activities follow the Consent Order.
- The Laboratory submitted 59 new or revised investigation work plans and reports.
- The Laboratory submitted initial or revised Corrective Measures Evaluations for TA-54, MDAs G, H, and L.
- The D&D of buildings at TA-21 was completed. The excavation of TA-21, MDA B was initiated.
- Investigations were completed or continued at TA-50, MDA C, TA-49, three canyons, and eight aggregate areas

Accomplishments in 2010 include the submission to NMED of initial or revised CME reports for TA-54, MDAs G, H, and L, completion of the D&D of buildings at TA-21, commencement of the TA-21, MDA B, excavation project, the completion of the remediation and investigations required by the TA-16 260 Outfall Corrective Measures Implementation (CMI) plan, and the completion or continued investigation of TA-50, MDA C, TA-49, three canyons, and eight aggregate areas. The CMEs recommend the removal of buildings from the TA-54 MDAs, construction of an evapotranspiration cover over disposal pits and shafts, and the operation of a soil vapor extraction (SVE) system at MDAs L and G. In conjunction with the CME reports, an SVE pilot test was conducted at MDA G demonstrating that this technology is effective

in removing volatile organic compound (VOC) vapors from the soil beneath the MDAs. Groundwater monitoring conducted to support the MDA G CME demonstrates no compelling evidence for the presence of contamination in the regional aquifer downgradient of MDA G.

The final buildings of the Laboratory's TA-21 plutonium processing facility were decontaminated and demolished during 2010. Excavation of MDA B began in June 2010. The asphalt cover on the site was removed and 7,265 yd^3 of waste materials were excavated. The active area of excavation was covered with a metal building with active air filtration to minimize the emission of contaminated soils during excavation operations.

The TA-16, 260 Outfall, CMI plan remediation and investigation activities were completed in 2010. Removal actions and final confirmation sampling were conducted in the lower drainage channel. Toxicity testing demonstrated no reductions in chironomids. A summary report on these activities was submitted to NMED. No potential unacceptable risks remain for industrial, construction worker, or residential scenarios. A CMI monitoring plan was submitted to NMED. Data generated from the monitoring activities will assist in determining if high explosives and barium contamination has been effectively remediated.

During 2010, environmental restoration activities collected samples at more than 1,600 locations and requested 850,000 analyses or measurements on these samples.

In 2010, LANL submitted 22 new or revised investigation work plans and 37 new or revised investigation reports to NMED. In 2010, NMED approved a total of 11 plans and 14 reports, most with modifications or directions. In addition, LANL submitted 35 periodic monitoring reports on periodic sampling activities, 53 plans and reports on groundwater monitoring well activities, and 24 miscellaneous reports or plans. NMED approved 34 SWMUs or AOCs as complete, requiring no further remedial actions.

Subsurface Vapor Monitoring

The Laboratory is conducting periodic monitoring of subsurface vapor at TA-54, MDAs G, H, and L, and at TA-21, MDAs T and V, for VOCs and tritium. The monitoring is conducted to determine if there is a threat to the groundwater from VOCs and tritium vapors originating from the waste buried at these MDAs. The Laboratory monitors subsurface vapors at 56 monitoring wells at a total of 196 ports. The ports are located from a few feet below the ground surface to as great as 700 feet below the ground surface. The approximate depth to the regional aquifer at TA-54 is between 930 and 1,300 feet. The Laboratory has also done some investigation sampling at TA-50 MDA C.

The primary VOCs of concern at MDA G and L are trichloroethane-1,1,1 (TCA) and trichloroethene (TCE) . We estimate that the mass of TCA and TCE at MDA G to be 210 kg and 79 kg, respectively. At MDA L, we estimate the mass of TCA and TCE to be 428 kg and 245 kg, respectively. The total amount of VOCs is much smaller at MDA H: we estimate the total mass of all VOCs to be less than 2 kg. Most of the mass of the VOC vapors below each of the TA-54 MDAs is contained within 200 feet of the surface, within the Bandelier tuff (Figure ES-7).

Subsurface tritium vapors at TA-54 are found primarily at MDA G which has active tritium waste disposal activities. The highest concentrations are located near tritium disposal shafts in the south-central portion of MDA G.

Methylene chloride, perchloroethylene (PCE), and TCA are the primary VOCs of concern at TA-21 MDA T; tritium is also monitored. VOCs and tritium consistently peak at a single depth below the surface over time. Further analyses are being conducted to support the Corrective Measures Evaluation (CME) report.

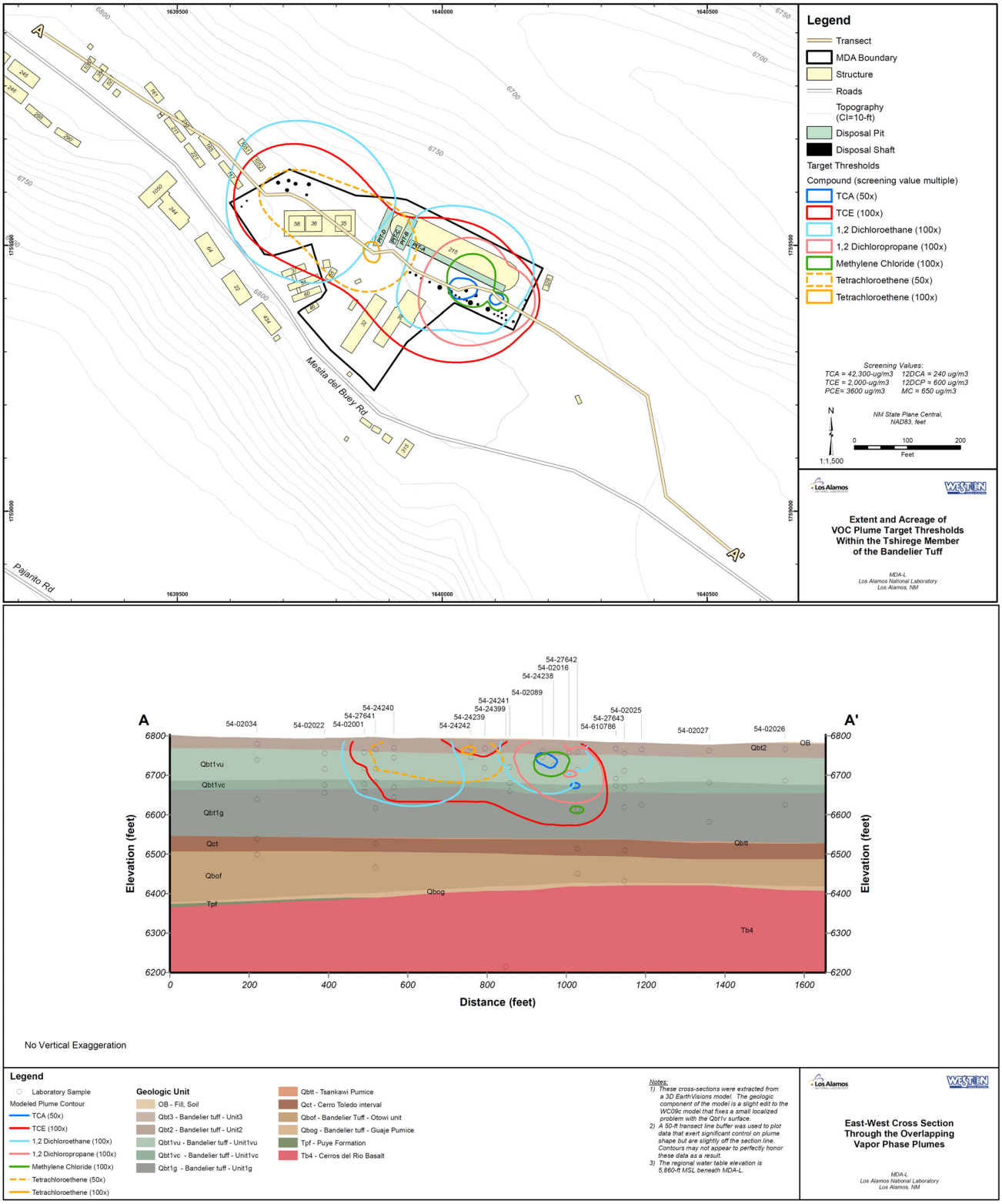

Figure ES-7 **East-west horizontal and vertical cross-section of MDA L VOC plume thresholds, including 1,2-dichloroethane; 1,2-dichloropropane; methylene chloride; tetrachloroethene; TCA; and TCE**

Remediation activities at TA-21, MDA V, were completed in 2005; however, the extent of tritium in subsurface vapors was not determined and so periodic monitoring has been conducted. A consistent prominent peak of tritium activity is found near 300 feet below ground surface. This may be produced by a subsurface geologic feature known as the Tsankawi pumice bed. Vapor monitoring will continue until remediation activities are completed at nearby MDA B.

Analytical Laboratory Quality Assurance

Environmental samples collected by the Laboratory are processed and analyzed by commercial independent analytical chemistry laboratories to determine contaminant concentrations in the samples. Each analytical laboratory must follow EPA-approved analysis methods to determine contaminant concentrations and implement a stringent quality assurance/quality control program to assure the accuracy of the results. All analytical laboratory results undergo validation by a LANL subcontractor. If data validation identifies analytical results that do not meet EPA or LANL requirements, then LANL will perform a follow-up assessment with the analytical laboratory to identify issues and corrective actions. Finally, LANL requires each analytical laboratory to participate in third-party independent review and certification programs as a further quality assurance requirement.

- Independent commercial chemistry laboratories analyze LANL environmental samples.
- The quality assurance performance of these laboratories is best-in-class.

For 2010, approximately 98% of all analytical chemistry results were of good quality and usable for environmental compliance and assessment. Approximately 16% of the accepted results were qualified due to some portion of the analysis not meeting requirements; however, the concentration results were still acceptable for use.

Data validation efforts identified three individual analytical laboratory data quality issues in 2010. Organic contaminants were introduced into several groundwater samples by the analytical laboratory or from sample bottles. Chromium concentrations in several groundwater samples that were near detection limits were incorrectly identified as detections due to analytical laboratory software issues. Selenium concentrations in soil were incorrectly identified as detections due to instrumentation errors. Each of these issues has been corrected and procedures implemented to prevent recurrence.

A new analytical laboratory for low-level tritium analyses was used by LANL during 2010; due to minor differences in analytical methods at the two laboratories, the more recent data are not directly comparable to earlier values.

LANL performed a review of some previous groundwater sampling results for plutonium-238 in the Buckman Well field. In 2006, one plutonium-238 detection was identified for a sample from Buckman Well #1. Upon additional review, this analysis was found to be incorrect; plutonium-238 was not detected in this 2006 sample. This information has been updated in the RACER database.

An analytical result data package assessment was conducted at one analytical laboratory during 2010, when validation identified more systematic issues at the analytical laboratory. A total of 109 individual issues and "time-savings" opportunities were identified. The analytical laboratory developed a comprehensive corrective action plan and each issue was resolved.

Each analytical laboratory participated in third party reviews; samples of known concentration are sent to the analytical laboratory and the laboratory must demonstrate that they can produce similar results. Each analytical laboratory that LANL uses met all independent testing and certification requirements during 2010.

Overall, the performance of LANL's analytical laboratories is excellent.

Monitoring of the Rio Grande

- LANL impacts on the Rio Grande are small.

Water quality, sediments, and biota/foodstuffs have been monitored for many years in and along the Rio Grande to assess LANL impacts. Radionuclides found in surface water samples are naturally occurring. In 2010, LANL sampled fruits and vegetables irrigated with Rio Grande water upstream and downstream of LANL. In general, contaminants in all produce samples were very low (pCi range) and most were either not detected or detected below the RSRLs.

Natural stream flow and sediment loading in the Rio Grande are quite large compared with Los Alamos area streams. A preliminary estimate of PCB flux in lower Los Alamos Canyon into the Rio Grande is 1% to 3% of the total estimated long-term flux in the Rio Grande. LANL installed grade control structures to stabilize sediments and contaminants in place to reduce the sediment from LANL property reaching the Rio Grande. Automated storm flow monitoring stations have been installed to notify BDD Project personnel of major flow events reaching the Rio Grande. Two storm water flows entered the Rio Grande from Los Alamos and Pueblo Canyons during 2010; notifications were made to BDD Project in both cases.

Past risk assessments of the potential risk to the public from chemicals and radioactive materials released from the Cerro Grande fire found minimal exposure risks. The Buckman Direct Diversion (BDD) Project Independent Peer Review found that no risk to BDD Project drinking water from LANL-derived radioactive or chemical contaminants.

In summary, any LANL contributions to the Rio Grande are masked and overwhelmed by contaminants from upriver sources. With the exception of mercury and PCBs in fish, derived from non-LANL sources, the levels of contaminants in the Rio Grande are below all levels of concern.

Monitoring In the Jemez Mountains and Valles Caldera

We performed a review of Laboratory environmental monitoring studies performed in the Jemez Mountains and the Valles Caldera to the west and southwest of the Laboratory. Elevated concentrations of trace elements occurred in vegetation when receiving episodic discharges from the Fenton Hill hot dry rock site. When the discharges ended, these elevated concentrations were no longer measured. A very few sporadic detections of radionuclides and chemicals have been measured in air, surface water, sediment, soil, and biota and foodstuffs over the period of record. The detections appear to be isolated instances and show no spatial or temporal trends. The detections cannot be attributed to Laboratory operations or influences.

Risk Reduction

- The Laboratory reduced environmental risks during 2010 though reduction in TRU waste inventories, D&D of plutonium processing buildings at TA-21, installation of sediment control structures, and ongoing wildland fire tree thinning.

The Laboratory is committed to reducing environmental hazards and the associated risk to people and the environment. Over the years, the Laboratory has decreased its release of materials into the environment and has reduced the amount of legacy contamination. These efforts 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 TA-54, Area G, to WIPP in Carlsbad, NM, the D&D and cleanup of the former plutonium processing facility at TA-21, and ongoing studies of groundwater contamination to evaluate future hazards and risks, and numerous investigations and corrective actions at potentially contaminated sites.

During 2010, the Laboratory continued design work on evaporation tanks to allow elimination of the TA-50 RLWTF outfall. The Laboratory also eliminated three cooling tower outfalls. LANL completed construction of grade control structures in Pueblo and DP Canyons to reduce the transport of contaminated sediments off LANL property. The Laboratory signed an MOU for five years of monitoring to support the BDD Project.

As part of the Laboratory's Wildland Fire Management Plan, the Laboratory performed tree thinning operations on 380 acres of LANL property. These mitigation actions were extremely important in minimizing the amount of LANL lands burned by wildfire during the 2011 Las Conchas fire.

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A. BACKGROUND AND REPORT PURPOSE

1. Background

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 through the Los Alamos Site Office of the US Department of Energy (DOE). 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, priorities, and the world community have changed. LANL defines its vision as: "Los Alamos, the premier national security science laboratory." The current mission is to develop and apply science and technology to

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

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. The foundation of the EMS and the demonstration of the Laboratory's commitment comprise the LANL environmental policy:

- We approach our work as responsible stewards of our environment to achieve our mission.
- We prevent pollution by identifying and minimizing environmental risk.
- We set quantifiable objectives, monitor progress and compliance, and minimize consequences to the environment, stemming from our past, present, and future operations.
- We do not compromise the environment for personal, programmatic, or operational reasons.

2. Report Purpose

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

- Characterize site environmental management performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials at DOE sites.

- 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.

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, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 36-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 at the edge of White Rock 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 Los Alamos County. The 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.

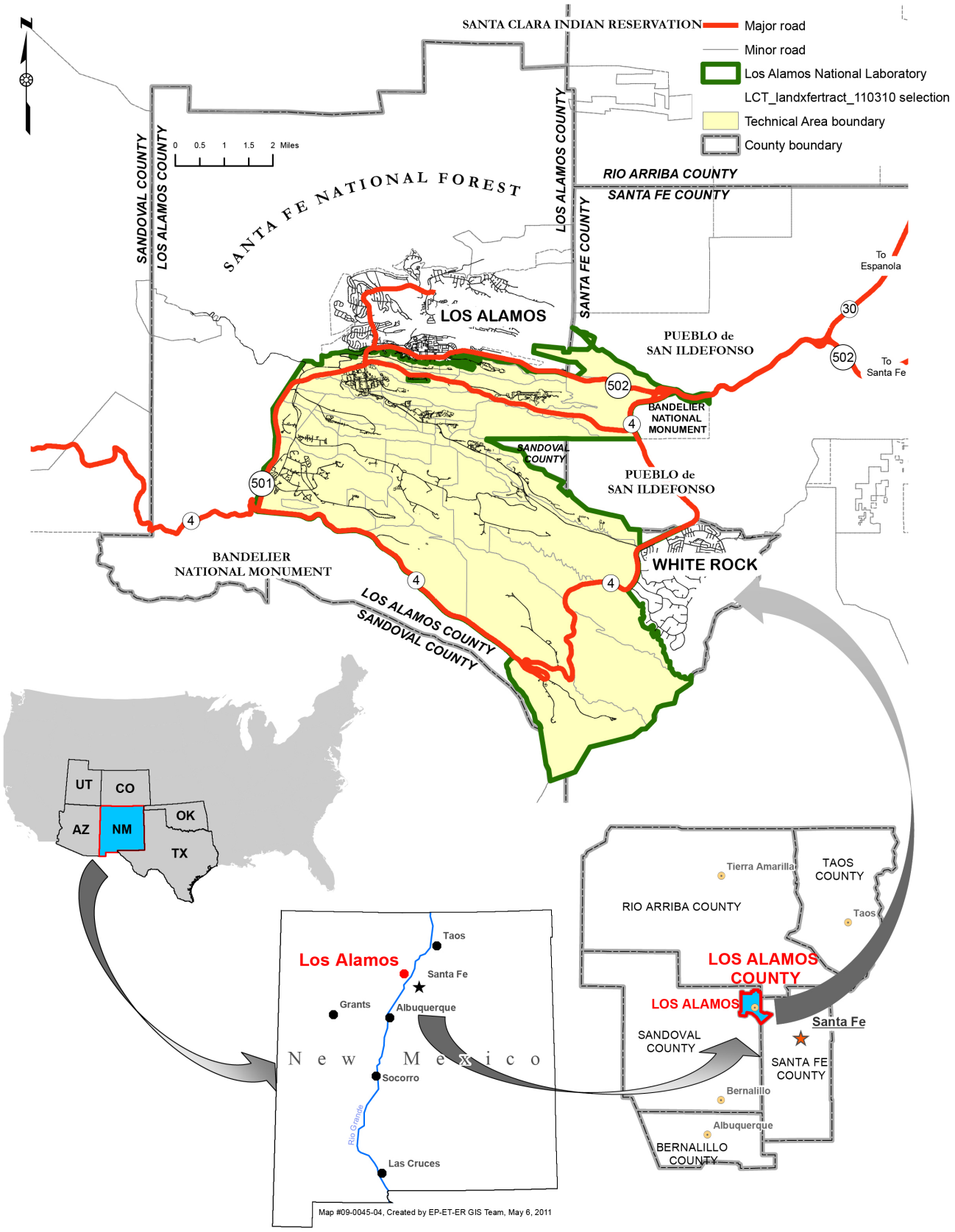

Figure 1-1 Regional location of Los Alamos National Laboratory

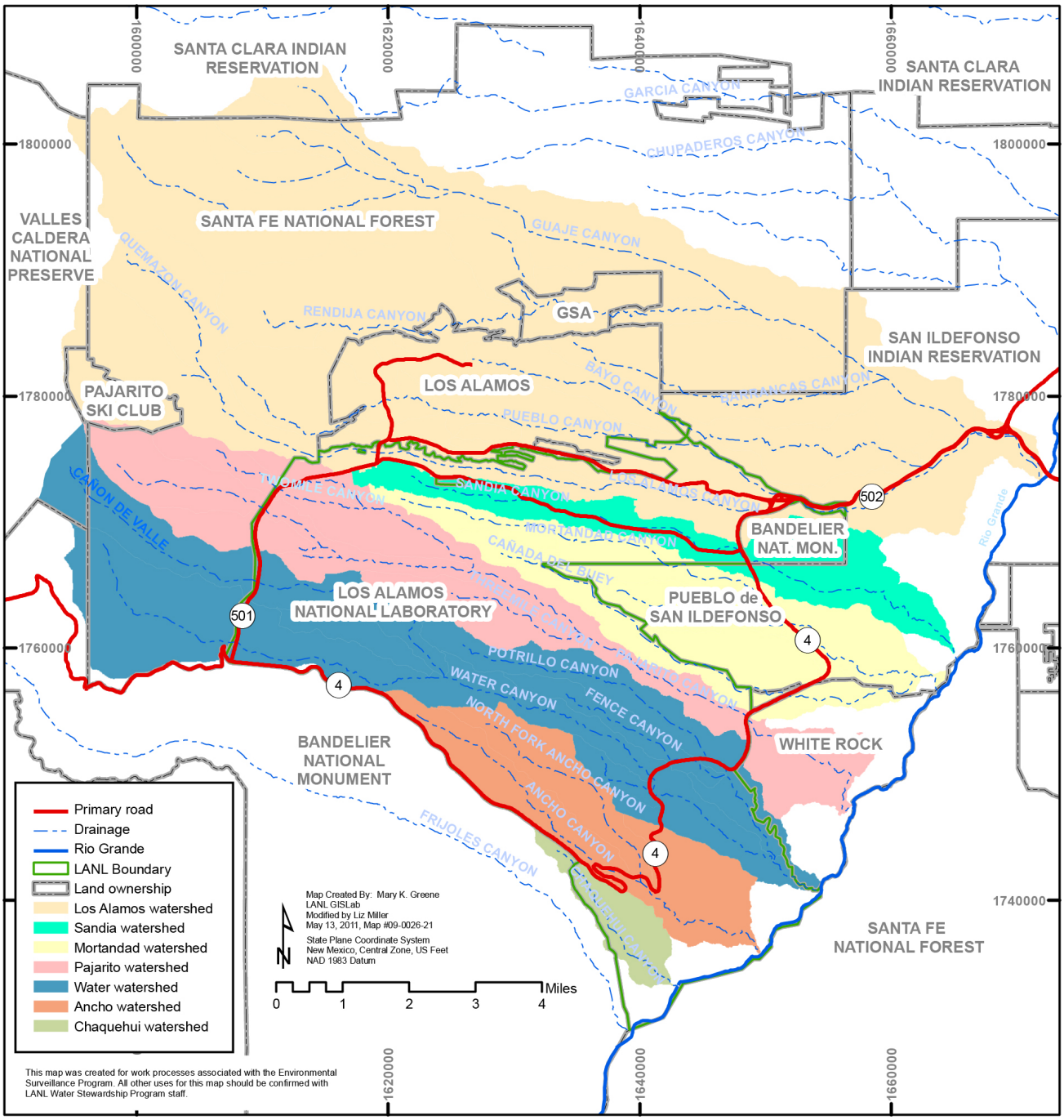

Figure 1-2 Primary watersheds at Los Alamos National Laboratory

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) intermediate 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 regional 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 acre-feet (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. and 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 the plateau, 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. The spruce (*Picea* spp.)-fir (*Abies* spp.) cover type 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 the plateau.

In May 2000, the Cerro Grande fire burned more than 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.

The extreme drought conditions prevalent in the Los Alamos area and all of New Mexico from 1998 through 2003 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 died in the Los Alamos area. Lower levels of mortality also occurred in ponderosa and mixed conifer stands. Mixed conifers on north-facing canyon slopes at lower elevations experienced widespread mortality.

Tree mortality has leveled off since 2005, as much through lack of live trees as an improvement in forest health (LANL 2010). Understory plant species have thrived during the wetter years, but show a neutral or negative response during dry years. It is unlikely that there will be an appreciable increase in tree species until current climate trends improve.

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 2006, sites that have been excavated since the 1950s were removed from the overall site count numbers. Thus, there are fewer recorded sites than the number reported in previous years. Nearly 80% 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 more than 68% located between 5,800 and 7,100 ft. Sixty two percent 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 500 buildings have been evaluated to date. In addition, facilities considered of national historic significance dating from 1963 to the end of the Cold War in 1990 are 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 1981 to 2010, 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) used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-3 and Appendix C, Description of Technical Areas). 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 2,800 structures, with approximately 8.6 million square feet under roof, spread over an area of approximately 36 square miles.

DOE National Nuclear Security Administration (NNSA) issued a new Site-Wide Environmental Impact Statement (SWEIS) in May 2008 (DOE 2008a) and two Records of Decision (ROD) in September 2008 (DOE 2008b) and June 2009. In the SWEIS, 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 environmental impacts associated with LANL operations.

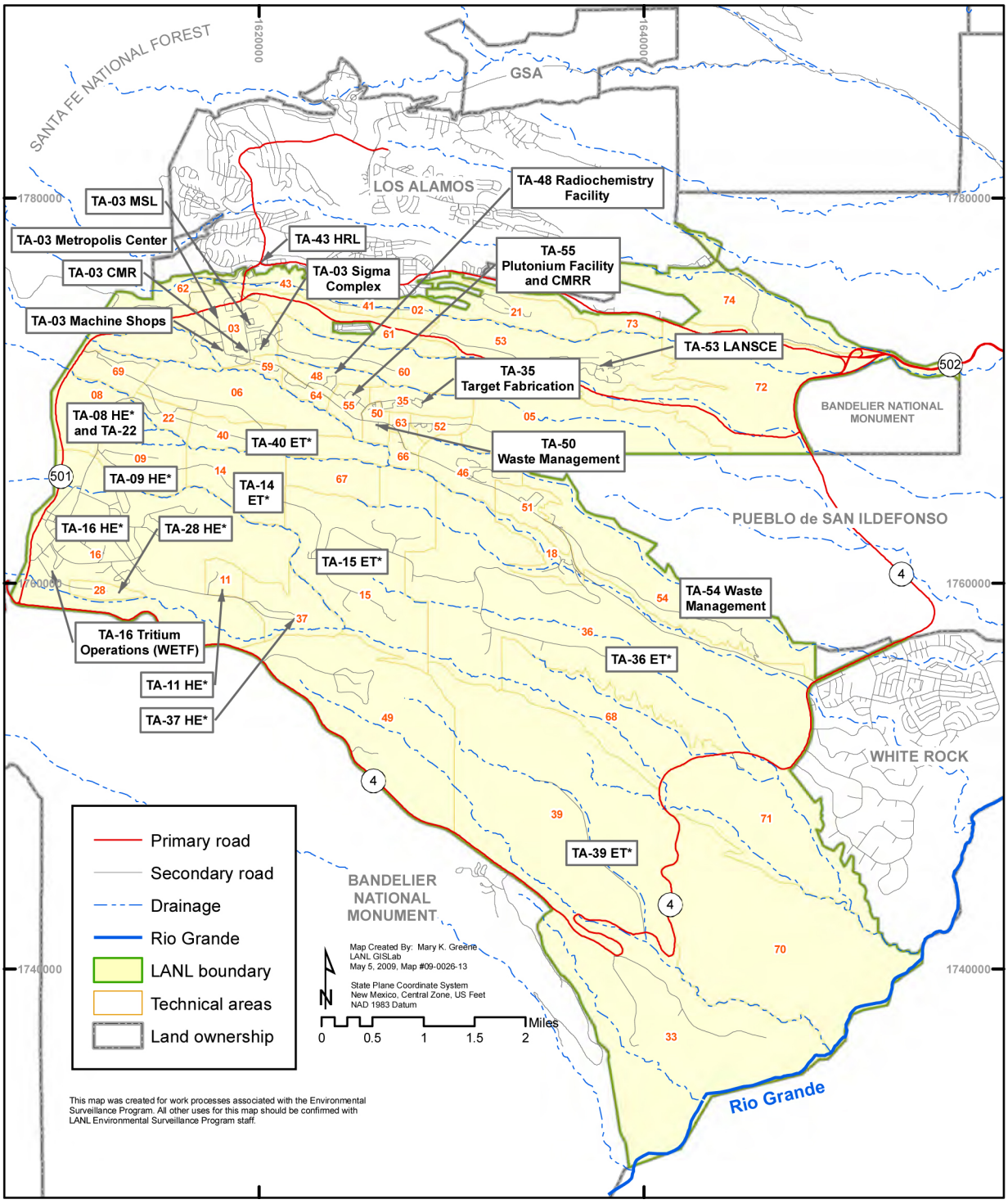

Figure 1-3 **Technical areas and key facilities of Los Alamos National Laboratory in relation to surrounding landholdings**

The facilities identified as "key" are those that house activities critical to meeting work assignments given to LANL. These facilities also:

- House operations that could potentially cause significant environmental impacts,
- Are of most interest or concern to the public based on scoping comments received, or
- Would be the facilities most subject to change as a result of programmatic decisions.

In the 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 49 TAs and approximately 14,224 acres of LANL's 26,480 acres. The Non-Key Facilities also currently employ about 74% of the total LANL workforce (LANL 2010). The Non-Key Facilities include such important buildings and operations as the Nonproliferation and International Security Center (NISC), the new National Security Sciences Building (NSSB), which is now the main administration building, and the TA-46 sewage treatment facility.

Table 1-1
Key Facilities*

Facility	Technical Areas
Plutonium Complex	TA-55
Tritium Facilities	TA-16
Chemistry and Metallurgy Research (CMR) Building	TA-03
Sigma Complex	TA-03
Materials Science Laboratory (MSL)	TA-03
Target Fabrication Facility (TFF)	TA-35
Machine Shops	TA-03
Nicholas C. Metropolis Center for Modeling and Simulation	TA-03
High-Explosives Processing	TA-08, -09, -11, -16, -22, -37
High-Explosives Testing	TA-14, -15, -36, -39, -40
Los Alamos Neutron Science Center (LANSCE)	TA-53
Biosciences Facilities (formerly Health Research Laboratory)	TA-43, -03, -16, -35, -46
Radiochemistry Facility	TA-48
Radioactive Liquid Waste Treatment Facility (RLWTF)	TA-50
Solid Radioactive and Chemical Waste Facilities	TA-50, TA-54

*Data from 2008 SWEIS.

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Safety, environmental protection, and compliance with environmental, safety, and health (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 commit 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.

Environmental management system, compliance, surveillance, and waste management operational support are managed within the Environment, Safety, Health, and Quality (ESH&Q) Directorate. Environmental characterization, remediation, and waste management programs are part of the Environmental Programs (EP) Directorate. An organizational chart and description is available at http://www.lanl.gov/organization/. The major environmental programs and management system are described below.

1. Environmental Management System

LANL has implemented a pollution-prevention-based-EMS, meeting the DOE Order 450.1A requirement to have an EMS implemented by December 31, 2005. An EMS is a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. LANL pursued and achieved registration to the ISO 14001-2004 standard in April 2006.

A key feature of the Laboratory EMS is the focus on ensuring that it is integrated with existing procedures and systems wherever possible. The intent is for the EMS to consolidate these existing programs into a systematic process for environmental performance improvement. The ISM provides an important foundation for the five core elements of the EMS:

1. Policy and Commitment
2. Planning
3. Implementation and Operation
4. Checking and Corrective Action
5. Management Review

More information about the EMS is available at http://www.lanl.gov/environment/risk/ems.shtml.

2. Waste Management Program

As part of the Laboratory's mission, the Laboratory generates

- Resource Conservation and Recovery Act (RCRA) regulated non-radioactive hazardous waste,
- Toxic Substances Control Act regulated waste (primarily PCB contaminated waste),
- Low-level radioactive waste (LLW), both solid and liquid,
- Mixed low-level waste (MLLW),
- Transuranic waste (TRU),
- Administratively controlled waste,
- Medical waste,
- New Mexico Special Waste, and
- Sanitary solid and liquid waste.

ADESHQ provides regulatory compliance support and technical assistance to waste generators to assure compliance with state, federal, and DOE requirements.

LANL disposes of wastes on-site and off-site. LANL releases liquid effluents liquid effluents from the Radioactive Liquid Waste Treatment Facility (RLWTF) and the Sanitary Wastewater Systems Plant into Mortandad and Sandia Canyons. Some LLW is disposed on site at TA-54-Area G. Waste acceptance criteria have been developed for each of these facilities to assure that all wastes disposed on-site meet state, federal, and DOE requirements. All other operational wastes, including the majority of LLW, are disposed off-site.

3. 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 of programs or projects, and reduce risks to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions.

"Green purchasing" is mandated by an executive order and calls for considering environmental factors in purchasing decisions in addition to traditional factors such as performance, price, health, and safety.

4. Environmental Restoration Programs

The environmental restoration and cleanup work at LANL is organized into several projects that have responsibility for different aspects of environmental restoration:

- Corrective Actions Program (includes investigations and remediations in canyons)
- TA-21 Closure Project
- TA-54 Closure Project

The goal of these programs is to ensure that residual 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. Program results for calendar year 2010 are presented in Chapter 9, Environmental Restoration.

5. Compliance and Surveillance Programs

LANL's environmental compliance and surveillance programs identify possible environmental hazards and impacts by regularly collecting samples and comparing results with previous results and applicable regulatory standards. The Laboratory routinely collects samples of air particles and gases, water, soil, sediment, foodstuffs, and associated biota from more than 4000 locations (Table 1-2). Program results for each of these monitoring programs are presented in Chapters 4-9 of this report. The Laboratory also works with and assists neighboring communities and pueblos in performing environmental monitoring.

Table 1-2
Approximate Numbers of Environmental Samples, Locations, and Analytes Collected in 2010

Sample Type or Media	Locations	Frequency of Sampling[a]	Analytes or Measurements
Ambient Air	63	Biweekly	7800[b]
Stack Monitoring	29	Weekly	23,000
Biota	38	Annual	1900
Routine Soil Surveillance Sampling	25	Annual	600
Sediment	601	Annual	180,000
Foodstuffs	136	Annual	3000
Groundwater	195	Quarterly/semi-annual/annual	160,000
NPDES Outfalls	14	Weekly	2200
Surface Water Base Flow	26	Quarterly/semi-annual/annual	16,000
Surface Water Storm Runoff	54	Following rains	25,000
Neutron Radiation	47	Quarterly	190
Gamma Radiation	98	Quarterly	390
Environmental Restoration Soil/Rock Investigation Sampling	1,609	Annual	850,000
Subsurface Vapor Monitoring	84	Monthly/Quarterly/Annually	160,000
Totals:	**4145**		**1,430,000**

Note: Not all the data counted in the table above are reported in this document. Totals include duplicate samples but do not include additional samples and results from the extensive quality assurance/quality control program, which are normally 10% to 20% more but can be over 60% more, depending on the media.

[a] Sampling frequency is location dependant, when more than one frequency is listed.

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

All monitoring data collected at LANL is available through the RACER Data Analysis Tool (http://www.racernm.com/). This tool was developed to provide public access to the same data that NMED and LANL use in making remediation and other environmental management decisions.

The Laboratory is regulated under 27 separate environmental regulatory permits issued by the New Mexico Environment Department and the Environmental Protection Agency (EPA). These permits govern air emissions, liquid effluents, waste generation/treatment/storage/disposal, and environmental restoration. The Laboratory's environmental compliance programs and results are presented in Chapter 2.

E. REFERENCES

DOE 2004: "Environment Safety and Health Reporting," US Department of Energy Order 231.1A (Changed June 3, 2004).

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WMO 1984: World Meteorological Organization, Technical Regulations, Vol. I. WMO-No. 49, Geneva, Switzerland (1984).

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A. INTRODUCTION

Many operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain non-radioactive hazardous and/or radioactive materials. These operations, emissions, and effluents are regulated by US Department of Energy (DOE) orders and federal and state laws. DOE Orders require management systems for environmental protection, resource conservation and protection, and control of radionuclides. 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. Los Alamos National Security (LANS), LLC, operates LANL for the National Nuclear Security Administration (NNSA), an agency of DOE, and is a co-permittee, with DOE and/or NNSA on all EPA- or NMED-administered permits. This chapter provides a summary of LANL compliance and status with respect to DOE environmental requirements and state and federal environmental regulations.

B. DOE ORDERS AND EXECUTIVE ORDERS

1. DOE Order 231.1A, Environment, Safety, and Health Reporting

DOE Order 231.1A, Environment, Safety, and Health Reporting, requires the timely collection and reporting of information on environmental issues that could adversely affect the health and safety of the public and the environment (DOE 2004). Specifically, DOE Order 231.1A requires the Laboratory to publish an annual site environmental report. The objectives of this report, are to

- Characterize site environmental management performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials at DOE sites.
- 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.

The Laboratory began environmental monitoring in the 1940s and published the first comprehensive environmental monitoring report in 1970.

2. DOE Order 450.1A, Environmental Protection Program

DOE Order 450.1A, Environmental Protection Program, requires all DOE sites to "implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements." The order further states this objective must be accomplished by implementing an Environmental Management Systems (EMS) at each DOE site.

An EMS is a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. DOE Order 450.1A 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.

LANL has implemented a pollution-prevention-based EMS, meeting the DOE Order 450.1A requirement to have an EMS implemented by December 31, 2005. LANL pursued and achieved registration to the ISO 14001-2004 standard in April 2006. There were two external audits and one internal audit of the LANL EMS system in 2010. No significant corrective actions were identified during these audits.

The EMS met several milestones in fiscal year (FY) 2010 (October 2009 – September 2010) and calendar year (CY) 2010. Multi-disciplinary teams from each Directorate 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. These plans committed to dozens of environmental improvement and pollution prevention actions for FY10 http://hsrasweb.lanl.gov/emsdb/org_list_public.asp. In addition, new action plans were developed for implementation in FY11 (October 2010 – September 2011).

We established six high level FY10 commitments to achieve our LANL goal of establishing excellence in environmental stewardship; these goals and our FY10 achievements are presented in Table 2.1. The Laboratory maintained a high level of environmental compliance performance, shipped a record number of transuranic (TRU) waste shipments to the Waste Isolation Pilot Project (WIPP), increased public involvement events, and maintained a fully compliant EMS.

Table 2.1
FY10 Environmental Stewardship Commitments and Results

Goal	Year End Final Status
Establish excellence in environmental stewardship. FY 10 Commitments (9/2010 target date unless otherwise noted) Increase the number of public outreach events focused on Environmental Management System (EMS) and Consent Order[a] activities to increase stakeholder knowledge and engagement.	During FY10, LANL held public forums related to several major environmental programmatic elements: Consent Order progress, Sanitary Effluent Reclamation Facility, NEPA[b], CMRR[c] Progress, Clean Air Act Compliance, and Water Quality Standards. The lab proactively met with the public and stakeholders to ensure that accurate information was available regarding our activities and commitment to env. Protection. As a result LANL increased the number of public interactions related to environment to 392 compared with 264 in FY09, including interactions with the Northern New Mexico Citizen's Advisory Board, testimony at the RCRA permit hearings, and interactions with several local government and citizen organizations. These efforts were rewarded with significant public support of the Laboratory mission in comments submitted to NMED.
Maintain 98% or higher successful inspection rates in all environmental self-inspection programs.	RCRA: 97.8%, Stormwater: 99.1%, NPDES[e]: 99%+, P2: rated outstanding.
Permits: RCRA Permit Implementation, Title V Air Permit Implementation.	Title V permit fully implemented, new RCRA permit not issued as of 10/1/10.
Mitigate potential environmental impact and risk to the public by completing the funded, FY10 Work-plan TRU waste shipments.	LANL achieved a record 158 transuranic waste shipments to WIPP[f] reducing the Material-at-Risk at Technical Area (TA)-54, Area G, from 88,000 plutonium-equivalent Curies to less than 81,000; LANL prepared 470 cubic meters of transuranic waste for disposition; LANL made 2,100 shipments of low-level waste off site, and increased transuranic waste processing capacity with start up of the Building 412 repacking system and upgrade of the Dome 231 line.

Table 2.1 (continued)

Goal	Year End Final Status
EMS: Implementation of departure process, materials clean-outs and pilot chemical pharmacy in support of materials disposition. Implement at least 15 GSAF projects for waste minimization. Develop Greenhouse Gas Baseline in support of energy conservation.	The Laboratory's ISO 14001 status is fully compliant. Third party surveillance audit in August found the EMS to be mature, leading to improvements in pollution prevention and regulatory compliance. Pilot chemical pharmacy centers opened in FY10, GSAF[h] projects were funded and first Greenhouse Gas Baseline completed in January 2010. First site Sustainability Plan was developed in FY10.

[a] NMED Order on Consent
[b] National Environmental Policy Act
[c] Chemistry and Metallurgy Research Replacement facility
[d] Resource Conservation and Recovery Act
[e] National Pollutant Discharge Elimination System
[f] Waste Isolation Pilot Project
[g] Material Disposal Area
[h] Generator Set Aside Funds

a. 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 of programs or projects, and reduce risks to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions.

P2 projects in FY10 yielded millions of dollars in cost avoidances to the Laboratory and allowed hundreds of hours of labor to be spent more productively. DOE gave the P2 Program an overall performance rating of "outstanding" for FY10 from DOE. The rating system was established by DOE and is based on progress in seven categories including hazardous waste generation, low-level waste generation, mixed low-level waste generation, TRU/mixed (MTRU) waste generation, recycling percentage, weight of sanitary trash generated per person, and percentage of purchases that comply with affirmative procurement. For 2010, LANL's goal was to generate less routine waste in each category than in 2009, increase the percentage of recycling, and be 100% compliant with affirmative procurement. In FY10, LANL generated less routine low-level waste, mixed low-level waste, TRU and MTRU waste than in FY09. In FY10, LANL increased its recycling percentage and reduced the amount of routine sanitary waste generated per person over FY09 levels. In FY10, LANL was only 84% compliant with affirmative procurement due to new purchasing software that cannot capture justifications for purchasing products without recycled content. The differences in routine waste generation, recycling percentage, and affirmative procurement are shown in Table 2-2.

Table 2.2
Comparison of FY2009 and FY2010 Routine Waste Generation, Recycling Percentage, and Affirmative Procurement

FY10 LANL P2 Performance Index	FY09 Generation Baseline	FY10 Generation
Routine Hazardous Waste	11.6 metric tons	15 metric tons
Routine Low-Level Waste	888 cubic meters	809 cubic meters
Routine Mixed Low-Level Waste	10.4 cubic meters	3.7 cubic meters
Routine Sanitary Waste	148 kg/person	141 kg/person
Recycling	50%	58%
Affirmative Procurement	Not calculated	84%
Routine TRU/MTRU Waste	72.5 cubic meters	38.2 cubic meters

NNSA gave six Pollution Prevention awards for the following projects and programs:

- Video Teleconferencing Cuts Travel Costs and Reduces Green House Gas Emissions
- Sustainable Projects for a Sustainable Future
- Sigma Electroplating Discharge Reduction Integration of Site Sustainability Plan Goals and LANL's EMS
- New Plutonium Removal Technique Means Less Waste

- LANL Algal Biofuels Consortium Development Team
- *Affirmative procurement refers to* the practice of *purcha*sing items that contain recycled content. The EPA designated seven categories of products that are known to offer many items that contain recycled content. These categories include paper and paper products, vehicular products, construction products, transportation products, park and recreation products, landscaping products, and non-paper office products. DOE requires that LANL report each year how much money was spent in each category and how much of that money was spent on products that contain recycled content. It's also acceptable to purchase products in these categories without recycled content if there is a justification such as the recycled-content product costs significantly more, the recycled-content product does not meet project specifications, or the recycled-content product cannot arrive quickly enough.

DOE's goal for LANL is to purchase all recycled-content products in these categories or justify all non-recycled content purchases. The old purchasing system at LANL, the Just-in-Time (JIT) catalog, was programmed to highlight recycled-content products and to mandate that users choose a justification if a non-recycled content product was chosen from one of EPA's categories. The new Oracle-based purchasing system at LANL does not currently highlight recycled-content products or require that users choose a justification for a non-recycled content purchase. Thus, LANL went from having 100% of their JIT catalog purchases compliant with affirmative procurement in 2008 to having a compliance percentage that could not be calculated. LANL is hoping to find a method for calculating a compliance percentage with affirmative procurement in 2011.

b. Energy, Transportation, and Water Stewardship

The Laboratory's energy conservation, transportation, and water conservation activities are governed by DOE Order 436.1, Departmental Sustainability, and Executive Orders (EO) 13423, Strengthening Federal Environmental, Energy, and Transportation Management, and EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance. These orders provide requirements for managing sustainability within the Laboratory to ensure operations incorporate energy, water, and greenhouse gas reduction strategies and commit to implementing a Site Sustainability Plan. Site sustainability seeks to reduce consumption of natural resources so that we can expand and increase mission growth. An environmentally sustainable organization seeks to participate within its community and seeks to balance economy, society and environment within its operations.

In 2008, DOE established specific FY15 goals of 30% reductions in energy usage per square foot of building space over FY03 and 16% reductions in potable water use over FY07. The Laboratory's Site Sustainability Plan identifies appropriate projects that will contribute to meeting the DOE's sustainability goals. Performance goals have been established for the Laboratory in these directives, including reductions in energy intensity, potable and industrial water use, green house gas (GHG) emissions, and waste generation. The Laboratory is dependent on the success of a number of projects, including the Energy Savings Performance Contract (ESPC), the Sanitary Effluent Reclamation Facility (SERF) expansion, High Performance Sustainable Building (HPSB) implementation, lighting retrofits, building automation system night setback scheduling, and the associated footprint reduction efforts to achieve our energy, water, and greenhouse gas management goals. In addition, to address the Laboratory's increased water usage, the LANL Generator Set Aside Funds (GSAF) program funded projects that contribute to water reduction goals. Specific projects include Use of Biodiesel Co-product to Boost Biological Oxygen Demand (BOD) at the LANL sanitary wastewater facility (SWWS) was initiated in FY10. Preliminary results indicate that it is possible to boost the BOD at the SWWS via crude glycerol, a by-product of biodiesel production. Long-term implementation of this project may allow increased hydraulic throughput at the SWWS. Increased flows to the SWWS (hydraulic throughput) eventually end up at the planned expanded-SERF. Processing of sanitary effluent at the SERF will directly contribute to reductions in potable water consumption. The SWWS BOD project may allow increased flows from routing cooling tower blowdown from permitted National Pollutant Discharge Elimination System (NPDES) outfalls to the SWWS, and therein the SERF.

Significant effort was devoted to the NPDES Outfall Reduction Project (ORP) in 2009 and 2010. This program addresses the remaining NPDES permitted outfalls at LANL, currently discharging approximately 154 million gallons per year. The ORP is intended to assist compliance with the EPA's NPDES permit for LANL, support increased efficiency and effective management of water, increase the use of "reclaimed water," and ensure compliance with DOE Order 430.2B. The ORP Integrated Project Team developed a plan for implementation of the program, which includes groups of projects designed to contribute to the FY15 goals established in DOE Order 430.2B. Conceptual design and total project costs were validated based on the FY08 Project Execution Plans developed by the ORP Integrated Project Team.

The DOE required its subcontractors to publish Site Sustainability Plans as part of meeting the requirements set forth in its Strategic Sustainability Performance Plan. The Laboratory published a FY10 Site Sustainability Plan (LANL 2010), and Table 2.3 shows the Laboratory's performance status toward meeting the sustainability goals.

Table 2.3
Sustainability Performance Status

DOE Goal	Performance Status
28% Scope 1 & 2 GHG reduction by FY20 from a FY08 baseline (related goals intended below)	In FY10, LANL increased Scope 1 & 2 GHG levels by 3% compared with the FY08 baseline.
30% energy intensity reduction by FY15 from a FY03 baseline and target reduction for FY10 of 15%	Between FY03 and FY10, LANL reduced its cumulative energy intensity by approximately 15%.
7.5% of a site's annual electricity consumption from on-site renewable sources by FY10	31,950 megawatt/hr (MWhr) renewable energy credits (RECs) were purchased in FY10: these comprise 7.5% of the total electrical energy use.
Every site to have at least one on-site renewable energy generating system	Currently, LANL has several solar power lighting systems in place. Additionally, Los Alamos Power Pool is proceeding with installation of the Abiquiu Dam low-flow turbine, which will be fully installed in 2011.
10% annual increase in fleet alternative fuel consumption relative to a FY05 baseline	LANL met this goal for FY10. Thirty-six percent of LANL's fleet is capable of using alternative fuels. Unfortunately, not all E-85 capable vehicles use E-85 due to lack of local supply. However, E-85 is being used in protective force vehicles due to an off hours refueling truck.
2% annual reduction in fleet petroleum consumption relative to a FY05 baseline	LANL met this goal for FY10. During FY09 LANL used 24,575 gallons of E-85 which represents 4% of the total fuel consumption. This 4% of E-85 meets the 2% petroleum reduction requirement.
75% of new light duty vehicle leases must consist of alternative fuel vehicles (AFV)	LANL met this goal for FY 2010. Fleet management developed a FY09 policy that states all new vehicles leases must be AFVs.
To the maximum extent practicable: advanced metering for electricity (by October 2012), steam, and natural gas (by October 2016); standard meters for water	LANL has achieved 81% of the Energy Policy Act of 2005 electric metering goal.
Cool roofs, unless uneconomical, for roof replacements unless project already has Critical Decision (CD)-2 approval. New roofs must have thermal resistance of at least R-30	LANL met this goal for FY 2010. Under the Roof Assessment Management Program (RAMP), LANL has been installing cool roofs for the last three years. Most current projects are CMR (145,000 sf), 55-0114 (8,000 sf), 03-0132 (11,000 sf), and 03-0039 (155,000 sf) in FY09.

Table 2.3 (continued)

DOE Goal	Performance Status
Training and outreach. DOE facility energy mangers to be Certified Energy Managers by September 2012	30 Sustainability/Energy-related training days were completed in FY10. In FY10, outreach included an Energy Town Hall with presentations open to the public. Currently, one Utilities & Institutional Facilities (UI) staff member is a Certified Energy Manager (CEM).
Sulfur hexafluoride (SF6) capture program by September 2012	According to our FY08 emissions, SF6 represents approximately 5% of our Scope 1 & 2 emissions.
10% Scope 3 GHG reduction by FY20 from a FY08 baseline	Recent investigation revealed that employee commuting comprises the majority of LANL's Scope 3 GHG emissions, which is 73,821 metric tons CO_2 equivalent.
All new construction and major renovations greater than $5 million to be LEED® Gold certified. Meet High Performance and Sustainable Building (HPSB) Guiding Principles if less than or equal to $5 million	CMRR/RLUOB* is in construction phase and is anticipated to achieve at least LEED Silver as the first LANL facility to achieve LEED certification. Projects in design and conceptual design phases are incorporating LEED Gold into project requirements.
15% of existing buildings larger than 5,000 gross square feet (GSF) to be compliant with the five guiding principles of HPSB by FY 2015	A gap analysis was completed to identify necessary systematic improvements. A plan was developed to bring identified HPSBs into compliance. DOE's HPSB Assessment Tool will be used to meet the Guiding Principles.
16% water use reduction by FY15 from a FY07 baseline - 2% reduction each year based on the previous year, 26% by FY 2020	Water use has increased by approximately 22% since FY07.
20% water consumption reduction of industrial, landscaping, and agricultural (ILA) water by FY20 from a FY 2010 baseline	LANL has determined that more than 500K square feet of non-native grass can be removed to reduce non-potable water use.

* Chemistry and Metallurgy Research Replacement facility/Radiological Laboratory/Utility/Office Building

3. DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5400.5, Radiation Protection of the Public and the Environment, establishes the requirements to protect the public and the environment against undue risk from radiation associated with activities conducted by DOE facilities. The Order establishes the all-pathway public dose limit of 100 mrem, requirements for clearance of real and personal property, As Low As Reasonably Achievable (ALARA) public exposure requirements, requirements for environmental monitoring, and all-pathway dose limits for the protection of biota.

The Laboratory was in compliance with DOE Order 5400.5 during 2010. Public and biota dose assessments, ALARA assessments, and the clearance of real and personal property are presented in Chapter 3, Radiological and Non-Radiological Dose Assessment.

4. DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of radioactive wastes: low-level waste (LLW), mixed low-level waste (MLLW), TRU waste, and mixed TRU waste. (Waste definitions are provided in the Glossary). MLLW is LLW that also contains a hazardous (RCRA-regulated) component, and mixed TRU waste is TRU waste with a hazardous component. Only LLW is disposed at LANL; all other radioactive wastes are shipped off-site for final treatment, if required, and disposal. All aspects of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1 and DOE Manual 435.1. LANL submitted a compliance report to DOE (LANL 2009) which was approved by DOE in 2009. The hazardous component of MLLW and mixed TRU wastes is also regulated under RCRA and the LANL Hazardous Waste Facility Permit.

a. Institutional Requirements

All LANL operations that generate, store, treat, or dispose radioactive waste must have a DOE/Los Alamos Site Office (LASO)-approved Radioactive Waste Management Basis (RWMB). DOE/LASO approved the most recent RWMB on December 28, 2010 for continued facility operations. The RWMB identifies the

physical and administrative controls to ensure the protection of workers, the public, and the environment. The RWMB documents that generated wastes (a) will meet the acceptance requirements for a disposal facility, (b) will meet LANL on-site storage requirements, and (c) can be transported to a disposal facility. Registration, facility self inspections, and surveillance of radioactive staging and storage areas ensure LANL radioactive waste management practices are consistent with the requirements in DOE Order/Manual 435.1.

During FY10, eight Laboratory Facility Operation Directorates (FODs) were approved to generate, treat, or dispose of radioactive waste. Four LANL FODs had received approval to extensions of their current operations, while their RWMB documentation was updated. During FY10, 171 internal inspections were conducted at LANL generation, storage, treatment, and disposal facilities. Eighteen findings were identified; corrective actions were implemented and closed out. DOE/LASO participates as an observer on internal inspections to assure continued compliance with the RWMB.

b. Low-Level Waste

The Laboratory disposes LLW on-site at TA-54 Area G. In order to dispose of LLW at Area G, DOE Order 435.1 requires the Laboratory to have an approved operational Closure Plan and Performance Assessment/Composite Analysis (PA/CA). The Closure Plan demonstrates the Laboratory's plan for decommissioning LLW disposal operations at TA-54, Area G. The TA-54, Area G Performance Assessment demonstrates that a reasonable expectation exists that the potential doses to representative future members of the public and potential releases from the facility will not exceed performance objectives established in DOE Order 435.1 during a 1,000-year period after closure. The TA-54 Area G Composite Analysis accounts for all sources of radioactive material that are planned to remain onsite at LANL that may interact with the low-level waste disposal facility, contributing to the dose projected to a hypothetical member of the public from Area G. As with the Area G PA, the Composite Analysis demonstrates a reasonable expectation of compliance with DOE Order 435.1 performance objectives. The status of Laboratory documents demonstrating DOE approval to dispose of LLW at TA-54, Area G is presented in Table 2-4. The Laboratory received authorization from DOE for continued operations from DOE on March 17, 2010.

Table 2-4
DOE Approval to Dispose of LLW at TA-54 Area G

DOE Order 435.1 Requirement	LANL Document	LANL or DOE Approval
Closure Plan	Closure Plan for Los Alamos National Laboratory Technical Area 54, Area G, LA-UR-09-02012	LANL approval March 2009
PA/CA	Performance Assessment and Composite Analysis for Los Alamos National Laboratory Technical Area 54, Area G, LA-UR-08-06764	DOE approval; September 15, 2009 via letter from Thad T. Konopnicki (DOE/HQ) to Donald L. Winchell (DOE/LASO)
PA/CA Maintenance Plan	Area G Performance Assessment and Composite Analysis Maintenance Program Plan, LA UR-11-01522, March 2011	LANL approval March 2011
Authorization to Dispose of LLW at Area G	Disposal Authorization Statement for the Department of Energy Los Alamos National Laboratory Area G in Technical Area 54	Issued March 17, 2010 via letter from Randal S. Scott (DOE HQ) to Donald L. Winchell (DOE/LASO)

During CY10, LANL generated, processed and disposed of approximately 25,000 m^3 of LLW. This amount includes waste generated during routine operations and by campaigns, such as environmental restoration clean-ups. During 2010, LLW generation was higher than in previous years because of American Recovery and Reinvestment Act (ARRA) funded decontamination and decommissioning (D&D) of TA-21 buildings (Figure 2-1). Approximately ten percent of this LLW was buried at TA-54 Area G. During CY10, LANL generated and processed approximately 119 m^3 of MLLW and shipped these wastes to an approved disposal facility in Clive, Utah. LANL maintained compliance with all aspects of its RWMB during 2010.

The Laboratory is implementing a strategy to shift to off-site LLW disposal where feasible and cost-effective, but continues to dispose of some LLW at TA-54, Area G.

c. Transuranic Waste

The transuranic waste disposition program expedites the disposal of TRU waste in storage and newly-generated transuranic waste to the WIPP located east of Carlsbad, NM. The program also ensures appropriate facilities and equipment are available to prepare legacy and current TRU for disposal at WIPP. Figure 2-2 presents the cumulative inventory of TRU wastes that have been shipped to WIPP from Los Alamos. During CY10, 723 m^3 of TRU (including MTRU) were shipped to WIPP. The DOE and Laboratory have set 2015 as the goal to complete the shipment of all stored TRU waste from Los Alamos to WIPP. After 2015, after all of the TRU waste stored at TA-54 has been shipped to WIPP, newly generated TRU is expected to be shipped at approximately 85 m^3 per year (approximately 18 shipments to WIPP per year) after all of the TRU waste stored at TA-54 has been shipped to WIPP.

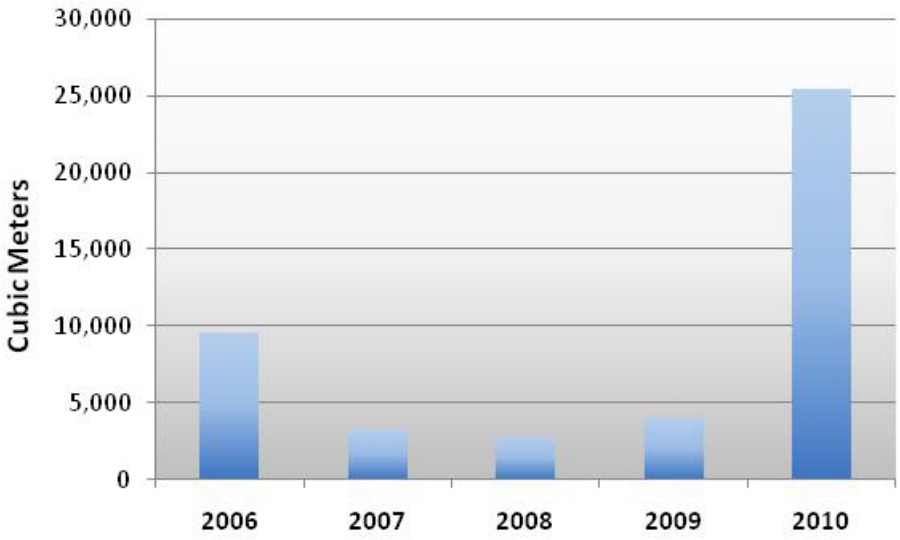

Figure 2-1 LANL LLW Generation

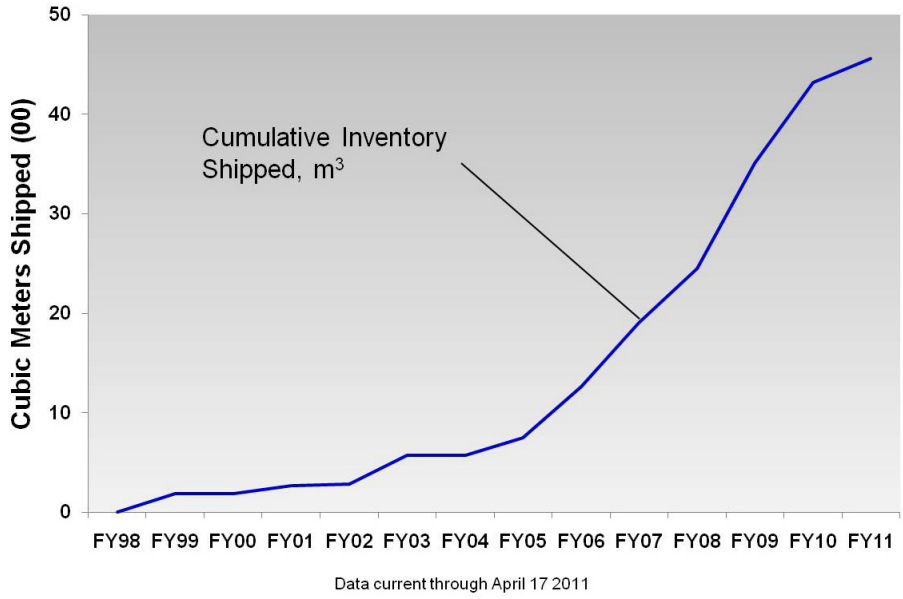

Figure 2-2 TRU waste shipping profile

C. COMPLIANCE STATUS

The EPA and NMED regulate Laboratory operations under various environmental statutes (e.g. Clean Air Act, Clean Water Act, etc.) through operating permits, construction approvals, and the DOE/NMED Consent Order. These permits are designed by the regulatory agencies to allow Laboratory operations to be conducted while assuring that the public, air, land, soils, water, and biota are protected. The Laboratory's compliance performance is an assessment of our protection of the environment. Table 2-5 presents the environmental permits or approvals the Laboratory operated under in 2010 and the specific operations and/or sites affected. Table 2-6 lists the various environmental inspections and audits conducted at the Laboratory during 2010. The following sections summarize the Laboratory's regulatory compliance performance during 2010.

Table 2-5

Environmental Permits or Approvals under which the Laboratory Operated during 2010

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Permit	Hazardous Waste Facility Permit: Permitted hazardous waste storage units: Technical Areas (TA)-3, 50, 54, and TA-55	November 1989, renewed November 2010	December 2020	NMED[b]
	40 CFR 265 Standards: Interim Status hazardous waste storage and treatment facilities: TAs-14, -16, -36, -39, and -54. Permit applications to be submitted to NMED.	Post-1980 hazardous waste units; Post-1991 mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring; revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised June 18, 2008	September 20, 2015	NMED
CWA[d]/NPDES[e]	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012	EPA[f]
	MSGP[g] for the discharge of storm water from industrial activities	September 29, 2008	September 29, 2013	EPA
	NPDES Individual Permit for storm water discharges from Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs)	November 1, 2010	March 31, 2014	EPA
	Construction General Permits (17) for the discharge of storm water from construction activities	June 30, 2008	July 31, 2011 (proposed extension until January 31, 2012)	EPA
CWA Sections 404/401	COE[h] Nationwide Permits (four)	NA	NA	COE/NMED
Groundwater Discharge Permit , TA-46 SWWS[i] Plant	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998 Renewal application submitted on July 2, 2010	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 Tank/Leachfield Systems	Discharge to groundwater	Submitted April 27, 2006 Application resubmitted on June 25, 2010	Approval pending	NMED

Table 2-5 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC[j])	LANL air emissions Renewal 1	August 7, 2009	August 7, 2014	NMED
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	Retired and removed from operating permit	June 15, 2006		
	Permit number will remain active to track exempt sources at LANL			
	TA-3 Power Plant	September 27, 2000	None	NMED
	Permit revision	November 26, 2003		
	Permit modification 1, Revision 1	July 30, 2004		
	Permit modification 1, Revision 2	March 5, 2009		
	1600-kW generator at TA-33	October 10, 2002	None	NMED
	Permit revision	May 28, 2008	None	NMED
	Two 20-kW generators and one 225-kW generator at TA-33	August 8, 2007	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Permit revision	September 12, 2006	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement (CMRR), Radiological Laboratory, Utility, Office Building (RLUOB)	September 16, 2005	None	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

[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

*Permit was administratively continued though 2010

Table 2-6
Environmental Inspections and Audits Conducted at the Laboratory during 2010

Date	Purpose	Performing Agency
3/9/10–3/11/10	Environmental Management System audit	Third Party Certifier
9/9/2010	TA-46 SWWS Plant Groundwater Discharge Permit	NMED
9/23-9/242010	Septic Tank/Leachfield Systems Discharge Plan	NMED
9/8/10-9/9/10	Title V Operating Permit compliance inspection	NMED
8/31/10–9/2/10	Environmental Management System audit	Third Party Certifier

1. Resources Conservation and Recovery Act

a. Introduction

As a research facility, the Laboratory produces a wide variety of hazardous wastes. Wastes are generated primarily from research and development activities, processing and recovery operations, D&D projects, and environmental restoration activities. Most of these waste streams are in small quantities compared with industrial facilities of comparable size because of the relatively diverse activities and the many research projects at the Laboratory.

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 regulations found in the New Mexico Administrative Code (NMAC) Title 20, Chapter 4, Part 1, as revised October 1, 2003.

The federal and state laws regulate management of hazardous wastes based on a combination of the facility's status, the quantities of waste generated, and the types of waste management conducted by the facility. Certain operations require a hazardous waste facility permit, often called a RCRA permit. The LANL hazardous waste facility permit was initially granted in 1989 for storage and treatment operations.

b. RCRA Permitting Activities

2010 marked the renewal and upgrading of the 1989 LANL Hazardous Waste Facility Permit. In 2007, NMED issued a preliminary draft of the permit for public comment. NMED received comments from the Northern New Mexico Citizens' Advisory Board, the Embudo Valley Environment Monitoring Group, the Southwest Research and Information Center, the Natural Resources Defense Council, the Concerned Citizens for Nuclear Safety, Nuclear Watch New Mexico, the Pueblos de San Ildefonso and Santa Clara, the EPA, several private citizens, and the Laboratory. These comments were extensive and addressed many conditions of the draft permit, including emergency procedures, information availability, seismic considerations, financial assurance, open burning operations, and hazardous waste management unit decontamination, among others. All commenters who requested a hearing were invited to participate in NMED-mediated permit negotiations to resolve comments.

The negotiations began in August 2008 and extended into January 2010. The negotiations included presentations, discussions and comment resolution that supported the development of a second revised draft permit. NMED issued the revised draft permit on July 6, 2009. Another public comment period for review of this draft was opened at that time. Additional negotiations addressing the revised draft were concluded in January 2010. A public hearing procedure regarding the draft permit was held from April 6 through May 7, 2010, including public meetings in Santa Fe, Pojoaque, Ohkay Owingeh, Albuquerque, and Los Alamos. The public comment period ended with the termination of the hearings. Among a wide range of comments received, major topics included open burning of hazardous waste, federal financial assurance for unit closures, public information procedures, waste disposal practices during unit closures, seismic concerns, and LANL waste generation practices. A corrected revised proposed permit was issued on September 10, 2010. On November 30, 2010, the NM Secretary of the Environment issued an order renewing the permit with an

effective date of December 30, 2010. The order also denied approval for the open burn units originally included in the permit applications.

In February 2010, the Laboratory submitted and provided public notice for a Request for TA-54 Class 1 Permit Modifications. The modifications revised the figures and descriptions of structures and equipment at TA-54 in the existing permit to reflect various changes occurring in support of waste management activities and closure of the area. This submittal also included additional figures and descriptions to revise or supplement the information included in the draft renewal permit then being negotiated with the NMED. The proposed modifications were approved on March 17, 2010.

In March 2010, the Laboratory submitted and provided public notice for a Class 1 Permit Modification to the Emergency Equipment Listing in the Contingency Plan. The permit modification updated the emergency equipment listing within the plan and updated the emergency communication procedures at the permitted hazardous waste storage units at TA-50 and TA-54. NMED approved the proposed modifications on April 23, 2010.

No hazardous waste management units at the Laboratory underwent full closure activities in 2010.

c. Other RCRA Activities

The compliance assurance program performed Laboratory self-assessments to determine whether hazardous waste and mixed waste are 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 2010, the Laboratory completed 1,650 self-assessments.

d. RCRA Compliance Inspection

From December 1, 2009 to December 10, 2009, NMED conducted a hazardous waste compliance inspection at the Laboratory. The Laboratory received one violation from 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 (STP). On June 1, 2006, LANS replaced UC as the operating contractor at LANL, and 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. In 2010, the Laboratory shipped approximately 76 m^3 of STP-covered low-level mixed waste and approximately 319 m^3 of covered MTRU waste for treatment and disposal.

f. Solid Waste Disposal

LANL sends sanitary solid waste (trash) and construction and demolition debris for transfer through the Los Alamos County Eco-Station 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 transfer station and is responsible for obtaining all related permits for this activity from the state. The transfer station is registered with the NMED Solid Waste Bureau. Laboratory trash sent to the transfer station in 2010 included 6,034 metric tons of trash and 1,208 metric tons of construction and demolition debris. Through LANL's recycling efforts in 2010, 8,594 metric tons of material was recycled and did not go to a landfill.

g. Compliance Order on Consent (Consent Order)

The Consent Order is an enforcement document that prescribes the requirements for corrective action at the Laboratory. The purposes of the Consent Order are (1) to define the nature and extent of releases of contaminants at, or from, the facility; (2) to identify and evaluate, where needed, alternatives for corrective measures to remediate contaminants in the environment and prevent or mitigate the migration of contaminants at, or from, the facility; and (3) to implement such corrective measures. The Consent Order supersedes the corrective action requirements previously specified in Module VIII of the Laboratory's

Hazardous Waste Facility Permit and applies to Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) subject to RCRA and HSWA requirements, but not to sites that are regulated by DOE under the Atomic Energy Act, such as those containing or releasing radionuclides. 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. A description of the Consent Order work done in 2010 is presented in Chapter 9 of this report.

In 2010, the Laboratory submitted 220 deliverables (plans and reports) required by the Consent Order on time to NMED (see Tables 9-1 and 9-2 in Chapter 9 of this report).

Figure 2-3 shows each aggregate area, as defined by the Consent Order, and indicates the status of LANL investigation activities in these aggregate areas as (1) complete, (2) in progress, or (3) pending. For those aggregate areas presented as complete in Figure 2-3, all investigation activities have been completed, and no additional field sampling campaigns, investigation reports, or corrective measures activities are anticipated. Aggregate areas listed as in progress include sites or areas where field sampling campaigns or corrective measure activities are currently being conducted, or investigation reports are being prepared or finalized. Aggregate areas listed as pending include sites or areas where work plan preparation and field sampling campaigns have not yet started. As of December 2010, Scheduled investigation activities are complete at six aggregate areas, are in progress at twenty one aggregate areas, and are pending at two aggregate areas.

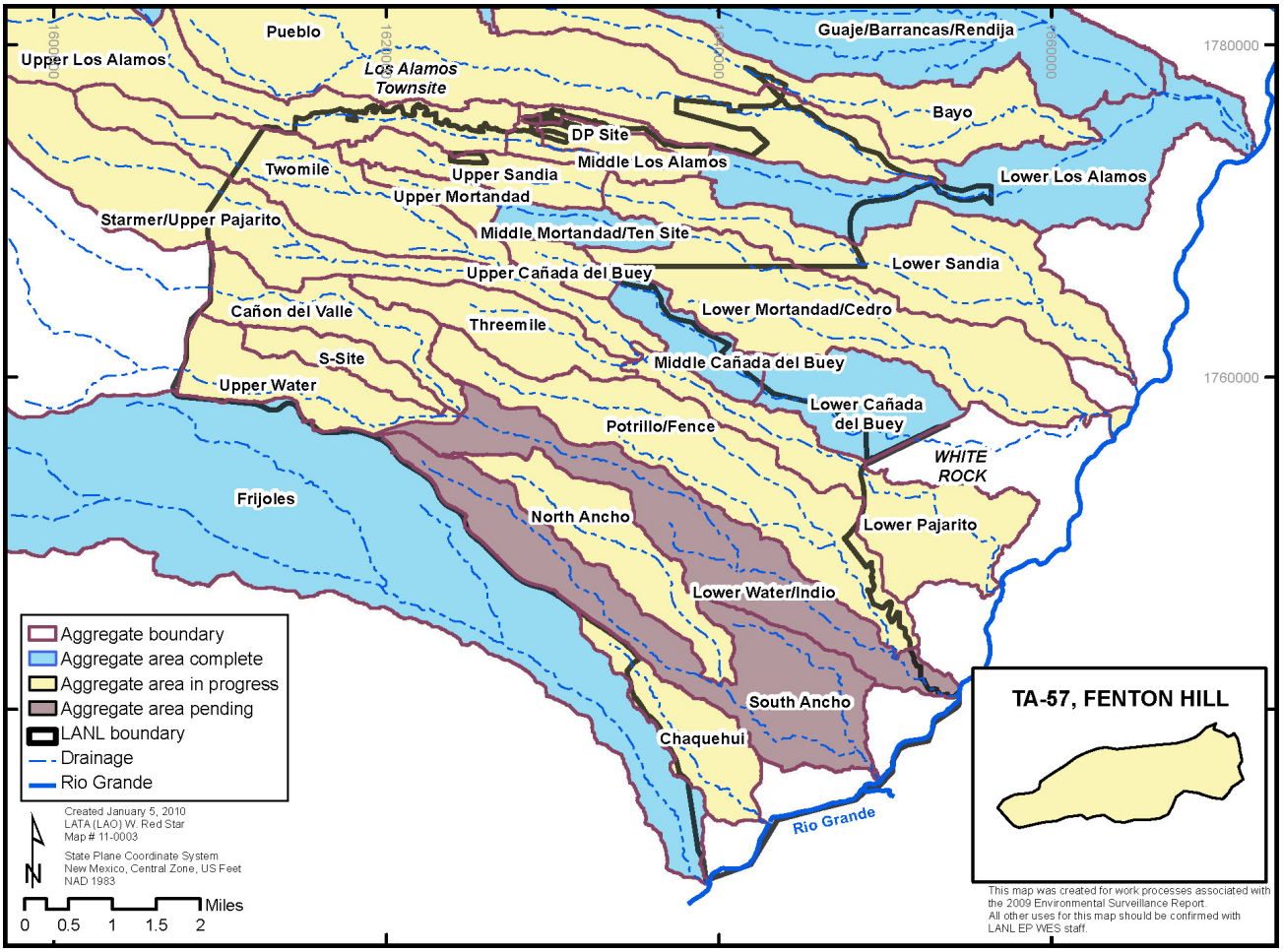

Figure 2-3 **Aggregate areas as defined for the NMED Consent Order and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending.**

h. Notices of Violation

In September 2010 the NMED Hazardous Waste Bureau issued LANS and DOE a Notice of Violation (NOV) identifying two alleged violations noted during the December 2009 RCRA compliance inspection. In January 2011, the NMED Hazardous Waste Bureau issued LANS and DOE a Resolution of Notice of Violation identifying one violation noted during the December 2009 inspection. A penalty was not assessed because it was determined that the violation was adequately addressed and no further action was required.

i. Other RCRA Non-Compliances

The following waste storage or transportation violations were found by internal inspections during waste processing operations at LANL:

- Seven hazardous waste labels were found to not include all of the required EPA Hazardous Waste Numbers applicable to the waste. The labels were corrected with the additional EPA Hazardous Waste Numbers.
- Internal RCRA inspections are required the day of or the day following waste management operations. At TA-50-69, waste management occurred on Thursday, August 5, 2010, however, no RCRA inspection occurred for the week of August 2, 2010, through August 8, 2010.

These incidents did not result in any actual or potential hazards to the environment and human health outside the facility, and no material was lost or had to be recovered as a result of any of these incidents. None of these incidents required other reporting to the NMED under the LANL Hazardous Waste Facility Permit.

2. Comprehensive Environmental Response, Compensation, and Liability Act

a. Land Transfer

Tracts A-13 and C-1 (http://www.lanl.gov/environment/nepa/docs/LA-UR-06-8860_ctmap_09-0027-01.pdf) were conveyed to Los Alamos County under Public Law 105-119 in 2010. Environmental Baseline Survey Reports for both tracts were completed, transmitted to, and accepted by LASO prior to conveyance to satisfy the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 120(h) requirements for environmental disclosure in federal real property transfers.

b. Natural Resource Damage Assessment

Under a memorandum of agreement established in 2008, the DOE and several other federal, state, and tribal entities in the region continued to work towards completing a natural resources damages assessment (NRDA) for LANL. Participating entities include the DOE, the Department of Interior, the Department of Agriculture, the State of New Mexico, and the Pueblo de San Ildefonso, Santa Clara Pueblo, and Jemez Pueblo (collectively known as Trustees). The governing regulations include the Clean Water Act (CWA), the Oil Pollution Act of 1990, the DOE Organization Act, CERCLA, and the New Mexico Natural Resources Trustee Act.

The Trustees may assess and recover compensatory damages for injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances to the environment from LANL. Damages may include the cost of restoring the injured resources to their baseline condition (i.e., the condition that would have existed but for the release) as well as the value of interim service losses pending restoration. Damages are used to restore, rehabilitate, replace, or acquire the equivalent of services provided by injured natural resources.

The LANL Natural Resource Trustee Council released a pre-assessment screen in January 2010. The pre-assessment screen is the initial step in the NRDA process and provides a rapid review of readily available information on hazardous substance releases and the potential impacts of those releases on natural resources. The Trustee Council determined that the pre-assessment screen criteria have been met and it is appropriate to pursue a full-scale assessment. In September 2010, the DOE completed procurement of an NRDA contractor to support Trustee Council development of an assessment plan for a full-scale assessment. Completion of the assessment plan is anticipated in 2012.

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 13423, Strengthening Federal Environmental, Energy, and Transportation Management.

b. Compliance Activities

For 2010, the Laboratory submitted reports to fulfill its requirements under EPCRA, as shown in Table 2-7 and described below.

Table 2-7
Compliance with Emergency Planning and Community Right-to-Know Act during 2010

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.	No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2010.
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 20 hazardous materials stored at LANL over specified quantities in 2010 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.	Laboratory use of lead exceeded the reporting thresholds in 2010, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the State Emergency Response Commission.

i. 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) if any changes at the Laboratory might affect the local emergency plan or (2) if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2010.

ii 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. No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2010.

iii. 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 the 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 20 chemicals and explosives at the Laboratory stored on site in quantities that exceeded reporting threshold limits during 2010.

iv. Toxic Release Inventory Reporting

Executive Order 13423 requires all federal facilities to comply with Title III, Section 313, of 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 operations exceeded the threshold for use of lead in 2010 and therefore was required to report the uses and releases of this chemical. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-8 summarizes the reported releases in 2010.

Table 2-8
Summary of 2010
Reported Releases under EPCRA Section 313

	Lead (lb)
Air Emissions	5.62
Water Discharges	0.012
On-Site Land Disposal	3,260
Off-Site Waste Transfers	7,759

4. Toxic Substances Control Act

Given that the Laboratory's activities are focused on R&D rather than the manufacture of commercial chemicals, the Laboratory's main concerns under the Toxic Substances Control Act (TSCA) are the regulations covering polychlorinated biphenyls (PCBs) and the 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 2010, the Laboratory shipped 399 containers of PCB waste off site for disposal or recycling. The quantities of waste disposed of included 2,994 lb (1358 kg) of capacitors and 25,574lb (11,600 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 document log that the Laboratory maintains on file for possible inspection by EPA Region 6. The renewal request for the Area G PCB disposal authorization was withdrawn in 2006. During 2010, EPA did not perform a PCB site inspection. Approximately 23 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 (FIFRA) regulates the manufacturing of pesticides and 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 licensing and certification of pesticide workers, record keeping, equipment inspection, as well as application, 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 2010. The Laboratory conducted three inspections of the pesticide storage area in 2009 and found that the storage area was maintained in accordance with FIFRA regulations.

Table 2-9 shows the amounts of pesticides and herbicides the Laboratory used in 2010.

6. Clean Air Act

Through the federal Clean Air Act (CAA) Amendments and NMAC 20.2.70 Operating Permits, LANS is authorized to operate applicable air emission sources at LANL. The Laboratory was issued Operating Permit No. P100 in April 2004. The term of this permit was five years, thus an application to renew the permit was submitted to NMED in April 2008. The renewed permit, P100R1, was issued in August 2009. This permit provides the terms and conditions that must be followed in order to operate the applicable air emission sources. The operating permit conditions are a collection of existing source-specific permit conditions that address operation, record keeping, monitoring, and reporting. By complying with the conditions of the Title V Operating Permit, the Laboratory is deemed to be in compliance with all applicable air requirements existing at the date of permit issuance.

As part of the Title V Operating Permit program, LANL reports the emissions from sources included in the Operating Permit to NMED twice a year. These sources include multiple boilers and electric generators, a power plant, a combustion turbine generator, a data disintegrator, two carpenter shops, a degreaser, and an asphalt plant. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities.

Table 2-9
Herbicides and Pesticides Used at LANL in 2010

Herbicides	Amount
Velossa (5905-579)	35 gal.
Velossa (5905-580)	16.7 quarts
Velpar L (Liquid)	1.5 gal.
Insecticides	**Amount**
Advion ANT Bait (Gel)	120 g
Prescription Treatment (PT) P.I. Contact	8 oz
Prescription Treatment (PT) Wasp Freeze	24 oz
Maxforce Ant Bait (granular)	46 oz
Maxforce Ant Bait Stations (Bait)	6
Silver Fish Bait	0.05 oz
Suspend SC	10 oz
Tempo WP	2.2 oz
Wasp Freeze	26 oz
Water Treatment Chemicals	**Amount**
Garrat-Callahan 312	2 gal.
Garrat-Callahan 314	2 gal.
Garrat-Callahan 314T	3,490 lbs
Garrat-Callahan 315	5.5 gal
Garrat-Callahan 316	38 packs
Sump Buddy	140 packs
Repellant	**Amount**
Bird-X Bird Proof (Liquid)	30 oz

The Title V Operating Permit requires the Laboratory to submit an Annual Compliance Certification to NMED. In the 2010, the Laboratory did not have any permit deviations or excess emissions.

LANL demonstrated full compliance with all applicable air permit terms and conditions and met all required reporting deadlines during 2010.

In 2010, LANL requested a revision to the Title V Operating Permit. The revision will incorporate the permit revisions found in the CMRR-RLUOB New Source Review (NSR) permit 2195-N. This permit revision is expected to be issued in 2011. In addition, a new template is being used by NMED for Title V Operating Permits and this revision will include additional formatting changes that will change the flow and look of the permit.

In 2010, LANL provided the second annual GHG emissions report to NMED, as required by NMAC 20.2.87. The 2010 report provided emissions of carbon dioxide (CO_2) and methane (CH_4) for the 2009 calendar year. The amount of these two gases emitted during 2009 was approximately 56,426 metric tons of CO_2 equivalents from the combustion of fossil fuels. The 2010 emissions for these two gases were approximately 60,460 metric tons of CO_2 equivalents from the combustion of fossil fuels. EPA will also require GHG emission reporting for the first time starting in 2011, for emissions during calendar year 2010. The DOE has set aggressive goals to reduce greenhouse gas emissions; the data submitted in the annual emission reports will be used to track progress made towards these goals.

Under the Title V Operating Permit program, LANL is considered a major source of pollutants, based on the potential to emit NO_X, CO, and volatile organic compounds (VOCs). In 2010, the TA-3 power plant and boilers located across the Laboratory were the major contributors of NO_X, CO, and particulate matter (PM).

However, LANL's highest emissions are still significantly lower than the permit limits, for example NOx emissions contributed to 20% of the permit limit, 10 % for CO, and 0.04% for PM. R&D activities were responsible for most of the VOC and hazardous air pollutant emissions. Table 2-10 summarizes these data.

Table 2-10
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2010

	Pollutants[a], tons					
Emission Units	**NO_x**	**SO_x**	**PM**	**CO**	**VOC**	**HAPs**
Asphalt Plant	0.05	0.003	0.03	1.60	0.006	0.006
TA-3 Power Plant (3 boilers)	13.2	0.14	1.7	9.1	1.3	0.43
TA-3 Power Plant (combustion turbine)	1.97	0.14	0.27	0.41	0.09	0.06
Regulated Boilers	6.6	0.044	0.6	4.8	0.39	0.13
R&D Chemical Use	NA[b]	NA	NA	NA	6.7	3.7
Degreaser	NA	NA	NA	NA	0.009	0.009
Data Disintegrator	NA	NA	0.05	NA	NA	NA
Carpenter Shops	NA	NA	0.06	NA	NA	NA
Stationary Standby Generators[c]	6.0	0.26	0.30	1.38	0.30	0.002
Miscellaneous Small Boilers[c]	21.3	0.13	1.60	18.0	1.17	0.41
TA-33 Generators (4 units)	1.88	0.24	0.08	1.24	0.06	<0.001
TOTAL	**50.98**	**0.957**	**3.69**	**36.53**	**10.025**	**4.748**

[a] NOx = nitrogen oxides; SOx = Sulfur oxides; PM = particulate matter; CO = carbon monoxide; VOC = volatile organic compounds; HAPs = hazardous air pollutants.
[b] NA = Not applicable.
[c] 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 2-4.

LANL staff calculates air emissions using emission factors from source tests, manufacturer's data, and EPA documents. Calculated emissions are based on actual production rates, fuel usage, and/or material throughput. To satisfy requirements found in NMAC 20.2.73, Notice of Intent and Emissions Inventory Requirements, and the Title V Operating Permit, LANL submits an annual Emissions Inventory Report and semi-annual Emissions Reports, respectively, to NMED. Figure 2-4 depicts a five-year history of criteria pollutant emissions. Emissions from 2006 through 2010 are very similar and remain relatively constant.

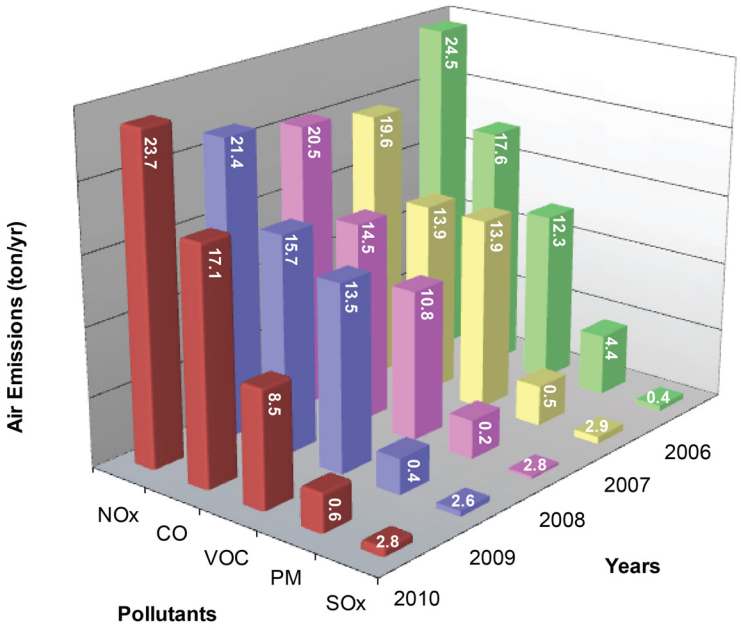

Figure 2-4 **LANL criteria pollutant emissions from 2006 through 2010 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.**

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 apply for construction permits or to submit notifications to NMED. In August 2009, NMED renewed and issued the Title V

Operating Permit. During 2010, the Laboratory requested a Title V Operating Permit revision. The permit revision will include requirements from the CMRR-RLUOB NSR permit. LANL submitted two exemption notifications to NMED during 2010. The exemptions were for bulb crushers and a small generator. During 2010, LANL operated under the air permits listed in Table 2-5.

ii. Open Burning

LANL may perform open burning under 20.2.60 NMAC (Open Burning) or 20.2.65 NMAC (Smoke Management) to thin vegetation and reduce the threat of fire. LANL did not perform any open burning during 2010.

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. In 2010, 25 large renovation and demolition projects were completed. NMED was provided advance notice on each of these projects. All waste was properly packaged and disposed of at approved landfills. To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly.

b. Federal Clean Air Act

i. Ozone-Depleting Substances

Title VI of the CAA 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 or otherwise releasing into the environment any refrigerant or refrigerant substitute 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 LANL Operations and Maintenance Manual.

The Laboratory continued to work at eliminating the use of Class I and Class II ODS. Class I and Class II ODS are the refrigerants that have high ozone-depleting potentials. In 2010, the Laboratory removed approximately 5,873 pounds of Class I ODS and 690 pounds of Class II ODS from the active inventory.

ii. Radionuclides

Under the NESHAP regulations, which regulate the air emissions of radionuclides other than radon from facilities owned or operated by the DOE, the EPA limits to 10 mrem/yr the effective dose equivalent of airborne releases of radioactive material from a DOE facility, such as LANL, to any member of the public. The 2010 annual dose to the maximally exposed individual (MEI), as calculated using EPA-approved methods, was 0.33 mrem. The location of the highest dose was on the rim of Los Alamos Canyon, immediately south of the Los Alamos Lodge (formerly the Los Alamos Inn). Resuspension of plutonium contaminated soils on the south facing slopes of Los Alamos canyon contributed over half of this dose; the remainder came from other Laboratory stack emissions and environmental cleanup work. See Chapter 4 for more information about these 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 Industrial Point Source outfall permit establishes specific chemical, physical, and biological criteria that the Laboratory's effluent must meet before it is discharged.

LANS and DOE/NNSA are co-permittees of the NPDES permit covering Laboratory operations. 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. During 2010, the Laboratory's industrial point-source NPDES permit contained 15 permitted outfalls that include one sanitary outfall and 14 industrial outfalls (Table 2-11). To facilitate full compliance with the requirements in the current permit, the Laboratory is planning to eliminate outfalls and to add additional treatment technologies. The Laboratory's NPDES permit is available online at http://www.lanl.gov/environment/h2o/permits.shtml?1. Outfalls listed on the current permit that did not discharge in CY10 include Outfall 02A129 (TA-21 Steam Plant has not been used since 2007 and is scheduled for D & D), Outfall 03A021 (air washers at CMR that were engineered to operate without discharging in late 2007), and Outfall05A055 (The High Explosives Wastewater Treatment Facility (HEWTF) currently uses a mechanical evaporator). Projects were completed in CY10 through the Outfall Reduction Program at Outfalls 03A021, 03A130, and 03A185 that will result in no future discharges at these outfalls. It is anticipated that these outfalls, in addition to Outfall 02A129, will be removed from the current permit in CY11.

Table 2-11
Volume of Effluent Discharge from NPDES Permitted Outfalls in 2010

Outfall Number	TA-Bldg	Description	Watershed (Canyon)	2010 Discharge (gal.)
02A129	21-357	TA-21 Steam Plant	Los Alamos	0
03A048	53-963/978	LANSCE Cooling Tower	Los Alamos	17,433,300
051	50-1	TA-50 Radioactive Liquid Waste Treatment Facility	Mortandad	571,088
03A021	3-29	CMR Building Air Washers	Mortandad	0
03A022	3-2238	Sigma Cooling Tower	Mortandad	847,260
03A160	35-124	National High Magnetic Field Laboratory Cooling Tower	Mortandad	18,771
03A181	55-6	Plutonium Facility Cooling Tower	Mortandad	1,042,273
13S	46-347	Sanitary Wastewater Treatment Plant	Sandia	98,666,000
001	3-22	Power Plant (includes treated effluent from Outfall 13S)	Sandia	94,968,216
03A027	3-2327	Strategic Computing Complex Cooling Tower	Sandia	16,778,600
03A113	53-293/952	LANSCE Cooling Tower	Sandia	442,205
03A199	3-1837	Laboratory Data Communications Center	Sandia	9,164,120
03A130	11-30	TA-11 Cooling Tower	Water	48
03A185	15-312	DARHT Cooling Tower	Water	542,788
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2010 Total:	**141,808,699**

The Laboratory's current NPDES outfall permit requires weekly, monthly, quarterly, and yearly sampling to demonstrate compliance with effluent quality limits. The Laboratory reports analytical results to EPA and NMED at the end of the monitoring period for each respective outfall category. During 2010, none of the 76 samples collected from the SWWS Plant's outfall exceeded effluent limits; however, four of the 1,243 samples collected from industrial outfalls exceeded effluent limits (described below). Monitoring data obtained from sampling at NPDES permitted outfalls are in Supplemental Data Table S2-1 and S2-2 (on included compact disc) and available online at www.racernm.com/.

EPA Region 6 issued LANS and DOE two NOV for exceedences of the NPDES permit limits in 2010. The first NOV was issued on March for 8 permit exceedences from February 2009 through January 2010. The second NOV was issued on November for 2 permit exceedences that occurred June through September.

The following is a summary of the corrective actions the Laboratory took during 2010 to address the NPDES outfall permit noncompliances cited above.

- *TA-55 PF Outfall 03A18:*. On January 20, 2010, during a discharge, a total residual chlorine (TRC) measurement of 0.11 mg/L was above the permit limit of 0.011 mg/L. The pump that injects chlorine neutralizer into the blowdown had a faulty diaphragm, resulting in inadequate dechlorination of the effluent. When the pump is set at a low rate, chlorine neutralizer was not delivered with every stroke of the pump. The rate of the pump was increased. A new pump was ordered and has been installed. The pump will be entered on a replacement schedule based on manufacturer's recommendations. Facility personnel have ordered and are using additional chlorine monitoring equipment for operational sampling of the cooling system.
- *TA-53 LANSCE Outfall 03A048*: On June 17, 2010, at 2:20 p.m. during a cooling tower discharge, the TRC result was measured at 0.72 mg/L, which is above the permit limit of 0.011 mg/L. A check valve on the chemical feed pump for the de-chlorination system was stuck closed and was fixed at 3:00 p.m. on June 17, 2010. Facility personnel are in the process of installing a chlorination control system that will continually monitor and control the amount of free chlorine in the cooling tower basin, keeping levels within a tight range. The new system will continually monitor the total chlorine in the blow down line and will initiate a redundant chlorine neutralization pump if total chlorine is detected. The completion is anticipated no later than May 31 2011.
- *TA-53 LANSCE Outfall 03A048:* On September 27, 2010 at 2:20 p.m. during a cooling tower discharge, the TRC result was measured at >2.2 mg/L which is above the permit limit of 0.011 mg/L. The chemical injector pump that feeds the de-chlorinator into the blowdown was seized. The pump was replaced on September 28, 2010. Facility personnel are in the process of installing a chlorination control system that will continually monitor and control the amount of free chlorine in the cooling tower basin, keeping levels within a tight range. The new system will continually monitor the total chlorine in the blow down line and will initiate a redundant chlorine neutralization pump if total chlorine is detected. The completion is anticipated no later than May 31, 2011.
- *TA-53 LANSCE Outfall 03A048:* On December 7, 2010, at 11:54 a.m., during a cooling tower discharge, the total arsenic was measured at 13.5 ug/L. This result (received January 3, 2011) exceeded the monthly average permit limit of 0.010 mg/L (10 ug/L). Facility personnel decreased the cycles of concentration from 2.75 cycles to 2.25 cycles on January 4, 2011, at approximately 3:30 PM. At the time compliance samples were collected, arsenic levels in the cooling tower were not being monitored by an installed arsenic analyzer. The arsenic analyzer malfunctioned at the end of November 2010 and the facility was awaiting the vendor to arrive and inspect the arsenic analyzer. The analyzer was functioning properly on December 14, 2010. A procedure to implement administrative controls when the analyzer is off-line is being finalized and an alarm is being tied in to the computer control system.

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. During 2010, the SWWS Plant generated approximately 19.3 dry tons (45,833 dry lbs) 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 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 are co-permittees at most construction sites. Compliance with the NPDES CGP includes developing and implementing a Storm Water Pollution Prevention Plan (SWPPP) before soil disturbance can begin and conducting site inspections once soil disturbance has commenced. A SWPPP describes the project activities, site conditions, best management practices (erosion control measures), 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 also identify corrective actions required to keep pollutants from moving off the construction site. Data collected from these inspections are tabulated weekly, monthly, and annually in the form of Site Inspection Compliance Reports.

During 2010, the Laboratory implemented and maintained 48 construction site SWPPPs and addendums to SWPPPs and performed 599 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 inspection compliance record in 2010 was 99.5%, which is 596 of the 599 inspections.

The LANL storm water team continued to use relatively new methods to assist with storm water compliance. Improvements in accounting for non-uniform distribution of precipitation were made by using a network of rain gauges in association with the Thiessen polygon method. This method associated 13 precipitation gauges across the Laboratory with LANL construction projects to ensure refined data were used for triggering storm water inspections. The gauges were equipped with 5-minute tipping buckets connected to existing stations with data loggers. The team incorporated solutions for preventing non-compliances in its Quality Improvement Performance Report. To further reduce future CGP non-compliances and to increase awareness of CGP requirements, the storm water team briefed subcontractors on CGP requirements at pre-bid and pre-construction meetings. Storm water requirements were put into subcontract requirements, so each bidder who responds to or bids on a subcontract for a Laboratory project is given project-specific environmental requirements. The team also gave presentations to multiple LANL organizations to increase awareness of CGP requirements and continued to hold a standing weekly meeting with LANL Project Management personnel to review the storm water compliance status of projects.

d. 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 and storage; vehicle and equipment maintenance; recycling activities; electricity generation; warehousing activities; and asphalt manufacturing.

LANS and the DOE are co-permittees under the EPA 2008 NPDES Storm Water Multi-Sector General Permit for Industrial Activities (MSGP-2008). MSGP-2008 requires the development and implementation of site-specific SWPPPs, which must include identifying potential pollutants and activities and installing erosion control measures. Permit requirements also include monitoring storm water discharges from permitted sites. In 2010, LANL implemented and maintained 15 SWPPPs under the MSGP-2008 requirements, covering 19 facilities. Compliance with the requirements for these sites is achieved primarily by implementing the following activities:

- Identifying potential contaminants and activities that may impact surface water quality and identifying and providing structural and nonstructural controls to limit the impact of those contaminants.
- Developing and implementing facility-specific SWPPPs
- Implementing corrective actions identified during inspections throughout the year
- Monitoring storm water runoff at facility gauging stations and stand-alone samplers for industrial sector-specific benchmark parameters, impaired water constituents, and effluent limitations, 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

e. NPDES Individual Permit for Storm Water Discharges from SWMUs/AOCs

In November 2010, EPA Region 6 issued a permit that authorizes discharges of storm water from certain Potential Release Sites (PRSs), SWMUs, and AOCs at the Laboratory. The individual permit (IP) was issued in September 2010 and became effective on November 1, 2010 (NPDES Permit No. NM0030759).

The sites listed in the IP are associated with historical LANL operations dating back to the Manhattan Project era of the 1940s. The IP lists 405 permitted sites that must be managed to prevent the transport of contaminants off site via storm water runoff. Potential contaminants of concern within these sites are metals, organics, high explosives and radionuclides. These contaminants are present in soils near the top of the soil profile and are susceptible to storm event driven erosion and transport through storm water runoff.

The IP is unique in that it is a technology-based permit and relies, in part, on non-numeric technology-based effluent limits. Site-specific storm water control measures that reflect best industry practice considering their technological availability, economic achievability and practicability are required for each of the 405 permitted sites to minimize or eliminate discharges of pollutants. These controls are referred to as Best Management Practices (BMPs). BMPs are routinely inspected and maintenance is performed as required.

The local storm water drainage around sites (called Site Monitoring Areas [SMAs]) has been hydrologically analyzed, and sampling locations have been identified to most effectively sample runoff from sites. Stormwater is monitored from these SMAs to determine the effectiveness of the controls. When target action levels (TALs) which are based on New Mexico water quality standards are exceeded, corrective actions are required. In summary, the process of complying with the IP can be broken down into five phases: (1) Installation and maintenance of baseline controls; (2) storm water confirmation sampling in support of baseline controls; (3) corrective action (if TAL exceeded); (4) confirmation sampling in support of corrective actions; and (5) closeout or alternative compliance.

In 2010, the Laboratory completed the following tasks:

- Development of a Site Discharge Pollution Prevention Plan (SDPPP) for SWMU/AOCs that describes three main objectives: identification of pollutant sources, description of control measures and monitoring that determines the effectiveness of controls at all regulated SWMU/AOCs
- Fieldwork:
- Completed more than 1,000 rain event inspections conducted on all 250 SMAs
- Conducted BMP maintenance during inspection at 140 SMAs
- Conducted BMP installation at 205 SMAs
- Maintained 45 gauge stations for storm event sampling in support of ESR and Los Alamos/Pueblo canyon monitoring
- Decommissioned/removed sampler and equipment at 45 previous Federal Facilities Compliance Agreement (FFCA) locations

f. 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 (Clean Water Act, 40 CFR, Part 112) and NMED's Petroleum Storage Tank Bureau (PSTB) Regulations (20.5 NMAC). During 2010, 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 (Oil Pollution Prevention Regulations, 40 CFR, Part 112).

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 November 10, 2011. Primary modifications address AST storage capacity, inspection frequency, integrity testing requirements, and equipment. The Laboratory completed four modifications to existing and new SPCC Plans and implementation of those modifications is in process. The Laboratory continues to maintain and operate ASTs in compliance with 20.5 NMAC of the NMED-PSTB regulations. The Laboratory paid annual AST registration fees of $100 per AST. The Laboratory has three tank systems that are operational pursuant to 20.5 NMAC. The remaining four tanks systems are under temporary closure status pursuant to 20.5 NMAC.

During 2010, the Laboratory continued to work on removing and decommissioning ASTs that are no longer in service. Four AST systems are expected to be officially closed out with NMED-PSTB pursuant to 20.5 NMAC in 2011.

g. Dredge and Fill Permit Program

Section 404 of the Clean Water Act 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 Clean Water Act requires states to certify that Section 404 permits issued by the Corps of Engineers 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 2010, Section 404/401 permits were issued for four construction projects at the Laboratory:

- Stream Gage E110 Construction Project, Los Alamos Canyon (Nationwide Permits Nos. 5, 18, and 43, for Scientific Measurement Devices, Minor Discharges, and Stormwater Management Facilities, respectively)
- Stream Gages E042 and E050 Construction Project, Los Alamos Canyon (Nationwide Permits Nos. 5, 18, 33, and 43, for Scientific Measurement Devices, Minor Discharges, Temporary Construction Access and Dewatering, and Stormwater Management Facilities, respectively)
- Stream Gage E059 Construction Project, Pueblo Canyon (Nationwide Permit No. 5, Scientific Measurement Devices)
- Tactical Training Facility Project, Installation of a Temporary Culvert, Cañon de Valle (Nationwide Permit No. 14, Linear Transportation Projects)

In addition, LANL reviewed 597 excavation permits and 79 project profiles for potential impacts to watercourses, floodplains, or wetlands. One Floodplain/Wetland Assessment was prepared in 2010 for potential impacts to the wetlands and floodplain in Sandia Canyon resulting from changes in discharge volumes from NPDES Outfall 001 and from possible clean-up activities. One violation of the DOE Floodplains/Wetlands Environmental Review Requirements was recorded in 2010. The construction of a temporary fill bridge over Cañon de Valle violated 10 CFR 1022 and was reported to DOE LASO. NMED and the Corps of Engineers did not inspect any sites permitted under the Section 404/401 regulations during 2010.

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 2007). 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 of New Mexico has adopted these standards in the New Mexico Drinking Water Regulations (http://www.nmenv.state.nm.us/dwb/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.losalamosnm.us/.

In 2010, the Laboratory conducted additional confirmation monitoring of the Los Alamos County water supply system for quality assurance purposes. The data are presented in Chapter 5 of this report and at the online RACER Data Analysis Tool (www.racernm.com/). Drinking water supplied by Los Alamos County has not been impacted by any LANL contaminants.

9. Groundwater

a. Groundwater Protection Regulations

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 discharge plan and obtain a permit from the NMED (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 permit. In 2010, the Laboratory had one discharge permit and two discharge plans pending NMED approval (see Table 2-5).

i. TA-46 SWWS Plant Discharge Permit DP-857

On July 20, 1992, the Laboratory was issued a discharge permit for the TA-46 SWWS Plant. The permit was renewed on January 7, 1998, and modified by the NMED on October 1, 2002. The permit requires quarterly sampling of the SWWS Plant's effluent, NPDES Outfalls 001 and 03A027, and Cañada del Buey alluvial groundwater well CDBO-6 to demonstrate compliance with NMWQCC groundwater standards. The Laboratory reports the analytical results to the NMED quarterly. During 2010, none of samples collected exceeded NMWQCC groundwater standards. Monitoring data are available online at the RACER Data Analysis Tool (www.racernm.com/). On April 6, 2010, the NMED requested an application for renewal and modification of discharge permit DP-857. Accordingly, the Laboratory submitted a renewal application on July 2, 2010. The NMED conducted a site inspection of the TA-46 SWWS Plant on September 9, 2010. Approval of the renewal application was pending at the end of 2010.

ii. TA-50 RLWTF Discharge Plan DP-1132

On August 20, 1996, at the NMED's request, the Laboratory submitted a discharge plan application for the RLWTF at TA-50; NMED approval was pending at the end of 2010. Since 1999, the Laboratory has conducted voluntary quarterly sampling of the RLWTF's effluent and alluvial groundwater monitoring wells MCO-3, MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon for nitrate (as N), fluoride, and total dissolved solids (TDS). The Laboratory reports the analytical results to the NMED quarterly. During 2010, none of the quarterly discharge plan samples exceeded NMWQCC groundwater standards. Monitoring data are available online at the RACER Data Analysis Tool (www.racernm.com/).

iii. Domestic Septic Tank/Leachfield Systems Discharge Plan DP-1589

On April 27, 2006, at the NMED's request, the Laboratory submitted a discharge plan application for the discharge of domestic wastewater from 21 septic systems. These septic systems (a combined septic tank and leach field) are located in remote areas of the Laboratory where access to the SWWS Plant's collection system is not practicable. On April 6, 2010, the NMED requested that LANL submit a new, up-to-date septic tank/leachfield systems discharge plan application. Accordingly, on June 25, 2010, LANL submitted an updated discharge plan application for 15 septic tank/leachfield systems. The NMED conducted a site inspection of all septic tank/leachfield systems on September 23-24, 2010. Approval of the new application was pending at the end of 2010.

b. Groundwater Monitoring Activities

The Laboratory performed significant groundwater compliance work in 2010 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and installation of monitoring wells and a hydrologic test well in support of various groundwater investigations and corrective measure evaluations (CMEs).

In 2010, LANL installed two monitoring wells (with three screens) in the perched/intermediate aquifer and 12 monitoring wells (with 20 screens) in the regional aquifer (Table 2-12). Figure 2-5 shows the locations of the new wells; maps of all monitoring well locations can be found in Chapter 5.

Table 2-12
Monitoring Wells Installed in 2010

Type[a]	Identifier	Watershed (Canyon)	Total Completed depth[b] (ft bgs)	Screened interval(s) (ft bgs)	Initial Water level (famsl)	Comments
I	CdV-16-4ip	Cañon de Valle	1146.0	815.6–879.2 1110–1141.1	6655 (Screen 1) 6375 (Screen 2)	Hydrologic test well installed downgradient of the 260 Outfall (Consolidated Unit 16-021(c)-99) to evaluate the hydrologic properties of the deep perched intermediate aquifer in TA-16. Completed on 8/23/2010.
R	R-3	Pueblo Canyon	1006.8	974.5–995.0	5743	Monitoring well installed in Pueblo Canyon, near the eastern boundary of the Laboratory's TA-74. Objective of the well was to provide a regional aquifer monitoring well within potential contamination flow paths in the regional aquifer near municipal production well Otowi 1. Completed on 6/21/2010.
R	R-29	Water/Ancho	1191.8	1170.0–1180.0	5949.2	Monitoring well installed to provide a regional aquifer monitoring well downgradient of TA-49 and MDA AB to determine whether zones of perched-intermediate groundwater occur under MDA AB and to reduce geologic uncertainty. Completed on 3/31/2010.
R	R-30	Water/Ancho	1171.8	1140.0–1160.9	5949.8	Monitoring well installed to provide a regional aquifer monitoring well at the eastern edge of TA-49 and downgradient of MDA AB, to determine whether zones of perched-intermediate groundwater occur under MDA AB, and to reduce geologic uncertainty. Completed on 4/3/2010.
R	R-50	Mortandad	1217.5	1077.0–1087.0 1185.0–1205.6	5837.0 (Screen 1) 5836.7 (Screen 2)	Monitoring well installed on the mesa south of Mortandad Canyon to define the southern extent of chromium contamination in the regional aquifer. Completed on 2/13/2010.
R	R-51	Pajarito	1046.1	915.0 to 925.2 1031.0 to 1041.0	5870.1 (Screen 1) 5868.6 (Screen 2)	Monitoring well installed west of MDAs H and J, and northwest of TA-18. Monitors TA-54 and other potential contaminant sources in Pajarito Canyon. Completed on 2/8/10.
R	R-52	Pajarito	1128.7	1035.2–1055.7 1107.0–1117.0	5865.7 (Screen 1) 5863.9 (Screen 2)	Monitoring well installed north-northeast of MDAs H and J, on mesa south of Cañada del Buey. Monitors for potential releases of contaminants from MDAs H and J. Completed on 3/31/10.

Table 2-12 (continued)

Type[a]	Identifier	Watershed (Canyon)	Total Completed depth[b] (ft bgs)	Screened interval(s) (ft bgs)	Initial Water level (famsl)	Comments
R	R-53	Pajarito	1001.9	849.2–859.2 959.7–980.2	5861.1 (Screen 1) 5852.0 (Screen 2)	Monitoring well installed north of MDA L in Cañada del Buey; monitors for potential releases from MDA L. Completed on 3/1/10.
R	R-54	Pajarito	936.0	830.0–840.0 915.0–925.0	5862.8 (Screen 1) 5864.6 (Screen 2)	Monitoring well installed immediately west of MDA L in Pajarito Canyon; monitors for potential releases from MDA L. Completed on 1/29/10.
R	R-55	Pajarito	1021.0	860.0–880.6 994.4–1015.4	5698.8 (Screen 1) 5698.6 (Screen 2)	Monitoring well installed downgradient of MDA G; monitors for potential contaminant releases from MDA G and other sources in Pajarito Canyon. Completed on 8/25/2010.
R	R-56	Pajarito	1078.8	945.0–965.6 1046.6 to 1067.1	5858.5 (Screen 1) 5855.8 (Screen 2)	Monitoring well installed on Mesita del Buey between MDA G and MDA L; monitors for potential contaminant releases from MDAs G and L, and other sources in Pajarito Canyon. Completed on 7/19/2010.
R	R-57	Pajarito	1013.8	910.0–930.5 971.5–992.1	5758.5 (Screen 1) 5750.2 (Screen 2)	Monitoring well installed downgradient of MDA G at the eastern end of TA-54; monitors for potential releases from MDA G. Completed on 6/8/2010.
R	R-60	Pajarito	1360.9	1330.0–1350.9	5908.7	Monitoring well installed east of MDA C; monitors for potential contaminant releases from MDA C. Completed on 10/18/2010.
I	TW-2Ar	Pueblo	113.9	102.0–112.0	6553.3	Replacement monitoring well for TW-2A; monitors perched-intermediate groundwater in lower Pueblo Canyon. Completed on 3/4/10.

[a] I = Perched intermediate aquifer well; R = regional aquifer well.

[b] Total depth refers to the completed well; bgs = below ground surface; famsl = feet above mean sea level.

Intermediate well CdV-16-4ip was installed downgradient of the 260 Outfall in TA-16 as a hydrologic test well to evaluate the properties of the deep perched groundwater. Regional well R-3 was installed east of TA-74 to monitor for potential contamination near the municipal production well Otowi 1. Regional wells R-29 and R-30 were installed downgradient of TA-49 and MDA-AB. Regional well R-50 was installed on the mesa south of Mortandad Canyon as part of the ongoing chromium investigation. Regional wells R-50, R-51, R-52, R-53, R-54, R-55, R-56, and R-57 were installed to monitor for potential contamination from material disposal areas (MDAs) in TA-54 and to support CMEs for MDAs at TA-54.

Sample analytical and other groundwater data can be reviewed online on the RACER Data Analysis Tool (www.racernm.com/). Periodic monitoring reports and water-level and well construction data can be found on the Laboratory's Environment Website at http://www.lanl.gov/environment/h2o/reports.shtml.

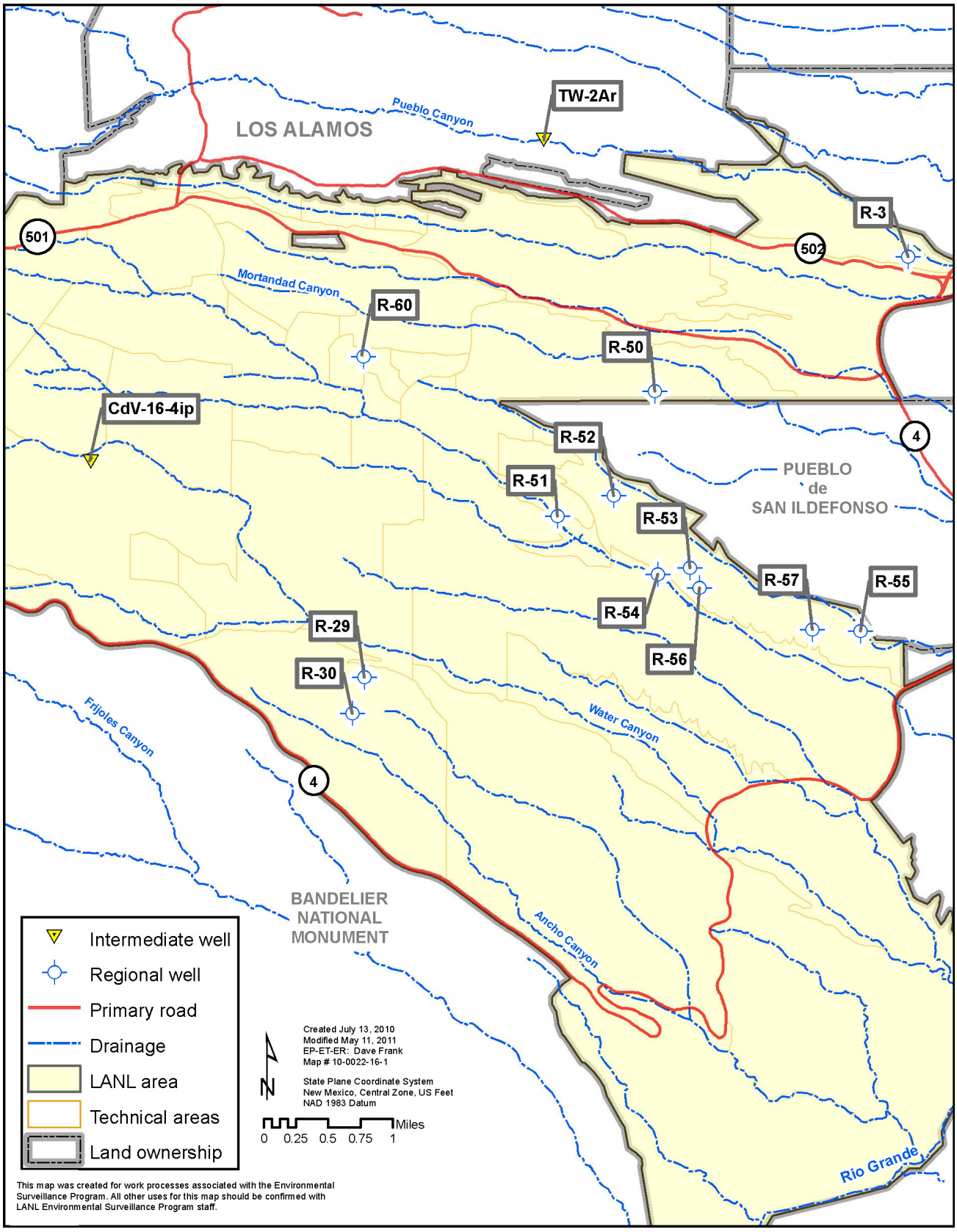

Figure 2-5 Groundwater monitoring wells installed during 2010

10. National Environmental Policy Act

Under the National Environmental Policy Act (NEPA) (42 U.S.C. 4331 et seq.), federal agencies such as DOE/NNSA must consider the environmental impacts of proposed projects and ensure public participation as part of the decision-making process. The Laboratory's Environmental Stewardship Group devotes considerable resources to assist NNSA in compliance with NEPA, pursuant to DOE Order 451.1B. Proposed projects and actions at LANL are reviewed to determine potential resource impacts and the appropriate coverage under NEPA, and these recommendations are provided to NNSA.

The DOE NEPA implementing regulations (10 CFR Part 1021.330[d]) require a Site-Wide Environmental Impact Statement (SWEIS) to be reviewed at least every five years and a Supplemental Analysis to examine whether the SWEIS still adequately covers site operations. In August 2005, a memo was issued to LANL from DOE/NNSA to prepare a new SWEIS. The final SWEIS was issued in May 2008 (DOE 2008a). Two Records of Decision (ROD) have been issued to date, one in September 2008 (DOE 2008b) and one in June 2009 (DOE 2009). In both RODs, DOE/NNSA decided to implement the No Action Alternative with the addition of some elements of the Expanded Operations Alternative.

The first Supplement Analysis to the 2008 SWEIS was issued by DOE in October 2009. This analysis was prepared to determine if the 2008 SWEIS adequately bounded offsite transportation of low specific activity and LLW by a combination of truck and rail to EnergySolutions in Clive, Utah. DOE/NNSA concluded that the proposed shipment of waste to EnergySolutions by truck and rail are bounded by 2008 SWEIS transportation analysis.

LANL reviews all proposed projects and verifies that they will be compliant with the existing SWEIS or other NEPA documents. In some cases, further NEPA analysis is done, and NEPA documents are prepared. For example, in 2010, LANL supported the completion of an environmental assessment for the Sanitary Effluent Reclamation Facility and Environmental Restoration of Reach S-2 of Sandia Canyon (DOE/EA-1736).

11. Endangered Species Act

The Endangered Species Act requires federal agencies to protect populations and habitats of federally listed threatened or endangered species. LANL implements these requirements through the Biological Resources Management Plan (LANL 2007) and the Habitat Management Plan (LANL 2011).

The Laboratory contains potential habitat for two federally endangered species (Southwestern willow flycatcher, *Empidonax traillii extimus*, and black-footed ferret, *Mustela nigripes*), one federally threatened species (Mexican spotted owl, *Strix occidentalis lucida*), and three candidate species (yellow-billed cuckoo, *Coccyzus americanus*, Jemez Mountains salamander, *Plethodon neomexicanus,* and New Mexico meadow jumping mouse, *Zapus hudsonius luteus*). The Southwestern willow flycatcher, black-footed ferret, and New Mexico meadow jumping mouse have not been observed on Laboratory property. In addition, several federal species of concern and state-listed species potentially occur within LANL (Table 2-13).

Table 2-13
Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL

Scientific Name	Common Name	Protected Status[a]	Potential to Occur[b]
Empidonax traillii extimus	Southwestern Willow Flycatcher	E	Moderate
Mustela nigripes	Black-footed Ferret	E	Low
Strix occidentalis lucida	Mexican Spotted Owl	T	High
Coccyzus americanus	Yellow-billed Cuckoo	C, NMS	Moderate
Zapus hudsonius luteus	New Mexico meadow jumping mouse	C, NMS	Moderate
Haliaeetus leucocepahlus	Bald Eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed Hummingbird	NMT, S1	Low
Gila pandora	Rio Grande Chub	NMS	Moderate

Table 2-13 (continued)

Scientific Name	Common Name	Protected Status[a]	Potential to Occur[b]
Plethodon neomexicanus	Jemez Mountains Salamander	C, NME	High
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
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

[a] E = Federal Endangered; T = Federal Threatened; C = Federal Candidate Species; 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.

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 2010, LANL reviewed 622 excavation permits and 148 project profiles for potential impacts to threatened or endangered species. The Laboratory conducted surveys for the Mexican spotted owl, Southwestern willow flycatcher, Jemez Mountains salamander, and grey vireo. The Laboratory also updated its Sensitive Species Best Management Practices Source Document.

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. In the project review process, LANL biologists provided specific comments for projects with the potential to impact migratory birds, their eggs, or nestlings if, for example, a project proposed an electrical power line or a project disturbed vegetation during the bird nesting season. During 2010 the Laboratory also updated its Migratory Bird Best Management Practices Source Document.

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. LANL describes its implementation of Section 106 in the Cultural Resources Management Plan (LANL 2004) available online.

In 2010, the Laboratory conducted 44 projects that required some field verification of previous cultural surveys. Three new archaeological sites and 19 new historical buildings were identified in 2010. Twelve historic buildings were determined eligible for the National Register of Historic Places. As part of Section 106, LANL conducts public outreach and provides site tours of historic and cultural sites for stakeholders, DOE/NNSA, and representatives of other federal agencies.

The Laboratory continued the Land Conveyance and Transfer Project (C&T) in 2010. The DOE/NNSA is in the process of conveying and transferring approximately 2,000 acres of DOE lands to Los Alamos County and to the Bureau of Indian Affairs to be held in trust for the Pueblo of San Ildefonso. Thirty-nine archaeological sites were excavated during the 2002 to 2005 field seasons, with more than 200,000 artifacts and 2,000 samples collected. During 2010, the artifacts and records from the C&T project were transferred for curation to the Museum of Indian Arts and Culture in Santa Fe, New Mexico. Data collected from these sites provide new insights into past activities on the Pajarito Plateau from 5000 B.C. to A.D. 1943. From a compliance perspective, these excavations resolve the anticipated adverse effects to archaeological sites from the future development of lands to be conveyed to Los Alamos County. These sites are also ancestral places to the local Pueblo populations, and, as such, representatives from the Pueblos de San Ildefonso and Santa Clara acted as tribal consultants and monitors on the project. The final report was submitted to the New Mexico State Historic Preservation Office in fulfillment of the Data Recovery Plan and the Programmatic Agreement between the DOE/LASO, the Advisory Council on Historic Preservation, and the State Historic Preservation Office and is available online.

In support of LANL's 2010 D&D program, square footage reduction, and Laboratory consolidation, the Laboratory conducted historic building assessments and other final documentation work related to five proposed projects as required under the provisions of the NHPA. Buildings included in these projects are located at TAs-3, -9, -18, and -21. 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 Laboratory continues to consult with the Pueblos 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. During FY10 consultations with the Pueblo de San Ildefonso were completed regarding the culturally affiliated human remains discovered in TA-36 the previous year. The area was protected with geotextile fabric covered by a soil layer.

D. UNPLANNED RELEASES

1. Air Releases

No unplanned air releases occurred at LANL during 2010.

2. Water Releases

No unplanned releases of radioactive liquids occurred on Laboratory lands in 2010. There were 23 unplanned releases of non-radioactive liquids in 2010 that were reported to NMED pursuant to 20.6.2.1203 NMAC (Table 2-14).

Table 2-14
2010 Unplanned Non-Radioactive Releases

Material Released	Instances	Approximate Total Release (gallons)
Potable Water	14	2,025,000
Hydraulic Fluid	2	52
Sanitary Wastewater	2	1900
Fire Suppression Water	1	200
Organic Solvent	1	5
Re-Use Water	2	100,100
Steam Condensate	1	5000

In addition, there were 12 reports for groundwater detections in excess of New Mexico Groundwater Quality Standards and 7 well packer failures that were reported pursuant to 20.6.2.1203 NMAC.

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 as required to ensure adequate cleanup. In 2010, the Laboratory was in the process of administratively closing all releases for 2010 with the NMED and the DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

E. REFERENCES

DOE 2004: "Environment, Safety, and Health Reporting." US Department of Energy Order 231.1A.

DOE 2008a: "Final Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico," US Department of Energy report DOE/EIS-0380 (May 16, 2008).

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LANL 2004: "A Plan for the Management of the Cultural Heritage at Los Alamos National Laboratory, New Mexico," Los Alamos National Laboratory document LA-UR-04-8964.pdf (2004) http://www.lanl.gov/environment/cultural/docs/CRMP_

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LANL 2010: Fiscal Year 2011 Site Sustainability Plan, Los Alamos National Laboratory document LA-UR-11-01856 (2010).

LANL 2011: "Threatened and Endangered Species Habitat Management Plan," Los Alamos National Laboratory document LA-UR-11-02582. http://www.lanl.gov/environment/bio/docs/HMP_LA-UR-11-02582.pdf

NMEIB 2007: "Drinking Water Regulations" (as amended through April 2007), found at 20.7.10 NMAC, New Mexico Environmental Improvement Board, State of New Mexico (2007).

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A. INTRODUCTION

This chapter presents the results of the calculation of radiological dose to the public and biota from Los Alamos National Laboratory (LANL or the Laboratory) operations in 2010 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 potential dose 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 calculated biota dose is potentially received throughout the interior of Laboratory property, usually at locations rarely visited by humans. In addition, the potential risks from non-radiological materials detected during 2010 and previous years' sampling activities are summarized.

As defined by US Department of Energy (DOE) Standard 1153-2002 (DOE 2002), biota are divided into plants and animals. Plants receive the highest radiation dose because they grow and remain in one location. Most animals range over an area, which usually minimizes their dose. Humans receive the lowest radiation 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 radiation dose may have a higher biota radiation dose.

B. RADIOLOGICAL DOSE ASSESSMENT FOR HUMANS

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; ICRP 1996; 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, from a human health risk perspective, 1 mrem of direct gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium. In addition, the dose results within this chapter reflect potential dose to hypothetical people and biota and are not to be construed as a dose assessment for any specific individual or organism.

Federal government standards limit the dose that the public may receive from Laboratory operations. The primary risk of receiving radiation dose is cancer. For low doses of radiation, the risk of contracting cancer is 8×10^{-7} per mrem received.

The DOE dose limit to a member of the public is 100 mrem/yr (DOE 1993) received from all pathways (i.e., all ways in which a person 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 "as low as reasonably achievable" (ALARA) process (LANL 2008a) and generally should not exceed a dose constraint of one-quarter of the primary dose limit, or 25 mrem/yr (DOE 1999). The dose received from airborne emissions of radionuclides is further restricted by the US Environmental Protection Agency (EPA) dose standard of 10 mrem/yr (EPA 1986), also known as the National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other than Radon from DOE (Rad-NESHAP) 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 rate (4 mrem/yr for man-made radionuclides) (EPA 2004).

2. Public Dose Calculations

a. Scope

The objective of our public dose calculations is to report incremental (above-background) doses resulting from LANL operations. Therefore, we do not 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) not on LANL property for the airborne pathway dose only and compared with the EPA Rad-NESHAP dose limit of 10 mrem/yr
3. The MEI not on LANL property for the all-pathways dose and compared with the DOE Order 5400.5 dose limit of 100 mrem/yr
4. Residents in Los Alamos and White Rock
5. Recreational scenarios on public trails near Los Alamos

b General Considerations

As discussed in Section B.4, below, the dose rate from naturally occurring radioactivity is approximately 450 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 US per capita background dose to about 700 mrem/yr on average (NCRP 1975, 1987a, 1987b, 2009). It is extremely difficult to measure doses from LANL that are less than 0.1% 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.

We begin with environmental measurements of radionuclides in air, water, soil, foodstuffs, sediment, and non-foodstuffs biota. We compare the concentrations of these radionuclides in the various media to pre-determined radionuclide-specific screening levels that are equivalent to 0.1 mrem/yr for specific exposure pathways such as ingestion of drinking water, ingestion of foodstuffs, and exposure to residual contamination in soil (LANL 2003). If the concentrations do not exceed the screening levels, no further assessment is required and the doses are assumed to be essentially zero. If the concentrations do exceed the screening levels, further dose assessment is required, and specific numerical dose values are reported in this chapter (LANL 2008b).

i. Direct Radiation Exposure

The Laboratory monitors direct radiation from gamma photons or neutrons at about 100 locations in and around LANL (see Chapter 4, Section C). Direct radiation doses above natural background are measured near Technical Area (TA) -54, but there are no other Laboratory sources of external radiation that can be measured at off-site areas.

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 kilometer, 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 (see Section B.3.b of this chapter).

To estimate the dose to the public near TA-54, we multiply the measurements of neutron dose by an occupancy factor of 1/16 (NCRP 1976). The direct radiation measurements reported in Chapter 4 apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/yr). We followed

standard guidance and assumed continuous occupancy for residences and places of business. For all other locations, we multiplied the measured dose by the 1/16 occupancy factor.

ii. Airborne Radioactivity (Inhalation Pathway)

At distances of 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 (PC Version 3.0) (EPA 2007), an atmospheric dispersion and dose calculation computer code that combines stack radionuclide emissions information with meteorological data to estimate where the released radioactive material may have gone and the dose from that radioactive material.

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 (see 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 of these radionuclides are short (mostly 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, Buckman wells, and natural springs) in 2010 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226. Except for tritium (refer to section B.d.*i.* in this chapter), radionuclides attributable to Laboratory operations are not found in recognized drinking water sources.

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 are collected on the perimeter of the Laboratory and at regional and on-site locations on a triennial basis (every three years). Routine soil samples were previously collected in 2006 and were collected again in 2009. No regional samples have had radionuclide concentrations detected 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. In 2010, soil samples were collected on Pueblo de San Ildefonso lands, at the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility, and at TA-54, Area G.

v. Food (Ingestion Pathway)

We report measurements of the radioactive content of food, mostly crops, fish, and native vegetation, in Chapter 8. The food is collected on a triennial basis, rotating with the collection of soils. In 2010, emphasis was placed on the collection of crops on site, around the perimeter of the Laboratory, and in the region.

vi. Release of Items and Real Property

The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public, following Laboratory requirements for release of such items (LANL 2009). All items destined for release from known or potentially contaminated areas are screened for radioactive contamination in accordance with the 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. In addition, items are not released if they are from a known or potentially contaminated area that cannot be completely surveyed. The authorized release limits for items (LANL 2009) are the limits in Figure IV-1 of DOE requirements (DOE 1993, DOE 1995).

The Land Conveyance & Transfer Project (LC&T) is a Department of Energy (DOE), National Nuclear Security Administration (NNSA) project for which Los Alamos National Laboratory (LANL) provides technical and project management support under Public Law (PL) 105-119. On November 26, 1997, Congress passed Public Law 105-119, the Departments of Commerce, Justice, and State, the Judiciary, and

Related Agencies Appropriations Act. Section 632 of that law directed the Secretary of Energy to convey or transfer parcels of Department of Energy (DOE) land in the vicinity of Los Alamos National Laboratory to the Incorporated County of Los Alamos, New Mexico, and to the Secretary of the Interior, in trust for the Pueblo of San Ildefonso. Such parcels or tracts of land were required to meet the suitability criteria established by the law:

- They were not required for the national security mission before the end of November 26, 2012
- They could be restored or remediated by November 26, 2012 (now extended to 2022)
- They were suitable for historic, cultural, or environmental preservation, economic diversification, or community self-sufficiency

In 1998, the DOE identified 10 tracts of land totaling approximately 4,800 acres for potential transfer to the County of Los Alamos or to San Ildefonso Pueblo. The original 10 tracts have been subdivided into 32 tracts. Some of the tracts withdrawn due to mission needs or remediation activities may be conveyed to Los Alamos County upon cleanup of Technical Area (TA) 21. The 2011 National Defense Authorization Act extended the PL to September 2022. To date, 20 parcels have been conveyed or transferred to the Incorporated County of Los Alamos, the Los Alamos Public Schools and to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso. All parcels were transferred with concentrations of residual radioactive material in the soil attributable to Laboratory operations less than the radionuclide screening levels for the residential scenario, which is the most conservative scenario. This approach results in a potential dose to the public of 15 mrem/yr or less. In addition, the ALARA concept has been applied to these transfers such that the potential dose is much less than 15 mrem/yr.

3. Dose Calculations and Results

a. Collective Dose to the Population within 80 Kilometers

We used the local population distribution to calculate the dose from 2010 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 New Mexico 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 population 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 3 mrem, the collective dose is 6 person-mrem. This collective dose results from airborne radioactive emissions only. 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 2010 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory is 0.22 person-rem, which is less than the collective population dose of 0.57 person-rem reported for 2009. Tritium contributed 31% of the dose, and short-lived air activation products such as carbon-11 from LANSCE contributed 60% of the dose. LANSCE has historically been the major contributor to the collective population dose. Collective population doses for the past 16 years have generally declined from a high of 4 person-rem in 1994 to less than 1 person-rem in 2010 (Figure 3-1). It is expected that future collective population doses will be less than 1 person-rem. No observable health effects in the local population are expected from this dose.

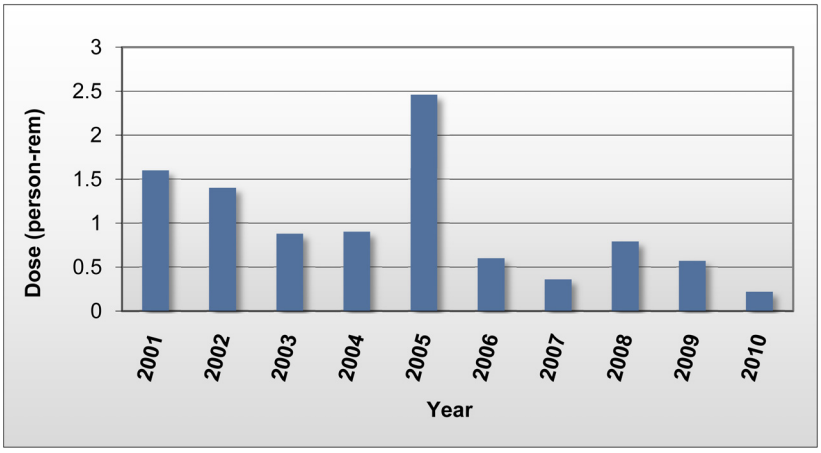

Figure 3-1 Annual collective dose (person-rem) to the population within 80 km of LANL over the past 10 years

b. Dose to the 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 most of the past 10 years, the airborne pathway (Rad-NESHAP) 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

Because the LANSCE emissions after 2005 have been reduced to such low levels (< 1.0 mrem/yr), the location of the MEI for 2010 was not as readily apparent as in the past and required more detailed evaluation, as follows.

We know the dose from LANSCE emissions is a significant contributor at the East Gate location, but much less so at other possible MEI locations. We evaluated the air pathway dose at the East Gate location from all LANSCE emissions. This air pathway dose totaled 0.0699 mrem. To this we added the contribution from the East Gate AIRNET station (0.021 mrem) for a total of 0.091 mrem. We used this value as a point of comparison for examining the dose at other AIRNET locations summed with the dose from the LANSCE emissions at each location.

Two AIRNET stations with relatively higher doses located at places of a business or residence close to LANSCE were considered. The first is AIRNET station 317, adjacent to the material disposal area (MDA)-B remediation project, representing a receptor at 278 DP Road. The second is AIRNET station 257, called the LA Inn-South station, representing a cluster of receptors along the southern edge of the Los Alamos town site near the former Los Alamos Inn. The 2010 AIRNET dose at the DP Road location is 0.133 mrem and the dose at the LA Inn-South location is 0.174 mrem for 2010. The LANSCE facility doses at these locations were 0.00781 mrem and 0.00404 mrem, respectively. The sums of the AIRNET dose and the LANSCE facility dose at each location were 0.141 mrem at the DP Road location and 0.178 mrem at the LA Inn South location. Because the dose at the LA Inn-South location is greater than the dose at DP Road, it is the Rad-NESHAP MEI location for 2010 operations. The total dose at the LA Inn-South location from all air emissions LANL sources for 2010 was 0.33 mrem (Fuehne 2011).

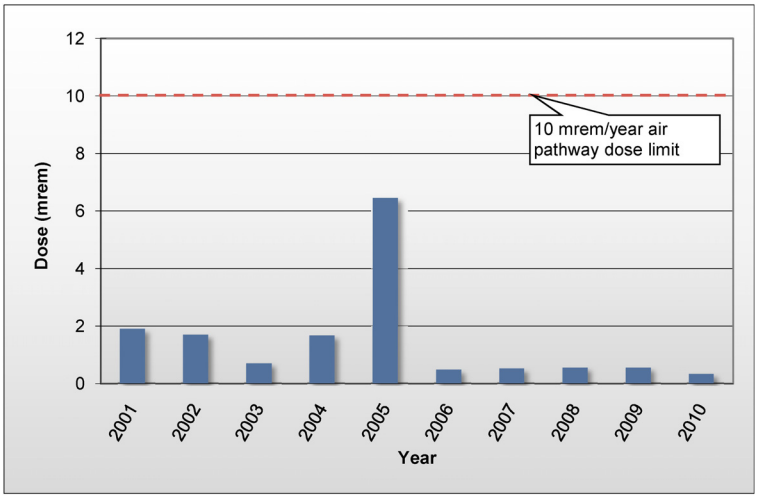

Figure 3-2 Annual airborne pathway (Rad-NESHAP) dose (mrem) to the MEI over the past 10 years

ii. All-Pathways MEI Dose

The location evaluated in 2010 as the potential all-pathways MEI is the Laboratory boundary near the Pueblo de San Ildefonso sacred area north of TA-54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, emits neutrons. The measured neutron dose at the boundary was 13 mrem/yr for 2010. After subtracting a 2-mrem/yr neutron background dose and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose is 11 mrem/16 = 0.7 mrem/yr. The gamma dose is calculated to be less than 0.01 mrem and is not included because it cannot be distinguished from the much larger gamma background measured at this and other nearby monitoring locations. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as 0.01 mrem/16 = 0.001 mrem/yr. We added the dose derived from measurements at the highest-dose AIRNET station along the northern boundary of Area G (3 mrem/yr) close to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.2 mrem/yr. This resulted in a total dose at this location of approximately 0.9 mrem/yr, which is greater than the airborne pathway MEI dose at the LA Inn-South location.

iii. MEI Dose Summary

The Rad-NESHAP MEI dose of 0.33 mrem/yr at the LA Inn-South location is below the 10 mrem/yr EPA airborne emissions dose limit for the public (EPA 1986), and, based on previous studies, we conclude it causes no observable health effects (BEIR 2006). The all-pathways MEI dose of 0.9 mrem/yr at the Laboratory 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). We conclude this dose will not result in observable human health effects.

In most past years, LANSCE has been the major contributor to the Rad-NESHAP MEI dose. Future operations of the facility and associated emissions are expected to stay consistent with recent past years' levels. The 2009 and 2008 Rad-NESHAP MEIs were located at East Gate and were primarily due to short-lived air activation emissions from LANSCE. The 2007 Rad-NESHAP MEI was located on DP Road and was primarily due to the re-suspension of plutonium-239 in soil from MDA B. With continued remediation activities at MDA B during 2011, it is possible that the Rad-NESHAP MEI may once again be located on DP Road in 2011.

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 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 stack emissions, 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 2010, the Laboratory contributions to the airborne pathway dose at an average Los Alamos residence were less than 0.1 mrem.

ii. White Rock

During 2010, the Laboratory contributions to the airborne pathway dose at an average White Rock residence were also less than 0.1 mrem.

iii. Dose Summary

The dose contributions from food, water, and soil are discussed in section B.3.d. and are considered to be essentially a zero dose (i.e., <0.1 mrem/yr). In summary, the total annual dose in 2010 to an average White Rock/Los Alamos resident from all pathways was less than 0.1 mrem and is well below the all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint. No observable human health effects are expected from this dose.

d. Pathway-Specific Doses

While the maximum airborne pathway dose for 2010 is described above in section 2.b.*i.*, other pathway-specific doses are presented below.

i. Water (Ingestion Pathway)

The highest concentration of tritium detected in a Los Alamos County drinking water supply well was 7 pCi/L in a sample collected from the Otowi-4 well located in Upper Los Alamos Canyon and is at the low end of the range of tritium concentrations found in rainwater (5 to 200 pCi/L) (Okada 1993). This concentration is far below the EPA MCL of 20,000 pCi/L and results in a dose of much less than 0.1 mrem/yr if this water were to be ingested for an entire year (assumes 730 L ingested for the year). Tritium was also detected in water samples from Basalt Spring on Pueblo de San Ildefonso land at levels up to 51 pCi/L, also within the range found in rainwater. The dose from ingesting this water for an entire year (730 L) would also be much less than 0.1 mrem/yr.

Surface water samples were obtained in 2010 from three locations along the Rio Grande: at Otowi Bridge, at the planned diversion site for the Buckman Direct Diversion Project, and at the mouth of Frijoles Canyon in Bandelier National Monument (downriver from all canyons draining LANL). Radionuclide analysis of these samples indicated the presence of radium-226, radium-228, thorium-228, thorium-230, thorium-232, tritium, uranium-234, uranium-235/236, and uranium-238. The tritium and uranium could possibly be attributed to Laboratory legacy operations. However, tritium is a component of nuclear fallout from previous atmospheric testing and is also cosmogenically produced, that is, created in the upper atmosphere from the interaction of cosmic radiation with gases. In addition, these concentrations are well within the tritium levels seen in rainwater from these non-LANL sources. In addition, the uranium-234 and uranium-238 concentrations are also well within natural background radioactivity levels, and the ratio of the two isotopes within each sample are indicative of natural uranium (~1:1). While some of the measured uranium concentrations exceed the 0.1 mrem/yr screening level specific to uranium (LANL, 2003), the doses are attributable to natural background levels, not to past or current Laboratory operations.

In conclusion, these water ingestion doses are very small relative to the 4-mrem/yr EPA community drinking water dose limit.

ii. Soil (Direct Exposure Pathway)

Because soil samples are collected every three years and the focus of the 2010 collection period was on crops, only a small number of soil samples was collected during this time frame. Radionuclide concentrations measured in soil samples collected from Pueblo de San Ildefonso lands (Tsankawai/PM-1 and San Ildefonso) during 2010 were all well below the 0.1 mrem/yr screening levels (LANL 2003). Screening of these offsite

soil concentrations indicates that the annual dose from the soil exposure pathway would result in less than 0.1 mrem/yr to a member of the public residing in these areas.

Only six sample results, from locations in and around TA-54, Area G, and the DARHT facility, exceeded the 0.1 mrem/yr screening criteria: two for transuranic radionuclides (Area G), one for tritium (Area G), and three for uranium-238 (DARHT). However, because these locations are not accessible to the public, there is no public dose through the soil exposure pathway.

In summary, we conclude that the dose from soil at the off site locations is less than 0.1 mrem/yr (essentially zero), and the anthropogenic radionuclides detected at those locations are primarily due to worldwide fallout.

iii. Food (Ingestion Pathway)

In 2010, we focused our analysis on crops, goat milk, eggs, honey, and road-killed elk.

Radionuclides analyzed in crops collected from regional, perimeter, and on-site locations in 2010 did not have concentrations above the 0.1 mrem/yr screening levels for food (LANL 2003). Radionuclide concentrations measured in goat milk collected from the perimeter of the Laboratory and in the regional locations in 2010 did not exceed 0.1 mrem/yr. In addition, both measured concentrations were below the RSRL. Radionuclide concentrations measured in medium sized chicken eggs collected from perimeter and regional sites in 2010 were well below the 0.1 mrem/yr screening levels for food. Honey collected at perimeter and regional locations during 2010 did not exceed the 0.1 mrem/yr screening levels. None of the muscle and bone radionuclide concentrations measured in road-killed elk found on Laboratory property exceeded the 0.1 mrem/yr screening levels. Consumption of these elk would, therefore, result in a dose to the public of less than 0.1 mrem/year. In conclusion, the food ingestion doses are very small relative to the all-pathways dose limit of 100 mrem/yr and the 25-mrem/yr dose constraint.

iv. Release of Items and Real Property

As part of the TA-21 closure program (refer to Chapter 9, section D.2. for further information), several lots of D&D (decontamination and demolition) debris were shipped to industrial landfills (974 cubic yards to Safe Harbors, Deer Trail, Colorado; 1466 cubic yards to U.S. Ecology in Idaho; and 320 cubic yards to Waste Control Specialists in Texas) for disposal in 2010. Some of this debris contained radioactive surface contamination below the authorized release limits in Figure IV-1 of DOE requirements (DOE 1993, DOE 1995). This debris met the waste acceptance criteria of each industrial landfill and each state's regulatory authority approved the acceptance of the waste. Given the levels of the surface contamination, the potential dose to the public from this pathway is expected to be negligible.

The transfer of real property (land) from DOE to the public is allowed if the modeled dose is no greater than the authorized release limit of 15 mrem/yr and the modeled dose is ALARA. An environmental ALARA analysis was performed during 2010 for the transfer of land tract A-18-a. Land tract A-18-a is part of the Pueblo Canyon stream channel and floodplain just west of the State Route 4/State Route 502 interchange, also known as the White Rock "Y." A draft quantitative analysis was performed for the land tract because the individual dose was assessed above 3 mrem/yr, but less than 15 mrem/yr (authorized release limit for real property). However, the analysis indicated that the cost of further remediation for this land tract far exceeded the benefit, and, therefore, the dose is ALARA and no further action was recommended. It should be noted that tract A-18-a has not been transferred into the public domain at this time, pending full implementation of DOE Order 458.1.

e. Doses from Recreation near Los Alamos

In the past, contamination from Laboratory operations was discharged into nearby canyons. In this section, we consider the potential dose to a recreational hiker in those canyons that are accessible to the public: Acid Canyon, Pueblo Canyon, the Rio Grande, and lower Ancho Canyon.

From 1943 through 1964, radioactive liquid waste was discharged into Acid Canyon. The resulting contaminated sediment was transported through Pueblo Canyon to Los Alamos Canyon and from there to the Rio Grande.

i. Pueblo Canyon

At some locations, the sediment contains 100 pCi/g of plutonium-239, 10 pCi/g of americium-241, 4 pCi/g of uranium-238 and -234, 2 pCi/g of cesium-137, and smaller amounts of other radionuclides (LANL 2004a). Almost all of this material is beneath the surface of the streambed or banks so resuspension is very small (LANL 2002). We used RESRAD (http://web.ead.anl.gov/resrad/home2/) using the default parameters, to calculate the dose to a hiker who walks directly on the contaminated sediment for 10 hours. This is a realistic scenario because the contaminated sediment is a very small fraction of the total exposed soil. In this case, the dose is less than 0.1 mrem (McNaughton 2011).

ii. Ancho Canyon

There are several public hiking trails in Ancho Canyon to the east of State Road 4. However, there is no measurable contamination from LANL (LANL 2011) and the annual dose from LANL operations is much less than 0.1 mrem (McNaughton 2011.)

iii. Rio Grande

It is difficult to measure the contamination in the Rio Grande from LANL operations because the radioactivity is similar to natural background and global fallout (LANL 2010, McNaughton 2011, ChemRisk 2010, and Englert 2008.)

However, detailed investigation by the New Mexico Environment Department (NMED) Oversight Bureau demonstrated the presence of legacy contamination that was carried in sediment from Los Alamos Canyon to a channel near Cañada Ancha, near the Buckman Direct Diversion Project (Englert 2008.) The average sediment concentrations are 0.22 pCi/g of cesium-137 and 0.012 pCi/g of plutonium-239. For any scenario, the annual dose from this sediment is less than 0.1 mrem (McNaughton 2011.)

4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section, we discuss the potential LANL dose 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 due to 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 and Lowder 1988). In addition, background doses from terrestrial radiation range from about 50 to 150 mrem/yr.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products. Nationwide, the average dose from radon is about 200 to 300 mrem/yr (NCRP 1987b.) In Los Alamos County, the average residential radon concentration results in a dose of 270 mrem/yr and is within the range of the national average (Whicker 2010). 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 300 mrem/yr from medical and dental uses of radiation. Compared to estimates used in previous years, this is a significant increase and is attributable to new information about the average medical dose received by members of the US population (NCRP 2009). About 10 mrem/yr comes from man-made products, such as stone or adobe walls, and less than 1 mrem/yr comes from global fallout from nuclear weapons tests. Therefore, the average total annual dose from sources other than LANL is approximately 790 mrem. Figure 3-3 compares the average natural radiation background (and other sources) in Los Alamos to the average background dose in the United States. The estimated LANL-attributable 2010 all-pathways MEI dose, 0.9 mrem/yr, is about 0.2% of the average US background radiation dose from all sources.

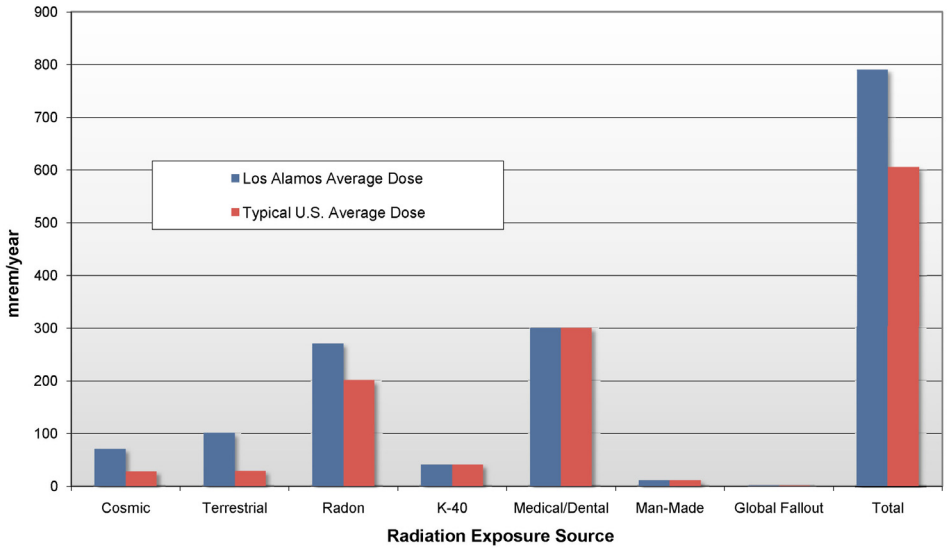

Figure 3-3 Average Los Alamos County radiation background dose compared with average US radiation background dose. Los Alamos County-specific background doses have not been determined for potassium-40 (K-40), man-made radiation, and global fallout and are assumed to be the same as the US average in this figure.

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), and as low as 1 rem (1,000 mrem) for the in utero fetus (BEIR 2006). However, doses to the public from LANL operations are much smaller (Table 3-1). Therefore, the doses presented in this chapter do not cause observable human health effects.

Table 3-1
LANL Radiological Doses for Calendar Year 2010

Pathway	Dose to Maximally Exposed Individual (mrem/yr)	% of DOE 100 mrem/yr Limit	Estimated Population Dose (person-rem)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	0.33[a]	0.33%	0.22	NA[b]	NA
Water	< 0.1	< 0.1%	0	NA	NA
Other Pathways (foodstuffs, soils, etc.)	< 0.1	< 0.1%	0	NA	NA
All Pathways	0.9[c]	0.9%	0.22	~280,000	~220,000[d]

[a] Rad-NESHAP MEI dose determined at LA Inn-South AIRNET station 257.

[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] All-pathways MEI dose at the boundary of the Pueblo de San Ildefonso sacred area north of Area G.

[d] Based on 270 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, 300 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 1153-2002 (DOE 2002) and in the computer program RESRAD-BIOTA (http://web.ead.anl.gov/resrad/home2/biota.cfm). Because the calculations apply to all types of biota and all types of ecosystems, the DOE methods are general in nature and allow specific parameters to be adjusted according to local conditions. 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/air/qa.shtml?2), 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 2004b). Trees of the pine family (Pinaceae) are representative of terrestrial plants because they are radiosensitive (UNSCEAR 1996) and because their deep roots might tap into buried contamination (Foxx et al. 1984a, 1984b; Tierney and Foxx 1987). Deer mice are representative of 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 representative plants and animals are common and widespread within 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 biota dose limits (DOE 2002) are applied to representative biota populations rather than to the MEIs because it is DOE's goal to protect populations, especially with respect to preventing the impairment of reproductive capability within the population.

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 began with a Level 1 initial screening (DOE 2002) comparing 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 Level 2 site-specific assessment (DOE 2002) is conducted that uses average concentrations and incorporates site-specific bioaccumulation factors. Following the guidance of the DOE Standard (DOE 2002), we did not include external-radiation dose from experimental facilities such as the DARHT facility and LANSCE.

2. Biota Dose Results

As reported in Chapters 5 through 8, we collected water, soil, sediment, vegetation, bees, and small mammals from several locations in 2010. All radionuclide concentrations in vegetation sampled were below the plant 0.1 rad/day biota dose screening level (10% of the 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled were below the terrestrial animal 0.01 rad/day biota dose screening level (10% of the 0.1 rad/day dose limit).

D. NON-RADIOLOGICAL RISK ASSESSMENT

1. Overview

Risk to members of the public and the environment from LANL radiological hazards is well understood and extensively documented. We place equal emphasis on the risk to members of the public and the risk to the environment 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 released from LANL during 2010 and, in some cases, during the previous 65 years of operations at LANL. The Clean Air Act regulates non-radiological air pollutants, 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 human health risks are summarized below.

2. Results

a. General Considerations

Off-site concentrations of non-radiological contaminants in air, water, soil, and food described elsewhere in this report are well below the applicable standards or risk-based concentrations (NMED 2009). The results from LANL monitoring and their potential human health impacts are summarized below.

i. Air (Inhalation Pathway)

Assessments of ambient air quality of non-radiological constituents, as reported in Chapter 4, Section D, indicate that LANL operations are not adversely impacting public health. The assessment of the ambient air impacts of high explosives testing, reported in Chapter 4, Section D.4, indicates no adverse impacts to the public. The beryllium concentrations reported in Chapter 4, Section D.5, are less than 1% of the National Emission Standards for Hazardous Air Pollutants (NESHAP) recommended concentration of 10 ng/m^3, and the PM-10 and PM-2.5 concentrations are lower than EPA limits (Chapter 4, Section D.3).

ii. Groundwater (Ingestion)

Past liquid effluent discharges have affected groundwater quality, but primarily in shallow perched alluvial aquifers in a few canyons. These aquifers are separated from deeper regional aquifers by hundreds of feet of dry rock preventing or minimizing the impact of these contaminants on drinking water quality. LANL sampled groundwater at numerous depths and in locations both within and beyond LANL boundaries. Results show that the levels of chemicals in potential sources of groundwater drinking water are below NMED and EPA recommended levels and thus, the drinking water is safe to drink. The details and a summary of the results of all groundwater measurements are provided in Chapter 5.

The only measureable Laboratory impact on a potential drinking water supply is at well Otowi-1 in Pueblo Canyon. For 2010, groundwater samples from this well had perchlorate concentrations ranging from up to 31% of the Compliance Order on Consent screening level (4 µg/L) and 8% of the EPA interim health advisory for perchlorate in drinking water of 15 µg/L, as referenced in Chapter 5. Although Los Alamos County does not use this well for its drinking water supply, these levels are safe and do not present a potential risk to human health.

LANL has detected hexavalent chromium in the Mortandad Canyon regional aquifer monitoring well samples at levels 25 times the New Mexico groundwater standard (50 µg/L of any dissolved form of chromium) and at about 40% of the New Mexico standard in a Sandia Canyon regional aquifer monitoring well. However, hexavalent chromium has not been detected in Los Alamos County and Santa Fe Buckman drinking water supply wells above natural levels, so there is no potential unacceptable human health risk from ingestion of water from the drinking water supply wells.

iii. Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. No potentially hazardous chemicals of LANL origin were detected off site. We conclude there is no current risk to the public from surface water and sediment exposure due to LANL operational releases.

Polychlorinated biphenyls (PCBs) are present in the onsite surface water and sediment at levels consistent with previous years. However, 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, so in 2010, sediment samples from the Rio Grande and the Abiquiu and Cochiti reservoirs were analyzed for PCBs using the Aroclor method. Results from upstream and downstream sampling locations show that sources for PCBs are primarily non-LANL. Looking at these data together, we conclude that there is no measurable contribution of PCBs from LANL to the Rio Grande and, therefore, no detrimental human health impacts exist from PCBs.

iv. Soil

Soil concentrations are reported in Chapter 7. The mean contaminant concentrations are below conservative soil screening levels and, therefore, do not pose a potential unacceptable human health risk.

v. Foodstuffs (Ingestion)

The concentrations of non-radioactive materials in foodstuffs are reported in Chapter 8. Of particular interest are PCB levels in crayfish sampled upriver and downriver of LANL in the Rio Grande. Edible portions of the crayfish from both locations contained low levels of PCBs with similar concentrations for crayfish upstream and downstream of the Laboratory. The levels are substantially below consumption limits for fish. Concentrations of target analyte list (TAL) metals in the edible portions of downstream crayfish were similar to upstream crayfish. TAL concentrations in both upstream and downstream crayfish are low. These concentrations represent a negligible contribution to human health risk (Chapter 8, section A.3.d.).

Concentrations of TAL metals and PCBs in several road-killed deer and elk from the Pajarito Plateau were measured. The concentrations are presented in Chapter 8 in Table S8-5 and Table S8-6. Concentrations of PCBs in the muscle and bone are low though there is no literature data to compare against. Human health risk from TAL metals and PCBs in deer is negligible.

vi. Biota Sampling

Metal concentrations were measured in several important indicator species to assess potential impacts of particular LANL operations. Specifically, deer mice and several species of birds were sampled near the DARHT facility (Chapter 8, section B.4.b.). Results show that the concentrations of TAL metals were either not detected or were below the RSRL. The concentrations of these metals in the soil near DARHT are below the LANL ecological screening levels. Also, no detectable concentrations of dioxin or furan congeners were measured in field mice near DARHT.

Additionally, overstory vegetation was sampled and analyzed for TAL metals, and concentrations were less than the RSRLs (Table S8-8). In a special study, PCBs in mice around the Los Alamos Canyon Weir were elevated, but the levels decreased down gradient of the weir and were below screening levels.

vii. Potential Future Risks

The possibility of hexavalent chromium and perchlorate from LANL sources entering the drinking water supply in the future is being evaluated. Our goal is to assess both present and future risk. Models to calculate future risks are being developed.

3. Conclusion

The environmental data collected in 2010 show that there is no potential human health and biota risk from non-radiological materials released from LANL.

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A. AMBIENT AIR SAMPLING

1. Introduction

The radiological air sampling network, AIRNET, measures levels of airborne environmental radionuclides, such as plutonium, americium, uranium, tritium, and some activation products. Most regional airborne radioactivity is from fallout (from past nuclear weapons tests worldwide), natural radioactive constituents in particulate matter, terrestrial radon and its decay products, and cosmic radiation products. Table 4-1 summarizes regional levels of airborne radioactivity for the past five years. A discussion of negative concentration values is presented in Appendix B.

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

			Annual Averages				
Analyte	Units[b]	EPA Concentration Limit[c]	2006	2007	2008	2009	2010
Tritium[c]	pCi/m^3	1,500	-0.2	0.2	0.8	0.2	-0.2
Am-241	aCi/m^3	1,900	0.2	-0.1	-0.3	-0.6	-0.4
Pu-238	aCi/m^3	2,100	-0.3	-0.3	0.1	0.4	1.2
Pu-239	aCi/m^3	2,000	0.1	0.6	-0.1	1.0	0.0
U-234	aCi/m^3	7,700	17	15	18	17	16
U-235	aCi/m^3	7,100	0.8	0.8	1.3	0.7	0.6
U-238	aCi/m^3	8,300	16	15	17	16	15

[a] Regional air sampling stations operated by LANL (locations can vary by year).

[b] Units definitions are presented in Appendix B.

[c] Each EPA Concentration Limit is from 10 CFR 40 and corresponds to 10 mrem/year.

[d] Tritium values 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 increase soil entrainment; precipitation washes particulate matter out of the air. Meteorological conditions cause large daily and seasonal fluctuations in airborne radioactivity concentrations.

LANL staff compared ambient air concentrations and resulting off-site dose equivalents to the Environmental Protection Agency (EPA) (EPA 1989) 10-mrem annual dose equivalent concentration limit. On-site air concentrations and resulting dose equivalents are compared to the Department of Energy (DOE) 100 mrem annual dose equivalent concentration limit (DOE 1993).

2. Air Monitoring Network

During 2010, LANL operated 60 environmental air stations to sample radionuclides by collecting water vapor and particulate matter. After reviewing the program LANL decided to eliminate gross alpha and gross beta analyses as these two are not required to be measured and because we could continue to depend on quarterly isotopic analysis to meet compliance requirements.

Tritium monitoring was stopped at a number of stations because no tritium had been detected at these stations in years and also because there is no reasonable expectation of detection at them. Tritium monitoring at compliance stations continues unchanged.

AIRNET sampling locations (Figures 4-1 through 4-4) are categorized as regional, pueblo, perimeter, waste site (Technical Area [TA] -54), decontamination and decommissioning (D&D) at Material Disposal Area B (MDA-B), or other on-site locations.

3. Sampling Procedures, Data Management, Chemical Analysis and Quality Assurance

The AIRNET quality assurance project plan and implementing procedures provide details about sample collection, sample management, chemical analysis, and data management. These documents are available at http://www.lanl.gov/environment/air/qa.shtml.

a. Sampling Procedures

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. We deliver the samples to all internal and external analytical laboratories under full chain-of-custody, including secure FedEx shipment, and track them at all stages of their collection and analysis through the AIRNET database. Field sampling and analytical completeness in AIRNET are assessed for each collection period.

The AIRNET run time for compliance stations averaged 99.3% for the year.

A station collects a continuous two-week sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates around 110 liters per minute. Cartridges containing about 135 grams of desiccant (silica gel) collect water vapor samples at some stations, with an air flow rate of 0.2 liters per minute. The silica gel is dried in an oven before use. After use in the field, the silica gel is removed from the cartridge and shipped to the analytical laboratory where the moisture is distilled and then analyzed for tritium.

b. Data Management

In the field, personnel record the sampling data on a palm-held microcomputer, including timer readings, volumetric flow rates at the beginning and end of the sampling period, and comments pertaining to these data. These data are later transferred to a database and are checked thereafter.

c. Chemical Analysis and Quality Assurance

A commercial laboratory analyzes the filters. Filters are grouped by geographical location into 'clumps' and screened for gamma-emitting radionuclides. At the end of the quarter a composite for each station is made up of six or seven half-filters. Analysts at the laboratory dissolve the composites, do a chemical separation, and then analyze for americium, plutonium, and uranium isotopes using alpha spectroscopy. Liquid scintillation spectrometry is used to analyze the gel distillate for tritium. Analytical procedures satisfy Title 40 Code of Federal Regulations (CFR) Part 61, Appendix B. The AIRNET quality assurance project plan specifies the target minimum detectable activities for all samples.

AIRNET maintains a program of blank, spike, duplicate, and replicate analyses. This program provides information on the quality of the data received from the analytical laboratory. These data are reviewed to ensure they meet all quality assurance requirements.

Electronic analytic data are uploaded into the AIRNET databases and promptly checked for quality and consistency. Analytical completeness is calculated, tracking and trending of all blank and control-sample data are performed, and all tracking information documented in the quality assessment memo mentioned in the field sampling section. All parts of the data management process are tracked electronically in database, and periodic reports to management are prepared.

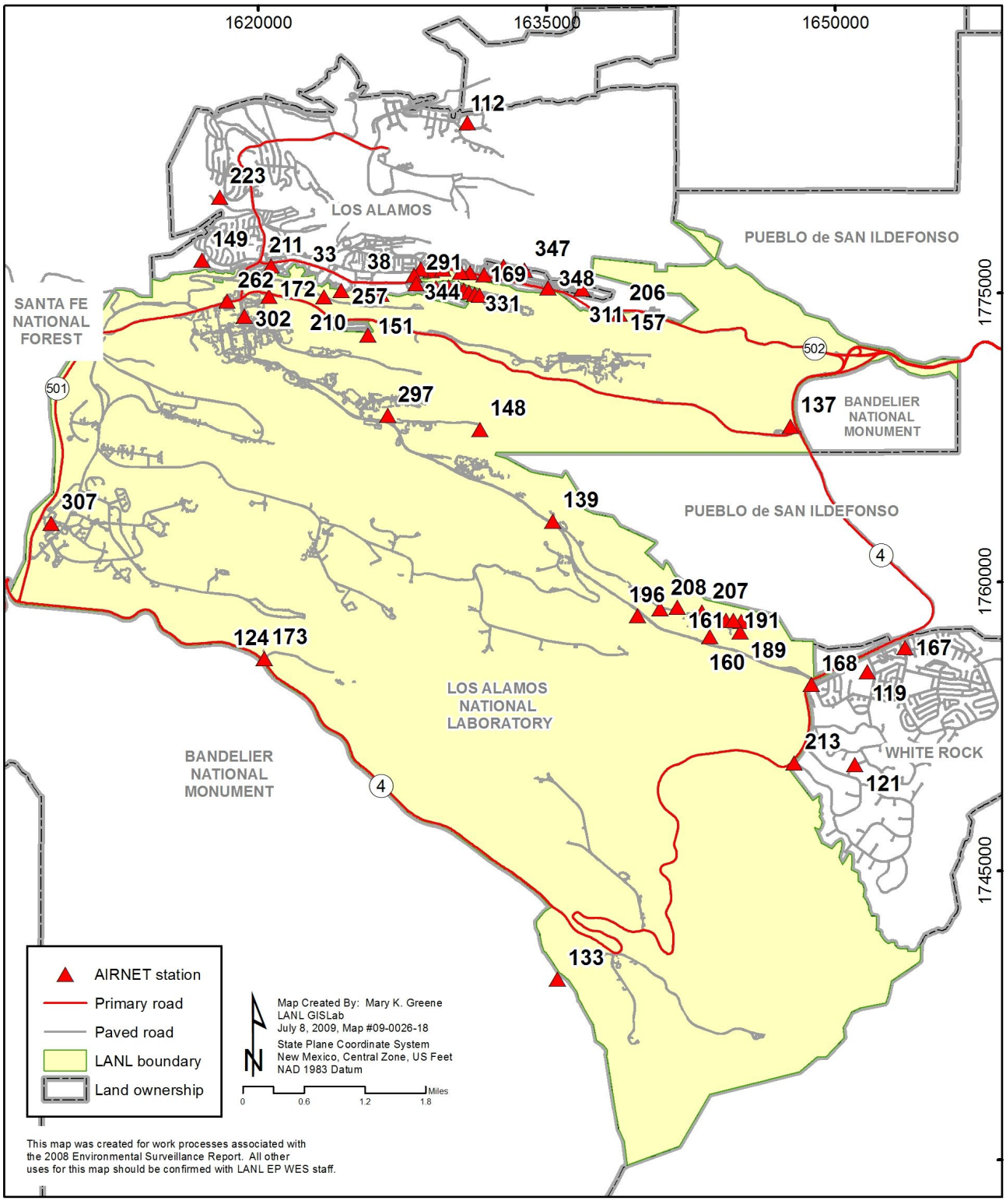

Figure 4-1 AIRNET locations at and near Los Alamos National Laboratory

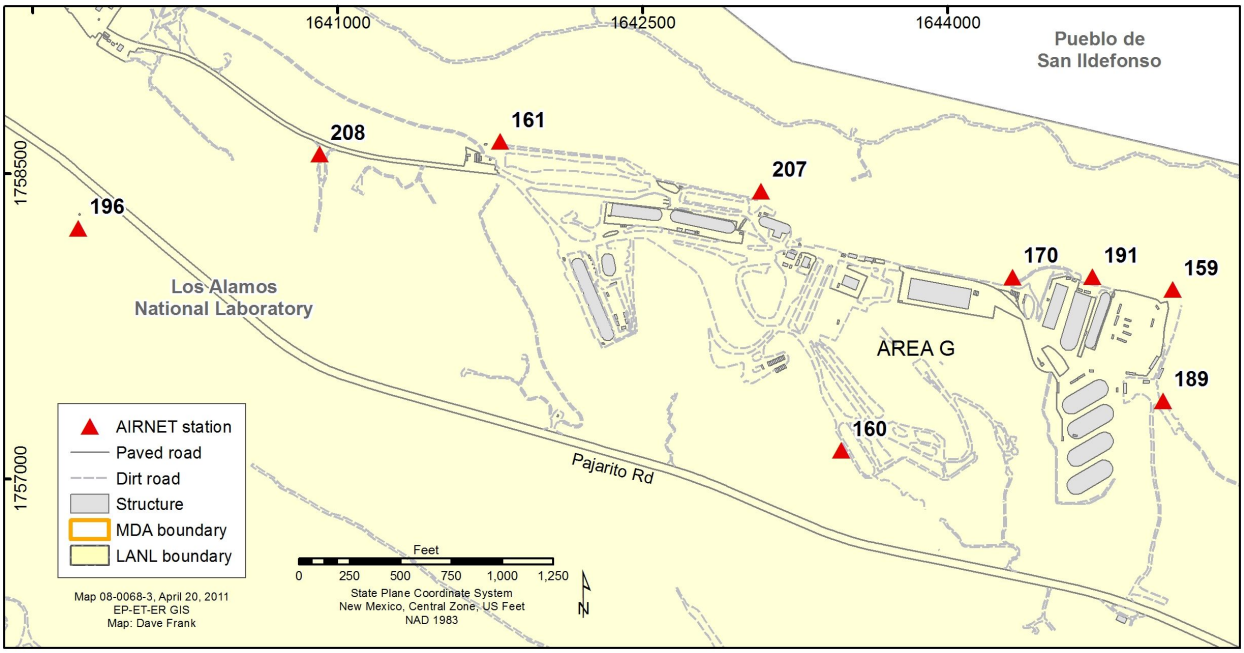

Figure 4-2 AIRNET station locations at TA-54, Area G, Los Alamos National Laboratory

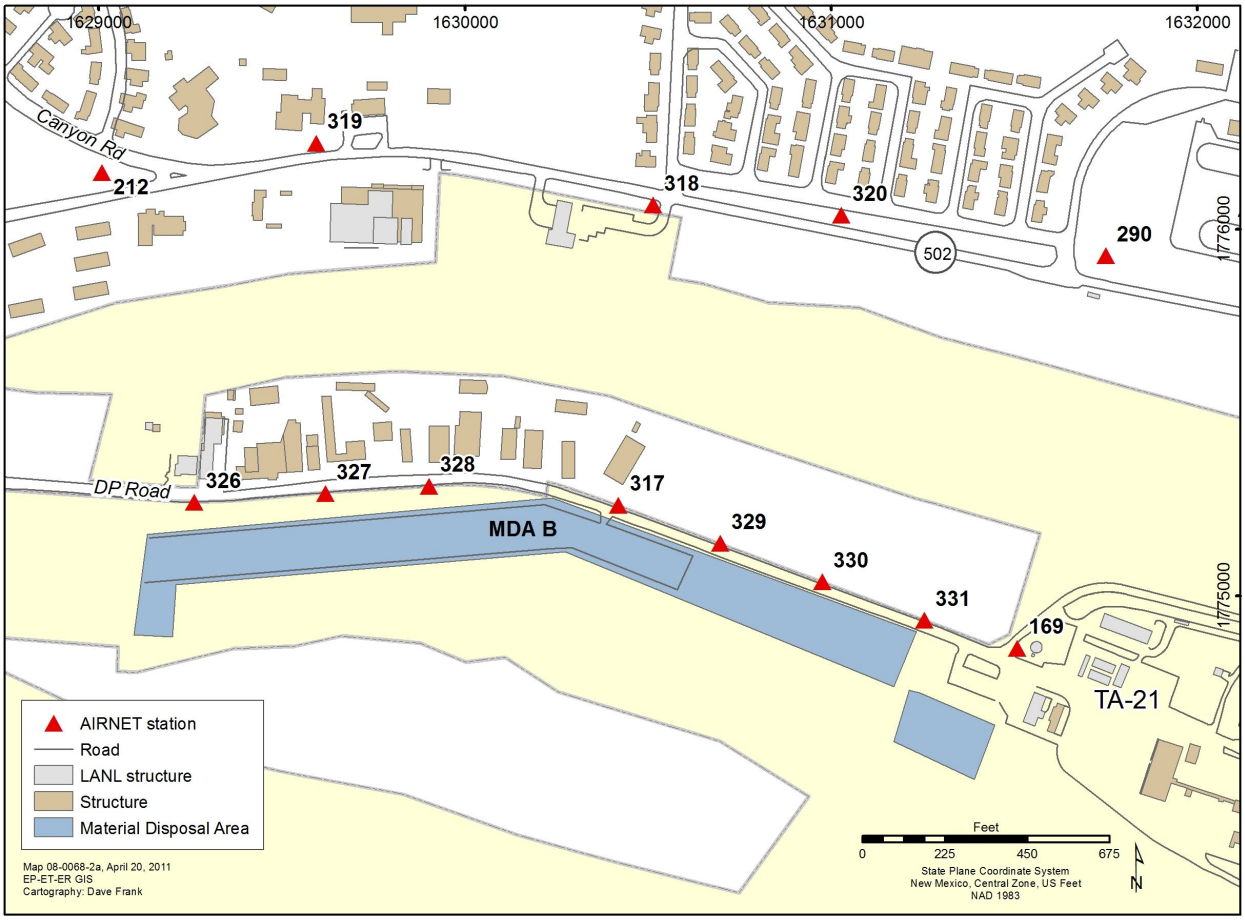

Figure 4-3 AIRNET station locations near TA-21, MDA B

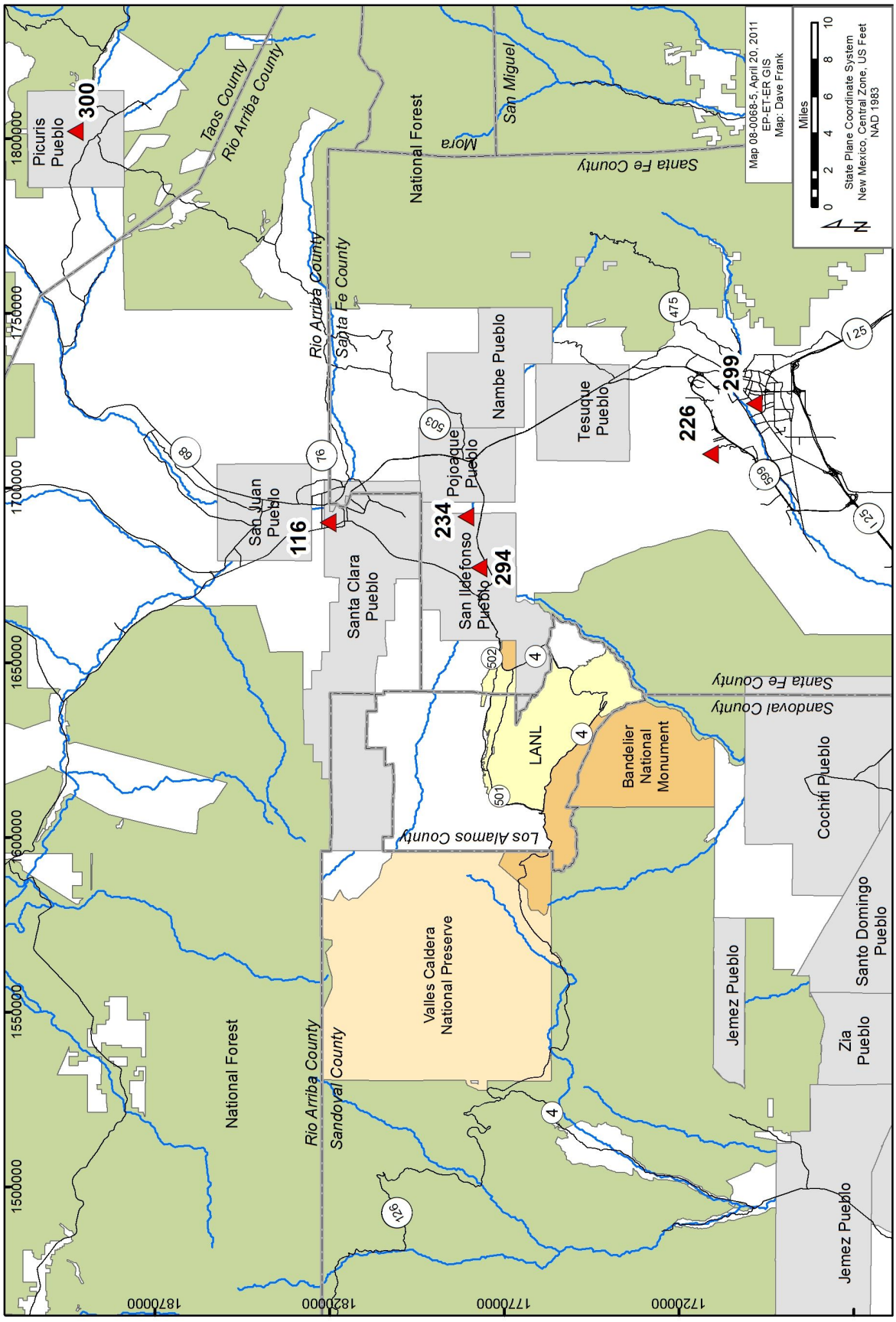

Figure 4-4 Regional and Pueblo AIRNET locations

Analytical data completeness was 100% for AIRNET filters and 99.4% for AIRNET silica gel. These numbers indicate that the analytical laboratory continues to perform at the same high level of control as seen in the past several years. See Chapter 11 for results from independent audits of the contracted laboratories.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-10 summarize measured 2010 ambient air concentrations. The supplemental data tables (on included compact disc). Tables S4-1 through S4-7, provide data from individual sites. AIRNET concentrations do not have background subtraction, but do include blank corrections for radioactivity in the filter material, acids used to dissolve the filter, and tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

Uncertainties for all data in this ambient air sampling section represent a 95% confidence (two sigma [2s]) interval. Since confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurements and analytical errors but also seasonal and spatial variations. The 95% confidence intervals are overestimated for the average concentrations and may represent confidence intervals closer to 99%. Negative values are included in averages as their omission would bias averages.

Concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. A control limit of 3s is widely used for statistical quality control charts (Duncan 1986, Gilbert 1987) since the rate of false positives or detections is 5% at 2s but only 0.3% at 3s.

b. Investigation of Elevated Air Concentrations

We have established two action levels to determine the potential impact of an unplanned release. The "investigation" action level, or screening level, is triggered when an air concentration exceeds a five-year average plus 3s at that location. "Alert" action levels are higher concentrations that are based on allowable EPA and DOE annual doses and require a more thorough and immediate follow-up.

When a measured air concentration exceeds an action level, we verify that the calculations were done correctly and that the sampled air concentrations are representative. If so, we work with LANL operations personnel to assess potential sources and implement possible mitigation plans.

During the year, investigation levels were exceeded 73 times, but no tritium, americium, plutonium or uranium concentrations exceeded their (EPA 10 mrem) alert action levels. All tritium measurements were below 0.5% of the EPA 10 mrem concentration. Americium-241 concentrations were all under 1% of the EPA standard. The plutonium-238 measurements did not exceed 0.5% of the 10 mrem standard. Only one plutonium-239 measurement, near the canyon edge south of Ashley Pond, was not on-site or near the MDA-B remediation. Of all the plutonium-239 investigations, only two (near MDA-B) were above 5% of the EPA 10 mrem concentration. These two measurements were between 25 and 30% of the standard but were not sustained or in the same location. We had discussions with MDA-B management on possible sources and mitigation measures. A more stringent effort was made to seal work enclosures. Concentrations outside the structures dropped in the following periods, seeming to respond.

The uranium investigations were all less than 1% of their EPA standards. They are discussed in more detail below in Section 4.g. on uranium.

c. Gross Alpha and Gross Beta Radioactivity

We discontinued the optional gross alpha and gross beta analyses during 2010. We continue to depend on quarterly isotopic analysis to meet compliance requirements for monitoring radio-isotopic particulate matter. Data from the first half of the year are in the supplementary data tables and exhibit similar patterns to previous years.

d. Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure tritiated water (HTO) because

the dose impact is about 25,000 times higher than from gaseous HT or T_2 (ICRP 1978). We used water-vapor concentrations in the air and tritium concentrations in the water vapor to calculate ambient levels of tritium, including corrections for blanks, bound water in the silica gel, and isotopic distillation effects.

During 2010, all annual mean concentrations were well below EPA and DOE guidelines (Table 4-2). The highest off-site annual tritium concentration is equivalent to about 0.2% of the EPA public dose limit. We measured elevated tritium concentrations at a number of on-site stations, with the highest annual mean concentration near a known source at TA-54 but at less than 3% of the on-site worker exposure limit.

Tritium concentrations reflect current operations and show no distinctive trends (Figure 4-5).

The number of stations measuring tritium was reduced in July 2010. Values for waste site and on-site average concentrations in Table 4.2 and Figure 4.5 include data up to June only.

Table 4-2
Airborne Tritium as Tritiated Water Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	108	-0.2	±0.3	2	-0.1
Pueblo[a]	65	0.3	±0.4	3	0.4
Perimeter[a]	665	0.7	±0.1	8	2
Waste Site[b]	124	30	±34	1590	430
On-Site[b]	96	1.6	±1.3	60	13
D&D[a]	220	0.8	±0.3	9	3

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 1,500 pCi/m^3.

[b] Ten times the public limit given in a.

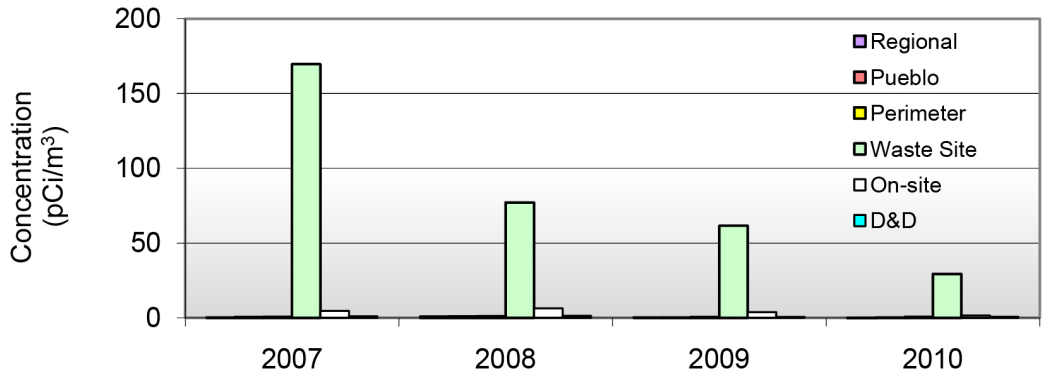

Figure 4-5 Annual average concentrations of tritium by group

e. Americium-241

Americium is present in very low concentrations in the environment. Table 4-3 summarizes the americium-241 sampling data. The highest annual off-site and on-site averages were about 0.25% and 0.02% of the public and worker limits, respectively.

Americium concentrations show no distinctive trends over the past four years (Figure 4-6).

Table 4-3
Airborne Americium-241 Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	16	-0.4	±1.2	1.4	-0.4
Pueblo[a]	9	-0.1	±1.9	2.8	0.3
Perimeter[a]	104	-0.2	±0.3	2.8	1.0
Waste Site[b]	32	0.7	±1.3	13	4
On-Site[b]	20	-0.1	±0.7	2	0.5
D&D[a]	52	0.9	±1.1	12	5

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 1,900 aCi/m^3.
[b] Ten times the public limit given in a.

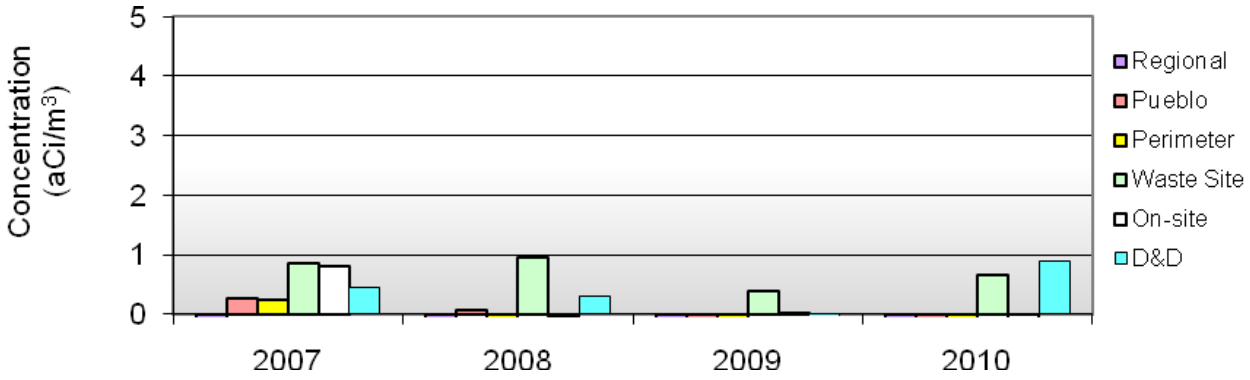

Figure 4-6 Annual average concentrations of Americium-241 by group

f. Plutonium

Plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997). Measurable sources in air are usually plutonium research activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, fallout from atmospheric testing of nuclear weapons is the primary source of plutonium in ambient air.

Table 4-4 summarizes the plutonium-238 data for 2010. The highest annual off-site and on-site averages were about 0.2% and 0.01% of the public and worker limits, respectively.

Table 4-4
Airborne Plutonium-238 Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	16	1.2	±0.9	3	2
Pueblo[a]	9	0.8	±0.8	2	1
Perimeter[a]	104	0.8	±0.3	4	3
Waste Site[b]	32	1.1	±0.6	3	2
On-Site[b]	20	0.9	±0.8	4	1
D&D[a]	52	1.8	±0.6	7	4

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 2,100 aCi/m^3.
[b] Ten times the public limit given in a.

Table 4-5 summarizes the plutonium-239/240 data. The highest annual off-site and on-site averages were about 9% and 0.09% of the public and worker limits, respectively. Higher than usual off-site concentrations are due to work at the MDA-B clean-up site.

Table 4-5
Airborne Plutonium-239/240 Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	16	0.0	±0.7	1.7	0.4
Pueblo[a]	9	0.0	±1.4	1.7	0.7
Perimeter[a]	104	2.1	±2.8	72	32
Waste Site[b]	32	5.0	±7.6	61	18
On-Site[b]	20	2.0	±3.4	16	8
D&D[a]	52	31	±46	590	179

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 2,000 aCi/m^3.

[b] Ten times the public limit given in a.

Concentrations of plutonium show no distinctive trends over the past four years. Figures 4-7 and 4-8 show the annual grouping average concentrations. The increased concentration of plutonium-239 in 2010 was due to operations involving cleanup at MDA-B.

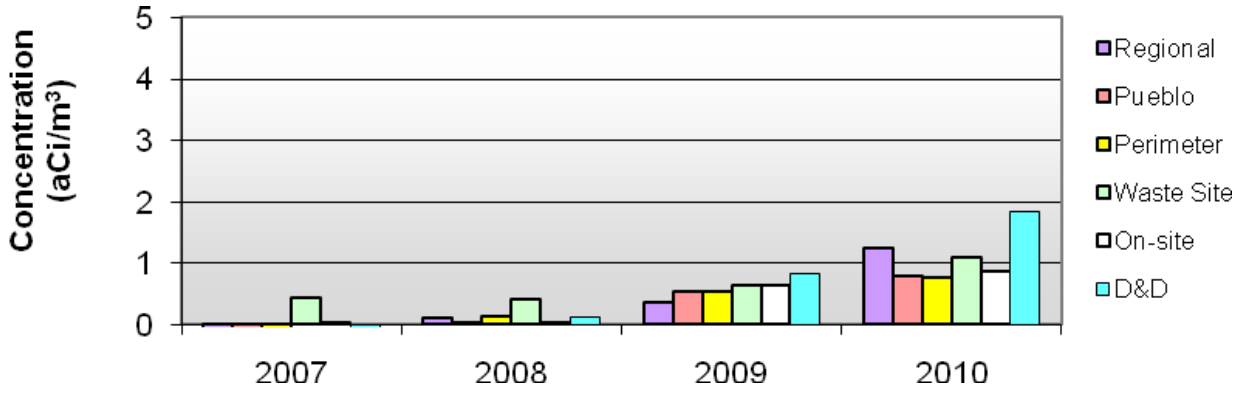

Figure 4-7 **Annual average concentrations of plutonium-238 by group**

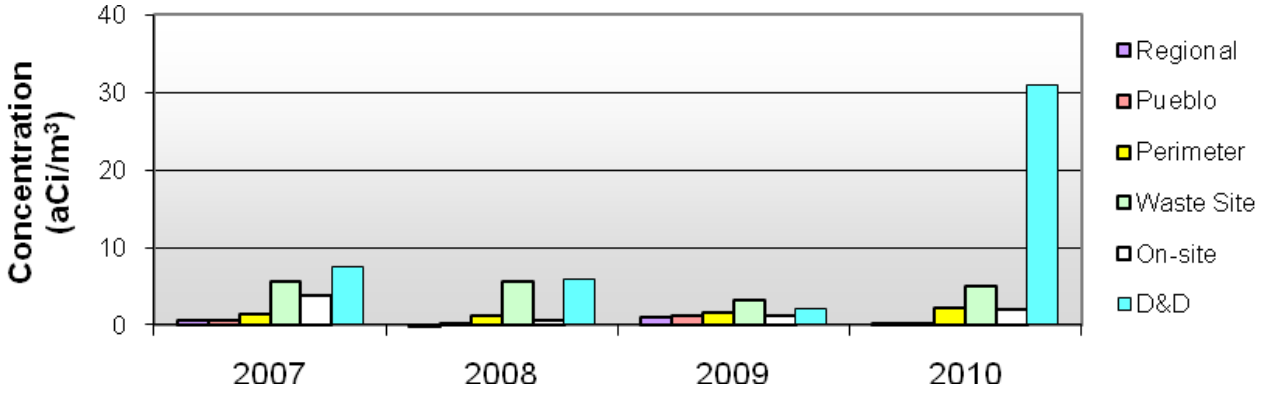

Figure 4-8 **Annual average concentrations of plutonium-239/240 by group**

g. Uranium

Uranium-234, -235, and -238 are found in nature. Natural uranium has constant and known relative isotopic abundances. Uranium-238 activity is roughly equal to uranium-234 (Walker et al., 1989). LANL emissions over the past 60 years have been either enriched in uranium-234 and uranium -235 (EU) or depleted uranium (DU). LANL compares uranium-234 concentrations to uranium-238 concentrations to estimate LANL's contributions to uranium in the environment. If uranium-234 and -238 concentrations differ by more than 3s, the sample was considered to have significant concentrations of EU or DU.

Off-site annual mean concentrations of uranium isotopes (Tables 4-6 to 4-8) were at or below 0.4% of the EPA guidelines; the on-site concentrations were below 0.05%. The highest annual uranium concentrations are typically at dusty locations. Over the last five years the trends have been flat.

Table 4-6
Airborne Uranium-234 Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	16	16	±8	35	23
Pueblo[a]	9	18	±18	46	28
Perimeter[a]	104	9	±2	63	28
Waste Site[b]	32	17	±13	104	36
On-Site[b]	20	9	±5	28	14
D&D[a]	52	19	±4	47	29

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 7,700 aCi/m^3.

[b] Ten times the public limit given in a.

Table 4-7
Airborne Uranium-235 Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	16	0.6	±0.7	2	1
Pueblo[a]	9	1.6	±1.3	3	2
Perimeter[a]	104	0.6	±0.3	8	2
Waste Site[b]	32	0.8	±0.7	5	2
On-Site[b]	20	0.8	±0.7	3	1
D&D[a]	52	1.1	±0.4	4	2

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 7,100 aCi/m^3.

[b] ten times the public limit given in a.

Table 4-8
Airborne Uranium-238 Concentrations for 2010 — Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 99.7% Confidence Interval (aCi/m³)		Maximum Station Concentration (aCi/m³)	
				Quarterly	Annual
Regional[a]	16	15	±8	33	20
Pueblo[a]	9	18	±15	40	28
Perimeter[a]	104	10	±3	67	31
Waste Site[b]	32	17	±12	93	32
On-Site[b]	20	10	±5	28	16
D&D[a]	52	17	±4	40	27

[a] EPA 40, CFR Part 61, Appendix E, public concentration limit is 8,300 aCi/m^3.

[b] Ten times the public limit given in a.

During 2010 EU was detected three times (near the environmental restoration work on MDA-B, a known source of EU). This is an increase from previous years (on detection in 2006; none in 2007; none in 2008; and one detection in 2009). DU was detected twice this year, a decrease from previous years (two detections in 2006; seven in 2007; one in 2008; and 15 in 2009).

h. Gamma Spectroscopy Measurements

For gamma screening, we group filters across sites in "clumps" for each sampling period and analyze for the following: arsenic-73 and 74, cadmium-109, cobalt-57 and 60, cesium-134 and 137, manganese-54, sodium-22, rubidium-83, rubidium-103, selenium-75, and zinc-65. We investigate any measurement of these analytes above its minimum detectable activity which we use as a screening level. None have been detected in the last five years.

We analyze for the naturally occurring radionuclides beryllium-7, potassium-40, and lead-210. We initiate investigations when elevated levels are found. No elevations were detected during 2010.

5. Special Monitoring

a. Fukushima Daiichi

On March 11, 2011, the Fukushima Daiichi nuclear power plant was damaged by the tsunami that followed the Great East Japan Earthquake, and the reactors subsequently leaked radioactive material. In response, LANL augmented the routine ambient (AIRNET) and stack (Rad-NESHAP) measurements with three high-volume samplers: #167 at the Old White Rock Fire Station; #173 at the TA-49 gate, and #211 at the Los Alamos Medical Center.

Previous accidents, such as the Three-Mile-Island accident in 1979 and the Chernobyl accident in 1986, indicated that the most likely releases were (a) the noble gases: krypton and xenon; and (b) the volatile elements: cesium, tellurium, and iodine. At the latitude of Fukushima, the predominant winds across the Pacific Ocean are from west to east, and models predicted that the plume would arrive in the western United States on about March 18. By this time, the shorter-lived isotopes would have decayed. Therefore, the expected radionuclides were xenon-133, cesium-134, cesium-136, cesium-137, tellurium-132, iodine-131, and iodine-132.

As expected, cesium-134, cesium-136, cesium-137, tellurium-132, iodine-131, and iodine-132 were all detected by all three high-volume samplers during March 17-21. The concentrations peaked during the March 24-28 period. After this, concentrations of all nuclides declined. In general, the concentrations were consistent with those measured by the EPA RadNet system and many other monitoring systems throughout the world. The EPA RadNet data are available at http://www.epa.gov/japan2011/rert/radnet-data-map.html.

At the time of writing, preliminary results from the AIRNET and Rad-NESHAP systems are being reported. More detailed results are described in McNaughton 2011 and will be reported in full in the annual environmental report for 2011.

All previous releases from nuclear reactors have been dominated by noble gases, primarily krypton and xenon, which are not measured by the high-volume samplers or the AIRNET system. However, in sufficient concentrations these and other fission products would be detected by NEWNET.

Consistent with this possibility, all NEWNET detectors recorded an increase of 0.2 μR/h from March 19-21, followed by an additional increase of 0.1 μR/h on March 24 (Figure 4-9). The consistency of the NEWNET stations is indicated by the error bars, which represent the standard error of the mean of the individual stations.

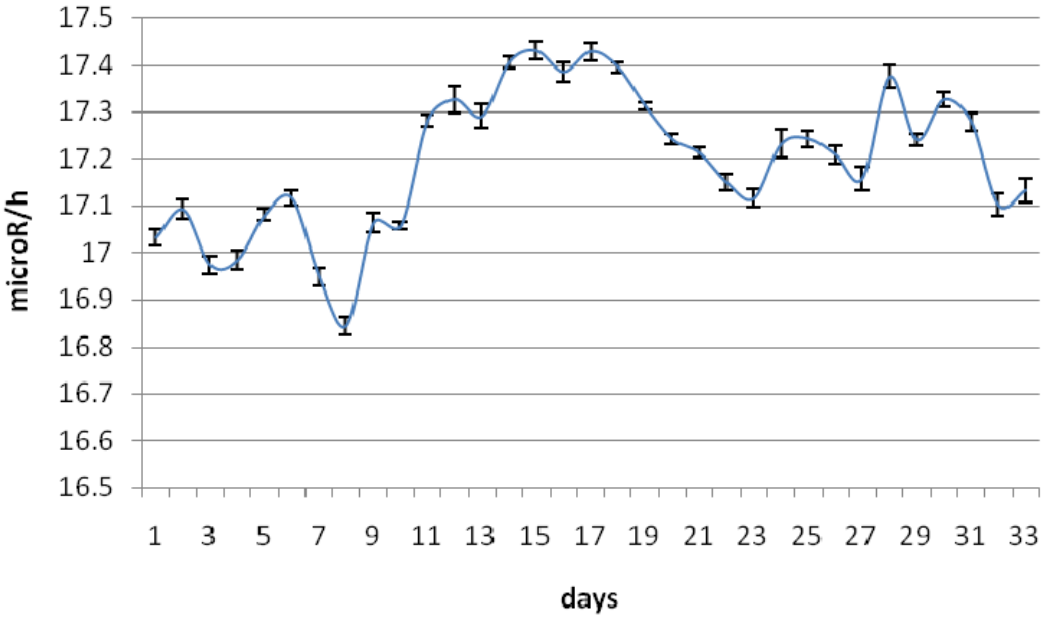

Figure 4-9 **Average radiation (microR/h) recorded by NEWNET from March 11 (day 1) through April 12 (day 33)** The annual average is 17 microR/h. The increased radiation from day 9 (March 19) through day 23 (April 2) may be caused by xenon-133 and other fission products from the Fukushima Daiichi nuclear power station. The fluctuations during days 1-9 and days 23-33 are caused by natural radon decay products. In addition, during these 33 days, there is probably a gradual increase in natural terrestrial radiation as the ground becomes dry.

Over the next 10 days, the NEWNET readings declined with approximately the 5-day half life of xenon-133, returning to near normal levels on April 2. After this, any further decrease was masked by high radon concentrations on April 3, by a weather system that moved into New Mexico on April 4, and by rainfall on April 6-9. Furthermore, it is likely that all NEWNET detectors responded to a gradually increasing trend in terrestrial radiation during the month of March as the ground dried out.

It is difficult to distinguish the hypothetical effects of xenon-133 from the fluctuations of radon decay products. However, at present we do not have an alternative hypothesis for the sharp increase that was observed in all NEWNET stations from March 19-21. Perhaps some of the increase was caused by radon or terrestrial radiation, in which case the observed increase is an upper limit to that caused by releases from Fukushima.

LANL data are consistent with those of the EPA Radnet monitoring system. The EPA has repeatedly stated that "The levels detected are far below levels of concern" (EPA 2011).

Additional analyses of AIRNET samples were requested in response to the incident, but these data are not yet available. This and further work will be discussed further in more detail in the 2011 edition of this document.

b. Las Conchas Fire

The Las Conchas fire started onSunday June 26, 2011 in the Santa Fe National Forest, approximately 12 miles southwest of LANL(http://www.inciweb.org/incident/2385/). Investigators believe the fire started after an aspen tree was blown down onto nearby power lines during a period of strong winds. Mandatory evacuation of the Los Alamos townsite was ordered on Monday June 27 and the Laboratory remained closed from June 27 through July 5. One spot fire occurred on the LANL property during this time period. This fire was approximately 2 acre in size, along the south boundary of TA-49. It was on the mesa top, not in the canyon. Additionally, 90 acres of LANL land burned during back burns west of State Road 501.

Air monitoring used several independent systems. The standard AIRNET system was supplemented by high-volume samplers operated by the AIRNET team, by the LANL Field Monitoring Team, and by the RAP team http://www.nv.doe.gov/library/factsheets/RAP.pdf . Data were also obtained by the EPA's Airborne Spectral Photometric Environmental Collection Technology, ASPECT http://www.epa.gov/NaturalEmergencies/flyinglab.htm .

Preliminary air monitoring results are consistent with those measured during the Cerro-Grande fire (SWEIS 2000, Dewart 2003, Eberhart 2010) and indicate no measurable LANL contamination. The complete set of data will be reported in RACER and discussed in the Environmental Report for 2011.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. Members of the stack monitoring team at LANL evaluate these operations to determine potential impacts to the public and the environment. Emissions are estimated using engineering calculations and radionuclide materials usage information with the assumption there are no emission controls in place, such as the high-efficiency particulate air filters which are present on all stacks. 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 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 2010, we identified 28 stacks meeting this criterion. Two new stacks at TA-54 became operational in 2010, supporting waste processing activities at Materials Disposal Area G.

2. Sampling Methodology

In 2010, 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.

We sample emissions of radioactive particulate matter generated by operations at facilities, such as the Chemistry and Metallurgy Research Building and the TA-55 Plutonium Facility, using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. We collect these samples weekly and ship them to an off-site analytical laboratory. The analytical 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 analytical 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. We use the isotopic data to calculate emissions from the 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 prior to the vapor sampling. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the charcoal filter, which is collected weekly at the same time as 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 HT. The air is then passed through a palladium catalyst that converts the HT to HTO. The sample is pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. We collected the vials of ethylene glycol weekly and sent them to an analytical laboratory for liquid scintillation counting to determine the amount of HTO and HT.

In previous years, we monitored stacks at LANSCE 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 2010 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 continuously 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 in 40 CFR 61, Appendix B, Method 114 (EPA 1989). Section F of this chapter presents the results of analytical quality assurance measurements. This section discusses the sampling and analysis methods for each type of LANL's emissions.

b. Particulate Matter Emissions

Each week, we remove and replace the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions, and we then ship them to an off-site analytical laboratory. Prior to shipping, we screen each sample filter with a hand-held instrument to determine if there are any unusually high levels of gross alpha or beta radioactivity. The laboratory performs analyses for the presence of alpha and beta radioactivity after the sample has 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 performs gamma spectroscopy analysis to identify specific isotopes in the sample. While alpha and beta counting are performed on individual glass-fiber filters, gamma spectroscopy is performed on "clumps" of filters, a group of seven or eight filters stacked together to allow quick analysis for gamma-emitting radionuclides. Subsequent analyses, if needed, are performed on individual filters.

The glass-fiber filters are composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We use the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compares 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.) identify 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, we perform hand-screening of each filter prior to shipping them to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions

We remove and replace the charcoal canisters weekly at facilities with the potential for significant vaporous activation products emissions and ship the samples to the off-site analytical laboratory where gamma spectroscopy identifies and quantifies the presence of vaporous radioactive isotopes. For charcoal filters, gamma spectroscopy analyses are performed on individual filters instead of clumped filters.

d. Tritium Emissions

Each week, we collected tritium bubbler samples, used to sample facilities with the potential for significant elemental and oxide tritium emissions, and transport them to LANL's Health Physics Analytical Laboratory. The Health Physics Analytical Laboratory adds an aliquot of each sample to a liquid scintillation cocktail and determines the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions

To record and report GMAP emissions, we used continuous monitoring, rather than off-line analysis, 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 are measured with the ionization chamber. The real-time current this ionization chamber measures is recorded on a strip chart and the total amount of charge collected in the chamber over the entire beam operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determine the relative composition of the emissions. Decay curves are typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes are made at LANSCE, new decay curves and energy spectra are recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2010 totaled approximately 298 Ci (compared to almost 800 Ci in 2009). Of this total, tritium emissions contributed approximately 87 Ci (compared to 80 Ci in 2009), and air activation products from LANSCE stacks contributed nearly 211 Ci (compared to nearly 716 Ci in 2009). Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 0.000020 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 0.016 Ci, which is slightly lower than recent years.

Table 4-9 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-9
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2010 (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		7/39 x 10^{-7}	7.83 x 10^{-6}	6.97 x 10^{-6}	5.11 x 10^{-7}			1.71x 10^{-7}
TA-03-102			6.90 x 10^{-11}	3.48 x 10^{-9}	5.20 x 10^{-10}			
TA-16-205/450	4.78 x 10^{1}							
TA-48-001				7.57 x 10^{-9}	2.89 x 10^{-9}	5.37 x 10^{-3}		2.36 x 10^{-9}
TA-50-001		3.79 x 10^{-9}		7.91 x 10^{-8}	4.85 x 10^{-8}			
TA-50-037								
TA-50-069		7.77 x 10^{-11}	1.24 x 10^{-8}	9.89 x 10^{-10}	4.87 x 10^{-10}			
TA-53-003	1.86 x 10^{1}					1.53 x 10^{-3}	5.44 x 10^{1}	
TA-53-007	4.79 x 10^{0}					3.60 x 10^{-3}	1.57 x 10^{2}	
TA-54-231		2.00 x 10^{-10}						7.08 x 10^{-10}
TA-54-412		5.78 x 10^{-11}	3.43 x 10^{-10}		5.99 x 10^{-10}			
TA-55-004	1.62 x 10^{1}	2.05 x 10^{-9}	1.85 x 10^{-9}	3.71 x 10^{-8}	2.26 x 10^{-8}			1.34 x $10^{x\,101}$
Total[h]	8.73 x 10^{1}	7.45 x 10^{-7}	7.85 x 10^{-6}	7.09 x 10^{-6}	5.87 x 10^{-7}	1.05 x 10^{-2}	2.32 x 10^{2}[i]	1.76 x 10^{-7}

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 do not include short-lived radioactive progeny of yttrium-90.

[h] Some differences may occur because of rounding.

[i] Total for GMAP includes 20.5 curies released from diffuse sources at TA-53.

Table 4-10 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-11 presents the half-lives of the radionuclides typically emitted by LANL. During 2010, the LANSCE facility non-point source emissions of activated air comprised approximately 20 Ci of carbon-11 and 1 Ci of argon-41.

5. Long-Term Trends

Figures 4-10 to 4-13 present radioactive emissions from sampled LANL stacks and illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions, respectively. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady over recent years, varying slightly each year but staying in the low-microcurie range. Tritium emissions showed a decrease in emissions relative to recent years, reflecting minimal operations taking place at the main tritium facility during the year. In 2010, emissions of GMAP decreased dramatically from 2010 levels due to a change-out of the primary beam irradiation target at TA-53 Building 7.

Table 4-10
Detailed Listing of
Activation Products Released
from Sampled LANL Stacks in 2010 (curies)

TA-Building	Nuclide	Emission (Ci)
TA-48-0001	As-73	0.000000602
TA-48-0001	As-74	0.00000102
TA-48-0001	Br-77	0.000192
TA-48-0001	Ga-68	0.00504
TA-48-0001	Ge-68	0.00504
TA-48-0001	Hg-197	0.0000285
TA-48-0001	Hg-197m	0.0000285
TA-48-0001	Se-75	0.000104
TA-53-0003	Ar-41	2.18
TA-53-0003	Be-7	0.00106
TA-53-0003	Br-76	0.00000337
TA-53-0003	Br-77	0.00000930
TA-53-0003	Br-82	0.0000818
TA-53-0003	C-11	52.2
TA-53-0003	Co-60	0.0000000734
TA-53-0003	Ga-68	0.00000199
TA-53-0003	Ge-68	0.00000199
TA-53-0003	H-3 (HTO)	18.6
TA-53-0003	Na-24	0.000371
TA-53-0003	V-48	0.00000297
TA-53-0007	Ar-41	15.3
TA-53-0007	As-73	0.00000688
TA-53-0007	Br-76	0.000327
TA-53-0007	Br-77	0.0000387
TA-53-0007	Br-82	0.00267
TA-53-0007	C-10	0.379
TA-53-0007	C-11	64.1
TA-53-0003	H-3 (HTO)	4.79
TA-53-0007	Hg-197	0.000525
TA-53-0007	Hg-197m	0.000525
TA-53-0007	N-13	30.4
TA-53-0007	N-16	0.575
TA-53-0007	Na-24	0.0000147
TA-53-0007	O-14	0.547
TA-53-0007	O-15	45.4
TA-53-0007	Os-191	0.00000507
TA-53-0007	Se-75	0.0000182

Table 4-11
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

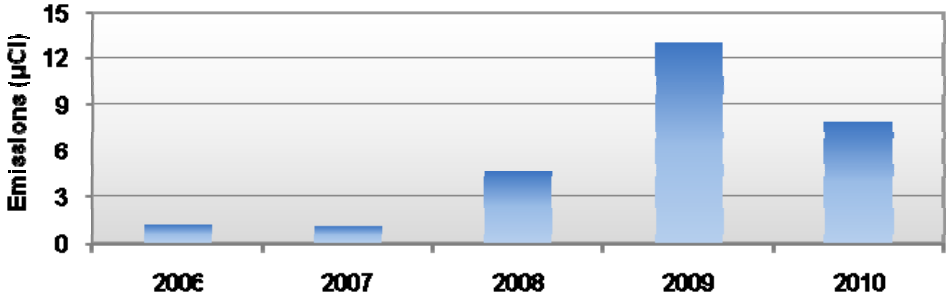

Figure 4-10 **Plutonium emissions from sampled LANL stacks**

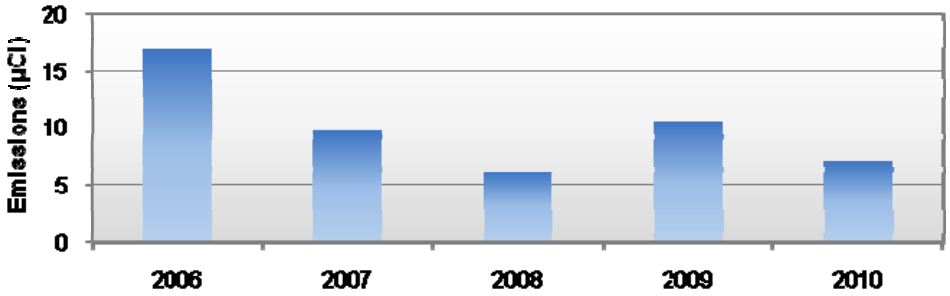

Figure 4-11 **Uranium emissions from sampled LANL stacks**

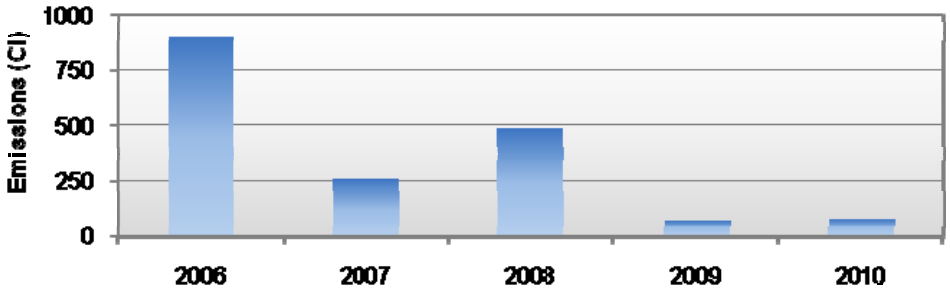

Figure 4-12 **Tritium emissions from sampled LANL stacks**

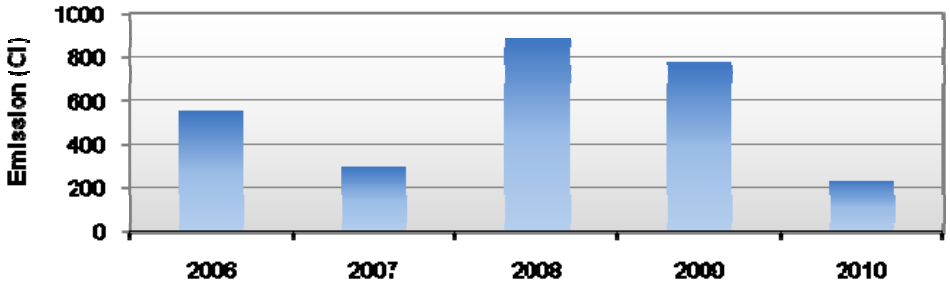

Figure 4-13 **GMAP emissions from sampled LANL stacks**

LANSCE operated in the same configuration as recent years, 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 late spring of 2010 through the end of the calendar year.

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.

As mentioned, the primary beam irradiation target at TA-53 Building 7 was changed out prior to the 2010 run cycle. This resulted in a more controlled irradiation environment and less generation of activated air or other particulates and vapors.

Figure 4-14 shows the individual contribution of each emission type to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. 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 facility 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 boundary.

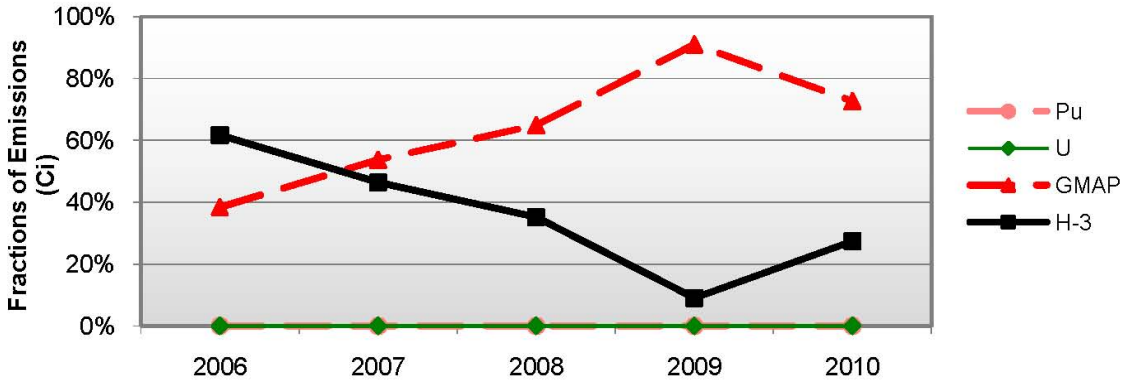

Figure 4-14 Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP

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) as part of a network of radiation detectors known as the Direct Penetrating Radiation Monitoring Network (DPRNET). 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 external dose rate from natural terrestrial and cosmic sources measured by the dosimeters 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 98 thermoluminescent dosimeter (TLD) stations around LANL and in the surrounding communities. There is a TLD at every AIRNET station (shown in Figures 4-1 and 4-3). The corresponding TLD station numbers are listed in Supplementary Data Table S4-10. Additional stations are around TA-54, Area G (shown in

Figure 4-15); at TA-53, LANSCE (eight stations); at Santa Clara Pueblo (five stations); and inside the Pueblo de San Ildefonso sacred area (two stations).

b. Neutron Dosimeters

We monitor potential neutron doses with 47 albedo TLD stations near known or suspected sources of neutrons: TA-53 (LANSCE) and TA-54 (Area G). Albedo dosimeters are sensitive to neutrons and use a hydrogenous material that causes neutron backscatter to simulate the human body.

c. Neutron Background

We measure the neutron background at station #25, near Bandelier National Monument, and #101 in Santa Fe. The average neutron background at these two stations is 2 ± 1 mrem. To be consistent with previous estimates, we use 2 mrem/yr as our estimated neutron background.

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 quality assurance (QA) 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 uncertainty (one standard deviation) is similar to previous data and is 8%.

4. Results

The annual dose equivalents at all stations except those within TA-53 or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Supplemental Data Table S4-8. The only locations with a measurable contribution from LANL operations are within the boundaries of TA-53 (Los Alamos Neutron Science Center [LANSCE]) and near TA-54 (Area G). Figure 4-15 shows the locations of the stations at TA-54, Area G.

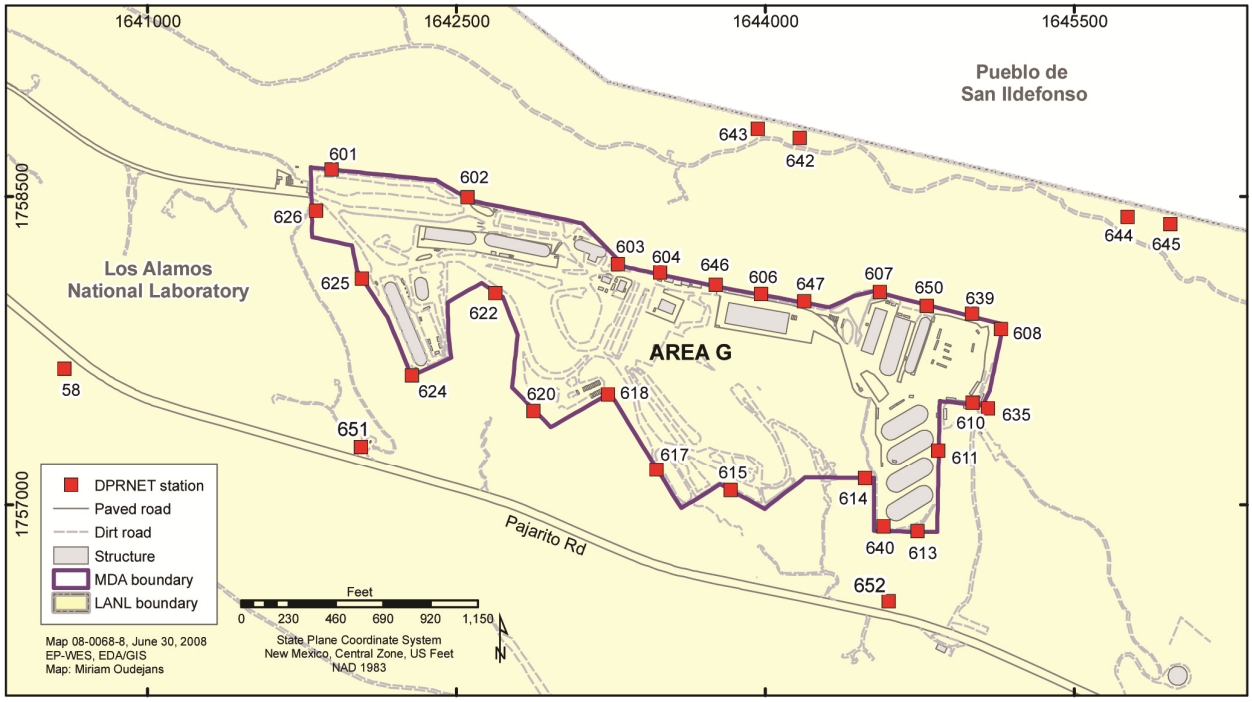

Figure 4-15 Thermoluminescent dosimeter locations at TA-54, Area G, as part of the Direct Penetrating Radiation Monitoring Network (DPRNET)

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, TLDs #133 and #134 are 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 11 mrem, 7 mrem, and 8 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Cañada 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, 365 days per year. As discussed in Chapter 3, we apply an occupancy factor of 1/16 (NCRP 1976) so the public dose near TLD #134 is calculated to be 0.7 mrem/yr, which is similar to previous years.

TLD #133 is located several hundred meters farther from Area G and measures nothing above the terrestrial and cosmic-ray natural background. This is expected because of the distance and the shielding provided by the air. Annual doses of 15 mrem were measured by TLDs #651 and #652, which are located along Pajarito Road, south of Area G. This section of Pajarito Road has limited public access.

D. NON-RADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

The non-radioactive ambient air monitoring network consists of two types of measurements: AIRNET total suspended particulate matter samples analyzed for selected non-radiological species and TEOM samplers, which directly measure particulate matter less than 10 micrometers (PM-10) and particulate matter less than 2.5 micrometers (PM-2.5).

2. Air Monitoring Network and Equipment

Ambient particulate matter monitoring continued at the old White Rock Fire Station on Rover Boulevard and at the Los Alamos Medical Center. Two monitors run at each location: one for particles smaller than 10 micrometers (PM-10) and another for those smaller than 2.5 micrometers (PM-2.5). A tapered-element oscillating microbalance ambient particulate monitor is fitted with an appropriate sample inlet. The microbalance has an oscillating ceramic "finger" with a filter that collects particles. The mass of accumulated particulate matter is derived and saved for later download. These data measure the dust and pollutant loadings in the atmosphere.

3. Ambient Air Concentrations

This year, the particulate matter data collection efficiency was above 97%. Annual averages, 24-hour maxima and EPA standards are shown in Table 4-12.

Table 4-12
PM-2.5 and PM-10 Concentration Summary for 2010

Station Location	Constituent	Maximum 24 Hour (µg/m³)	Annual Average (µg/m³)
Los Alamos Medical Center	PM-10	58	13
	PM-2.5	12	6
White Rock Fire Station	PM-10	60	13
	PM-2.5	19	6
EPA Standard[a]	PM-10	150	n/a[b]
	PM-2.5	35	15

[a] EPA 40 CFR Part 50 and http://www.epa.gov/air/criteria.html.

[b] None applicable.

4. Detonation and Burning of Explosives

LANL uses explosives at firing sites and maintains records that include the type of explosives used and other materials expended. Supplemental Table S4-9 summarizes the amounts of expended materials for the last three years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2010, LANL burned roughly 3,600 kilograms of high explosives. An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicated no adverse air-quality impacts.

5. Beryllium Sampling

We analyzed quarterly composite samples from 38 sites for beryllium (Supplemental Data Table S4-11). These sites are located near potential beryllium sources at LANL, or in nearby communities. New Mexico has no ambient air quality standard for beryllium. All concentrations measured this year were at or below about 2% of the NESHAP standard of 10 ng/m^3 from 40 CFR Part 61 Subpart C (EPA 1989) and were similar to concentrations found in recent years.

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 (Johnson and Young 2008) 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 stations gathers meteorological data at the Laboratory (Figure 4-16). Four of the stations 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). A precipitation gauge is also located in North Community (NCOM) of the Los Alamos town site. The TA-6 station is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is part of the TA-6 meteorological station and measures wind speed and direction to an elevation of approximately 2000 meters above ground level.

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 on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers at TA-6, TA-41, TA-49, TA-53, and TA-54. 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. The Mortandad Canyon (MDCN) station includes a 10-m tripod tower which measures wind at a single level (tower top). In addition, temperature and humidity are measured at ground level at all stations except North Community (NCOM) which only measures precipitation.

Data loggers at the station sites sample most of the meteorological variables at 0.33 Hz, store the data, average the samples over a 15-min period, and transmit the data by telephone or cell phone to a Hewlett-Packard workstation located at the Meteorology Laboratory (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. For more than 50 years, we have provided these daily weather statistics to the National Weather Service. In addition, cloud type and percentage cloud cover are logged three times daily.

We calibrate all meteorological instruments through the LANL Standards and Calibration Laboratory on an annual basis. An external audit of the instrumentation and methods is typically performed once every three to five years. The most recent audit was an "assist visit" by the DOE Meteorological Coordinating Council (DMCC) in August 2006. The DMCC report can be requested at http://www.weather.lanl.gov/. An external subcontractor inspects and performs maintenance on the station network structures and hoists on an annual basis.

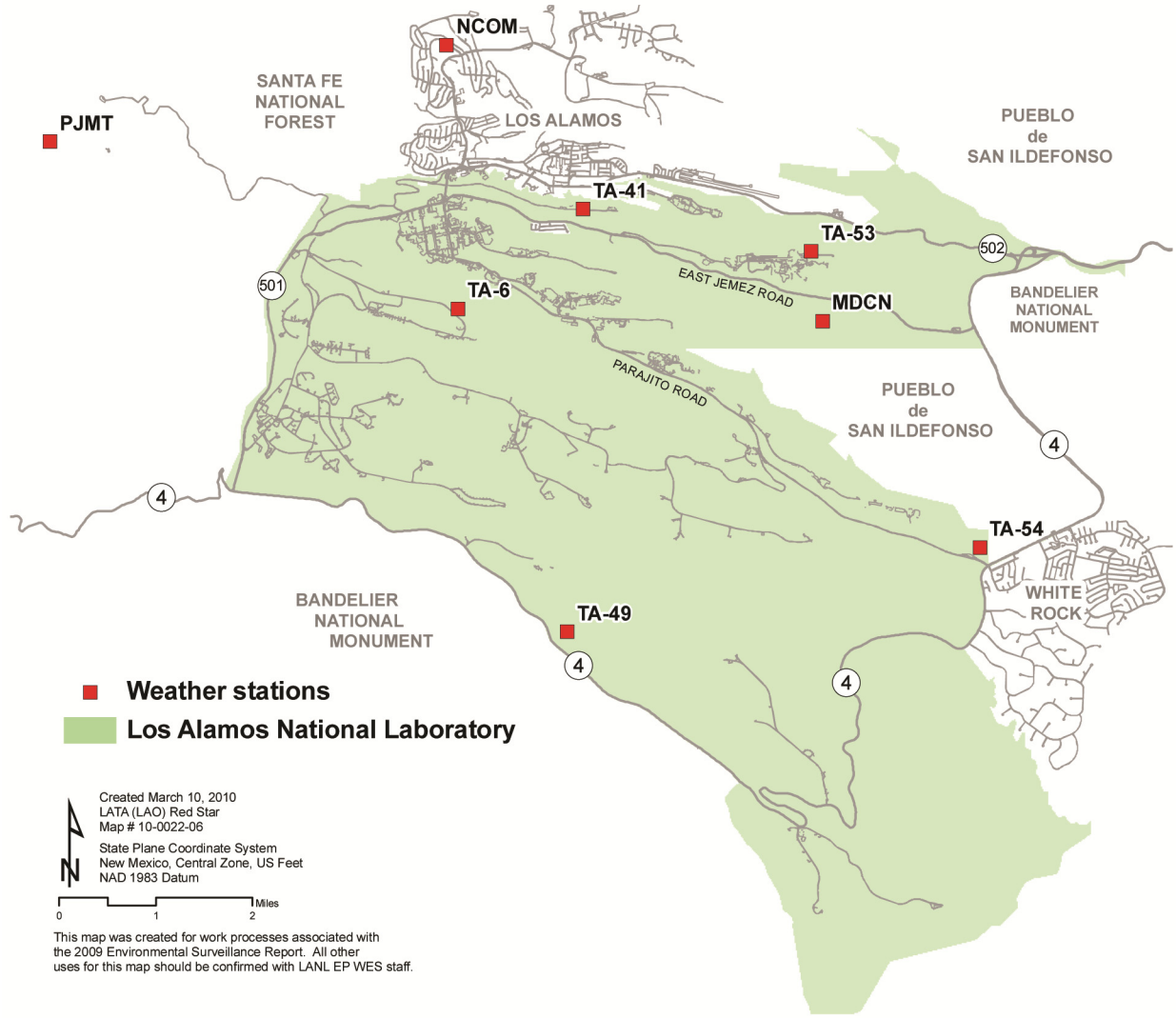

Figure 4-16 Location of meteorological monitoring towers and rain gauges

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 1981 to 2010 represent the time period over which the climatological standard normal is defined. According to the World Meteorological Organization, the standard should be 1961–1990 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 1981–2010 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. Ninety percent 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. Wintertime arctic air masses that descend into the central United States tend to have sufficient time to heat before they reach our

southern latitude so the occurrence of local subzero temperatures is rare. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. During these months, 90% of minimum temperatures range from 45°F to 61°F. Ninety percent 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 18.97 in. The average annual snowfall is 57.0 in. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are occasionally enhanced as a result of orographic lifting of the storms by the high terrain. The record single-day snowfall is about 39 inches, which occurred between 11 a.m. on 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. 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. 2010 in Perspective

Figure 4-17 presents a graphical summary of Los Alamos weather for 2010. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared with monthly normals (averages during the 1981–2010 time period). Table 4-13 presents a tabular perspective of Los Alamos weather during 2010.

The year 2010 was slightly warmer and drier than normal. The average annual temperature in 2010 of 49.0°F exceeded the normal annual average of 48.4°F by 0.6°F. The total precipitation of 18.8 in. was 99% of normal (18.97 in.). The first half of the year was generally cooler than normal and the second half was warmer than normal. June and September in particular were considerably warmer than normal. The year began with two snowy months and then precipitation see-sawed through the year. March was dry, April was wet, May was dry, and so on. June and November were particularly dry. July had an abundance of monsoon precipitation. The total precipitation at year's end was close to normal and the total snowfall of 5 feet was 2 inches above normal.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-18 shows the historical record of temperatures in Los Alamos from 1925 through 2010. The annual average temperature is not the average temperature per se, but the mid-point between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-18. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it appears 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 warm trend is longer-lived.

Figure 4-19 shows the historical record of the annually summed total precipitation. The most recent drought spanned the years 1998 through 2003. The 2010 total of 18.8 in. was slightly below normal. As with the historical temperature profile, the five-year running mean is also shown. The five-year average suggests not only that the recent drought is behind us, but that it was the most severe drought during the 80-year record. Precipitation in 2009 and 2010 has been very close to normal, but again warm temperatures have resulted in a 25% decrease in snowfall over the past two years.

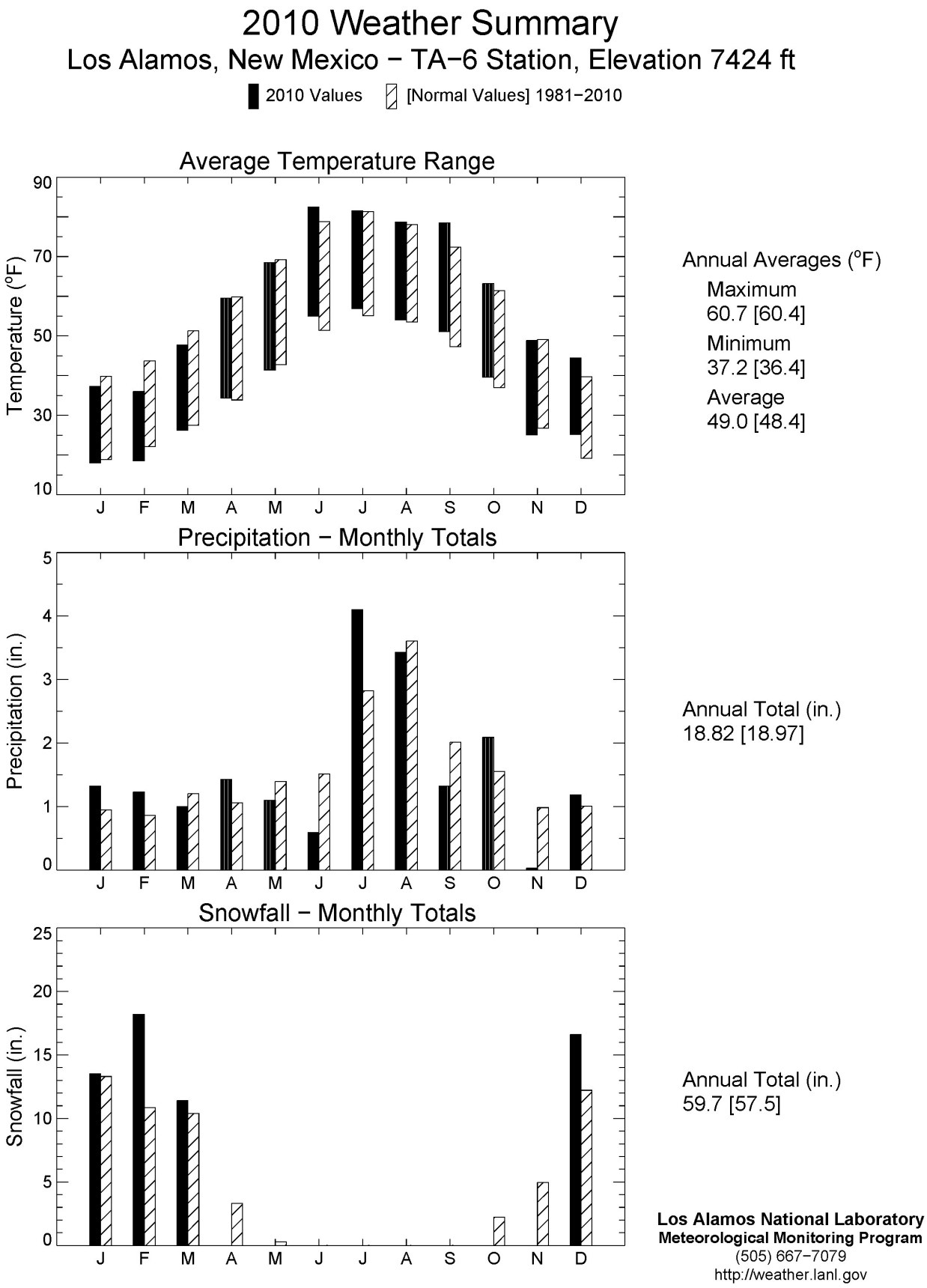

Figure 4-17 Weather summary for Los Alamos for 2010 at the TA-6 meteorology station

Table 4-13
Monthly and Annual Climatological Data for 2010 at Los Alamos

Month	Temperatures (°F)[a]								Precipitation (inches)[a]				12-meter wind (mph)[a]				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure[b]	Highest	Date	Lowest	Date	Total	Departure[b]	Total	Departure[b]	Average Speed	Departure[c]	Speed	From	Date
January	37.3	18.0	27.6	-1.8	45	11th	3	8th	1.32	0.37	13.5	0.2	4.9	-0.1	47	WNW	23rd
February	36.0	18.6	27.3	-5.6	44	18th	4	23rd	1.23	0.37	18.2	7.3	8.5	2.7	36	WNW	22nd
March	47.8	26.2	37.0	-2.4	70	30th	15	20th	1.0	-0.2	11.4	1.0	6.6	0.1	49	WNW	26th
April	59.5	34.3	46.9	0.1	70	12th	19	2nd	1.44	0.38	0	-3.3	9.6	2.0	53	WNW	23rd
May	68.5	41.5	55.0	-1.0	80	27th	27	1st	1.1	-0.29	0	-0.3	9.2	1.8	51	WNW	23rd
June	82.4	55.0	68.7	3.6	90	5th	44	13th	0.59	-0.92	0	0	8.1	1.0	47	SSW	19th
July	81.5	56.9	69.2	1.0	91	19th	51	8th	4.1	1.28	0	0	6.2	0.6	33	NW	20th
August	78.7	54.1	66.4	-1.4	84	14th	44	25th	3.43	-0.18	0	0	6.0	0.7	42	NW	12th
September	78.5	51.1	64.8	5.0	85	16th	41	11th	1.32	-0.69	0	0	6.6	0.9	38	WNW	9th
October	63.2	39.6	51.4	2.2	76	1st	23	26th	2.09	0.54	0	-2.2	6.3	0.6	61	W	25th
November	48.8	25.1	37.0	-0.9	65	6th	8	30th	0.03	-0.95	0	-4.9	6.7	1.4	49	WNW	16th
December	44.5	25.2	34.9	5.5	57	3rd	-4	31st	1.18	0.17	16.6	4.4	5.4	0.6	41	W	31st
Year	60.7	37.2	49.0	1.1	91	July 19th	-4	Dec 31st	18.8	-0.13	59.7	1.0	6.7	0.7	61	W	Oct 25th

[a] Data from Technical Area 6, the official Los Alamos weather station.

[b] Departure columns indicate positive or negative departure from 1981-2010 (30-year) climatological average.

[c] Departure column indicates positive or negative departure from 1990-2010 (21-year) climatological average.

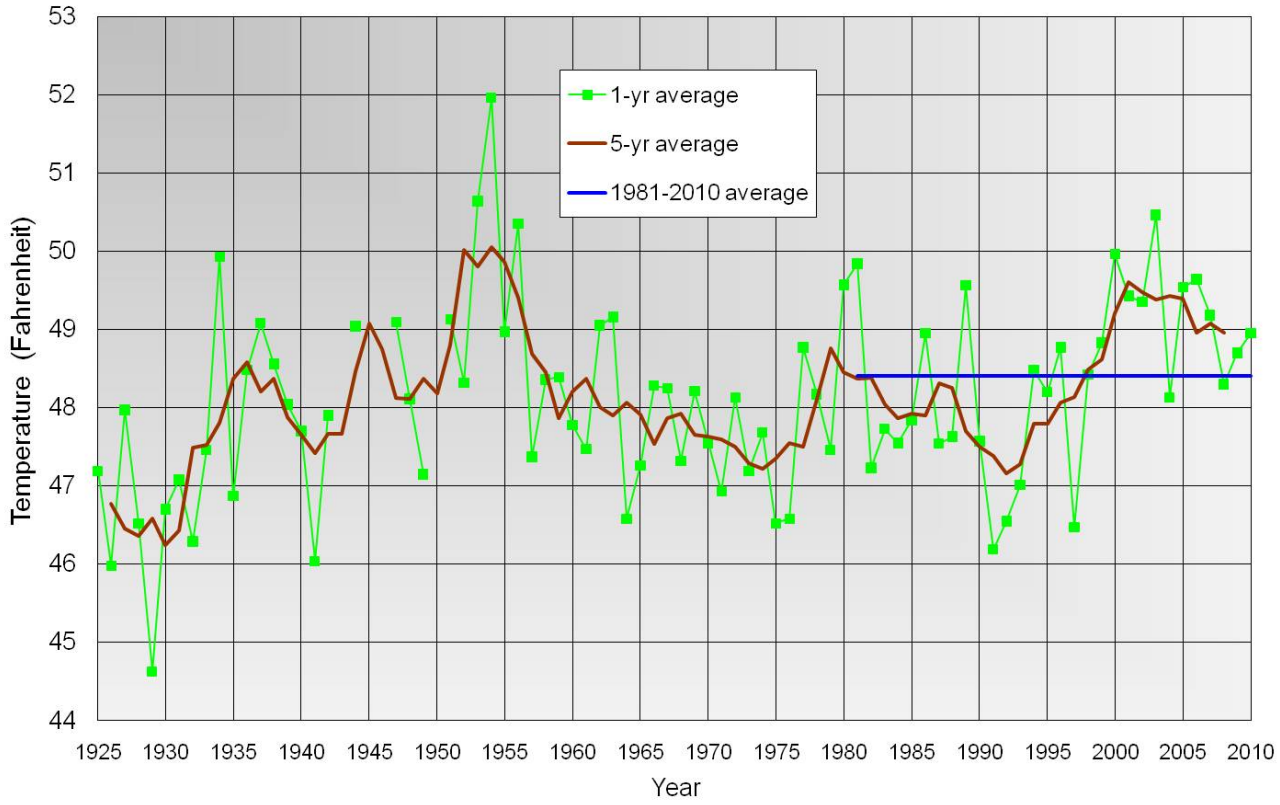

Figure 4-18 Temperature history for Los Alamos

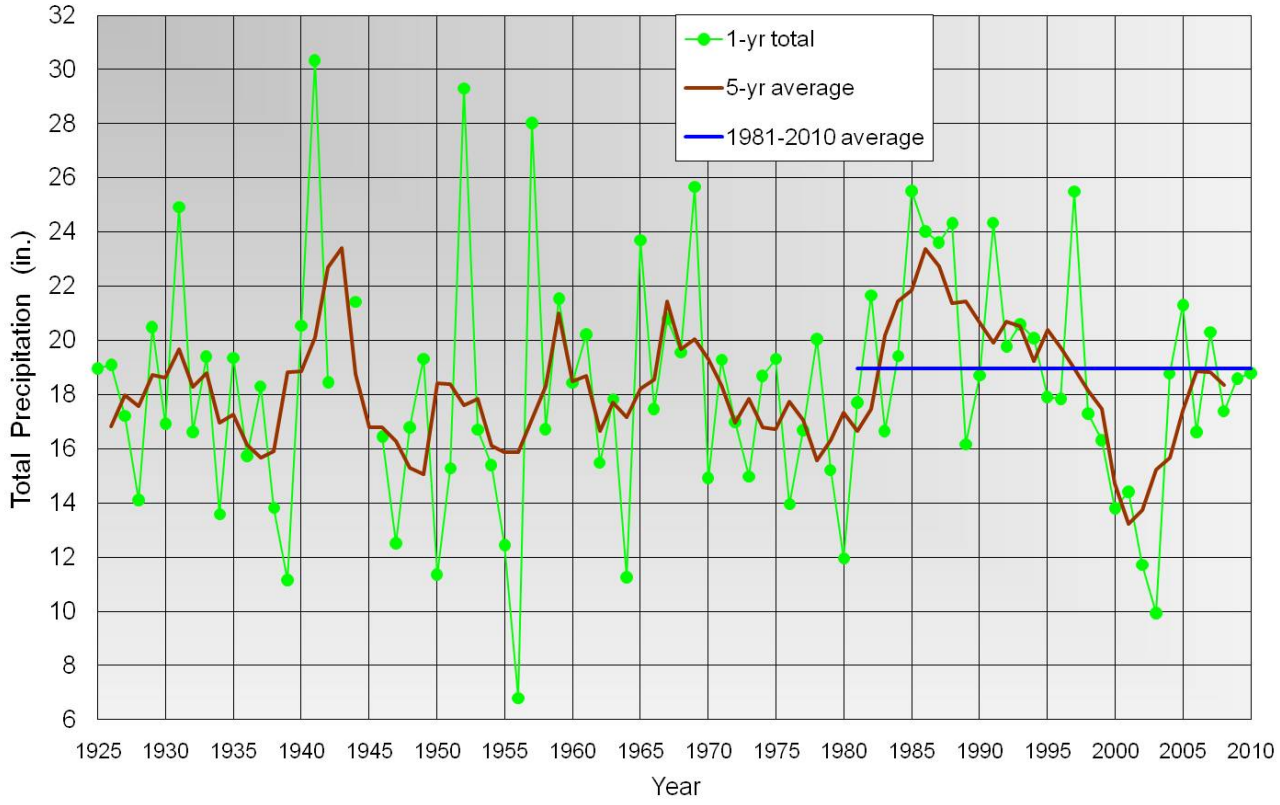

Figure 4-19 Total precipitation history for Los Alamos

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-20. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are directly from the south at TA-6 over 15% of the time during days in 2010. Winds are directly from the north just over 2% of the time during the day. Wind roses also show the distribution of wind speed. A little over 8% of the time, for example, winds at TA-6 are from the south and range from 2.5 to 5 meters per second. Winds from the south at TA-6 exceed 7.5 meters per second only a fraction of 1% of the time, and winds are calm there 1.3% of the time.

The wind roses are based on 15-minute-averaged wind observations for 2010 at the four Pajarito Plateau stations. Although it is not shown here, 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 stations 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 have a westerly component, resulting from a combination of prevailing westerly winds and downslope katabatic flow of cooled mountain air.

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 faster surface winds. At night, there is little mixing so wind at the surface receives less boosting from aloft.

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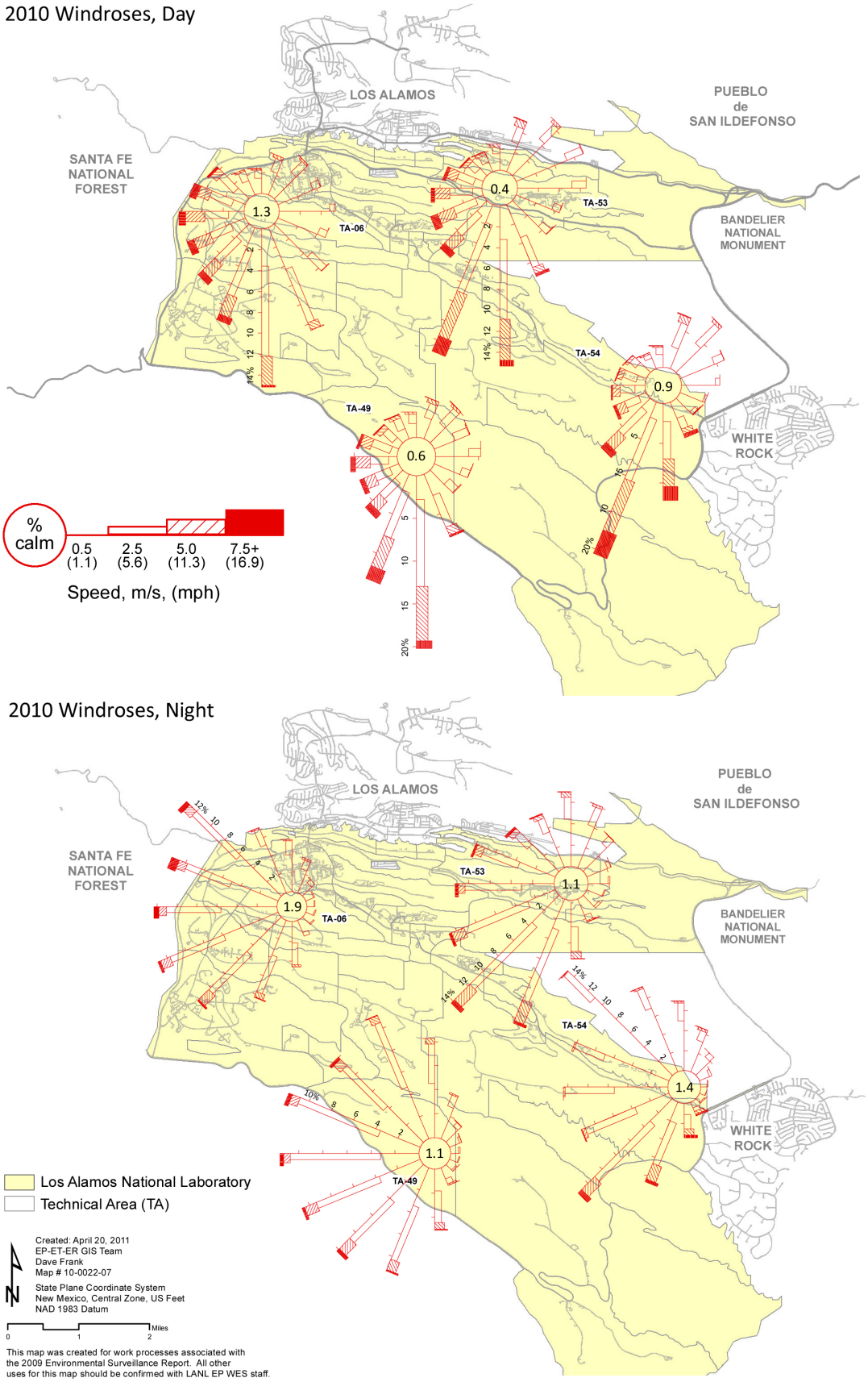

Figure 4-20 Daytime and nighttime wind roses for 2010

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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and 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 groundwater programs are to determine compliance with waste discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources.

Because of the Laboratory's semiarid, mountainside setting, significant groundwater is found only at depths of more than several hundred feet. The Los Alamos County public water supply comes from supply wells that draw water from the regional aquifer, which is found at a depth that ranges from 600 to 1,200 ft. Groundwater protection efforts at the Laboratory focus on the regional aquifer and also include small bodies of shallow perched groundwater found within canyon alluvium and at intermediate depths above the regional aquifer.

Most of the groundwater monitoring conducted during 2010 was carried out according to the Interim Facility-wide Groundwater Monitoring Plans (LANL 2009a, 2010) approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (Consent Order). The LANL Environmental Programs Directorate 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 reports available at http://lanl.gov/environment/.

1. Geologic Setting

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

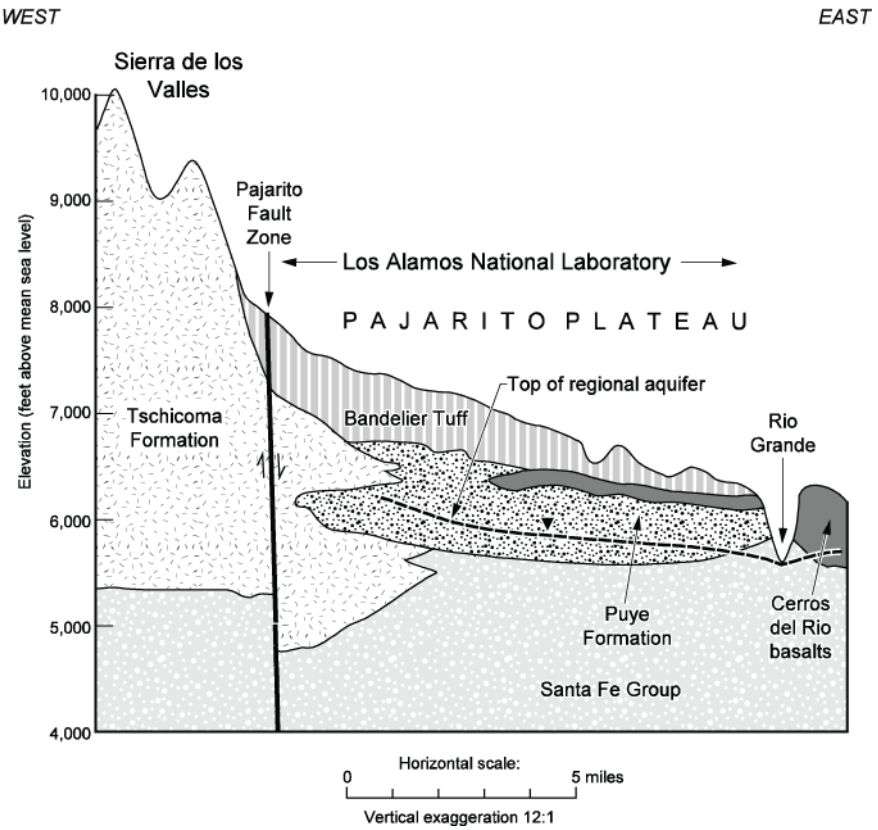

Figure 5-1 Generalized geologic cross-section of the Pajarito Plateau

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 land sits 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 a zone of saturation with limited extent that is retained above less permeable layers and is separated from underlying groundwater by unsaturated rock.

The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) discontinuous 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 a thickness of 100 ft. In wet canyons, runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rock, maintaining shallow bodies of perched groundwater within the alluvium. These saturated zones have limited extent; evapotranspiration and percolation into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

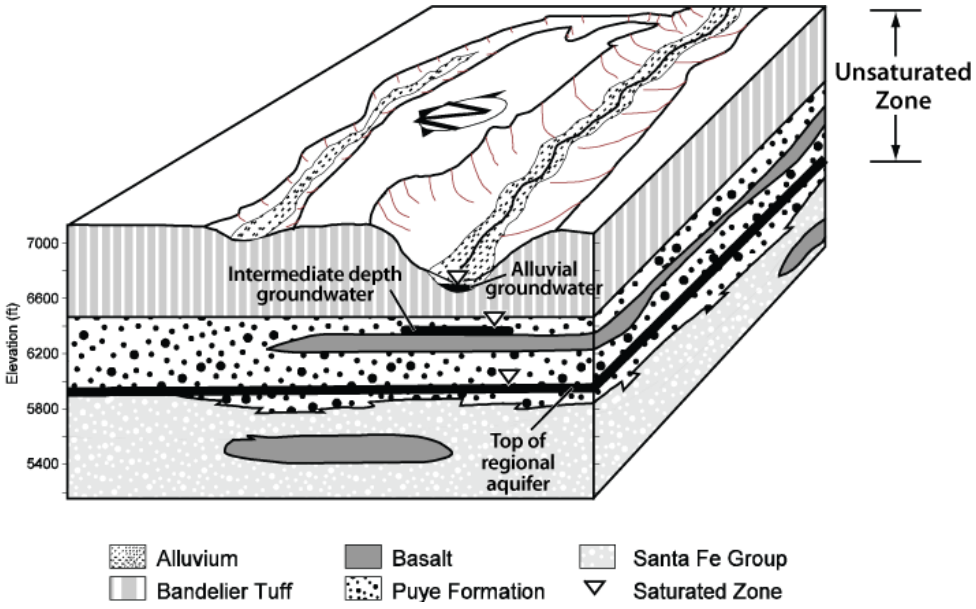

Figure 5-2 **Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence**

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and 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. The intermediate groundwater may be discontinuous or may connect with other zones across canyons. Depths of the intermediate perched groundwater vary. For example, the depth to intermediate perched groundwater is approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched groundwater occurs in volcanic rocks on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs and yields a significant flow from a gallery in Water Canyon. Two types of intermediate groundwater occur 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. Also, intermediate groundwater is found in the Bandelier Tuff at a depth of approximately 700 ft. The source of this deeper perched groundwater may be percolation from streams that discharge from canyons along the mountain front or may be underflow of recharge from the Sierra de los Valles.

The regional aquifer 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 generally flows 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 2005a). Groundwater velocities vary spatially but are typically 30 ft/yr.

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.

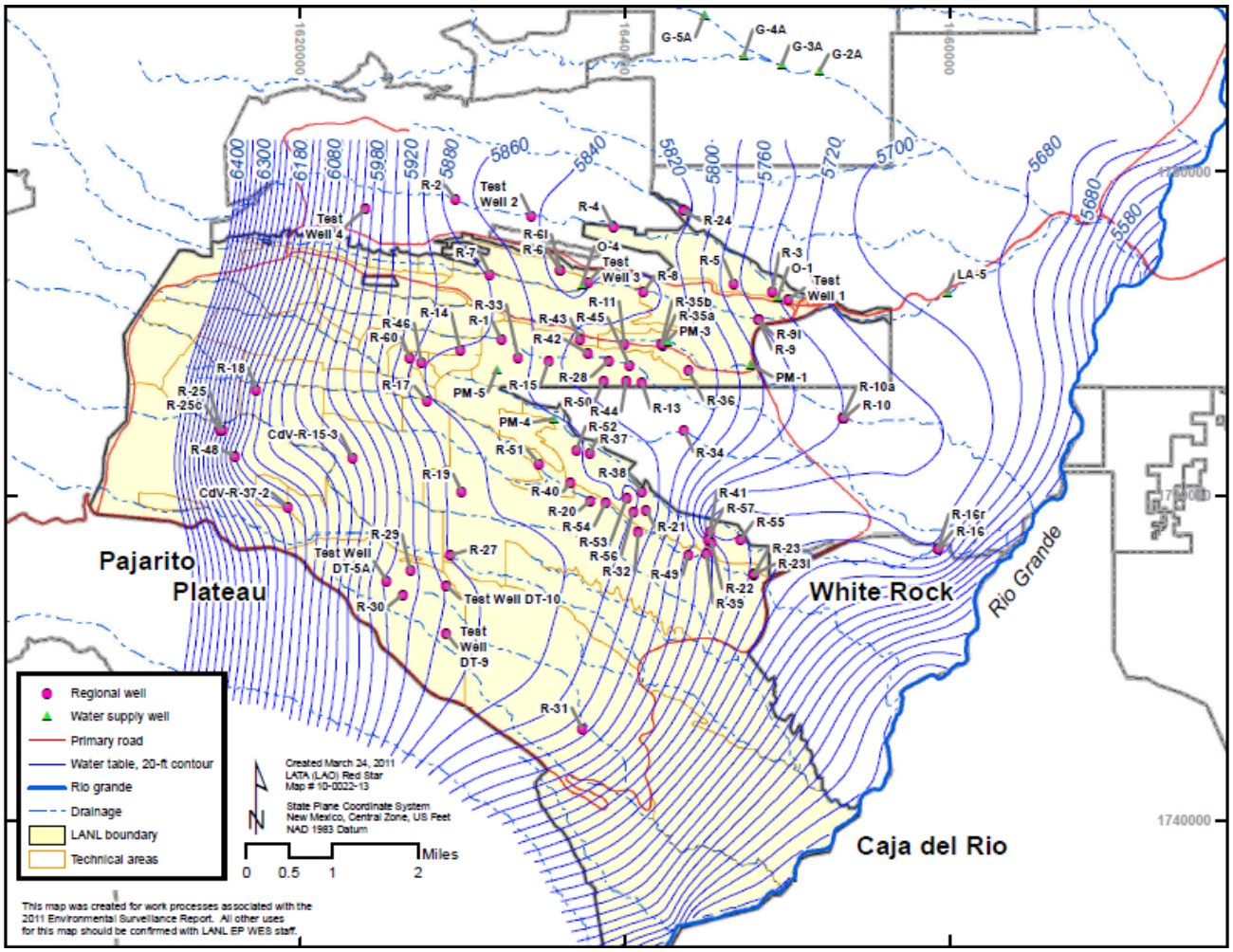

Figure 5-3 **Contour map of average water table elevations for the regional aquifer (based on a map in LANL 2011). This map represents a generalization of the data; other interpretations are possible.**

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 600 ft of unsaturated tuff, basalt, and sediments with generally low moisture content (< 10%). 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, restricts their volumetric contribution to recharge reaching the regional aquifer.

3. Overview of Groundwater Quality

Since the 1940s, liquid effluent discharge by the Laboratory has affected water quality in the shallow perched alluvial groundwater that lies beneath the floor of a few canyons. Liquid effluent discharge is also the primary means by which Laboratory contaminants have affected the quality of intermediate perched zones and the regional aquifer. Where 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 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 is found in the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced or not present.

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.

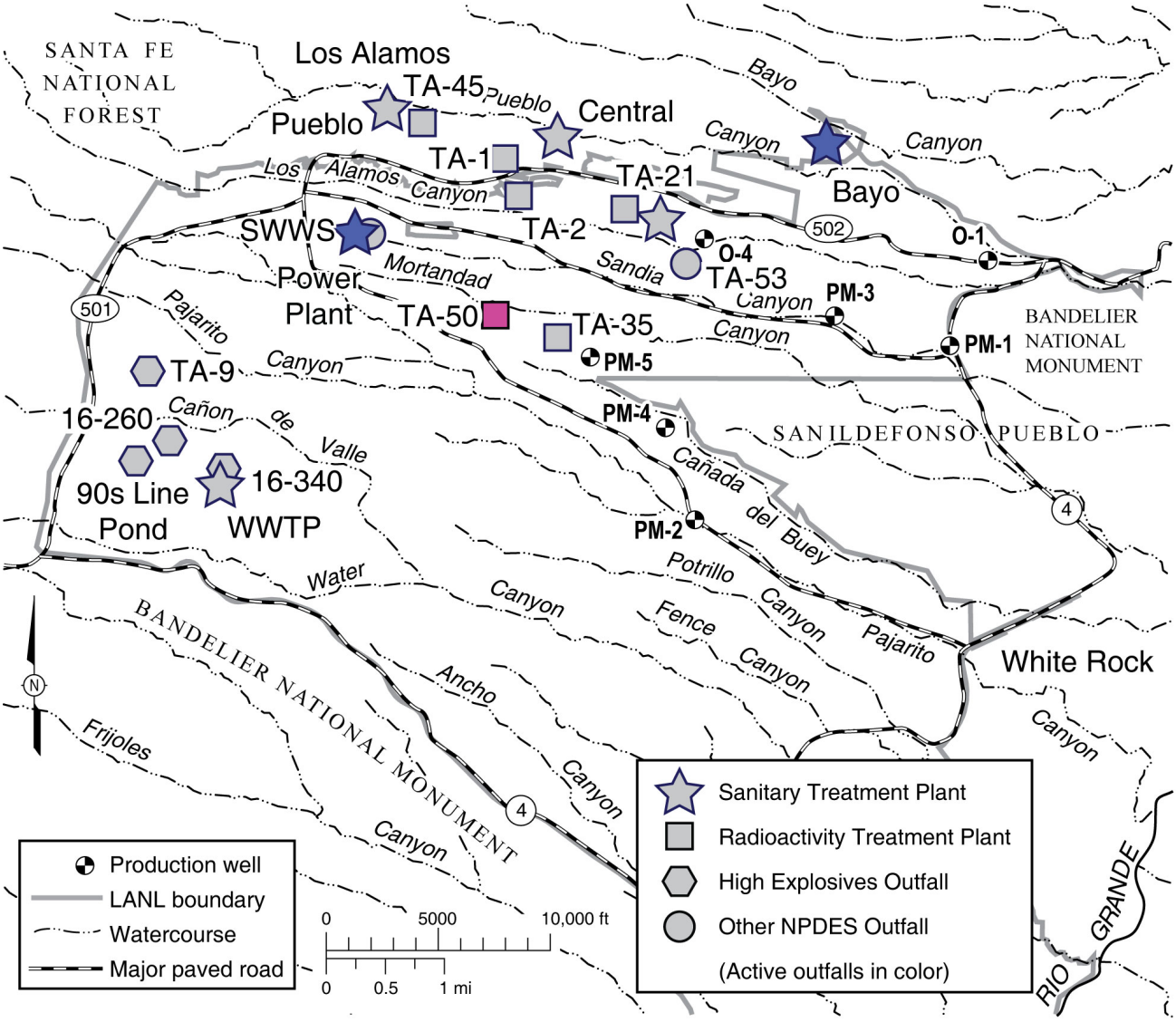

Figure 5-4 **Major liquid release sources (effluent discharge) potentially affecting groundwater. Active outfalls are in color; most outfalls shown are inactive.**

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. 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 several sanitary wastewater treatment plants in Pueblo Canyon (ESP 1981). Only the Los Alamos County Wastewater Treatment Plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

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%). From 1993 to 1997, total estimated average flow was 1,300 million gallons per year (M gal./yr); flow decreased to 230 M gal./yr from 1998 to 2005

(Rogers 2006) and to 133 M gal./yr in 2009. The quality of the remaining discharges has been improved through treatment process improvements so that they meet applicable standards.

Certain chemicals are good indicators of the possible effect of Laboratory effluents on groundwater. These chemicals are described as being chemically conservative; that is, their concentrations are usually not affected by chemical reactions. Examples of these conservative chemicals 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 not necessarily affected by LANL discharges.

Liquid effluent discharges have affected intermediate perched groundwater and the regional aquifer to a lesser degree than the shallow perched alluvial groundwater. The intermediate groundwater in various locations shows localized contamination from Laboratory operations, including presence of tritium, high explosives compounds, chlorinated organic chemical compounds, dioxane(1,4-), hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate.

In 2010, the HE compound Research Department Explosive (RDX) continued to be detected in the regional aquifer at Pajarito Canyon monitoring well R-18. The RDX concentration was at 15% of the Environmental Protection Agency's (EPA's) Human Health tap water screening level of 6.1 μg/L. Earlier detection of RDX in the regional aquifer at regional aquifer well R-25 (to the south of R-18) was probably due to cross-contamination from shallower well screens that occurred for several months before the sampling system was installed, allowing flow between the screens.

Hexavalent chromium and nitrate have been found in several regional aquifer monitoring wells. In regional aquifer monitoring wells R-42 and R-28 in Mortandad Canyon, hexavalent chromium is found at concentrations of about 25 times and nine times the 50 μg/L NM groundwater standard, respectively. Beginning in 2010, LANL has detected chromium at concentrations up to 81 μg/L (in May 2011) at 1077 ft in regional aquifer monitoring well R-50, which is about 250 ft north of the LANL/San Ildefonso boundary. Nitrate (as nitrogen) concentrations in regional aquifer monitoring wells R-43 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon are up to 60% of the 10 mg/L NM groundwater standard. Traces of tritium and perchlorate are also found in the regional aquifer. Tritium activities are far below the EPA maximum concentration level (MCL) of 20,000 pCi/L, but at a few wells, perchlorate concentrations are above the 4 μg/L Consent Order screening level.

Beginning in late 2008, trichloroethene was detected at 1,147 ft in Pajarito Canyon regional aquifer monitoring well R-20 and continues to be detected in every sample event. The concentrations increased to 60% of the 5 μg/L EPA MCL screening level in late 2009 but during 2010 fell to 11% of the screening level.

With one exception, drinking water wells in the Los Alamos area have not been impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate was found during 2010 at concentrations up to 31% of the 4 μg/L Consent Order screening level. These values are also 8% of the EPA's interim health advisory of 15 μg/L for perchlorate in drinking water. Even though the perchlorate levels are below regulatory limits, 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 standards.

C. GROUNDWATER STANDARDS AND SCREENING LEVELS

In evaluating groundwater samples, we applied regulatory standards and risk levels as described in Table 5-1. For drinking water supply wells, which draw water from the regional aquifer, we compared concentrations of radionuclides in samples to (1) the derived concentration guides (DCGs) for ingested water calculated from DOE's 4-mrem/yr drinking water dose limit and (2) the EPA MCLs. EPA MCLs are the maximum permissible level of a contaminant in water delivered to any user of a public water system. Thus, compliance with the MCL is measured after treatment; measurements in a water supply well may be higher and allow the MCLs to be met through blending of water in a distribution system.

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

Constituent	Sample Type	Standard	Risk-Based Screening Level	Reference	Location	Notes
Radionuclides	Water supply wells	DOE 4-mrem/yr DCGs, EPA MCLs	None	DOE Order 5400.5, 40 CFR 141-143	On site and off site	A 4-mrem/yr dose limit and EPA MCLs apply to water provided to users of drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem/yr DCGs	None	DOE Order 5400.5	On site	DOE public dose limit of 100 mrem/yr applies to effluent discharges
Radionuclides	Non water supply groundwater samples	None	4-mrem/yr DCGs EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On site and off site	A 4-mrem/yr dose limit and EPA MCLs are for comparison purposes because they apply only to drinking water systems
Non-radionuclides	Water supply wells	EPA MCLs, NM groundwater standards, EPA Human Health 10–5, and HQ = 1 tap water risk levels for NM toxic pollutants with no standard	None	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	On site and off site	EPA MCLs apply to water provided to users of drinking water systems. Use EPA Human Health tap water table for 10–5 and HQ = 1 risk levels
Non-radionuclides	Non-water supply groundwater samples	NM groundwater standards, EPA Human Health 10–5 and HQ = 1 tap water risk levels for NM toxic pollutants with no standard	EPA MCLs	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	On site and off site	NMED regulations apply to all groundwater. EPA MCLs are for comparison purposes because they apply only to drinking water systems. Use EPA Human Health tap water table for 10–5 and HQ = 1 risk levels

For radioactivity in groundwater other than drinking water, there are the New Mexico Water Quality Control Commission (NMWQCC) groundwater standards (NMWQCC 2002) 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/yr drinking water DCGs and with EPA MCLs. Where used in this chapter for such comparison purposes, in assessing water samples from sources other than water supply wells, these DCGs and EPA MCLs are referred to as screening levels. The DCGs for the 100-mrem/yr public dose limit apply as effluent release guidelines.

The NM drinking water regulations and EPA MCLs apply as regulatory standards to nonradioactive constituents in water supply samples after treatment. They may be used as risk-based screening levels for other groundwater samples. The NMWQCC groundwater standards apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples. Except for mercury and organic compounds, these standards apply only to dissolved (that is, filtered) concentrations. Because many metals are either chemically bound to or components of aquifer material that makes up suspended sediment in water

samples, the unfiltered concentrations of these substances are often higher than the filtered concentrations. The EPA MCLs are intended for application to water supply samples that generally have low turbidity. As the EPA does not specify that the MCLs apply to dissolved concentrations, we use them to screen both filtered and unfiltered concentrations. The Consent Order specifies a screening level for perchlorate of 4 µg/L.

The Consent Order and NMWQCC (2002) specify how to determine standards for the toxic pollutants listed in the NMWQCC groundwater standards if they have no other state or federal standard. As required in the Consent Order, we screened results for these compounds at a risk level of 10^{-5} for cancer-causing substances or a hazard quotient of one (HQ = 1) for non-cancer-causing substances. A HQ of one or less indicates that no (noncancer) adverse human health effects are expected to occur from that chemical. We used the EPA Human Health tap water screening levels to screen these toxic pollutant compounds (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). For cancer-causing substances, the EPA Human Health tap water screening levels are at a risk level of 10^{-6}, so we use 10 times the values to screen at a risk level of 10^{-5}. These screening levels are updated several times each year; the November 11, 2010, edition was used to prepare this report.

Groundwater is a source of flow to springs and other surface water that may be used by neighboring tribal members and wildlife. NMWQCC's surface water standards (NMWQCC 2000), including the wildlife habitat standards, also apply to this surface water. (For a discussion of surface water, see Chapter 6.)

D. MONITORING NETWORK

In 2005, DOE and its Operations and Management Contractor and NMED signed a 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 NMED for its approval. Groundwater monitoring conducted during calendar year 2010 was carried out according to two Interim Plans approved by NMED under the Consent Order (LANL 2009a, 2010). The monitoring locations, analytical suites, and frequency of monitoring reflect the technical and regulatory status of each area and are updated annually in the Interim Plan. In some cases, when monitoring results demonstrate little change or no impacts, sampling frequency has decreased.

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: perched alluvial groundwater beneath the floor of some canyons, localized intermediate-depth perched groundwater systems, and the regional aquifer (Figures 5-5 through 5-9).

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 5-9 and mainly sample the regional aquifer. Basalt Spring, Los Alamos Spring, and Pine Rock Spring are intermediate groundwater sampling points, and wells LLAO-4 and LLAO-5 sample alluvial groundwater. The Laboratory also monitors Los Alamos County water supply wells (Figure 5-7) and three City of Santa Fe supply wells (Figure 5-9).

LANL conducts a regular program of water level measurements for monitoring wells. A summary of groundwater level measurements for 2010 is given in Koch et al. (2011).

1. Regional Aquifer and Intermediate Perched Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. The majority of the monitoring network consists of wells constructed since the Hydrogeologic Workplan (LANL 1998). The Laboratory added several new wells to the monitoring well network in 2010, as described in Chapter 2, Section C.9.b. A column on the supplemental data tables for Chapter 5 (located on the included compact disk) identifies the groundwater zones sampled by different screens of the wells and gives the depth of the sampled well screen for multiscreen wells or top of the sampled well screen for single screen wells.

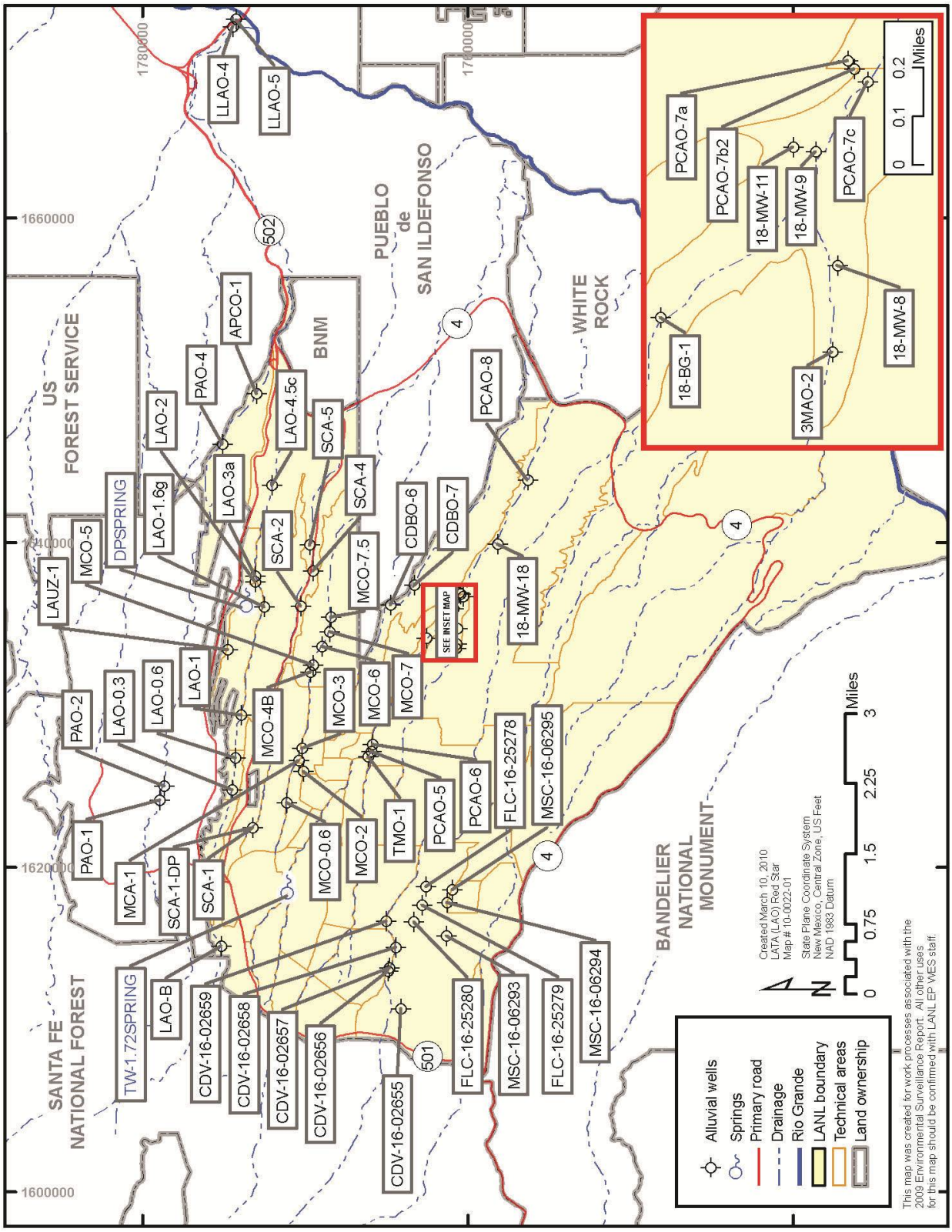

Figure 5-5 Springs and wells used for alluvial groundwater monitoring

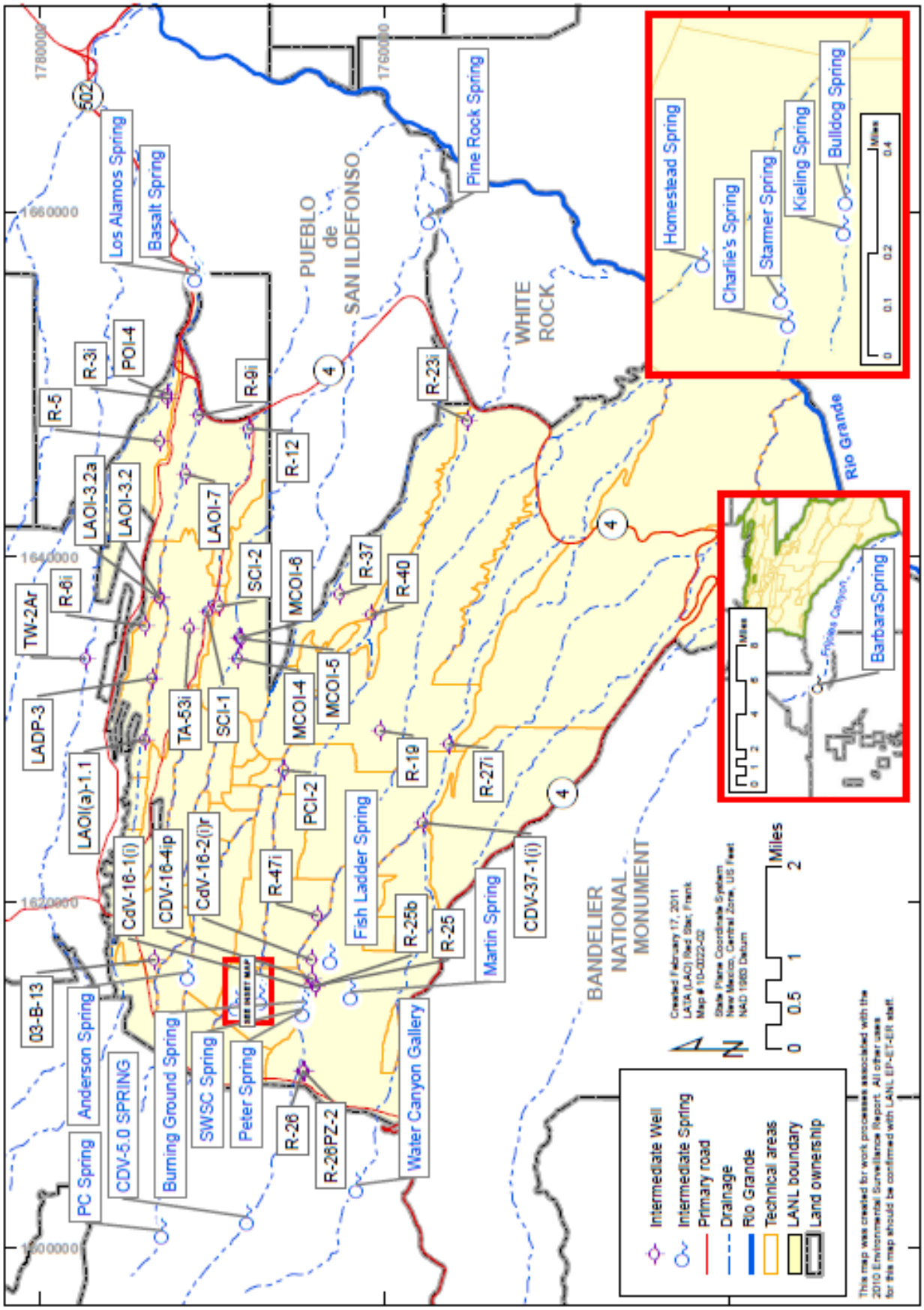

Figure 5-6 Springs and wells used for intermediate-depth perched zone monitoring

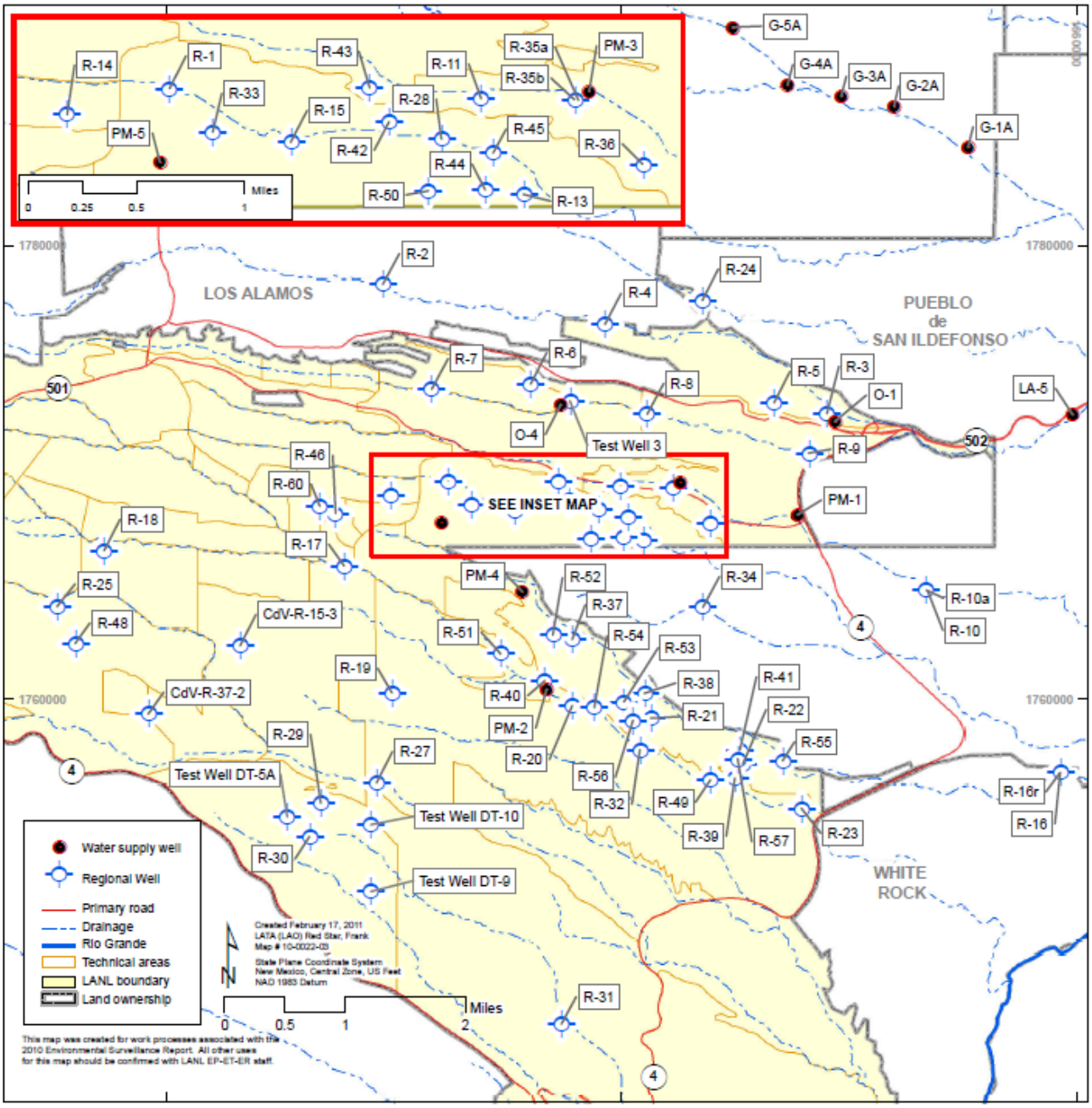

Figure 5-7 Wells used for regional aquifer monitoring

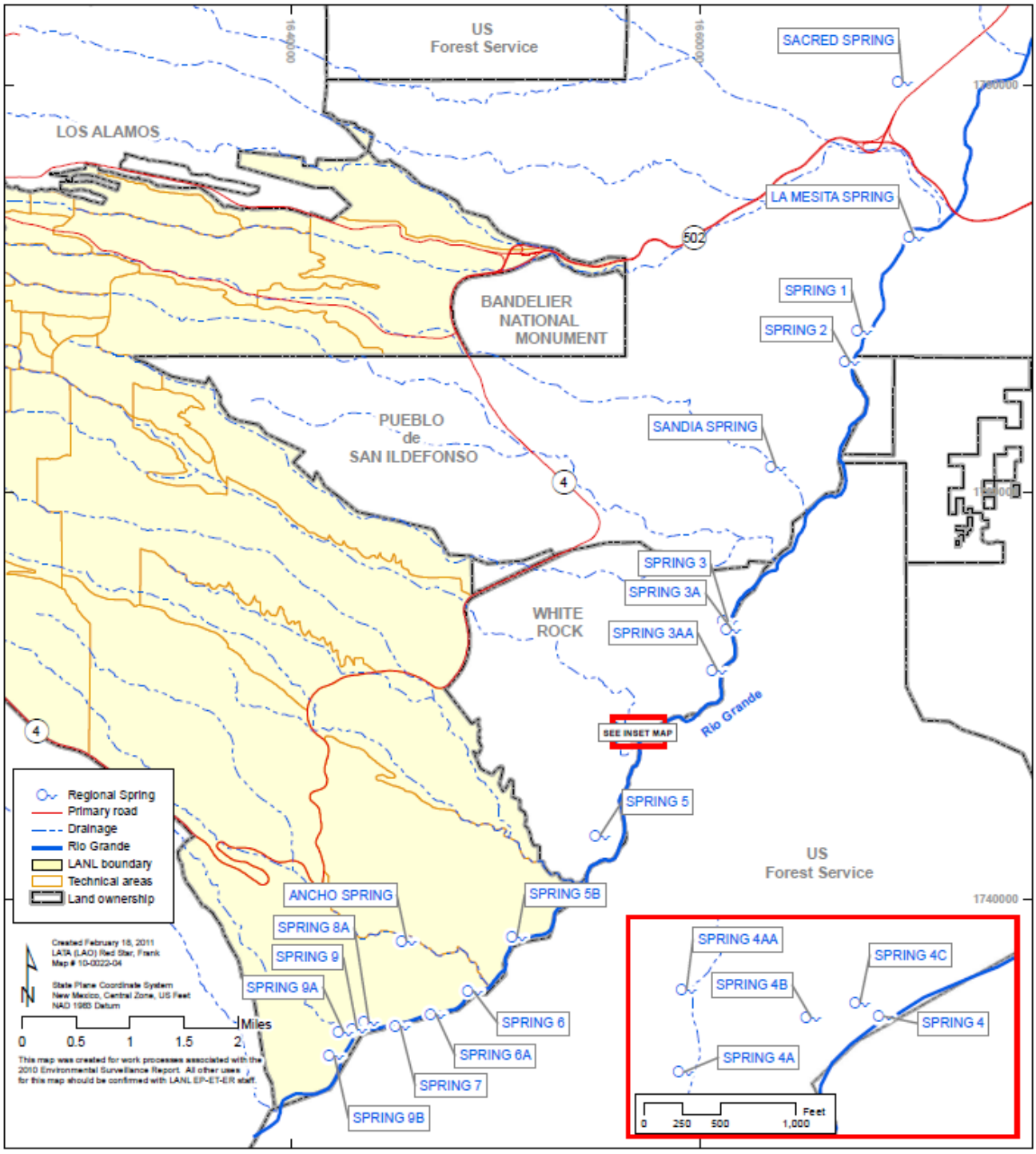

Figure 5-8 Springs used for regional aquifer monitoring

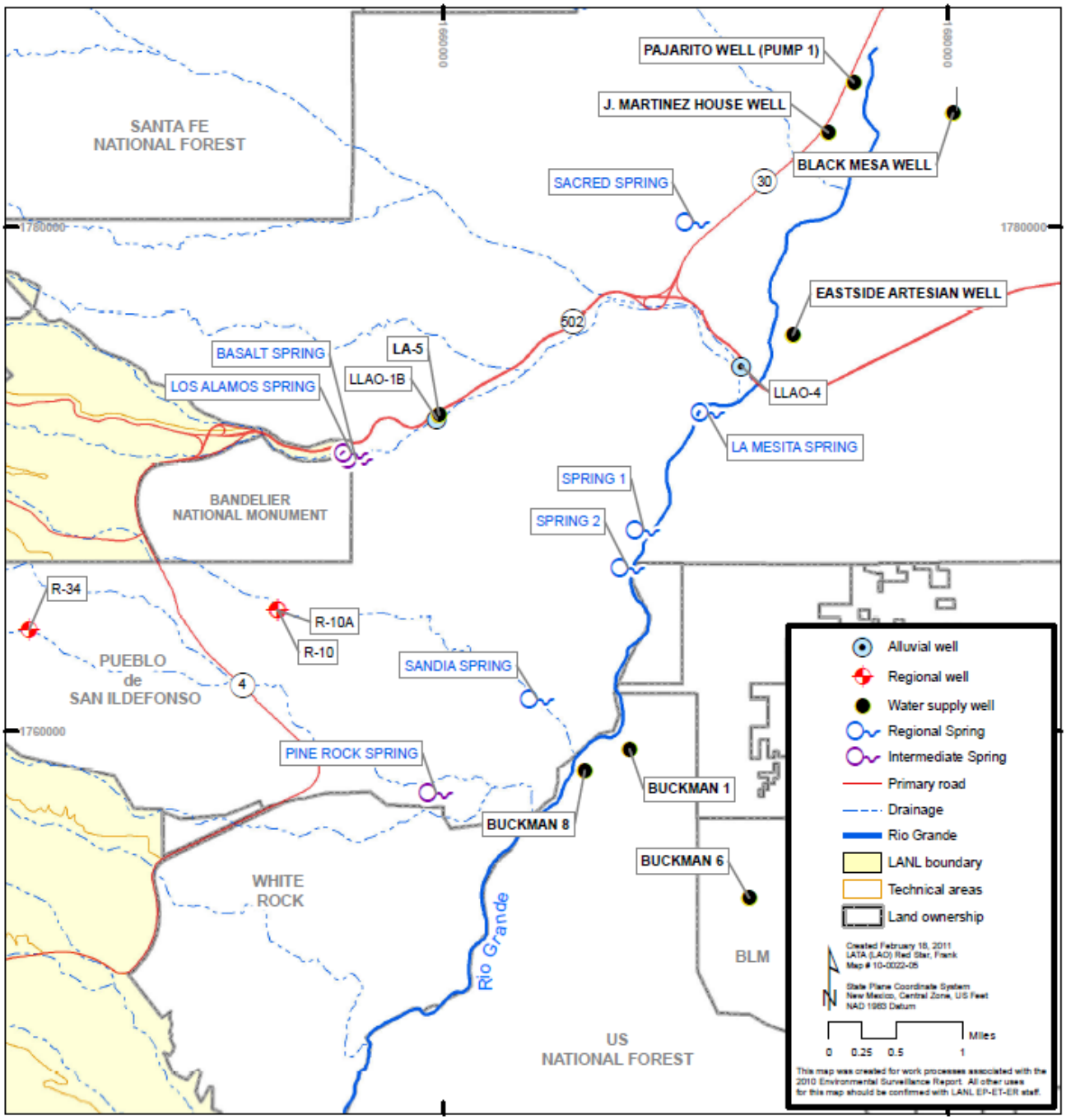

Figure 5-9 **Springs and wells used for groundwater monitoring on neighboring Pueblo de San Ildefonso lands and at the City of Santa Fe Buckman well field**

The Laboratory collects samples from 12 Los Alamos County water supply wells in three well fields that produce drinking 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 they draw samples that integrate water over a large depth range. Los Alamos County owns and operates these wells and 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 came from wells located on Pueblo de San Ildefonso lands and from the Buckman well field operated by the City of Santa Fe.

We also 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 used 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 Plugging and Abandonment

During the last fiscal year, using funds from the American Reinvestment and Recovery Act, we plugged and abandoned Test Well 1, Test Well 1A, Test Well 2, Test Well 2A, Test Well 2B, and Test Well 4. We also plugged and abandoned two alluvial wells in Water Canyon; WCO-1 and WCO-3 and installed replacements for these two alluvial wells.

Test Well 1 and Test Well 1A were replaced by TW-1Ar; Test Well 2 and Test Well 2A were replaced by TW-2Ar; WCO-1 was replaced by WCO-1r; and WCO-3 was replaced by WCO-3r.

E. SUMMARY OF 2010 SAMPLING RESULTS

In 2010, LANL sampled 232 groundwater wells, well screens, and springs in 561 separate sampling events. The samples collected were analyzed for about 215,636 separate results. If results for field parameters (for example, temperature or pH) and field quality control blanks are excluded, the samples were analyzed for 155,984 results. The total numbers of results are given in Table 5-2 for each analytical suite and groundwater zone. The bottom row of the table gives the number of sample results, not including field quality control blanks or field parameters.

Table 5-3 gives the total number of sample results that were above the screening levels described in Section C. About 0.2% of the results had values greater than a screening level. These totals are based on omitting field quality control blanks, field parameters, and measurements made at an in-house analytical laboratory. Samples analyzed in-house are used mainly for evaluating water quality in newly drilled wells or in wells affected by drilling fluids; these samples are not used for compliance monitoring. The analytes, number of times above the screening level, and the screening level value are given in Table 5-4.

The total number of sample results that were above the screening levels (Tables 5-3 and 5-4) may be an overestimate for several reasons. In many cases the given screening level may not apply to a particular groundwater sample. For example, some of the screening levels (the EPA MCLs and EPA Human Health tap water screening levels) apply specifically to drinking water and not to a sample result from a non-drinking water source. As well, for a particular sample event, multiple measurements made for an analyte may be included in the total. The multiple measurements could include both filtered and unfiltered sample results, multiple analytical laboratory analyses (for example, made on diluted samples to improve analytical accuracy), and results from field duplicate samples. The monitoring results are described in detail in the following sections.

Table 5-2
Total Number of Groundwater Sample Results Collected by LANL in 2010

Groundwater Zone	Total Results	Dioxins & Furans	Diesel Range Organics	General Inorganic Chemistry	Gasoline Range Organics	Herbicides	High Explosives	Isotopes	Metals	Pesticides & PCBs	Radio-activity	Semivolatile Organic Compounds	Volatile Organic Compounds
Alluvial	27,024	350		2,382		10	1,346		3,867	501	729	5,279	12,560
Alluvial Spring	102			37					49		16		
Intermediate	49,385	1,100	1	4,003		50	1,743	3	6,169	2,070	1,366	11,120	21,760
Intermediate Spring	8,821			787			554		1,369		351	1,440	4,320
Regional	113,686	3,250	1	9,827	1	60	4,157	24	15,263	4,482	3,181	24,480	48,960
Regional Spring	10,346			980			412		1,473	24	421	2,316	4,720
Water Supply	6,273		2	727			400		754	152	478	1,040	2,720
Total	215,637	4,700	4	18,743	1	120	8,612	27	28,944	7,229	6,542	45,675	95,040
Number of groundwater sample results omitting field parameters and field quality control blanks													
Total	155,985	3,875	3	14,330	1	110	8,316	27	26,750	5,607	6,327	38,717	49,280

Table 5-3
Total Number of Groundwater Sample Results above Screening Levels in 2010
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed in-House)

Analytical Suite	Total Results	Dioxins & Furans	Diesel Range Organics	General Inorganic Chemistry	Gasoline Range Organics	Herbicides	High Explosives	Isotopes	Metals	Pesticides & PCBs	Radio-activity	Semivolatile Organic Compounds	Volatile Organic Compounds
Number of results	153,343	3,875	3	14,330	1	110	8,316	27	26,750	5,607	6,327	38,717	49,280
Number above Screening Level	261	0	0	61	0	0	27	0	97	2	18	32	24
% above Screening Level	0.17	0.00	0.00	0.43	0.00	0.00	0.32	0.00	0.36	0.04	0.28	0.08	0.05

Table 5-4
Groundwater Analytes with Results above Screening Levels in 2010
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed In-House)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
General Inorganic Chemistry	**61**			
Chloride	6	250	mg/L	NM groundwater standard
Perchlorate	40	4	µg/L	NM Consent Order
Fluoride	2	1.6	mg/L	NM groundwater standard
Nitrate + Nitrite (as nitrogen)	9	10	mg/L	NM groundwater standard
Total Dissolved Solids	4	1,000	mg/L	NM groundwater standard
High Explosives	**27**			
RDX	27	6.11	µg/L	EPA Human Health tap water screening level
Metals	**112**			
Aluminum	5	5,000	µg/L	NM groundwater standard
Arsenic	4	10	µg/L	EPA MCL[a]
Boron	3	750	µg/L	NM groundwater standard
Barium	9	1,000	µg/L	NM groundwater standard
Beryllium	1	4	µg/L	EPA MCL
Chromium (dissolved)	24	50	µg/L	NM groundwater standard
Chromium (total)	15	100	µg/L	EPA MCL
Iron	21	1,000	µg/L	NM groundwater standard
Manganese	19	200	µg/L	NM groundwater standard
Nickel	1	200	µg/L	NM groundwater standard
Lead (total)	4	15	µg/L	EPA Drinking Water System Action Level
Antimony	6	6	µg/L	EPA MCL
Radioactivity	**18**			
Gross Alpha	4	15	pCi/L	EPA MCL
Gross Beta	4	50	pCi/L	EPA Drinking Water Screening Level
Radium-228	2	4	pCi/L	DOE 4 mrem/yr DCG[b]
Strontium-90	5	8	pCi/L	EPA MCL
Uranium	3	30	µg/L	NM groundwater standard
Pesticides/PCBs	**2**			
Aroclor-1242	1	0.5	µg/L	EPA MCL
Aroclor-1254	1	0.5	µg/L	EPA MCL
Semivolatile Organic Compounds	**32**			
Benzo(a)pyrene	4	0.2	µg/L	EPA MCL
Benzo(b)fluoranthene	3	0.29	µg/L	EPA Human Health tap water screening level
Bis(2-ethylhexyl)phthalate	6	6	µg/L	EPA MCL
Dibenz(a,h)anthracene	1	0.029	µg/L	EPA Human Health tap water screening level
Dioxane[1,4-]	15	6.7	µg/L	EPA Human Health tap water screening level
Indeno(1,2,3-cd)pyrene	2	0.29	µg/L	EPA Human Health tap water screening level
Pentachlorophenol	1	1	µg/L	EPA MCL

Table 5-4 (continued)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
Volatile Organic Compounds	**10**			
Dichloroethene[1,1-]	4	5	µg/L	NM groundwater standard
Methylene Chloride	1	5	µg/L	EPA MCL
Naphthalene	1	1.4	µg/L	EPA Human Health tap water screening level
Tetrachloroethene	1	5	µg/L	EPA MCL
Trichloroethane[1,1,1-]	3	60	µg/L	NM groundwater standard

[a] MCL = Maximum contaminant level

[b] DCG = DOE derived concentration guide

F. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables for this chapter present groundwater quality monitoring data for 2010 (on the included compact disc). 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 screens, the depth and groundwater zone sampled for each screen 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 2010. The table also gives the total propagated one standard deviation analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. A "<" symbol indicates that based on the analytical laboratory or secondary validation qualifiers the result was a nondetect. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results. In 2010, we changed analytical laboratories for low-level tritium analyses. In August 2011 investigation revealed that results from the new provider (ARSL) were subject to calculation errors. At the time of this report, these data had not been corrected.

Table S5-4 lists radionuclides detected in groundwater samples, as reported by the analytical laboratory. For most radionuclide measurements, we reported 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 a result that is greater than the measurement-specific MDA as detected. Some low-detection-limit tritium data do not have laboratory qualifiers; in that case, a result is considered as detected when analytical results are greater than three times the reported one standard deviation 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, there were analytical quality 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 received the analytical laboratory data packages, an independent contractor, Analytical Quality Associates, Inc. (AQA), performed a secondary validation on the packages. 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 with the regulatory standards or screening levels listed on the table.

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2010. Table S5-9 lists perchlorate results. We analyzed samples for perchlorate by the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method (SW-846:6850). The results of trace metal analyses appear in Table S5-10.

1. Contaminant Distribution Maps

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross Laboratory property. The accompanying maps depict the location of groundwater contaminants that are found at levels near or above screening levels or standards. The maps provide a spatial context for distribution of groundwater contamination.

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.

2. Organic Chemicals in Groundwater

In 2010, we analyzed samples from selected springs and monitoring wells for organic chemicals. Table S5-11 summarizes the 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 (DRO), and HE. Chapter 11 presents analytical chemistry quality assurance results for 2010. Table S5-12 shows organic chemicals detected during 2010 in groundwater and field QC samples.

Certain organic compounds used in analytical laboratories or derived from sampling equipment are frequently detected in laboratory blanks, that is, contamination introduced by the sampling or 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) and many others.

Bis(2-ethylhexyl)phthalate is derived from plastics including sample bottles and tubing. It has been detected repeatedly at several wells since 2005, particularly in a few wells drilled since 2008. In some cases, the compound was found at concentrations above the 6 µg/L EPA MCL. From the bis(2-ethylhexyl)phthalate concentration histories, it appears that the compound initially leaches from some material used during drilling or well construction. Concentrations generally have fallen significantly during the years following initial well sampling.

The first samples, collected in 2010, from Water Canyon intermediate well CDV-37-1(i) had bis(2-ethylhexyl)phthalate concentrations up to 13 µg/L. Remaining samples during 2010 had concentrations between 3 µg/L and 4 µg/L.

Five newly-drilled wells first sampled in late 2008 or 2009 also show high initial bis(2-ethylhexyl)phthalate detections: regional wells R-36, R-38 (Figure 5-10), R-42, and R-46, and intermediate well TA-53i.

Mortandad Canyon intermediate well MCOI-6 showed bis(2-ethylhexyl)phthalate concentrations ranging from 2.3 µg/L to 12.4 µg/L between June 2005 and August 2007. The compound was detected at concentrations just above the MDL in three samples since that time. Two other wells constructed nearby at the same time (MCOI-4 and MCOI-5) did not show such frequent bis(2-ethylhexyl)phthalate detections; one June 2006 sample in MCOI-4 contained 16.2 µg/L.

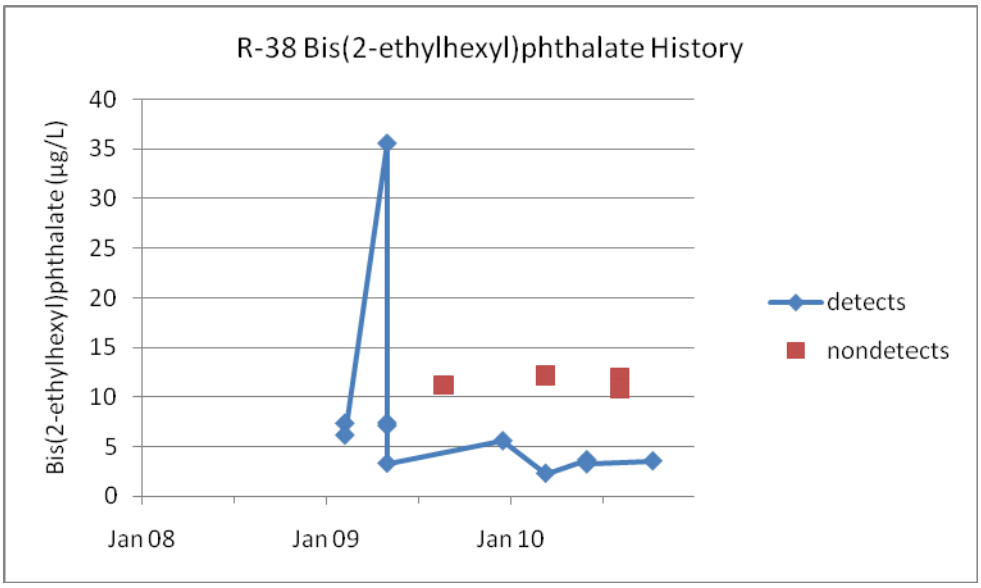

Figure 5-10 **Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-38. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. For comparison purposes, theEPA MCL is 6 µg/L.**

The detection of several other organic compounds in well samples was likely the result of analytical contamination rather than their presence in groundwater. Two Aroclor (PCB) compounds were found in a field duplicate from R-16 but not in the primary sample or any previous sample. Several polycyclic aromatic hydrocarbon compounds (such as benzo(a)pyrene) were found in samples from MCOI-6, PCI-2, R-27, R-60 and R-55. In these cases, some compounds were found in a primary sample or field duplicate sample, but not both. The compounds have generally not been detected in other samples from the wells.

3. Radioactivity in Groundwater

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at high concentrations in springs and wells throughout the Rio Grande Valley. Other radioactivity in groundwater samples comes from members of the decay chains for naturally occurring uranium-235, uranium-238 (including radium-226 and uranium-234), and thorium-232 (including radium-226). Potassium-40 is also a source of natural radioactivity.

A May 18, 2010, sample from Los Alamos County water supply well G-1A in Guaje Canyon had a gross alpha activity of 41.4 pCi/L, above the EPA drinking water screening level of 15 pCi/L (Table 5-5). A reanalysis of the sample gave 50.2 pCi/L. Results for sample events before and after were nondetections with results below 0.25 pCi/L and MDAs below 2.9 pCi/L. Other than the May 2010 result, 63 gross alpha results for this well taken since 1968 include a maximum value of 7.6 pCi/L (in 1974). The remaining results are mostly nondetections, having one or two standard deviation total propagated uncertainties greater than or equal to the result.

Table 5-5
Radioactivity Results above Screening Levels in Regional Aquifer Groundwater for 2010

Chemical	Location	Result	Trends
Gross Alpha	G-1A	41.4 pCi/L and reanalysis of 50.2 pCi/L, above EPA screening level of 15 pCi/L	Most of results since 1968 are nondetects
Radium-228	O-4	11.8 pCi/L, above EPA MCL screening level of 5 pCi/L; field duplicate was nondetect at < 0.412 pCi/L	Naturally occurring isotope, first detection of seven sample events
Radium-228	PM-5	6.58 pCi/L, above EPA MCL screening level of 5 pCi/L	Naturally occurring isotope, first detection of seven sample events

In 2008, the method for analyzing radium-228 changed from EPA:901.1 to EPA:904, with a corresponding decrease in MDA from a range of 10 to 30 pCi/L to a range of 0.3 to 1 pCi/L. This change in method sensitivity corresponds to an increased number of detections. In 2010, radium-228 was detected in water supply wells O-4 and PM-5 at respective concentrations of 11.8 pCi/L and 6.58 pCi/L, above the EPA MCL of 5 pCi/L. A result at O-4 for a field duplicate sample was nondetect at <0.412 pCi/L. Each well has been sampled six previous times since 2001 for radium-228, and all earlier results were nondetects.

Otherwise, no activity or concentration value for a radioactivity analyte in a water supply well exceeded any regulatory standard, including the 4-mrem/yr DOE DCGs applicable to drinking water.

Pine Rock Spring, which flows from intermediate groundwater on Pueblo de San Ildefonso lands, had a uranium concentration above the NM groundwater standard (Table 5-6). 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). The gross alpha result is correspondingly high, reflecting the uranium content.

The uranium result from a filtered sample in the 755-ft intermediate screen of monitoring well R-25 was also above the NM groundwater standard. A reanalysis of the result gave a value in line with the usual much lower uranium concentration. The unfiltered result for the sample was also much lower, suggesting that the filtered result was an analytical artifact.

Other radioactivity results near screening levels are shown in Table 5-6.

Table 5-6
Radioactivity Results near Screening Levels in Intermediate Groundwater for 2010

Chemical	Location	Result	Trends
Uranium	Pine Rock Spring (Pueblo de San Ildefonso)	34.6 µg/L, above NM groundwater standard of 30 µg/L	Steady over five years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields
Gross Alpha	Pine Rock Spring (Pueblo de San Ildefonso)	24.6 pCi/L, above EPA screening level of 15 pCi/L	Results since 2006 range from 20 pCi/L to 40 pCi/L; gross alpha is due to uranium content
Uranium	R-25 at 755 ft	43.7 µg/L, above NM groundwater standard of 30 µg/L; unfiltered sample result was 0.506 µg/L and reanalysis was 0.696 µg/L	Apparent analytical artifact; previous filtered results are between 0.475 µg/L and 1.43 µg/L
Tritium	MCOI-4, MCOI-5, MCOI-6 in Mortandad Canyon	3,020 to 7,000 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values decreasing slowly over six years of sampling; wells sample separate isolated perched zones

Results for strontium-90 from alluvial groundwater in Mortandad Canyon (and past results from Los Alamos Canyon, not sampled in 2010) were near or exceeded the 4-mrem/yr DOE DCG and EPA MCL screening levels (Table 5-7, Figures 5-11 and 5-12). For samples taken in 2010, strontium-90 contributed most of the dose in alluvial groundwater; other radioactive analytes contributed little. In past years, americium-241, plutonium-238, and plutonium 239/240 results in some Mortandad Canyon alluvial wells have occasionally exceeded the 4 mrem/yr DOE DCG screening levels, mainly in unfiltered samples. Note that strontium-90 has a half-life of 28.8 years.

Table 5-7
Radioactivity Results above Screening Levels in Alluvial Groundwater for 2010

Chemical	Location	Result	Trends
Strontium-90	Four wells in Mortandad Canyon	29.3 pCi/L to 61.6 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Fairly stable for 10 years due to retention on sediments
Gross Beta	Four wells in Mortandad Canyon	94 pCi/L to 136 pCi/L, above EPA drinking water screening level of 50 pCi/L	Due to strontium-90 content
Gross Alpha	CDV-16-02655	15.8 pCi/L, above EPA screening level of 15 pCi/L	Second measurement, twice the 2009 result

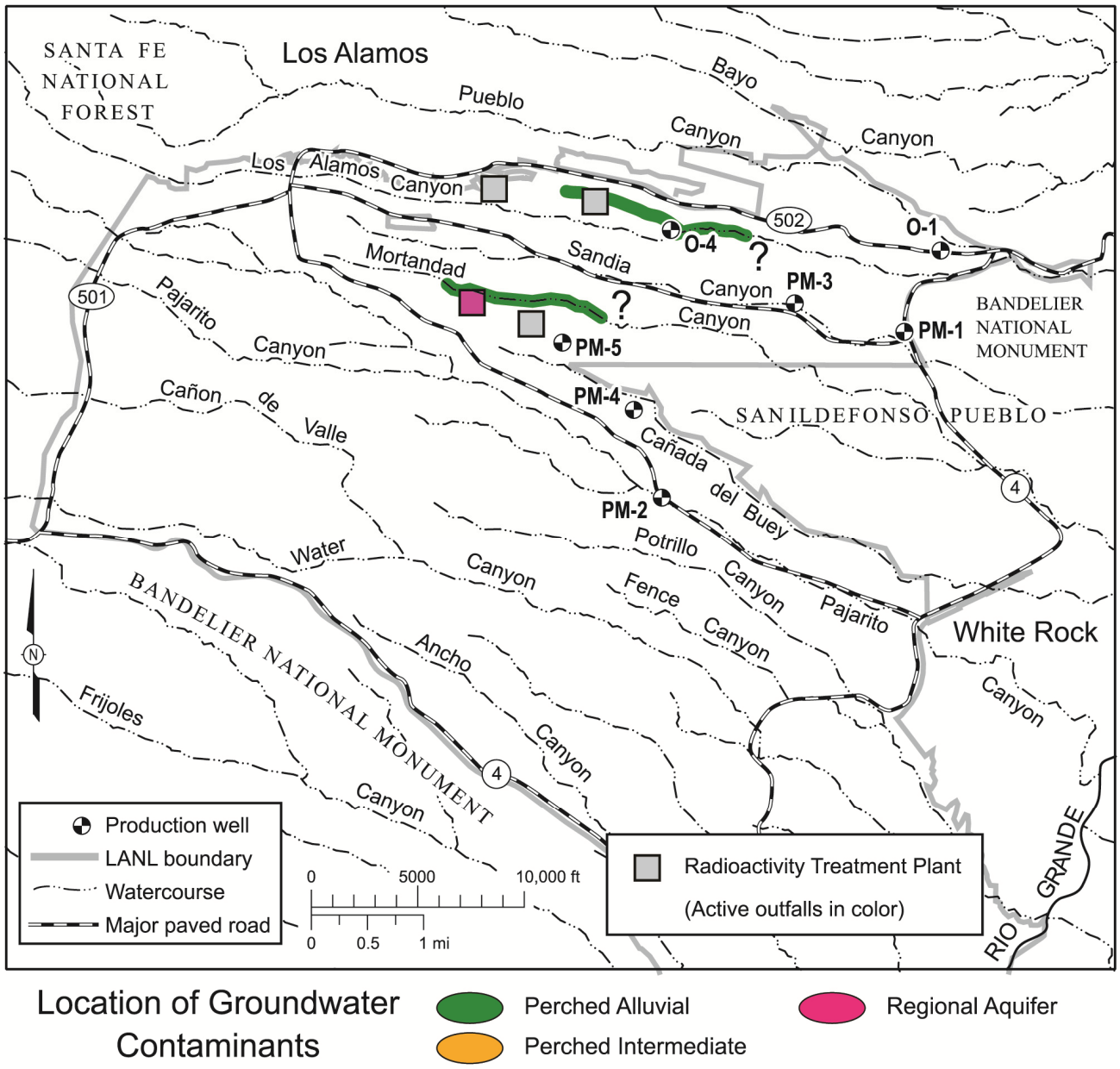

Figure 5-11 **Location of groundwater contaminated by strontium-90 above the 8-pCi/L EPA MCL screening level. (The MCL applies only to drinking water, not to alluvial groundwater.) Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage. 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.**

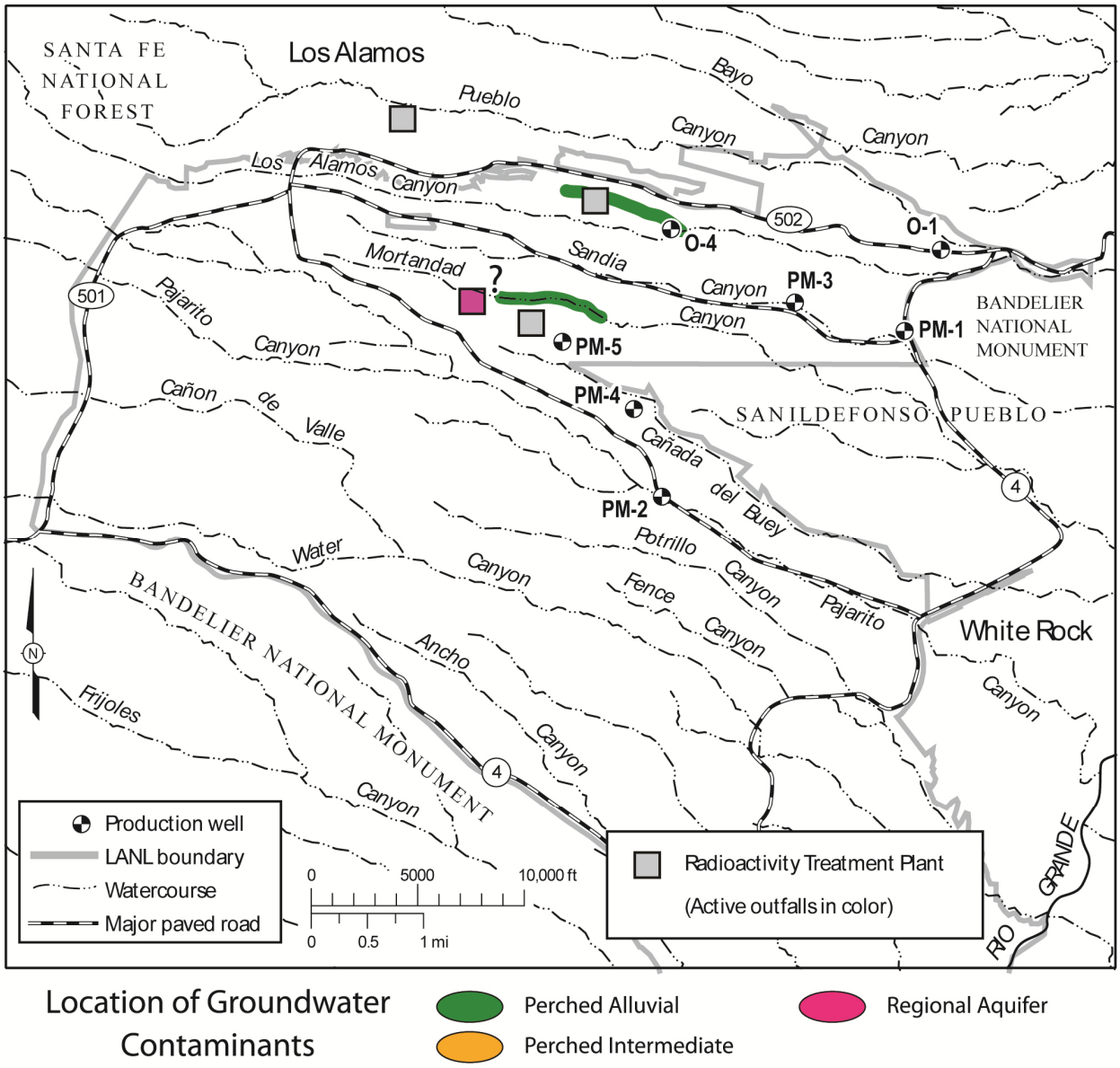

Figure 5-12 **Location of groundwater contaminated by radioactivity: areas indicated have the sum of radioactivity from a DOE source (that is, Sr-90, Pu-238, Pu-239/240, and Am-241) above the 4-mrem/yr DOE DCG screening level. (The 4-mrem/yr DOE DCG applies only to drinking water, not to alluvial groundwater.) Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

In 2010, we changed analytical laboratories for low-level tritium analyses. In August 2011 investigation revealed that results from the new provider (ARSL) were subject to calculation errors. At the time of this report, these data had not been corrected.

4. Perchlorate in Groundwater

Perchlorate is an important contaminant to monitor at LANL because it was discharged in some effluents and travels readily through groundwater. In December 2008, EPA issued an interim health advisory of 15 µg/L for perchlorate in drinking water (http://water.epa.gov/drink/contaminants/unregulated/perchlorate.cfm). The Consent Order 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. At LANL, perchlorate concentrations in groundwater samples from Pueblo, Los Alamos, and Mortandad canyons are above background as a result of past effluent discharges (Figure 5-13), above the Consent Order screening level, and in some cases, above the EPA Health Advisory. Otherwise perchlorate concentrations are near the values found by Plummer et al. (2006).

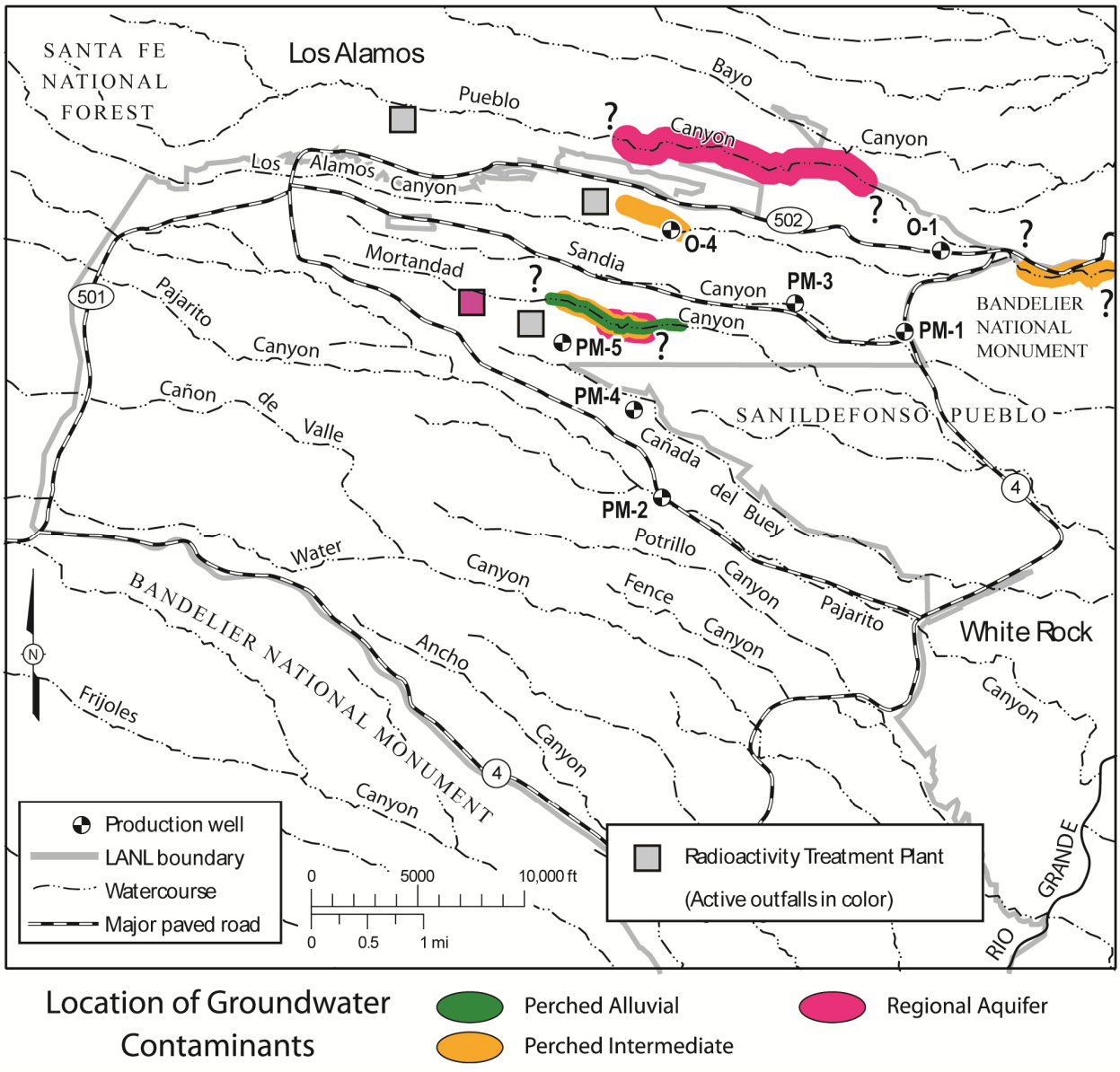

Figure 5-13 **Location of groundwater contaminated by perchlorate; the concentrations in the areas indicated are above the 4 µg/L NM Consent Order screening level. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

5. Metals in Groundwater

The presence of some metals in groundwater at concentrations near or above screening levels may be due to natural occurrence or to well sampling and well construction issues, rather than LANL releases.

In some LANL characterization wells the use of fluids to assist well drilling affected the chemistry of groundwater samples. From 1998 through 2006, more than 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. The potential for residual drilling fluids and additives to mask detection of certain contaminants led to concern about the reliability or representativeness of the groundwater quality data obtained from some wells, as described in the "Well Screen Analysis Report, Rev. 2" (LANL 2007).

Addition of the organic matter in drilling fluids into the aquifer near a well stimulates bacterial activity, consuming available oxygen and changing 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. Wells drilled since 2007 have been drilled without the use of drilling fluids other than water in the saturated zone. There have been minor exceptions of using foam approximately 100 ft above the water table. These wells also undergo extensive well development at the outset to remove drilling fluids and reduce the turbidity of water samples.

In addition to the effect of drilling fluids, well samples may have relatively high turbidity or natural colloid content. The presence of residual aquifer or soil material in groundwater samples 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. The effects of turbidity on water quality are also seen in many samples from alluvial wells and springs. This occurs in the case of springs because samples may incorporate surrounding soil material.

G. GROUNDWATER SAMPLING RESULTS BY WATERSHED

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross Laboratory property. The tables and discussions are grouped according to groundwater mode, proceeding from the regional aquifer to the alluvial groundwater. Contamination found in the regional aquifer results from effluents released in past decades because of the time required for percolation to that depth. Contaminants found in alluvial groundwater reflect contamination that occurred during the past few years, except for adsorbed or reactive contaminants such as barium or strontium-90.

The accompanying tables and text mainly address contaminants found at levels near or above standards or screening levels. In the case of the regional aquifer, information regarding contaminants (such as nitrate, perchlorate, and tritium) found at lower concentrations but possibly indicating effects by LANL activities is included. The discussion addresses radioactivity, general inorganic compounds (major anions, cations, and nutrients), metals, and then organic compounds for each groundwater zone. The accompanying plots and maps give a temporal and spatial context for most of the contaminants found near or above screening levels.

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 5-8). The Guaje well field, located northeast of the Laboratory, contains five drinking water supply wells. Naturally occurring arsenic has generally been found in this well field at levels above the EPA MCL of 10 µg/L since the field was developed in the early 1950s (Table 5-9). In 2010, two arsenic sample results were above the 5 µg/L practical quantitation limit (PQL). One gross alpha result in G-1A was unusually high. An alluvial spring in Upper Guaje Canyon, Campsite Spring, shows background water quality.

The tributary Rendija and Barrancas Canyons have seen, respectively, little and no past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

Table 5-8
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 non-effluent sources	None, alluvial groundwater only in upper Guaje Canyon	No intermediate groundwater	Natural arsenic above EPA MCL

Table 5-9
Groundwater Quality in Guaje Canyon
(includes Rendija and Barrancas Canyons)

Chemical	Location	Result	Trends
Gross Alpha	G-1A	41.4 pCi/L and reanalysis of 50.2 pCi/L, above EPA screening level of 15 pCi/L	Most of results since 1968 are nondetects
Arsenic	Regional aquifer water supply wells	Two highest results of 5.9 µg/L and 7.2 µg/L, below EPA MCL of 10 µg/L; NM groundwater standard is 100 µg/L	Sporadic values above EPA MCL for many years in this well field

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 5-10).

Table 5-10
Summary of Groundwater Contamination in Los Alamos Canyon
(includes Bayo, Acid, Pueblo, and DP Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		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	Not sampled in 2010	Not sampled in 2010 except for one new well	Many wells not sampled in 2010, trace perchlorate, tritium, and nitrate
Los Alamos and DP Canyons	Multiple past effluent discharges	Not sampled in 2010	Perchlorate above Consent Order screening level, tritium up to 17% of EPA MCL screening level, fluoride at 56% of NM groundwater standard and dioxane[1,4-] at 54% of EPA tap water screening level	Ra-228 above EPA MCL screening level in O-4
Lower Los Alamos Canyon	Multiple past effluent discharges	None	Perchlorate at 57% of Consent Order screening level, fluoride at 52% of NM groundwater standard	None

Pueblo Canyon receives effluent from the new Los Alamos County Wastewater Treatment Plant. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity is found in current groundwater samples. Perchlorate results from one regional aquifer monitoring well in this canyon are above the Consent Order screening level, and tritium, nitrate, and fluoride concentrations in some wells are elevated but are below standards. These findings may indicate a lingering influence on the regional aquifer of past discharges from radioactive wastewater discharges in Acid Canyon. In the case of nitrate in regional aquifer wells, the source may also be from past sanitary effluent discharges in the upper part of the canyon. In recent years, the high nitrate (as well as total dissolved solids [TDS] and boron) concentrations found in alluvial and intermediate groundwater in lower Pueblo Canyon and downstream in lower Los Alamos Canyon may be due to sanitary effluent from the former 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 in recent decades.

No alluvial wells in Pueblo Canyon or Upper Los Alamos Canyon were sampled in 2010. A number of intermediate and regional wells in Pueblo Canyon also were not sampled. These wells will be sampled during 2011.

a. Pueblo Canyon

The levels of tritium, perchlorate (Figure 5-14), and nitrate at supply well O-1, though below standards or screening levels, indicate the presence of past effluent and surface water recharge in the regional aquifer (Table 5-11). Los Alamos County does not use the well for water supply, although the concentrations are below the 4 µg/L Consent Order screening level and the 15 µg/L EPA interim health advisory for perchlorate in drinking water.

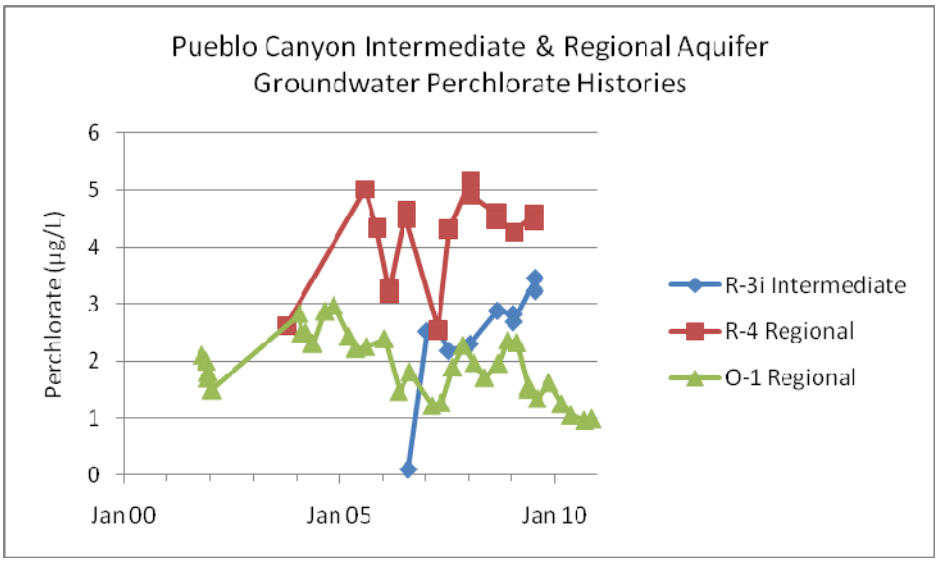

Figure 5-14 **Perchlorate in Pueblo Canyon intermediate and regional aquifer groundwater. The Consent Order screening level is 4 µg/L.**

Table 5-11
Groundwater Quality in Pueblo Canyon (includes Acid Canyon)

Chemical	Location	Result	Trends
Tritium	Water supply well O-1	3.6 pCi/L, below EPA MCL of 20,000 pCi/L	New analytical provider; results are variable between 14 pCi/L and 58 pCi/L since 2000; have declined since 2004
Perchlorate	Water supply well O-1	0.96 µg/L to 1.25 µg/L, below Consent Order screening level of 4 µg/L	Variable between 1.2 µg/L and 3 µg/L since 2001; values have declined since 2008

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, has shown perchlorate or low-detection-limit tritium values indicative of past discharges. Perchlorate concentrations in R-4 have been above the Consent Order screening level of 4 µg/L (Figures 5-13 and 5-14). The tritium values range up to 60 pCi/L. Two regional aquifer wells (R-4 and R-5) have shown fluoride values higher than those in unaffected wells, but the results were below the NM groundwater standard.

Intermediate groundwater samples have also shown the effects of past effluent releases, with concentrations near standards of perchlorate, fluoride, and nitrate (Figures 5-14 through 5-16). The nitrate concentration in intermediate well POI-4 has nearly doubled over 14 years of sampling (Figure 5-17). Intermediate locations R-3i and Basalt Spring show nitrate concentrations and patterns similar to POI-4. An intermediate screen in regional aquifer well R-5 shows fluoride values higher than that in unaffected wells, but the results are below the NM groundwater standard. The 2009 uranium concentrations in samples from Pueblo Canyon intermediate well R-3i ranged from 9.2 µg/L to 9.7 µg/L, above levels in unaffected wells but below the standard. The higher uranium may result from dissolution of uranium from surrounding bedrock by sanitary effluent (Teerlink 2007).

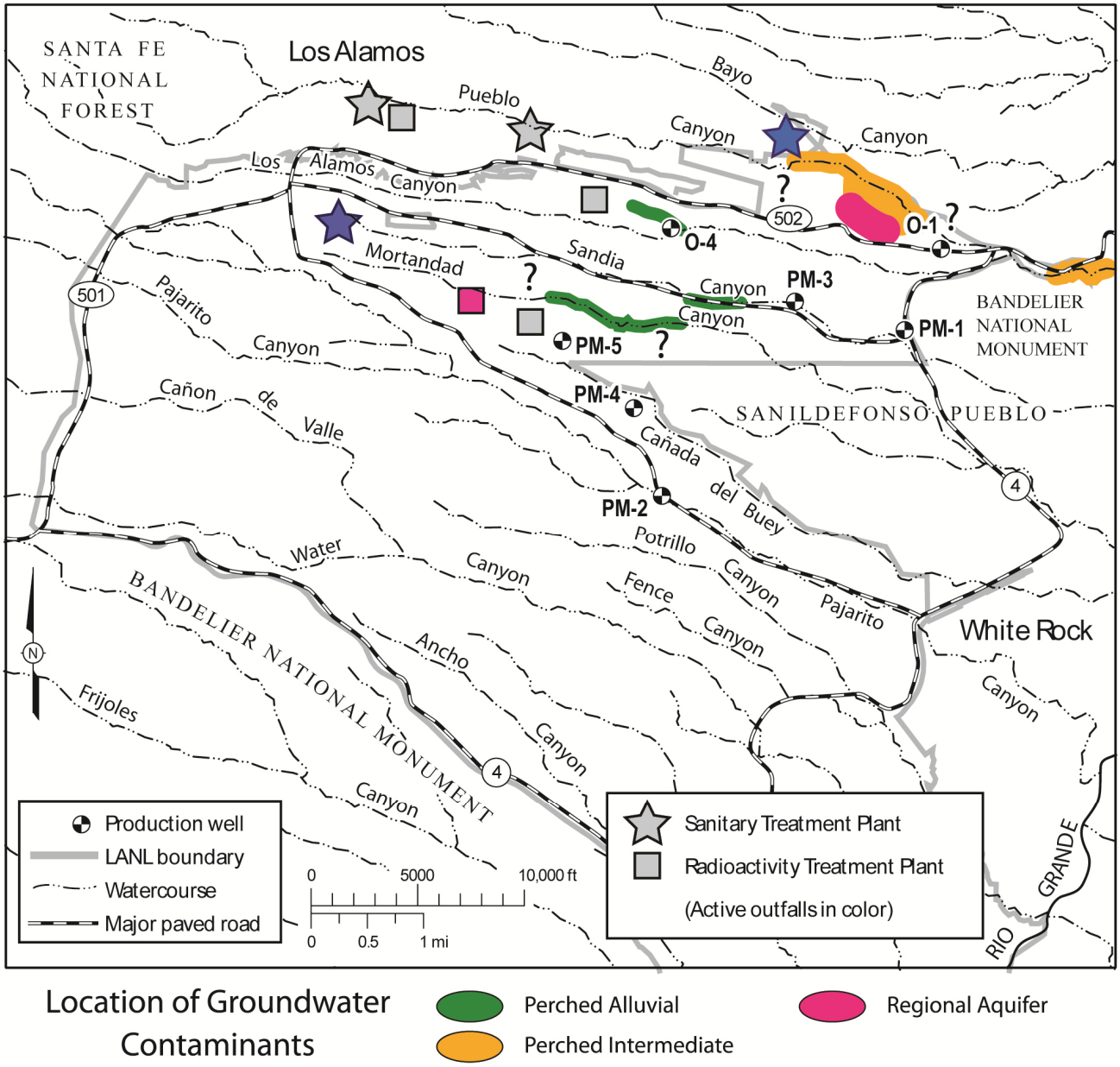

Figure 5-15 **Location of groundwater containing fluoride above one half of the 1.6-mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

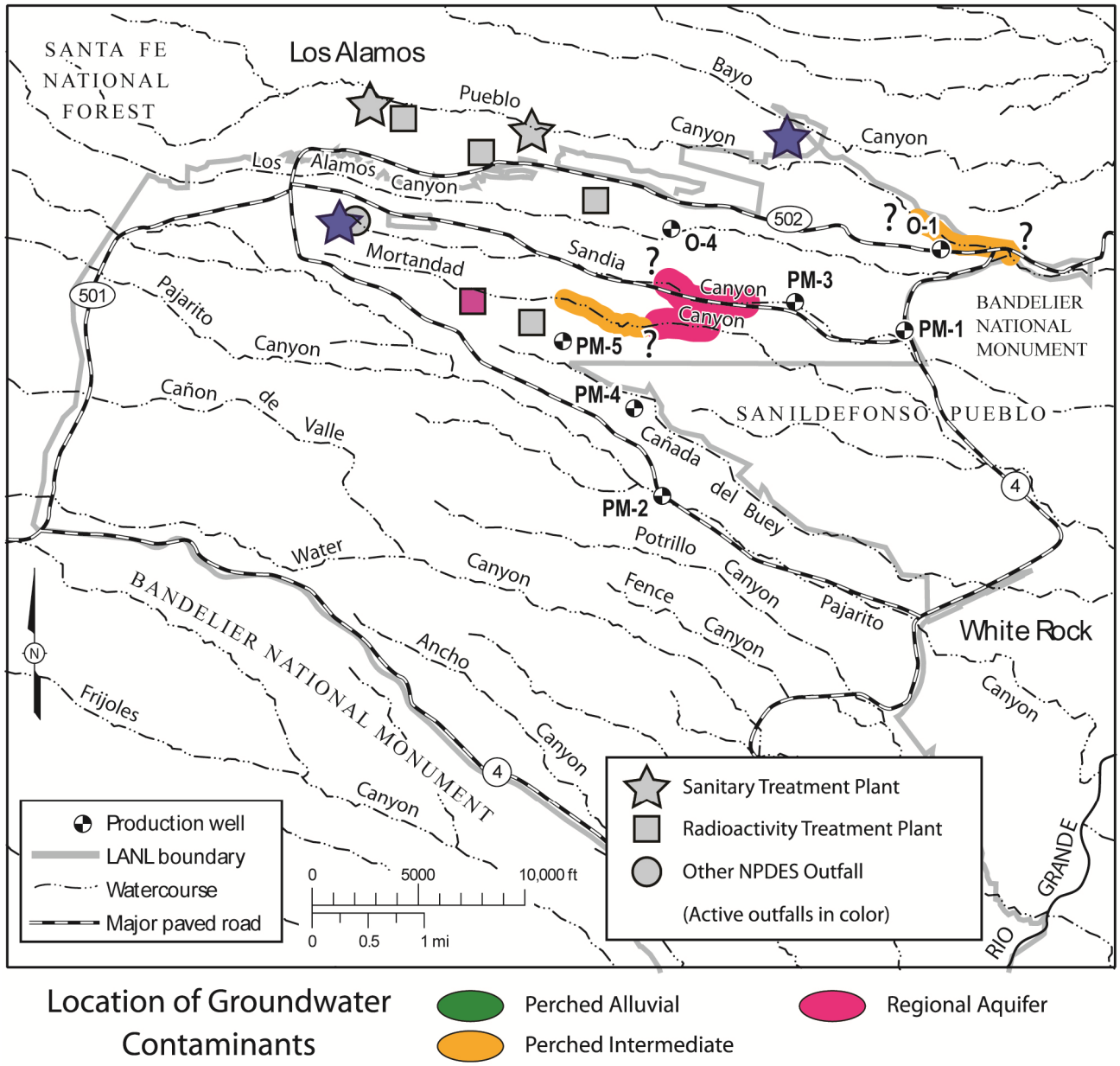

Figure 5-16 **Location of groundwater containing nitrate (as nitrogen) above one half of the 10 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

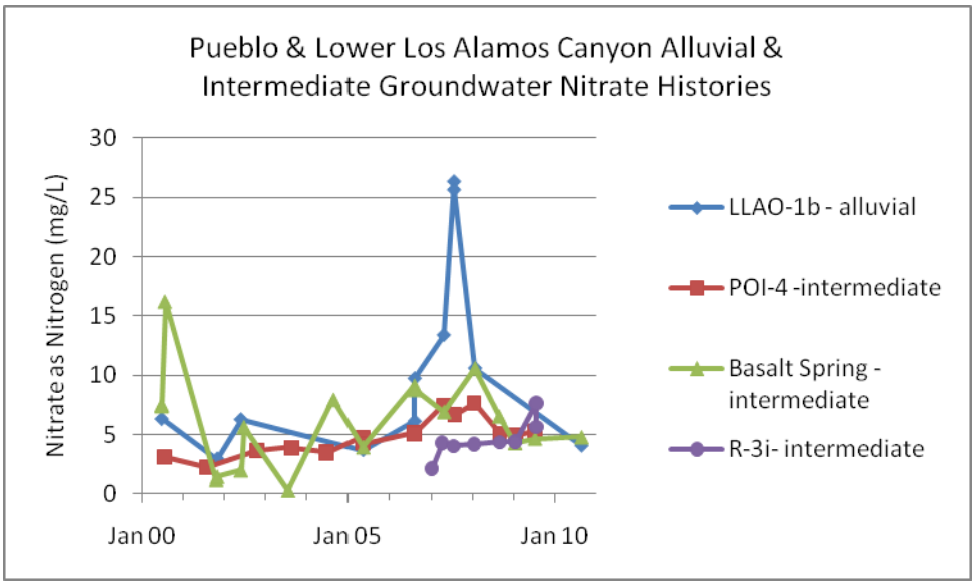

Figure 5-17 **Nitrate (as nitrogen) in Pueblo Canyon and lower Los Alamos Canyon alluvial and intermediate groundwater. The NM groundwater standard is 10 mg/L. Many of the values, including the 2007 higher results in LLAO-1b, are estimated due to analytical quality issues.**

Beginning in 2006, several alluvial wells in Pueblo Canyon have shown unusually high unfiltered plutonium-239/240 results near or above the 4-mrem/yr DOE DCG screening level of 1.2 pCi/L. In general, these results corresponded to unusually high sample turbidity. The first high values appeared to be caused by flooding in August 2006 that submerged the wells. In 2009, the highest plutonium-239/240 activity was in PAO-4, at 0.84 pCi/L. These wells were not sampled in 2010.

Prior to 2007, samples at many surface water and alluvial groundwater locations were often taken annually. Beginning in 2007, more frequent samples from Pueblo Canyon locations showed higher chloride concentrations in mid-winter and early spring. Along with similar sodium and TDS concentrations trends, this suggests an impact on water quality by runoff from road salting (Figure 5-18). High chloride concentrations in 2007 and 2008 were up to 280 mg/L in surface water and 135 mg/L in groundwater. Locations that previously showed highest winter chloride concentrations were not sampled in early 2009 or in 2010.

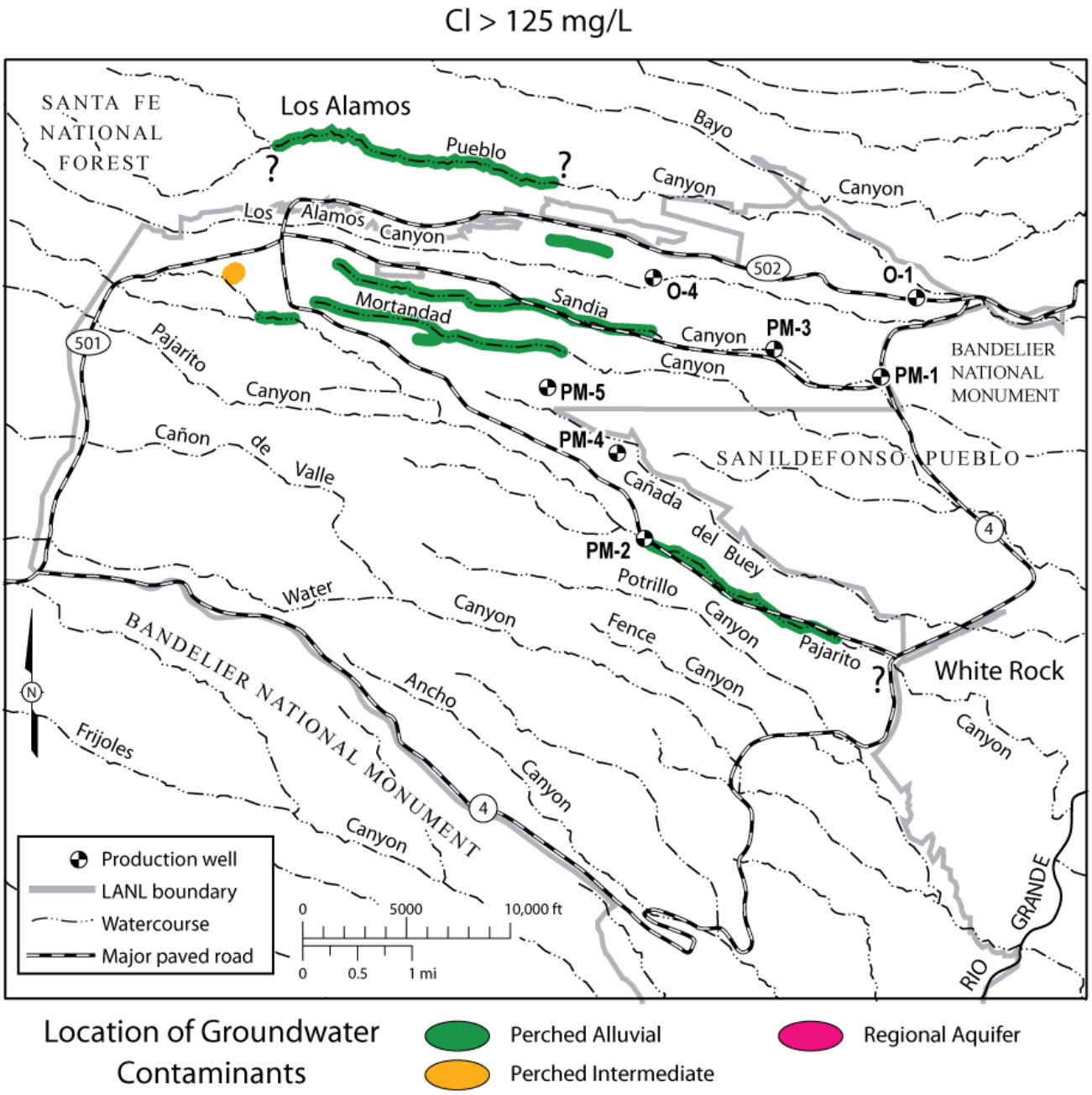

Figure 5-18 **Location of groundwater containing chloride above one half of the 250 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

b. Los Alamos Canyon

Alluvial and intermediate groundwater in Los Alamos Canyon show effects of past effluent releases (Table 5-12).

Table 5-12
Groundwater Quality in Los Alamos Canyon (includes DP Canyon)

Chemical	Location	Result	Trends
Radium-228	O-4	11.8 pCi/L, above EPA MCL screening level of 5 pCi/L; field duplicate was nondetect at < 0.412 pCi/L	Naturally occurring isotope, first detection of seven sample events
Tritium	Five intermediate wells	435 pCi/L to 3,490 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Highest activities in R-6i, decreasing in LAOI-3.2 and LAOI-3.2a
Nitrate (as N)	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a	1.8 mg/L to 3.9 mg/L, below NM groundwater standard of 10 mg/L	Highest in R-6i, decreasing in other wells
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, R-9i	2.1 µg/L to 6.7 µg/L, above Consent Order screening level of 4 µg/L	Highest in R-6i, lowest but steady for two years in R-9i, decreasing in other wells
Dioxane[1,4-]	Intermediate well R-6i	2.6 µg/L to 3.6 µg/L, below EPA Human Health tap water screening level of 6.7 µg/L	Detected in nearly every sample event since 2006, all values just above 2 µg/L MDL and estimated
Bis(2-ethylhexyl)phthalate	Intermediate well TA-53i	2.4 µg/L to 2.9 µg/L, below EPA MCL screening level of 6 µg/L	Steady decline since first sample in May 2009
Nitrate (as N)	Intermediate Basalt and Los Alamos Springs (Pueblo de San Ildefonso)	2.8 mg/L to 4.8 mg/L, below NM groundwater standard of 10 mg/L	Apparent result of discharge from Bayo Sanitary Treatment Plant, above standard in past years
Perchlorate	Intermediate Basalt Spring (Pueblo de San Ildefonso)	2.3 µg/L, below Consent Order screening level of 4 µg/L	At times above 4 µg/L since August 2008; about 1 µg/L for prior four years
Fluoride	Intermediate Los Alamos Spring (Pueblo de San Ildefonso)	0.85 mg/L, below NM groundwater standard of 1.6 mg/L	Similar levels since 1961

Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 3,490 pCi/L of tritium (Figure 5-19). These moderate values indicate a residual impact of past effluent discharges; the wells lie downstream from the former radioactive liquid waste discharge from TA-21 in DP Canyon. Nitrate (as nitrogen) concentrations in these wells have fluctuated over the period of sampling but are below the 10 mg/L NM groundwater standard. The perchlorate concentrations in these wells ranged up to 6.7 µg/L, above the Consent Order screening level of 4 µg/L (Figure 5-13, Figure 5-20).

The perchlorate concentration in the deeper intermediate screen at R-9i since late 2008 has been between 2.0 µg/L and 2.4 µg/L (Figure 5-21). At Basalt Spring, fed by intermediate groundwater in lower Los Alamos Canyon on Pueblo de San Ildefonso land, perchlorate concentrations since late 2008 have been near or above the Consent Order screening level of 4 µg/L but declined in 2010.

In 2006, we measured and detected dioxane[1,4-] for the first time in intermediate well R-6i. The compound has been detected in nearly every sample event (Figures 5-22 and 5-23). The dioxane[1,4-] EPA Human Health tap water screening level is 6.7 µg/L. In November 2010, the screening level was revised from a previous value of 61 µg/L.

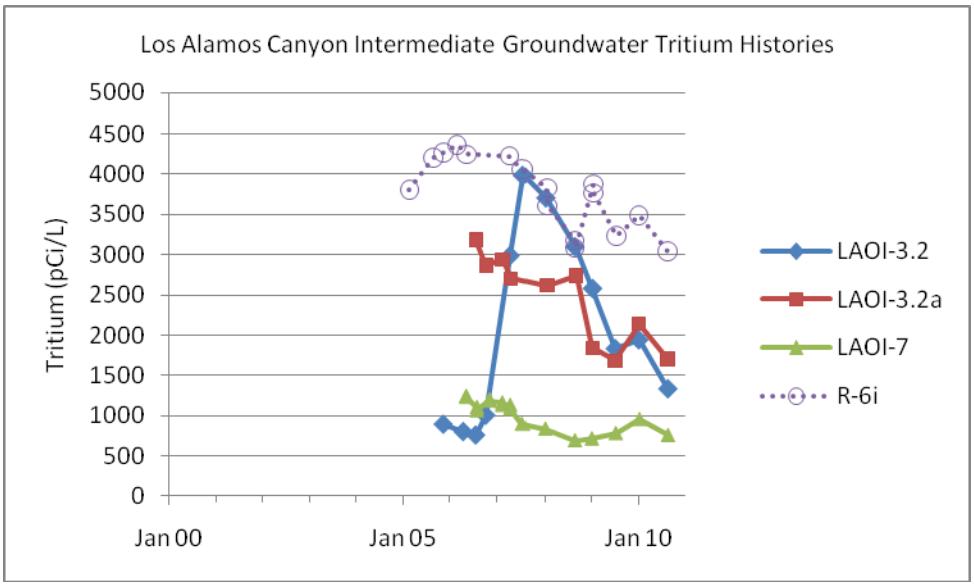

Figure 5-19 **Tritium in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level is 20,000 pCi/L.**

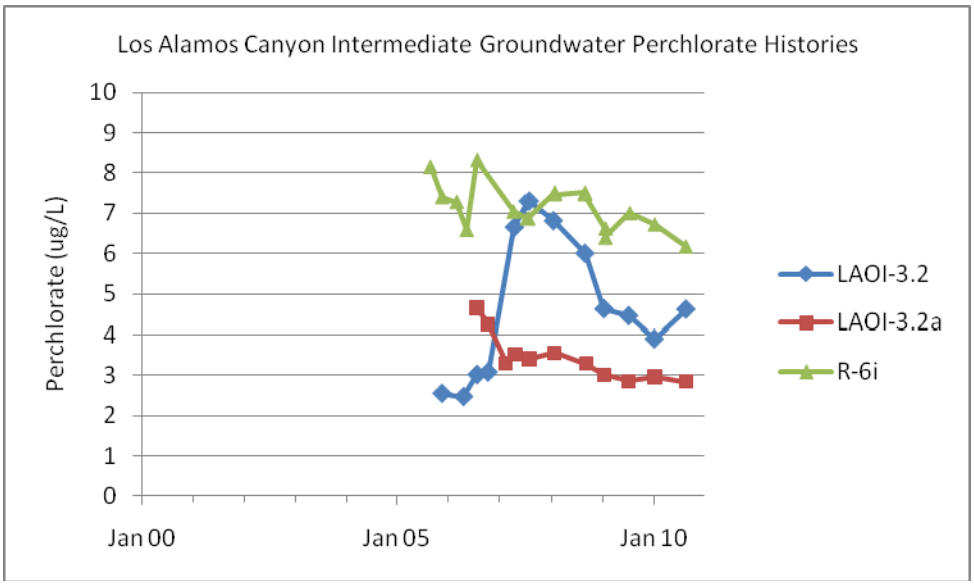

Figure 5-20 **Perchlorate in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

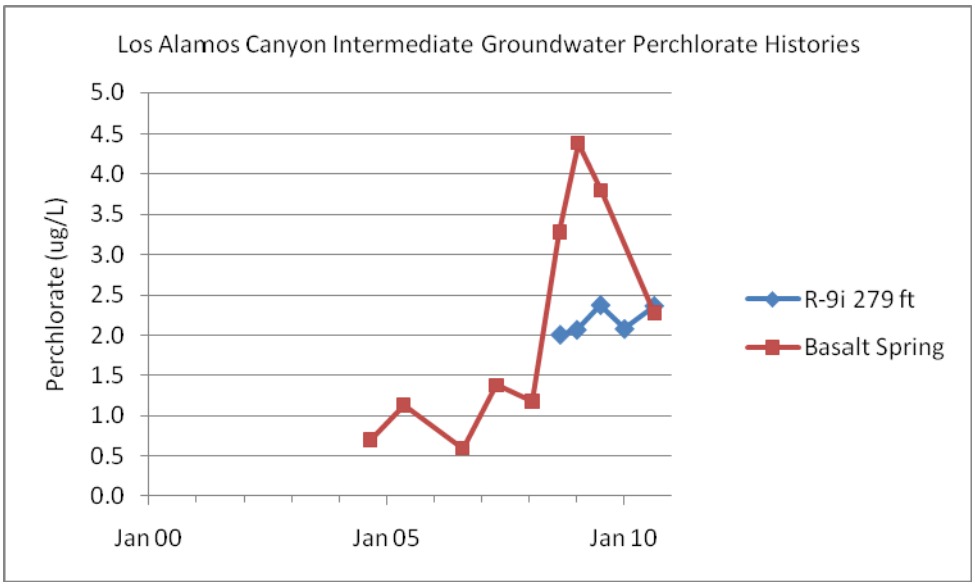

Figure 5-21 **Perchlorate in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

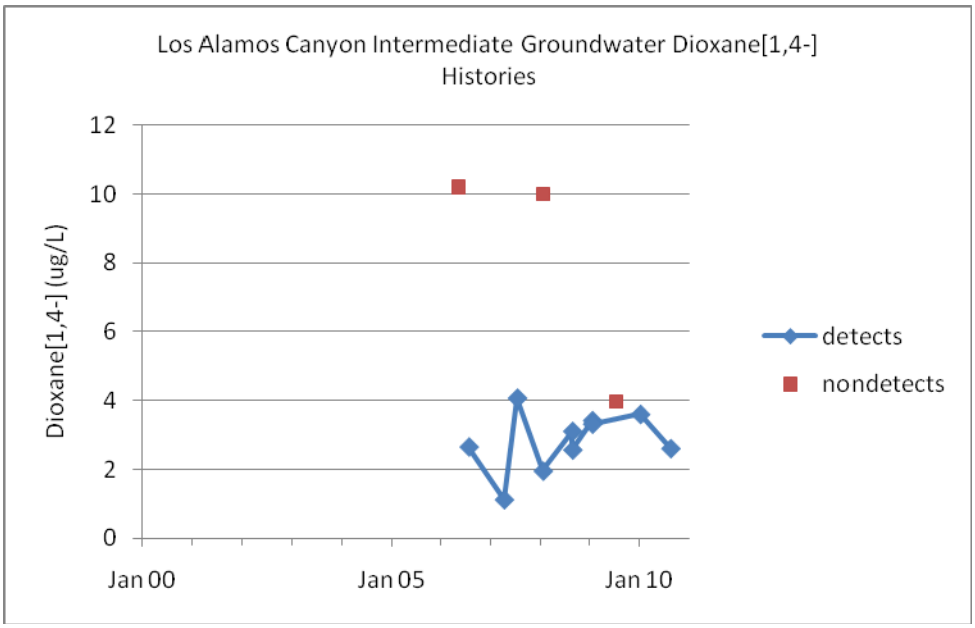

Figure 5-22 **Dioxane[1,4-] in Los Alamos Canyon intermediate groundwater at R-6i. For comparison purposes ; the EPA Human Health tap water screening level is 6.7 µg/L. All of the detected results are estimated; nondetects (ND) are indicated separately, generally at the 10 µg/L PQL.**

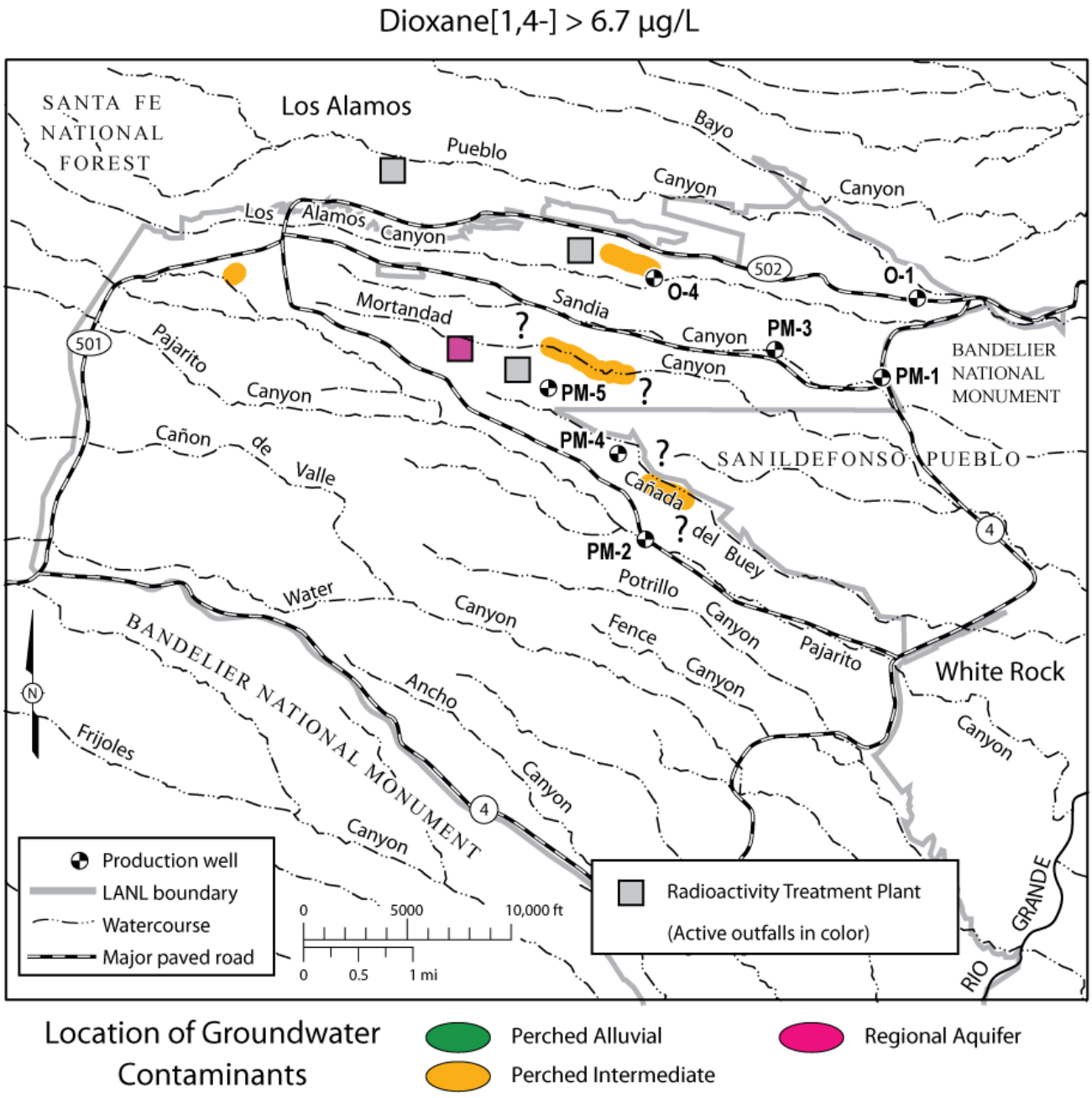

Figure 5-23 Location of groundwater containing dioxane[1,4-] above one half of the 6.7 µg/L EPA Human Health tap water screening level. Different colors indicate the affected groundwater zones.

Los Alamos Spring is near Basalt Spring on Pueblo de San Ildefonso land; both are fed by intermediate groundwater. One 2008 nitrate (as nitrogen) result from Basalt Spring was above the NM groundwater standard of 10 mg/L. For 2009 and 2010, the nitrate (as nitrogen) concentrations at the two springs ranged from 2.8 mg/L to 4.8 mg/L. The source of nitrate may be releases into Pueblo Canyon from the present and former Los Alamos County sanitary treatment plants.

Alluvial groundwater in DP and Los Alamos Canyons continues to show high activities of strontium-90; the values range up to and above the 8 pCi/L EPA MCL screening level (Figures 5-11 and 5-24). These locations were not sampled in 2010. Results from filtered and unfiltered samples from the same date are usually similar so both are shown in Figure 5-24. Fluoride is also present in samples as a result of past effluent release but at concentrations below the NM groundwater standard of 1.6 mg/L. In 2009, fluoride

concentrations in four alluvial wells and a spring in DP and Los Alamos Canyons ranged from 0.53 mg/L to 0.76 mg/L.

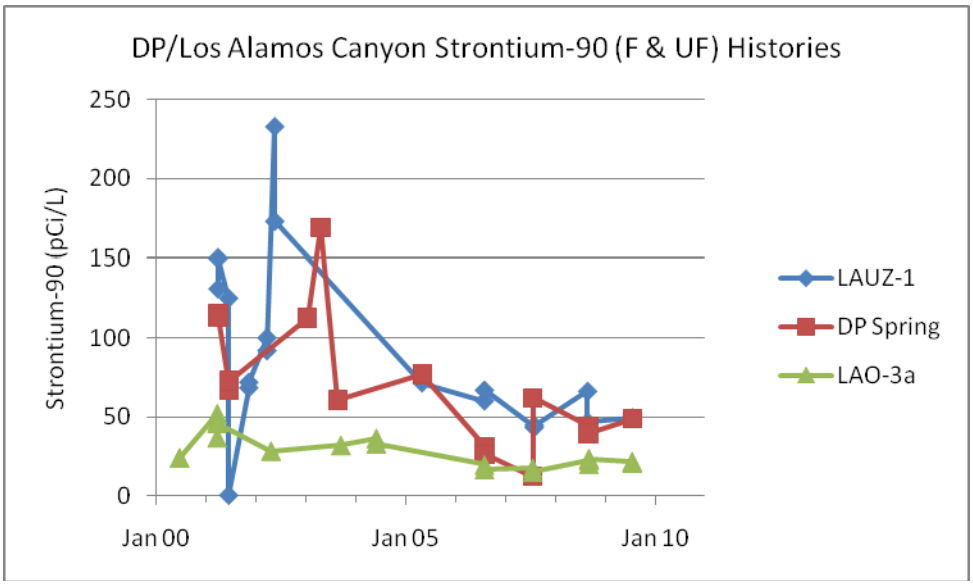

Figure 5-24 **Strontium-90 in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results. For comparison purposes, the EPA MCL screening level is 8 pCi/L.**

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, including sanitary effluent, releases from the steam plant, and cooling tower discharges from computing facilities and the TA-3 power plant (Table 5-13). Treated sanitary effluent from the TA-46 SWWS Plant has been routed to Sandia Canyon since 1992. Chromate was used to treat cooling water at the power plant until 1972 (ESP 1973). These earlier discharges are identified as the source for hexavalent chromium concentrations discovered in intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons that are above the 50 µg/L NM groundwater standard (Figure 5-25). This standard applies to dissolved chromium (regardless of the chemical form). Sandia and Mortandad Canyons lie close together, and water percolating downward beneath Sandia Canyon may have been diverted to the south by southwesterly dipping strata prior to reaching the regional aquifer (ERSP 2006, LANL 2008a).

Table 5-13
Summary of Groundwater Contamination in Sandia Canyon

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Sandia Canyon	Multiple liquid discharges	Chloride above and TDS at 80% of NM groundwater standard; total chromium at 98% of EPA MCL screening level	Chromium 12 times above NM groundwater standard	Chromium at 45% and nitrate at 57% of NM groundwater standard; and bis(2-ethylhexyl)phthalate above EPA MCL screening level

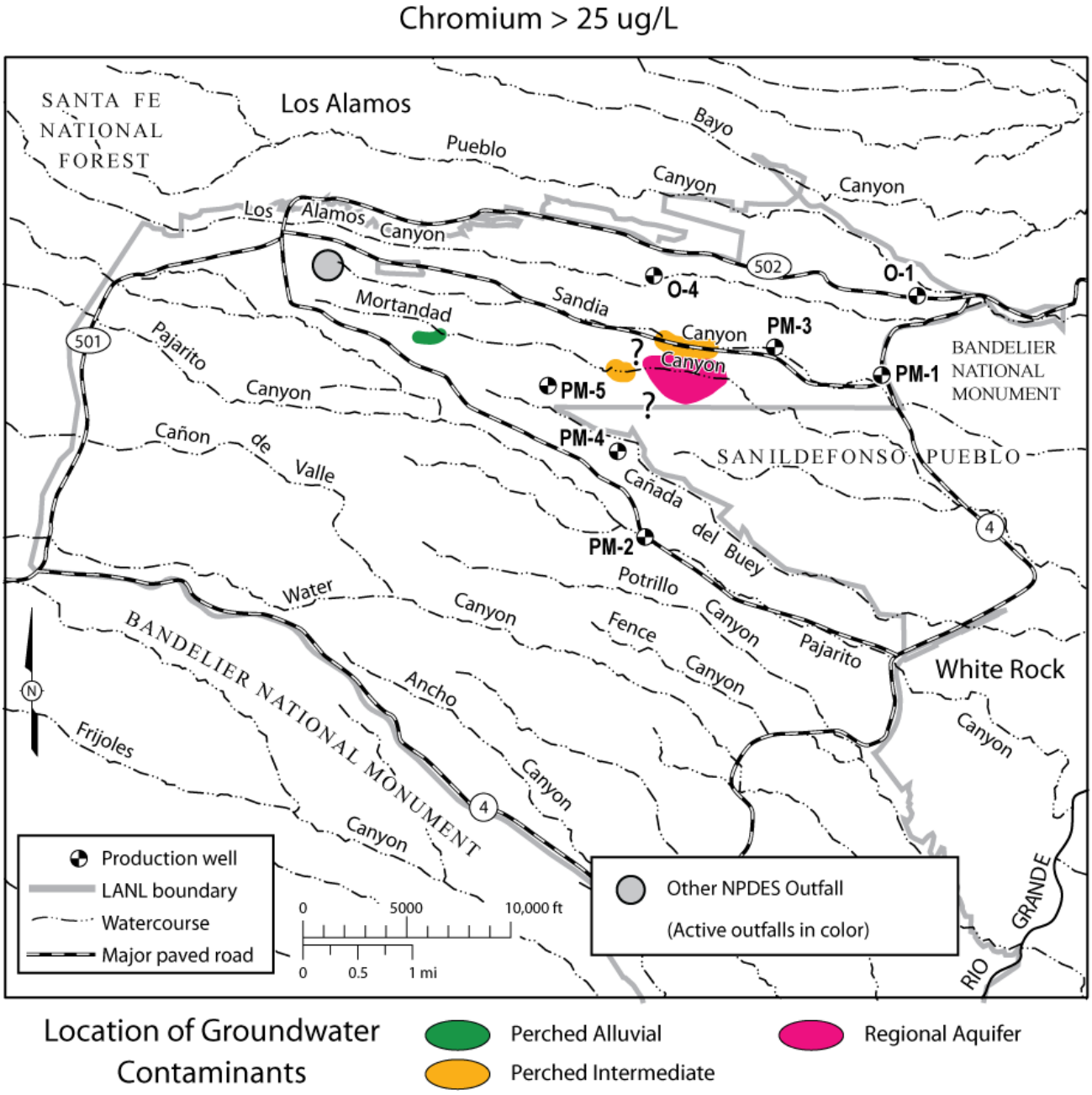

Figure 5-25 **Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard. Different colors indicate the affected groundwater zones.**

In 2010, chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon were up to 22.7 µg/L or 45% of the groundwater standard (Table 5-14, Figure 5-26); other analyses show the chromium is in the hexavalent form. Nitrate (as nitrogen) in R-11 and regional aquifer well R-43 were up to 61% of the NM groundwater standard, due to past Laboratory sanitary effluent releases (Figure 5-16, Figure 5-28).

Intermediate well SCI-2 had chromium at concentrations up to 12 times the NM groundwater standard (Table 5-14, Figure 5-27). The nitrate concentration in this well was 44% of the NM groundwater standard (Figure 5-16, Figure 5-28).

Table 5-14
Groundwater Quality in Sandia Canyon

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring well R-11	15 µg/L to 23 µg/L, below NM groundwater standard of 50 µg/L	Rose to 35 µg/L over four years of sampling, now decreasing
Nitrate (as N)	Regional aquifer monitoring wells R-11, R-43	4.3 mg/L to 5.7 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over four years of sampling, recent range is 4 mg/L to 6 mg/L
Bis(2-ethylhexyl)phthalate	Regional aquifer monitoring well R-36	6.4 µg/L, above EPA MCL screening level of 6 µg/L	Steady decline with one detection in 2010
Chromium	Intermediate well SCI-2	512 µg/L to 615 µg/L, above NM groundwater standard of 50 µg/L	Some fluctuation over two years of sampling
Nitrate (as N)	Intermediate well SCI-2	4.4 mg/L to 4.8 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over one year of sampling, recent range is mainly 4 mg/L to 5 mg/L
Chloride	Alluvial wells SCA-1-DP and SCA-2	66 mg/L to 263 mg/L, above NM groundwater standard of 250 mg/L	Variable results over four years, high in winter/spring and low in summer/fall
TDS	Alluvial well SCA-1-DP	419 mg/L to 798 mg/L, below NM groundwater standard of 1,000 mg/L	Somewhat steady for four years, though higher in winter/spring
Perchlorate	Alluvial well SCA-4	1.7 µg/L, below Consent Order screening level of 4 µg/L	Highest result for well, most below 0.44 µg/L for four years
Total Chromium	Alluvial well SCA-1-DP	Unfiltered concentrations of 8.5 µg/L to 98 µg/L, below EPA MCL screening level of 100 µg/L	Highest results for well

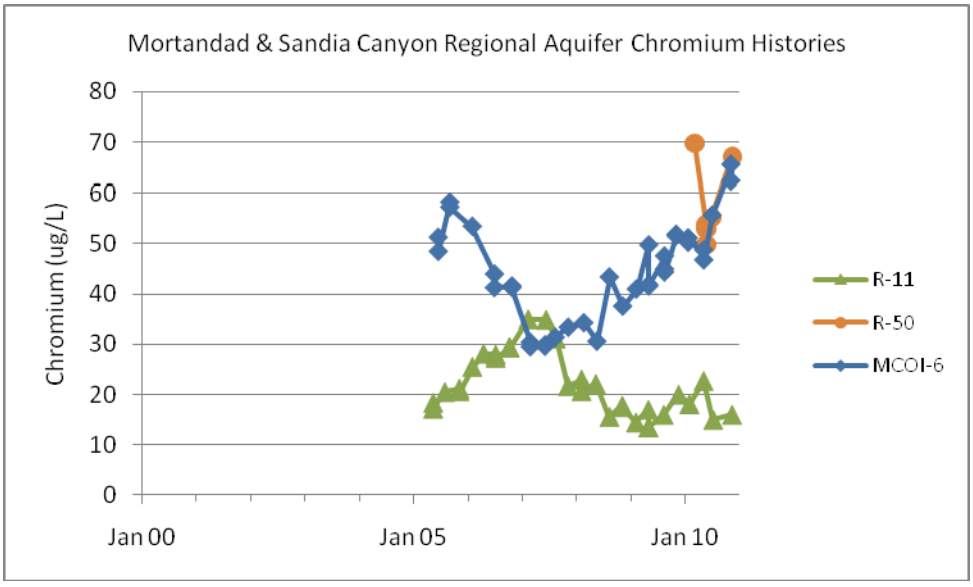

Figure 5-26 **Filtered chromium in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.**

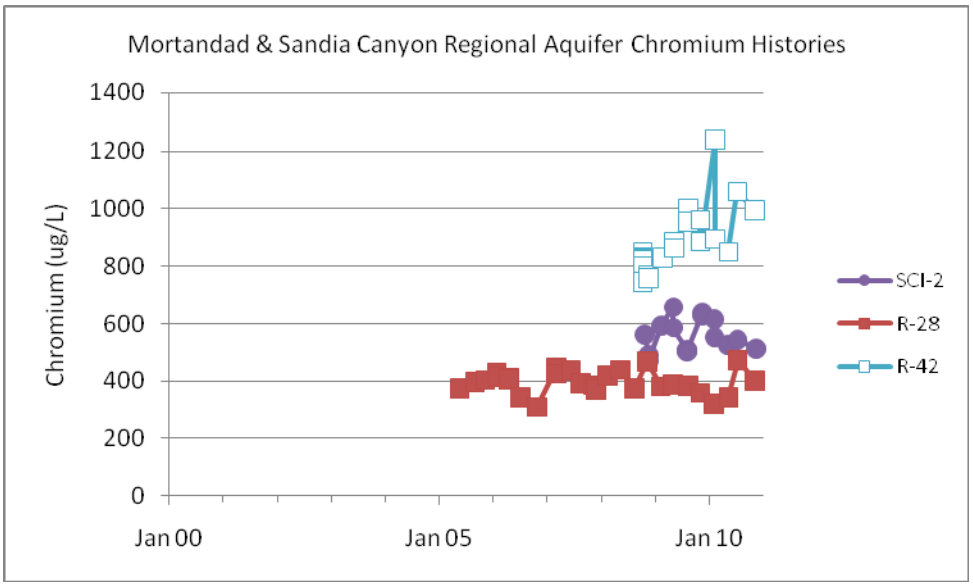

Figure 5-27 **Filtered chromium in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.**

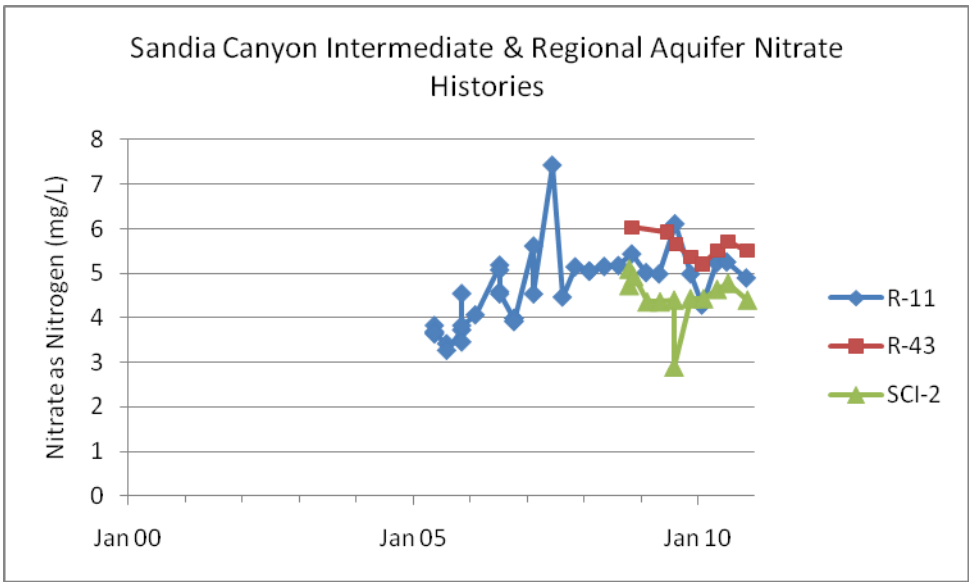

Figure 5-28 **Nitrate (as nitrogen) in Sandia Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Many of the results in 2007 and 2008 were estimated due to analytical quality issues.**

Perchlorate concentrations in Sandia Canyon surface water and alluvial groundwater samples since 2007 show an annual cycle (Figures 5-29 and 5-30). The locations of surface water monitoring stations are shown in Chapter 6. At the surface water location named Sandia right fork at Power Plant, the perchlorate concentration on February 1, 2010 was 5.8 µg/L, above the 4 µg/L Consent Order screening level. At two surface water locations farther downstream, unusually high concentrations of perchlorate were seen in late 2009 and early 2010. The concentration on November 3, 2009, in alluvial well SCA-2 reached 2.7 µg/L, or 67% of the screening level. The perchlorate concentration was 5.2 µg/L on November 23, 2009, in a sample taken from the Power Plant outfall (EPA NPDES outfall 1) by the NMED Oversight Bureau. This suggests

that variation in downstream surface and groundwater concentrations is caused by effluent perchlorate concentration variation.

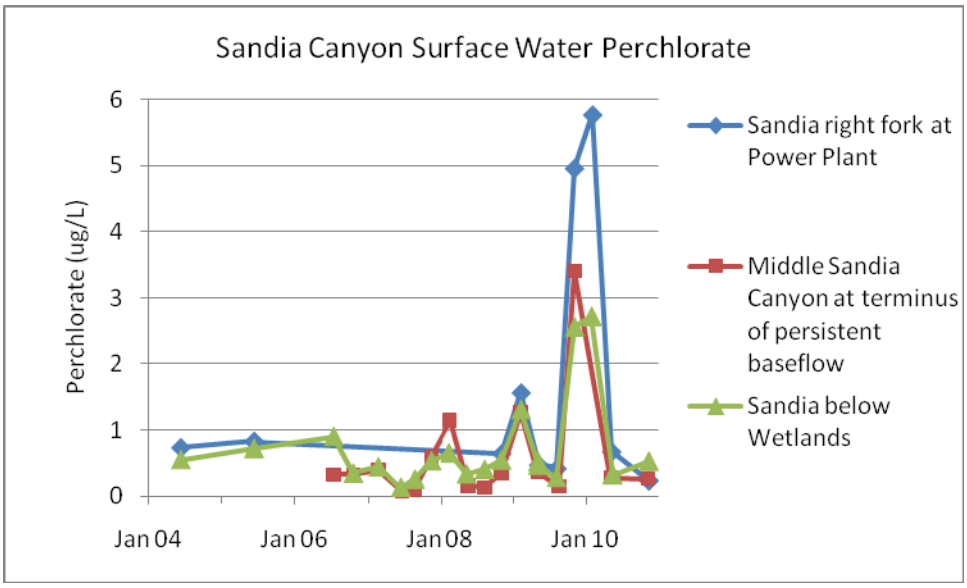

Figure 5-29 **Perchlorate in Sandia Canyon surface water. The Consent Order screening level is 4 µg/L.**

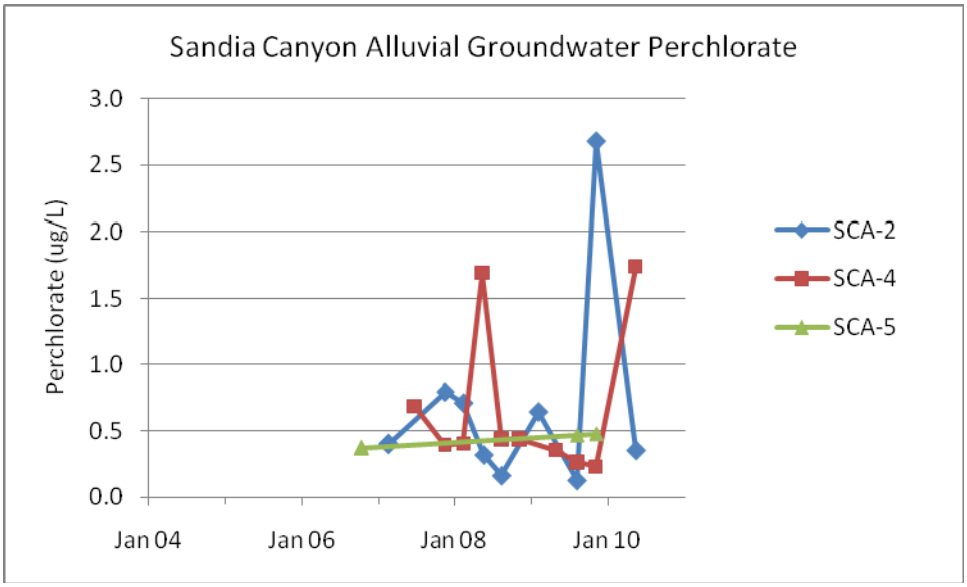

Figure 5-30 **Perchlorate in Sandia Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.**

Two alluvial wells, SCA-1-DP (a substitute for SCA-1) and SCA-2, had results for chloride and TDS that were above or approached NM groundwater standards. Data from these wells and more frequent data from adjacent surface water monitoring locations indicate seasonal variation in chloride concentrations, with highest values in winter (Figure 5-18, 5-31, and 5-32). The surface water locations show peaks in chloride concentrations in early winter, evidently the result of road salt runoff. Similar trends occur in sodium and

TDS concentrations (not shown). Although alluvial groundwater data are less frequent, they support the pattern of high concentrations of chloride, sodium, and TDS in winter. At SCA-4, the well located farthest downstream, the chloride concentration peaks appear to be delayed and have lower amplitude.

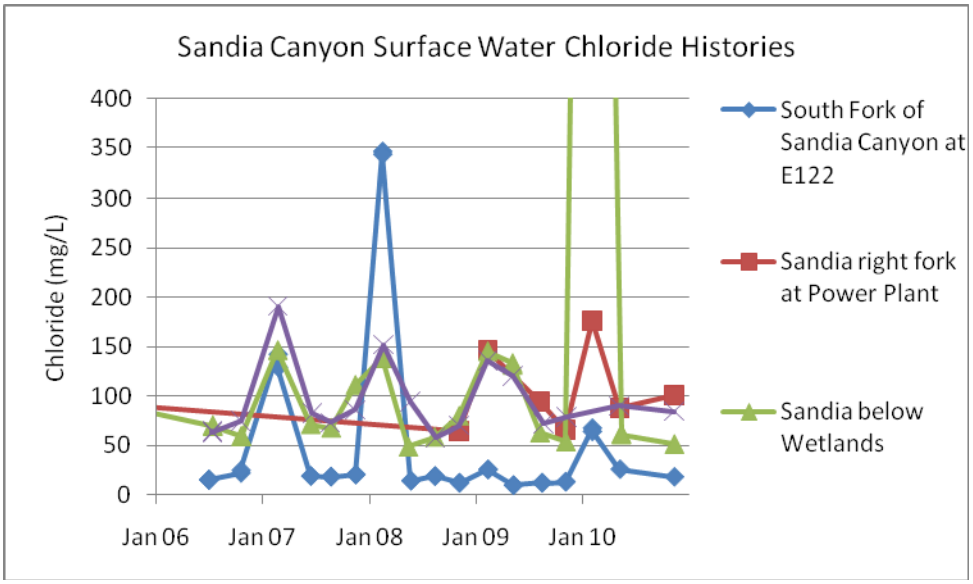

Figure 5-31 **Chloride in Sandia Canyon surface water. The concentration in January 2010 at Sandia below Wetlands was 1,820 mg/L. The NM groundwater standard is 250 mg/L.**

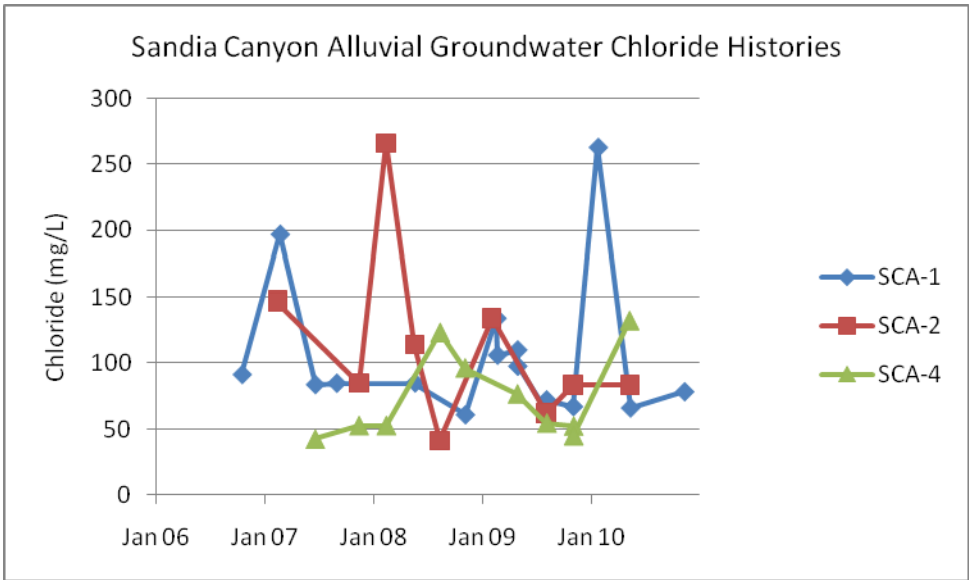

Figure 5-32 **Chloride in Sandia Canyon alluvial groundwater. Because two wells are substitute monitoring locations, data for SCA-1 and SCA-1-DP are shown together. The NM groundwater standard is 250 mg/L.**

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 (Table 5-15). Past

discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35. These discharges have affected groundwater quality in the canyons (Table 5-16).

Table 5-15
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, fluoride, TDS and barium above and cobalt at 71% of NM groundwater standards; strontium-90 and total chromium above EPA MCL screening levels; perchlorate above Consent Order screening level	Nitrate, chromium and uranium above, fluoride at 80%, and TDS at 65% of NM groundwater standards; tritium up to 35% of EPA MCL screening level; dioxane[1,4-] above EPA Human Health tap water screening level; total lead at 59% of EPA drinking water system action level, perchlorate above Consent Order screening level	Chromium above and nitrate at 63% of NM groundwater standards; perchlorate above Consent Order screening level; bis(2-ethylhexyl)phthalate above, antimony at 63% of EPA MCL screening levels, total lead above EPA drinking water system action level
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Table 5-16
Groundwater Quality in Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring wells R-28, R-42, and R-50	Average of 384 µg/L at R-28, 1008 µg/L at R-42, and 58 µg/L at R-50, above NM groundwater standard of 50 µg/L	Increasing over three years of samples at R-42; results at R-28 in this range for six years of sampling; R-50 first sampled in 2010
Nitrate (as N)	Regional aquifer monitoring wells R-42, R-28, R-45 and R-15	1.9 mg/L to 6.3 mg/L, below NM groundwater standard of 10 mg/L	Higher values in R-42 and lowest in R-15 and R-45, results in this range in R-28 and R-15 for six years of sampling
Perchlorate	Regional aquifer monitoring well R-15	7.0 µg/L to 8.1 µg/L, above Consent Order screening level of 4 µg/L	Results generally between 5.5 µg/L to 7.5 µg/L since 2004
Total lead	Regional aquifer monitoring well R-15	< 2 µg/L to 39.5 µg/L, above EPA drinking water system action level of 15 µg/L; filtered lead < 2 µg/L	Earlier results were nondetects or were below 2 µg/L
Bis(2-ethylhexyl) phthalate	Regional aquifer monitoring wells R-38, R-46	About 3 µg/L in R-38, up to 35 µg/L in R-46, above EPA MCL screening level of 6 µg/L	Declining concentrations after first sample rounds
Tritium	Intermediate wells MCOI-4, MCOI-5, MCOI-6	3,000 to 7,000 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values decreasing over five years of sampling; wells sample separate isolated perched zones
Nitrate (as N)	Intermediate wells MCOI-4, MCOI-5, MCOI-6	4.2 mg/L to 11.6 mg/L, above NM groundwater standard of 10 mg/L	Results decreasing in MCOI-6 for three years, in MCOI-4 for five years; wells sample separate isolated perched zones
Perchlorate	Intermediate wells MCOI-4, MCOI-5, MCOI-6	50 µg/L to 99 µg/L, above Consent Order screening level of 4 µg/L	Results decreasing in MCOI-6 for three years, decreasing in MCOI-4 for five years
Chromium	Intermediate well MCOI-6	47 µg/L to 66 µg/L, above NM groundwater standard of 50 µg/L	Increasing for four years following two-year decrease
Dioxane[1,4-]	Intermediate wells MCOI-4, MCOI-5, MCOI-6	7.1 µg/L to 32 µg/L, above EPA Human Health tap water screening level of 6.7 µg/L	Results at MCOI-4 and MCOI-5 fairly steady over four years; many estimated results; 50% decline at MCOI-6 for two years

Table 5-16 (continued)

Chemical	Location	Result	Trends
Dioxane[1,4-]	929 ft Intermediate screen of R-37	4.1 µg/L to 5.0 µg/L, below EPA Human Health tap water screening level of 6.7 µg/L	Detected in nearly every sample event for two years; all values just above 2 µg/L MDL and estimated
Uranium	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	23.4 µg/L to 34.6 µg/L, above NM groundwater standard of 30 µg/L	Between 22.3 µg/L and 34.6 µg/L for five years, may be leached from bedrock by sanitary effluent used to irrigate Overlook Park athletic fields
Nitrate (as N)	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	9.6 mg/L, below NM groundwater standard of 10 mg/L	Values range from 3.6 mg/L to 14.4 mg/L over five years; from sanitary effluent used to irrigate Overlook Park athletic fields
Fluoride	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	1.28 mg/L, below NM groundwater standard of 1.6 mg/L	Values range from 0.84 mg/L to 1.4 mg/L over five years
TDS	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	645 mg/L, below NM groundwater standard of 1,000 mg/L	Values range from 528 mg/L to 645 mg/L over five years; from sanitary effluent used to irrigate Overlook Park athletic fields
Strontium-90	Alluvial wells MCO-3, MCO-4B, MCO-5, MCO-6	29 pCi/L to 62 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Fairly stable between 30 pCi/L to 80 pCi/L for 10 years due to retention on sediments
Fluoride	Eight alluvial wells	0.21 mg/L to 8.8 mg/L, above NM groundwater standard of 1.6 mg/L	Results stable below RLWTF outfall and generally below standard since 1999 effluent treatment upgrades; unusually high above outfall in MCO-2 due to road salt runoff
Chloride	Alluvial wells MCO-0.6, MCO-2, MCO-3, MCO-4B	26 mg/L to 3,300 mg/L, above NM groundwater standard of 250 mg/L	Caused by road salt runoff; peaks in mid-winter; generally above standard for six years at MCO-0.6 and MCO-2
TDS	Alluvial wells MCO-0.6, MCO-2	685 mg/L to 6,180 mg/L, above NM groundwater standard of 1,000 mg/L	Caused by road salt runoff; often above standard for six years at MCO-0.6, highest results at MCO-2
Perchlorate	Six alluvial wells	4.6 µg/L to 23 µg/L, above Consent Order screening level of 4 µg/L	Results substantially decreasing since 2002 effluent treatment upgrades
Barium	Alluvial wells MCO-0.6, MCO-2	223 µg/L to 2,360 µg/L, above NM groundwater standard of 1,000 µg/L	Caused by road salt runoff; often at 60% of standard for five years at MCO-0.6, highest results at MCO-2
Cobalt	Alluvial well MCO-0.6	35.6 µg/L, 71% of NM groundwater standard of 50 µg/L	6.3 µg/L to 25.4 µg/L for six years; values generally increase with turbidity
Total Chromium	Alluvial well MCO-0.6	662 µg/L, above EPA MCL screening level of 100 µg/L	< 3 µg/L to 112 µg/L for six years; values correspond somewhat to turbidity

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two wells have ever contained water. Because treated effluent from the Laboratory's SWWS facility 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. 2010 Radioactive Liquid Waste Treatment Facility Discharges

Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2008 through 2010 appear in Supplemental Data Table S5-13. Table S5-13 shows mean annual levels in effluent for each radionuclide and the ratio of each of these to the 100-mrem/yr DOE DCG for public dose. Figures 5-33 and 5-34 show RLWTF average annual radionuclide activities in discharges compared to DOE DCGs and the fluoride and nitrate concentrations relative to NM groundwater standards since 1996.

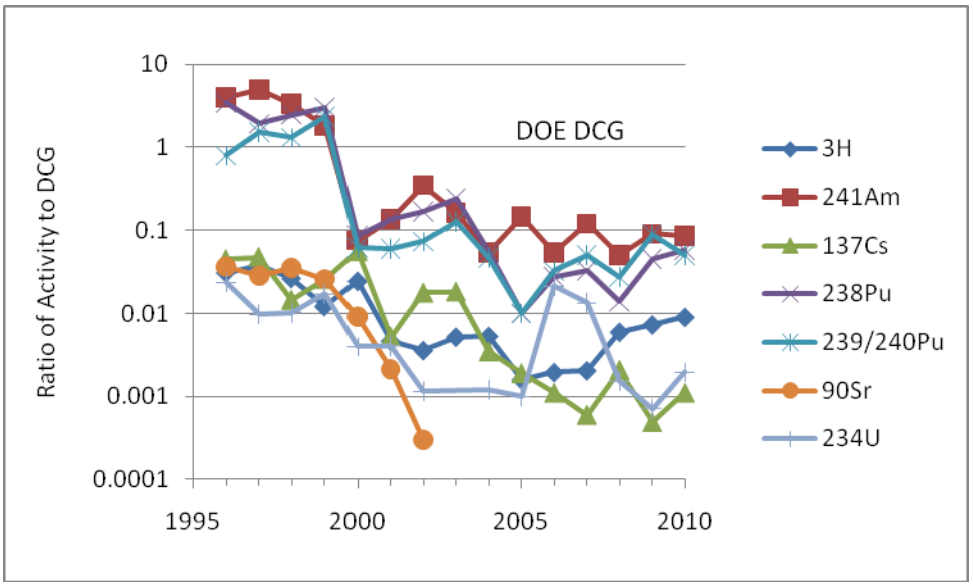

Figure 5-33 **Ratio of 1996–2010 average annual radionuclide activity in RLWTF discharges to the 100-mrem/yr public dose DOE DCGs, which are applicable to effluent releases**

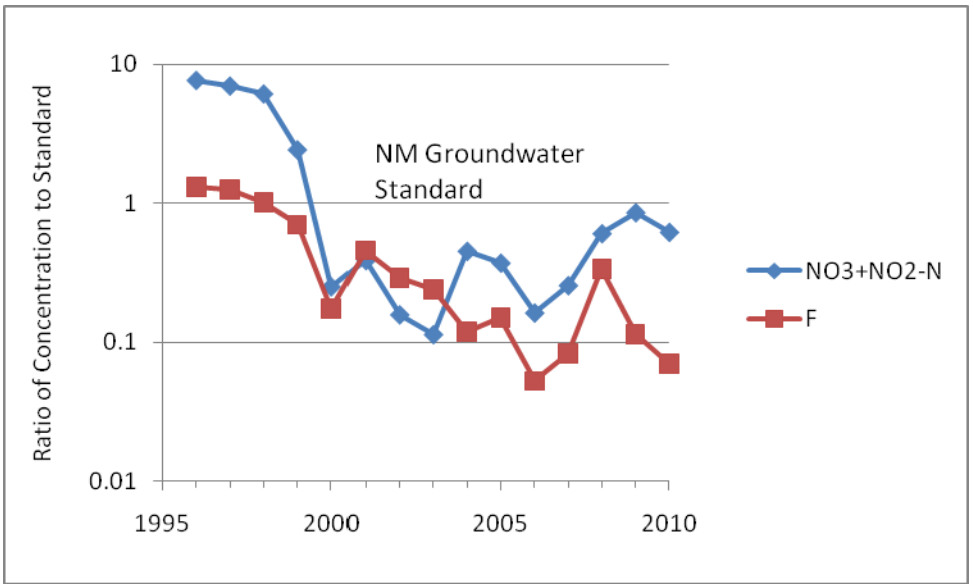

Figure 5-34 **Ratio of 1996–2010 average annual nitrate plus nitrite (as nitrogen) and fluoride concentrations in RLWTF discharges to the NM groundwater standards**

Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, activities of radionuclides in the effluent have dropped one or more orders of magnitude, and several can no longer be detected in samples. For the last 10 years, including 2010, the RLWTF has met all DOE radiological discharge standards. Concentrations of nitrate, fluoride, and TDS in the effluent decreased substantially. A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002. Since then, perchlorate was detected in effluent samples only for five weeks in 2008.

From 2000 to 2009, the nitrate (as nitrogen) concentrations of all monthly analyses of effluent discharges from the RLWTF were less than the NM groundwater standard for nitrate (as nitrogen) of 10 mg/L. However, in some cases the nitrate + nitrite (as nitrogen) concentration of the effluent discharges was near or slightly above 10 mg/L. During 2010, the nitrate (as nitrogen) concentrations of most monthly analyses of

effluent discharges from the RLWTF were less than the NM groundwater standard. In May 2010, the nitrate (as nitrogen) concentration was 11 mg/L. In June 2010, the nitrate + nitrite (as nitrogen) concentration of the effluent discharges was 10.8 mg/L. The average 2010 effluent total nitrate + nitrite (as nitrogen) concentration was 6.16 mg/L. In 2010, no base flow grab samples were collected in Mortandad Canyon below the outfall in Effluent Canyon (a tributary).

The fluoride concentration in the effluent has also declined over the last few years (Figure 5-35). The 2010 effluent fluoride concentration (average value of 0.11 mg/L) was below the NM groundwater standard of 1.6 mg/L. In 2010, no base flow grab samples were collected in Mortandad Canyon below the Effluent Canyon outfall.

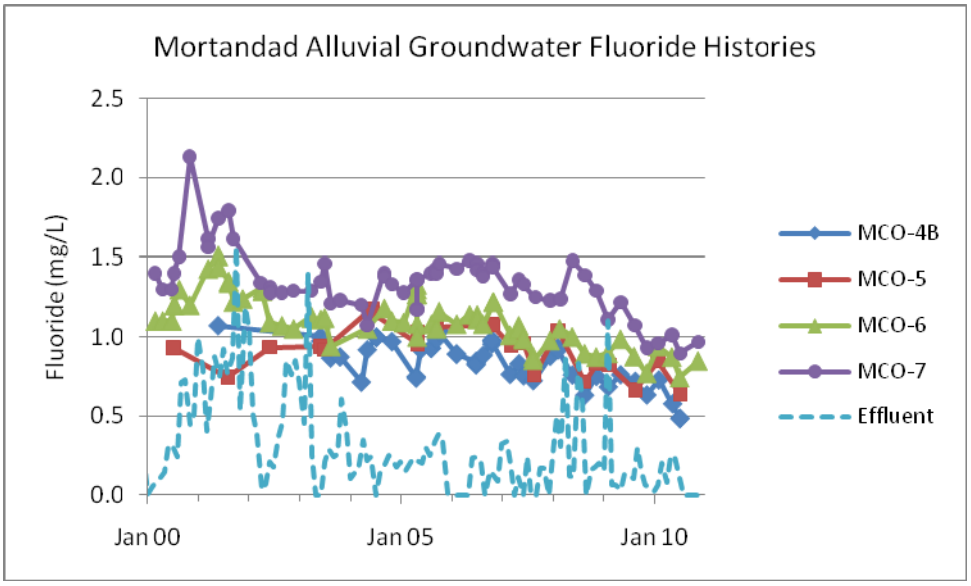

Figure 5-35 **Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater. The NM groundwater standard is 1.6 mg/L.**

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer

The regional aquifer beneath Mortandad Canyon shows impacts from past LANL discharges; intermediate groundwater shows a larger effect. In 2010, sampling at two regional aquifer monitoring wells continued to show contamination by hexavalent chromium above the NM groundwater standard of 50 µg/L (which applies to any dissolved form of chromium) (Table 5-16, Figures 5-25 to Figure 5-28). The concentrations found at regional aquifer monitoring well R-42 averaged 1,008 µg/L, and in R-28 averaged 384 µg/L. A new regional aquifer monitoring well, R-50, had an average concentration of 58 µg/L. The Laboratory is investigating this issue in cooperation with NMED and identified past cooling tower discharges in Sandia Canyon as the likely source (ERSP 2006, LANL 2008a, LANL 2009k).

The 2010 nitrate (as nitrogen) concentration in R-28 was up to 47% of the NM groundwater standard (Figure 5-36). The nitrate (as nitrogen) concentration in R-42 was up to 63% of the standard. In nearby regional aquifer monitoring well R-15, results for tritium are higher than in unaffected wells but are below standards or screening levels. Nitrate (as nitrogen) concentrations in 2010 in R-15 ranged up to 22% of the NM groundwater standard and the 880-ft screen of R-45 had concentrations up to 23% of the standard. The perchlorate concentration in R-15 was above the Consent Order screening level of 4 µg/L (Figure 5-37). Samples taken from R-15 since June 2004 generally have perchlorate concentrations between 5.5 µg/L and 7.5 µg/L.

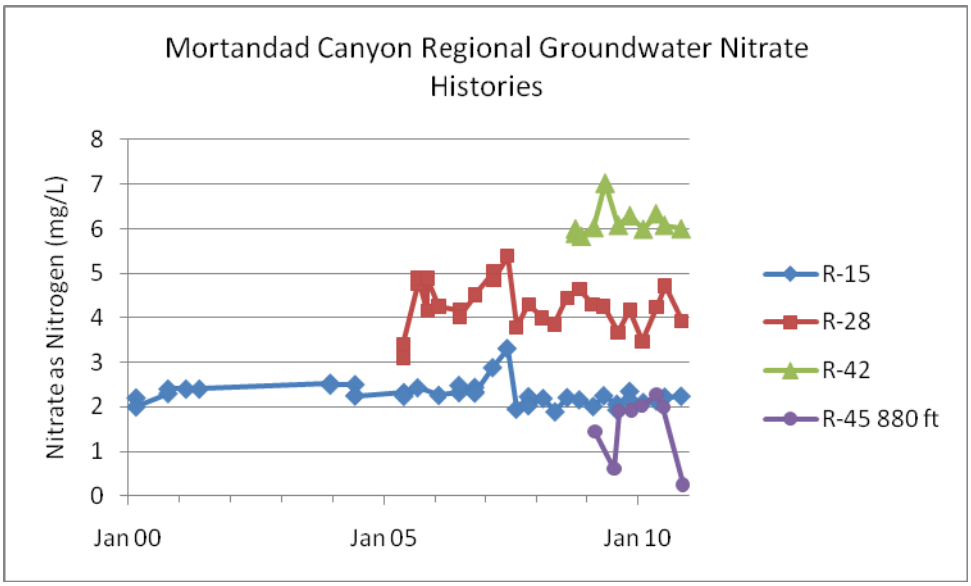

Figure 5-36 **Nitrate (as nitrogen) in Mortandad Canyon regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Most of the 2007 and some 2009 results were estimated due to analytical quality issues.**

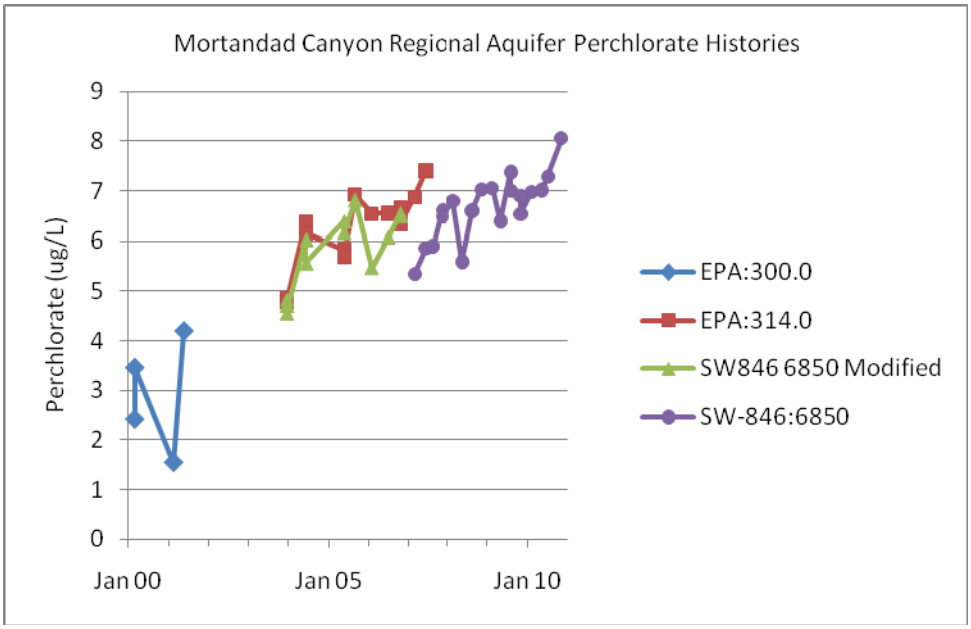

Figure 5-37 **Perchlorate in Mortandad Canyon regional aquifer well R-15. The Consent Order screening level is 4 µg/L. Data are separated by analytical method. Most results by SW846 6850 Modified were estimated due to analytical laboratory quality issues.**

In 2009, bis(2-ethylhexyl)phthalate was detected in samples from new regional aquifer wells R-38 and R-46 at concentrations above the 6 µg/L EPA MCL screening level. The concentrations, apparently caused by drilling or construction materials, ranged from 3.3 µg/L to 96 µg/L and are declining with time (Figures 5-10 and 5-15). Benzene was found in R-38 in 2009 at concentrations up to 24 µg/L, above EPA MCL screening level of 5 µg/L, but was not detected in samples during 2010.

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with some concentrations near or exceeding regulatory standards or screening levels. MCOI-6, an intermediate groundwater well, consistently shows chromium in filtered samples at concentrations near the NM groundwater standard (Figures 5-25 and 5-26). Nitrate (Figures 5-16, 5-38, and 5-39), dioxane[1,4-] (Figures 5-23, 5-40, and 5-41), and perchlorate (Figures 5-13 and 5-42) are consistently near or above standards or screening levels in some of these intermediate groundwater monitoring wells.

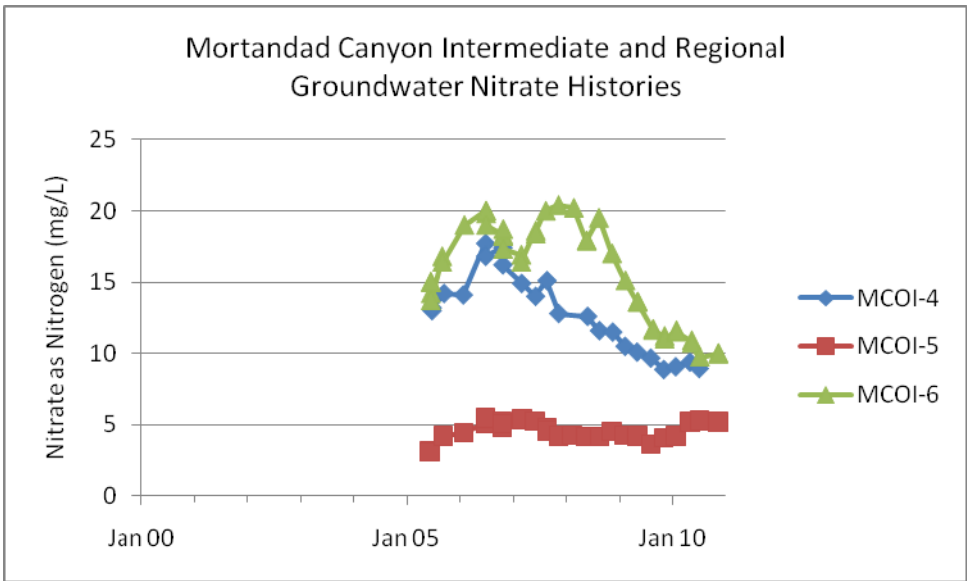

Figure 5-38 **Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L. Many of the results, particularly in 2006, were estimated due to analytical laboratory quality issues.**

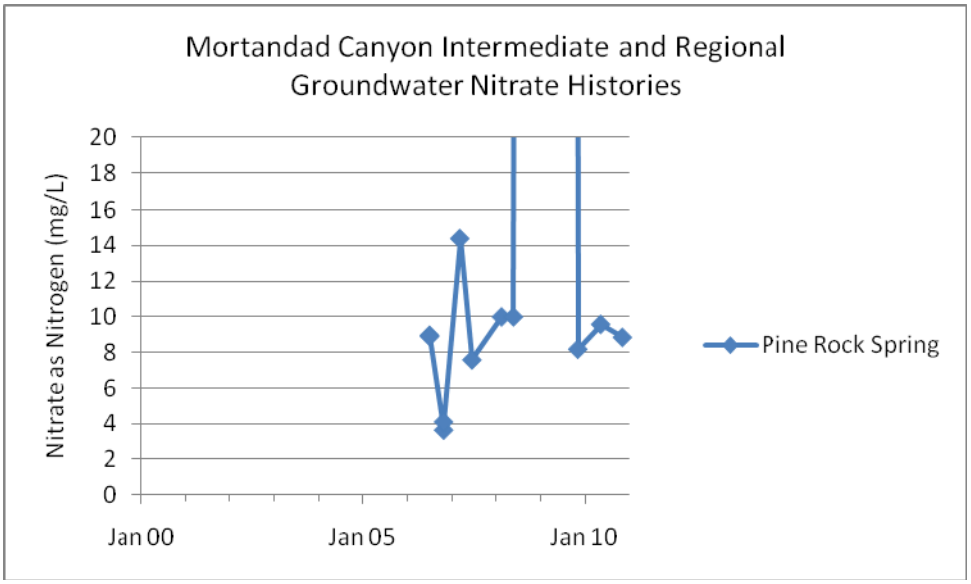

Figure 5-39 **Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater at Pine Rock Spring on Pueblo de San Ildefonso land. The NM groundwater standard is 10 mg/L. A high May 2009 result was caused by a field preservation error.**

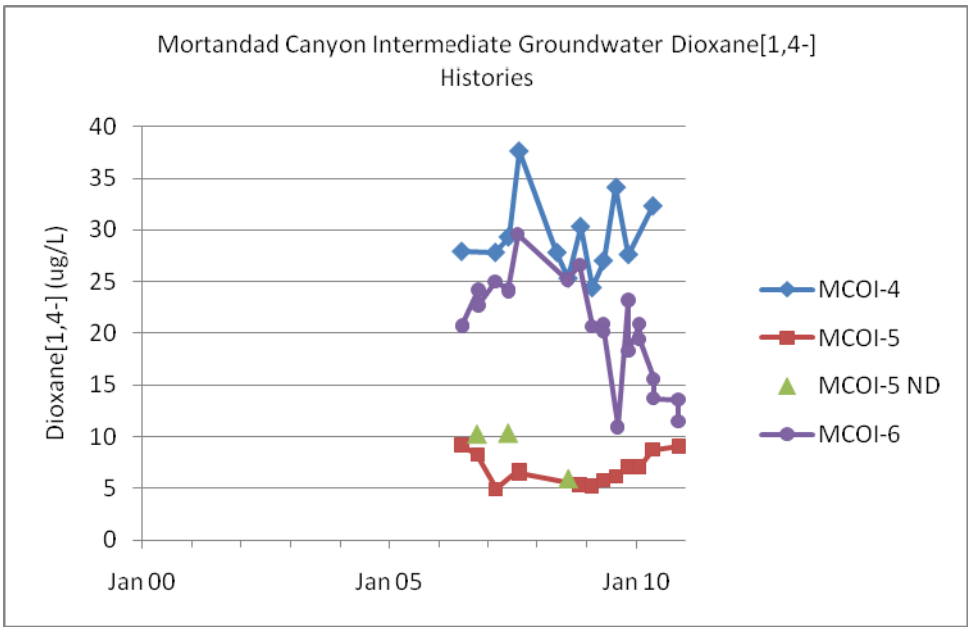

Figure 5-40 **Dioxane[1,4-] in Mortandad Canyon intermediate groundwater; for comparison purposes, the EPA Human Health tap water screening level is 6.7 µg/L. About half the results are estimated; nondetects (ND) are indicated separately for MCOI-5.**

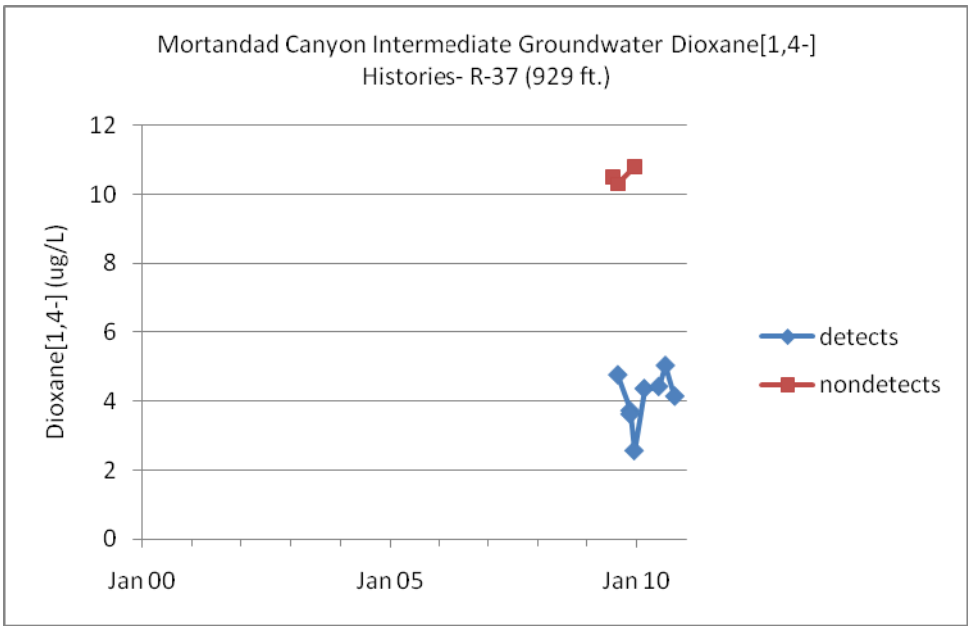

Figure 5-41 **Dioxane[1,4-] in Mortandad Canyon intermediate groundwater at 929 ft in R-37; for comparison purposes, the EPA Human Health tap water screening level is 6.7 µg/L. All detected results are estimated; nondetects (ND) are indicated separately at the PQL.**

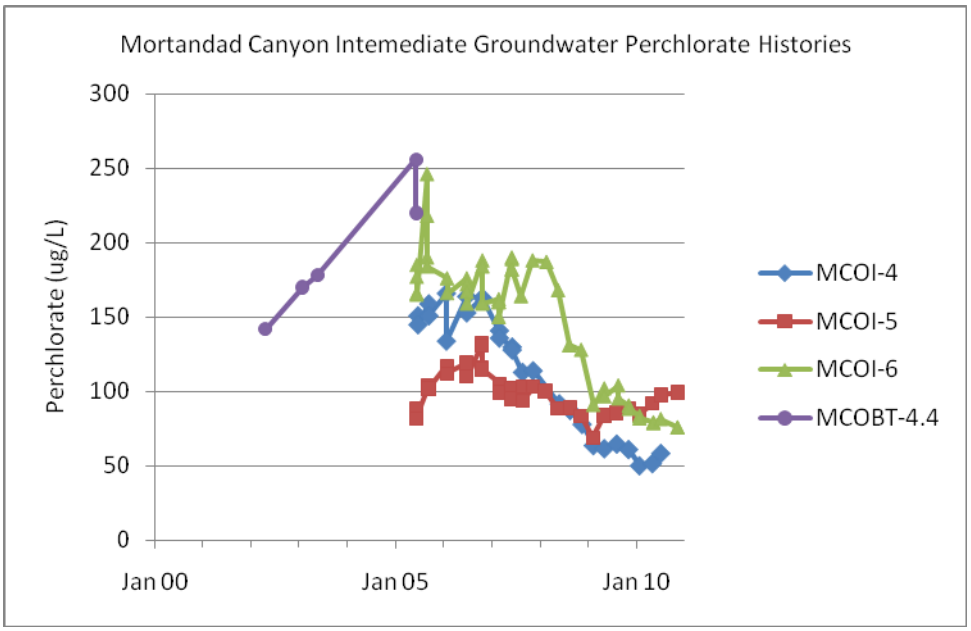

Figure 5-42 **Perchlorate in Mortandad Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

Three intermediate wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 15% to 35% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-43). Tritium activities in these wells have decreased during the past three to four years. Another intermediate well, MCOBT-4.4, was installed in 2001 and had construction problems that caused groundwater to leak from the perched zone it sampled; it was plugged and abandoned in 2009 (LANL 2009b). The Laboratory drilled nearby MCOI-4 as a replacement.

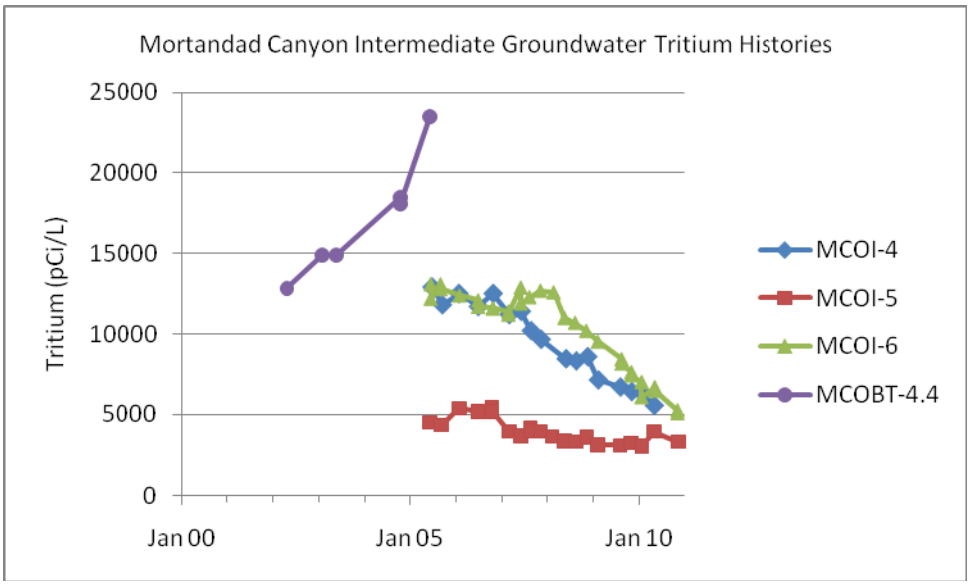

Figure 5-43 **Tritium in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level is 20,000 pCi/L.**

Pine Rock Spring on Pueblo de San Ildefonso land had uranium concentrations above and nitrate concentrations (Figure 5-39) just below the NM groundwater standards. Fluoride and TDS were also near the NM groundwater standards. The uranium 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 nitrate, fluoride, and TDS concentrations also appear to be caused by the contribution of effluent to spring flow. One total lead measurement at the spring, of 8.9 µg/L, was at 59% of the EPA drinking water system action level. Another result in 2010 was a nondetection. Total lead has been detected in most samples at this location since 2008, at concentrations up to 14.2 µg/L. All of the filtered lead samples and the 2006 and 2007 total lead samples were nondetects.

In 2005, we measured and detected dioxane[1,4-] for the first time in two intermediate wells in Mortandad Canyon. Dioxane[1,4-] has been detected since 2006 in MCOI-4, MCOI-5, and MCOI-6 using the semivolatile organic compound method SW-846:8270C (Figures 5-23 and 5-40). The dioxane[1,4-] EPA Human Health tap water screening level is 6.7 µg/L. In November 2010, the screening level was revised from a previous value of 61 µg/L. In 2010, the highest result of 32 µg/L was in MCOI-4, above the screening level. Earlier results using the volatile organic compound method SW-846:8260B were higher, but results lack accuracy; the method is not suitable for this compound.

Dioxane[1,4-] was also detected at the 929-ft intermediate screen of a new well, R-37, located near the upper part of Cañada del Buey (Figures 5-23 and 5-41). The highest value was 75% of the EPA Human Health tap water screening level. All of the results were estimated as they were near the MDL of about 2.1 µg/L.

c. Alluvial Groundwater

Prior to effluent quality improvements in 1999, radionuclide levels in Mortandad Canyon alluvial groundwater were, in general, highest just below the TA-50 RLWTF outfall at wells MCO-3 or MCO-4B and decreased down the canyon. Most radionuclides adsorb to sediment closer to the outfall and subsequently move with sediment rather than in groundwater. Since the early 1990s, radionuclide levels in alluvial groundwater samples have not exceeded the 100-mrem/yr public dose DOE DCG screening levels (applicable to effluent discharges).

The strontium-90 activity in the RLWTF effluent has been below detection since 2003 (Figure 5-33). The inventory of strontium-90 in the alluvium is gradually declining, since discharge amounts have decreased and the half-life of strontium-90 is 28.8 years. Strontium-90 continues to be found in groundwater samples because it has been retained by cation exchange on sediment within the upstream portion of the alluvium.

In 2010, total LANL-derived radioactivity exceeded the 4-mrem/yr DOE DCG screening level in Mortandad Canyon alluvial groundwater samples from wells MCO-4B and MCO-5, was 99% of the screening level in MCO-3, and 95% of the screening level in MCO-6 (Figure 5-12). Strontium-90 was the dominant contributor to dose in these samples. The 2010 results for strontium-90 were close to or exceeded the 4-mrem/yr DOE DCG screening level (40 pCi/L) and the EPA MCL screening level (8 pCi/L) in all four wells (Figure 5-11, Figure 5-44).

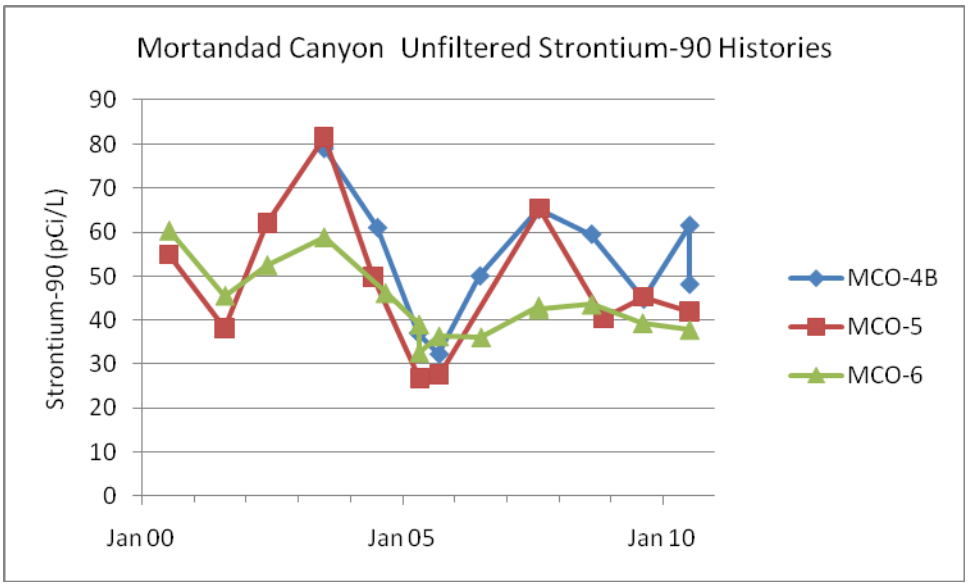

Figure 5-44 **Total (unfiltered) strontium-90 in Mortandad Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level is 8 pCi/L.**

Variable americium-241, plutonium-238, and plutonium-239/240 results in some Mortandad Canyon alluvial wells have occasionally exceeded the 4-mrem/yr DOE DCG screening levels in the last decade. In a 2009 sample at MCO-3, americium-241, plutonium-238, and plutonium-239/240 activities were each above the 4-mrem DCGs. In 2010, these radionuclides were detected at 5% to 9% of their DCGs.

Four alluvial wells (MCO-0.6, MCO-2, MCO-3, and MCO-4B) had results for chloride and TDS that approached or exceeded NM groundwater standards. MCO-0.6 is in Mortandad Canyon upstream of Effluent Canyon, and MCO-2 is in Effluent Canyon. For the past four years, more frequent data from these wells and from adjacent surface water monitoring locations show seasonal variation in chloride concentrations, with highest values beginning in winter (Figure 5-18, Figures 5-45 and 5-46). The locations of surface water monitoring stations are shown in Chapter 6. These locations show peaks in chloride concentrations in early winter, evidently the result of runoff affected by road salting. Similar trends occur in sodium concentrations and TDS (not shown).

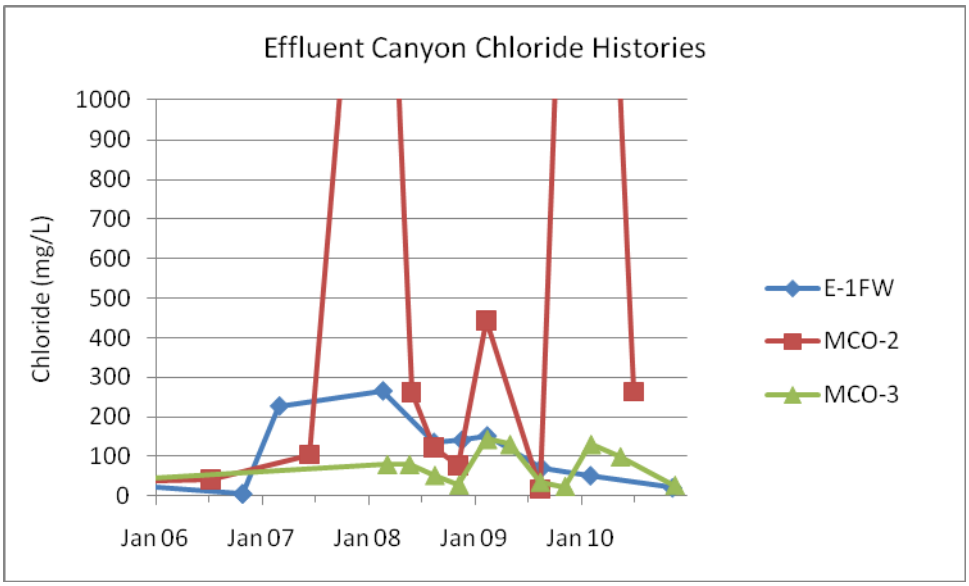

Figure 5-45 **Chloride in Mortandad Canyon surface water and alluvial groundwater. The NM groundwater standard is 250 mg/L. Surface water location E-1FW and alluvial well MCO-2 are in Effluent Canyon, a tributary of Mortandad Canyon.**

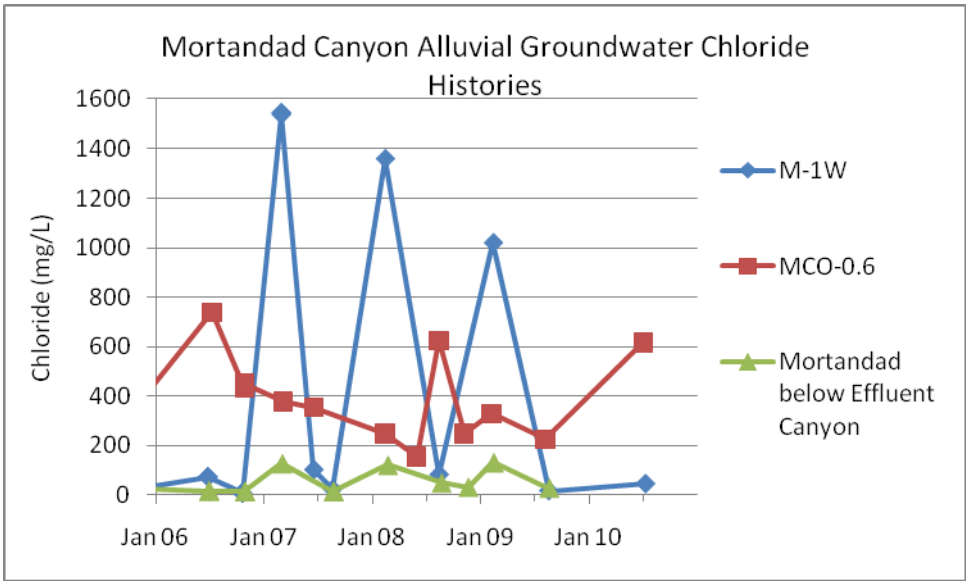

Figure 5-46 **Chloride in Mortandad Canyon surface water and alluvial groundwater. The NM groundwater standard is 250 mg/L. Surface water location M-1W and alluvial well MCO-0.6 are in Mortandad Canyon, upstream of Effluent Canyon, a tributary. Mortandad below Effluent Canyon is a surface water monitoring location.**

The highest surface water chloride concentrations were seen at location M-1W (Figure 5-46) in February of 2007, 2008, and 2009 (up to 1,540 mg/L, above the 250 mg/L NM groundwater standard). This station is in upper Mortandad Canyon, just east of a large area of roads and parking lots in the Laboratory's main technical area. Since September 2005, the chloride concentration at alluvial well MCO-0.6, located farther down the canyon, ranged from 155 mg/L to 759 mg/L. The highest values at MCO-0.6 occurred in August 2006 and 2008 and July 2010; the cause of this timing is unclear.

Surface water locations in Effluent Canyon show similar chloride concentrations pattern (Figure 5-45). The chloride concentration at E-1FW in February 2008 was 265 mg/L. Alluvial groundwater data at MCO-2 (in the middle of Effluent Canyon) also show a pattern of high concentrations of chloride and sodium in winter. High chloride concentrations occurred at MCO-2 in February 2008 (2,180 mg/L), February 2009 (444 mg/L), and January 2010 (3,300 mg/L). These two monitoring locations are upstream of the RLWTF outfall in Effluent Canyon. The canyon receives runoff from a large area of roads and parking lots.

At surface water location Mortandad below Effluent Canyon (Figure 5-46), located downstream of these monitoring sites and the RLWTF outfall, chloride concentrations also have peaked in February 2007, 2008, and 2009 (up to 132 mg/L, below the 250 mg/L NM groundwater standard). At nearby alluvial well MCO-3, chloride values in 2008 through 2010 were highest each year during February through May, up to 144 mg/L (Figure 5-45). MCO-3 has been sampled since 1963. With the exception of a few chloride results in about 1971 and 1990, the recent chloride concentrations at MCO-3 are the highest measured at the well over its monitoring history.

The chloride concentrations at MCO-3 and downstream alluvial groundwater wells have risen since 2003 and are now higher than most previous values (Figure 5-47). The annual volume of RLWTF effluent discharge and the total chloride mass discharged have decreased since 1990. The annual average effluent chloride concentration has also decreased. As the RLWTF effluent is now contributing less volume to stream flow in Mortandad Canyon and less chloride mass, this is not likely to be the cause of the increasing chloride concentration in downstream alluvial groundwater samples. These results suggest that increased application of road salt during the past few years has a greater impact on groundwater chloride concentrations than the past RLWTF effluent discharges did.

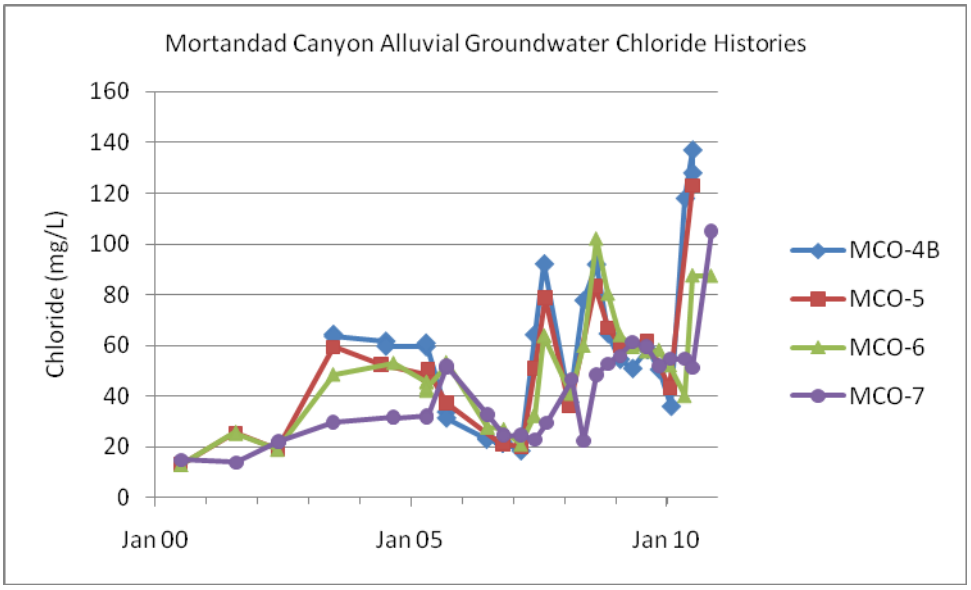

Figure 5-47 **Chloride histories for Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.**

The high salinity runoff during the winter appears to be the cause of unusually high concentrations for other constituents observed in some alluvial wells. A January 2010 sample from MCO-2 had a TDS of 6180 mg/L, above the NM groundwater standard of 1000 mg/L. TDS results are available for MCO-2 mainly since 2006 and this is the highest TDS for the well. A prior high of 3800 mg/L was measured in February 2008. Further, these are the highest TDS results for any Mortandad Canyon alluvial well, some sampled since the 1960s.

The fluoride concentration for the January 2010 sample from MCO-2 of was 8.75 mg/L, above the NM groundwater standard of 1.6 mg/L. The highest prior fluoride results were 1.0 mg/L in 1961 and 0.88 mg/L in 2000. The barium concentration of 2360 µg/L was above the NM groundwater standard of 1000 µg/L. The high sodium concentration in road salt runoff increases the groundwater barium concentration through

cation exchange replacement of barium bound to sediments. This is the highest barium result observed at MCO-2; earlier values have been elevated in winter samples as a result of road salt runoff.

Similarly, the July 2010 sample at MCO-0.6 (upstream of Effluent Canyon and the RLWTF outfall) had a TDS of 1,560 mg/L (above the NM groundwater standard). TDS at MCO-0.6 has often been above the standard during six years of sampling. The barium concentration of 670 µg/L was below the NM groundwater standard. During the past five years, the barium concentrations have frequently reached 60% of the 1,000 µg/L standard.

In addition to high concentrations related to increased runoff salinity, other metals results from the July 2010 sample at MCO-0.6 were near or above standards. The filtered cobalt concentration of 35.6 µg/L was at 71% of the 50 µg/L NM groundwater standard. Previous filtered cobalt results collected since 2005 range from 6.3 µg/L to 25.4 µg/L.

The filtered iron and manganese results at MCO-0.6 were above the respective NM groundwater standards of 1,000 µg/L and 200 µg/L. Most of the prior results at this well have been above the standards. The 2010 filtered iron result of 49,500 µg/L at MCO-0.6 is the highest measured at the location; earlier values since 2005 range from 364 µg/L to 26,500 µg/L. The filtered manganese result of 7,800 µg/L was also the highest measured at MCO-0.6; earlier values since 2005 range from 1,460 µg/L to 5,870 µg/L.

The total chromium concentration at MCO-0.6 of 662 µg/L was above the 100 µg/L EPA MCL screening level. Previous total chromium results range from nondetect (<3.3 µg/L) to 112 µg/L. Filtered chromium measurements at this location are below 17.7 µg/L. The turbidity measured on this date was the instrument maximum of 1000 nephelometric turbidity units (NTU). Earlier values ranged from 8.9 NTU to 77 NTU.

As shown in Figures 5-34 and 5-35, the nitrate plus nitrite (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 have generally been below the NM groundwater standards. As mentioned above, in some cases the combined nitrate + nitrite (as nitrogen) concentration of the effluent discharges after 1999 was near or slightly above 10 mg/L. Under the groundwater discharge plan application for the RLWTF, the Laboratory collected additional quarterly samples for nitrate, fluoride, perchlorate, and TDS during 2010 from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7.

The 2010 nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L; the maximum was 2.67 mg/L in MCO-3. Fluoride concentrations were below the NM groundwater standard of 1.6 mg/L (Figure 5-35). Many alluvial groundwater samples collected below the RLWTF outfall had fluoride concentrations above 50% of the NM groundwater standard (Figures 5-15 and 5-35). The highest groundwater fluoride concentration downstream of the RLWTF outfall was 1.48 mg/L in MT-3.

Mortandad Canyon alluvial groundwater samples from wells downstream of the RLWTF outfall had high perchlorate concentrations (Figures 5-13 and 5-48). The 2010 concentrations at six alluvial wells were above the Consent Order screening level of 4 µg/L. Alluvial groundwater concentrations of perchlorate have dropped, especially near the outfall, following the removal of perchlorate from RLWTF effluent in March 2002.

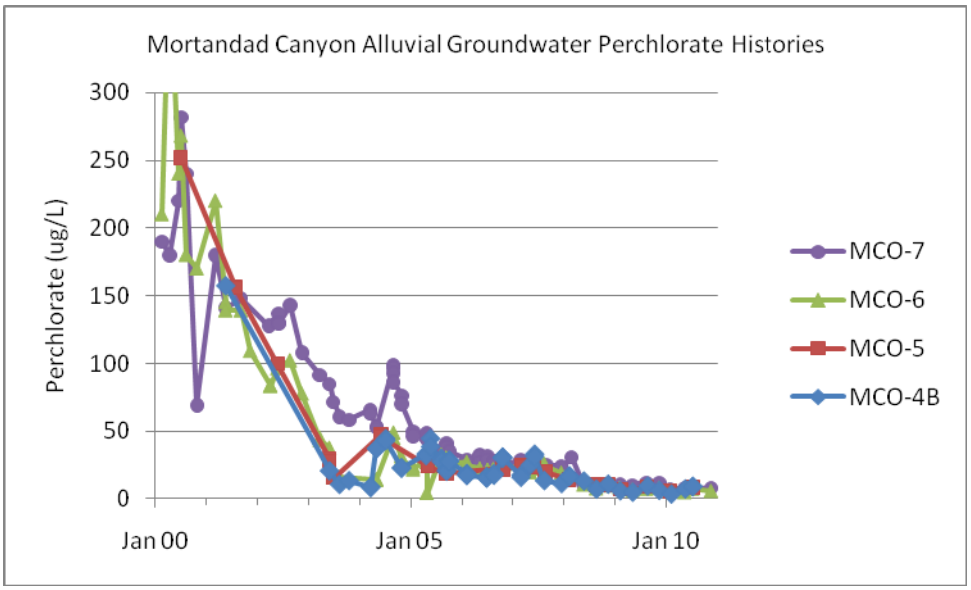

Figure 5-48 **Perchlorate in Mortandad Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.**

d. Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was sampled three times in 2010. There were no results measured near or above regulatory standards or screening levels. All other alluvial wells in Canada del Buey were dry.

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. Saturated alluvium occurs in lower Pajarito Canyon near the eastern Laboratory boundary, but does not extend beyond the 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 5-17). 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 at TA-54, used for disposal of organic chemicals 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. The main water quality impacts are from organic chemicals released at the TA-3 warehouse and from HE (Table 5-18).

Table 5-17
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 non-effluent sources; liquid sources major in past but minor currently	Barium at, chloride, and TDS above NM groundwater standards	Dichloroethene[1,1-] and trichloroethane[1,1,1-] above and chloride at 88% of NM groundwater standards; total antimony above, trichloroethene at 33%, and total beryllium at 65% of EPA MCL screening levels; dioxane[1,4-] above and RDX at 61% of EPA Human Health tap water screening level; total lead above EPA drinking water system action level	Trichloroethene at 35% of EPA MCL screening level; trace RDX

Table 5-18
Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-18	0.80 µg/L to 0.89 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Found in all sample events since August 2006; values increasing
Trichloroethene	Regional aquifer well R-20	0.56 µg/L to 1.8 µg/L, below EPA MCL screening level of 5 µg/L	Found in every sample event since December 2008; concentration decreasing since December 2009
Chloride	Intermediate well 03-B-13	75 mg/L to 221 mg/L, below NM groundwater standard of 250 mg/L	From road salt; previously above standard; highest results during March and December for four years of sampling
Total lead	Intermediate well 03-B-13	1.1 µg/L to 21.8 µg/L, above EPA drinking water system action level of 15 µg/L; filtered lead up to 7.1 µg/L	Detected in nearly every sample for five years; variable concentrations
Dichloroethene [1,1-]	Intermediate well 03-B-13	1.12 µg/L to 13.9 µg/L, above NM groundwater standard of 5 µg/L	Detected in every sample for five years; seasonally variable with highest concentrations in 2008
Trichloroethane [1,1,1-]	Intermediate well 03-B-13	39.9 µg/L to 176 µg/L, above NM groundwater standard of 60 µg/L	Detected in every sample for five years; seasonally variable with highest concentrations in 2006
Trichloroethene	Intermediate well 03-B-13	0.53 µg/L to 1.6 µg/L, below EPA MCL screening level of 5 µg/L	Detected in every sample for five years; seasonally variable with highest concentrations in 2006
Dioxane[1,4-]	Intermediate well 03-B-13	10.2 µg/L to 919 µg/L, above EPA Human Health tap water screening level of 6.7 µg/L	Detected for five years; seasonally variable with highest concentration in June 2010
Trichloroethene	Intermediate well R-40	0.46 µg/L to 0.81 µg/L, below EPA MCL screening level of 5 µg/L	Found in two of three sample events in 2010; not found in 2011 or 2009
RDX	Intermediate Bulldog Spring	3.7 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Found in every sample at Bulldog Spring; sampled since 2004; values fluctuate
Total antimony	Intermediate well R-40	0.6 µg/L to 8.9 µg/L, above EPA MCL screening level of 6 µg/L	High and low values in two of four sample events in 2010, reflecting higher turbidity of 4.7 NTU
Chloride	Alluvial wells PCAO-7a, PCAO-7b2, 18-MW-18, PCO-2, PCAO-8, PCAO-9	38.6 mg/L to 590 mg/L, above NM groundwater standard of 250 mg/L	Concentrations peak in summer, possibly delayed movement of road salt plume
TDS	Alluvial wells PCAO-8, PCAO-9	604 mg/L to 1,740 mg/L, above NM groundwater standard of 1,000 mg/L	Concentrations peak in summer, possibly delayed movement of road salt plume
Barium	Alluvial well PCAO-7a, PCAO-7b2, PCAO-8, PCAO-9	117 µg/L to 998 µg/L, near NM groundwater standard of 1,000 µg/L	Possibly due to cation exchange caused by high sodium in road salt runoff

Rehabilitation activities were conducted at regional aquifer well R-20 through December 2007 to improve sample quality (LANL 2008b). Beginning with a December 18, 2008, sample, trichloroethene has been detected at the 1,147-ft regional aquifer screen in every sample event (Figure 5-49). Results from the first sample events were near the detection limit of 0.25 µg/L and were estimated. Results from the next two sample events reached 3.04 µg/L in December 2009. Sample concentrations declined during 2010. The EPA MCL for trichloroethene is 5 µg/L. Trichloroethene has not been detected at the shallower 904 ft regional screen and was not detected at R-20 prior to rehabilitation. A source for trichloroethene has not been determined at this time, and additional wells are being drilled to investigate water quality in the area.

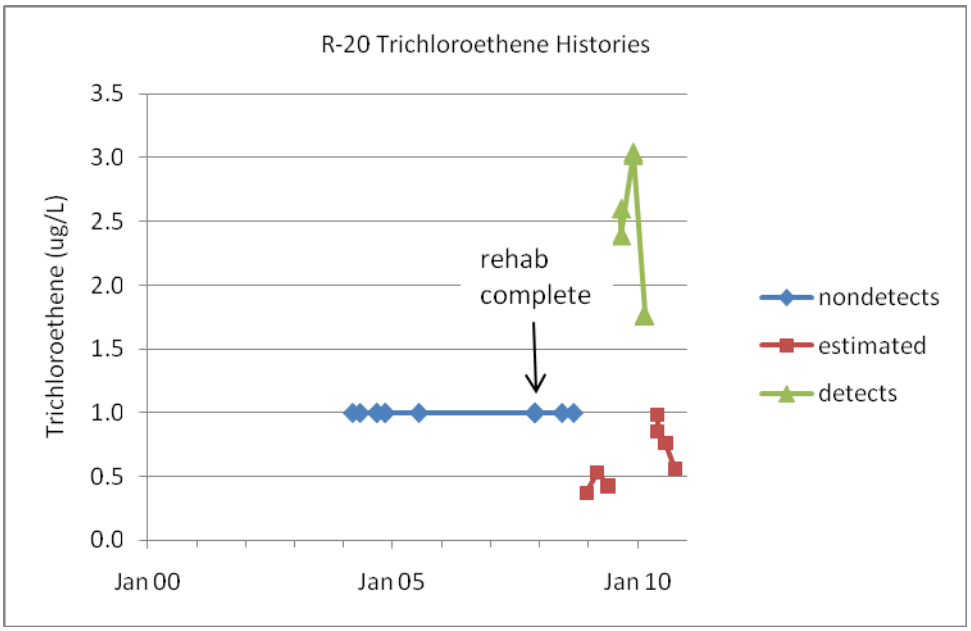

Figure 5-49 **Trichloroethene in Pajarito Canyon regional aquifer well R-20. For comparison purposes, the EPA MCL is 5 µg/L. Nondetects are reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L. The well underwent rehabilitation in 2007.**

Trichloroethene was also detected twice (out of four sample events) during 2010 at the 751-ft intermediate screen in R-40. This well is about 0.25 mile up Pajarito Canyon from R-20. The estimated concentrations were 0.46 µg/L and 0.81 µg/L. Trichloroethene was not detected in 2009 or 2011 at this screen, or at all in the other intermediate screen (at 649 ft) or the regional screen (at 849 ft) of R-40.

The total antimony concentrations at the 751-ft intermediate screen in R-40 ranged from 0.6 µg/L to 8.9 µg/L, above the EPA MCL screening level of 6 µg/L. Two of four sample events in 2010 had values at the high end of the range, reflecting higher turbidity of 4.7 NTU.

RDX was detected at Pajarito Canyon regional well R-18 at a concentration that is at 15% of the EPA Human Health tap water screening level. RDX has been detected at this well since August 2006 in every sample at increasing concentrations.

During sampling of three wells in 2010, samples were improperly preserved with nitric acid instead of another acid. As a result high nitrate (as nitrogen) concentrations were found in samples at R-20 (at 904 ft on August 3), R-19 (at 1412 ft on October 14) and at PCI-2 (an intermediate well, on August 2). The nitrate (as nitrogen) concentrations in these samples ranged from 735 mg/L to 810 mg/L and were far above the measured TDS values of 120 mg/L to 145 mg/L.

Samples from several of the intermediate groundwater springs in upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. One RDX result from Bulldog Spring was just below the EPA Human Health tap water screening level (Figures 5-50 and 5-51).

SWMU 03-010(a) is the outfall area from a former vacuum repair shop and is currently under investigation (LANL 2005b). The outfall area is located on a steep slope on the rim of Twomile Canyon about 30 ft west of a general warehouse (Building 03-30). Technicians working at the vacuum repair shop discarded vacuum pump oil at this site in the 1950s. The oil contained radionuclides, rinse solvents, and mercury. A small zone of shallow intermediate perched groundwater is apparently recharged by runoff from the parking lot and building roofs; the groundwater becomes contaminated through contact with the soil.

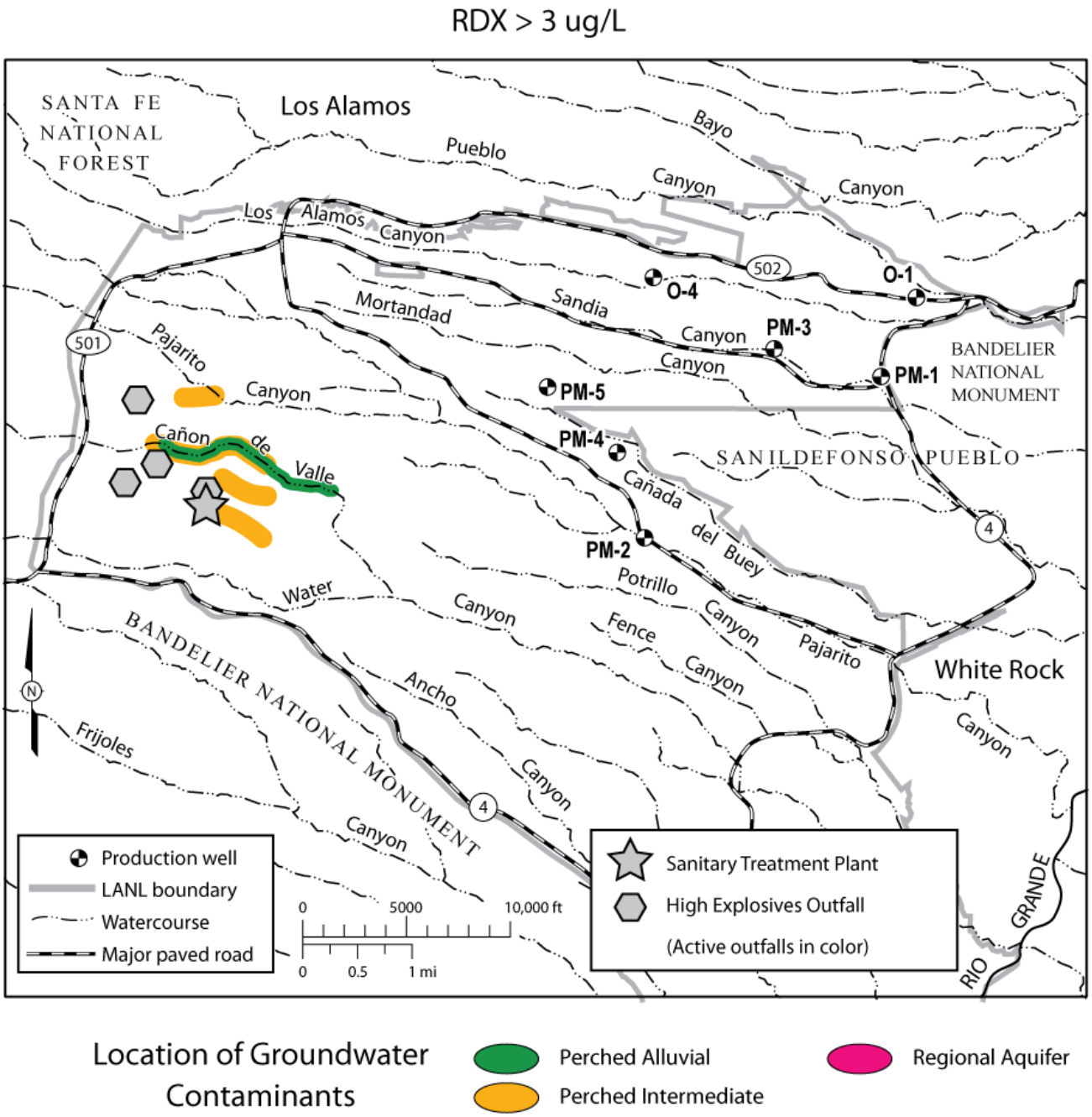

Figure 5-50 **Location of groundwater containing RDX above one half of the EPA Human Health tap water screening level of 6.1 µg/L. Different colors indicate the affected groundwater zones.**

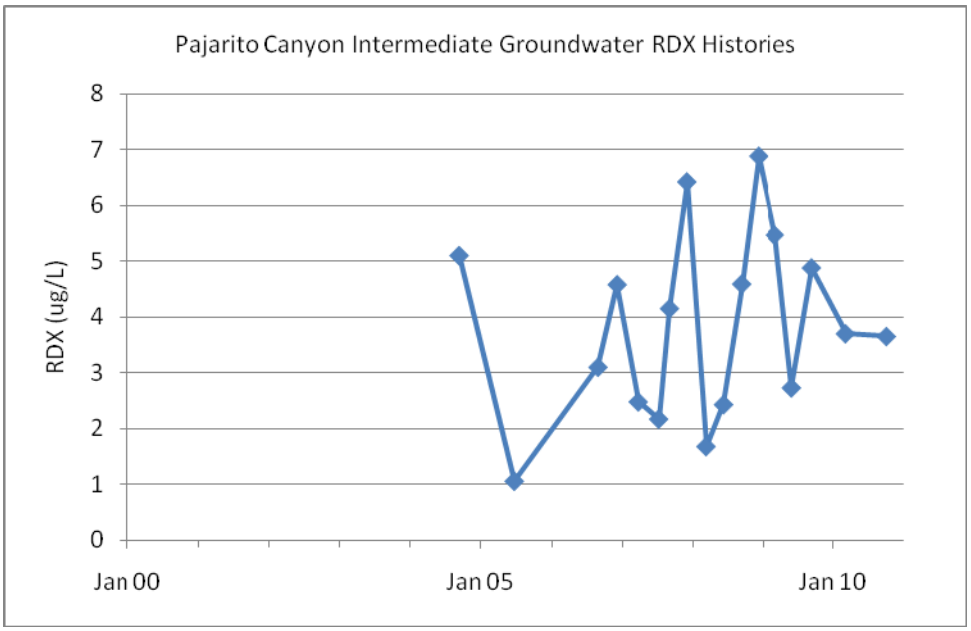

Figure 5-51 **RDX in Pajarito Canyon intermediate groundwater at Bulldog Spring. For comparison purposes, the EPA Human Health tap water screening level is 6.1 µg/L.**

This perched groundwater is tapped by well 03-B-13. Two other wells, 03-B-09 and 03-B-10, were plugged and abandoned in 2009 (LANL 2009c). Samples from 03-B-13 during 2010 had chloride (Figure 5-18, Figure 5-52) and TDS (not shown) results that were high but below groundwater standards. The seasonal pattern of sodium (not shown) and chloride concentrations, with high values in winter, suggest that road salting is the source of this variation. Samples from these wells also contained several organic chemicals including four chlorinated solvents (Table 5-18). Several organic chemicals were at concentrations exceeding NM groundwater standards or other screening levels. Compounds found in well samples included dichloroethane[1,1-], dichloroethene[1,1-], trichloroethene, trichloroethane[1,1,1-], and dioxane[1,4-].

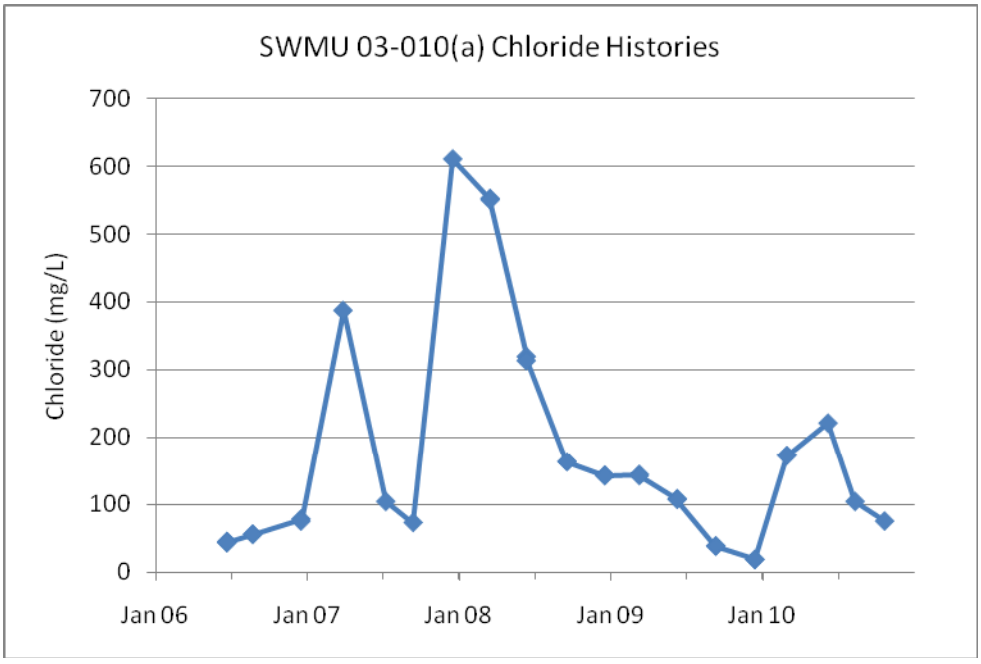

Figure 5-52 **Chloride history in Pajarito Canyon intermediate groundwater at TA-3 well 03-B-13. The NM groundwater standard is 250 mg/L.**

Seasonal variation is shown by several other field parameters and chemical compounds measured in water samples from wells 03-B-10 and 03-B-13 (LANL 2009). Variation in oxidation-reduction potential (ORP) and total organic carbon (TOC) indicate changes in reducing conditions. Changes in oxidation-reduction potential lead to observed seasonal changes in turbidity and concentrations of dissolved iron and manganese; under more reducing conditions, iron and manganese are more soluble.

Figures 5-53 through 5-55 show dichloroethene[1,1-], trichloroethane[1,1,1-], and dioxane[1,4-] histories for 03-B-13. For some solvents, their retention on solid surfaces is lower in higher ionic strength solutions. Thus, increases in concentration of dichloroethene[1,1-] and trichloroethane[1,1,1-] could result from increasing concentration of sodium and chloride, which releases these compounds from the aquifer matrix. For example, the high chloride (Figure 5-52) and TDS observed in the groundwater in December 2007 might cause release of trichloroethane[1,1,1-] during the following months (Figure 5-54).

The 2010 total lead concentration in 03-B-13 of up to 21.8 µg/L was above the EPA drinking water system action level of 15 µg/L. Total lead has been detected at variable concentrations in nearly every sample for five years.

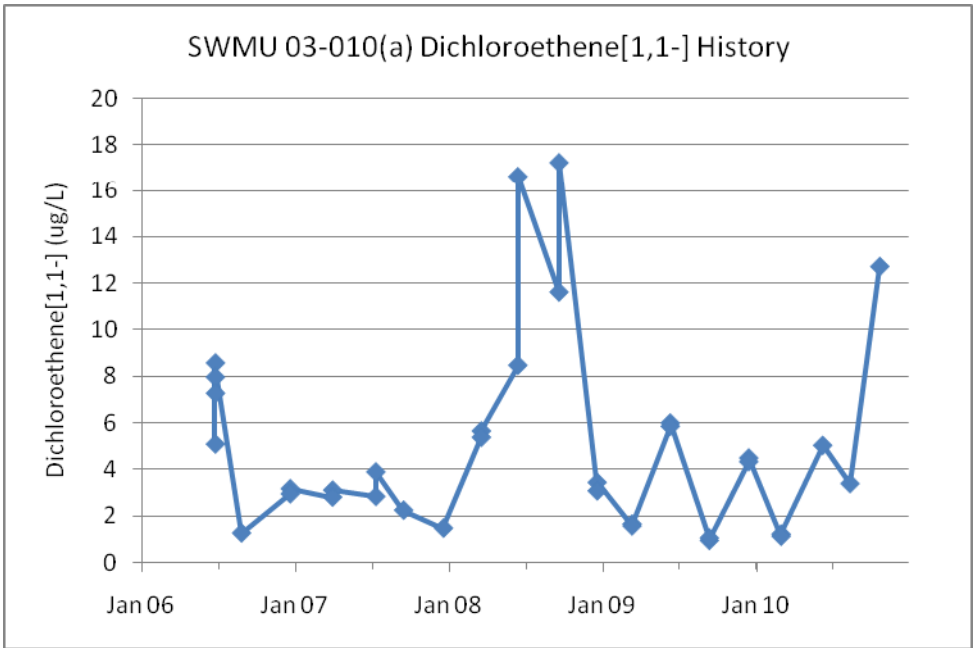

Figure 5-53 **Dichloroethene[1,1-] history in Pajarito Canyon intermediate groundwater at TA-3 well 03-B-13. The NM groundwater standard is 5 µg/L.**

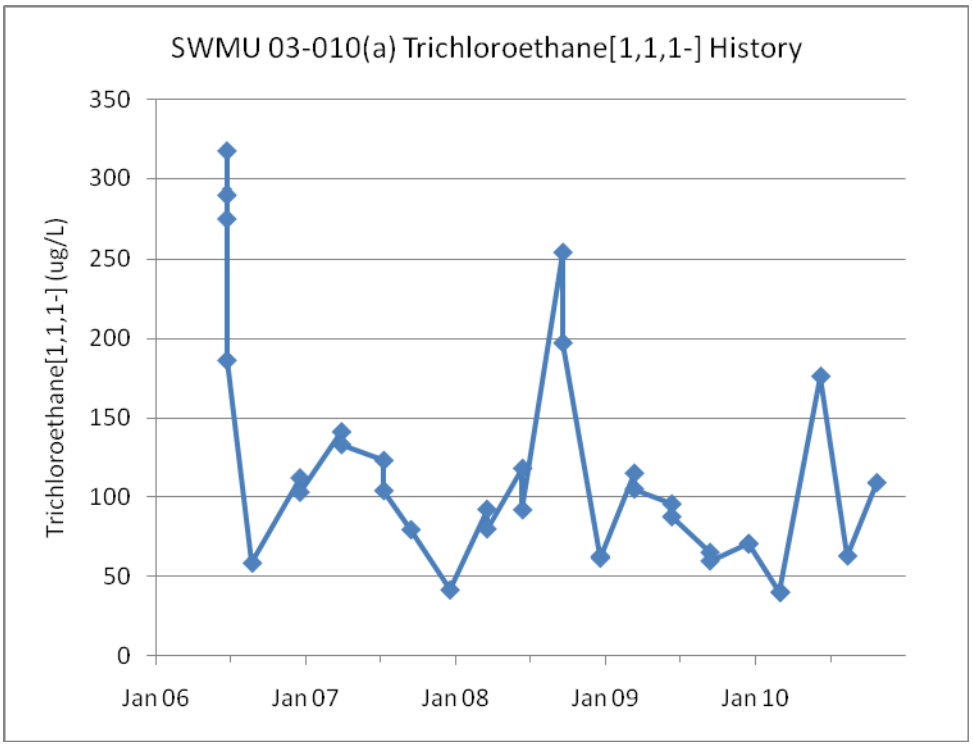

Figure 5-54 **Trichloroethane[1,1,1-] history in Pajarito Canyon intermediate groundwater at TA-3 well 03-B-13. The NM groundwater standard is 60 µg/L.**

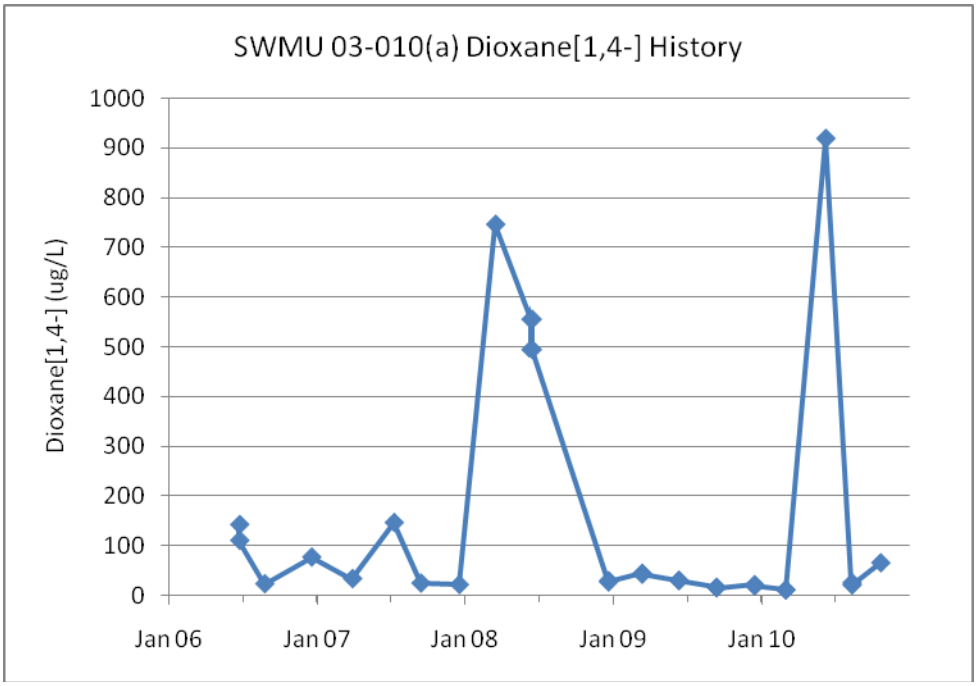

Figure 5-55 **Dioxane[1,4-] history in Pajarito Canyon intermediate groundwater at TA-3 well 03-B-13. For comparison purposes, the EPA Human Health tap water screening level is 6.7 µg/L.**

Several alluvial groundwater wells along Pajarito Road (including PCAO-7a, PCAO-7b2, 18-MW-18, PCO-2, PCAO-8, and PCAO-9) showed high chloride (Figures 5-18 and 5-56) and TDS concentrations

during 2010. More frequent sampling in recent years shows a seasonal pattern of winter increase in concentrations of chloride, sodium, and TDS. Runoff related to road salting is the apparent cause. The highest chloride concentrations in 2010 were at PCAO-8 (203 mg/L) and PCAO-9 (590 mg/L). The concentration at PCAO-9 was above the NM groundwater standard of 250 mg/L. These two wells are not shown on Figure 5-56 because they are often dry. Chloride and TDS concentrations at these wells peak in the summer, possibly due to slow movement of the chloride plume. An alluvial spring, TW-1.27 Spring in upper Pajarito Canyon, also shows high winter chloride concentrations. In March 2009, the chloride concentration at TW-1.72 Spring was 170 mg/L, below the NM groundwater standard. The spring was not sampled in 2010.

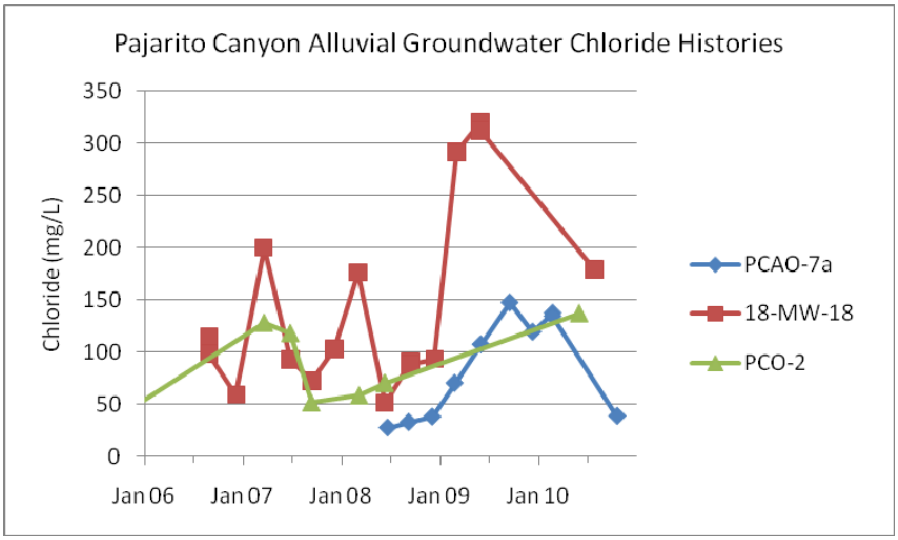

Figure 5-56 Histories for chloride in Pajarito Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

Barium concentrations are elevated in several alluvial wells and, at 998 µg/L in PCAO-9, are just below the NM groundwater standard of 1,000 µg/L (Figures 5-57 and 5-58). Barium concentrations show seasonal fluctuations; high sodium concentrations in road salt runoff lead to cation exchange replacement of barium bound to sediments, increasing the groundwater barium concentration.

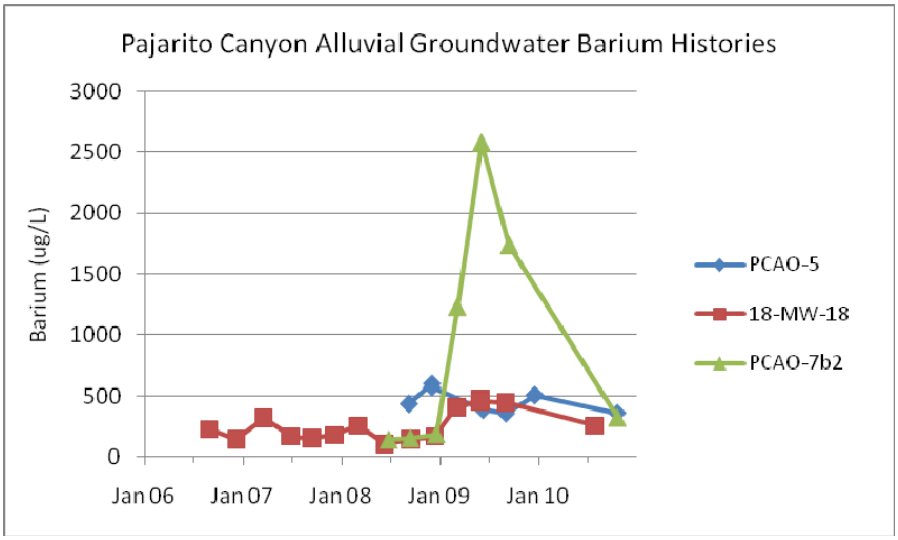

Figure 5-57 Histories for barium in Pajarito Canyon alluvial groundwater. The NM groundwater standard is 1,000 µg/L.

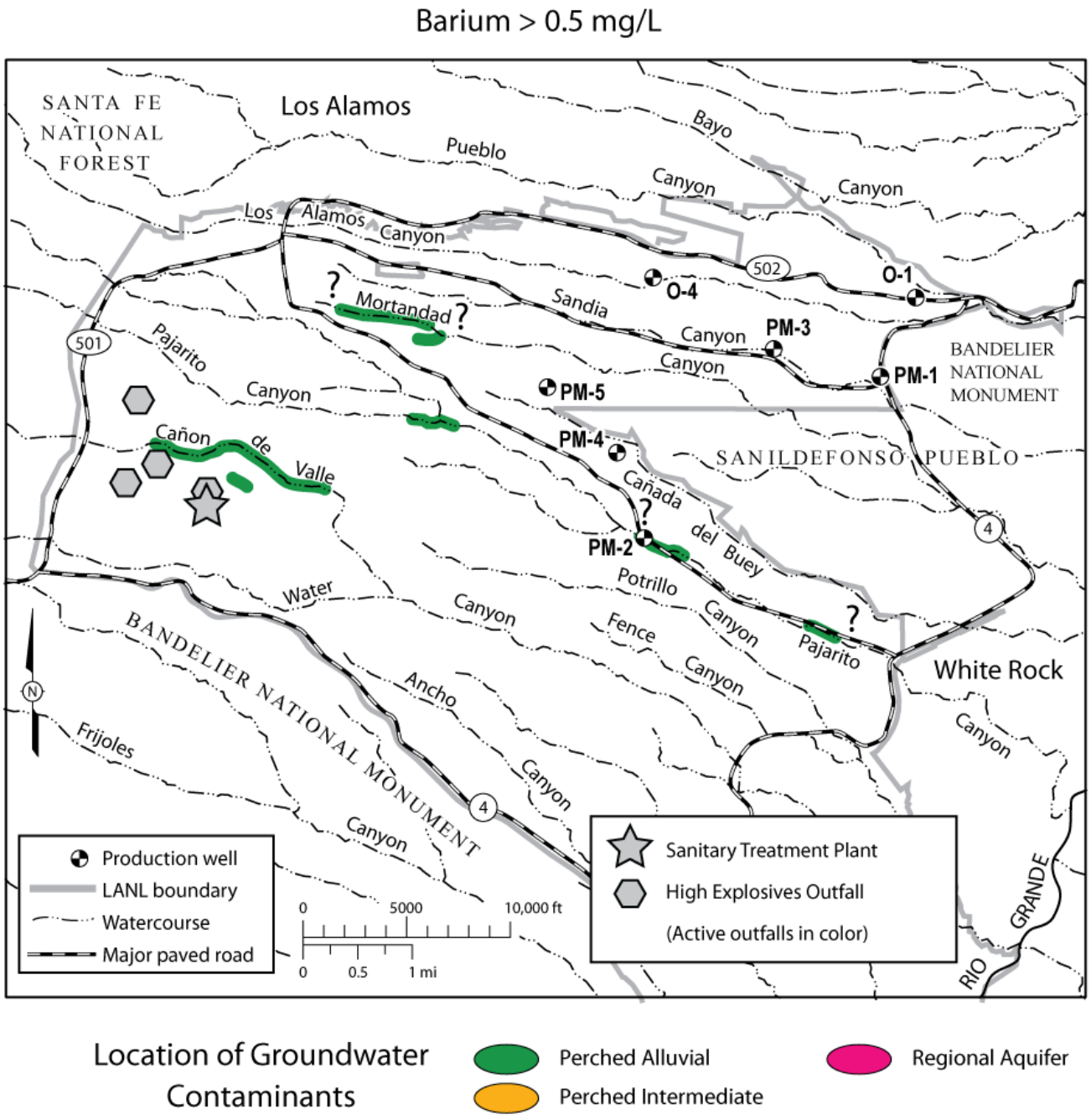

Figure 5-58 Location of groundwater containing barium above one half of the NM groundwater standard of 1,000 µg/L. Different colors indicate the affected groundwater zones.

Samples from alluvial well PCAO-5 had the highest 2009 filtered manganese values of any groundwater samples, up to 14,000 µg/L, above the 200 µg/L NM groundwater standard. The 2010 filtered manganese result was 8,350 µg/L. Filtered iron values were also high: up to 20,800 µg/L in 2009, above the 1,000 µg/L NM groundwater standard. The 2010 filtered iron result was 12,200 µg/L. Turbidity values for 2009 and 2010 were below 2 NTUs. This well is located in a wetland. Based on high TOC values, the groundwater is under reducing conditions. These reducing conditions would increase solubility of iron, manganese, and other metals. Alternatively, the metals could be present in groundwater as organic-metal colloids.

6. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon and Cañon de Valle (a tributary) traverse 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 5-19). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. This outfall discharges a much smaller amount of water that generally meets NPDES permit requirements. Alluvial groundwater in Cañon de Valle shows barium above 1,000 µg/L, the NM groundwater standard (Table 5-20, Figure 5-58), and RDX above the EPA Human Health tap water screening level of 6.1 µg/L (Figure 5-50). 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.

Table 5-19
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 and boron above and TDS at 86% of NM groundwater standards; tetrachloroethene, and total beryllium above and trichloroethene at 77% of EPA MCL screening levels; total lead above EPA drinking water system action level; and RDX above EPA Human Health tap water screening level	Boron and nickel above NM groundwater standards; total chromium above , tetrachloroethene at 32%, and trichloroethene at 32% of EPA MCL screening levels; total lead at 71% of EPA drinking water system action level; RDX above EPA Human Health tap water screening level	Trace tetrachloroethene, trace RDX
Water Canyon	Multiple dry and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None
Potrillo, Fence, and Indio Canyons	Minor non-effluent sources	No alluvial groundwater	No intermediate groundwater	None

Table 5-20
Groundwater Quality in Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-25	0.37 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Perhaps present due to well construction delays in 2000; levels have decreased; present in two regional screens in 2010
Tetrachloroethene	Regional aquifer well R-25	0.38 µg/L, below EPA MCL screening level of 5 µg/L	Present for four years of sampling at shallowest regional screen
Boron	Intermediate Martin Spring	1,240 µg/L to 1,440 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected over 20-year period; approximate 40% decrease since 2003
Nickel	Intermediate well R-25	454 µg/L, above NM groundwater standard of 200 µg/L	Similar results in shallowest screen since 2001 due to construction damage
Total chromium	Intermediate well R-25	29 µg/L, below EPA MCL screening level of 100 µg/L	High total results in shallowest screen due to construction damage, declining from 153 µg/L since 2005
Total lead	Fish Ladder Spring	9.6 µg/L, below EPA drinking water system action level of 15 µg/L	Variable concentrations, often this high for 12 years of sampling

Table 5-20 (continued)

Chemical	Location	Result	Trends
RDX	Three intermediate springs, eight wells or well screens	Up to 265 µg/L, above EPA Human Health tap water screening level of 6.1µg/L	Present for 15 years of sampling at springs, during several years of sampling of wells
Tetrachloroethene	Three intermediate springs, nine wells or well screens	0.34 µg/L to 1.6 µg/L, below EPA MCL screening level of 5 µg/L	Present for 15 years of sampling at springs, during several years of sampling of wells
Trichloroethene	Three intermediate springs, five wells or well screens	0.31 µg/L to 1.6 µg/L, below EPA MCL screening level of 5 µg/L	Present for 15 years of sampling at springs, during several years of sampling of wells
Barium	Four alluvial wells in Cañon de Valle, one in Fish Ladder Canyon	713 µg/L to 6,470 µg/L, above NM groundwater standard of 1,000 µg/L	Present at these levels for 13 years of sampling in Cañon de Valle, three years in Fish Ladder Canyon
Total beryllium	Alluvial well CDV-16-2644	4.01 µg/L, above EPA MCL screening level of 4 µg/L	< 1 µg/L to 9.6 µg/L during 14 years of samples
Boron	Martin Spring Canyon alluvial well MSC-16-06293	929 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Median of concentrations in five samples since 2000
Total Lead	CDV-16-02655, FLC-16-25280	10 µg/L to 19 µg/L, above EPA drinking water system action level of 15 µg/L	Similar results for three years in Fish Ladder Canyon well, many detections up to 67 µg/L in Cañon de Valle well
TDS	Cañon de Valle alluvial well CDV-16-02655	858 mg/L, below NM groundwater standard of 1,000 mg/L	In mid-range of concentrations since 1998
RDX	Alluvial wells in Cañon de Valle, Martin Spring Canyon, Fish Ladder Canyon	0.2 µg/L to 18 µg/L, above EPA Human Health tap water screening level of 6.1 µg/L	Highest in Cañon de Valle, present at these levels for 12 years; also near screening level in Fish Ladder Canyon
Tetrachloroethene	Fish Ladder Canyon alluvial well FLC-16-25280	127 µg/L, above EPA MCL screening level of 5 µg/L	Similar concentrations for three years
Trichloroethene	Fish Ladder Canyon alluvial well FLC-16-25280	3.8 µg/L, below EPA MCL screening level of 5 µg/L	Fourth sample in five years, previously up to 11.8 µg/L

Boron was found in samples from intermediate Martin Spring at concentrations above the NM groundwater standard for irrigation use, a reflection of past effluents (Figure 5-59). This spring is not used for irrigation. Boron is also present at high levels in downstream alluvial wells (Figure 5-60).

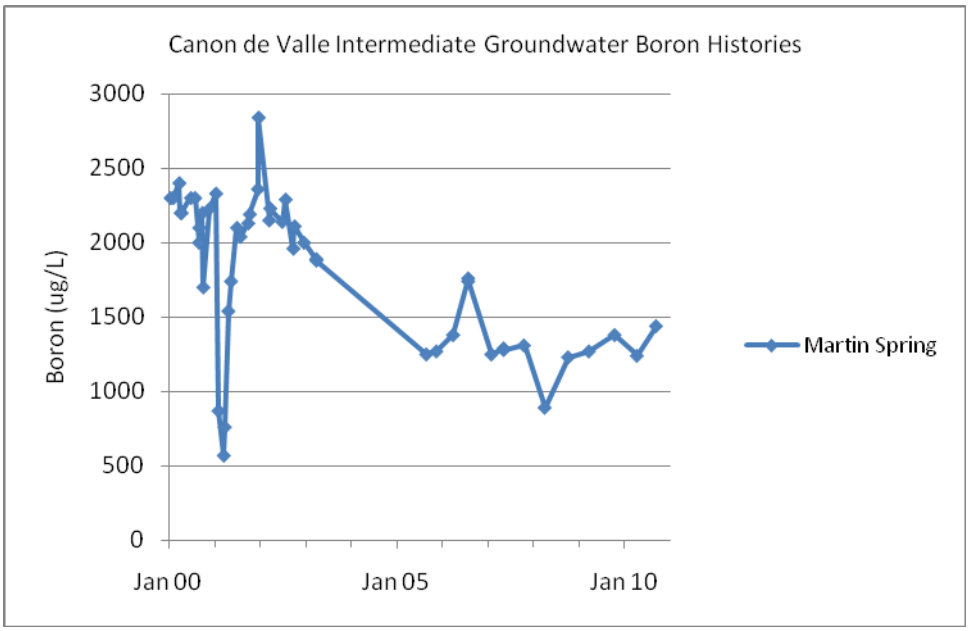

Figure 5-59 **Boron in Cañon de Valle tributary Martin Spring Canyon intermediate groundwater at Martin Spring. The NM groundwater standard (for irrigation use) is 750 µg/L.**

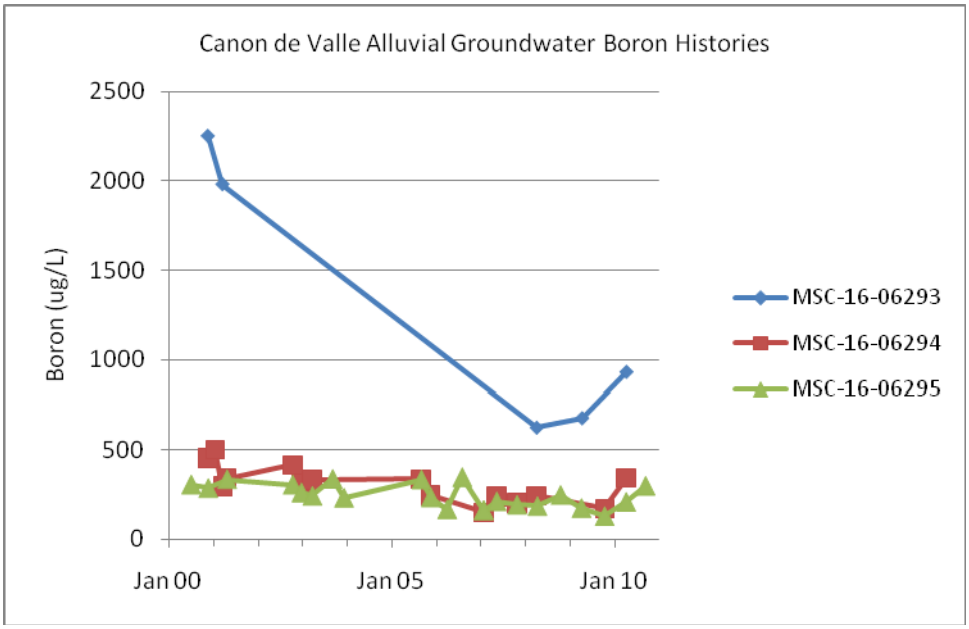

Figure 5-60 **Boron in Cañon de Valle (tributary Martin Spring Canyon) alluvial groundwater. The NM groundwater standard (for irrigation use) is 750 µg/L.**

The shallowest two screens at well R-25 (which sample intermediate groundwater) have shown high concentrations of metals such as nickel and chromium for several years. These screens were damaged during drilling of the well. In 2008, new wells were drilled to replace some of the upper R-25 screens.

A number of intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX was present at the highest concentrations compared with screening levels, above the 6.1 µg/L EPA Human Health tap water screening level (Figures 5-50, 5-61, 5-62, and 5-63). The RDX levels have been fairly steady at most of these monitoring sites. The concentrations show some seasonal fluctuation, for example, at Martin Spring (Figure 5-63).

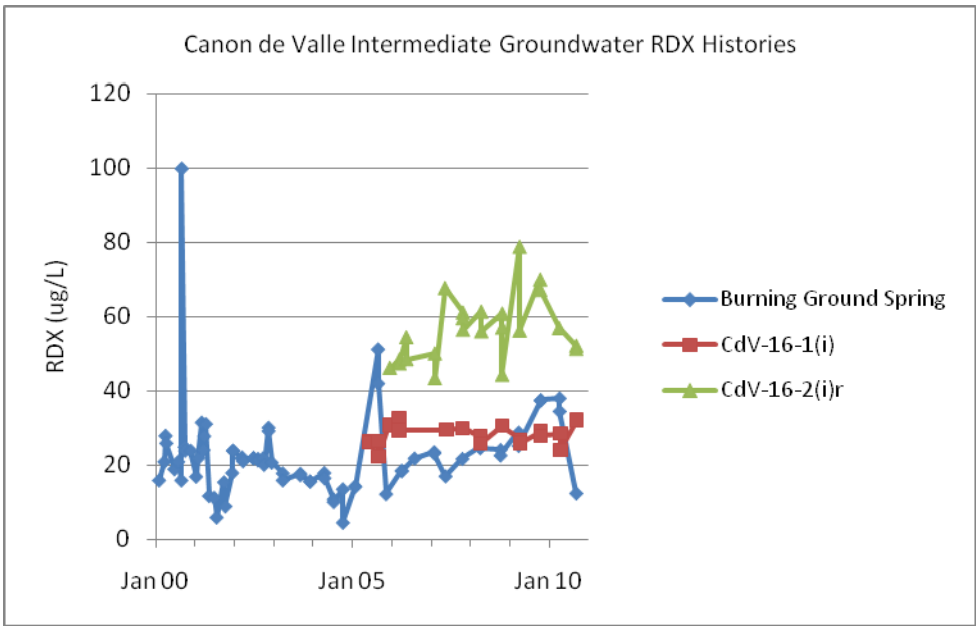

Figure 5-61 **RDX in Cañon de Valle intermediate groundwater. For comparison purposes, the EPA Human Health tap water screening level is 6.1 µg/L.**

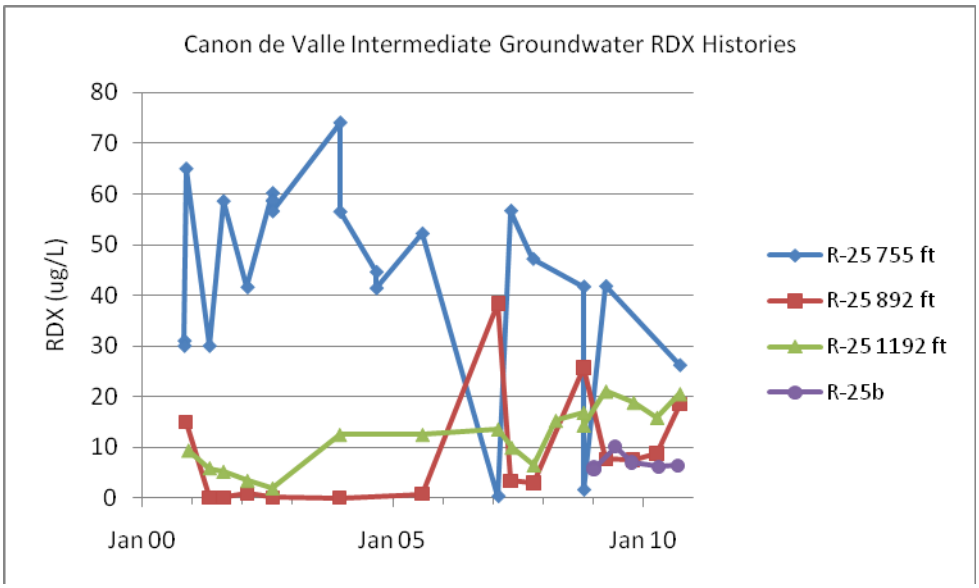

Figure 5-62 **RDX in Cañon de Valle intermediate groundwater. For comparison purposes, the EPA Human Health tap water screening level is 6.1 µg/L.**

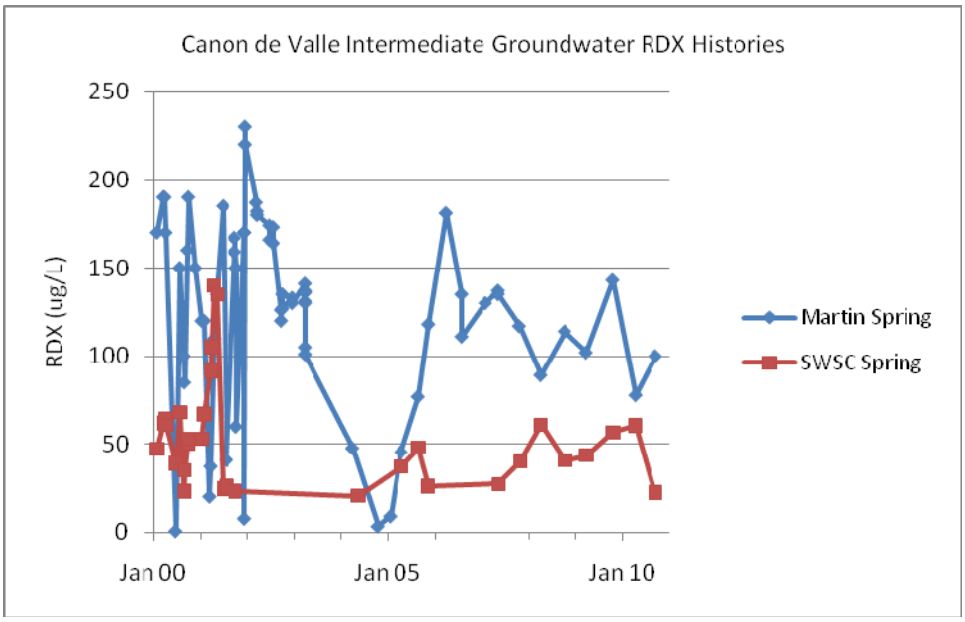

Figure 5-63 **RDX in Cañon de Valle intermediate groundwater. For comparison purposes, the EPA Human Health tap water screening level is 6.1 µg/L.**

As seen in Figure 5-62, samples from the shallowest two screens at well R-25, which sample intermediate groundwater, show variability that may be due to switching of samples or drilling of new nearby wells (LANL 2009d).

The chlorinated solvents tetrachloroethene and trichloroethene continue to be found in several intermediate wells and springs (Table 5-20).

Barium, present due to past HE wastewater discharges, exceeded the NM groundwater standard in several alluvial wells in Cañon de Valle (Figures 5-58 and 5-64). These alluvial well samples also contained several HE compounds. As with intermediate perched groundwater, RDX was the HE compound present in alluvial groundwater at the highest concentrations compared with risk levels, with some sample results above the 6.1 µg/L EPA Human Health tap water screening level (Figures 5-50 and 5-65).

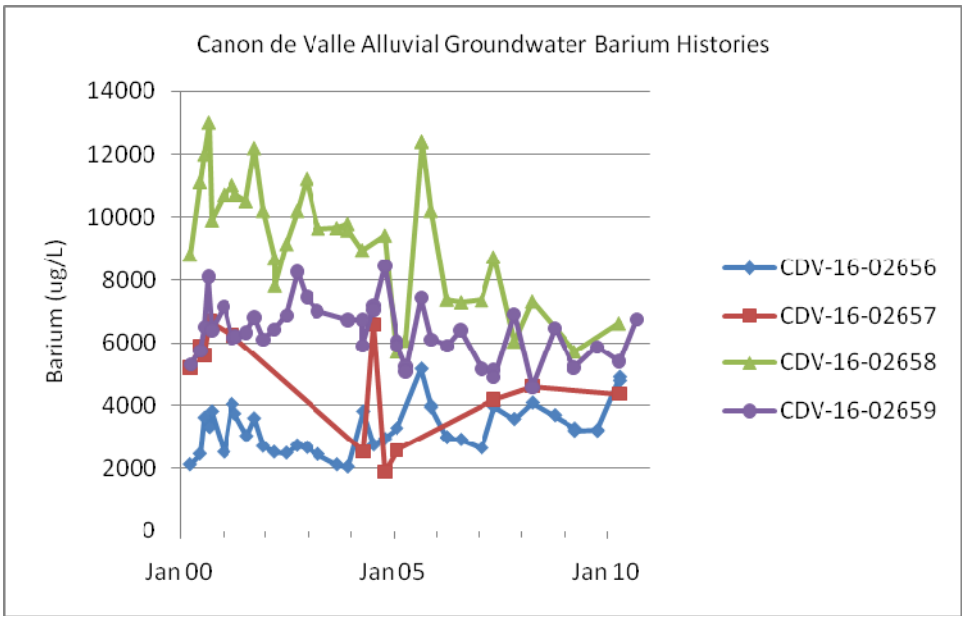

Figure 5-64 **Barium in Cañon de Valle alluvial groundwater. The NM groundwater standard is 1,000 µg/L.**

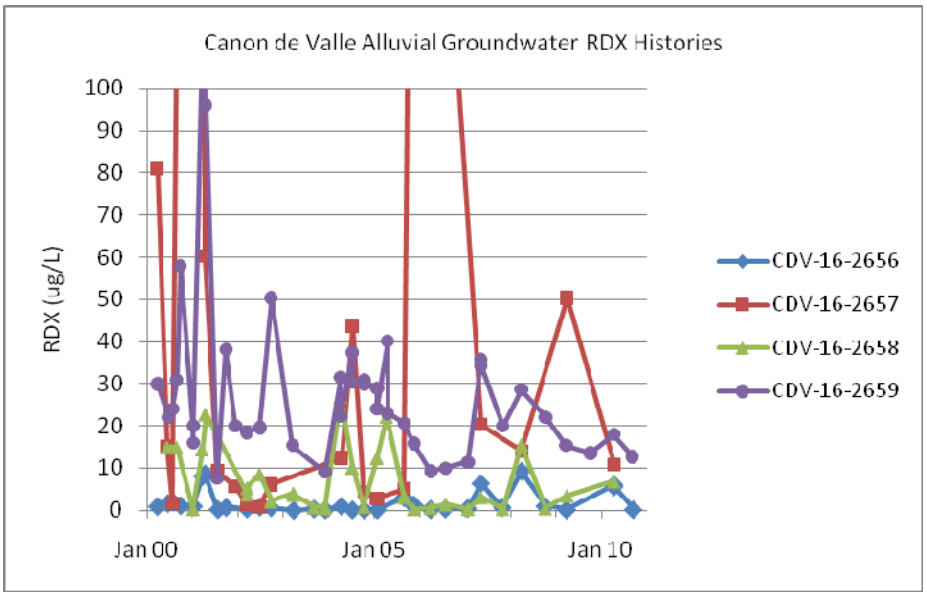

Figure 5-65 **RDX in Cañon de Valle alluvial groundwater. For comparison purposes, the EPA Human Health tap water screening level is 6.1 µg/L.**

The 2010 sample from alluvial well FLC-16-25280 in Fish Ladder Canyon contained high concentrations of tetrachloroethene (127 µg/L) and trichloroethene (3.5 µg/L) (Figures 5-66 and 5-67). Tetrachloroethene was above the EPA MCL screening level of 5 µg/L. This is the fourth sample at this well; the first sample was collected in 2006. Similarly high tetrachloroethene concentrations of about 40 µg/L have also been found in past samples from nearby Fish Ladder Spring. Otherwise, the tetrachloroethene concentration measured at FLC-16-25280 is the highest in groundwater samples at LANL, by nearly two orders of magnitude. The trichloroethene concentration measured at FLC-16-25280 is also among the highest measured. Both compounds are found in other groundwater samples in this part of LANL.

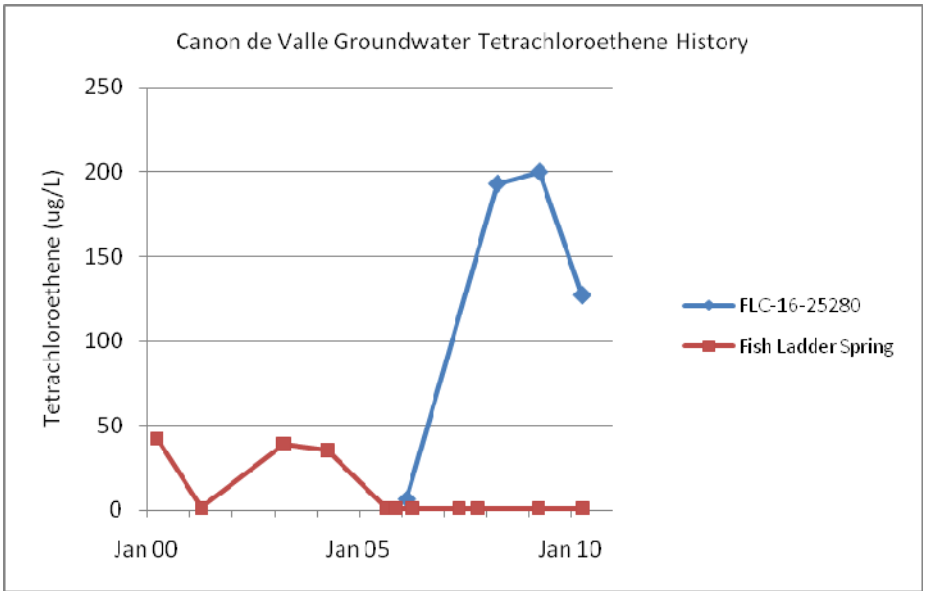

Figure 5-66 **Tetrachloroethene in Cañon de Valle alluvial and intermediate groundwater; for comparison purposes, the EPA MCL is 5 µg/L. Recent results at Fish Ladder Spring are nondetects reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L.**

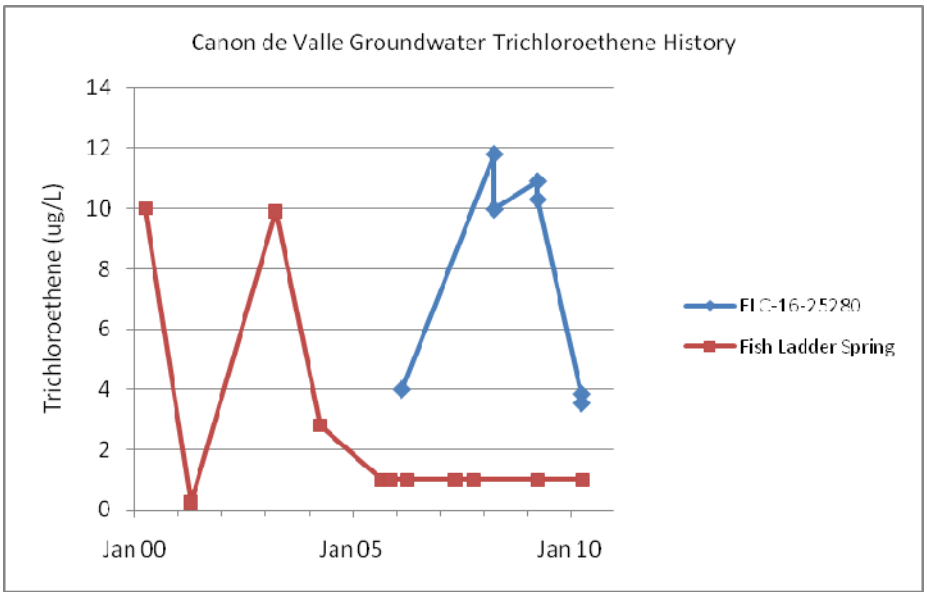

Figure 5-67 **Trichloroethene in Cañon de Valle alluvial and intermediate groundwater; for comparison purposes, the EPA MCL is 5 µg/L. Recent results at Fish Ladder Spring are nondetects reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L.**

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. 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 regional aquifer well, R-31, lies downstream from firing sites at TA-39. No contaminants were found in these wells at concentrations near or above standards (Table 5-21). As with other wells installed during that period, samples from these three test wells have shown high metals concentrations related to corrosion or flaking of well components. In 2010, the total lead concentration in a sample from Test Well DT-9 of 20.1 µg/L was above the EPA drinking water system action level of 15 µg/L. Another sample during the year had a total lead result of < 2 µg/L. Some results during the 1990s were above 50 µg/L.

Table 5-21
Summary of Groundwater Contamination in Ancho Canyon

		Groundwater Contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Ancho Canyon	Minor non-effluent sources and past effluent sources	Little or no alluvial groundwater	No intermediate groundwater	None

8. White Rock Canyon Springs

The springs that issue along the Rio Grande in White Rock Canyon represent a 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 5-22). A few springs such as Spring 2B (near Spring 2 on Figure 5-8) appear to represent discharge of intermediate perched groundwater; that spring is supplied by percolation of

municipal sanitary effluent discharge or irrigation with effluent from athletic fields near White Rock. It has only been sampled in 2003 and 2005 due to lack of flow. Other springs may be a mixture of regional aquifer groundwater, intermediate perched groundwater, and percolation of recent precipitation (Longmire et al., 2007).

Table 5-22
Summary of Groundwater Contamination in White Rock Canyon Springs

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: Springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, arsenic, uranium

In 2010, we changed analytical laboratories for low-level tritium analyses. In August 2011 investigation revealed that results from the new provider (ARSL) were subject to calculation errors. At the time of this report, these data had not been corrected. Nonetheless, the tritium values in the White Rock Canyon springs are broadly similar to results measured during the last decade. Tritium was not detected in most of the springs.

In previous years, the highest results have been found at the Spring 4 group of springs. Tritium activities in samples from these springs decreased after 2002 and in 2009 were about 8 pCi/L at Spring 4 and Spring 4C and 23 pCi/L at Spring 4B. In 2010, results were nondetect at Spring 4 (due to method blank contamination), 6.7 pCi/L at Spring 4C, and 29.5 pCi/L at Spring 4B. These three springs discharge within a hundred yards of each other near the Rio Grande.

Other than tritium, the only radionuclide detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring (Table 5-23). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs.

Table 5-23
Groundwater Quality in White Rock Canyon Springs

Chemical	Location	Result	Trends
Uranium	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	12.7 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Total arsenic	Regional aquifer Spring 2 (Pueblo de San Ildefonso)	Up to 13 µg/L, above EPA MCL screening level of 10 µg/L; NM groundwater standard is 100 µg/L	Naturally occurring

Results for White Rock Canyon spring perchlorate samples collected in 2010 are consistent with prior data; concentrations are below background levels observed in sampling of NM groundwater by Plummer et al. (2006). The highest perchlorate value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso land at a concentration of 0.87 µg/L. This spring also shows 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 0.7 µg/L, the highest concentrations for springs along the west side of the Rio Grande.

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 (Table 5-24). 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 below the NM groundwater standard of 30 µg/L (Table 5-25). 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 lands.

Table 5-24
Summary of Groundwater Contamination in White Rock Canyon Wells

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: San Ildefonso Pueblo and Buckman Well Field	None	No alluvial groundwater	No intermediate groundwater	Natural fluoride, arsenic, boron, and uranium

Table 5-25
Groundwater Quality in White Rock Canyon Wells

Chemical	Location	Result	Trends
Uranium	Pueblo de San Ildefonso and Buckman Well Field supply wells	Up to 15 µg/L at Pueblo de San Ildefonso and 21 µg/L at Buckman Well field, below NM groundwater standard of 30 µg/L	Naturally occurring
Fluoride	Buckman Well Field	Up to 0.83 mg/L, below NM groundwater standard of 1.6 mg/L	Naturally occurring
Boron	Pueblo de San Ildefonso supply wells	644 µg/L, below NM groundwater standard of 750 µg/L	Naturally occurring
Total arsenic	Pueblo de San Ildefonso and Buckman supply wells	Up to 17 µg/L at Pueblo de San Ildefonso and 11.5 µg/L at Buckman Well field, above EPA MCL of 10 µg/L	Naturally occurring

10. Buckman Well Field

In 2010, we sampled three wells in the City of Santa Fe's Buckman Well Field (Tables 5-24 and 5-25). As in past samples, these wells contain natural uranium below the NM groundwater standard of 30 µg/L.

The water in some of these wells has high TDS, so concentrations of several chemicals including chloride are near or above NM groundwater standards or EPA health advisory levels. Naturally occurring metals such as arsenic and boron are also high in some wells.

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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) monitors the quality of surface water, including storm water, and stream sediment in northern New Mexico to evaluate the potential environmental effects of Laboratory operations on affected watersheds. The Laboratory collects and analyzes samples for a variety of constituents, including radionuclides and inorganic and organic chemicals. In this chapter, the effects of Laboratory operations on surface water and stream sediment are evaluated geographically and over time. Additionally, the sampling results are compared with standards and screening criteria established to identify potential contaminants and to protect human health and the aquatic environment.

Annual monitoring of sediment sampled from selected locations at and near LANL has occurred since 1969, as part of the U.S. Department of Energy (DOE) Environmental Protection Program (DOE 2008). This currently includes sampling of active stream channels, overbank sediment on floodplains, and other settings, and is intended to evaluate possible changes in contaminant concentrations at specific locations over time. More detailed evaluations of contaminants in sediment across LANL have indicated that they do not currently pose risks to human health or ecosystems (e.g., LANL 2004; LANL 2005; LANL 2006a; LANL 2009a; LANL 2009b; LANL 2009c; LANL 2009d; LANL 2011a; LANL 2011b). Ongoing monitoring is designed to confirm that contaminant concentrations are not increasing due to changing conditions in the watersheds or, alternatively, to identify such changes if they occur. An additional objective of this monitoring is to evaluate the effects of sediment transport mitigation activities that have been undertaken in the Los Alamos Canyon watershed (LANL 2008a, 2008b). Sediment monitoring in 2010 occurred following the annual summer monsoon season, and this work is described in a sampling and analysis plan (LANL 2010a).

Surface water monitoring and assessments at the Laboratory in 2010 occurred under several tasks. The annual Interim Facility-Wide Groundwater Monitoring Plan (IFWGMP) (LANL 2009e, LANL 2010b) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels for an extensive list of constituents. These plans are prepared following the March 1, 2005, Compliance Order on Consent (the Consent Order) with the New Mexico Environment Department (NMED). Extensive sampling of storm water occurred in Los Alamos and Pueblo Canyons under a plan to monitor the effectiveness of sediment transport mitigation activities (LANL 2009f). Sampling of snowmelt runoff and storm water at gaging stations occurred as part of the Laboratory's environmental surveillance activities. Sampling of base flow along the Rio Grande at two locations occurred under an agreement with the City and County of Santa Fe and the Buckman Direct Diversion (BDD) Project. Storm water sampling at other locations to monitor industrial activities occurred under the Multi-Sector General Permit (MSGP) with the U.S. Environmental Protection Agency (EPA). Two locations that are included in an Individual Permit (IP) with the EPA were sampled in 2010. Storm water sampling also occurred in 2010 as part of a special study to evaluate background and baseline concentrations of polychlorinated biphenyls (PCBs), metals, and gross alpha radiation in and near the Laboratory (LANL 2009g).

B. HYDROLOGIC SETTING

Laboratory lands contain parts or all of seven primary watersheds that drain directly into the Rio Grande, each defined by a master canyon (Figure 6-1). Listed from north to south, the master canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui Canyons. Each of these watersheds includes tributary canyons of various sizes. Los Alamos, Pajarito, and Water Canyons have their headwaters west of the Laboratory in the eastern Jemez Mountains (the Sierra de los Valles), mostly within the Santa Fe National Forest, while the remainder head on the Pajarito Plateau. Only the Ancho Canyon watershed is entirely located on Laboratory land.

Canyons that drain Laboratory property are generally dry for most of the year, and no perennial surface water (i.e., water that is present all year) extends completely across Laboratory land in any canyon. Approximately three miles of canyon in the western part of the Laboratory have streams that are naturally perennial and fed by springs. These perennial segments are located in Water Canyon, Cañon de Valle (a major tributary to Water Canyon), and Pajarito Canyon and its tributaries. Approximately four miles of canyon on Laboratory land have perennial streams created by discharges of sanitary effluent from wastewater treatment plants (WWTPs) in Pueblo and Sandia Canyons. Spring-fed perennial stream segments are also located in lower Ancho and Chaquehui Canyons on Laboratory land near the Rio Grande, as well as in other canyons upstream and downstream from the Laboratory.

The remaining stream channels are dry for varying lengths of time. The driest segments flow only after local precipitation events or during snowmelt periods, and flow in these streams is ephemeral. Other stream segments sometimes have alluvial groundwater that discharges into the stream bed and/or experience extensive snowmelt runoff and are considered intermittent. Intermittent streams may flow for several weeks to a year or longer.

To aid in water quality interpretation, we consider three basic types of stream flow. At times, the flow might represent a combination of several of these flow types:

- Base flow—persistent stream flow but not necessarily perennial water. This type of flow is generally present for periods of weeks or longer. The water source may be springs, effluent discharge, or alluvial groundwater that emerges along stream beds.
- Snowmelt runoff—flowing water present because of melting snow. This type of water may be present for up to a month 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 and snowmelt runoff can be present for extended periods of time, they may be available for potentially longer-term exposures, such as when wildlife uses them for watering. Storm water runoff may provide a short-term water source for wildlife, particularly when it collects in bedrock pools or other local depressions, and water quality will improve at these locations over time as the suspended sediment settles out. Storm water runoff in particular is capable of transporting Laboratory-derived constituents associated with sediment particles off site and possibly into the Rio Grande.

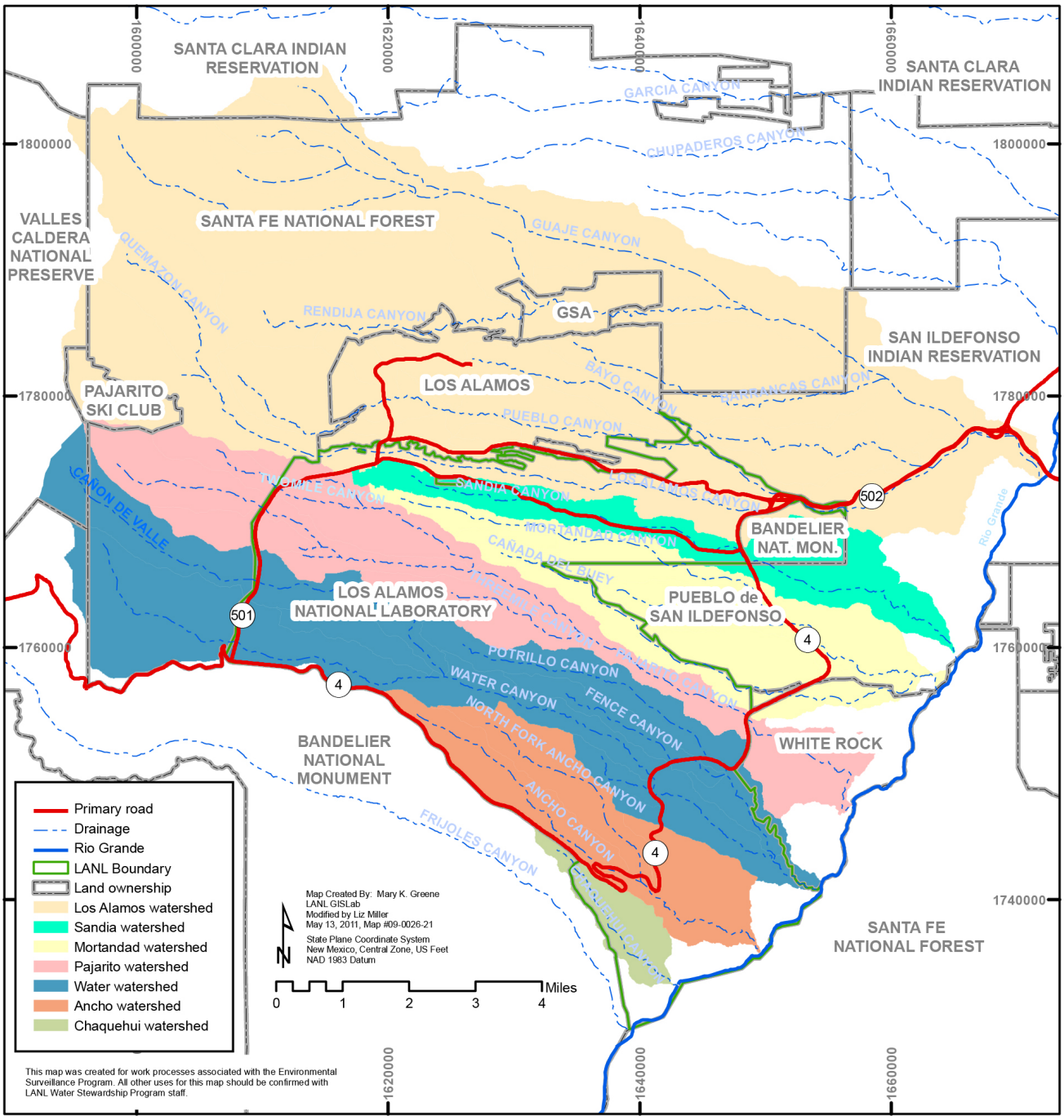

Figure 6-1 Primary watersheds at Los Alamos National Laboratory

The largest storm water runoff events in and near LANL in 2010 occurred in the Los Alamos Canyon watershed. On August 16, stream gages in Acid, DP, and Pueblo Canyons recorded peak discharges greater than 100 cubic feet per second (cfs). The largest discharge at LANL, 315 cfs, was measured at gaging station E039.1 in DP Canyon (LANL 2011c). DP Canyon receives runoff from large areas of pavement and buildings in the Los Alamos town site, and as a result has relatively frequent runoff events during the summer monsoon season. Larger discharges occurred in Los Alamos Canyon near the Rio Grande, at gaging station E109.9, with a maximum estimated discharge of about 779 cfs on August 23. The larger discharges near the Rio Grande resulted from runoff from Guaje Canyon, a major tributary to Los Alamos Canyon north of LANL.

None of the streams within the Laboratory boundary average more than one cfs of flow annually, and it is unusual for the combined mean daily flow leaving LANL to be greater than 10 cfs. This occurred once in 2010, on August 16, with a total estimated mean daily flow of 14 cfs leaving LANL in Los Alamos and Pueblo Canyons. Guaje Canyon also flowed on August 16, resulting in a total estimated mean daily flow into the Rio Grande of 25 cfs from the Los Alamos Canyon watershed. In comparison, the average daily flow in the Rio Grande at Otowi Bridge on August 16 was 1,060 cfs, or approximately 45 times higher than the flow in lower Los Alamos Canyon and 75 times higher than the flow from LANL.

In 2010, snowmelt runoff only crossed the eastern Laboratory boundary in Los Alamos Canyon, estimated at about 185 acre-feet (ac-ft) at gage E050, below the Los Alamos Canyon weir. Continuous flow occurred here for 48 days in April and May. Total storm water runoff at downstream gages in the canyons leaving the Laboratory is estimated at about 42 ac-ft, approximately 92% of this occurring in Los Alamos and Pueblo Canyons and 7% in Cañada del Buey above White Rock. Small events also occurred in Ancho, Potrillo, and Sandia Canyons. In addition, approximately 4 ac-ft of effluent released from the Los Alamos County WWTP is estimated to have passed the eastern LANL boundary in Pueblo Canyon. Figure 6-2 shows the estimated storm water runoff volume at LANL from June through October and the seasonal precipitation since 1995, indicating that the total storm water runoff in 2010 was relatively low.

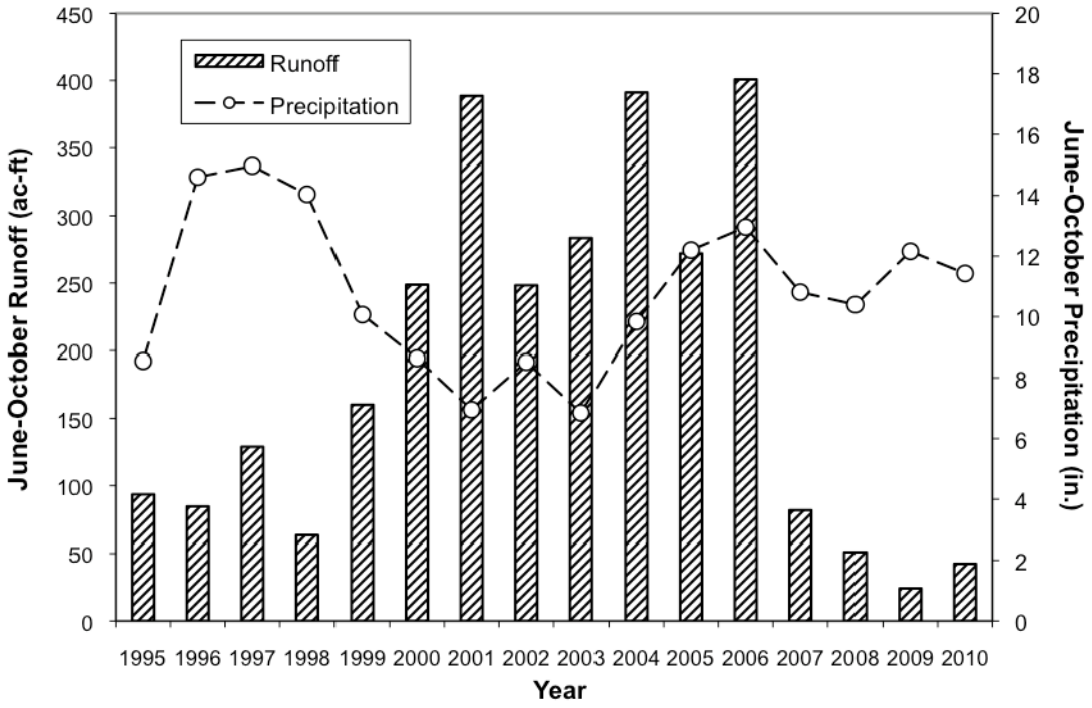

Figure 6-2 Estimated storm water runoff volume in LANL canyons (Pueblo Canyon to Ancho Canyon) and precipitation at TA-6 during the months of June through October from 1995 through 2010

C. SURFACE WATER AND SEDIMENT STANDARDS AND SCREENING LEVELS

This section discusses surface water quality standards and screening levels used to evaluate monitoring data from surface water and sediments. These standards and screening levels are summarized in Table 6-1.

Table 6-1
Application of Surface Water and Sediment Standards and Screening Levels to Monitoring Data

Media and Analyte Type	Standard	Screening Level	Reference	Notes
Surface Water, Radionuclides and Radioactivity	New Mexico gross alpha, radium-226 + radium-228, and tritium water quality standard for surface water		NMWQCC (2008)	Based on the protection of livestock watering for radium-226, radium-228, tritium, and gross alpha radiation. NMWQCC standards are not specific about exposure frequency or duration, and single sample results are compared with numeric criteria. The gross alpha standard excludes alpha radiation from source, special nuclear, and byproduct material regulated by the Atomic Energy Act. NMWQCC standards do not apply on Pueblo land or lands slated for land transfer from DOE. For samples from those locations, the standards are applied as screening levels in this report.
		Biota Concentration Guides (BCGs)	2002, 2004)	Surface water is generally present sporadically or is not available for long-term access and does not provide persistent drinking water. The actual exposure pathway is to plants and animals and not to humans. Perennial water BCGs are used for samples collected from designated perennial stream segments, and terrestrial water BCGs are applied to all other locations. BCGs are obtained from RESRAD-BIOTA 1.5 and are based on 1 rad/day exposure limit for aquatic animals and 0.1 rad day for riparian or terrestrial animals.
Surface Water, Non-radionuclides	New Mexico water quality standards for surface water		NMWQCC (2008)	Single sample results are compared with applicable segment-specific water quality standards. Standards for livestock watering, wildlife habitat, and acute and chronic aquatic life criteria apply to all stream segments, excluding samples from Pueblo land or lands slated for land transfer from DOE. At those locations, the standards are applied as screening levels in this report. Standards for human health criteria, including PCBs, apply to all stream segments.
Sediment, Radionuclides	None	BCGs	DOE (2002, 2004)	Dose limit to biota is the same as for surface water. Individual results are compared with BCGs obtained from RESRAD-BIOTA 1.5.
		Background	Ryti et al. (1998) or McLin and Lyons (2002)	Results from samples from the Pajarito Plateau are compared with plateau-specific background levels to identify potential contaminants. Results from samples along the Rio Grande and from Cochiti Reservoir are compared with background levels specific to major rivers and reservoirs within the Rio Grande drainage system.
Sediment, Non-radionuclides	None	Background	Ryti et al. (1998)	Results for inorganic chemicals from Pajarito Plateau stations are compared with plateau-specific background levels to identify potential contaminants. There are no established background levels for organic chemicals on or off the Pajarito Plateau, and all detected organic chemicals are considered as potential contaminants.

1. New Mexico Surface Water Standards

The New Mexico Water Quality Control Commission (NMWQCC) establishes surface water standards for New Mexico in its Standards for Interstate and Intrastate Surface Waters, presented in New Mexico Administrative Code (NMAC) 20.6.4.1 through 20.6.4.901 (NMWQCC 2008). New Mexico's surface water standards are intended to protect water quality through a three-step process: (1) designating uses for rivers, streams, lakes, and other surface waters, (2) setting criteria to protect those uses, and (3) establishing anti-degradation provisions to preserve water quality. On a triennial basis, surface water standards are reviewed and revised by the NMWQQC and approved by the EPA. The current standards were approved by EPA on January 14, 2011, and can be found on the New Mexico Environment Department's Web site at http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.htm. These differ in certain regards from standards that are applicable to the period described in this report (2010). For example, both acute and chronic criteria for aquatic life were applicable to ephemeral and intermittent waters at LANL in 2010, whereas only acute criteria are applicable in 2011. New Mexico water quality standards do not apply to surface waters on Native American lands, and in this report we use these standards as screening levels for comparison with surface water data from Pueblo de San Ildefonso land.

New Mexico surface waters are divided into "classified" or "unclassified" water segments and are described as ephemeral, intermittent, or perennial. Unclassified surface waters are regulated as "ephemeral," "intermittent," or "perennial" and have differing designated uses and must meet use-specific water quality criteria. Classified surface waters, have segment-specific designated uses that may be an attainable or an existing use (e.g., livestock watering, wildlife habitat, aquatic life, secondary contact). To protect and sustain designated uses, the NMWQCC sets general numeric criteria applicable to all surface waters and use-specific water quality criteria that apply to stream-specific segments. Some of the standards are for total concentrations, which are compared with data from non-filtered surface water samples. Other standards are for dissolved concentrations, which are compared with data from filtered samples.

The NMWQCC has classified all stream segments and set segment-specific designated uses for all surface waters within Laboratory boundaries (Figure 6-3, Table 6-2, and NMWQCC 2008). Only four stream segments at LANL are classified as perennial, with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact (NMAC 20.6.4.126). Three of the designated perennial segments at LANL are spring-fed (Cañon de Valle, Pajarito Canyon, and Water Canyon), and the fourth is supplied by treated sanitary effluent (Sandia Canyon). The majority of the Laboratory's remaining stream segments are classified as ephemeral or intermittent, with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact (Figure 6-3, Table 6-2, and NMAC 20.6.4.128; NMWQCC 2008). Under the NMWQCC regulations that were effective in 2010, both acute and chronic aquatic life criteria apply to all classified stream segments at LANL. Human health criteria also apply to these stream segments. The part of Pueblo Canyon which is on LANL land, and which receives sanitary effluent discharges from the Los Alamos County WWTP, is excluded from NMAC 20.6.4.128 because it is scheduled for land transfer. Pueblo Canyon is instead considered an unclassified ephemeral or intermittent stream under NMAC 20.6.4.97 and 20.6.4.98, and has designated uses of livestock watering, wildlife habitat, aquatic life (the intermittent portion) or limited aquatic life (the ephemeral portion), and secondary contact (Figure 6-3, Table 6-2, and NMAC 20.6.4.98). Only the acute aquatic life criteria, not the chronic criteria, apply to ephemeral parts of Pueblo Canyon. For samples collected from ephemeral stream segments outside the LANL boundary, chronic aquatic life criteria also do not apply. For these samples and those from Pueblo Canyon, we compare results with the chronic criteria as a screening level for simplicity and consistency with comparable samples from LANL land outside Pueblo Canyon. Human health criteria also apply to all of Pueblo Canyon and canyons outside the LANL boundary.

Surface water within the Laboratory is not a source of drinking water, municipal, industrial, or irrigation water. As described above, the NMWQCC standards do not protect surface waters within the Laboratory for drinking water. However, wildlife may use surface waters within the Laboratory and standards are set at levels to protect wildlife habitat. Stream flow may also extend beyond the LANL boundary (i.e., onto Pueblo de San Ildefonso land).

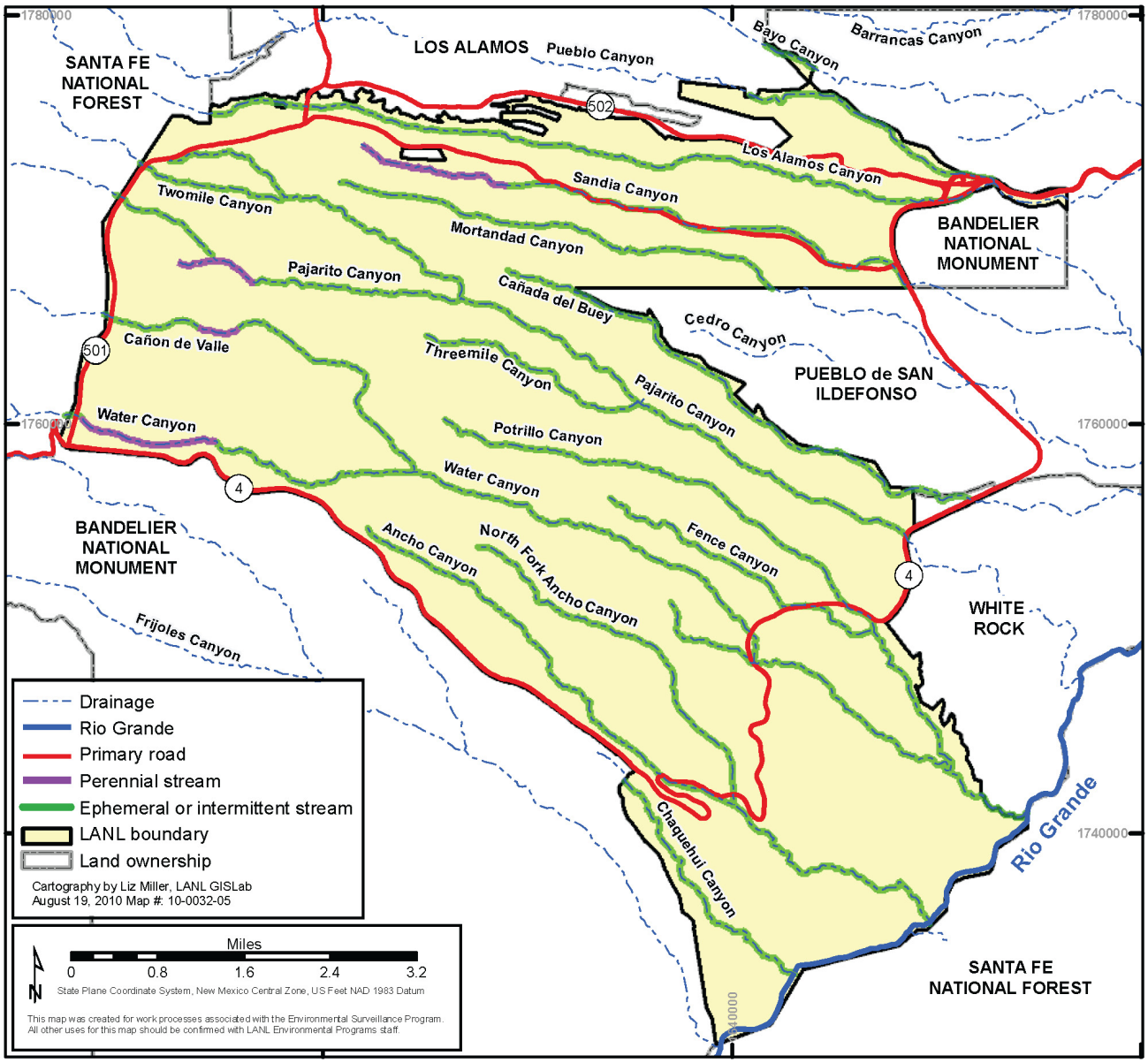

Figure 6-3 Major drainages within Los Alamos National Laboratory land, showing designated stream segments

Table 6-2
NMWQCC Designated Uses for LANL Surface Waters

Stream Segments	Designated Uses[a]	Description of Associated Users[a]
Designated perennial segments on LANL property, including parts of Cañon de Valle, Pajarito Canyon, Water Canyon, and Sandia Canyon. See Figure 6-3 and NMWQCC 2008	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur with minimal probability for ingesting the water. Examples include fishing, wading, and boating.
	Coldwater aquatic life	Fish, aquatic invertebrates, etc.
Non-perennial segments on LANL property and all of Pueblo Canyon[b]	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur with minimal probability for ingesting the water. Examples include fishing, wading, and boating.
	Limited aquatic life	Aquatic invertebrates, etc.

[a] Designated use indicates that the stream segment is protected for these uses. However, livestock are not legally grazed on Laboratory lands.

[b] One additional criterion applies to non-perennial segments on LANL property for acute total ammonia that doesn't apply in Pueblo Canyon.

Water in the Rio Grande in the vicinity of LANL is also classified by the NMWQCC and has segment-specific designated uses. Designated uses are irrigation, livestock watering, wildlife habitat, marginal coldwater aquatic life, primary contact, and warmwater aquatic life (NMAC 20.6.4.114; NMWQCC 2008).

Hardness-dependent aquatic life numeric criteria are calculated using a water hardness value of 100 mg $CaCO_3$/L (EPA 2006). For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life in perennial stream segments, the Laboratory uses the protocol employed by NMED for assessing standards attainment in New Mexico (NMED 2011).

2. Radionuclides in Surface Water

DOE Order 5400.5 prescribes total dose limits associated with exposure to radionuclides in environmental media. Because of the limited extent of stream flow, there are no drinking water systems on the Pajarito Plateau that rely on surface water supplies. The emphasis of the radiological assessment of surface water is, therefore, on potential exposures to aquatic organisms. For protection of biota, concentrations of radionuclides in surface water are compared with the DOE BCGs (DOE 2002, 2004), with site-specific modifications by McNaughton et al. (2008). For screening purposes, single sample results are first compared with BCGs to identify if radionuclides at a location pose a potential risk to biota. Following DOE guidance (DOE 2003), final evaluations of potential risk at these locations use annual time-weighted radionuclide content of the water rather than individual sample results. For water samples from in or near designated perennial stream segments, we use BCGs for aquatic or riparian animals for our evaluation, and for samples from ephemeral or intermittent segments, we use BCGs for terrestrial animals.

Surface water analytical results for gross alpha radiation, radium isotopes, and tritium are also compared with the NMWQCC standards for protection of livestock watering use, which is a designated use for surface water within the Laboratory boundary. (We note that there are no livestock at the Laboratory except for some feral cows grazing at low elevations near the west bank of the Rio Grande.) NMWQCC standards are not specific about exposure frequency or duration. Therefore, for screening purposes, single sample results are compared with numeric criteria for these analytes. It should be noted that the gross alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act, and the gross alpha radiation data discussed in this chapter were not adjusted to remove these sources of radioactivity.

3. Sediment

There are no standards for sediment. Sediment data from the Pajarito Plateau are instead compared with established plateau-specific background concentrations of inorganic chemicals or radionuclides that are naturally occurring or result from atmospheric fallout (Ryti et al. 1998; McDonald et al. 2003). Results above background values are considered to represent potential contaminants. Radionuclide data from regional sediment stations are compared with background levels established for major drainages of the area: the Rio Grande, the Rio Chama, and the Jemez River (McLin and Lyons 2002; McLin 2004). There are no established background levels for organic chemicals, and all detected results are considered to represent possible contamination.

D. SAMPLING LOCATIONS AND METHODS

1. On-Site and Perimeter Monitoring Locations

Surface water and sediment are sampled in all major canyons that cross current or former Laboratory lands, and are also sampled along some short tributary drainages. Stream channel sediment is sampled to evaluate the potential accumulation of contaminants in the aquatic environment (DOE 1991) and to evaluate trends over time. LANL collects surface water samples across the Pajarito Plateau within and near the Laboratory as part of several programs and to meet different regulatory requirements. This includes an emphasis on monitoring close to and downstream of potential Laboratory contaminant sources, such as at the downstream Laboratory boundary or NM 4. These samples include base flow grab samples from locations where effluent discharges or natural springs maintain stream flow and storm water samples collected using automated samplers.

Figure 6-4 shows surface water locations sampled in 2010 as part of the Environmental Surveillance Program and as part of a task to monitor the effectiveness of sediment transport mitigation measures in the Los Alamos Canyon watershed. These are mostly at stream gages, and also include grab samples at a sediment detention basin in upper Los Alamos Canyon. Figure 6-5 shows surface water locations sampled as part of the IFWGMP and in support of the BDD Project. These are entirely grab samples. Figure 6-6 shows locations sampled under the MSGP, which are from automated storm water samplers located close to LANL facilities. Also included on Figure 6-6 are two storm water sample locations at site-monitoring areas (SMAs). These samples are generally not representative of surface water along major drainages. Figure 6-7 shows locations of storm water samples collected in 2010 as part of a baseline PCB, metals, and gross alpha study.

Seven of the surface water sampling locations at the Laboratory in 2010 were situated within or very close to designated perennial stream segments, as discussed in Chapter C.1 and shown on Figure 6-3. These locations are in the south fork of Sandia Canyon ("Sandia right fork at power plant," gage E121), Sandia Canyon below the wetland (gage E123), middle Sandia Canyon at the terminus of persistent base flow, Pajarito Canyon below North Anchor East basin, Cañon de Valle below Material Disposal Area (MDA) P (now removed) (gage E256), Water Canyon above NM 501 (gage E252), and Water Canyon between NM 501 and Cañon de Valle ("between E252 and Water at Beta").

Sediment stations on the Pajarito Plateau and vicinity in 2010 (Figure 6-8) were located within approximately 8 km of the Laboratory's boundary, with the majority located within the Laboratory's boundary. Many of the annual sediment sampling stations on the Pajarito Plateau are located within canyons to monitor sediment in the active channel related to past and/or present effluent discharges. In accordance with the Consent Order, LANL has completed extensive evaluations of sediment, including both active channel and floodplain sediment deposits, in most canyons affected by Laboratory activities (LANL 2004, 2006a, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b; Reneau et al., 2004). These evaluations complement the active channel sampling at these annual sediment stations. Figure 6-8 shows active channel locations from Consent Order investigations in 2010 in Ancho, Chaquehui, Fence, Indio, Potrillo, and Water Canyons that are included in the data set examined in this report.

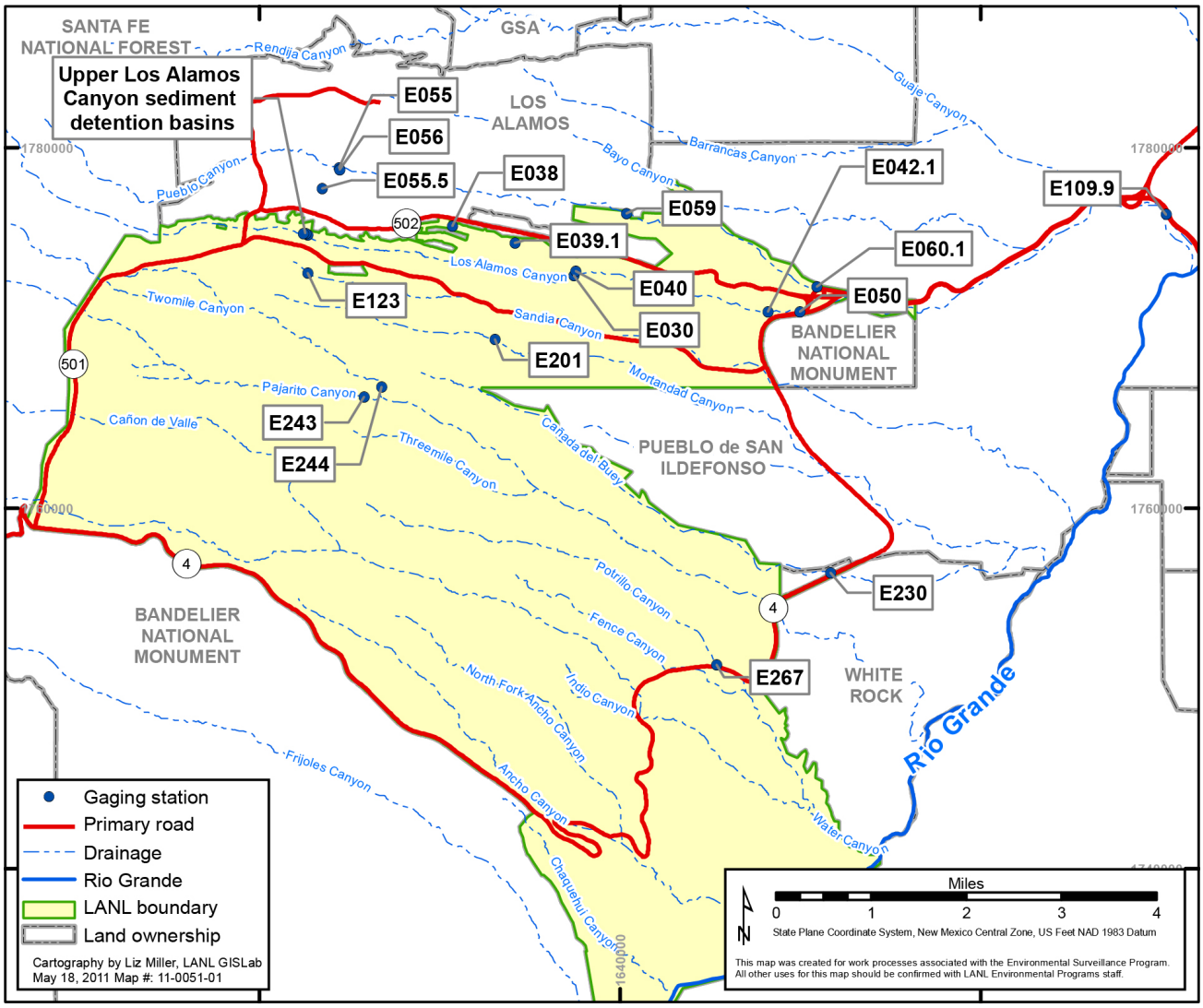

Figure 6-4 Surface water locations sampled in 2010 as part of the Environmental Surveillance Program and the Los Alamos and Pueblo Canyons monitoring plan

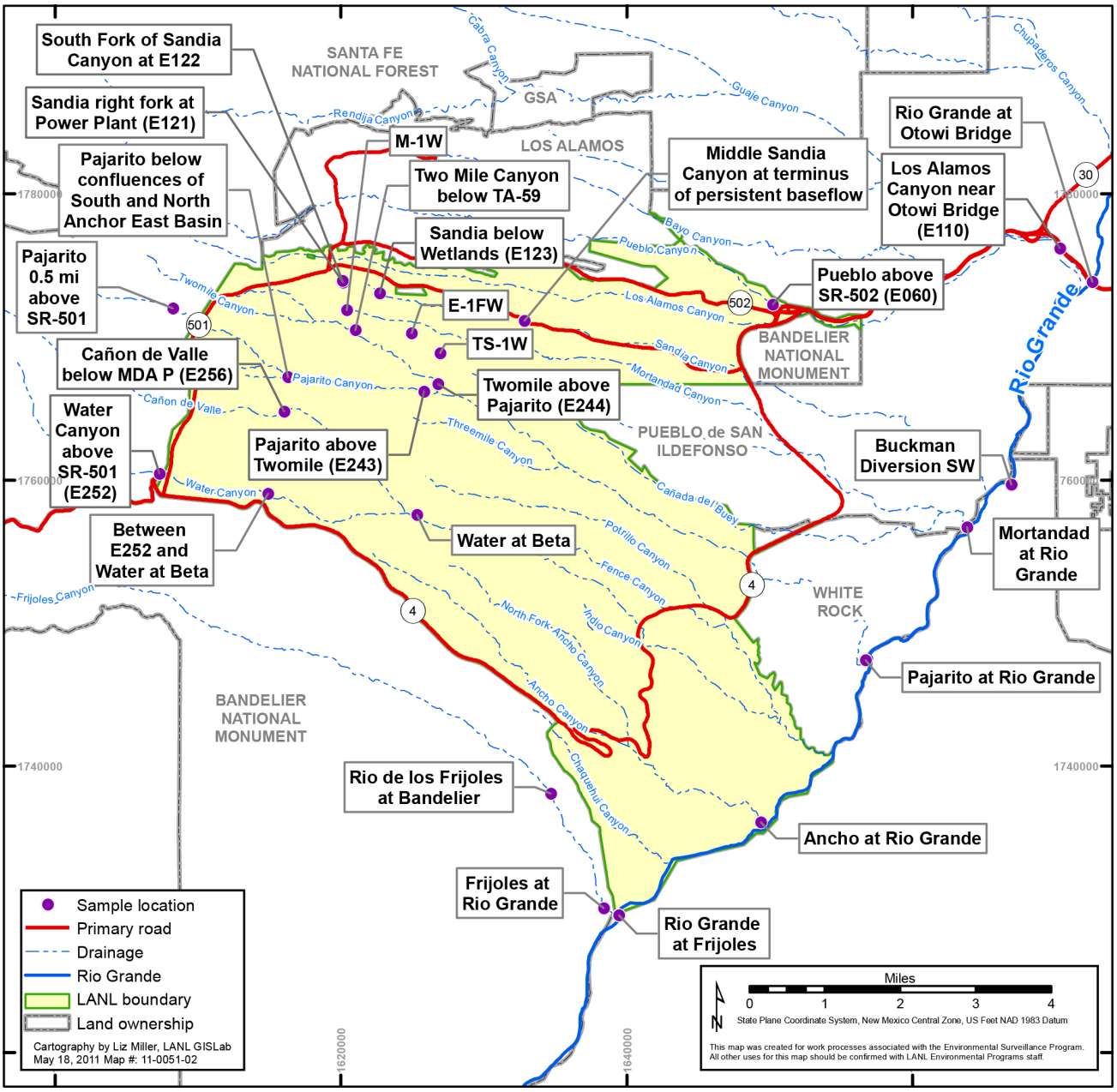

Figure 6-5 Surface water locations sampled in 2010 as part of the IFWGMP and in support of the BDD project

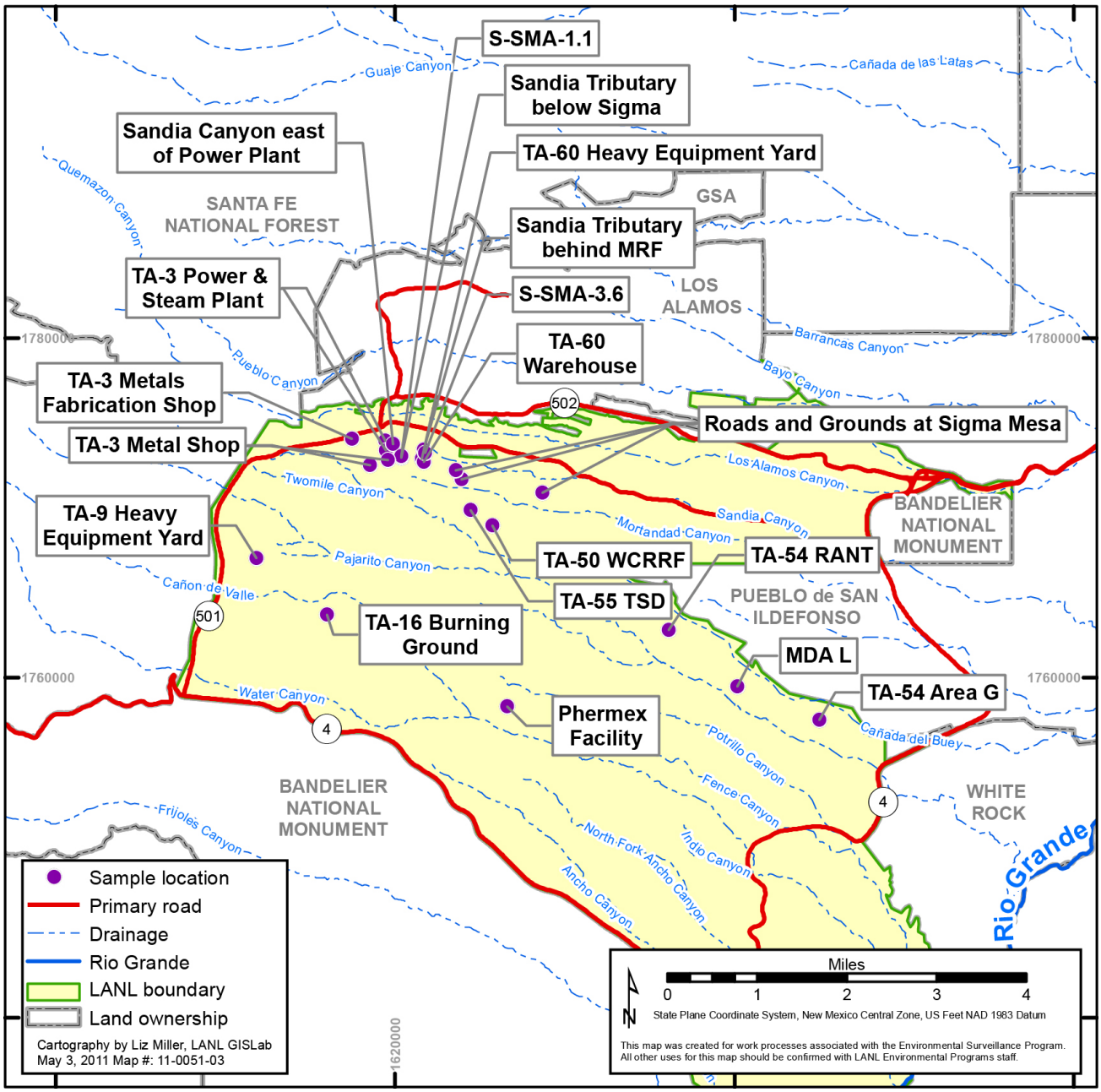

Figure 6-6 Surface water locations sampled in 2010 under the MSGP and at IP SMAs

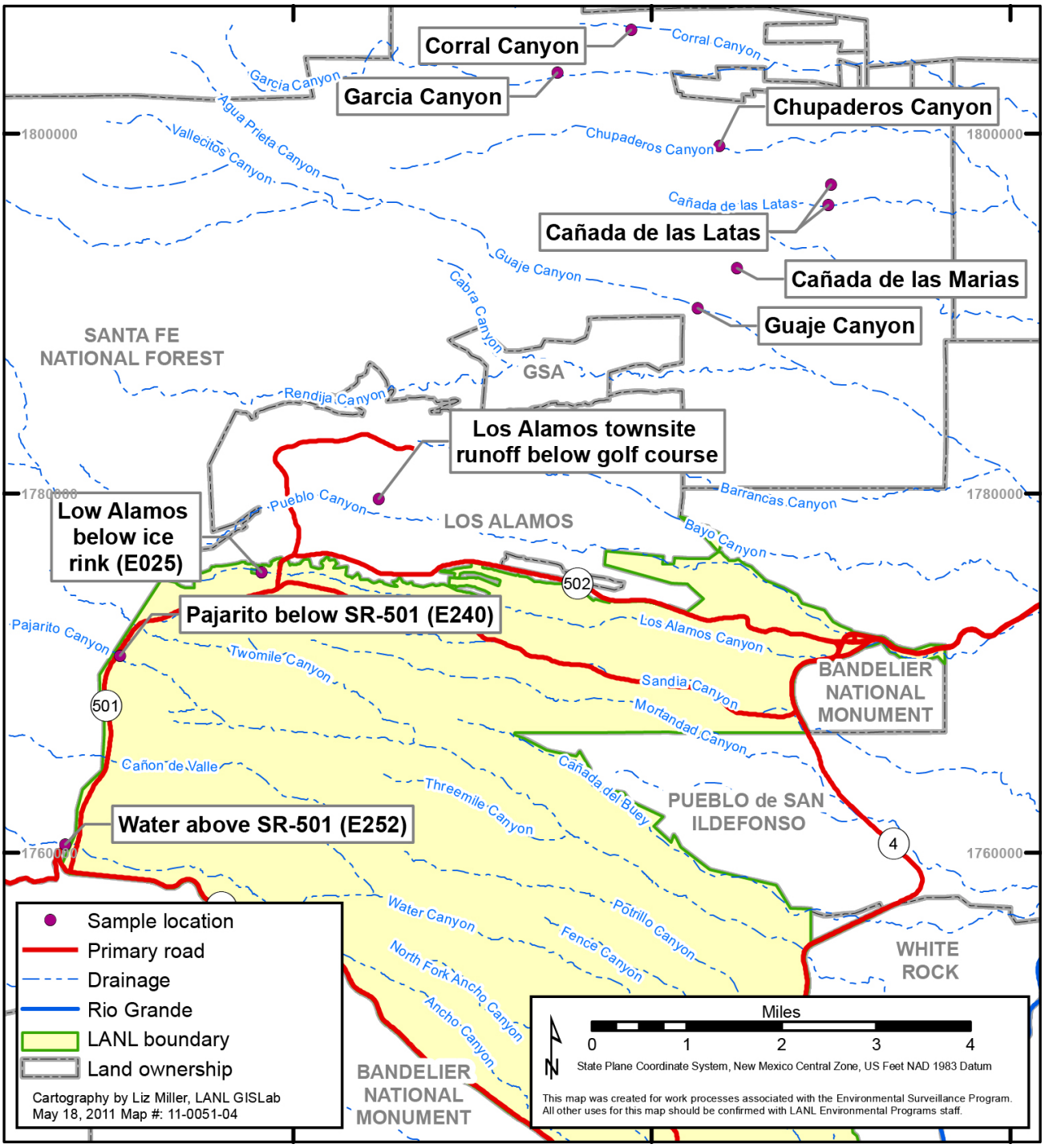

Figure 6-7 Surface water locations sampled in 2010 as part of a baseline PCB, metals, and gross alpha radiation study

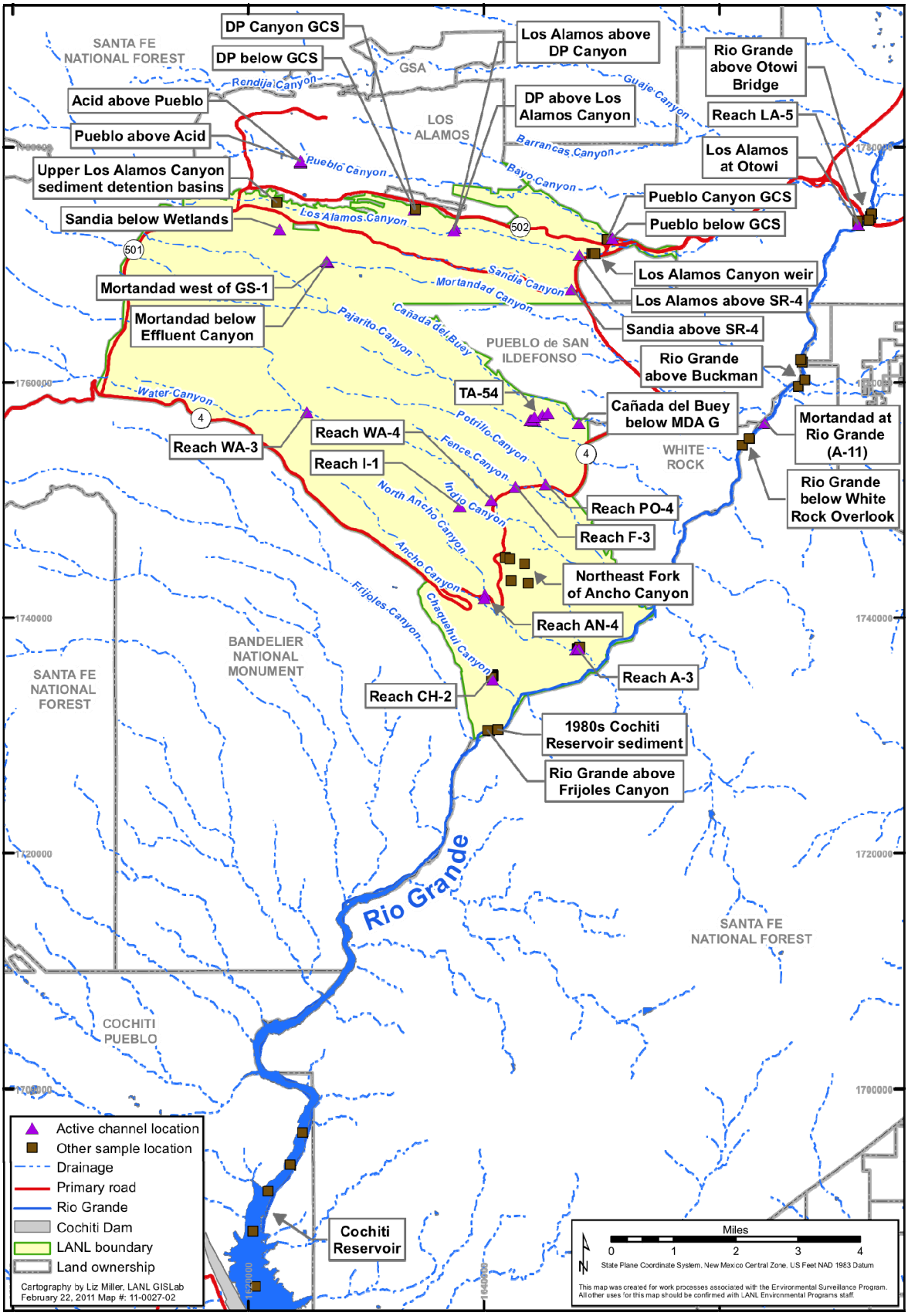

Figure 6-8 Sediment locations sampled in 2010 within and in the vicinity of LANL

Additionally, surface water and sediment were sampled at several locations on Pueblo de San Ildefonso lands in canyons draining the Laboratory. 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 drainages that pass from LANL onto Pueblo de San Ildefonso land are Bayo, Los Alamos, Mortandad, Pueblo, and Sandia Canyons and Cañada del Buey.

In 2010, we collected sediment samples from dry stream beds on the Pajarito Plateau to a depth of 2 to 37 cm, depending on the thickness of the uppermost sediment layer. For flowing streams, samples were collected from near the edge of the main channel. Locations outside the main stream channel were also sampled to variable depths in hand-dug holes, up to 65 cm deep in the sediment retention basins above the Los Alamos weir. Additional samples of older fine-grained sediment were collected in Ancho and Chaquehui Canyons and from hand-dug holes and stream banks to depths of up to 86 cm to evaluate PCB congeners.

2. Regional Monitoring Locations

Regional base flow and sediment sampling stations for 2010 were located along a 19-km long stretch of the Rio Grande, extending from immediately upriver of Otowi Bridge and Los Alamos Canyon to near Frijoles Canyon, downriver of all canyons draining LANL. Samples from upriver stations reflect baseline concentrations and provide a basis for evaluating potential Laboratory impacts to the Rio Grande. In 2010, we collected sediment samples from four areas along the Rio Grande, one area upgradient from the Laboratory (above Otowi Bridge), and three areas down gradient (above Buckman, below the White Rock Overlook, and between Chaquehui and Frijoles Canyons; Figure 6-8). Deposits of fine-grained sediment along the Rio Grande were sampled from the sides of shallow hand-dug holes to depths of up to 58 cm, after identifying the probable base of the 2010 sediment. Sediment samples were collected from Cochiti Reservoir using a clam shell (Ponar) grab sampler. Samples were also collected near the Rio Grande from a hand-dug hole in an area near Frijoles Canyon where sediment was deposited during high water conditions in Cochiti Reservoir in the 1980s (Figure 6-8). These latter samples extended to a depth of 75 cm and provide a comparison of modern sediment with conditions existing several decades ago. In addition, in 2010 LANL collected paired surface water samples from the Rio Grande (above Otowi Bridge and above Buckman; Figure 6-5) in three sampling events and two other Rio Grande samples (above Otowi Bridge and at Frijoles Canyon).

3. Surface Water Sampling Procedures

The procedures for surface water sampling depend on the type of stream flow and location. Grab samples of base flow and snowmelt runoff are collected from free-flowing streams near the bank. The grab samples are either filtered or left unfiltered and preserved in the field. Stream gages, located mostly in canyon bottoms, are equipped with automated ISCO samplers that are activated at the start of significant storm water runoff events. Typically, the automated samplers collect water from the first 30 minutes of the runoff event to sample water near the leading edge of flood bores, also called the "first flush." This is the seventh year that the first flush of storm water has been sampled at many stations, and it is a significant change from previous years (2003 and earlier) when samples were collected over a two-hour period. Higher concentrations occur in the first flush compared with the average concentration during a flow event because suspended sediment concentration is highest near the flood bore (Malmon et al. 2004, 2007). As a result, these post-2003 data are not directly comparable to data from previous years. Beginning in 2010, LANL also collected multiple storm water samples through hydrographs at many gages to evaluate variations in suspended sediment and contaminant concentrations during individual runoff events. All storm water samples are filtered and preserved in LANL's storm water operations facility because filtering highly sediment-laden waters in the field is difficult. These samples are then shipped to commercial analytical laboratories without compositing or splitting the samples.

E. SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables on the included compact disk present all the 2010 watershed-related surface water and sediment analytical results. The tables present radiological results in sequence for each of these

media and then present the results for major water quality analytes and inorganic and organic chemicals. Samples are analyzed for gross alpha and gross beta radiation and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, uranium-235/236, uranium-238, tritium, cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22). The tables also list the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity, where available. For most radionuclide measurements, a detection is an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (indicating not detected). The tables and their contents are as follows:

- Table S6-1 -- presents the results of radiochemical analyses of surface water for 2010.
- Table S6-2 -- presents the results of radiochemical analyses of sediment.
- Table S6-3 -- presents the concentrations of major chemical constituents in surface water.
- Tables S6-4 and S6-5 -- present results of inorganic chemical analyses for surface water and sediment, respectively.
- Table S6-6 -- presents the number and type of organic chemical analyses performed on surface water samples.
- Table S6-7 -- presents all detected organic chemical results in surface water.
- Tables S6-8 and S6-9 --present summaries of organic chemical analyses of sediment samples.
- Table S6-10 -- presents results of particle size analyses of the sediment samples.

Particle size analyses were obtained on all sediment samples because particle size distribution can have a strong effect on contaminant concentrations, and particle size data are useful in understanding differences in chemical and radionuclide concentrations between samples. Many contaminants released into the environment tend to preferentially adsorb onto the smallest particles (e.g., silt and clay), and contaminant concentrations will be highest where the finest-grained sediment is deposited. For example, coarse-grained sediment deposited in an active stream channel can have much lower contaminant concentrations than fine-grained sediment deposited on an adjacent floodplain during the same runoff event.

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).

Of the more than 100 analytes reported in sediment and surface water within the Laboratory, most are at concentrations below standards or screening levels. However, every major watershed has some impact from Laboratory operations. The following sections present a Laboratory-wide overview of surface water and sediment quality and then discuss the key findings in more detail on a watershed-by-watershed basis. It should be noted that analytical results that are above standards or screening levels can be derived from a variety of sources including Laboratory releases, runoff from developed areas such as the Los Alamos town site, naturally occurring radionuclides and chemicals, or "false positives" from analytical laboratories. It is not always possible to identify specific sources, and results above standards or screening levels are considered to represent potential Laboratory impacts unless the evidence is compelling for non-LANL sources.

1. Radionuclides and Radioactivity in Surface Water and Sediment

a. Surface water

During 2010, the Laboratory obtained analytical data on radionuclides and/or radioactivity from 211 surface water samples at 71 locations on the Pajarito Plateau. At some locations, multiple samples were collected during single runoff events to evaluate how concentrations of sediment and potential contaminants varied through events. An additional eight samples were collected at three locations along the Rio Grande.

Table 6-3 presents a summary of results for Pajarito Plateau samples from 2010 that exceed standards or that have known sources at Laboratory sites. No results exceeded applicable BCGs in these samples.

Table 6-3
Summary of Results for Select Radionuclides and Radioactivity in Non-Filtered Surface Water Samples from the Pajarito Plateau in 2010

Analyte	Standard or Guide (pCi/L)[a]	Percentage of Samples with Detected Results Above Standard or Guide	Master Watersheds with Detected Results Above Standard or Guide	Notes
Gross alpha radiation	15 (lw)	56%	Los Alamos, Mortandad, Pajarito, Sandia, and Water Canyons, and several non-LANL canyons	NMWQCC impaired listing for many canyons; above standard in non-LANL affected stream segments, including three highest results from 2010 (481 to 1,090 pCi/L), indicating elevated local background
Americium-241	438 (aa) 1,460 (ra) 202,000 (ta)	0%	None	Maximum result (6.91 pCi/L), from Los Alamos Canyon below a former outfall at TA-21, is 0.003% of terrestrial BCG
Cesium-137	20,000 (sr)	0%	None	Maximum result (283 pCi/L), from Mortandad Canyon below the TA-50 RLWTF[b] outfall, is 1.4% of LANL-specific BCG
Plutonium-238	176 (aa) 551 (ra) 189,000 (ta)	0%	None	Maximum result (33.1 pCi/L), from Mortandad Canyon below the TA-50 RLWTF outfall, is 0.02% of terrestrial BCG
Plutonium-239/240	187 (aa) 622 (ra) 201,000 (ta)	0%	None	Maximum result (150 pCi/L), from Acid Canyon below former TA-1 and TA-45 outfalls, is 0.08% of terrestrial BCG
Radium-226 + Radium-228	30 (lw)	2%	Corral Canyon	Single result above standard (37.8 pCi/L), from background area
Strontium-90	30,000 (sr)	0%	None	Maximum result (137 pCi/L), from DP Canyon below a former outfall at TA-21, is 0.5% of LANL-specific BCG
Uranium-234	202 (aa) 684 (ra) 405,000 (ta)	0%	None	Maximum result (18.9 pCi/L), from Los Alamos Canyon near the Rio Grande, is 0.005% of terrestrial BCG; may represent natural background
Uranium-235/236	218 (aa) 737 (ra) 420,000 (ta)	0%	None	Maximum result (1.54 pCi/L), from Pueblo Canyon above the WWTP, is 0.0004% of terrestrial BCG; may represent natural background
Uranium-238	224 (aa) 757 (ra) 406,000 (ta)	0%	None	Maximum result (20.4 pCi/L), from Los Alamos Canyon near the Rio Grande, is 0.005% of terrestrial BCG; may represent natural background

[a] aa = BCG for aquatic animal; lw = livestock watering standard ; ra = BCG for riparian animal; sr = LANL-specific site-representative BCG; ta = BCG for terrestrial animal.

[b] RLWTF = Radioactive Liquid Waste Treatment Facility.

Consistent with previous years, many surface water samples in 2010 had gross alpha radiation levels above the NMWQCC surface water standard of 15 pCi/L for livestock watering. Of the 114 non-filtered storm water samples analyzed from the Pajarito Plateau for gross alpha radiation, 56% exceeded 15 pCi/L, including background sample sites with no upstream releases of radionuclides from Laboratory activities. For example, the three highest concentrations, 481 to 1,090 pCi/L, were measured in storm water samples collected from Corral Canyon, Garcia Canyon, and Cañada de las Marias on Santa Fe National Forest land north of Los Alamos. The analytical results from 2010 support earlier conclusions that the majority of the alpha radiation in surface water on the plateau is due to the decay of naturally occurring isotopes in sediment and soil from uncontaminated areas carried in storm water runoff and that Laboratory impacts are relatively small (e.g., Gallaher 2007). Naturally occurring radionuclides that are alpha emitters include isotopes of radium,

thorium, and uranium. As noted previously, livestock watering does not occur at the Laboratory except for some feral cows near the Rio Grande.

One surface water sample collected in 2010 had the sum of radium-226 and radium-228 above the livestock watering standard of 30 pCi/L. This was a storm water sample collected from Corral Canyon, a background area on Santa Fe National Forest land north of Los Alamos, with 37.8 pCi/L radium-226 and radium-228.

Gross alpha radioactivity is a general screening measurement of limited value in assessing radiological hazards because this measurement does not identify or quantify specific alpha emitters in water samples. Therefore, gross alpha radiation results are not discussed in detail in this report. The naturally occurring radium isotopes are also not discussed further. Instead, this report focuses on specific individual radionuclides identified in LANL waste streams from prior work.

The maximum concentrations of americium-241, cesium-137, plutonium-238, plutonium-239/240, and strontium-90 in surface water samples in 2010 were measured in storm water during the summer monsoon season at different locations in Acid, DP, Los Alamos, and Mortandad canyons, downstream from facilities that have released radioactive effluents. These results are summarized in Table 6-3 and discussed in Sections F.1 and F.3. All of these results are consistent with prior data from these canyons. In contrast, the highest concentration of tritium was measured in the Rio Grande above Otowi Bridge, upriver of LANL sources and indicating a source in regional atmospheric fallout. The highest concentrations of uranium-234, uranium-235/236, and uranium-238 were measured in storm water samples from Los Alamos and Pueblo Canyons, a watershed where there was relatively little use of uranium at Laboratory facilities. The close relationships in these samples of uranium isotope concentrations to suspended sediment concentrations, with no difference between different sample locations, supports a natural origin for this uranium (LANL 2011c).

b. Sediment

Analytical data on radionuclides in sediment were obtained from 60 samples in 2010 as part of the annual surveillance program, including 30 samples from canyons draining the Pajarito Plateau, 20 samples from banks, bars, and slackwater areas along the Rio Grande, and 10 samples from Cochiti Reservoir sediment. The Pajarito Plateau samples were mostly from active channel locations that are typically dominated by coarse-grained sediment and also included fine-grained sediment at several locations. The Rio Grande and Cochiti Reservoir samples were all fine-grained sediment.

Eight radionuclides were measured at concentrations greater than the LANL sediment background values in the 2010 environmental surveillance samples from the Pajarito Plateau, in Acid, Los Alamos, and Mortandad canyons. A summary of sediment results for Pajarito Plateau from 2010 that exceed background values is presented in Table 6-4, and these results are discussed further in Sections F.1 and F.3. Note that the percentage of samples with results above background values is biased high because of the tailoring of analytical suites to known contaminants in each watershed in the annual surveillance samples. In addition to the Pajarito Plateau samples, four of the five samples collected from the bottom of Cochiti Reservoir had plutonium-239/240 concentrations above the regional reservoir background of McLin and Lyons (2002). No sediment results from 2010 were greater than BCGs. These results are all consistent with previous sampling events (e.g. Reneau and Kuyumjian 2009; Reneau et al., 2010).

Table 6-4
Summary of Results for Select Radionuclides in Pajarito Plateau Sediment Samples from 2010

Analyte	Sediment Background Value (pCi/g*)	Percentage of Samples with Detected Results Above Background Value	Master Watersheds with Detected Results Above Background Value	Notes
Americium-241	0.040	36%	Los Alamos, Mortandad, and Pajarito Canyons	Maximum result (0.876 pCi/g) is from the Mortandad Canyon stream channel below the TA-50 RLWTF
Cesium-137	0.90	25%	Los Alamos and Mortandad Canyons	Maximum result (5.65 pCi/g) is from the Mortandad Canyon stream channel below the TA-50 RLWTF
Plutonium-238	0.006	29%	Los Alamos, Mortandad, Pajarito, and Water Canyons	Maximum result (0.43 pCi/g) is from the Mortandad Canyon stream channel below the TA-50 RLWTF
Plutonium-239/240	0.068	47%	Los Alamos, Mortandad, and Pajarito Canyons	Maximum result (7.43 pCi/g) is from the Acid Canyon stream channel below former outfalls at TA-1 and TA-45
Strontium-90	1.04	4%	Los Alamos Canyon	Single result above background (1.13 pCi/g) is from the sediment retention basins above the Los Alamos Canyon weir, below a former wastewater treatment facility at TA-21
Uranium-234	2.59	5%	Los Alamos Canyon	Maximum result (21.7 pCi/g) is from the upper Los Alamos Canyon sediment detention basins, below SWMU 01-001(f)
Uranium-235/236	0.20	5%	Los Alamos Canyon	Maximum result (1.7 pCi/g) is from the upper Los Alamos Canyon sediment detention basins, below SWMU 01-001(f)
Uranium-238	2.29	5%	Los Alamos Canyon	Maximum result (24.5 pCi/g) is from the upper Los Alamos Canyon sediment detention basins, below SWMU 01-001(f)

*pCi/g = Picocuries per gram.

2. Inorganic Chemicals in Surface Water and Sediment

a. Surface Water

During 2010, the Laboratory obtained analytical data on metals and other inorganic chemicals from 173 surface water samples at 74 locations on the Pajarito Plateau. At some locations, multiple samples were collected during single runoff events to evaluate how concentrations of sediment and potential contaminants varied through events. An additional eight samples were collected at three locations along the Rio Grande. These data were compared with various standards and screening levels, as discussed in Section C.3. Some of these screening levels are for dissolved constituents, which are compared with filtered sample results, and some are for totals, which are compared with non-filtered sample results. A total of eight inorganic chemicals had maximum concentrations above screening levels. Under the Clean Water Act §303(d) list, the NMWQCC listed parts of one or more canyons within or near LANL as impaired for six metals: aluminum, arsenic, copper, mercury, silver, and zinc (NMWQCC 2010). These metals are discussed below, along with other inorganic chemicals that have results above standards or screening levels. Table 6-5 presents a summary of results and their significance for these inorganic chemicals.

Table 6-5
Summary of Results for Select Inorganic Chemicals
in Surface Water Samples from the Pajarito Plateau in 2010

Metal	Sample Preparation	Standard (µg/L)*	Percentage of Samples with Detected Results Above Standard*	Master Watersheds with Detected Results Above Standards	Notes
Aluminum	Filtered	750 (aa) 87 (ca)	30% (aa) 80% (ca)	Ancho, Los Alamos, Mortandad, Pajarito, Sandia, and Water canyons and several non-LANL canyons	NMWQCC impaired listing for many canyons; above standards in non-LANL affected stream segments, indicating elevated local background; maximum result (14,000 µg/L) is from Effluent Canyon below TA-46
Arsenic	Filtered	9 (hh)	2% (hh)	Los Alamos and Sandia canyons	NMWQCC impaired listing in Ten Site Canyon, but no results above standard in this canyon; elevated arsenic probably derived from natural sources and runoff from developed areas; maximum result (29.3 µg/L) is from Los Alamos Canyon near the Rio Grande
Cadmium	Filtered	2.0 (aa) 0.25 (ca)	2% (ca)	Chupaderos and Los Alamos canyons	Single result above standard (1.1 µg/L) from LANL in DP Canyon above TA-21, which receives runoff from Los Alamos town site; also one result above the standard (used a screening level) from a background area
Chromium	Filtered	570 (aa) 74 (ca)	1% (ca)	Mortandad Canyon	Single result above standard (146 µg/L) from Effluent Canyon below TA-46, a known source for chromium
Copper	Filtered	13.4 (aa) 9.0 (ca)	3% (aa) 5% (ca)	Mortandad and Sandia canyons	NMWQCC impaired listing for many canyons; results above standards are from sites that receive runoff from developed areas; maximum result (15.6 µg/L) is from the upper part of Mortandad Canyon below TA-3
Mercury	Non-filtered	0.77 (wh)	1% (wh)	Los Alamos Canyon	NMWQCC impaired listing for several canyons; single results above standard from two locations; maximum result (1 µg/L) is from the south fork of Acid Canyon
Selenium	Non-filtered	5.0 (wh and ca)	2% (wh and ca)	Mortandad and Sandia canyons	Single results above standard from two locations; maximum result (15.3 µg/L) is from upper Sandia Canyon
Silver	Filtered	3.2 (aa)	0%	none	NMWQCC impaired listing in Ten Site Canyon, but no results above standard at any location
Zinc	Filtered	117 (aa) 118 (ca)	2% (aa) 2% (ca)	Los Alamos and Sandia canyons	NMWQCC impaired listing for several canyons; single results above standard from two locations that receive runoff from developed areas; maximum result (246 µg/L) is from DP Canyon below TA-21

* aa = acute aquatic life standard; ca = chronic aquatic life standard; hh = human health standard; wh = wildlife habitat standard.

The screening level for aluminum is based on aluminum dissolved in the water column, and filtered surface water samples collected on the Pajarito Plateau in 2010 commonly contained aluminum concentrations above the acute aquatic life standard of 750 µg/L and the chronic aquatic life standard of 87 µg/L. However, most or all of this aluminum may be naturally occurring (e.g., Reneau et al., 2010). For example, Water Canyon above NM 501, upstream from Laboratory operations, had 4,900 and 381 µg/L aluminum in two samples collected in 2010. Similarly, a sample from the perennial stream in Frijoles Canyon in Bandelier National Monument had 922 µg/L aluminum. Aluminum is a natural component of soil and is not known to be derived from Laboratory operations in any significant quantity. The NMED Surface Water Quality Bureau

has also noted that "the large number of exceedances" for aluminum on the Pajarito Plateau "may reflect natural sources associated with the geology of the region" and that aluminum also exceeds 750 μg/L in other parts of the Jemez area (NMED 2009).

The screening level for arsenic is based on arsenic dissolved in the water column. Two filtered surface water samples collected on the Pajarito Plateau in 2010 had arsenic above the human health standard. The highest concentration was measured in Los Alamos Canyon near the Rio Grande. The absence of arsenic above the standard in the Los Alamos Canyon watershed closer to LANL sources indicates that this arsenic is probably derived from natural sources. The other sample, in the north fork of Sandia Canyon (gage E122) below developed areas at LANL's TA-3, had arsenic <5% above the standard. Ten Site Canyon is listed as impaired for arsenic by the NMWQCC, but arsenic was not detected in the single filtered surface water sample collected from this canyon in 2010.

The screening level for copper is based on copper dissolved in the water column, and six filtered surface water samples from the Pajarito Plateau in 2010 had copper results above aquatic life standards. These results are from the watersheds of Mortandad and Sandia canyons from sites that receive runoff from developed areas. No results from a designated perennial stream segment on the Pajarito Plateau contained copper concentrations above the chronic aquatic life standard. The sources of copper in LANL watersheds have not been thoroughly evaluated, but its spatial distribution indicates copper is at least partly derived from runoff from developed areas.

The screening level for mercury is based on total mercury. Two non-filtered surface water samples collected from the Pajarito Plateau in 2010 contained detected mercury concentrations above the wildlife habitat standard. The highest result was from a sample collected from the south fork of Acid Canyon (gage E055.5). Three other samples from this location in 2010 had mercury below the standard, and results from 2009 were also below the standard. The other result above the standard was from Los Alamos Canyon above DP Canyon (gage E040). Three other samples from this location in 2010 also had mercury below the standard. These two canyons are listed as impaired for mercury by the NMWQCC, and the results indicate relatively infrequent exceedances of standards in these canyons.

The screening level for silver is based on silver dissolved in the water column, and no filtered surface water samples collected from the Pajarito Plateau in 2010 contained detected silver concentrations above standards. Although Ten Site Canyon is listed as impaired for silver by the NMWQCC, silver concentrations in this canyon are below the standard.

The screening level for zinc is based on zinc dissolved in the water column. Two of the filtered surface water samples collected from the Pajarito Plateau in 2010 had detected results above aquatic life standards. The highest zinc concentration was from DP Canyon below the grade-control structure (GCS) (gage E039.1), and three other samples from this location in 2010 had zinc concentrations below the standards. The other result above the standards was from an SMA in Sandia Canyon, which includes runoff from developed areas at TA-3. Although Acid, Los Alamos, and Ten Site canyons are listed as impaired for zinc by the NMWQCC, the 2010 surface water data did not indicate any concerns with zinc in these canyons.

In addition to the metals discussed above, three other metals, cadmium, chromium, and selenium, exceeded a standard in surface water samples. The screening level for cadmium is based on cadmium dissolved in the water column. Two filtered surface water samples collected on the Pajarito Plateau in 2010 had cadmium results above the chronic aquatic life standard. These results are from the watersheds of Chupaderos and Los Alamos canyons. The highest value was obtained from DP Canyon above TA-21 (gage E038), a location that receives runoff from urban areas in the Los Alamos town site. The second result is from a background area in Chupaderos Canyon on Santa Fe National Forest land north of Los Alamos. These results indicate that the source of the cadmium is a combination of urban runoff and naturally occurring soils.

The screening level for chromium is based on chromium dissolved in the water column. One filtered surface water sample collected on the Pajarito Plateau in 2010 had chromium above the chronic aquatic life standard. This result was from a base flow sample collected from the upper part of Effluent Canyon below TA-46

(reach E-1FW). TA-46 is a known source for chromium at the Laboratory (LANL 2006a). A second sample from this location in 2010 had chromium below the standard.

The screening level for selenium is based on total recoverable selenium. Two non-filtered surface water samples collected from the Pajarito Plateau in 2010 contained detected selenium above standards. The highest result was from a sample collected from the north fork of Sandia Canyon (gage E122). Two other samples from this location in 2010 had selenium below the standards, and results from 2009 were also below the standards. The other result above the standards was from Cañada del Buey above NM 4. Two other samples from this location in 2010 and others in 2009 also had selenium below the standards.

b. Sediment

For metals and other inorganic chemicals in sediment, analytical data were obtained from 29 samples collected on the Pajarito Plateau in 2010 as part of the annual surveillance program. These samples were mostly from active channel locations that are typically dominated by coarse-grained sediment and also included fine-grained sediment at several locations. In addition, 10 other active channel samples were collected as part of sediment investigations in the Ancho, Chaquehui, and Water canyon watersheds and are included in the data set examined here. Table 6-6 presents a summary of results for inorganic chemicals in Pajarito Plateau sediment samples from 2010 that exceed background values.

Table 6-6
Summary of Results for Select Inorganic Chemicals in Pajarito Plateau Sediment Samples from 2010

Analyte	Sediment Background Value (mg/kg)	Percentage of Samples with Detected Results Above Background Value	Master Watersheds with Detected Results Above Background Value	Notes
Antimony	0.83	8%	Los Alamos, Sandia, and Pajarito canyons	Maximum result (3.63 mg/kg) is from the MDA G-7 drainage at TA-54
Barium	127	3%	Los Alamos Canyon	Single result above background (182 mg/kg) is from lower Los Alamos Canyon and probably represents naturally occurring barium
Cadmium	0.4	5%	Los Alamos and Mortandad canyons	Maximum result (0.803 mg/kg) is from the Acid Canyon stream channel below former outfalls at TA-1 and TA-45 and the Los Alamos town site
Calcium	4,420	5%	Los Alamos Canyon	Both results above background (7280 and 8700 mg/kg) are from lower Los Alamos Canyon and probably represent naturally occurring calcium
Chromium	10.5	13%	Los Alamos, Mortandad, and Sandia canyons	Maximum result (67.1 mg/kg) is from the Sandia Canyon stream channel below the TA-3 power plant
Cobalt	4.73	8%	Los Alamos and Mortandad Canyons	Maximum result (7.04 mg/kg) is from the Cañada del Buey stream channel and probably represents naturally occurring cobalt
Copper	11.2	10%	Los Alamos Canyon	Maximum result (13.8 mg/kg) is from the sediment retention basins above the Los Alamos Canyon weir, below several LANL TAs and the Los Alamos town site
Iron	13,800	3%	Mortandad Canyon	Single result above background (21,200 mg/kg) is from the Cañada del Buey stream channel and probably represents naturally occurring iron
Lead	19.7	13%	Los Alamos Canyon	Maximum result (53.4 mg/kg) is from the Acid Canyon stream channel below former outfalls at TA-1 and TA-45 and the Los Alamos town site
Magnesium	2,370	5%	Los Alamos Canyon	Both results above background (2,420 and 3,250 mg/kg) are from lower Los Alamos Canyon, and probably represent naturally occurring magnesium

Table 6-6 (continued)

Analyte	Sediment Background Value (mg/kg)	Percentage of Samples with Detected Results Above Background Value	Master Watersheds with Detected Results Above Background Value	Notes
Manganese	543	3%	Los Alamos Canyon	Single result above background (655 mg/kg) is from the Acid Canyon stream channel below former outfalls at TA-1 and TA-45 and the Los Alamos town site
Mercury	0.1	3%	Sandia Canyon	Single result above background (0.105 mg/kg) is from the Sandia Canyon stream channel below the TA-3 power plant
Selenium	0.3	3%	Los Alamos Canyon	Single result above background (0.795 mg/kg) is from the sediment retention basins above the Los Alamos Canyon weir, below several LANL TAs and the Los Alamos town site
Silver	1	3%	Sandia Canyon	Single result above background (1.64 mg/kg) is from the Sandia Canyon stream channel below the TA-3 power plant
Vanadium	19.7	10%	Los Alamos and Mortandad canyons	Maximum result (37 mg/kg) is from the Cañada del Buey stream channel and probably represents naturally occurring vanadium
Zinc	60.2	16%	Los Alamos, Mortandad, and Sandia canyons	Maximum result (105 mg/kg) is from the sediment retention basins above the Los Alamos Canyon weir, below several LANL TAs and the Los Alamos town site

In 2010, 16 metals and other inorganic chemicals were detected in sediment at concentrations above the LANL sediment background values. Maximum results for these inorganic chemicals were obtained at six different locations in Acid, Los Alamos, Pajarito, and Sandia canyons and Cañada del Buey. Several of these results probably indicate background variability. For example, the highest concentrations of cobalt, iron, and vanadium were measured in a coarse-grained active channel sample from Cañada del Buey. These elements are all elevated in black magnetite-rich sands that are common on the Pajarito Plateau (Reneau et al., 1998a), and the presence of black sands in this sample was noted in the field. The highest concentrations of barium, calcium, and magnesium were measured in a fine-grained sample from lower Los Alamos Canyon near the Rio Grande, and these are not recognized as contaminants upstream. Instead, the source of these constituents was probably floods emanating from Guaje Canyon, where geologic units are different than on the Pajarito Plateau at LANL.

Other results for inorganic chemicals in sediment samples are consistent with known contamination at LANL. The maximum results for chromium, mercury, and silver were measured in an active channel sample from upper Sandia Canyon, below the TA-3 power plant, and are consistent with previous results (e.g., LANL 2009c). The maximum result for antimony came from a sample collected from a small drainage below MDA G at TA-54 within the Pajarito Canyon watershed, which is consistent with results from prior surveillance sediment samples (e.g., Reneau et al., 2010). The maximum results for cadmium, lead, and manganese were obtained from an active channel sample in Acid Canyon, where these metals have been previously identified as above background concentrations (LANL 2004). The maximum concentrations of copper, selenium, and zinc were obtained from fine-grained sediments deposited above the Los Alamos Canyon weir. Copper and zinc have been previously detected above background concentrations at this site (LANL 2008b). The Acid Canyon and Los Alamos Canyon weir locations both receive runoff from both present or former LANL TAs and the Los Alamos town site, and the metals detected above background concentrations at these locations may have both LANL and town site sources.

3. Organic Chemicals in Surface Water and Sediment

a. Surface Water

During 2010, the Laboratory obtained analytical data on organic chemicals from 185 surface water samples at 61 locations on the Pajarito Plateau. At some locations, multiple samples were collected during single runoff events to evaluate how concentrations of sediment and potential contaminants varied through events. An additional eight samples were collected at three locations along the Rio Grande. The analyses included the following suites: dioxins and furans, explosive compounds, pesticides, PCBs, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). These data were compared with various screening levels, as discussed in Section C.3. Under the federal Clean Water Act §303(d) list, the NMWQCC has listed parts of several canyons within or near LANL as impaired for PCBs (NMWQCC 2010). A summary of results for organic chemicals exceeding standards is presented in Table 6-7, and results from all organic chemical analyses in surface water are discussed below.

Table 6-7
Summary of Results for Organic Chemicals in Non-Filtered Surface Water Samples from the Pajarito Plateau in 2010

Analyte and Method	Standard (µg/L) *	Percentage of Samples with Detected Results Above Standard *	Master Watersheds with Detected Results Above Standard	Notes
PCBs by Aroclor Method	0.00064 (hh) 0.014 (wh)	5% (hh) 5% (wh)	Sandia Canyon	Arolcor-1260 detected in one sample from a small drainage in the upper Sandia Canyon watershed, at 0.095 µg/L
PCBs by Congener Method	0.00064 (hh) 0.014 (wh)	82% (hh) 57% (wh)	Los Alamos, Mortandad, Pajarito, and Sandia canyons, and several non-LANL-affected canyons	Maximum result, 15.1 µg/L, from upper Los Canyon sediment detention basin below SWMU 01-001(f); human health standard exceeded in background areas north of Los Alamos associated with atmospheric fallout and also in areas receiving runoff from Los Alamos town site and other developed areas

*hh = Human health standard; wh = wildlife habitat standard.

Analyses for dioxins and furans were obtained from 47 non-filtered surface water samples collected at 18 locations on the Pajarito Plateau in 2010. One or more dioxin or furan congeners were detected in 40 of these samples from 15 locations in Acid, DP, Effluent, Los Alamos, Pajarito, Pueblo, and Twomile canyons. Maximum results for different congeners were obtained from four locations: Los Alamos Canyon above the weir (gage E042.1), the south fork of Acid Canyon (gage E055.5), Pueblo Canyon above Acid Canyon (gage E056), and upper Effluent Canyon (reach E-1FW). None of these results were above standards.

For explosive compounds, analyses were obtained from 16 non-filtered storm water samples collected at 11 locations on the Pajarito Plateau in 2010. A total of eight different explosive compounds were detected at five locations in Cañon de Valle, Pajarito Canyon, and Water Canyon. The highest concentrations of each were measured in Cañon de Valle below MDA P, downstream from a high-explosive machining facility at TA-16. None of these results were above standards.

For pesticides, analyses were obtained from six non-filtered surface water samples collected at two locations along the Rio Grande in 2010. No pesticides were detected in these samples.

For PCBs, analyses were obtained in 2010 using both the Aroclor method (EPA method 8082) and the congener method (EPA method 1668A). Aroclor analyses were obtained from 22 non-filtered surface water samples collected at 15 locations on the Pajarito Plateau, and Aroclor-1260 was detected in one of these samples from Sandia Canyon. Aroclor analyses were also obtained from three samples at two locations along the Rio Grande, but no Aroclors were detected in these samples.

PCB congener analyses were obtained from 108 non-filtered surface water samples collected at 37 locations on the Pajarito Plateau. Of these samples, 104 samples from 35 locations, including samples from background areas, had detected PCBs. PCB congener analyses were also obtained from six samples at two locations along the Rio Grande, and PCBs were detected in one of these samples, collected upriver from canyons draining the Laboratory. Most of the Pajarito Plateau samples, 82%, had total detected PCB concentrations above the human health standard of 0.00064 µg/L, including locations that receive runoff from the Los Alamos town site and other developed areas. Most of these samples, 57%, were also above the wildlife habitat standard of 0.014 µg/L. For example, a sample collected from Pueblo Canyon above Acid Canyon, which receives runoff from the Los Alamos town site, had 0.225 µg/L PCBs, and a sample from Cañada de los Latas, on Santa Fe National Forest land north of Los Alamos, had 0.0133 µg/L PCBs. The source of PCBs in background areas is atmospheric fallout. The highest concentrations of PCB congeners were measured in Los Alamos Canyon, below known Laboratory sources of PCBs, and these results are discussed later in section F.1.

For SVOCs, analyses were obtained from 23 non-filtered surface water samples collected at 19 locations on the Pajarito Plateau in 2010. Six samples were also collected from two locations along the Rio Grande. Single SVOCs were detected in three samples from three different locations on the Pajarito Plateau in Cañon de Valle, Mortandad Canyon, and Pajarito Canyon. None of these results were above standards.

For VOCs, analyses were obtained from 36 non-filtered surface water samples collected at 22 locations on the Pajarito Plateau in 2010 and from an additional eight samples from three locations along the Rio Grande. Five VOCs were detected in one or more samples from three locations, all in Sandia Canyon. None of these results were above standards.

b. Sediment

For organic chemicals in sediment, analytical data were obtained from 44 samples collected on the Pajarito Plateau in 2010 as part of the annual surveillance program. These samples were mostly from active channel locations that are typically dominated by coarse-grained sediment but also included fine-grained sediment at several locations. In addition, 10 other active channel samples were collected as part of sediment investigations in the Ancho, Chaquehui, and Water Canyon watersheds, and are included in the data set examined here. Table 6-8 presents a summary of results for detected organic chemicals in Pajarito Plateau sediment samples from 2010.

Table 6-8
Summary of Results for Organic Chemicals in Pajarito Plateau Sediment Samples from 2010

Analyte and Method	Percentage of Samples with Detected Results	Master Watersheds with Detected Results	Notes
Dioxin and Furan Congeners	100%	Los Alamos and Pajarito canyons	Highest concentrations were obtained from the sediment retention basins above the Los Alamos Canyon weir
PCBs by Aroclor Method	18%	Los Alamos and Sandia canyons	Highest concentrations, 22.3 mg/kg Aroclor-1254 and 10.8 mg/kg Aroclor-1260, were obtained from the upper Los Alamos Canyon sediment detention basins
PCBs by Congener Method	100%	Ancho, Chaquehui, and Los Alamos canyons	Maximum result for total PCB congeners, 0.105 mg/kg, was obtained from the sediment retention basins above the Los Alamos Canyon weir

In 2010, as part of the annual surveillance program, we obtained analytical data on dioxins and furans in sediment from nine samples: five from the Los Alamos Canyon weir and four from small drainages below MDA G at TA-54. Dioxin and furan congeners were detected in each sample, and maximum concentrations were measured in fine-grained samples collected at the weir.

We obtained analytical data on PCBs in sediment by the Aroclor method (EPA method 8082) from 18 samples in 2010 as part of the annual surveillance program. These samples were all collected from canyons

draining the Pajarito Plateau and were mostly active channel locations that are typically dominated by coarse-grained sediment. We also obtained analytical data on PCBs by the Aroclor method from 10 other active channel samples collected as part of sediment investigations in the Ancho, Chaquehui, and Water Canyon watersheds that are included in the data set examined here. Aroclor-1254 and Aroclor-1260 were both detected in the same five samples, four from Los Alamos Canyon and one from Sandia Canyon. Maximum concentrations for both Aroclors were from a fine-grained sample collected from the upper Los Alamos Canyon sediment detention basins, where a PCB cleanup recently occurred (LANL 2010c).

Also as part of the annual surveillance program in 2010, we obtained analytical data for PCB congeners in sediment using EPA method 1668A on 56 fine-grained samples, including 26 samples from the Pajarito Plateau, 20 samples from along the Rio Grande, and 10 samples from Cochiti reservoir sediment. PCB congeners were detected in all samples, with the highest concentrations obtained from the sediment retention basins above the Los Alamos Canyon weir. We obtained these data to evaluate congener "fingerprints," PCB sources, and spatial and temporal variations in PCB concentration, and they are discussed further in Sections F.1, F.6, F.7, and G.3.

In 2010, we also obtained analytical data on explosive compounds from the 10 active channel samples in the Ancho, Chaquehui, and Water canyon watersheds mentioned above. No explosive compounds were detected in these samples.

F. CANYON-SPECIFIC RESULTS

1. Los Alamos Canyon (includes Acid, Barrancas, Bayo, DP, Guaje, Pueblo, and Rendija Canyons)

Los Alamos Canyon has a large drainage area that heads in the Sierra de los Valles, with a stream channel length of about 17 mi (27 km). The total drainage area is about 61 mi^2 (157 km^2), of which 54% is located within Guaje Canyon and its tributaries (including Barrancas and Rendija Canyons). The Laboratory has used land in the Los Alamos Canyon watershed continuously since the early 1940s, with operations conducted in the watersheds of several tributary canyons (Acid, Bayo, DP, and Pueblo canyons). Several of the canyons within the watershed also receive urban runoff from the Los Alamos town site, and lower Pueblo Canyon receives treated sanitary municipal wastewater from the Los Alamos County WWTP.

Historical releases of radioactive liquid effluents into Acid, DP, and Los Alamos Canyons have introduced americium-241, cesium-137, plutonium-238, plutonium-239/240, and strontium-90, among other radionuclides, into the canyon bottoms. Most of these radionuclides bind to stream sediment and persist at concentrations well above atmospheric fallout levels. Cesium-137 and plutonium-239/240 are the most important radionuclides in the Los Alamos Canyon watershed from the perspective of potential human health risk, although concentrations are low enough that they do not pose an unacceptable risk to recreational users of the canyons (LANL 2004; LANL 2005). The main source for cesium-137 was discharges into DP Canyon from a treatment facility at TA-21 between 1952 and 1986. The main source for plutonium-239/240 was discharges into Acid Canyon from former TA-1 and former TA-45, located within the current Los Alamos town site, between 1945 and 1964. These radionuclides and other contaminants have been transported by floods down these canyons, off-site across Pueblo de San Ildefonso land, and to the Rio Grande near Otowi Bridge (Graf 1994, 1996; Reneau et al., 1998b; LANL 2004). Plutonium-239/240 from historic Acid Canyon discharges has been traced in sediment more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002).

PCBs have also been released into the Los Alamos Canyon watershed from multiple sources, with their spatial distribution indicating both Laboratory and Los Alamos town site sources. The transport of PCBs in storm water is of particular concern in this watershed because the standard for PCBs in water is very low (0.00064 µg/L, the NMED human health standard), and most samples are higher than the standard. In the last 10 years, the Laboratory has taken a series of measures to reduce potential human health and ecological risk and storm water transport of contaminants in the Los Alamos Canyon watershed. In the last two years, this work has included construction of GCSs along the main stream channels in lower Pueblo Canyon and in

DP Canyon (LANL 2010d; LANL 2010e) and excavation of PCB-contaminated sediment and soils in upper Los Alamos Canyon below SWMU 01-001(f) (also referred to as Hillside 140 or LA-SMA-2) (LANL 2010c). In addition, in March 2011, approximately 1,500 willows were planted in the area above the Pueblo Canyon GCS to both improve habitat and aid in slowing floodwaters.

Results of sediment sampling in the Pueblo Canyon watershed show that plutonium-239/240 concentrations in sediment transported by floods are much less at present than concentrations during the period of active releases of radioactive effluent into Acid Canyon. Figure 6-9 shows variations in plutonium-239/240 concentration in active channel sediment in lower Pueblo Canyon between ca. 1950 and 2010, extending the record presented previously (LANL 2004; Reneau et al., 2004; Reneau et al., 2010) with data from more recent surveillance sediment samples. As shown in the previous studies, plutonium-239/240 concentrations were much higher prior to 1965 and since that time have shown no distinct trends. The year-to-year variations seen in these samples may be due at least in part to variability in silt and clay percentages, as there are strong relations between sediment particle size and contaminant concentration (LANL 2004; Reneau et al., 2004).

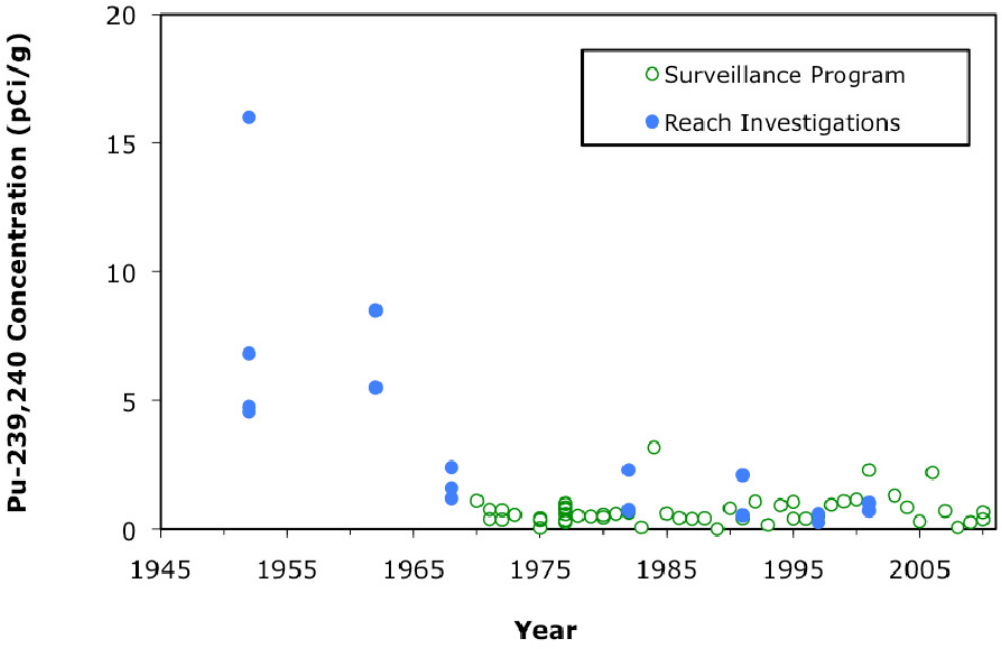

Figure 6-9 Variations in plutonium-239/240 concentration over time in active channel sediment in lower Pueblo Canyon; all results are detects, and most are above the background value of 0.068 pCi/g.

In lower Acid Canyon, analyses of active channel sediment samples show an overall decrease in plutonium-239/240 concentrations between 1970 and 2010 (Figure 6-10, modified from Reneau et al., 2010), with inter-year and intra-year variability also seen. The plutonium-239/240 concentration measured here in 2010, 7.43 pCi/g, is higher than that measured in the previous four years, but within the range measured over the last 10 years (1.41 to 12.5 pCi/g). Plutonium-239/240 concentrations in the active stream channel decrease downstream, measured at 0.662 and 0.382 pCi/g in lower Pueblo Canyon above and below the GCS, respectively, and 0.0979 pCi/g in lower Los Alamos Canyon near the Rio Grande.

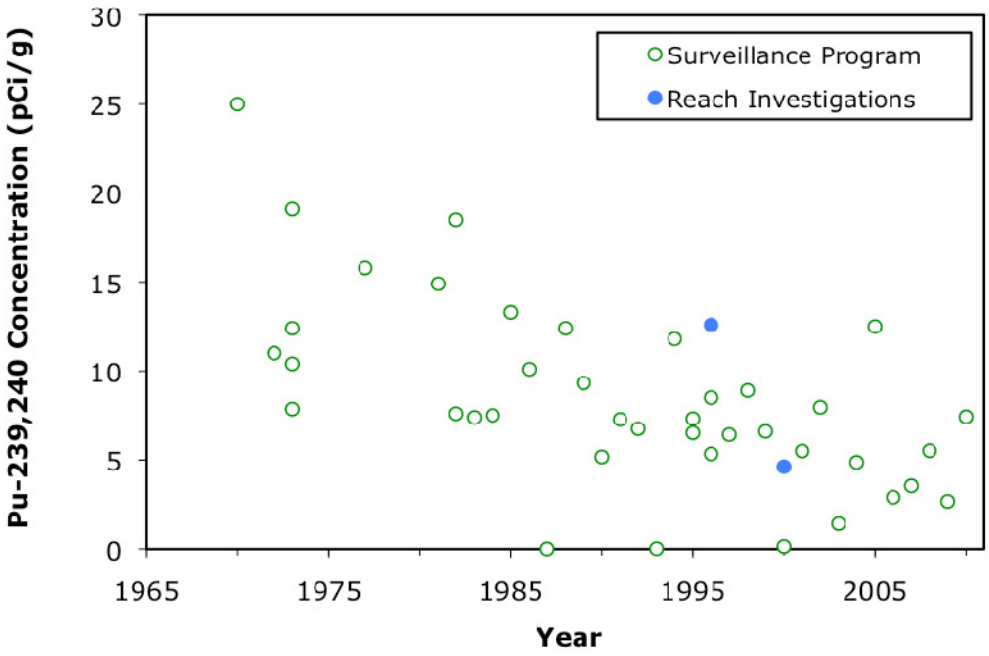

Figure 6-10 Variations in plutonium-239/240 concentration over time in active channel sediment in lower Acid Canyon; most values are detects and are above the background value of 0.068 pCi/g.

In two areas, samples of fine-grained sediment were collected in 2010 for radionuclide analysis for comparison with nearby coarse-grained samples. In Pueblo Canyon above the GCS, plutonium-239/240 concentrations were higher in the fine-grained sediment, consistent with results of previous studies (LANL 2004; Reneau et al., 2004). In contrast, in lower Los Alamos Canyon near the Rio Grande, plutonium-239/240 was measured at 0.0931 and 0.124 pCi/g in fine-grained sediment, similar to the measurement of 0.0979 pCi/g in a coarse-grained active channel sample. The sampled sediment in this part of Los Alamos Canyon probably includes mixtures of sediment derived from Guaje Canyon as well as upper Los Alamos Canyon, on LANL land, and Pueblo Canyon. These mixtures of sediment likely obscure the relationships between particle size and contaminant concentrations that are seen elsewhere.

Plutonium analyses were obtained from 53 storm water samples collected in the Los Alamos Canyon watershed in 2010. Figure 6-11 shows the spatial variations in plutonium-239/240 concentrations in this watershed. The highest plutonium-239/240 concentration, 150 pCi/L, was measured in the south fork of Acid Canyon (gage E055.5), close to the original Manhattan Project outfalls. Concentrations decreased downstream, measured at up to 44 pCi/L in Pueblo Canyon and 5 pCi/L in Los Alamos Canyon near the Rio Grande. In Los Alamos Canyon above NM 4, plutonium-239,240 concentrations were measured at up to 19 pCi/L, being similar above and below the confluence with DP Canyon (Figure 6-11). Concentrations were much lower in DP Canyon, supporting prior data that the primary source of plutonium-239,240 in upper Los Alamos Canyon was upstream from DP Canyon (LANL 2004). Plutonium-239,240 concentrations in storm water samples from gages in lower Pueblo Canyon (E060 and E060.1) are shown in Figure 6-12 and indicate that results from 2010 are within the range measured in previous years.

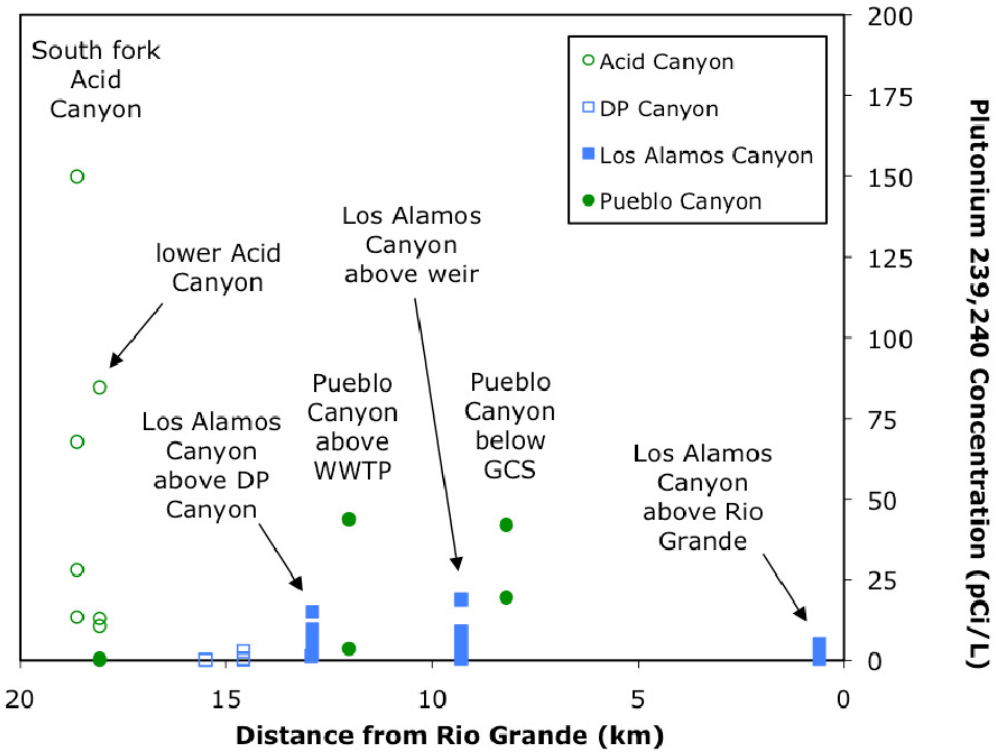

Figure 6-11 Spatial variations in plutonium-239/240 concentrations in non-filtered storm water samples from the Los Alamos Canyon watershed in 2010; all results over 0.03 pCi/L are detects

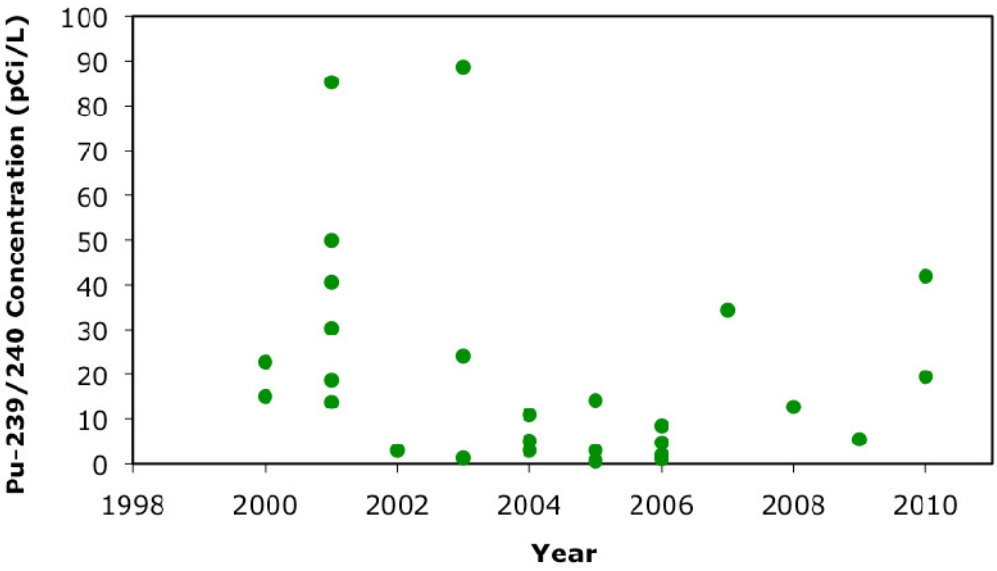

Figure 6-12 Variations in plutonium-239/240 concentration over time in non-filtered surface water samples in lower Pueblo Canyon (gages E060 and E060.1); all values are detects.

Results of sediment sampling in Los Alamos Canyon show that cesium-137 concentrations in sediment transported by recent floods are much less than concentrations during the period of active releases of radioactive effluent into DP Canyon. Figure 6-13 plots cesium-137 concentrations in samples from the active channel of lower DP Canyon since 1971 and shows that concentrations have been relatively low and constant

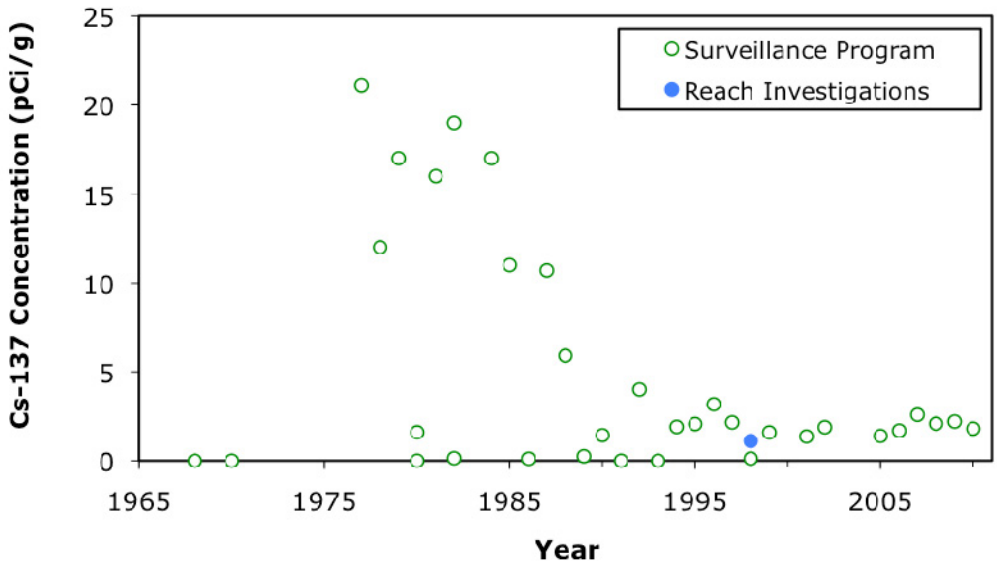

Figure 6-13 Variations in cesium-137 concentration over time in active channel sediment in lower DP Canyon; most values are detects and are above the background value of 0.9 pCi/g.

since about 1989. Downstream, samples from the active stream channel in Los Alamos Canyon above NM 4 and near the Rio Grande in 2010 had cesium-137 concentrations below the background value of 0.9 pCi/g, consistent with the findings from 2008 and 2009.

In 2010, analyses were also obtained for cesium-137 and other radionuclides in coarse-grained active channel sediment closer to the source, immediately upstream and downstream of the newly constructed GCS below the former outfall for the radioactive liquid waste treatment facility at TA-21. Cesium-137 concentrations in both samples were below the sediment background value, indicating that sediment deposited above the GCS and also transported past it was largely derived from upstream of the former outfall. These data also indicate that sediment analyzed from lower DP Canyon, where cesium-137 is above the background value, is derived from erosion of sediment in the lower canyon, below the GCS.

Cesium-137 analyses were obtained from 40 storm water samples collected in the Los Alamos Canyon watershed in 2010, and spatial variations in cesium-137 concentrations are shown in Figure 6-14. Most results are below detection limits, and cesium-137 was only detected in lower DP Canyon and in Los Alamos Canyon above the weir. The highest concentrations are from the gage above the weir (E042.1), indicating that the cesium-137 transported in storm water is mostly derived from erosion of stream banks between DP Canyon and the weir, which is consistent with inferences from previous investigations (e.g., LANL 2004; Malmon et al., 2005).

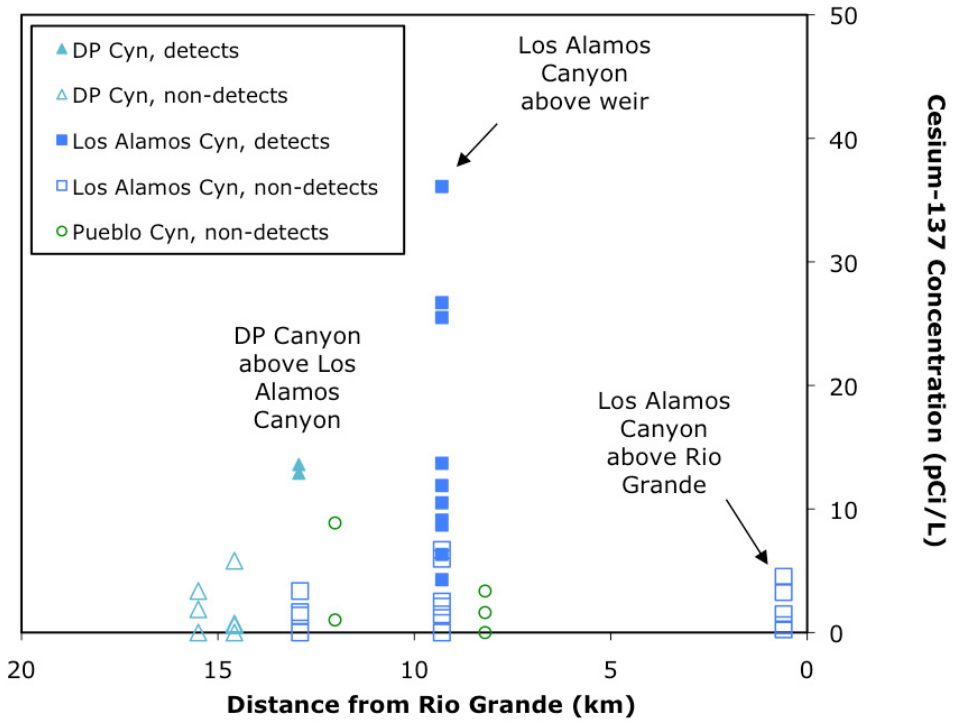

Figure 6-14 Spatial variations in cesium-137 concentrations in non-filtered storm water samples from the Los Alamos Canyon watershed in 2010

The highest concentrations of americium-241 in surface water at LANL in 2010 were also obtained from Los Alamos Canyon above the weir, on the same day as the maximum cesium-137 at that station (August 16). This americium-241 has the same source as the cesium-137, a former TA-21 outfall into DP Canyon. As shown in Figure 6-15, concentrations in storm water at this location in 2010 were within the range measured in previous years, and the maximum result was lower than in most years.

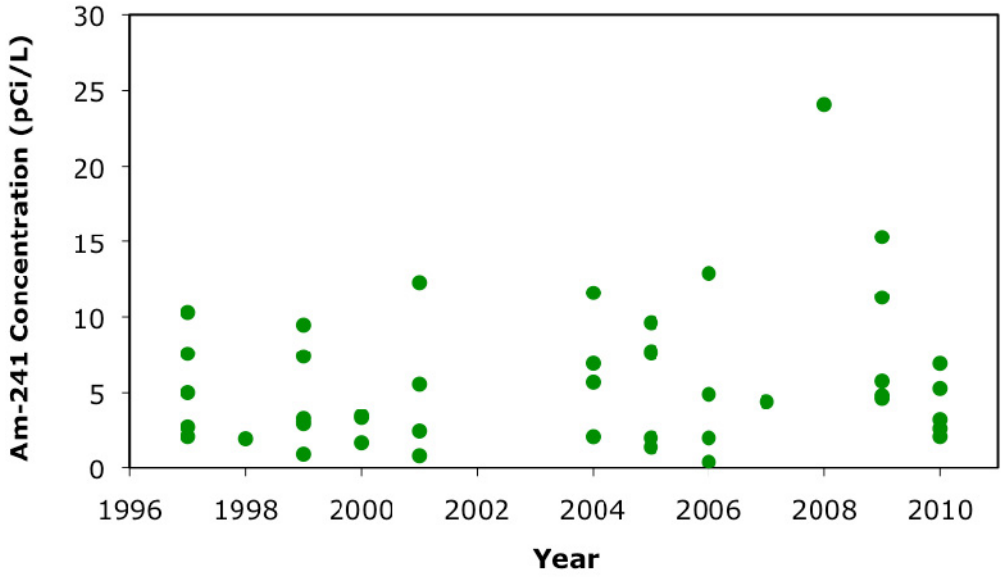

Figure 6-15 Variations in americium-241 concentration over time in non-filtered storm water samples at gages above Los Alamos Canyon weir (E042 and E042.1); all values are detects.

The highest concentration of strontium-90 in surface water at LANL in 2010 was measured in a storm water sample collected from DP Canyon below the GCS on July 22. The strontium-90 has the same source as the americium-241 and cesium-137 but is more soluble and therefore has different geochemical behavior. Figure 6-16 shows its spatial distribution in the Los Alamos Canyon watershed in 2010.

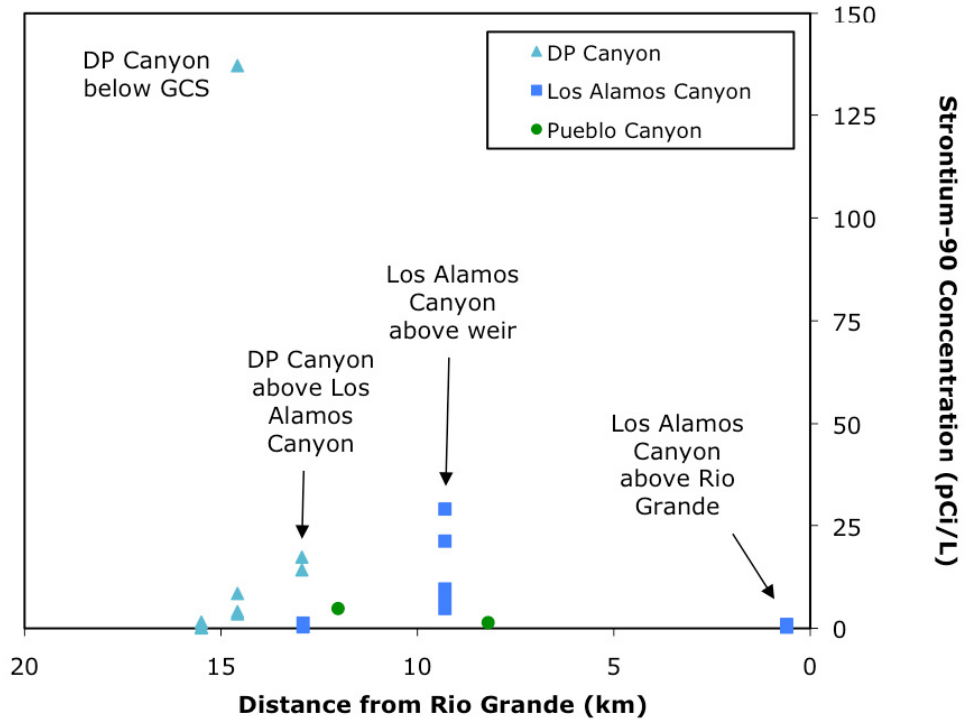

Figure 6-16 Spatial variations in strontium-90 concentrations in non-filtered storm water samples from the Los Alamos Canyon watershed in 2010; all results above 0.5 pCi/L are detects.

The highest concentrations of uranium-234, uranium-235/236, and uranium-238 in the 2010 surveillance program sediment samples were measured in a fine-grained sediment sample from upper Los Alamos Canyon, in the upper Los Alamos Canyon sediment detention basin below SWMU 01-001(f). These results are consistent with known activities at this SWMU and prior data from the site (LANL 2010f).

Five metals in surface water samples from the Los Alamos Canyon watershed had results above standards in 2010: aluminum, arsenic, cadmium, mercury, and zinc. The aluminum results probably represent background conditions, as discussed in Section E.2.a. A single result for arsenic is above the human health standard of 9 µg/L, 29.3 µg/L from Los Alamos Canyon near the Rio Grande (gage E109.9) on August 23. Arsenic has not been identified as a contaminant in surface water at LANL upstream in this watershed, and this result probably represents naturally occurring arsenic associated with geologic units present in the lower watershed. A single result for cadmium is above the acute aquatic life standard of 0.25 µg/L: 1.1 µg/L from DP Canyon above TA-21 (gage E038) on July 22. Cadmium has been identified as a contaminant in urban runoff (Breault and Granato 2000), and runoff from the Los Alamos town site into the head of DP Canyon may be the source of this cadmium. Zinc also has a single result above the acute aquatic life standard of 117 µg/L and the chronic aquatic life standard of 118 µg/L, collected from DP Canyon below the GCS (gage E039.1) on July 21. Zinc is also a common contaminant in urban runoff, and runoff from the Los Alamos town site may also be the source of this zinc.

Two results for mercury in the Los Alamos Canyon watershed in 2010 were above the wildlife habitat standard of 0.77 µg/L, one from Los Alamos Canyon above DP Canyon (gage E030; 0.85 µg/L on August 5) and one from the south fork of Acid Canyon (gage E055.5; 1.0 µg/L, also on August 5). At both sites, three additional samples had mercury concentrations below the standard. Mercury has been previously identified as

a contaminant in both areas, derived from LANL sites (LANL 2004; Reneau et al., 2010). However, the low concentrations and low frequency of results above the standard indicates there is relatively little impact from mercury in this watershed.

In sediment, there were 13 inorganic chemicals measured above background values in the Los Alamos Canyon watershed in 2010. As discussed in Section E.2.b, three of these (barium, calcium, and magnesium) were only above background values in lower Los Alamos Canyon near the Rio Grande and probably represent natural background, associated with runoff events from Guaje Canyon where bedrock units differ from the Pajarito Plateau at LANL. Chromium, cobalt, copper, and vanadium are also elevated here and may also represent natural background conditions or runoff from developed areas, as discussed below.

Six metals were measured above background values in fine-grained samples from the sediment detention basins above the Los Alamos Canyon weir. Two of these, antimony and chromium, had not been previously measured above background here, and the maximum concentrations of two others, lead and zinc, were higher than previous sample results from the weir (LANL 2008b). The other two metals, copper and selenium, were within the range of previous measurements. All six of these metals have recognized sources in urban runoff (e.g., Breault and Granato 2000; Callender and Rice 2000; Walker et al., 1999), and runoff from the Los Alamos town site into the head of DP Canyon may be an important source. Zinc was also measured above the background value in an active channel sample below the DP Canyon GCS.

Contaminant concentrations in sediment are often strongly related to particle size distribution, and comparisons of analytical data with silt and clay content of samples are often useful in understanding variability between samples. Figures 6-17 and 6-18 present data on lead and zinc at the weir and demonstrate that for a given particle size lead and zinc concentrations in some of the recent samples (representing sediment deposited in 2009 and 2010) are higher than previous samples (sediment deposited between original construction of the weir in June 2000 and its excavation in May 2009). Although the cause of these increases is not certain, they may result from continued transport of lead and zinc, along with other contaminants, from roads and other developed areas within the Los Alamos town site.

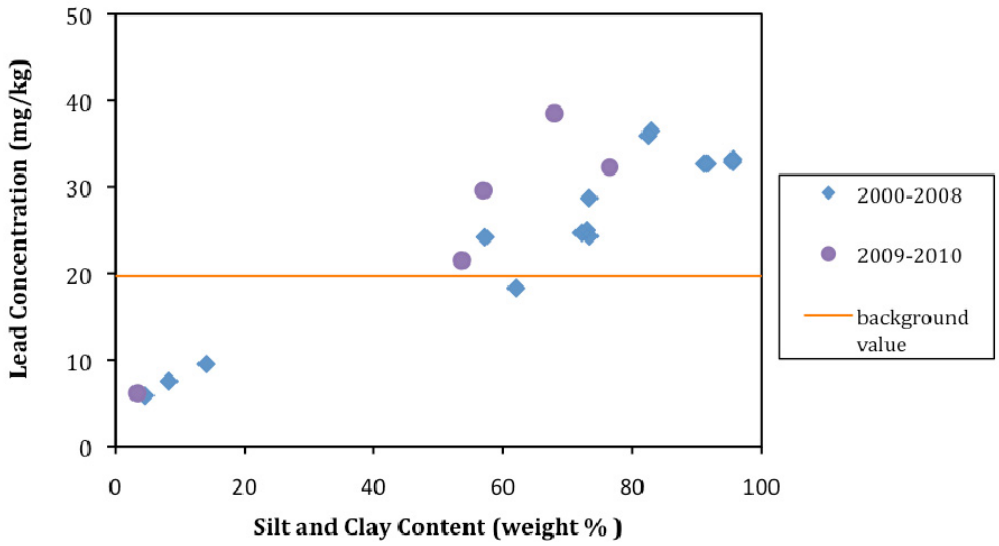

Figure 6-17 Variations in lead concentration in sediment samples from the Los Alamos Canyon weir as a function of silt and clay content

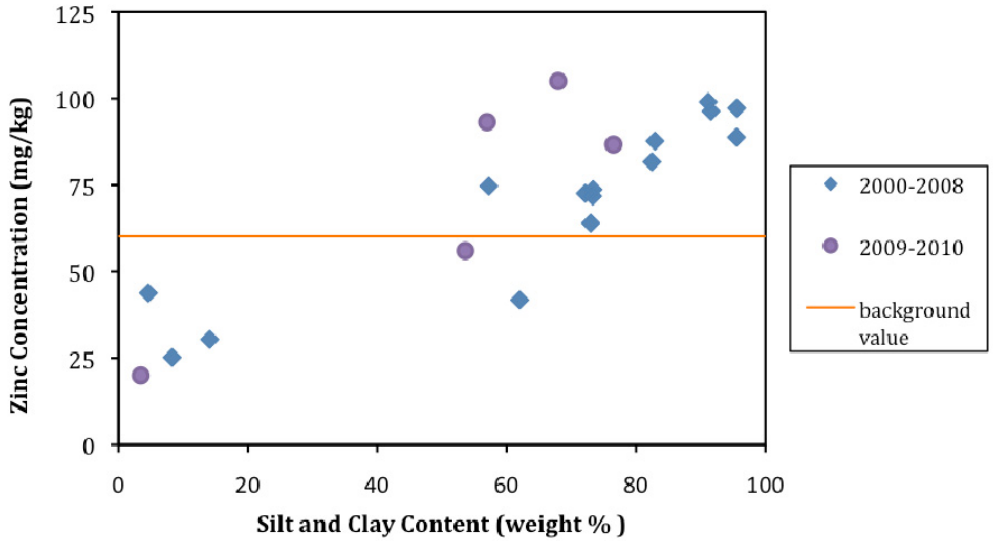

Figure 6-18 Variations in zinc concentration in sediment samples from the Los Alamos Canyon weir as a function of silt and clay content

Five metals were measured above background values in an active channel sample from lower Acid Canyon, and three of these (cadmium, lead, and manganese) had their highest concentrations in the 2010 surveillance samples from this location. Cobalt and vanadium were also elevated in this sample. Previous sediment data from upstream in Acid Canyon indicate that this cadmium, and possibly the lead, were probably derived from past releases into the south fork of Acid Canyon from Laboratory outfalls at TA-1 or TA-45, whereas the other metals probably have sources in urban runoff or naturally occurring soils (LANL 2004)

PCBs were analyzed in surface water samples in the Los Alamos Canyon watershed in 2010 using both the Aroclor method (one sample) and the congener method (74 samples). The Aroclor analyses consisted of one base flow sample from Pueblo Canyon below the Los Alamos County WWTP and had no detected PCBs. The congener analyses included 68 storm water samples, five snowmelt runoff samples, and one base flow sample. All but one sample had detected PCB congeners, including nine samples from background areas in Guaje and Los Alamos canyons and three samples from a site receiving runoff from the Los Alamos town site (a "baseline" area). Baseline samples had up to 0.225 µg/L of PCBs in Pueblo Canyon above Acid Canyon, and background samples had up to 0.0168 µg/L in Los Alamos Canyon above the skating rink. PCB concentrations in snowmelt runoff were much lower than in storm water runoff, with a maximum of 0.00865 µg/L measured in Los Alamos Canyon on April 21. The single base flow sample, derived from effluent releases from the Los Alamos County WWTP in Pueblo Canyon, also had low concentrations of PCBs, measured at 0.000168 µg/L on January 13.

Total detected congeners for all storm water samples from the Los Alamos Canyon watershed are plotted in Figure 6-19, excluding the maximum result (which is discussed below). The highest concentration in the watershed, 15.1 µg/L, was measured in Los Alamos Canyon at the western sediment detention basin in upper Los Alamos Canyon, on July 26. The same day, water in the lower basin had 1.01 µg/L PCBs, and surface water below the lower basin had 0.545 µg/L PCBs. These decreases are consistent with sediment settling out in the ponds. Along the main Los Alamos Canyon stream channel, total PCBs on LANL property were up to 1.96 µg/L, above the weir on August 16. In Pueblo Canyon, total PCB concentrations were measured up to 0.352 µg/L, above the WWTP on August 5. Concentrations were lower in Acid Canyon, DP Canyon, and lower Los Alamos Canyon near the Rio Grande (Figure 6-19). Concentrations in these areas are also less than in Pueblo Canyon above Acid Canyon, a baseline area receiving runoff from the Los Alamos town site. These data support earlier conclusions that Los Alamos Canyon on LANL property includes the most important PCB sources in the watershed, that concentrations decrease greatly downstream from the sources, and that storm water runoff is more important than snowmelt runoff or base flow in the transport of PCBs. PCBs in storm water in the Los Alamos Canyon watershed in 2010 are discussed further in LANL (2011c).

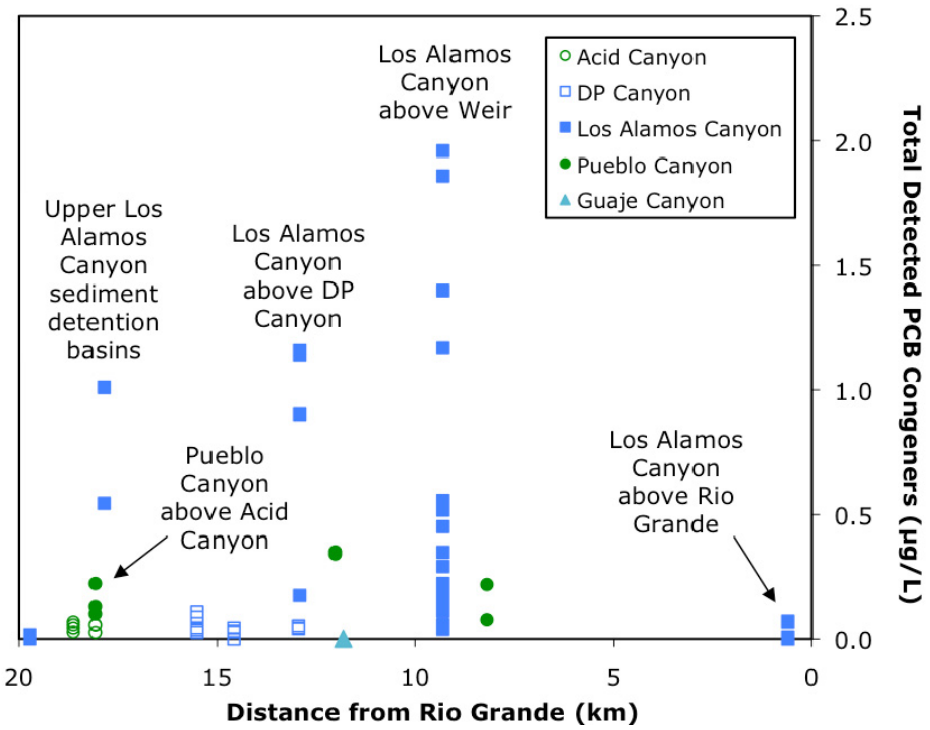

Figure 6-19 Spatial variations in total detected PCB congener concentrations in non-filtered storm water samples from the Los Alamos Canyon watershed in 2010, with the highest result, from upper Los Alamos Canyon sediment detention basins, excluded.

Using the Aroclor method, PCBs were detected in sediment at four locations in the Los Alamos Canyon watershed in 2010, all in Los Alamos Canyon above NM 4. Both Aroclor-1254 and Aroclor-1260 were detected in each of these samples. The highest concentration of detected Aroclors (sum of Aroclor-1254 and Aroclor-1260) was in a fine-grained sample from the western sediment detention basin in upper Los Alamos Canyon, at 33.1 mg/kg. Concentrations were lower in coarse-grained sediment in this same basin, 7.5 mg/kg, and much lower in coarse-grained active channel sediment downstream (0.0394 and 0.0079 mg/kg above DP Canyon and above the weir, respectively). Aroclors were not detected in the samples from Acid, DP, or Pueblo Canyons, or Los Alamos Canyon near the Rio Grande. These results are consistent with earlier sediment data which indicated that Los Alamos Canyon above DP Canyon was the most important source area for PCBs in this watershed (e.g., LANL 2008a; Reneau et al., 2010). These results are also consistent with the storm water data from 2010 discussed previously.

PCB congeners from sediment or water samples can be grouped together into 10 homologs, based on the number of chlorine atoms on the biphenyl rings, which allows visual comparison of similarities or differences between samples or groups of samples. The designations for the 10 homologs range from monochlorobiphenyl (or monoCB, with a single chlorine atom) to decachlorobiphenyl (or decaCB, with 10 chlorine atoms). Figure 6-20 shows average homolog percentages in sediment in each of the four areas in DP, Los Alamos, and Pueblo canyons that were sampled in 2010. Figure 6-20 also shows the average from the canyon bottom below SWMU 01-001(f) for comparison (the latter from Reneau et al., 2010). As found with data from 2009 (Reneau et al., 2010), the congener signatures in lower Pueblo Canyon, lower Los Alamos Canyon (reach LA-5), and Los Alamos Canyon above the weir are very similar, and cannot be distinguished. The 2010 data also indicate that PCB congener signatures are essentially the same in DP Canyon. However, these areas all have different signatures than SWMU 01-001(f), indicating that this site is not a major source for the PCBs found farther downstream in Los Alamos Canyon.

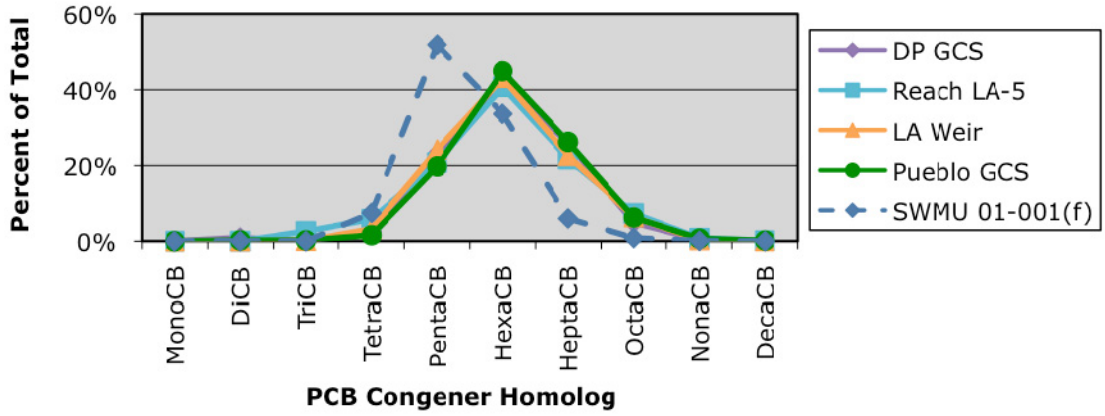

Figure 6-20 Average values for PCB congener homologs from sediment samples collected in DP, Los Alamos, and Pueblo canyons in 2010 and prior data from sediment samples below SWMU 01-001(f).

PCB congener data from surface water samples in the Los Alamos Canyon watershed generally indicate similar homolog signatures to sediment samples, and also show variability related to different sources for runoff and associated sediment between different events. As an example, Figure 6-21 shows average values for PCB homologs from 2010 snowmelt runoff below the Los Alamos Canyon weir (gage E050) and in lower Los Alamos Canyon near the Rio Grande (gage E109.9), and storm water runoff in two events in lower Los Alamos Canyon. Snowmelt runoff at the two locations and one of the storm water runoff events (on September 22) have the same signature, essentially the same as found in sediment at the weir (Figure 6-21). In contrast, the other storm water event on August 15 has a much different signature, associated with runoff from Guaje Canyon.

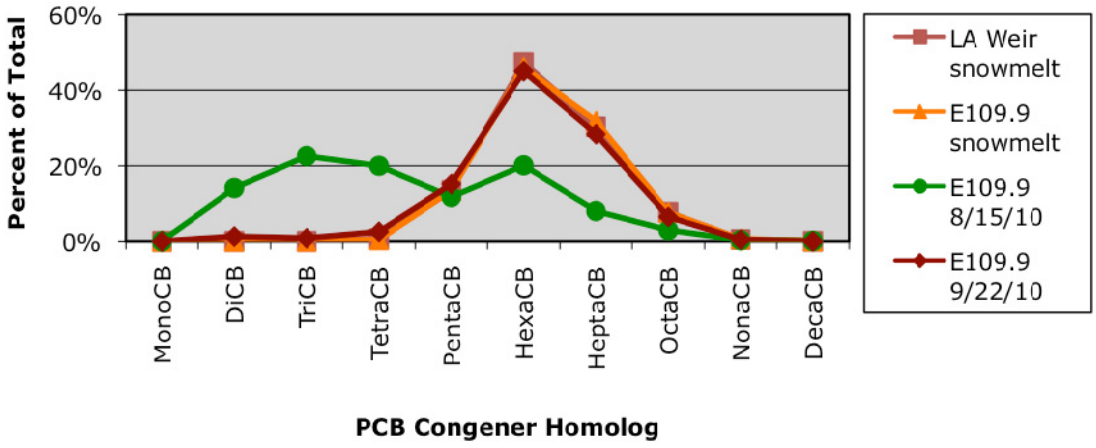

Figure 6-21 Average values for PCB congener homologs from surface water samples collected in lower Los Alamos Canyon in 2010 and snowmelt runoff at Los Alamos Canyon weir

In 2010, dioxin and furan analyses were included in the analytical suite for sediment at the Los Alamos Canyon weir to follow up on an increase in their concentrations that resulted from erosion of SWMU 21-027(a) below a potable water line break at TA-21 in 2008 (Reneau and Kuyumjian 2009). Figure 6-22 shows variations in the concentration of total tetrachlorodibenzodioxin (TCDD) a function of sediment age and silt and clay content, and Figure 6-23 shows variations in total tetrachlorodibenzofuran (TCDF) concentration. These figures show that for a given silt and clay content concentrations of both TCDD and TCDF in sediment deposited in 2009 and 2010 were much less than in 2008 and that the effects of the erosion at SWMU 21-027(a) were short-lived.

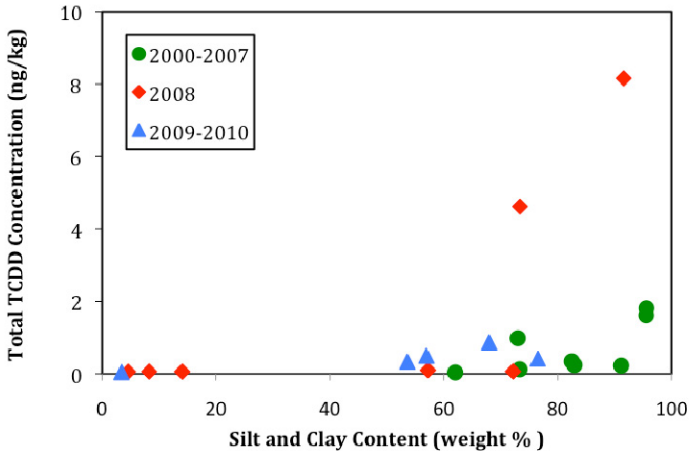

Figure 6-22 Variations in total TCDD concentration in sediment behind the Los Alamos Canyon weir as a function of sediment age and silt and clay content

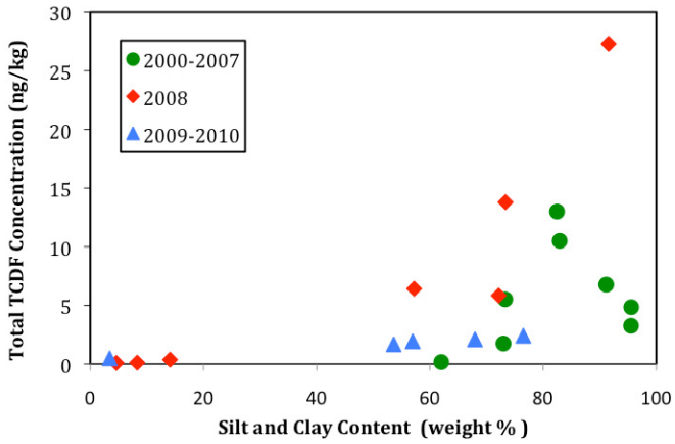

Figure 6-23 Variations in total TCDF concentration in sediment behind the Los Alamos Canyon weir as a function of sediment age and silt and clay content

Data on sediment volumes in the basins behind the Los Alamos Canyon weir (LANL 2011d) can be combined with data on contaminant concentrations to estimate the total inventory, or mass, of contaminants that have been deposited here since it was excavated and modified in May 2009. In 2009 and 2010, we estimate that about 0.02 kg of PCBs were deposited behind the weir, or about 0.01 kg/yr. For comparison, we previously estimated that an average of about 0.02 kg/yr of PCBs were deposited there from 2000 through 2008 (Reneau et al., 2010). As discussed in Section G.3, this is much less than the PCB flux in the Rio Grande past Otowi Bridge, above Los Alamos Canyon.

2. Sandia Canyon

Sandia Canyon heads on the Pajarito Plateau within TA-3 and has a total drainage area of about 5.5 mi^2 (14 km^2) and a channel length of about 11 mi (18 km). This relatively small watershed extends eastward across the central part of the Laboratory and crosses Bandelier National Monument and Pueblo de San Ildefonso land before ending at the Rio Grande. Effluent discharges from a sanitary WWTP, supplemented by releases from a steam plant, create perennial flow conditions along a 2-mile reach below TA-3. Surface flow rarely extends past the Laboratory boundary, and only two small runoff events were recorded at the E125 gage above NM 4 in 2010, with an estimated peak discharge of 1.6 cfs on August 15.

Two contaminants that have been of concern in Sandia Canyon are chromium and PCBs. Chromium, discharged in water from the TA-3 power plant from 1956 to 1972, has been the focus of extensive ongoing investigations related to groundwater contamination (LANL 2009c). PCBs were released from a former transformer storage area at TA-3 and were the target of remediation activities involving excavation of soil near the source (LANL 2001). Contaminant concentrations in sediment deposits decrease downstream from TA-3, and relatively low levels of contaminants are present above NM 4, adjacent to the eastern Laboratory boundary (LANL 2009c).

Five metals in surface water samples from the Sandia Canyon watershed had results above screening levels in 2010: aluminum, arsenic, copper, selenium, and zinc. The aluminum results probably represent background conditions, as discussed in Section E.2.a. The result for selenium, 15.3 µg/L from a non-filtered base flow sample from the south fork of Sandia Canyon (gage E122) on May 7, was the highest at LANL in 2010, exceeding the wildlife habitat and chronic aquatic life standards of 5.0 µg/L. Arsenic and copper were both elevated in the filtered sample from this location collected on the same day. Arsenic was slightly above the human health standard of 9 µg/L, at 9.39 µg/L, and copper was slightly above the chronic aquatic life standard of 9 µg/L, at 9.09 µg/L. The source of this water is an outfall at TA-3 (03A-199), which discharges cooling water from the Laboratory Data Communications Center. Samples collected on two other days from this location in 2010, on February 1 and November 9, were below the standards for arsenic, copper, and selenium. Results from 2009 were also below the standard for arsenic and selenium, but copper was elevated here in one sample in 2009, at 32.8 µg/L.

A storm water sample collected from S-SMA-3.6 in the upper Sandia Canyon watershed on October 20 had results above standards for copper and zinc. This site receives runoff from developed areas, and the results for copper and zinc are within the range measured in 2009 for storm water samples in upper Sandia Canyon.

PCBs were detected in one out of 19 surface water samples analyzed from the Sandia Canyon watershed in 2010 by the Aroclor method. Aroclor-1260 was measured at 0.095 µg/L in a storm water sample collected from a small drainage below the Sigma Building at TA-3 on May 14, which is above the human health standard of 0.00064 µg/L and the wildlife habitat standard of 0.014 µg/L. Using the congener method, PCBs were also analyzed in four base flow samples and two storm water samples from the Sandia Canyon watershed. PCBs were detected in all six samples, at concentrations of 0.00164 to 0.797 µg/L. The highest concentration was measured on October 2 in a storm water sample collected from the main Sandia Canyon stream channel below the wetland (gage E123).

Active channel sediment collected from Sandia Canyon below the wetland in 2010 had five metals detected above sediment background values: antimony, chromium, mercury, silver, and zinc. All of these metals except antimony have been previously identified as contaminants in this part of Sandia Canyon (e.g., LANL 2009c), and antimony is only slightly above the background value (0.94 mg/kg vs. 0.83 mg/kg). The results for chromium, mercury, and silver were the highest measured in the 2010 surveillance sediment data set, although they were within the range previously measured at this location. Concentrations in sediment at this location have varied widely, as shown for chromium in Figure 6-24. The variations may, in part, reflect variations in particle size between samples (e.g., the anomalously high concentration measured in 2003), but also, in part, different source areas. For example, a short distance up canyon from the sample site is a side drainage from the Los Alamos County landfill that has an active alluvial fan, and years with relatively low chromium and silver concentration may include a larger percentage of sediment from this source. Low concentrations of PCBs were also detected in the active channel below the wetland in 2009, at similar concentrations to recent years (0.0637 mg/kg Aroclor-1254 and 0.062 Aroclor-1260). Figure 6-25 shows variations in the concentrations of detected PCBs in active channel samples at and near this location since 1998, indicating generally higher values from 1998 to 2005 than from the last five years (2006 to 2010). No radionuclides were detected above background values at this location in 2009.

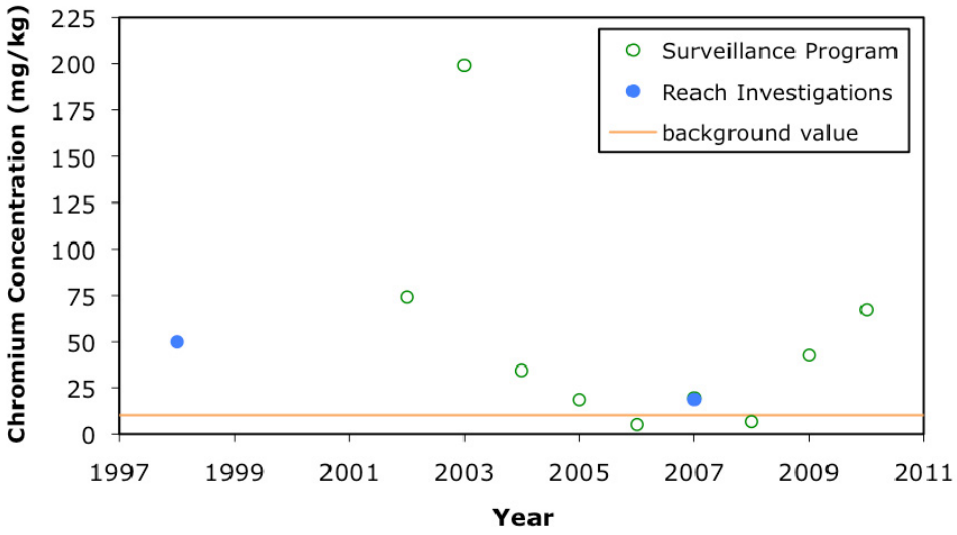

Figure 6-24 Variations in chromium concentration over time in the active stream channel of Sandia Canyon below the wetland

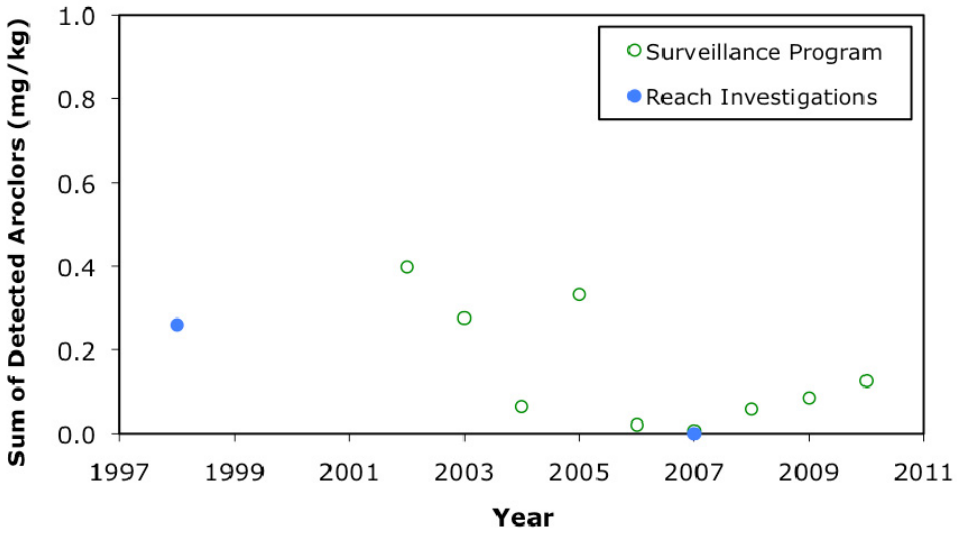

Figure 6-25 Variations in PCB concentration over time in the active stream channel of Sandia Canyon below the wetland; values are the sum of detected Aroclors

3. Mortandad Canyon (includes Cañada del Buey and Effluent, Pratt, and Ten Site Canyons)

Mortandad Canyon heads on the Pajarito Plateau in the main Laboratory complex at TA-3 and crosses Pueblo de San Ildefonso land before reaching the confluence with the Rio Grande. It has a total drainage area of about 10 mi^2 (27 km^2) and a main channel length of about 10 mi (16 km). Mortandad Canyon receives treated water discharged into Effluent Canyon from the TA-50 RLWTF. No runoff events have crossed the Laboratory boundary in Mortandad Canyon proper since a stream gage was installed in 1993, and the only reported event that crossed the boundary occurred in 1952 (LANL 2006a). The Mortandad Canyon sediment traps are located approximately two miles upstream of the Laboratory's eastern boundary, and in most years, including 2010, runoff events have not extended past the sediment traps.

Cañada del Buey is a major tributary that heads in TA-63 and passes through the town of White Rock and Pueblo de San Ildefonso land before joining Mortandad Canyon near the Rio Grande. It has a drainage area

of about 4 mi^2 (11 km^2) and a main channel length of about 8 mi (13 km). Runoff events have crossed the Laboratory boundary in Cañada del Buey every year since a gage (E230) was established above NM 4 in 1994, although in most years flow has not been recorded at the next upstream station (E225), indicating that the runoff originates in the lower part of the watershed. The lower part of Cañada del Buey receives treated sanitary wastewater from a Los Alamos County WWTP near the White Rock Overlook, which flows into Mortandad Canyon and the Rio Grande.

The highest concentrations of two radionuclides in surface water samples collected in 2010, cesium-137 and plutonium-238, were measured in a storm water sample collected on August 16 from the stream channel in Mortandad Canyon above Ten Site Canyon (gage E201). Figures 6-26 and 6-27 show time series plots for cesium-137 and plutonium-238 at E201 and E202 (located near the Ten Site Canyon confluence) from 2005 to 2010, indicating that results from 2010 are within the ranges measured in recent years in this part of Mortandad Canyon.

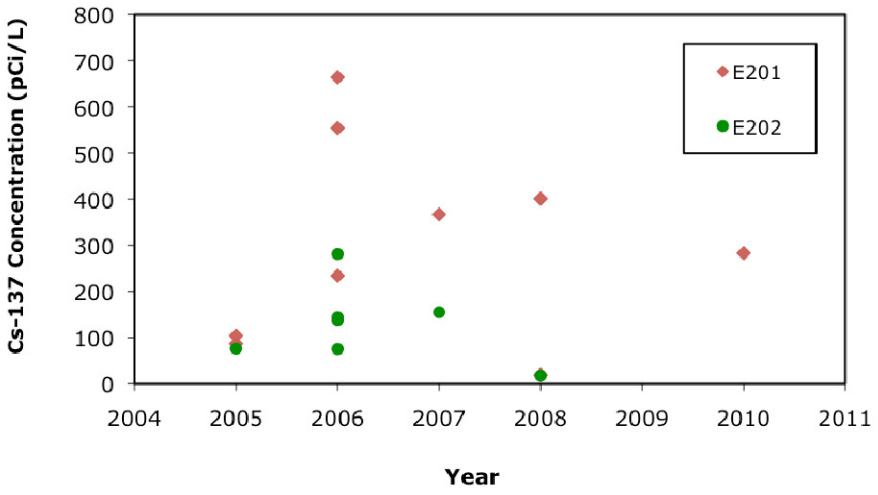

Figure 6-26 Variations in cesium-137 concentration over time in non-filtered storm water samples in Mortandad Canyon above the sediment traps (gages E201 and E202); all values are detects.

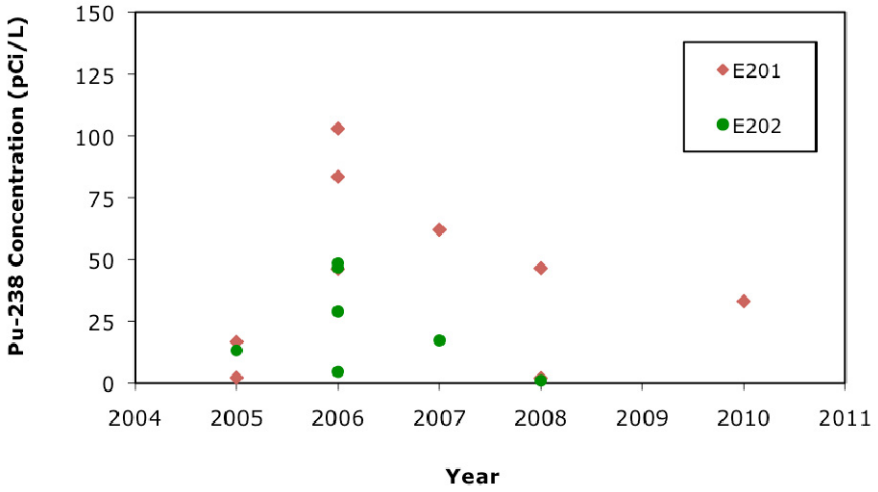

Figure 6-27 Variations in plutonium-238 concentration over time in non-filtered storm water samples in Mortandad Canyon above the sediment traps (gages E201 and E202); all values are detects.

Stream sediment in Mortandad Canyon downstream of Effluent Canyon to near regional well R-28 (1 km above the eastern LANL boundary) contains above-background concentrations of radionuclides, with concentrations decreasing to at or near background levels at the Laboratory boundary (LANL 2006a). Cesium-137 is the most important radionuclide in Mortandad Canyon from the perspective of potential human health risk (LANL 2006a). Cesium-137 concentrations in sediment transported by recent floods are much less than concentrations measured during the period of peak releases of radioactive effluent from the RLWTF into Effluent Canyon prior to 1980. Figure 6-28 plots cesium-137 concentrations in samples from the active channel of Mortandad Canyon below Effluent Canyon since 1972 (updated from LANL 2006a and Reneau et al., 2010) and shows that concentrations have been relatively low and constant since about 1983. Similar trends are present for other radionuclides in Mortandad Canyon (LANL 2006a).

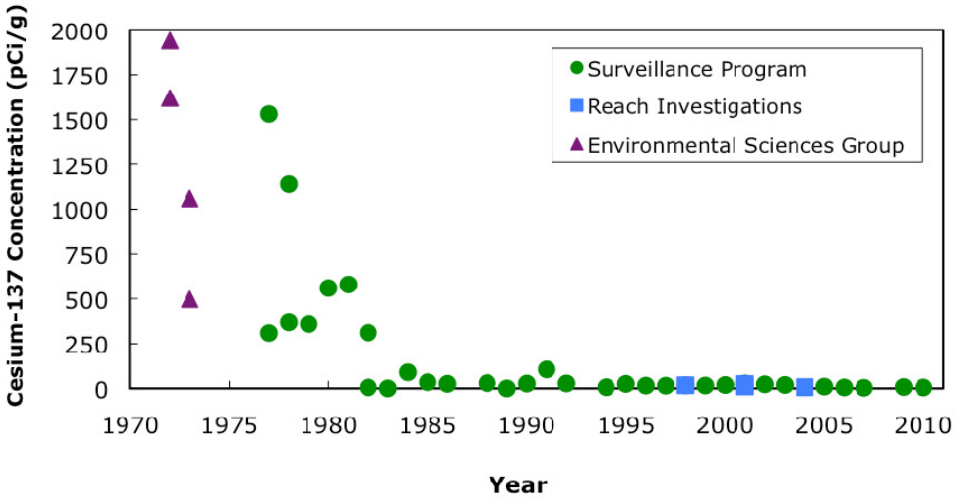

Figure 6-28 Variations in cesium-137 concentration over time in active channel sediment in Mortandad Canyon below Effluent Canyon; most values are detects and are above the background value of 0.9 pCi/g.

Sediment samples have been collected from small drainages below MDA G in the Cañada del Buey watershed since 1982 and have been generally above background levels for radionuclides. In 2010, only the MDA G-8 drainage was sampled because there was no evidence of flow at other stations. Americium-241, plutonium-238, and plutonium-239,240 were all measured above background values at this location, with concentrations of 0.116, 0.197, and 0.318 pCi/g, respectively. Results for 2010 were within the range measured in previous years. None of these radionuclides were detected above background levels downstream in the active channel of Cañada del Buey.

Four metals in surface water samples from the Mortandad Canyon watershed had results that were above standards in 2010: aluminum, chromium, copper, and selenium. The aluminum results probably represent background conditions, as discussed in Section E.2.a. The single result for chromium above standards at LANL in 2010 (146 µg/L from reach E-1FW on February 2, above the chronic aquatic life standard of 74 µg/L) was from upper Effluent Canyon below TA-46, a known source of chromium (LANL 2006a). A second sample from this location, collected on November 11, had chromium below the standard. Chromium was also slightly above the standard in one of two samples collected here in 2009, at 75.4 µg/L, but not in three samples from 2008. Four results for copper were above the chronic aquatic life standard of 9 µg/L, and two were also above the acute aquatic life standard (13.4 µg/L). The highest result, 15.6 µg/L from the upper part of Mortandad Canyon (reach M-1W), is from a location that receives runoff from a large developed area in TA-3, and the presence of copper here is consistent with urban runoff. A copper result of 11.4 µg/L from lower Mortandad Canyon near the Rio Grande, below the community of White Rock, may also be due to urban runoff. The other two copper results above standards from the Mortandad Canyon watershed in 2010 were from reach E-1FW (10.4 and 14.1 µg/L), and these elevated results could be either associated with releases from TA-46 or runoff from developed areas. The single result for selenium above standards in the

Mortandad Canyon watershed in 2010 (5.6 µg/L vs. the wildlife habitat and chronic aquatic life standards of 5.0 µg/L) was collected in Cañada del Buey above NM 4 on August 15 and may represent naturally occurring selenium since there are no known releases of selenium in this watershed (LANL 2009d).

In sediment, six metals from the Mortandad Canyon watershed in 2010 had results above background values in a sample from the Cañada del Buey stream channel below MDA G: cadmium, chromium, cobalt, iron, vanadium, and zinc. Field observations recorded the presence of naturally occurring black, magnetite-rich sands in this sample, and many heavy metals are known to be elevated in black sands on the Pajarito Plateau (Reneau et al., 1998b). Therefore, these elevated results probably represent natural mineralogic variations and not Laboratory releases.

4. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads in the Sierra de los Valles in the Santa Fe National Forest and crosses the central part of the Laboratory before passing through the community of White Rock east of NM 4. It has a total drainage area of about 13 mi^2 (33 km^2) and a main channel length of about 15 mi (24 km). Major tributary canyons include Twomile Canyon, which also heads in the Sierra de los Valles, and Threemile Canyon, which heads on the Pajarito Plateau. The Pajarito Canyon watershed includes a variety of active and inactive Laboratory sites (summarized in LANL 2009b). In 2010, there was no recorded runoff at the E250 stream gage in Pajarito Canyon above NM 4. Because of this, there were no surface water or sediment samples collected at E250 or downstream in 2010.

In 2010, aluminum and PCBs, by the congener method, were the only chemicals in surface water samples from the Pajarito Canyon watershed that exceeded standards. The aluminum results probably represent background conditions, as discussed in Section E.2.a. The PCB congeners probably include a combination of Laboratory and non-Laboratory (atmospheric fallout) sources. The highest concentrations of total detected PCB congeners in the Pajarito Canyon watershed were measured in Twomile Canyon above Pajarito Canyon (gage E244), above the wildlife habitat standard of 0.014 µg/L in both samples, at 0.0662 and 0.0716 µg/L. One sample from Pajarito Canyon below Twomile Canyon (gage E244), was below the wildlife habitat standard but above the human health standard of 0.00064 µg/L, at 0.012 µg/L. Four samples were collected from a background area near NM 501 (gage E240), and three of these results were above the human health standard, at 0.00189 to 0.00528 µg/L.

In sediment samples from the Pajarito Canyon watershed, three radionuclides (americium-241, plutonium-238, and plutonium-239/240) and one metal (antimony) were detected above background values in 2010. These samples were all collected from small drainages below MDA G at TA-54, and the maximum result for each was from the MDA G-7 drainage. The result for antimony, 3.63 mg/kg, was the highest concentration measured in the 2010 surveillance sediment data set, and this location also had the highest result for antimony in 2009. Results for the radionuclides have been lower in recent years than in previous years, and americium-241 results from 1999 to 2010 are shown in Figure 6-29 as an example. In contrast, antimony has in general increased since 2006, as shown in Figure 6-30. The reason for this increase in antimony concentrations in the MDA G-7 drainage is not known.

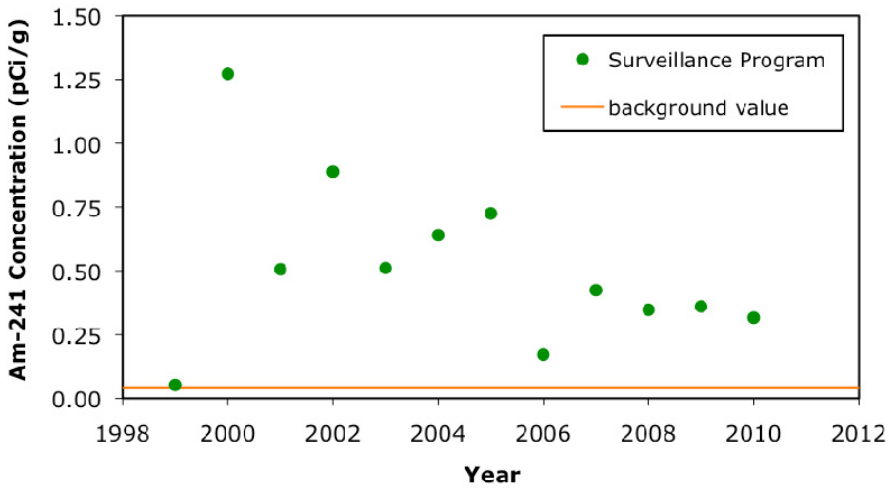

Figure 6-29 Variations in americium-241 concentration over time in sediment in the MDA G-7 drainage in the Pajarito Canyon watershed; all values above 0.06 pCi/g are detects.

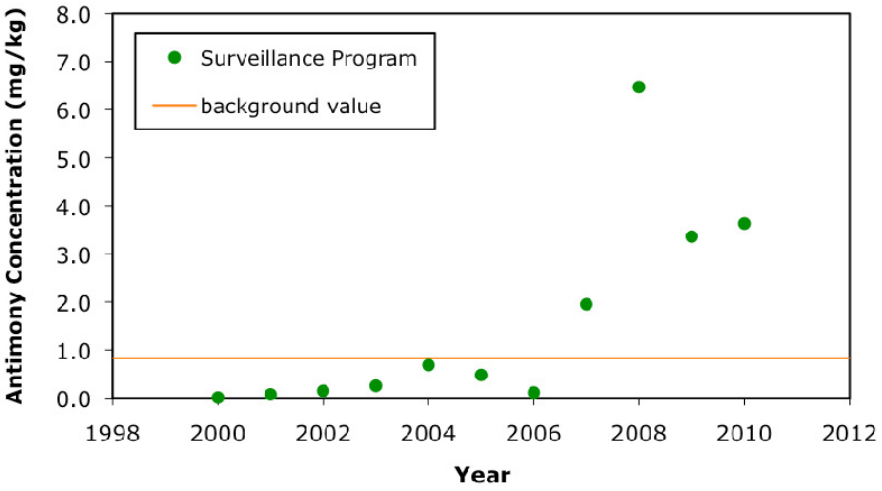

Figure 6-30 Variations in antimony concentration over time in sediment in the MDA G-7 drainage in the Pajarito Canyon watershed; all values above 0.26 mg/kg are detects.

Analyses for dioxin and furan congeners were also obtained from the MDA G sediment samples in 2010, which is the first year these analyses have been conducted here. Dioxin and furan congeners were detected in each sample, and the highest concentrations for each were also from the MDA G-7 drainage. These concentrations are lower than previous results from Pueblo Canyon, which receives urban runoff from the Los Alamos town site (LANL 2005).

5. Water Canyon (includes Cañon de Valle and Fence, Indio, and Potrillo Canyons)

Water Canyon heads in the Sierra de los Valles in the Santa Fe National Forest and extends across the southern portion of the Laboratory to the Rio Grande. It has a total drainage area of about 19 mi^2 (49 km^2) and a main channel length of about 14 mi (23 km). Cañon de Valle is a major tributary that also heads in the Sierra de los Valles. The Water Canyon watershed also includes the shorter canyons of Fence, Indio, and Potrillo Canyons that head on the Pajarito Plateau within LANL. Explosives development and testing and

other activities take place in this part of the Laboratory, and elevated concentrations of uranium isotopes, barium, silver, the high-explosive (HE) compounds HMX and RDX, along with other analytes have previously been measured in sediment and surface water in the watershed (LANL 2006b). Cañon de Valle has been the subject of focused Laboratory investigations to address barium and HE contamination in surface water and groundwater (LANL 2003; LANL 2006c), and the Laboratory implemented corrective measures for the canyon in 2009 and 2010 that included construction of a permeable reactive barrier within the alluvium (LANL 2010g).

One chemical, aluminum, had results above the standard in surface water samples from the Water Canyon watershed in 2010. The aluminum results probably represent background conditions, as discussed in Section E.2.a.

The highest concentrations of RDX, HMX, and other HE compounds in surface water at the Laboratory in 2010 were measured in non-filtered base flow samples from Cañon de Valle below MDA P (gage E256) in TA-16, in an area where development of explosive compounds has occurred. These results are consistent with previous years. A time series of RDX concentrations in Cañon de Valle below MDA P is presented in Figure 6-31. The figure shows that the results from 2010 are within the range measured in recent years. The data presented in Figure 6-31 also indicate that concentrations in base flow are typically higher than in storm water, indicating that the RDX is not primarily associated with sediment particles.

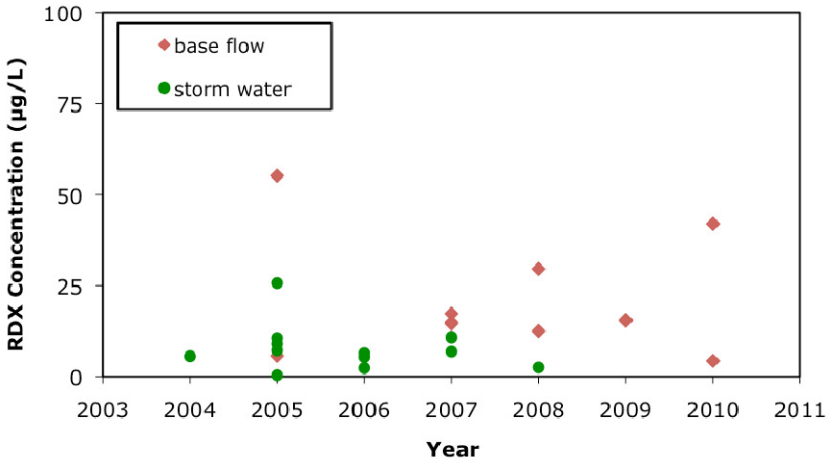

Figure 6-31 Time series of RDX concentrations in surface water samples from Cañon de Valle below MDA P (gage E256); all values are detects.

Five samples of active channel sediment collected from the Water Canyon watershed in 2010 are included in the data set examined here. Within these samples, one radionuclide, plutonium-238, was detected above the sediment background value at one location in Indio Canyon. No Laboratory activities have occurred in Indio Canyon, and this result probably represents a background outlier (LANL 2011a). No metals had results above background values in these samples, and no explosive compounds or PCBs were detected.

6. Ancho Canyon

Ancho Canyon heads on the Pajarito Plateau in TA-49 and extends across the Laboratory to the Rio Grande. It has a total drainage area of about 7 mi^2 (17 km^2) and a main channel length of about 7 mi (12 km). Potential Laboratory sources of contamination in the Ancho Canyon watershed include MDA AB in TA-49, the site of underground testing from 1959 to 1961, and firing sites in the north fork of Ancho Canyon in TA-39 (LANL 2006b).

One chemical, aluminum, had results above the standard in surface water samples from the Ancho Canyon watershed in 2010. The aluminum results probably represent background conditions, as discussed in Section E.2.a.

Four samples of active channel sediment collected from the Ancho Canyon watershed in 2010 are included in the data set examined here. No inorganic chemicals or radionuclides were detected at concentrations above sediment background values in these samples, and no explosive compounds or PCBs were detected.

Ten samples of fine-grained sediment were collected from the Ancho Canyon watershed in 2010 for analyses of PCB congeners. These were collected to help evaluate anomalous PCB congener signatures that were measured in sediment samples downriver along the Rio Grande in 2009 (Reneau et al., 2010) and also to help define "background" PCBs derived from atmospheric deposition. These included five samples from the lower part of the main canyon (reach A-3), between LANL SWMUs and the Rio Grande, and five samples from a background area (the northeast fork of Ancho Canyon). PCB congeners were detected in all samples. The range of total detected PCB congener concentrations was similar in each area, 0.000115 to 0.000337 mg/kg in lower Ancho Canyon and 0.000101 to 0.000286 mg/kg in the northeast fork. The mixture of PCB congener homologs was also similar in each area, as shown in Figure 6-32, but differed from that in Chaquehui Canyon (reach CH-2) where concentrations were higher (as discussed in the next section). These data indicate that atmospheric fallout is the primary source for PCBs in sediment in lower Ancho Canyon and are consistent with other sediment data using the Aroclor method that also indicate little or no PCB contamination in lower Ancho Canyon sediment and no recognizable transport of PCBs to the Rio Grande in this canyon (LANL 2011a).

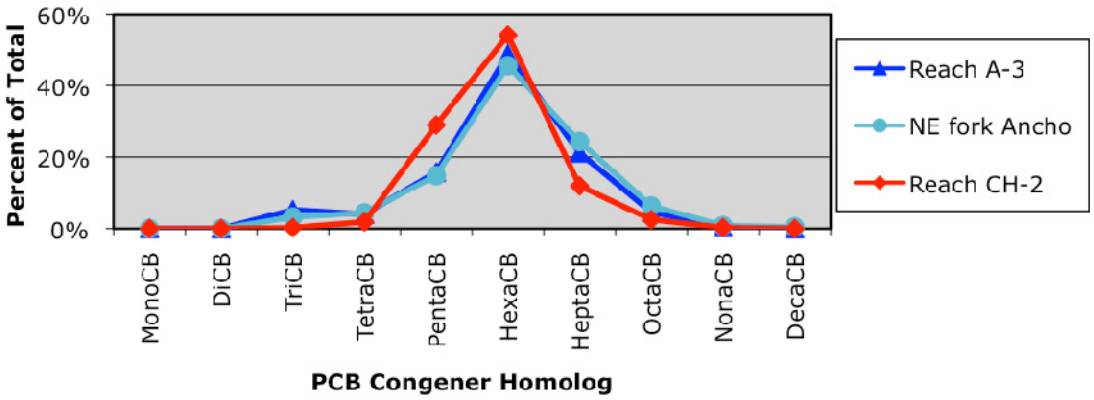

Figure 6-32 Average values for PCB congener homologs from sediment samples collected in Ancho and Chaquehui Canyons in 2010

7. Chaquehui Canyon

Chaquehui Canyon heads on the Pajarito Plateau near the Bandelier National Monument entrance station and extends across the Laboratory to the Rio Grande. It has the smallest of the primary watersheds at LANL, with a total drainage area of about 1.6 mi^2 (4 km^2) and a main channel length of about 3 mi (5 km). Potential Laboratory sources of contamination in the Chaquehui Canyon watershed are located at TA-33 and include firing sites and outfalls (LANL 2006b).

No surface water samples were collected in the Chaquehui Canyon watershed in 2010. One active channel sediment sample collected in 2010 is included in the data set examined here, and no inorganic chemical or radionuclide was detected at concentrations above sediment background values in this sample, In addition, no explosive compounds or PCBs were detected.

Five samples of fine-grained sediment were collected from lower Chaquehui Canyon (reach CH-2) in 2010 for analyses of PCB congeners. PCB congeners were detected in all samples. The maximum result for total detected PCB congeners, 0.00282 mg/kg, was higher than in the adjacent watershed of Ancho Canyon, and the PCB homolog signature was also different (Figure 6-32). These data are consistent other sediment data using the Aroclor method that also indicate LANL sources for PCBs in Chaquehui Canyon (LANL 2011a). However, these data also indicate that Chaquehui Canyon was not the source for anomalous PCB congener homolog signatures found downriver along the Rio Grande in 2009. Specifically, those samples were elevated

in the monochlorobiphenyl (monoCB) homolog (Reneau et al., 2010), and this homolog is not elevated in the Chaquehui Canyon samples.

G. POTENTIAL IMPACTS TO THE RIO GRANDE

In 2010, we assessed potential Laboratory impacts to the Rio Grande by comparing data from sediment and water samples collected upriver and downriver of LANL drainages and also comparing these data with analytical results obtained from canyons draining the Pajarito Plateau.

Natural stream flow and sediment loading in the Rio Grande are quite large compared with Los Alamos area streams. These factors reduce the possibility of identifying significant impacts from the Laboratory in the Rio Grande. Daily average flow in the Rio Grande at the Otowi gage in 2010 ranged from 407 to 4,580 cfs. In contrast, the maximum combined flow leaving LANL in 2010, on August 16, is estimated at 14 cfs. Similarly, the average annual amounts of suspended sediment and bed sediment passing the Otowi gaging station has been calculated to be 1,000 and 100 times, respectively, that contributed by Los Alamos Canyon (Graf 1994).

1. Surface Water Sampling Results

Surface water samples were collected from three locations along the Rio Grande in 2010 for analysis of inorganic and organic chemicals and radionuclides. These locations are upriver of Los Alamos Canyon and LANL at Otowi Bridge, at the planned surface water diversion site for Santa Fe at Buckman (at the mouth of Cañada Ancha, downriver from Los Alamos, Sandia, and Mortandad Canyons), and at the mouth of Frijoles Canyon in Bandelier National Monument (downriver from all canyons draining LANL). Three sets of paired samples were collected at Otowi Bridge and Buckman on the same days, and single samples were collected at Otowi Bridge and Frijoles Canyon in another sampling event.

Nine radionuclides were detected in the Rio Grande water samples in 2010: radium-226, radium-228, thorium-228, thorium-230, thorium-232, tritium, uranium-234, uranium-235/236, and uranium-238. Gross alpha and gross beta radiation were also detected in these samples. No screening levels were exceeded. All of these radionuclides are naturally occurring except for tritium, which is associated with atmospheric fallout. The highest concentrations for radium-226, thorium-228, thorium-232, tritium, and uranium-235/236 were measured at Otowi Bridge, upriver from LANL, demonstrating non-LANL sources. Although uranium-234 and uranium-238 were measured at higher concentrations at Buckman than at Otowi Bridge (maximums 6% to 20% higher on January 26), these differences are within measurement uncertainties and there was no runoff from Los Alamos Canyon during that month, and these results indicate naturally occurring uranium.

For organic chemicals, samples from the Rio Grande were analyzed for explosive compounds, pesticides, PCBs (by both the Aroclor and the congener methods), SVOCs, and VOCs. PCB congeners were detected in one sample, collected from Otowi Bridge on July 13, below the human health standard of 0.00064 µg/L at 0.0000385 µg/L. All other results were non-detects.

For inorganic chemicals, two results from the Rio Grande were above screening levels in 2010. A non-filtered sample collected at Otowi Bridge on May 10 had ammonia slightly above the chronic standard of 179 µg/L, at 184 µg/L. A filtered sample collected at Frijoles Canyon on September 29 had copper slightly above the chronic aquatic life standard of 9.0 µg/L, at 9.71 µg/L. These data indicate that water quality in the Rio Grande is good, with average values for these constituents being below chronic standards.

2. Sediment Sampling Results

In 2010, we collected sets of five sediment samples each for analysis of isotopic plutonium, gamma spectroscopy radionuclides, and PCB congeners from four areas along the Rio Grande. The four areas were as follows: (1) upriver from Otowi Bridge, which is upriver from Los Alamos Canyon and other LANL sources; (2) upriver from Buckman and the BDD Project surface water intake for the City and County of Santa Fe, which is downriver from Los Alamos Canyon; (3) below the White Rock Overlook, downriver from Sandia and Mortandad canyons; and (4) between Chaquehui and Frijoles canyons, downriver from all canyons

draining LANL. These samples included a similar range in geomorphic setting and particle size in each area, including low-water and high-water settings and coarse silt to very fine sand. Figures 6-33 and 6-34 show examples of the sample sites. In addition, we also collected five samples of sediment from the bottom of Cochiti Reservoir (Figure 6-35) and five samples of Cochiti Reservoir sediment deposited in the 1980s for the same analytical suite. Cochiti Reservoir had a higher water level than at present for several years in the mid-1980s, and deposits of sediment from this time period are preserved above the current reservoir level as far upriver as Ancho Canyon. We sampled the 1980s-vintage Cochiti Reservoir sediment at a location upriver from Frijoles Canyon and downriver from all LANL canyons (Figure 6-8), collecting a continuous sequence from the surface to a depth of 75 cm. The sediment from the 1980s had median particle size of fine to coarse silt, compared to the modern Cochiti Reservoir samples of fine silt to clay.

Figure 6-33 Photograph of sediment sampling area along the Rio Grande above Frijoles Canyon; November 11, 2010.

Figure 6-34 Photograph of sediment sampling area along the Rio Grande above Buckman; November 12, 2010.

Figure 6-35 Photographs of sediment sampling in Cochiti Reservoir; October 27, 2010.

In these samples, one radionuclide was detected above the sediment background concentrations of McLin and Lyons (2002) and McLin (2004). Plutonium-239/240 was detected at 0.0223 to 0.039 pCi/g in four of the samples collected from Cochiti Reservoir, above the regional reservoir background concentration of 0.0201 pCi/g but below the Pajarito Plateau sediment background value of 0.068 pCi/g. These results are consistent with previous data from Cochiti Reservoir obtained after the May 2000 Cerro Grande fire, as shown in Figure 6-36. Figure 6-36 also presents data from Abiquiu Reservoir obtained from 1995 to 2008. In comparison, plutonium-239/240 concentrations in the 1980s-vintage Cochiti Reservoir sediment are below the upper limit of background and are consistent with pre-fire data obtained in 1995 to 1999. (Figure 6-36).

PCB congener data were also obtained from the sediment samples, and are discussed further in Section G.3.

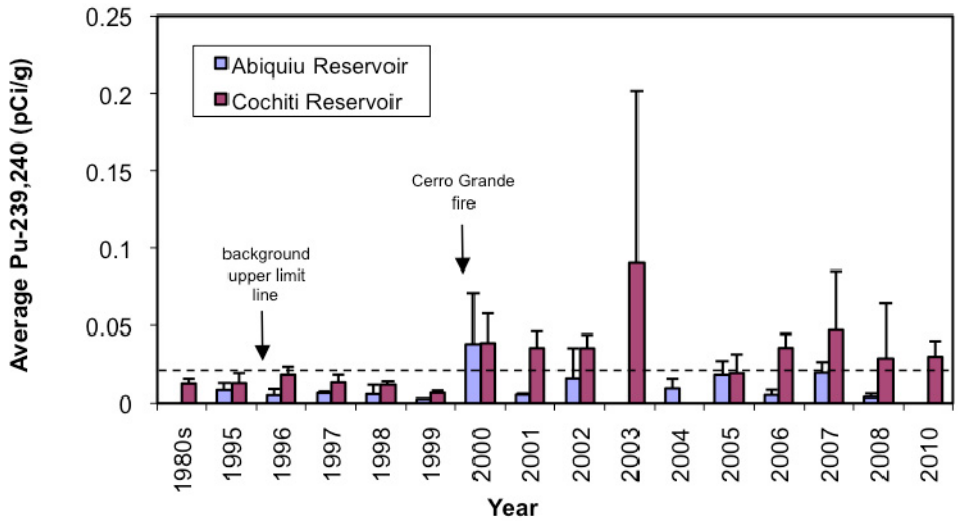

Figure 6-36 Plutonium 239/240 concentrations (mean + 1 standard deviation of 3-5 results) in Abiquiu and Cochiti Reservoir bottom sediment from the mid-1980s through 2010

3. PCBs in Sediment

a. PCB Concentrations and Sources

PCB congener data were obtained from 20 sediment samples along the Rio Grande in 2010, building on previous sampling events in 2008 and 2009 (Reneau and Kuyumjian 2009; Reneau et al., 2010). These were supplemented by five samples each from Cochiti Reservoir bottom sediment and from 1980s-vintage Cochiti Reservoir sediment. In addition to comparing PCB concentrations in samples collected from different locations, comparison of PCB congener "fingerprints" upriver and downriver from Los Alamos Canyon with congener data within the Los Alamos Canyon watershed allow further evaluation of potential Los Alamos contributions to PCBs along the Rio Grande.

Total detected PCB congener concentrations in Rio Grande sediment samples in 2010 are similar to concentrations measured in 2008 and 2009, though the ranges are greater. In the 2008 and 2009 sample areas, the average concentrations in each sampling area ranged from 0.000066 mg/kg (66 ng/kg) to 0.000090 mg/kg (90 ng/kg). In the four 2010 sample areas, average concentrations ranged from 47 ng/kg below the White Rock Overlook to 115 ng/kg above Frijoles Canyons. The average of 10 Rio Grande samples collected in 2010, 83 ng/kg, is similar to the averages in 2008 and 2009, 73 ng/kg and 76 ng/kg, respectively. The maximum concentration measured in 2010, 347 ng/kg from the sample area above Otowi Bridge, is higher than maximums from 2008 and 2009 (199 ng/kg and 208 ng/kg, respectively). Average concentrations in the Cochiti Reservoir bottom sediments, 115 ng/kg, were higher than in the Rio Grande sediments, although the maximum was less (220 ng/kg). Average PCB concentrations in the sediment samples in each area from 2008, 2009, and 2010, along with Cochiti Reservoir sediment from the 1980s and 2010, are shown in Figure 6-37.

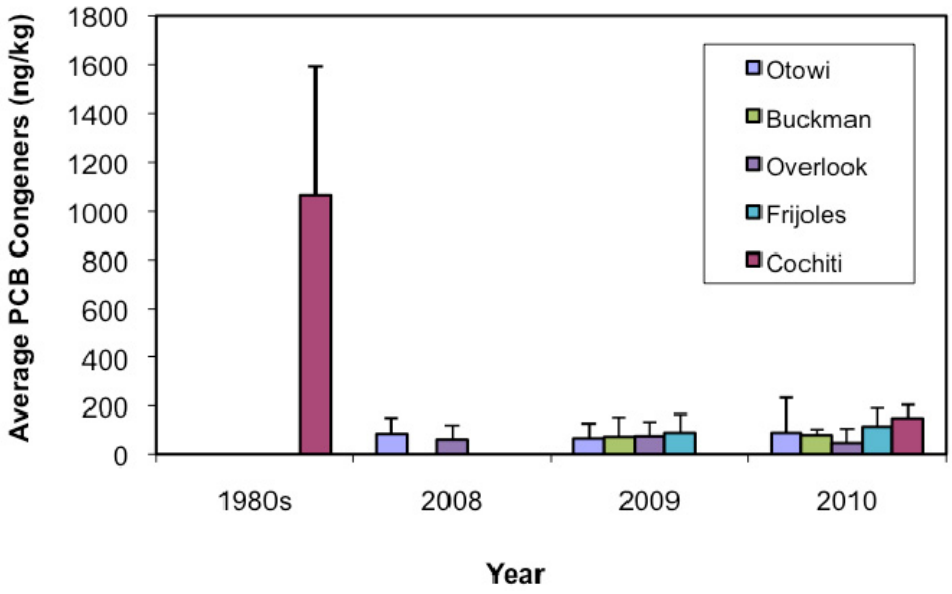

Figure 6-37 Total detected PCB congener concentrations (mean + 1 standard deviation of five results) in Rio Grande and Cochiti Reservoir sediment

Data from the 1980s-vintage Cochiti Reservoir sediments indicate that PCB concentrations were significantly higher at that time. Total detected PCB congeners in these samples ranged from 350 to 1,660 ng/kg, averaging 1,063 ng/kg (Figure 6-37). This decrease in PCB concentrations between the 1980s and present is consistent with the discontinuation of use of PCBs that began in 1979, when the U.S. Congress banned their production because of concerns about their toxicity and persistence in the environment.

The PCB congeners from each sample can be grouped together into 10 homologs, as discussed previously in Section F.1, which allows visual comparison of similarities or differences between samples or groups of samples. Compared with data from 2008 and 2009, the homolog signatures were much more variable in the 2010 sediment samples from along the Rio Grande, as shown in Figure 6-38. The variability is caused by

different sediment layers being associated with different runoff events that transport sediment from different sources with the upper Rio Grande watershed, and indicate large variability in PCB congener signatures in sources areas. Figure 6-38 also shows the congener signature from lower Los Alamos Canyon (reach LA-5) in 2010 and indicates that additions of PCBs from Los Alamos Canyon are not responsible for the differences in homologs between the Otowi Bridge sample area and downriver areas. For example, all downriver areas are elevated in triCB and tetraCB relative to Otowi Bridge, but the Los Alamos Canyon samples are not elevated in these homologs. The variability that exists in PCB congeners in the Rio Grande is also shown in Figure 6-39, which presents averages in 2008, 2009, and 2010 in samples from the Otowi Bridge area.

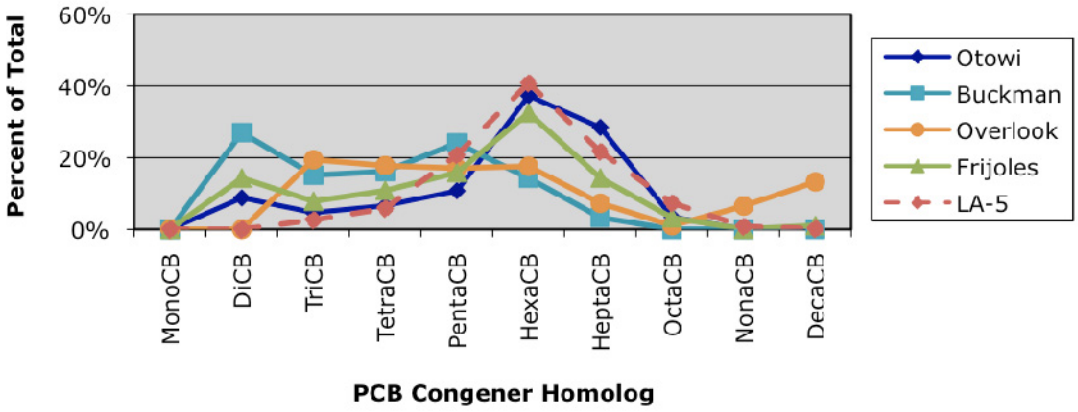

Figure 6-38 Average values for PCB congener homolog data from sediment samples collected along the Rio Grande and in lower Los Alamos Canyon in 2010

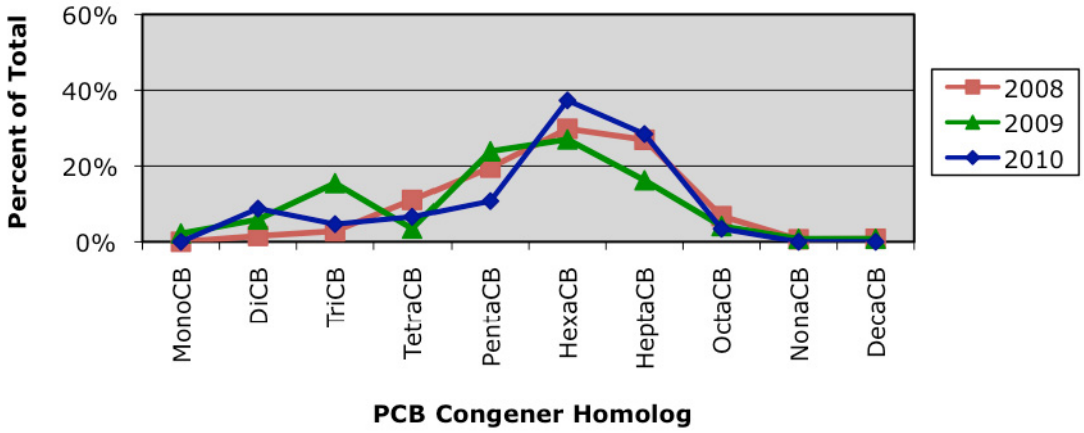

Figure 6-39 Average values for PCB congener homolog data from sediment samples collected along the Rio Grande near Otowi Bridge in 2008, 2009, and 2010.

PCB congener signatures also differ between sediment deposited along the Rio Grande and in Cochiti Reservoir, as shown in Figure 6-40. These Cochiti Reservoir sediment samples have a higher clay content than the sediment samples collected along the Rio Grande (average of 45% vs. 11% clay) and indicate that sources may also vary for sediment with differing particle size. Figure 40 also shows data on PCB congeners from the 1980s-vintage Cochiti Reservoir sediment, showing that PCB characteristics in the upper Rio Grande watershed were much different at that time.

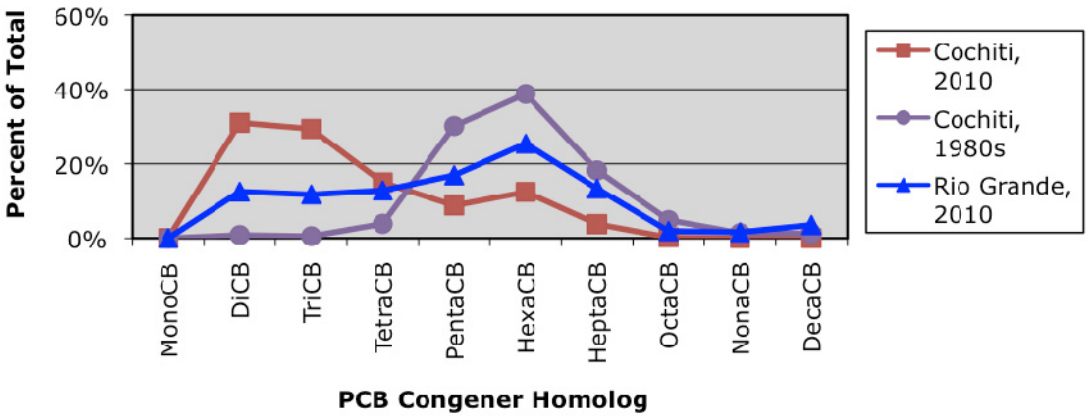

Figure 6-40 Average values for PCB congener homolog data from 2010 sediment samples from the Rio Grande and Cochiti Reservoir and from 1980s Cochiti Reservoir sediment.

b. PCB Flux

PCB congener data obtained from sediment samples along the Rio Grande, in combination with measurements of discharge and sediment flux at the Otowi Bridge gaging station made by the US Geological Survey (USGS), allow estimates to be made of the total mass of PCBs transported by the Rio Grande. These estimates can be compared with estimates of PCB flux at LANL, particularly in Los Alamos Canyon, which contains the main potential LANL sources of PCBs that could be transported to the Rio Grande.

Using data presented by the USGS (e.g., Stile 2011), the average annual flux of suspended sediment in the Rio Grande at Otowi Bridge was about 2,100,000 megagrams per year (Mg/yr)from 1948 to 2010 and was about 2,000,000 Mg/yr over the last 10 years (2001–2010). These are very similar to the value of 2,000,000 Mg/yr used in a previous study of plutonium along the Rio Grande, based on data from 1948 to 1985 (Graf 1994). Graf (1994) estimated that bedload sediment flux was much less, averaging about 300,000 Mg/yr or 14% of the suspended sediment flux and was a smaller component of the plutonium budget because of the inverse relation between contaminant concentrations and particle size. He estimated that only about 5% of the plutonium in the Rio Grande was associated with bedload sediment, and bedload can also be assumed to be a minor part of the PCB flux in the Rio Grande.

Suspended sediment flux in the Rio Grande in water year 2010 (WY2010) was below average, estimated as about 650,000 Mg (Stile 2011). Using this value and the average PCB concentration measured in Rio Grande sediment near Otowi Bridge in 2010 (90 ng/kg) provides an estimated flux of 0.06 kg of PCBs past Otowi Bridge in FY2010, similar to the estimate of 0.05 kg in FY2009 (Reneau et al., 2010). However, this may be an underestimate because of the sampling of coarser sediment that settled out of the river instead of the sediment that remained in suspension. For example, the sediment samples from this area in 2010 had an average of 6% clay, 45% silt, and 49% sand, whereas the five samples of Cochiti Reservoir sediment collected in 2010 averaged 45% clay, 55% silt, and <1% sand. Average PCB concentrations in Cochiti Reservoir sediment samples in 2010 were about 67% higher than average concentrations at Otowi Bridge. If we assume the average PCB concentration in suspended sediment is 50% higher than we measured at Otowi Bridge, the estimated PCB flux in WY2010 is increased to 0.09 kg.

Estimates of longer-term average PCB flux in the Rio Grande can also be made by combining our sediment data with the long-term average suspended sediment flux of 2,100,000 Mg/yr. Use of our average PCB concentration near Otowi Bridge of 80 ng/kg from 2008 to 2010 yields a PCB flux of 0.18 kg/yr, and using a 50% increase to adjust for particle size effects yields a PCB flux of 0.27 kg/yr.

The estimates of PCB flux in the Rio Grande can be compared with estimates of PCB flux in the Los Alamos Canyon watershed to evaluate the relative importance of Los Alamos Canyon as a PCB source for the Rio Grande. The only published estimate of suspended sediment yield from Los Alamos Canyon into the Rio Grande was made by Graf (1994), with an average of 2,000 Mg/yr. Combined with the average PCB

concentrations measured in fine-grained sediment samples in lower Los Alamos Canyon in 2009, 2,623 ng/kg (0.0026 mg/kg; Reneau et al., 2010), this yields an estimated PCB flux of 0.005 kg/yr. Because these samples included old floodplain sediment, they may not be representative of current concentrations. Instead, if we use the average PCB concentration in two fine-grained samples collected from lower Los Alamos Canyon in 2010 of 1,560 ng/kg, we obtain a lower estimate of 0.003 kg/yr. These values are 1–3% of the total estimated long-term flux in the Rio Grande. This small percentage is consistent with the absence of notable differences in PCB homolog signatures along the Rio Grande above and below Los Alamos Canyon, as found in a previous evaluation (Reneau et al., 2010). Enhanced sampling of storm water in lower Los Alamos Canyon at gaging station E109.9 and improved discharge estimates that began in 2010 (LANL 2011c) should result in improved estimates of PCB flux from Los Alamos Canyon into the Rio Grande.

The values presented above should be considered as preliminary estimates because of the small data set and the uncertainties and assumptions that went into these estimates. However, they provide a starting point for understanding the sources and fluxes of PCBs in the Rio Grande, and these estimates should be improved with additional data collection that is planned for 2011.

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A. INTRODUCTION

A soil monitoring program offers the most direct means of determining the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities (DOE 1991). Soil is an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous emissions, indirectly from re-suspension of contaminants, or through liquid effluents released to a stream that may be used for irrigation on farmlands. Consequently, soil contaminant data may provide information about potential pathways (e.g., soil ingestion, food ingestion, re-suspension into the air, and groundwater contamination) that could deliver radioactive materials or chemicals to humans and biota.

The overall soil surveillance program implemented by Los Alamos National Security, LLC (LANS), at the Los Alamos National Laboratory (LANL or the Laboratory) consists of the following:

1) An institutional component that monitors soil within and around the perimeter of LANL in accordance with US Department of Energy (DOE) Orders 450.1A (DOE 2003) and 5400.5 (DOE 1993);

2) A facility component that monitors soil (and sediment) within and around the perimeter of two Laboratory sites:

   - 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); and

3) A special studies component that investigates cases where there may be an absence of data concerning a localized (or potential) contaminant source that has the potential to impact human health and/or the environment as mandated from mitigation action plans, environmental surveillance program, or public concern.

The objectives of LANL's soil surveillance program are to determine the following:

1) Radionuclide and chemical concentrations in soil collected from potentially impacted areas (institution-wide, facility-specific, or potential source) and compared with the appropriate soil comparison levels (e.g., regional background levels, screening levels, and regulatory standards);

2) Concentration trends over time (i.e., whether radionuclide and/or chemical concentrations are increasing or decreasing); and

3) The committed effective dose equivalent from radionuclides potentially received by surrounding area residents and biota (see Chapter 3 for the potential radiation doses that individuals and biota may receive from exposure to soil), and risk to residents and biota from heavy metal and organic chemical exposures.

B. SOIL COMPARISON LEVELS

To evaluate potential Laboratory impacts from radionuclides and chemicals in soil, we first compare the analytical results of samples collected from the Laboratory's on-site and perimeter areas with regional statistical reference levels (RSRLs). Where the results exceed these regional background levels, we then compare the concentrations with human health screening levels (SLs) and, finally, if needed, with the appropriate regulatory standard, if available. A more detailed description of the levels and/or the standard used to evaluate the results of radionuclides and chemicals in soil are given below. An overall summary can be found in Table 7-1.

- Regional Statistical Reference Levels: RSRLs are the mean plus three standard deviations (= 99% confidence level) for radionuclides and chemicals in soil collected from background locations away from the influence of the Laboratory (> 9 miles) (DOE 1991) over at least the last five sampling periods. RSRLs, which represent natural and fallout levels, are calculated as additional data become 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 constraint of 25 mrem/yr (DOE 1993, DOE 1999c) so that potential human health concerns may be identified in advance, i.e., a "yellow flag." If a radionuclide exceeds the SL, we investigate the basis for the higher amounts, check laboratory records, and reanalyze the sample, if possible, and/or resample the site to determine the possible cause for the higher than normal result. LANL developed SLs to identify radionuclides of potential human health concern on the basis of a 15-mrem/yr protective dose limit for several scenarios (residential or industrial) (LANL 2009) using the residual radioactive (RESRAD) computer model (Yu et al., 1995).

  For other chemicals (inorganic and organic), we compare concentrations to the New Mexico Environment Department (NMED) (residential or industrial) SLs that are set at a 10^{-5} risk level for carcinogens and a hazard quotient (HQ) of one for non-carcinogens (NMED 2006).

  To evaluate radionuclide and other chemicals in soil, the results from on-site areas are evaluated against industrial screening levels (ISLs), and perimeter areas are compared with residential screening levels (RSLs). The RSLs assume that families live at these locations on a year-round basis.
- 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 for a given year. (These data are presented in 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 are presented in a report by Fresquez, Mullen, Ferenbaugh, and Perona (1996). This calculated dose is compared with the 25-mrem/yr DOE single-pathway dose constraint.

Table 7-1
Application of Soil Standards and Other Reference Levels to LANL Monitoring Data

Constituent	Sample Location	Standard	Screening Level (Scenario)	Background Level
Radionuclides	Perimeter	25 mrem/yr	15 mrem/yr (residential)	RSRL
	On-site, Area G, DARHT	25 mrem/yr	15 mrem/yr (industrial)	RSRL/BSRL[a]
Chemicals	Perimeter	na[b]	10^{-5} risk (residential) or HQ = 1	RSRL
	On-site, Area G, DARHT	na	10^{-5} risk (industrial) or HQ = 1	RSRL/BSRL[a]

[a] Baseline Statistical Reference Level. A discussion of these levels is provided in Section D.3.

[b] na = Not available

C. INSTITUTIONAL MONITORING

1. Monitoring Network

Institutional surface soil samples are collected from 17 on-site (LANL), 11 perimeter, and six regional (background) locations on a triennial basis (every third year) (Figure 7-1). The last comprehensive soil survey, which included the analysis of radionuclides, target analyte list (TAL) elements (mostly metals), polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), and high explosives (HEs), occurred in 2009 (Fresquez 2010). In general, all radionuclides and TAL elements were far below ISLs for on-site soils or far below RSLs for perimeter soils. Moreover, no HEs were detected above the reporting level of quantification in any soil collected from on-site, perimeter, or regional locations. And only trace amounts of a few PCB Aroclors (Aroclor 1254 and 1260) and SVOCs (aniline and fluoranthene) in soil from a few sites were detected; however, all levels were far below either ISLs or RSLs, and no increasing trends were evident. The next planned full-scale institutional soil assessment will occur in 2012.

Although the institutional soil sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we collect on an annual basis two perimeter soil samples for radionuclides and TAL elements on Pueblo lands that are downwind of Area G, the Laboratory's principal low-level radioactive waste disposal site. Area G, approximately 63 acres in size, is located in Technical Area (TA)-54 at the Laboratory's eastern boundary. Soil samples on Pueblo de San Ildefonso lands were collected in June 2010 from relatively level, open (unsheltered by trees or buildings), and rock-free areas. One sample, identified as "San Ildefonso," was collected across Cañada del Buey about one-half mile north of Area G, and the other sample, identified as "Tsankawi/PM-1," was collected just a little over two miles away and is also located north of Area G.

We compared soil sample (analysis) data from these two perimeter stations with RSRLs. These RSRLs are derived from samples collected from northern New Mexico background locations that surround the Laboratory in all major directions and from samples in which radionuclides and chemicals in the soil are primarily from natural sources or worldwide fallout events. These regional areas are located near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast; Rowe Mesa (near Pecos) to the southeast; Youngsville to the northwest; and Jemez Springs to the southwest. As required by the DOE, all locations are at similar elevations as LANL, are more than 20 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (> 9 miles) (DOE 1991).

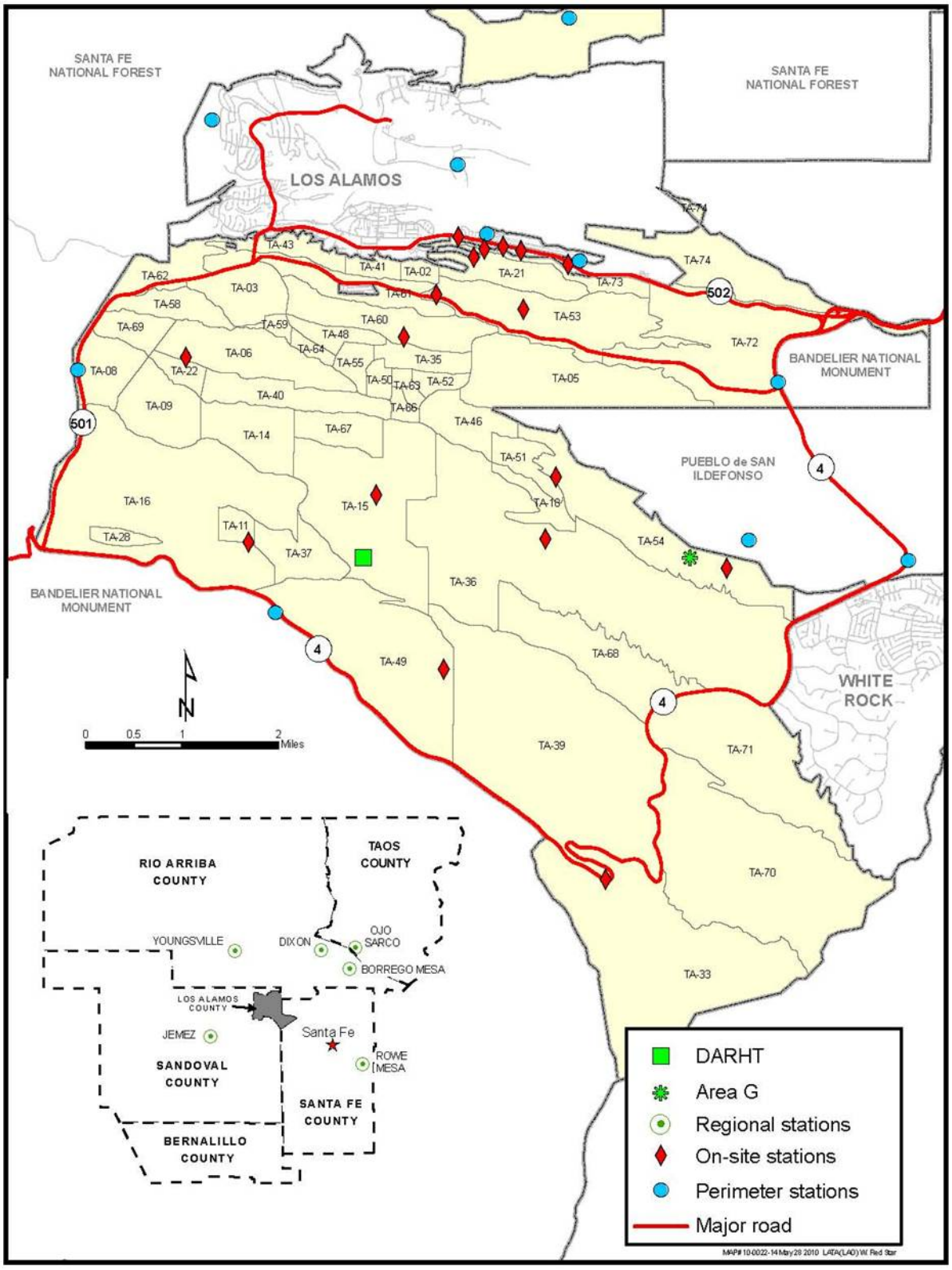

Figure 7-1 **On-site, perimeter, and regional soil sampling locations. The Otowi perimeter station is not shown but is about five miles east of LANL on State Route 502.**

2. Methods and Analysis

At each site, soil composite samples for radionuclides and TAL elements (mostly metals) were collected with a stainless steel soil ring 4 inches in diameter pushed 2 inches deep at the center and corners of a 33-ft by 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 then placed in pre-labeled 500-mL polyethylene bottles, sealed with chain-of-custody tape, placed into individual Ziploc bags, and submitted to the LANL Sample Management Office. All samples were handled and shipped under full chain-of-custody procedures to ALS (formerly Paragon) Laboratory Group for analysis. These samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, and uranium-238 and for 23 TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury). The results from these sample analyses are presented in supplemental Tables S7-1 and S7-2.

3. Radionuclides

All radionuclide (activity) concentrations in soil collected from the two perimeter areas on Pueblo de San Ildefonso lands downwind of Area G in 2010 were very low (pCi/g range), and most were either not detected or detected below the RSRLs (Table S7-1). A non-detected value is one in which the result is lower than three times the counting uncertainty and is not significantly different (α = 0.01, or 99% confidence level) from zero (Keith 1991; Corely et al., 1981) or less than the minimum detectable activity.

The only radionuclide that was detected in higher concentrations than the RSRL was plutonium-238 in the Pueblo de San Ildefonso soil location closest to Area G. The amount of plutonium-238 in soil from the "San Ildefonso" site, however, was just slightly above the RSRL and was far below the RSL. The long-term trend showed only normal variability along the RSRL line (Figure 7-2). Other radionuclides associated with Area G operations like tritium and plutonium-239/240 in the "San Ildefonso" soil sample were very similar to past years, are not increasing over time, and remain well below the RSL (Figures 7-3 and 7-4).

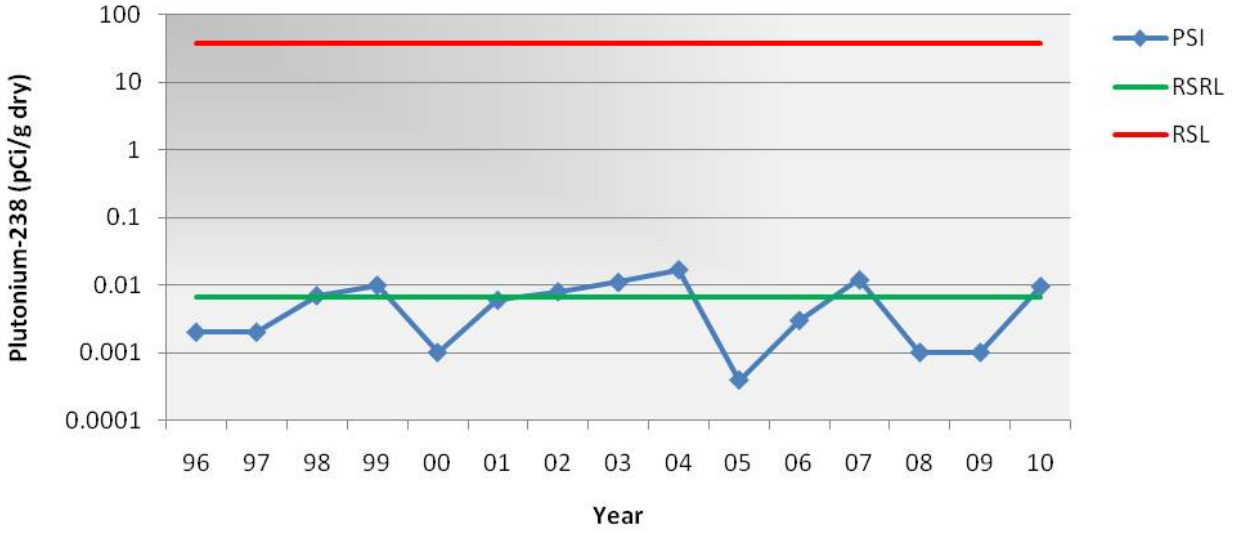

Figure 7-2 **Plutonium-238 (detectable and non-detectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately one-half mile northeast of Area G from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the residential screening level (RSL).**

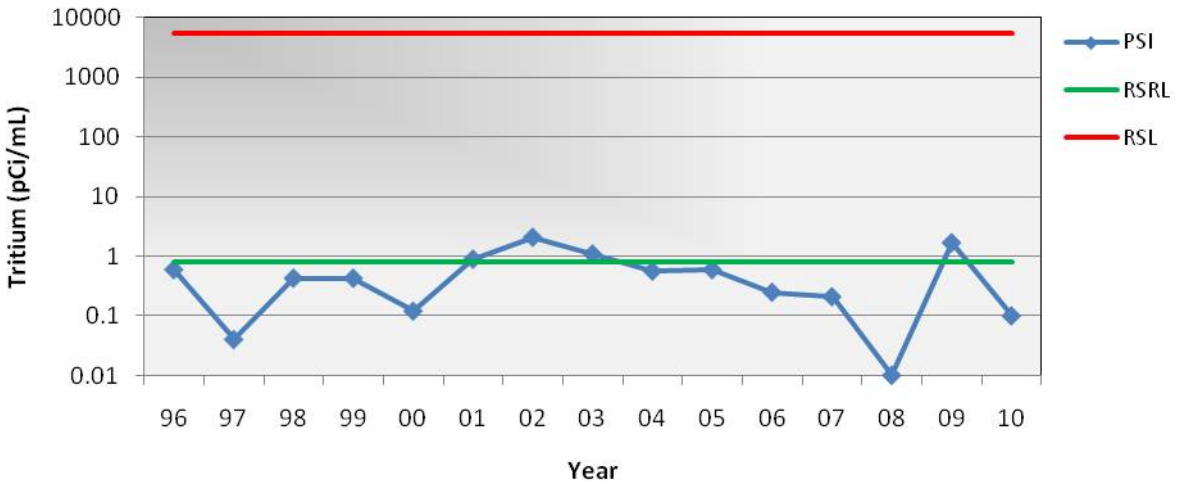

Figure 7-3 **Tritium (detectable and non-detectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately one-half mile northeast of Area G from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the residential screening level (RSL).**

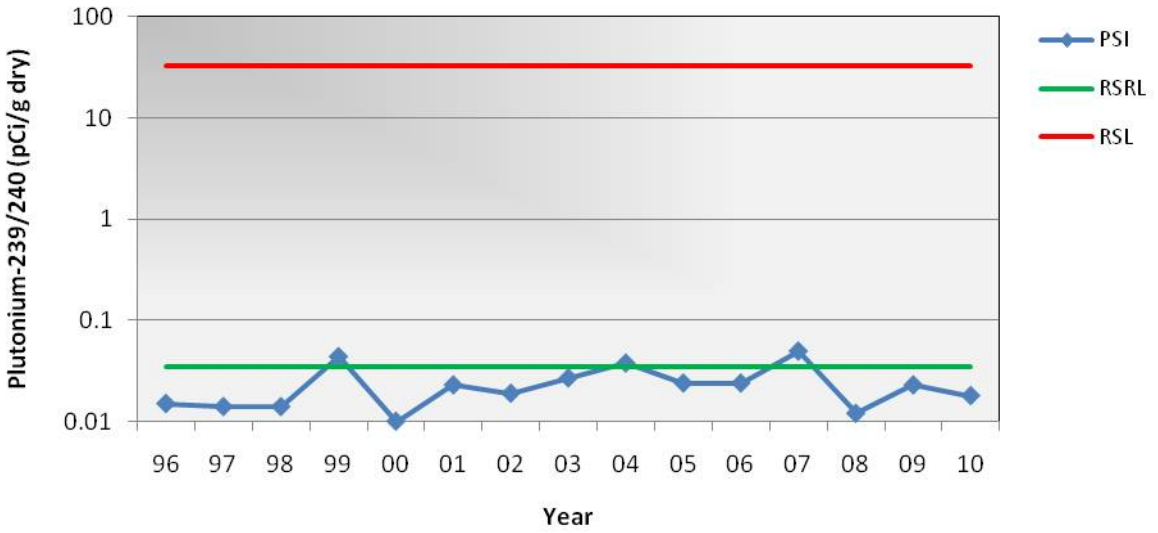

Figure 7-4 **Plutonium-239/240 (detectable and non-detectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately one-half mile northeast of Area G from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the residential screening level (RSL).**

4. TAL Elements

Table S7-2 shows the results of the TAL element analyses in surface soil collected from the two perimeter sites located on Pueblo de San Ildefonso lands in 2010. All metal concentrations, with the exception of selenium, from these two areas, were either not detected or detected below RSRLs. The amounts of selenium, however, were just above the RSRL and far below RSLs.

5. TAL Elements: Follow-up of 2009 Results of Soil Manganese at Two Mile Mesa at TA-6

In 2009 we reported that manganese (3,600 mg/kg) in a soil sample collected from Two Mile Mesa at TA-6 site was far above the RSRL (766 mg/kg) (albeit far below the ISL of 48,400 mg/kg) and above the long-term average of 500 mg/kg (Fresquez 2010). To determine if there was a potential problem in the area, we re-sampled the site of interest in 2010. The 2010 results showed only normal concentrations (600 mg/kg) similar to past years (Table S7-2). Since there were no physical disturbances or any operations using manganese-

containing chemicals at or near the sample site, the high manganese level reported in 2009 was probably due to an analytical laboratory error.

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 (see Figure 7-1). Established in 1957, Area G is the Laboratory's primary low-level 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 at Area G (DOE 1979).

Thirteen surface soil samples were collected in May 2010 at designated locations around the perimeter of Area G, and one surface soil sample (site #T3) was collected at the LANL/Pueblo of San Ildefonso boundary line approximately 800 ft northeast of Area G (Figure 7-5).

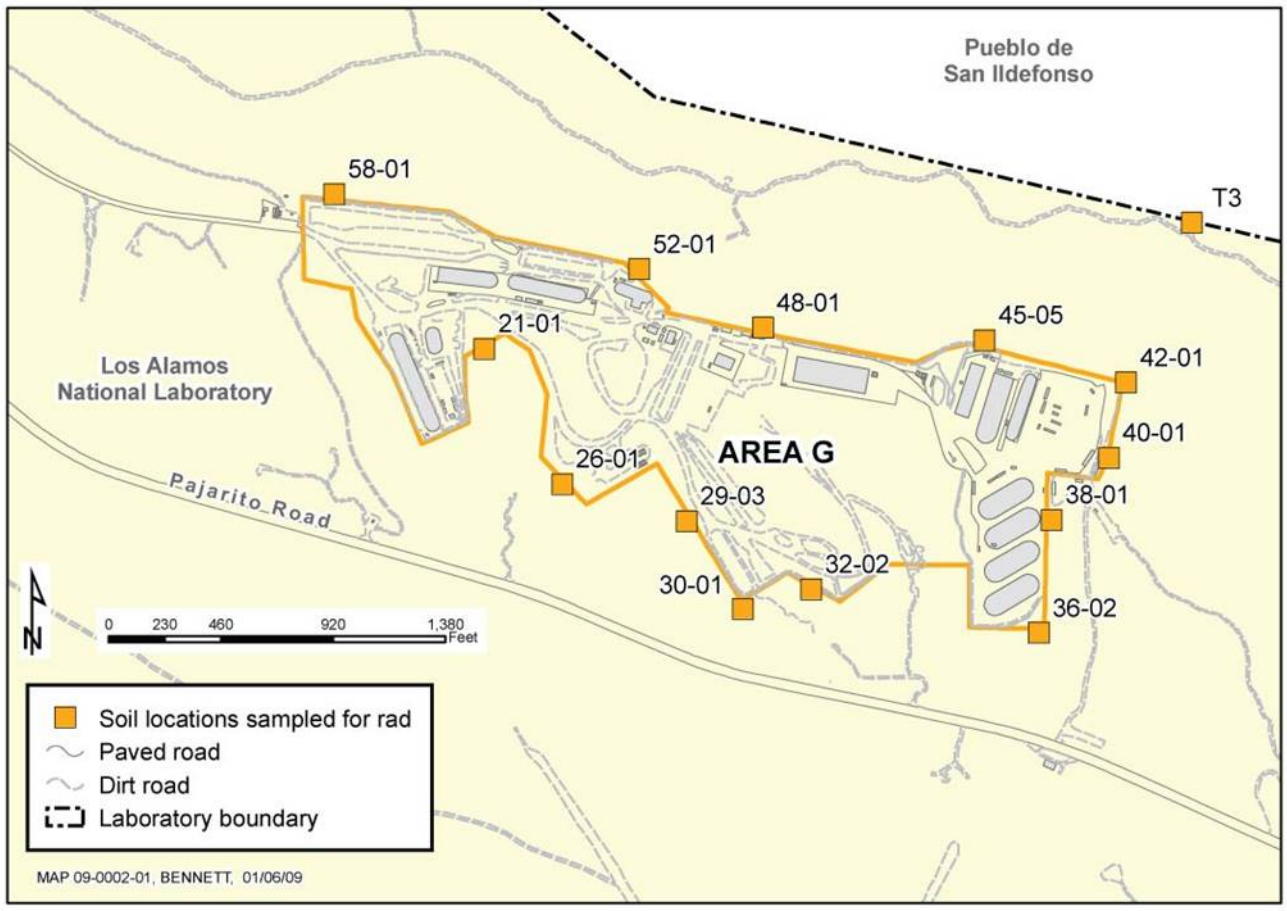

Figure 7-5 Locations of soil samples collected around Area G in 2010

All samples were analyzed by ALS for tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. The results from these samples are presented in supplemental Table S7-3.

TAL elements were not analyzed in 2010 because previous sampling in 2006 showed no levels of concern. Results from that sampling period showed that most metals (478 out of 483 measurements) were similar to RSRLs (Fresquez 2007), and the few detected above RSRLs were far below the ISLs and no trends were evident.

2. Radionuclide Analytical Results for Area G

a. Perimeter Results

Tritium, americium-241, plutonium-238, and plutonium-239/240 were detected at concentrations above the RSRLs in several of the 13 soil samples collected around the perimeter of Area G in 2010 (Table S7-3).

Specifically, tritium was detected above the RSRL (0.80 pCi/mL) in 23% of the samples collected around Area G. The highest concentration (169 pCi/mL) occurred in the southern portion (around site #29-03) where the tritium shafts are located. Although these data are within the range of concentrations detected in past years, they are quite variable from year to year (Figure 7-6).

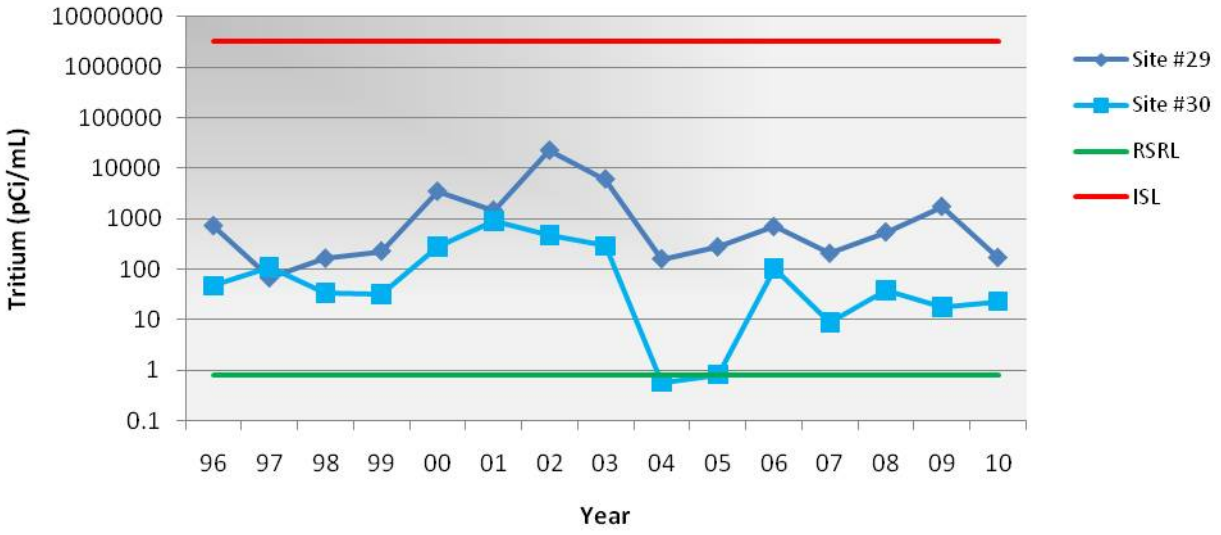

Figure 7-6 **Tritium concentrations in surface soil samples collected from the southern portions of Area G at TA-54 from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the industrial screening level (ISL). Note the logarithmic scale on the vertical axis.**

The degree of variability in tritium concentrations in surface soil from year to year may be influenced by engineering and environmental factors (Purtymun 1973; Abeele and Nyhan 1987; Vold 1997; Childs and Conrad 1999; Budd et al., 2004). Nonetheless, the concentrations of tritium in soil at Area G are far below the ISL of 3.2E06 pCi/mL (equivalent to 4.4E05 pCi/g at 12% moisture), and the migration of tritium from the Area G boundary at surface depths, is not extensive. In a 2003 study, the measurement of tritium in trees at the southern portion of Area G, starting from the perimeter fence line outward (approximately 33, 165, 330, 490, and 660 ft), showed that the concentrations of tritium decreased greatly with distance; and at about 330 ft away, the concentrations of tritium were similar to the RSRL (Fresquez et al., 2003).

More than 50% of the soil samples collected around the perimeter of Area G contain concentrations of americium-241, plutonium-238, and plutonium-239/240 greater than their respective RSRLs, particularly around the perimeter of the northern, northeastern, and eastern sections (Table S7-3). The highest concentrations of americium-241 (0.36 pCi/g dry at site #38-01), plutonium-238 (1.3 pCi/g dry at site #40-01), and plutonium-239/240 (1.7 pCi/g dry at site #38-01) were detected in soil samples located on the perimeter of the eastern side of Area G near the Transuranic Waste Inspection Project domes. Although the concentrations of these radionuclides in soil collected around the perimeter of Area G are higher than the RSRLs, all levels are still far below ISLs and, except for their high variability from year to year at some points, the concentrations are generally not increasing over time (Figures 7-7, 7-8, and 7-9).

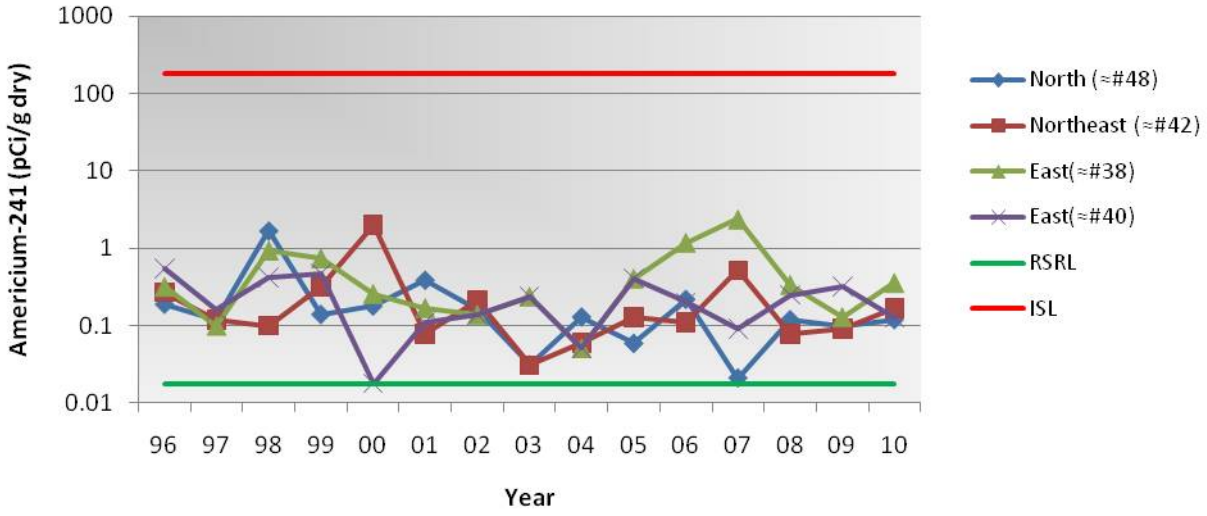

Figure 7-7 **Americium-241 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the industrial screening level (ISL). Note the logarithmic scale on the vertical axis.**

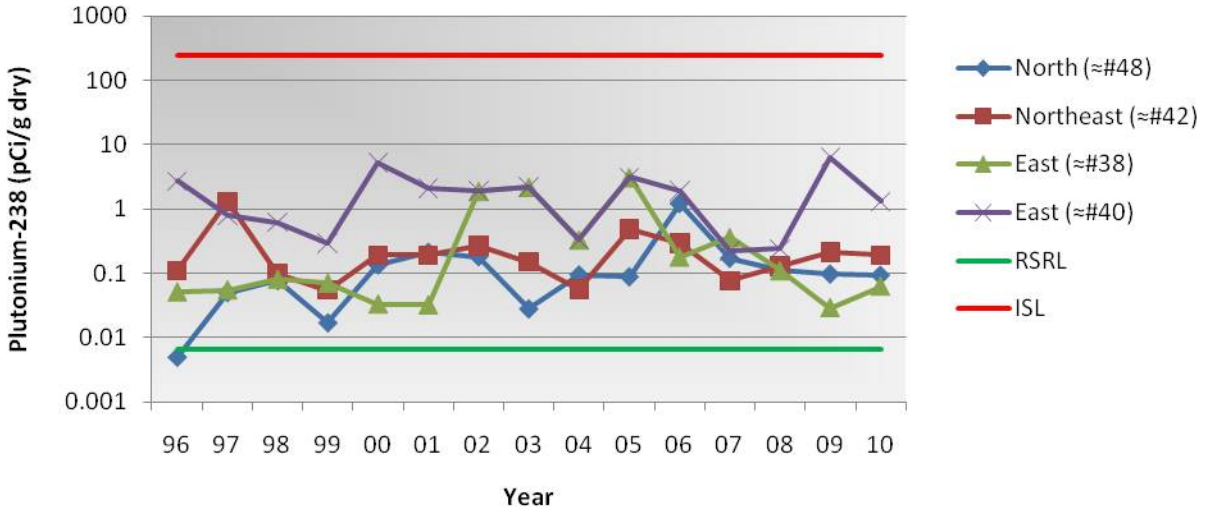

Figure 7-8 **Plutonium-238 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the industrial screening level (ISL). Note the logarithmic scale on the vertical axis.**

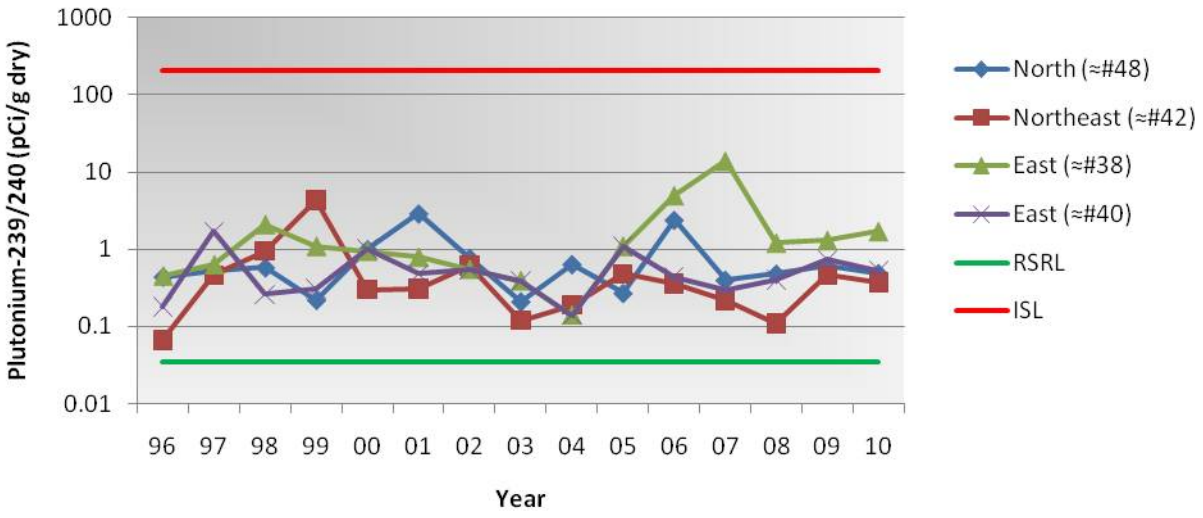

Figure 7-9 **Plutonium-239/240 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2010 as compared with the regional statistical reference level (RSRL) and the industrial screening level (ISL). Note the logarithmic scale on the vertical axis.**

b. Results at the Pueblo de San Ildefonso Boundary

Plutonium-238 and plutonium-239/240 in a soil sample collected at the LANL/Pueblo de San Ildefonso boundary northeast and down gradient of Area G (Site #SI-T3) were detected at concentrations just above the RSRLs in 2010 (Table S7-3). However, the levels of these radionuclides were far below the RSLs and have generally remained stable over the five-year time period of study (Figures 7-10 and 7-11).

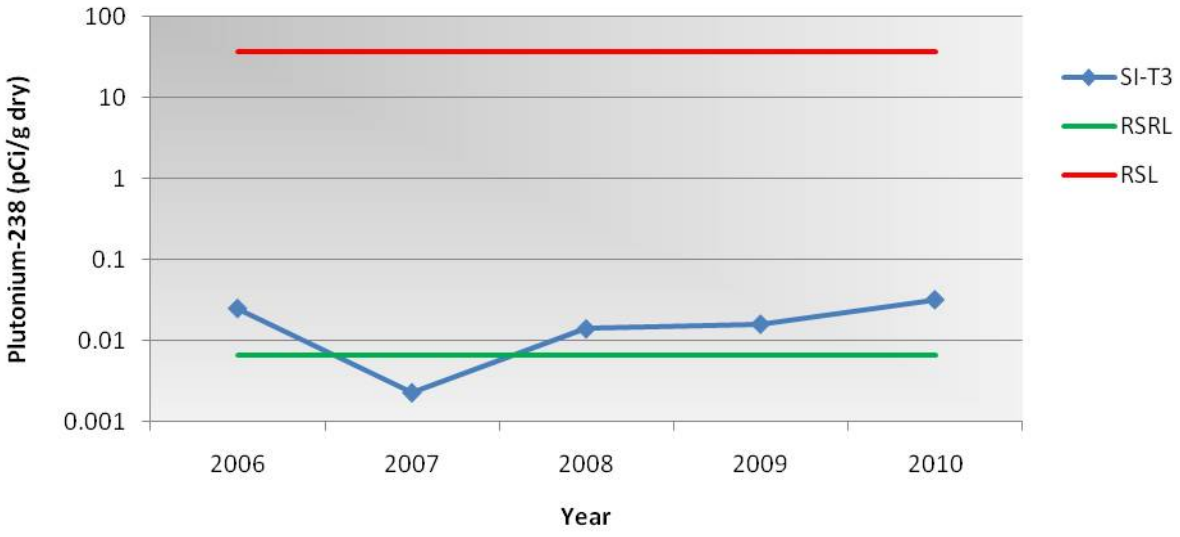

Figure 7-10 **Plutonium-238 (detectable and non-detectable) concentrations in surface soil collected from the LANL/Pueblo of San Ildefonso boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2010 as compared with the regional statistical reference level (RSRL) and the residential screening level (RSL). Note the logarithmic scale on the vertical axis.**

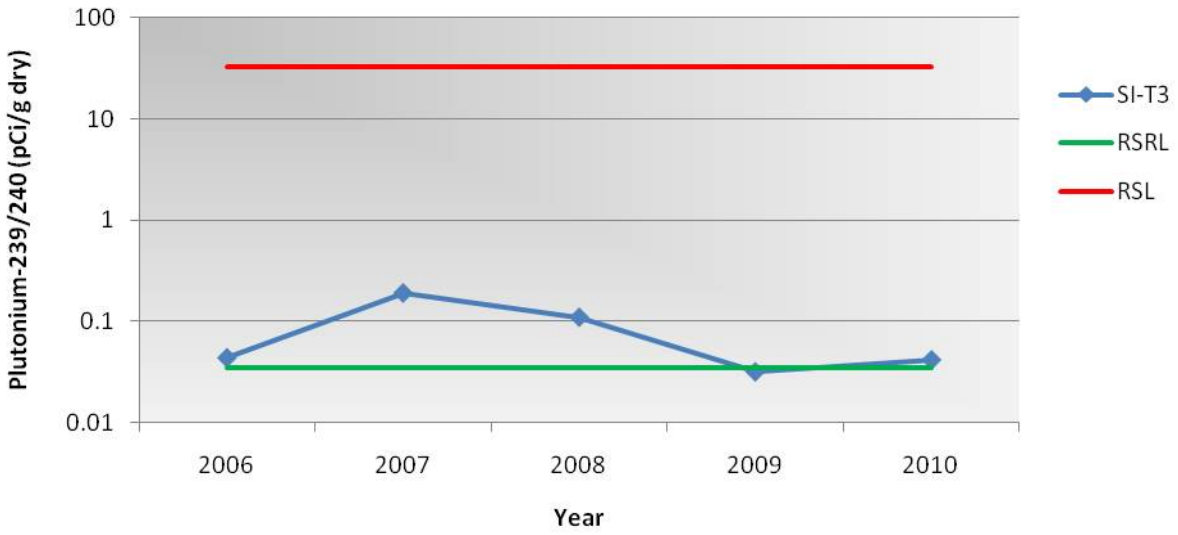

Figure 7-11 **Plutonium-239/240 (detectable and non-detectable) concentrations in surface soil collected from the LANL/Pueblo of San Ildefonso boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2010 as compared with the regional statistical reference level (RSRL) and the residential screening level (RSL). Note the logarithmic scale on the vertical axis.**

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 side (see Figure 7-1). Activities at DARHT include the use 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). Open-air detonations occurred from 2000 to 2006; detonations using foam mitigation were conducted from 2002 to 2006; and detonations within closed steel containment vessels were conducted starting in 2007 (three in fiscal year [FY] 2007, two in FY08, none in FY09, and four in FY10) (DOE 2009, 2010, 2011). Potential contaminants include radionuclides, beryllium (and other heavy metals), and organic chemicals like PCBs, SVOCs, and HEs.

Soil samples were collected in May 2010 on the north, east, south, and west sides (Figure 7-12) of the DARHT perimeter. An additional soil sample was collected about 23 meters north of the firing point (the firing point has since been paved). Sediment samples were collected on the north, east, south, and southwest sides. All soil and sediment samples were analyzed by the ALS for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, TAL element, and HEs. The firing point sample was also analyzed for dioxin and furans by Cape Fear Analytical. Although not analyzed in 2010, PCBs and SVOCs were not detected in soil and sediment samples collected within and around the perimeter of the DARHT facility in 2007 (Fresquez 2008). (Note: We report on the analyses of vegetation, small mammals, bees, and birds collected around the DARHT facility in Chapter 8, Section B.4.b.)

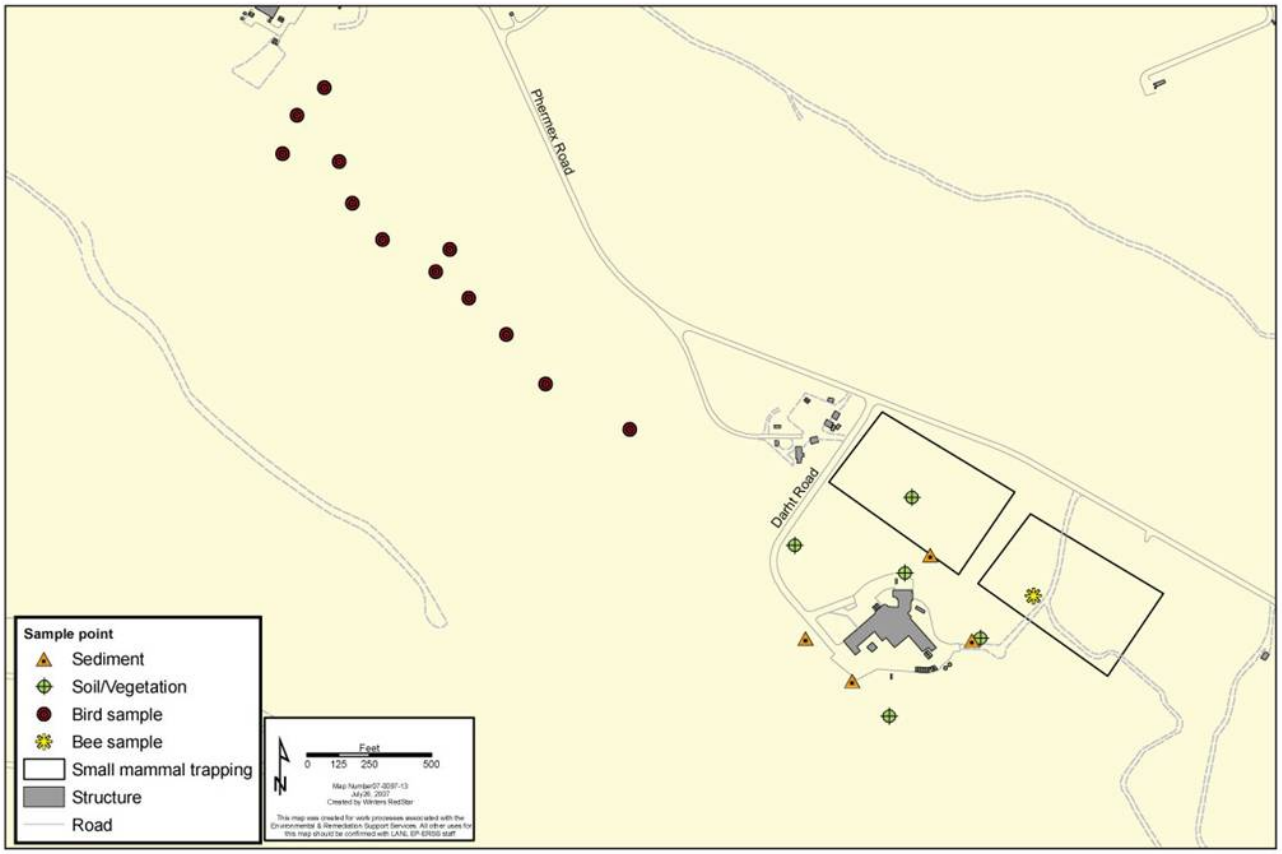

Figure 7-12 Soil, sediment, and biota sample locations at DARHT in 2010.

We compared the radionuclide and TAL element results in soil and sediment from the DARHT sampling to both RSRLs and BSRLs. The BSRLs are the concentrations of radionuclides and inorganic chemicals (mean plus three standard deviations) in soil and sediment collected from around the DARHT facility from 1996 through 1999 before the start-up of operations (Fresquez et al., 2001), per the DARHT Mitigation Action Plan (DOE 1996). Both reference levels are employed because the BSRLs for some elements may be biased as a result of changes in pre- and post-sampling locations and a change in analytical techniques. A comparison of BSRLs with RSRLs, for example, shows that some baseline radionuclide concentrations, such as cesium-137 from fallout, may be biased low and some baseline inorganic chemical concentrations, such as silver, may be biased high regardless of DARHT activities. Moreover, some TAL elements analyzed recently have no baseline levels at all. To accommodate parking spaces and storage areas within the DARHT complex after operations began, soil sampling locations had to be 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 (fallout) because the pre-operation samples were collected in mostly disturbed soil and the post-operation start-up samples were 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. Moreover, the change in analytical techniques may have improved detection capabilities for some metals. The use of inductively coupled plasma mass spectrometry instrumentation to analyze post-operation start-up samples, for example, substantially decreased the detection limits of silver, from 2 to 0.2 mg/kg.

4. Radionuclide and Chemical Analytical Results for DARHT

Most radionuclides, with the exception of uranium isotopes, in soil and sediment collected from within and around the perimeter of the DARHT facility were either not detected or below the statistical reference levels

(Table S7-4). Uranium isotopes, but predominantly uranium-238, were detected above the BSRL in two of the five soil samples collected. The highest amount of uranium-238 was detected in a soil sample collected just north of the firing point (5.8 pCi/g dry); however, this amount was dramatically lower than some of the previous years, particularly in 2008 (55 pCi/g dry), and far below the ISL (Figure 7-13).

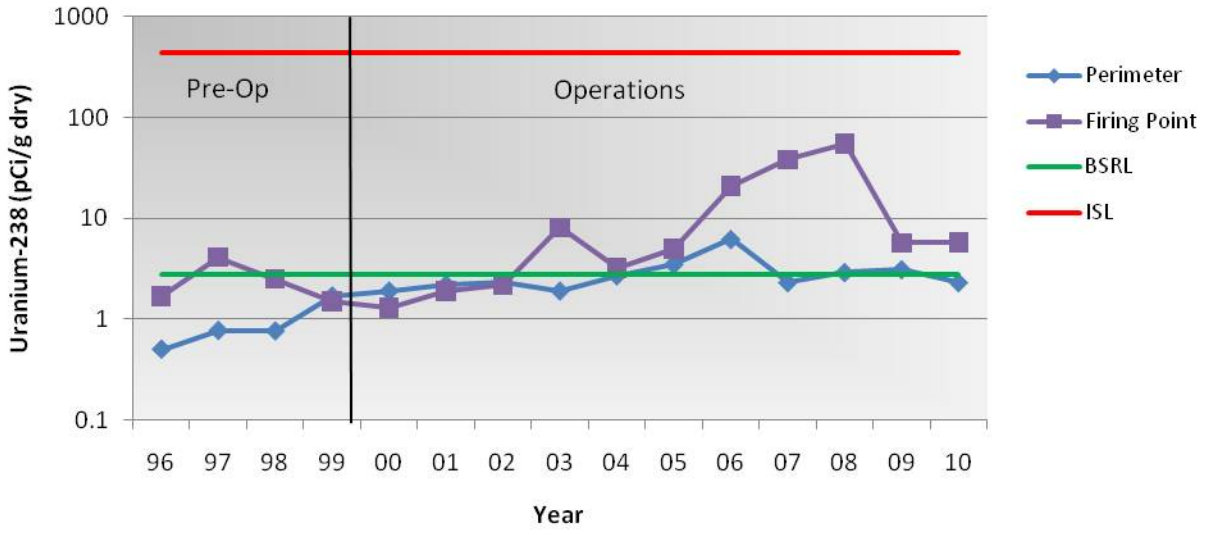

Figure 7-13 **Uranium-238 concentrations in surface soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and east side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2010 (operations) as compared with the baseline statistical reference level (BSRL) and the industrial screening level (ISL). Note the logarithmic scale on the vertical axis.**

All of the TAL elements, including beryllium, in the soil and sediment samples collected within and around the DARHT facility were below both the statistical reference levels (Table S7-5). Beryllium, listed as a chemical of concern prior to the start-up of operations at DARHT (DOE 1995), was not detected in any of the soil or sediment samples above reference levels. Also, beryllium concentrations in soil over the 11-year operations period has been mostly below the BSRL, far below ISLs, and remains relatively stable over time (Figure 7-14).

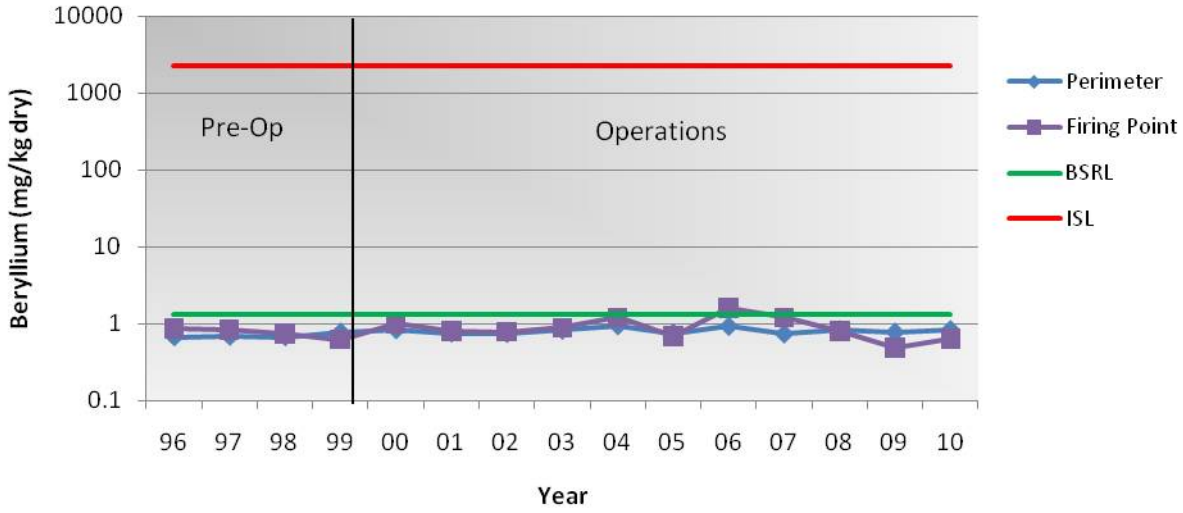

Figure 7-14 **Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and east side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2010 (operations) as compared with the baseline statistical reference level (BSRL) and the industrial screening level (ISL)**

HEs were not detected in any of the soil or sediment samples collected within and around the perimeter of the DARHT facility, including the sample closest to the firing point (Table S7-6). Also, dioxin and furans were not detected above the limit of quantification (reporting limit) in the soil sample nearest the firing point (Table S7-7).

E. SPECIAL MONITORING STUDIES

1. Origin of Plutonium and Cesium-137 in Soil Samples Collected in High-Elevation Locations in New Mexico and Colorado

In 2008, the NMED collected five soil samples from high-elevation areas (11,099 to 12,476 ft) and analyzed them for cesium and plutonium activity (NMED 2008a); the goal of the study was to determine potential contaminants and their impacts to the watershed used for irrigation in the Embudo Valley (NMED 2007). Four samples were collected from the Sangre de Cristo Mountains of New Mexico (Cebolla, Puerto Nambe, and two from Trampas Lake), and one sample was collected from Rock Lake, Colorado. Results showed detectable concentrations of cesium-137 and plutonium-239/240 in the Trampas Lake samples in particular and concluded that the amounts were consistent with those measured at other high-elevation lakes in the Rocky Mountains (NMED 2008b). Normally, higher amounts of radionuclides from global fallout are detected at higher altitudes because of greater precipitation from rain and snow (Ulsh et al., 2000).

To determine the origin of the detectable concentrations of cesium-137 and plutonium-239/240 reported by the NMED, all five soil samples were provided to LANL to determine the distribution of isotopic ratios of the radionuclides in these samples. The isotopic ratios of these radionuclides vary, depending upon the origin of the radionuclides, and possible sources include LANL operations, fallout from nuclear tests at the Nevada Test Site (NTS), or from large thermonuclear tests conducted by the United States or the former Soviet Union. Cesium was analyzed by gamma-ray spectrometry and plutonium was analyzed by thermal ionization mass spectrometry. Based on the plutonium-240/plutonium-239 isotope ratio and cesium-137/plutonium-239,240 activity ratio measured for each sample, it was determined that all of the radionuclides present were from fallout from nuclear tests (LaMont et al., 2009; Steiner et al., 2010).

In the four samples from New Mexico, approximately 75% of the radionuclides were from global fallout from large thermonuclear atmospheric tests conducted by the United States and the former Soviet Union, and 25% of the radionuclides were from regional fallout from much smaller atmospheric nuclear tests conducted at the NTS. The sample from Colorado showed a much larger NTS fallout content at 78%, with only 22% of radionuclides coming from global fallout. The cesium-137/plutonium-239,240 ratios also demonstrated that fallout was the only source of radionuclides in these samples, and no measurable contribution to the plutonium concentration from LANL operations could be detected.

F. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

1. Quality Assurance Program Development

The sampling team collects soil, foodstuffs, and biota (SFB) samples 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:

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program
- Sampling Soil and Vegetation at Facility Sites
- Analytical Chemistry Data Management and Review for Soil, Foodstuffs, and Biota
- Analytical Data Verification/Validation Process

These procedures, which are available on the LANL public website (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 manner consistent from year to year. Locations 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 the carefully documented procedures, listed above, which govern all aspects of the sample-collection program.

The team collects all samples under full chain-of-custody procedures to minimize the chances of data transcription errors. Once collected, we hand-deliver the samples to the LANL Sample Management Office, which ships them via express mail directly to an external analytical laboratory under full chain-of-custody control. The project leader of the Soil, Foodstuffs, and Biota monitoring program tracks all samples. Upon receipt of data from the analytical laboratory (electronically and in hard copy), the completeness of the field-sample process and other variables are assessed. A quality assessment document is created, attached to the data packet, and provided to the project leader.

Field data completeness for SFB in 2010 was 99%.

3. Analytical Laboratory Quality Assessment

We had no analytical laboratory data quality issues related to the SFB sampling program during 2010. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 11. Analytical data completeness for all SFB sampling programs was 99% in 2010.

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A. FOODSTUFFS MONITORING

1. Introduction

A wide variety of wild and domestic crops, including vegetables, fruits, berries, nuts, and grains, are grown and/or harvested at many locations surrounding Los Alamos National Laboratory (LANL or the Laboratory). Also, many food products from domestic livestock (e.g., milk, eggs, and meat) and apiaries (honey) are available, and fishing and hunting for small and big game animals (e.g., rabbits, turkey, deer, and elk) on neighboring properties around LANL are a common occurrence.

Conceptually, these foodstuffs within and around LANL might become contaminated through air stack emissions and fugitive dust (inhalation by animals; deposition on plant surfaces), soil contamination sites (ingested and/or dermal contact by animals; splash and root uptake by plants), and storm and irrigation water exposures (ingested and/or dermal contact by animals; root uptake by plants). Elk and deer, for example, might graze through areas on LANL land or drink from water catchments that might contain radioactive and/or chemical contamination, and fish might be exposed to potential contaminants entering the Rio Grande from runoff discharging from the Cerro Grande and/or from the many canyons that cross Laboratory property. Please note, however, that the many years of data collected to date do not demonstrate LANL impacts above screening levels on these resources. Nonetheless, the ingestion of these foods might conceptually constitute an important exposure pathway by which radionuclides (Whicker and Schultz 1982) and other chemicals (Gough et al., 1979) might be taken in by humans (i.e., food web transfer).

The purpose of the foodstuff monitoring program is to determine whether Laboratory operations are affecting human health via the food chain. US Department of Energy (DOE) Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993) define the framework and requirements for this monitoring program. We accomplish this effort through the following tasks:

1) Measuring radioactive and (other) chemical concentrations in foodstuffs on Laboratory land, if available, and from neighboring communities and comparing these results to regional background levels, screening levels, and, if available, standards;

2) Determining concentration trends over time; and

3) Providing data used to estimate potential dose from the consumption of the foodstuffs (see Chapter 3 for dose estimates to individuals from the ingestion of foodstuffs).

In general, as part of the soil/foodstuffs and biota program (see Chapters 7 and 8, respectively), we conduct sampling of major area resources on a three-year rotating schedule. The collection of Rio Grande–related samples (fish, crayfish, and benthic macroinvertebrates) was accomplished in 2008 (Fresquez et al., 2009) and surface soil/native vegetation related samples was completed in 2009 (Fresquez et al., 2010). This year, we present the results of agriculture-related samples (produce crops, goat milk, chicken eggs, and honey) collected from the neighboring communities surrounding the Laboratory. (Note: Other foodstuffs like wild edible plants, livestock, and small and large game animals are analyzed as they become available and an adequate number of samples can be submitted to the laboratory.)

Also, we present additional (follow-up) metal data on crayfish collected from the Rio Grande upstream and downstream of LANL; radionuclide, metal, and polychlorinated biphenyls (PCBs) in meat of two (road-killed) elk collected on LANL lands; and (follow-up) of metals and PCBs in meat of several (road-killed) deer that were collected along roads that cross LANL lands.

2. Foodstuffs Comparison Levels

Radionuclides and chemicals in foodstuffs potentially impacted by LANL operations are compared with regional statistical reference levels (RSRLs). RSRLs are the upper-level background concentration (mean plus three standard deviations = 99% confidence level) for radionuclides (both detected and nondetected values are used) and chemicals calculated from foodstuffs collected over the past five sampling events from regional locations away from the influence of the Laboratory (more than 9 miles away) (DOE 1991). The concentrations of radionuclides and chemicals in foodstuffs collected from regional background areas are the result of worldwide fallout and natural processes (e.g., elements in soil to plants to animals). (Note: In some cases where there are numerous detections above RSRLs and a large number of samples are collected from a defined population, a statistical test at the 0.05 probability level may be used to aid in comparisons.)

If any radionuclide/chemical concentration in a foodstuff exceeds the RSRL(s), we would then compare the concentration with screening levels (SLs). For radionuclides, the SLs in concentration units are based on 4% (= 1 mrem/yr) (LANL 2003) of the 25-mrem/yr DOE single-pathway constraint (DOE 1999) so that potential concerns may be identified in advance of the standard, i.e., a "yellow flag." If a radionuclide concentration exceeds an SL, the basis for that increase is investigated. For target analyte list (TAL) elements, with the exception of mercury in aquatic animals, there are no SLs for the majority of foodstuffs collected around LANL. The SL for mercury in aquatic animals, based on US Environmental Protection Agency (EPA) guidelines, is 0.30 mg/kg wet weight (parts per million) (EPA 2001). (Note: Although not SLs, per se, EPA guidelines for limited consumption of fish are based on the amounts of mercury, cadmium, selenium, and arsenic [EPA 2007]. They are presented as a range and as the concentrations increase, the number of fish that can be consumed decreases.) Similarly, for PCBs in fish, we use EPA guidelines for SLs; in this case, we would compare Toxicity Equivalent Quotients (TEQs), which are calculated from the 12 dioxin-like PCB compounds (Van den Berg et al., 2006) to the EPA risk-based consumption limits for human health (EPA 2007).

If radionuclides, mercury, or PCB concentrations exceed an SL, they would then be compared with the applicable action limit. In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured within a single pathway and compared with the 25-mrem/yr DOE single-pathway dose constraint (DOE 1999). In the case of mercury and PCBs, the concentrations would be compared with the Food and Drug Administration (FDA) action limits of 1 ppm (fish) and 3 ppm (for red meat and poultry), respectively (FDA 2000). Table 8-1 presents a summary of the RSRLs, SLs, and the standards used to evaluate the results of radionuclides, mercury, and PCBs in foodstuffs.

Table 8-1
Standards and Other Reference Levels Applied to Foodstuffs

Constituent	Media	Standard	Screening Level	Background Comparison Test or Level
Radionuclides	All foodstuffs	25 mrem/yr	1.0 mrem/yr	RSRLs
Mercury	Aquatic animals	FDA: 1 ppm (wet) in edible portion (complete consumption restrictions)	EPA: 0.30 ppm (wet) in edible portion	RSRLs
TAL Elements per EPA Risk-Based Consumption Limits of Edible Portions				
Mercury	Fish		0.029–1.9 ppm (wet)	RSRLs
Cadmium	Fish		0.088–5.6 ppm (wet)	
Selenium	Fish		1.5–94 ppm (wet)	
Arsenic	Fish		0.002–0.13 ppm (wet)	
Polychlorinated Biphenyls (PCBs)				
	Red meat and poultry	FDA (complete consumption restrictions). Total PCBs = 3 ppm		RSRLs
	Fish		EPA (limited consumption restrictions). Total PCBs = 0.0015–0.094 ppm or TEQs = 0.019–1.2 ppt from 12 dioxin-like PCB congeners	RSRLs

3. Crop (Produce) Monitoring

a. Monitoring Network

We collected more than 100 fruit and vegetable samples from on-site, perimeter, and regional background locations in the summer/fall of 2010 (Figure 8-1). The locations with respect to the Laboratory, number of samples collected, and potential transport pathway(s) were as follows:

- On-site (LANL): Technical Areas (TA) 3/16/21/35/36/46/52/54/61, 15 samples, downwind air pathway and storm water runoff pathway;
- Perimeter: Los Alamos town site, located north of LANL, 19 samples, downwind air pathway;
- Perimeter: White Rock/Pajarito Acres town sites, located southwest of LANL, 19 samples, downwind air pathway;
- Perimeter: Pueblo de San Ildefonso/El Rancho/Jacona/Nambé corridor, located along State Road 502 northeast of LANL, 23 samples, downwind air pathway;
- Perimeter: Algodones/Bernalillo/Corrales corridor, located along the Rio Grande basin south of LANL, 14 samples, water/irrigation pathway; and,
- Regional Background: Española/Velarde/Dixon/Alcalde/Santa Fe, 19 samples.

Approximately 15 on-site produce samples were collected from nine TAs located throughout the Laboratory. Most of the LANL samples were of fruit, but three samples were vegetables collected from the Otowi garden at TA-3 that is maintained by Laboratory volunteers. Similarly, more than 70 samples of fruits and vegetables were collected from perimeter communities located to the north, northeast, southeast, and south of the Laboratory and include crops irrigated with water from the Rio Grande.

Results obtained from the on-site and perimeter samples were compared with crop samples collected from regional (background) areas away from the Laboratory. Radionuclides and TAL elements detected in produce from background areas are the result of worldwide fallout and naturally occurring sources. This year, we collected 19 produce samples from the following regional areas: Alcalde, Dixon, Española, Santa Fe, and Velarde, New Mexico.

All samples, about two to three pounds each, were placed into Ziploc bags (Figure 8-2) and submitted to the LANL Sample Management Office (SMO) under chain-of-custody procedures where they were shipped to ALS Laboratory Group (formally Paragon Analytical) for the processing and analysis of tritium, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. In addition to these radionuclides, three samples representing a leafy vegetable crop (e.g., lettuce, cabbage), a root vegetable crop (e.g., radishes, garlic), and a fuzzy fruit crop (e.g., apricot) from each location, if available, were analyzed for strontium-90, cesium-137, americium-241, and 23 TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury). Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g dry weight basis; and the results for the TAL elements are reported on a mg/kg (part per million) dry weight basis.

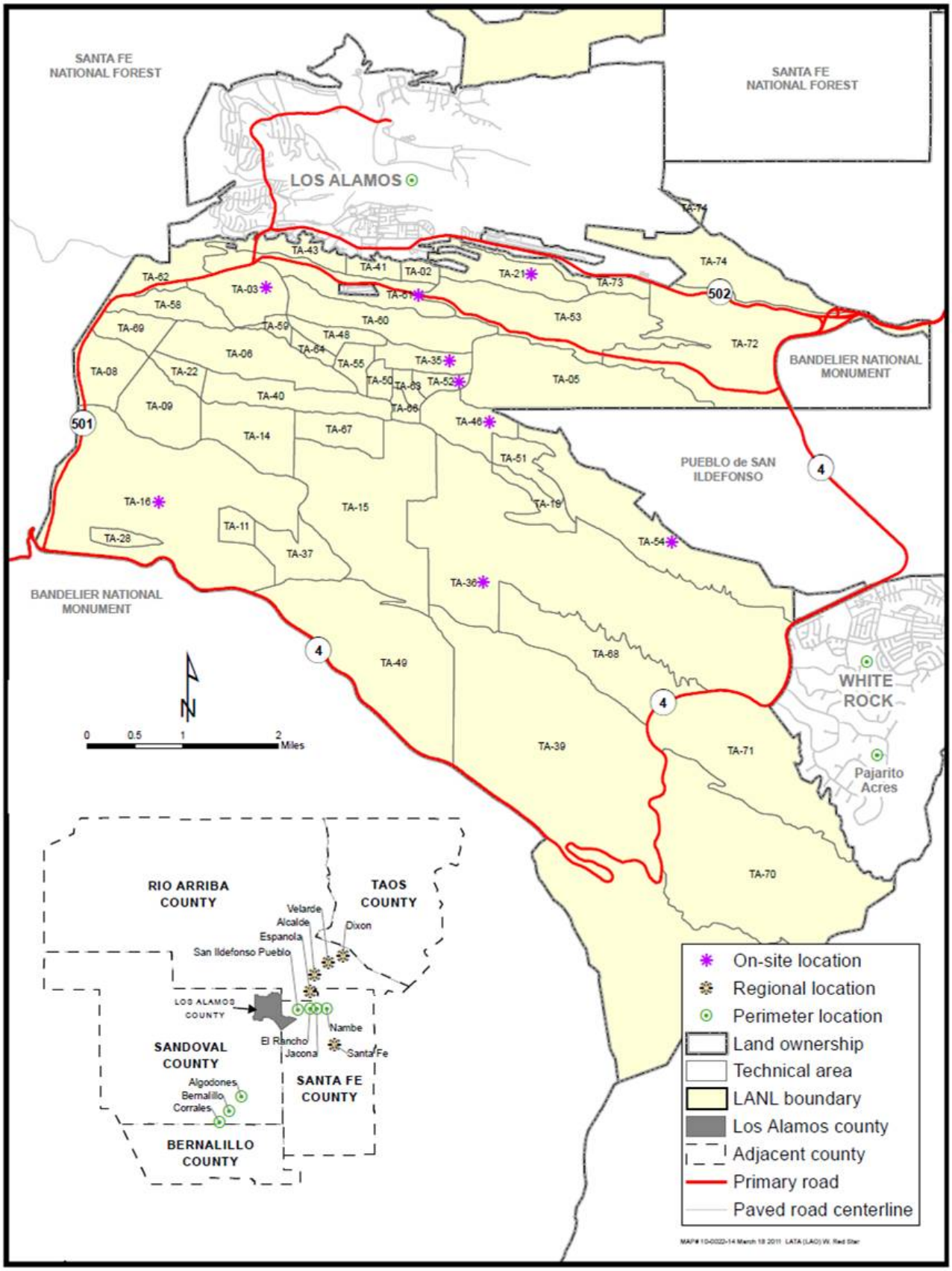

Figure 8-1 On-site, perimeter, and regional produce sampling locations

Figure 8-2 Collecting fruit samples from neighboring communities surrounding the Laboratory

b. Radionuclide Analytical Results

Radionuclide (activity) concentrations in produce collected from on-site, perimeter, and regional (background) locations during the 2010 growing season are presented in Table S8-1.

In general, all radionuclides in all produce samples, regardless of location, were very low (pCi range) and most were either not detected or detected below the RSRLs. A nondetected result is one in which the result is lower than the minimum detectable concentration and/or lower than three times the total propagated uncertainty (e.g., not significantly different from zero at the 0.01 probability level) (Keith 1991, Corely et al., 1981).

The few detected radionuclides in produce samples from on-site and perimeter areas that were higher than the RSRLs included tritium in a peach sample collected from the DP East facility at TA-21 (2.8 vs 0.56 pCi/mL); tritium in an apricot sample from the Area G waste disposal site at TA-54 (6.7 vs 0.56 pCi/mL); tritium in a grape sample from White Rock (1.0 vs 0.56 pCi/mL); tritium in a pear sample from Pajarito Acres (0.70 vs 0.56 pCi/mL); and uranium-234 (0.034 to 0.068 vs 0.030 pCi/g dry), uranium-235 (0.0019 to 0.0029 vs 0.017 pCi/g dry), and uranium-238 (0.027 to 0.058 vs 0.022 pCi/g dry) isotopes in five vegetable samples collected from the Jacona area, most from the same farm.

The higher tritium concentrations in the two fruit samples from LANL lands (DP East at TA-21 and Area G at TA-54) are a result of tritium processing work and waste disposal operations, respectively. The slightly higher tritium concentrations in two fruit samples collected from the White Rock/Pajarito Acres area are unknown; but the closest tritium source is from Area G at TA-54, which is located about one to three miles west and northwest of these communities. Based on only two detections out of the 19 samples, however, tritium in fruit and vegetables from these communities is not widespread, and the overall mean concentration (combining detectable and nondetectable values) is similar to past years (Figure 8-3).

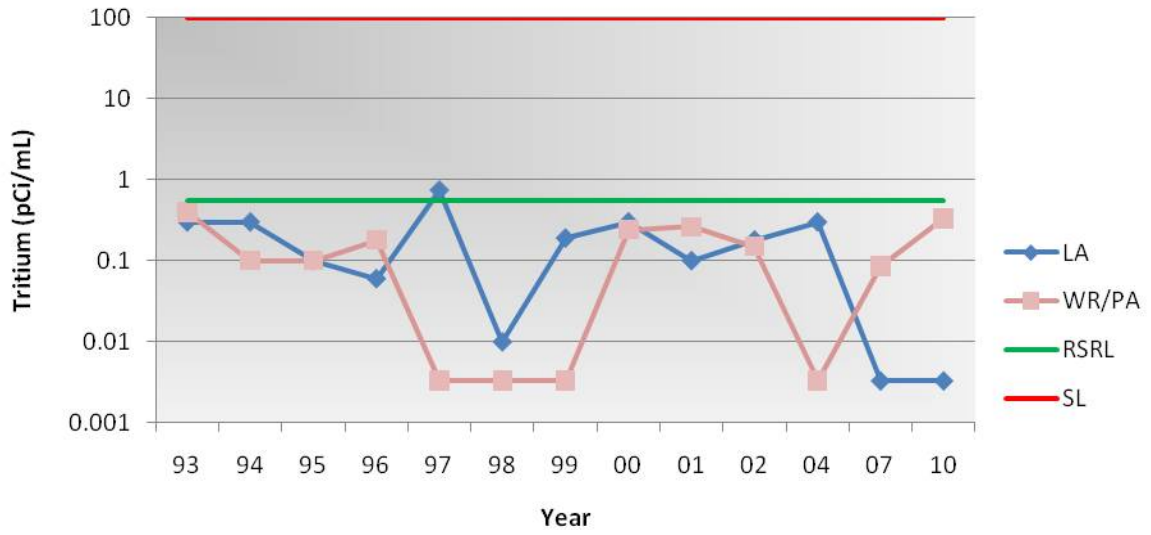

Figure 8-3 **Mean tritium concentrations in produce collected from the closest LANL neighbors, Los Alamos (LA) to the north and White Rock/Pajarito Acres (WR/PA) to the east, from 1993 through 2010 compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

As for the slightly higher uranium isotopes in vegetables from the Jacona area compared with the RSRLs, the uranium was naturally occurring (e.g., the uranium-234 and uranium-238 distribution was 1:1) and was probably a result of the water source used for irrigation. A high amount of naturally occurring uranium in stream and well waters in the general area of Jacona is well documented (Maassen and Bolivar 1979; McQuillan and Montes 1998; Hayes et al., 2000 and 2002).

Overall, the few detected tritium and uranium results in produce samples from on-site and some perimeter areas collected in 2010 were far below the SLs and do not pose a potential unacceptable dose to humans who may ingest these fruits and vegetables.

c. TAL Elements Analytical Results

Nearly all of the TAL elements in produce samples collected from on-site locations were below RSRLs (68 out of 69), and the few TAL elements that were higher than the RSRLs in produce samples collected from perimeter areas were probably a result of natural causes (Table S8-2). The type of crop, parent material (soil type), soil pH, tillage, irrigation source, and organic and inorganic fertilizer amendments that the gardener might add are all potential reasons the TAL elements differ from one place to another in perimeter farm land areas.

4. Goat Milk Monitoring

a. Monitoring Network

Milk from dairy cows and goats has been collected from 1994 to 1997 and from 1997 to present, respectively. The (cow) dairy, which was located approximately 25 miles (40 km) east of LANL, closed in 1998 and no detections of radionuclides or detections above regional background were ever made in those milk samples.

The collection of goat milk from the surrounding communities has continued—the milk is for private use and is not sold commercially. This year, we sampled (unprocessed) goat milk from a farm in the Pajarito Acres area (perimeter) and from a regional background farm located in Peña Blanca, New Mexico. Radionuclides in goat milk from regional background areas are due to worldwide fallout and to naturally occurring sources.

The goat milk samples were collected directly by the farmer, placed into labeled 1-L polyethylene bottles provided by the Laboratory, submitted under chain of custody to our SMO, and then to ALS for the analysis of tritium, cesium-137, strontium-90, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. All results are reported on a pCi/L basis.

b. Radionuclide Analytical Results

All radionuclides analyzed in goat milk from the Pajarito Acres area were not detected (Table S8-3). These data, including those from regional background, are unchanged from previous years.

5. Egg Monitoring

a. Monitoring Network

We collected two dozen (medium-sized) eggs each from farmers raising free-ranging chickens from the following perimeter areas: Los Alamos (North Mesa), Pajarito Acres, and Pueblo de San Ildefonso. Eggs from two regional background areas, Española and Peña Blanca, were also collected. All samples were submitted to ALS for the analysis of tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. With the exception of tritium, which was reported in pCi/mL, all of the other radionuclides were converted from pCi/g ash to pCi/L by first multiplying the results by the ash/wet ratio of 0.0071 and then multiplying by the density of eggs (1,033 g/L).

b. Radionuclide Analytical Results

All radionuclides analyzed in eggs from the three perimeter sites around the Laboratory were either not detected or similar to RSRLs (Table S8-4). These data, including those from regional background, are similar to past years.

6. Honey Monitoring

a. Monitoring Network

We collected honey from bee hives located (1) east of Area G at TA-54, (2) Los Alamos town site, and (3) a regional background site near Pojoaque, New Mexico. We collected the honey from the hives at TA-54 and bought the perimeter and background honey directly from the producer. Approximately one quart of honey in glass jars was submitted under chain of custody to our SMO and then to ALS for the analysis of tritium, cesium-137, strontium-90, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. All results are reported on a pCi/L basis.

b. Radionuclide Analytical Results

The complete data set of radionuclides in honey from on-site, perimeter, and the regional location can be found in Table S8-5. All radionuclides analyzed for, with the exception of tritium at TA-54, in honey from all locations were either not detected or below RSRLs and similar to past years. Tritium in honey from TA-54 is from Area G operations and is not sold or consumed by the public; it is solely maintained as an experimental hive and shows that honey bees can be used as effective environmental monitors.

7. Crayfish Monitoring

a. Monitoring Network

Crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp) samples were collected from the Rio Grande within two reaches relative to the location of LANL: upstream and downstream (Figure 8-4). Upstream (or background) samples were collected starting from the Otowi Bridge north to the Black Mesa area (about a three-mile stretch), and downstream samples were collected from the Los Alamos Canyon confluence south (about a one-mile stretch). Of the major drainages that cross LANL lands, the majority of LANL contaminants that may reach the Rio Grande are carried by storm water flow down Los Alamos Canyon (Gallaher and Efurd 2002; Reneau and Koch 2008; Fresquez et al., 2008). Note that other non-Laboratory sources may also contribute contaminants to the Los Alamos Canyon drainage; these include constituents in storm water carried from roads and grounds from the Los Alamos town site, treated effluent from the Los Alamos sewage treatment plant, atmospheric fallout of radionuclides, and some naturally occurring and anthropogenic materials in ash from the Cerro Grande Fire in May 2000 (Miranda 2009).

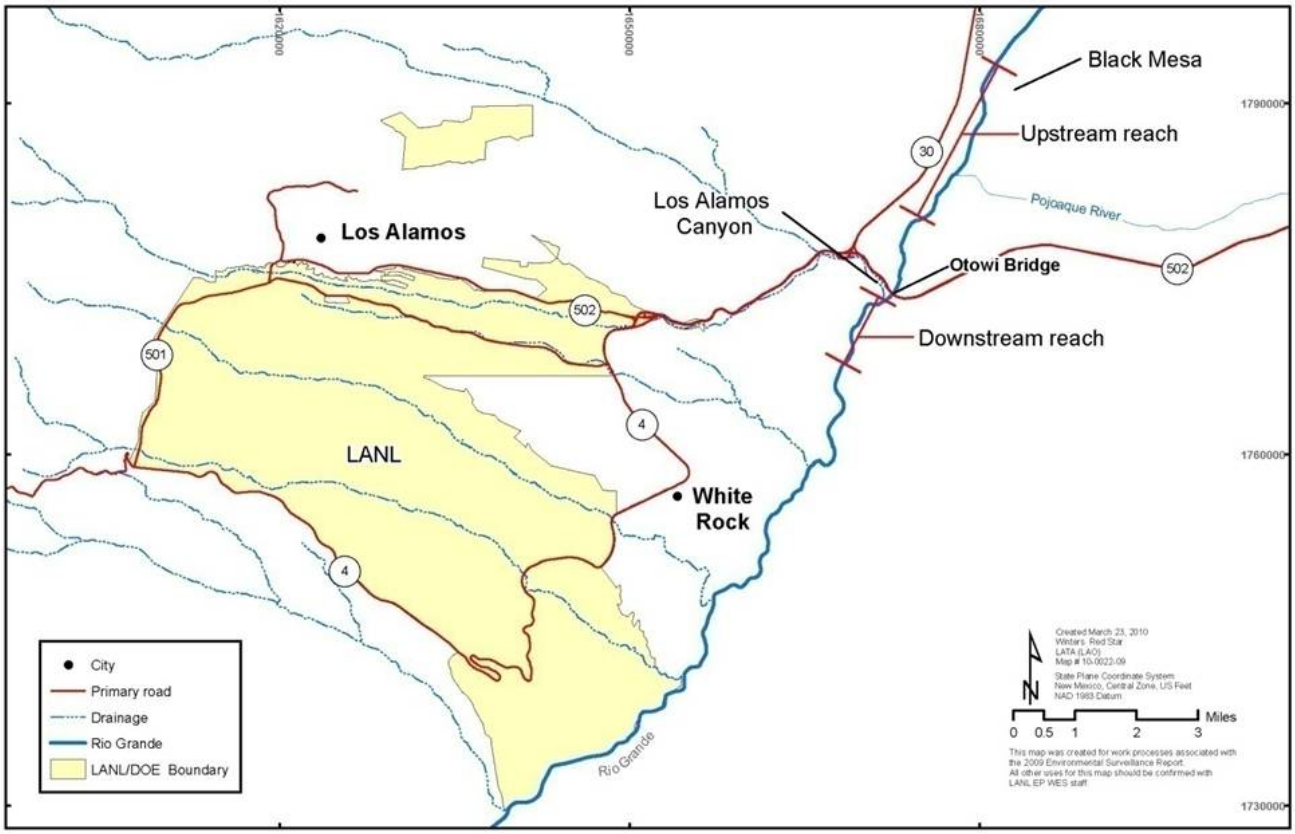

Figure 8-4 **Location of (crayfish) sampling reaches within the Rio Grande in relation to the location of LANL. The upstream reach is above the Otowi Bridge north to Black Mesa and the downstream reach starts below the Los Alamos Canyon confluence south.**

Last year, samples of whole body crayfish were analyzed for radionuclides, TAL elements, and PCB congeners. With the exception of some TAL elements (aluminum, barium, beryllium, chromium, cobalt, magnesium, vanadium, and arsenic), all of the other constituents measured in whole body crayfish from downstream reaches were similar to upstream reaches. The TAL element results, however, were based on only three samples from each reach.

This year, we collected more crayfish from upstream and downstream reaches to add to the database for a better evaluation of TAL elements. Also, some crayfish from both reaches were separated into edible (meat) and non-edible (head, gut, claws, and shell) portions to determine the differences in TAL element concentrations between the two parts and relative risk from the ingestion of only the meat portion.

b. Methods and Analysis

Within each reach, crayfish traps were randomly set with Purina Cajun World Crawfish Bait at the one-foot depth. Traps were checked every day for about two weeks (Figure 8-5).

Six crayfish from the upstream reach were collected; three of them were used for whole body analysis (Table S8-6), and the other three were analyzed for the edible portions (meat only) (Table S8-7). Two crayfish from the downstream reach were collected and divided: two edible and two non-edible portions were analyzed (Table S8-7). (Note: Whole body concentrations of these two downstream crayfish were estimated from the divided portions by multiplying the concentrations of each portion by the percentage of the total [edible = 13% and non-edible = 87%] and then summing the two. Results were added to Table S8-6).

All sample portions were weighed and placed into Ziploc bags, cooled to 4ºC, and submitted under full chain-of-custody procedures to our SMO where they were then sent to ALS for TAL element analysis. These elements are reported on a wet weight basis in mg/kg.

Figure 8-5 Collection of crayfish samples from the Rio Grande

c. TAL Elements

Based on both 2009 and 2010 data, most of the TAL elements, including aluminum, barium, beryllium, chromium, cobalt, magnesium, vanadium, and arsenic, in whole body crayfish from upstream (n = 6) and downstream (n = 5) reaches were below the RSRLs (Table S8-6). The only TAL element in whole body crayfish from the downstream reach that was higher than the RSRL (and statistically as a group at the 0.05 probability level) was mercury. The differences in mercury concentrations in whole body crayfish collected from the two reaches, however, were small. Of the total, higher amounts were detected in the non-edible parts of crayfish from the downstream reach rather than the edible portions by a factor of nearly two (Table S8-7).

All TAL elements, including mercury, in the edible portions of crayfish collected from the downstream reach were similar to the edible portions collected from the upstream reach (< RSRLs) (Table S8-7). Also, all concentrations of mercury in the edible portion of crayfish collected from both reaches were an order of magnitude below the screening level of 0.30 mg/kg (EPA 2001). Mercury sources and contamination in fish inhabiting the Rio Grande upstream and downstream of LANL are well documented (see Foodstuffs and Biota related references); however, the amount of mercury in crayfish compared with bottom-feeding fish within these same reaches is an order of magnitude lower and does not appear to be a significant risk factor to humans if ingested.

8. Deer and Elk Monitoring

a. Monitoring Network

Since 1991, deer and elk have been routinely picked up as road kills along highways within and around LANL. We have analyzed samples from 26 deer and 43 elk from LANL, perimeter, and regional background sites from 1991 through 2010.

b. Elk

This year, two road killed elk on LANL property along Pajarito Road were collected: one within TA-36 and the other within TA-54. At each kill site, the muscle and bone from one of the front shoulders of the animal were collected for analysis of radionuclides and TAL elements. The muscles from these elk were also analyzed for PCB congeners. Samples were placed into the appropriate containers and submitted under chain-of-custody procedures to the SMO; samples were then submitted to ALS for the analysis of radionuclides and TAL elements and to Cape Fear Analytical Laboratory, Inc., for the analysis of PCB congeners.

i. Analysis

Radionuclides analyzed were tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per mL of water basis. Results of the other radionuclides were reported in pCi/g dry weight after being converted from pCi/g ash weight. The 23 TAL elements listed earlier were also analyzed. These elements are reported on a mg/kg wet weight basis. PCBs were analyzed for 209 possible chlorinated structures or congeners and reported as pg/g (parts per trillion) wet weight basis. (Note: Because the bone tissue of deer and elk consist of both bone and bone marrow, the analytical chemist considered the material to be too heterogeneous to successfully achieve consistent results of TAL elements and PCBs; thus, bone tissue for TAL elements and for PCBs in elk and deer will be discontinued after this year and only the muscle portions will be analyzed.)

ii. Radionuclides

Most of the radionuclides that we analyzed for in both muscle and bone tissues from two elk collected on LANL lands were either not detected or below the RSRLs (Table S8-8). Only two radionuclides, uranium-234 and uranium-238, were detected in higher amounts than the RSRLs in muscle and/or bone tissue of the elk collected at TA-54. However, the amounts of uranium-234 and uranium-238 in tissues of elk were far below the SL of 0.56 and 0.50 pCi/g dry, respectively. Also, based on the uranium-234 and uranium-238 distribution (i.e., 1:1 ratio), the uranium was naturally occurring. These data agree with past results (Fresquez et al. 1999).

iii. TAL Elements

Results of TAL elements in muscle and bone tissues from two road-killed elk collected along Pajarito Road at TA-36 and TA-54 can be found in Table S8-9. Since this is the first time that TAL elements have been assessed in muscle and bone tissues of elk at LANL, we do not have a comparable data set from background elk, and an evaluation cannot be made at this time. These data are given at this time for future reference. However, since most of the radionuclide elements in muscle and bone from elk collected from LANL lands were not different from elk collected from regional background areas, the TAL elements are also not expected to be higher.

iv. Polychlorinated Biphenyls

PCB congeners, homologs, and totals in muscle tissues of road-kill elk collected alongside Pajarito Road at TA-36 and TA-54 can be found in Table S8-10. The amounts of PCBs in LANL elk muscle tissues from both elk were negligible.

c. Deer

Last year, one road-kill deer was collected along Pajarito Road within TA-46 and another road kill deer was collected along State Road 4 as it passes through the Pueblo of San Ildefonso property. All radionuclides in muscle and bone from these animals collected from these sites were similar to radionuclides in deer tissues collected from regional background sites. TAL elements and PCBs were also analyzed and reported in 2009, but there were no comparable datasets of TAL elements and PCBs from background deer to make an evaluation of any possible LANL contributions, if any. Data were given for future reference.

This year, we collected two deer from regional background areas and analyzed the muscle tissue for TAL elements and PCBs to compare with the deer collected in 2009; the analysis results are reported below. (Note: Because the bone tissue of deer and elk consist of both bone and bone marrow, the analytical chemist considered the material to be too heterogeneous to successfully achieve consistent results of TAL elements and PCBs; thus, bone tissue for TAL elements and for PCBs in elk and deer will be discontinued, and only the muscle portions will be analyzed in the future.)

i. TAL Elements

Results of TAL elements in muscle tissues from two road-kill deer collected in 2009 along State Road 4 and Pajarito Road as they pass through Pueblo of San Ildefonso and LANL lands, respectively, can be found in Table S8-11. Based on only two background deer, most TAL elements in deer collected from LANL and Pueblo de San Ildefonso lands were similar. We will continue to collect background deer as they become available.

ii. Polychlorinated Biphenyls

Total PCBs and homolog distributions in muscle tissues of a road-kill deer collected alongside Pajarito Road at TA-46 can be found in Table S8-12. The total amount of PCBs in the deer collected from LANL lands is at very low levels and is not higher than the RSRL. Similarly, the homolog distribution between the LANL deer and regional background appear to have the same general pattern, and both appear to possibly contain trace amounts of Aroclor 1242 and 1260, with more Aroclor 1242 detected than 1260 (Figure 8-6). We plan to continue to analyze deer tissues for PCBs to increase the amount of data to support a statistical assessment of the data.

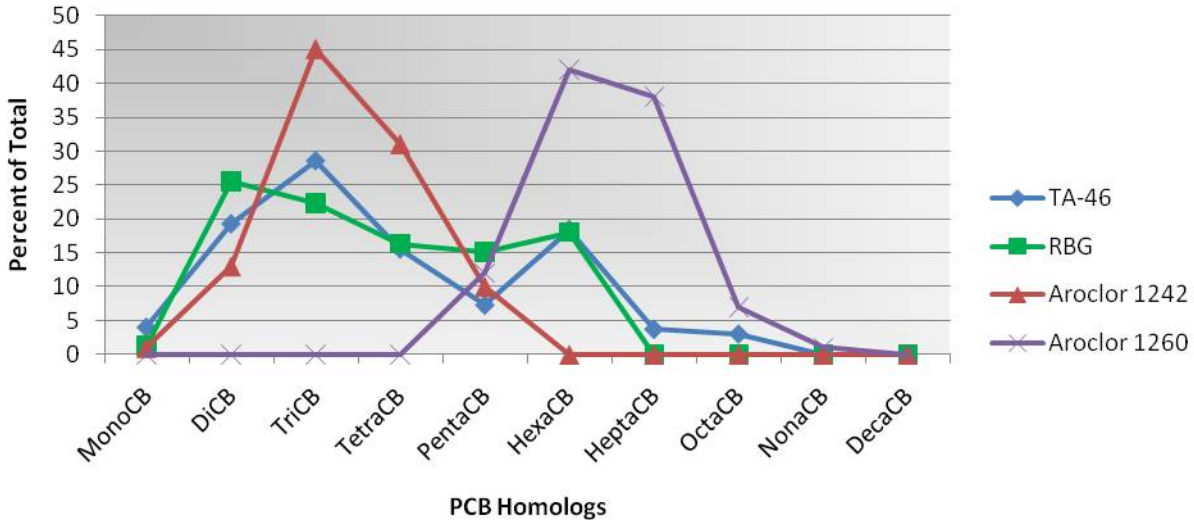

Figure 8-6 The PCB homolog distribution in muscle tissue of a road-kill deer collected alongside Pajarito Road at TA-46 in 2010 compared with regional background (RBG) and with Aroclor 1242 and 1260 formulations

B. BIOTA MONITORING

1. Introduction

DOE Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993) define requirements for the monitoring of biota (plants and animals not normally ingested by humans) for the protection of ecosystems. Monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, while site-wide native vegetation monitoring started in 1994. Presently, in addition to native vegetation, we also monitor small mammals, amphibians, reptiles, birds, and bees within and around LANL on a systematic basis or for special studies. Detection of contaminants in biota may indicate that these animals may be entering contaminated areas (e.g., burrowing in waste burial grounds) or that material is

moving out of contaminated areas (e.g., blowing dust, transported soil/sediment via storm water, or food-chain transport).

The three objectives of the biota program are as follows:

1) Determine radionuclide and chemical concentrations in biota from on-site (LANL property) and perimeter areas and compare these results with regional (background) areas,

2) Determine concentration trends over time, and

3) Estimate potential radiation dose to plants and animals. (Chapter 3 presents the results of the 2010 biota dose assessments at LANL.)

2. Biota Comparison Levels

Like the foodstuffs data, radionuclides and chemical concentrations in biota from Laboratory areas are first compared with RSRLs. If the levels of potentially impacted areas are higher than the levels of non-impacted areas (RSRLs), then we would compare the concentrations with the SLs, if available, and then with the standards, if available. More information about comparison levels are summarized below and presented in Table 8-2:

- Regional background levels: RSRLs are the upper-level background concentrations (mean plus three standard deviations = 99% confidence level) for radionuclides and chemicals calculated from biota data collected over the past five sampling periods from regional locations away from the influence of the Laboratory (more than 9 miles away) (DOE 1991). RSRLs represent natural and fallout levels; they are calculated annually and presented in this report.
- Screening Levels: SLs are set below DOE dose standards so that potential concerns may be identified in advance, i.e., a "yellow flag." If a constituent exceeds an SL, then the reason for the higher levels is thoroughly investigated. For radionuclides in 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). For chemicals, there are no SLs based on biota tissue concentrations. Instead, if a chemical in biota tissue exceeds the RSRL (or Baseline Statistical Reference Levels [BSRLs]), then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2010). ESLs are derived from the literature and reflect the (highest) concentration of contaminants in the soil that are not expected to produce any adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on soil (i.e., they are the concentrations that are protective of ecological receptors under chronic exposure conditions).
- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1-rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/day for terrestrial animals (DOE 2002).

Table 8-2
Standards and Other Reference Levels Applied to 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[a]	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs/BSRLs[b]
	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
Chemicals	On site and perimeter	Biota	na[c]	ESLs[d]	RSRLs
	DARHT	Biota	na	ESLs	RSRLs/BSRLs

[a] Dual Axis Radiographic Hydrodynamic Test Facility
[b] Baseline Statistical Reference Levels and a discussion of these levels can be found in Section 4.b.i.
[c] na = Not available
[d] Ecological Screening Levels are based on the concentration in the soil.

3. Institutional Monitoring

No wide-scale institutional monitoring of native vegetation was performed in 2010. Native understory (grasses and forbs) or overstory (trees) vegetation are collected on a triennial basis at the same time and at the same locations as the soil (17 on-site, 11 perimeter, and six regional locations) described in Chapter 7, Section C.1 (Figure 7-1). The next sampling period for the collection of native (understory) vegetation is in 2012. Past sampling shows that, in general, all radionuclide and TAL element concentrations in native understory and overstory vegetation sampled from Laboratory and perimeter areas are very low, and most concentrations are indistinguishable from regional background areas.

4. Facility Monitoring

a. Area G at TA-54

i. Monitoring Network

Native overstory vegetation (branches and needles) around Area G was collected at the same general locations as the soil samples described in Chapter 7, section D.1 (Figure 7-5). Radionuclides analyzed by the ALS included tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Results for tritium in vegetation are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash weight basis; and results for the TAL elements are reported on an mg/kg dry weight basis.

ii. Vegetation at Area G

With the exception of tritium, all of the other radionuclides in tree samples collected around the perimeter of Area G were mostly not detected or below the RSRLs (Table S8-13). Tritium, on the other hand, was detected above the RSRL in nearly 40% of the tree samples collected around the perimeter of Area G with the highest amounts (83 to 8,420 pCi/mL) occurring in trees growing in the southern sections near the tritium disposal shafts. All levels of tritium, however, are far below the SL, and despite the large variation in tritium concentrations from year to year, the concentrations are generally not increasing over time (Figure 8-7).

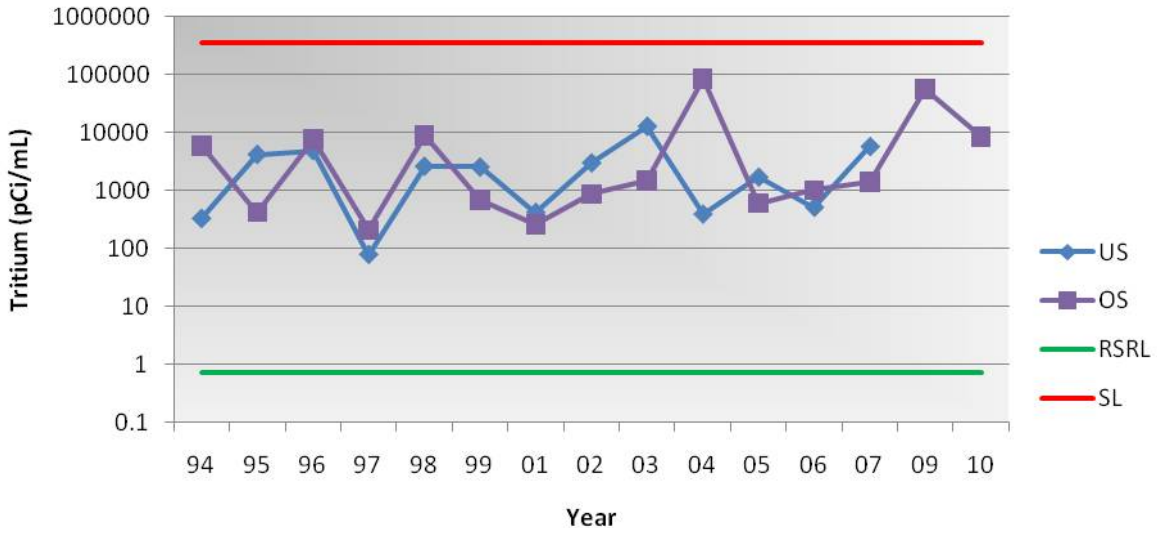

Figure 8-7 Tritium in understory (US) and overstory (OS) vegetation collected from the south side of Area G at TA-54 from 1994 through 2010 compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

One other radionuclide that was detected above the RSRL in trees around Area G was plutonium-239/240; this sample was collected on the northwestern side of Area G (around site #58-01). These data, however, are far below the SL and do not pose an unacceptable dose to the tree.

b. Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility at TA-15

i. Monitoring Network

The Laboratory conducts facility-specific biota monitoring on an annual basis at the DARHT facility—the principal firing site at LANL—as required by the Mitigation Action Plan (MAP) resulting from the environmental impact statement for the construction and operation of the DARHT facility (DOE 1996). The history of operations at the site has included open air detonations from 2000–2006; detonations using foam mitigation from 2002–2006; and detonations within closed steel containment vessels starting in 2007 to present (three in fiscal year [FY] 2007, two in FY08, none in FY09, and four in FY10). Another factor that may influence the amount of potential contamination around the DARHT site (and cleanup) is that the firing point was paved with an asphalt surface in 2007.

The biota samples collected at DARHT include overstory vegetation (tree), field mice, bees, and birds (see Chapter 7, Figure 7-12, for sample locations). Vegetation, field mice, and bee samples are collected for chemical analysis, whereas birds are mostly collected (and released) for population, composition, and diversity estimates. Sometimes, however, birds are inadvertently caught on the field mice traps and, in these cases, the birds are used for contaminant analysis.

Overstory samples (branches plus needles) were collected on the north, south, west, and east sides of the DARHT perimeter and analyzed for radionuclides and TAL elements; small mammals, mostly deer mice (*Peromyscus* spp), were collected on the north and northeast side of the DARHT perimeter and analyzed for radionuclides and dioxin/furans; bee samples were collected from three hives located on the northeast side of the DARHT perimeter and analyzed for TAL elements; and bird samples were collected using 12 mist capture net traps spaced about 200 ft to 1600 ft outward from the west side of the DARHT facility. (Spacing of the nets was about 150 ft from one another.)

Vegetation, field mice, and bee samples were submitted to ALS where they were processed and analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and/or TAL elements. Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash weight basis; results for the TAL elements in vegetation are reported on an mg/kg dry weight basis; and results for the TAL elements in field mice and bees are reported on an mg/kg wet weight basis. Two field mouse samples were submitted to Cape Fear Analytical Laboratory and analyzed for dioxin/furans; results for dioxin/furans are reported on a pg/g (parts per trillion) wet weight basis.

Results of most of the biota chemical analysis were compared with BSRLs as per the MAP (DOE 1996). BSRLs are the upper-limit baseline data established over a four-year period (1996–1999) before the start-up of DARHT operations in 2000 (Nyhan et al., 2001). The BSRLs, at the three sigma level, are based on summaries provided by Fresquez et al. (2001) for vegetation, Haarmann (2001) for bees, and Bennett et al. (2001) for small mammals. Similarly, the population, composition, and diversity of birds collected from DARHT were compared with bird samples collected before the operation of the DARHT facility (Fresquez et al., 2007a). In cases where there are no BSRLs, then a comparison with RSRLs will be made.

ii. Vegetation at DARHT

All radionuclide concentrations analyzed for, including uranium-238, in overstory vegetation collected from around the perimeter of the DARHT facility were either not detected or detected below the BSRLs (or RSRLs when BSRL data were not available) (Table S8-14). In the past, uranium-238 was the only radionuclide most of the time to be detected in overstory vegetation around the DARHT facility (probably as a result of foliar deposition more than by root uptake), but since 2007 the concentrations have generally decreased from all sides of the DARHT perimeter. This general decrease in uranium-238 concentrations to BSRLs was probably due to the change in contaminant mitigation procedures from open and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation starting in 2007 (Figure 8-8).

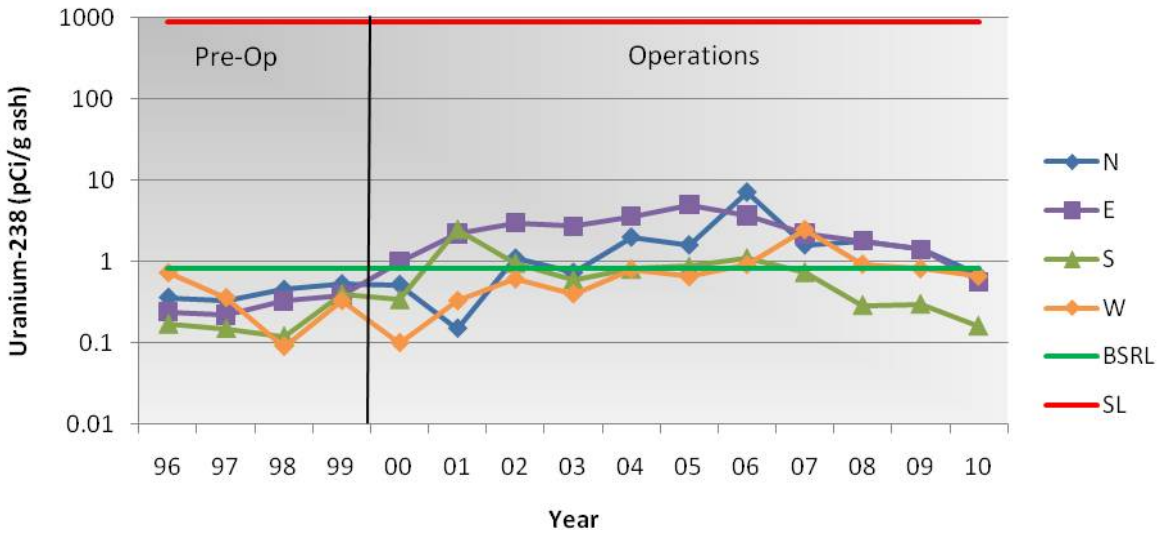

Figure 8-8 **Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) sides of the DARHT facility at TA-15 from 1996–1999 (pre-operations) through 2000–2010 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

The TAL element results, including metals like beryllium, in overstory vegetation collected from around the DARHT facility are summarized in Table S8-15. All of the metals were either not detected or below the BSRLs (or below the RSRLs).

iii. Small Mammals at DARHT

Most radionuclides analyzed for were either not detected or below the BSRLs in a composite field mouse sample (five mice per sample) collected from the north and northeast side of the DARHT facility (Table S8-16). Uranium-234, uranium-235, and uranium-238 concentrations were just slightly above their respective BSRLs, but the amounts were orders of magnitude below the SL.

The isotopic distribution of uranium-234 to uranium-238 in the field mouse sample collected from the north-northeast side of DARHT indicates the type of uranium is depleted uranium.

Using uranium-238 concentrations to model trends over time, the amounts, as seen with vegetation, exhibit an increase until the year 2007 and then decrease thereafter to the BSRL; this is concurrent with the change in detonation mitigation practices from open and/or foam-mitigated detonations during the 2000–2006 period to closed vessel containment starting in 2007 (Figure 8-9).

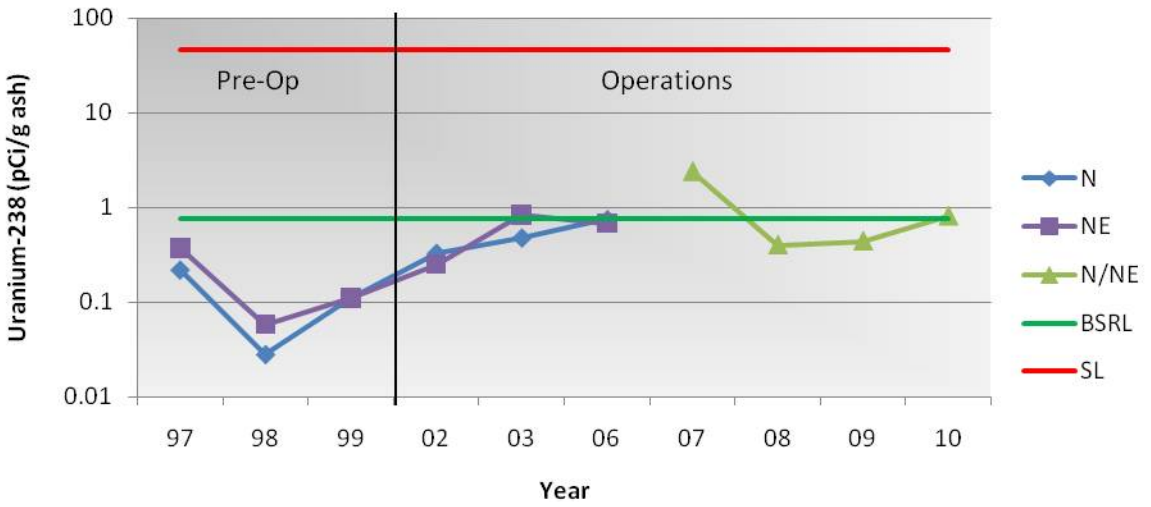

Figure 8-9 **Uranium-238 concentrations in (whole body) mice (n = 5) collected from the north (N) and northeast (NE) sides of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2002–2010 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

No TAL element analysis was conducted on the field mice in 2010. However, based on previous years, all TAL elements in field mice collected from the perimeter of the north and northeast sides of the DARHT facility were either not detected, were similar to RSRLs, or below ESLs. No trends were evident.

No detectable amounts of dioxin or furan chemicals in field mice samples were found that were above the limit of quantification (e.g., reporting limit); only trace amounts (greater than the minimum detectable level but less than the reporting limit) of hepta- and octachlorodibenzodioxins were estimated in one of the two field mice samples (Table S8-17). These data correlate well with the soil data reported in Table S7-7; no amounts of dioxin or furans were detected above the reporting level. (Note: No regional background data for dioxin and furans in field mice were collected prior to this year's report; however, background field mice were collected in March of 2011 for dioxin/furan analysis, and results will be reported next year.)

iv. Bees at DARHT

Radionuclide concentrations in bees from hives located on the northeastern perimeter of the DARHT facility were not analyzed this year; but based on previous years, no significantly higher amounts of radionuclide concentrations in bees from DARHT have been observed compared with BSRLs. In fact, the most prevalent radionuclide at DARHT, uranium-238, basically mimics the trends shown with other matrices, in that uranium-238 after an initial rise in 2005/2006 decreases to the BSRL (Figure 8-10). Again, this decrease may have been a result of the change in detonation mitigation practices from open and/or foam-mitigated detonations during the 2000–2006 periods to closed vessel containment starting in 2007.

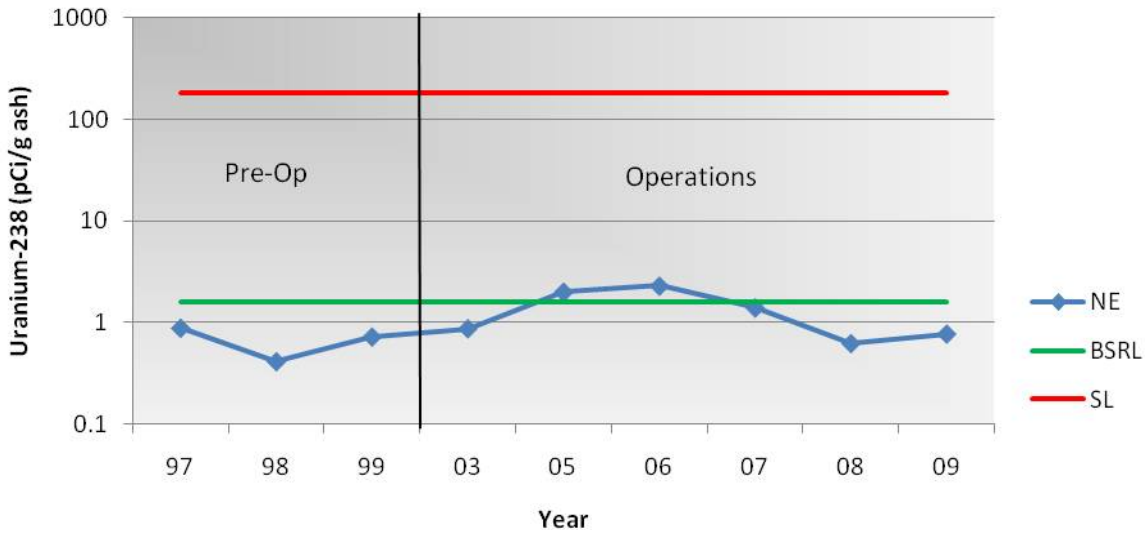

Figure 8-10 **Uranium-238 concentrations in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2003–2010 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

Because we did not have a strong database for TAL elements from regional background sites to compare with DARHT bees, resources were diverted to analyze bees for metals from both sites in 2010. Most of the TAL elements in bee samples collected from hives northeast of the DARHT facility were similar to RSRLs (Table S8-18). The few TAL elements in bees that were higher than the RSRLs included aluminum, copper, vanadium, and lead. There are no ESLs listed for these elements in soil for bees, but the highest levels of these elements in soil around the grounds at DARHT (Table S7-5) are far below ESLs for other indicator biota receptors.

v. Birds at DARHT

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2010 compared with samples collected in 1999 (preoperational phase) are presented in Table S8-19. The purpose of the bird monitoring project is to determine the general ecological stress levels around the vicinity of DARHT that may be associated with facility operations (e.g., noise, disturbance, traffic, etc.). The number of birds, number of bird species, diversity, and evenness (distribution) collected in 2010 are similar to those collected before the start-up of operations at DARHT in 1999 (Figure 8-11); in general, there are a large number of birds and types of birds located in the vicinity of the DARHT complex. The most common bird species collected regardless of time periods were the chipping sparrow (*Spizella passerina*), Virginia's warbler (*Vermivora virginiae*), western tanager (*Piranga ludoviciana*), western bluebird (*Sialia mexicana*), and the broad-tailed hummingbird (*Selasphorus platycercus*).

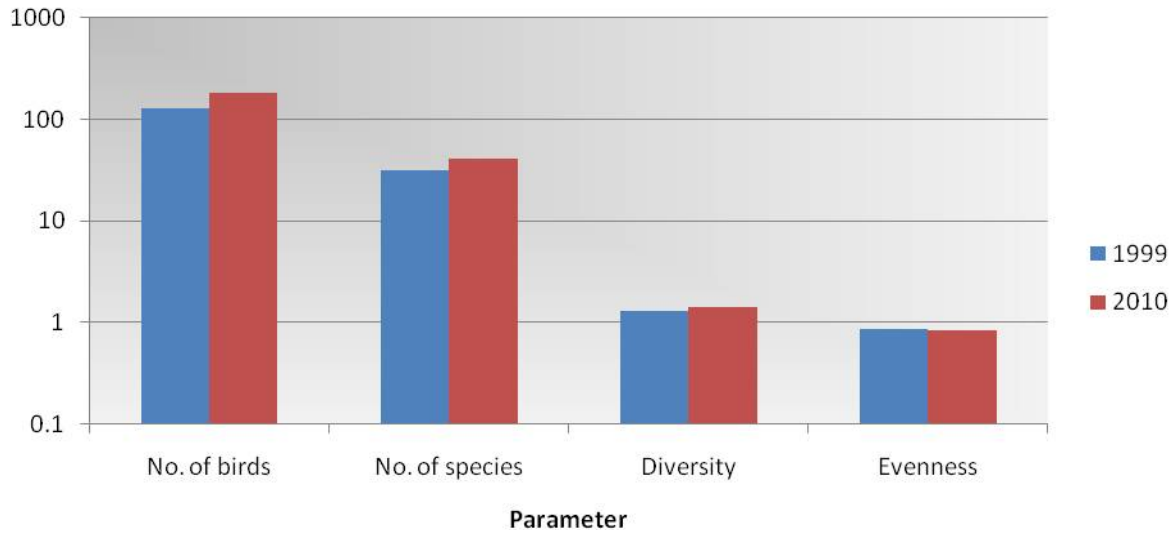

Figure 8-11 Populations, number of species, diversity, and evenness of birds occurring before (1999) and during (2010) operations at DARHT. Note the logarithmic scale on the vertical axis.

C. SPECIAL MONITORING STUDIES

In general, special studies are conducted when there is a lack of data concerning a contaminant that has the potential to impact human health and/or the environment. The following special studies were conducted in 2010 in support of Mitigation Action Plans and the Environmental Surveillance Program.

1. Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Areas: 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 43,000 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 US Army Corps of Engineers constructed two large erosion control structures to control storm water and sediment runoff from burned areas. These structures consist of (1) a low-head, rock-filled gabion weir that lies across the streambed in Los Alamos Canyon near the junction of State Road 4 and State Road 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 MAP as an extension of the fire suppression, erosion, and flood control actions. One of the tasks identified in the 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 upstream (upgradient) of 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 and to determine to what extent they impact the biota.

To this end, we collect native understory vegetation (grasses and forbs) and field mice (mostly deer mice, *Peromyscus* spp) in the areas upgradient of the Los Alamos Canyon Weir (LACW) and the Pajarito Canyon Flood Retention Structure (PCFRS). Native plants are monitored because they are the primary food source of biota, and field mice are monitored because they have the smallest home range of the mammals.

ALS analyzed the field mice (whole body) samples for radionuclides and TAL elements. PCBs (congeners, homologs, and totals) in whole body field mice were analyzed by Cape Fear Analytical Laboratory. The following two sections report the 2010 results of this monitoring.

a. Los Alamos Canyon Weir

The LACW structure was installed in 2001 and was partially excavated of sediments for the first time in 2009. The accumulated sediment was placed along the north slope of the LACW basin.

The concentrations of radionuclides and TAL elements in a composite understory vegetation sample that was collected on the upgradient side of the LACW can be found in Tables S8-20 and S8-21, respectively. As in previous years, radionuclides such as strontium-90, plutonium-238, plutonium-239/240, and americium-241 in vegetation growing behind the LACW were in higher concentrations than the RSRLs. With the exception of strontium-90, the actinides are not usually taken up very readily by plants, so the higher amounts of these radionuclides on vegetation on the upgradient side of the LACW may be due to either wind deposition or rain splash from the old or newly accumulating sediment. In either case, the concentrations of these particular radionuclides, including strontium-90, are still very far below the SLs and generally not increasing over the five-year time period (Figure 8-12). All TAL elements in understory vegetation were below the RSRLs.

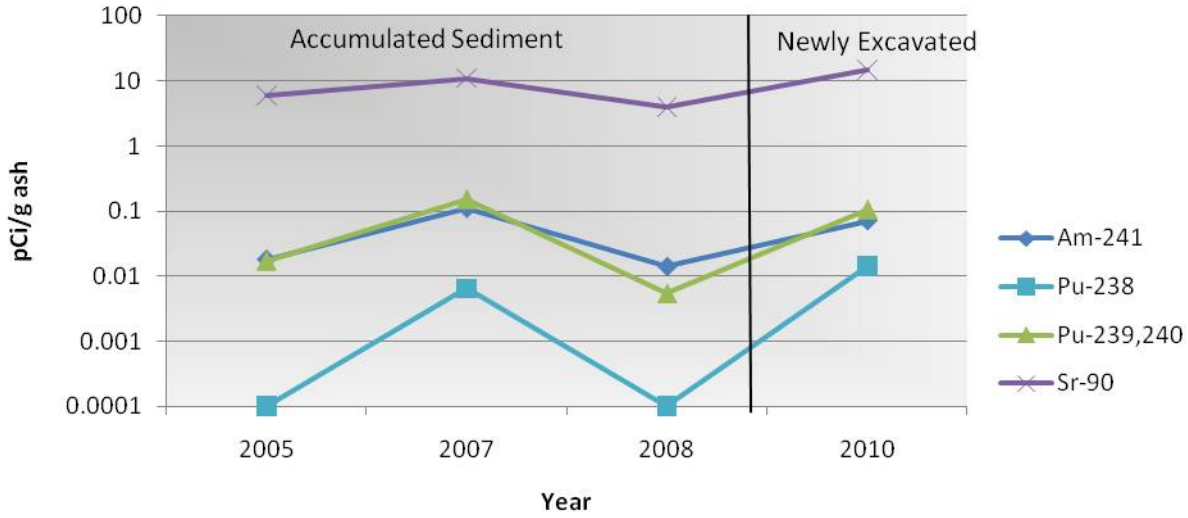

Figure 8-12 Americium-241, plutonium-238, plutonium-239/240, and strontium-90 concentrations in understory vegetation collected on the upgradient side of the Los Alamos Canyon Weir from 2005 through 2010. Note the logarithmic scale on the vertical axis.

Most concentrations of radionuclides analyzed for in a composite field mouse sample (n = 5) collected on the upgradient side of the LACW were either not detected or below the RSRLs (Table S8-22). The only radionuclides that were detected in higher concentrations than the RSRLs were americium-241 and plutonium-239/240. These data, particularly the americium-241 and plutonium-239/240 data, correlate well with the understory vegetation data and are basically similar to earlier results (regardless of excavation activities); all concentrations, however, are still far below the SLs (Figure 8-13).

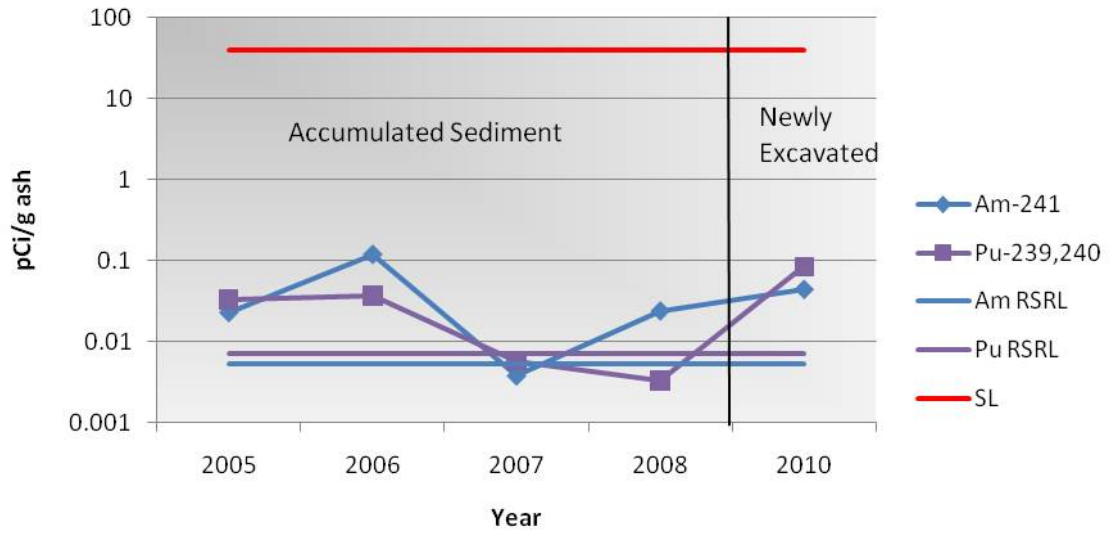

Figure 8-13 Americium-241 and plutonium-239/240 concentrations in whole body field mice samples collected on the upgradient side of the Los Alamos Canyon Weir from 2005 through 2010. Note the logarithmic scale on the vertical axis.

Results of the TAL elements in whole body field mice can be found in Table S8-23. Most TAL elements in field mice (n = 3) collected on the upgradient side of the LACW were lower than the RSRLs. The TAL elements in field mice collected from the upgradient side that were higher than the RSRLs were few (calcium, lead, and thallium) and not consistent within replications; in fact, the mean concentrations of these TAL elements were statistically similar ($p > 0.05$) to TAL elements in field mice collected from regional background locations (n = 9) (Fresquez 2009).

All concentrations of total PCBs in field mice (n = 3) collected from the upgradient side of the LACW were higher than the RSRL by one and two orders of magnitude (Table S8-24). Though there are no direct SLs for total PCBs in tissues, ESLs for PCBs in animals are derived from soil concentration levels from the study site. Based on the highest total PCB concentrations in surface sediments within the LACW in 2010 (0.11 mg/kg) (Reneau 2011), the level was below the ESL for field (deer) mice of 20 mg/kg for Aroclor 1260 (LANL 2010) and is not expected to significantly impact the field mice population.

The mean total PCBs in field mice collected around the LACW over a four-year period show that the levels are relatively similar in three of the four years and significantly decrease with distance from the LACW (Figure 8-14). Although the amounts of PCBs in field mice collected approximately 4.5 miles down gradient from the LACW were an order of magnitude lower than in field mice collected from areas around the LACW, the levels were still statistically higher ($p < 0.05$) than in field mice collected from regional background locations.

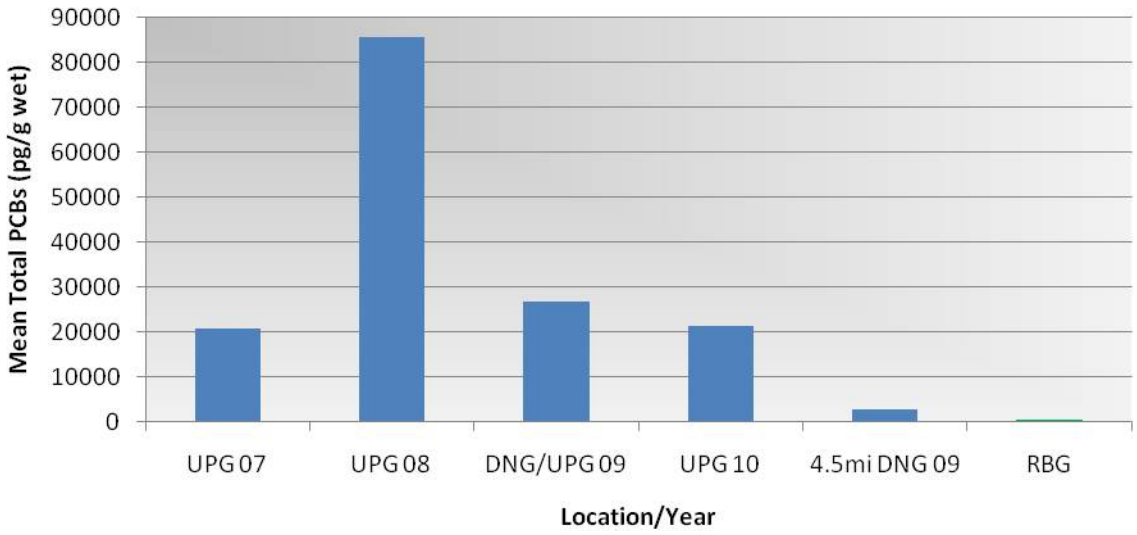

Figure 8-14 **Mean total PCB concentrations in whole body field mice collected on the upgradient (UPG) and down gradient (DNG) side from 2007 through 2010 of the Los Alamos Canyon Weir compared to the mean total regional background (RBG).**

A comparison of the mean PCB homolog distribution of field mice collected around the LACW from 2007 to 2010 shows that the patterns are mostly within the Aroclor 1260 profile formulation (Figure 8-15). Aroclor 1260 has been the most consistently detected PCB formulation in sediment collected upgradient of the LACW (Fresquez et al., 2007b; Reneau and Koch 2008).

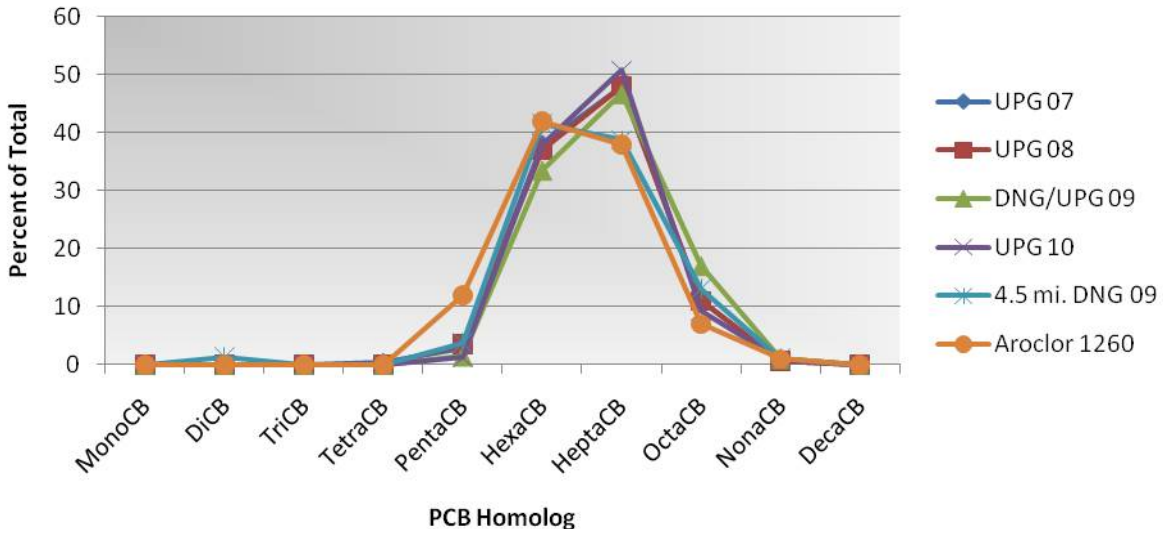

Figure 8-15 **Mean PCB homolog distribution for whole body field mice samples collected on the upgradient (UPG) and down gradient (DNG) side from 2007 through 2010 of the Los Alamos Canyon Weir compared with Aroclor 1260.**

b. Pajarito Canyon Flood Retention Structure

Concentrations of radionuclides, TAL elements, and PCBs in native understory vegetation (grasses and forbs) and field mice samples collected from within the silt retention area (upgradient side) of the PCFRS in 2010 are presented in Tables S8-25 through S8-29.

All of the radionuclides and most of the TAL elements analyzed for in a composite native understory sample collected on the upgradient side of the PCFRS were either not detected or were below the RSRLs (Table S8-25 and S8-26). The only TAL element in vegetation upgradient of the PCFRS that was higher than the

RSRL was antimony (4.2 mg/kg); but the levels were far below toxicity reference values (> 50 mg/kg to impact plant growth) (Gough et al., 1979). As a matter of record, the amounts of antimony in vegetation from the upgradient side of the PCFRS in past years ranged from undetected to 0.53 mg/kg; so the current concentration is unusually high, but will be watched.

All of the radionuclides in a composite field mouse sample (n = 5 subsamples) collected from the upgradient side of the PCFRS were similar to RSRLs (Table S8-27). Similarly, the only TAL element that was consistently higher along replications than the RSRL was barium—and as a group the mean was statistically higher ($p < 0.05$) in field mice from the PCFRS (n = 3) compared with background (n = 9) (Table S8-28). The levels of barium in tissue, however, were just slightly higher than the RSRL, and the highest soil concentration of barium encountered within the PCFRS basin (120 mg/kg) (Fresquez et al., 2008) was far below the ESLs for field mice (> 1800 mg/kg) (LANL 2010), and, thus, barium is not expected to be a significant concern.

There were virtually no PCBs detected in field mice (n = 3) from the upgradient side of the PCFRS in 2010 (Table S8-29); individual samples were all below the RSRL. And as a group, the mean total PCB level was statistically lower ($p < 0.05$) than in mice collected from regional background locations (n = 8). These data are far below the levels reported in past years (Figure 8-16).

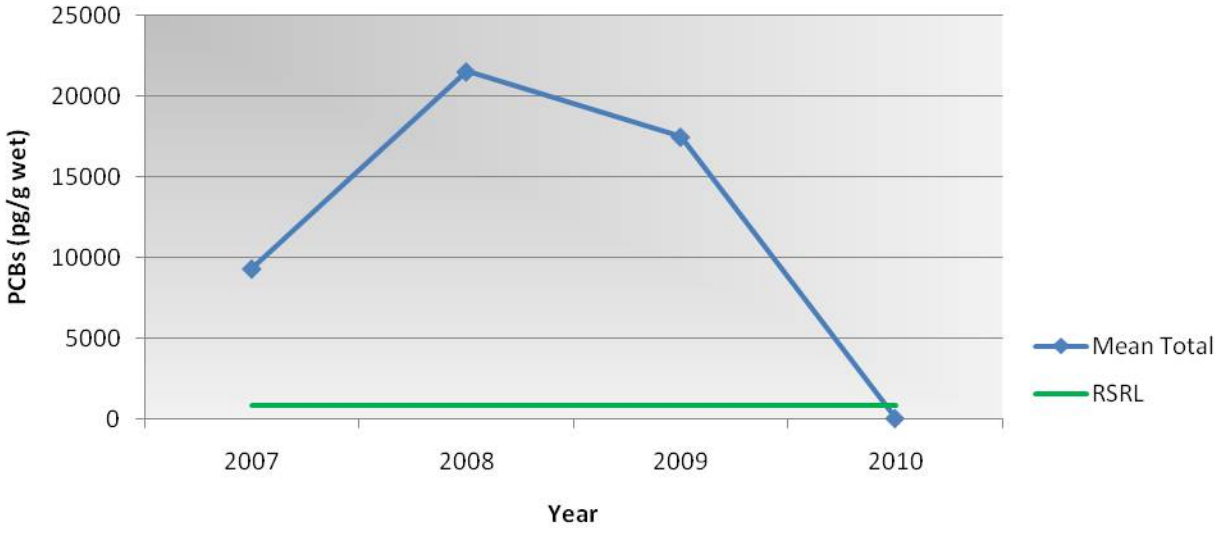

Figure 8-16 Mean total PCB concentrations in whole body field mice samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2007 through 2010 compared with the regional statistical reference level (green line).

The mean PCB homolog distribution of field mice collected from the PCFRS throughout the years from 2007 to 2010 generally overlaps the distribution pattern of Aroclor 1260 (Figure 8-17). Trace amounts of Aroclor 1254 and Aroclor 1260 have been detected in sediment collected upgradient (Fresquez et al., 2009; Reneau and Koch 2008) and down gradient of the PCFRS in past years (LANL 2008).

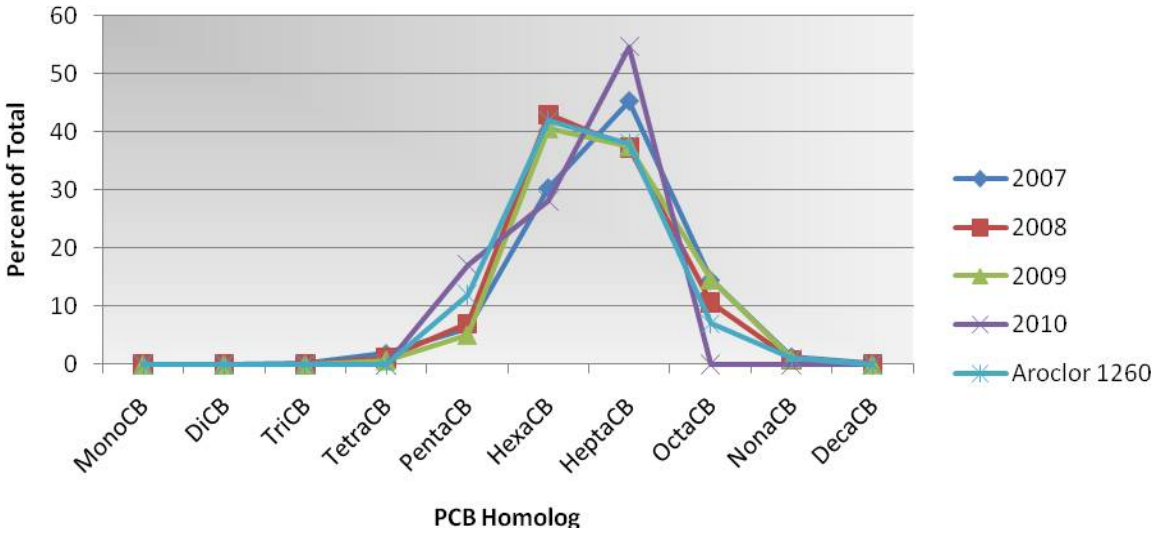

Figure 8-17 Mean PCB homolog distribution of whole body field mice samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2007 through and 2010 compared with Aroclor 1260.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS AND BIOTA PROGRAM

This program uses the same quality assurance (QA) protocols described in Chapter 7 (QA program development, field sampling QA, analytical laboratory quality assessment, field data, analytical, and analytical laboratory quality assessment, and program audits) and also some of the same Standard Operating Procedures (SOPs) and analytical laboratories, plus the following SOPs:

- Produce sampling
- Fish sampling
- Game animal sampling
- Collection of crawfish in the Rio Grande
- Collection of macroinvertebrates in the Rio Grande
- Processing biota samples for analysis

These procedures, which are available on the LANL public website (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 manner consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is characterizing and remediating, as necessary, sites to ensure that past operations do not threaten human health or the environment. Corrective actions at the Laboratory are subject to the requirements of a Compliance Order on Consent (the Consent Order). The Environmental Programs (EP) Directorate is leading the site investigations with the objectives of (1) determining the nature (the origin, type, and amount of chemicals, either natural or man-made, that are present in the environment) and extent (the way a chemical is distributed in the environment) of contamination, and (2) identifying, evaluating, and implementing, where needed, remediation or other corrective measures to remove or mitigate the presence and/or migration of contaminants.

An investigation involves the collection and evaluation of data and information about the sites. The sites under investigation are designated as consolidated units, solid waste management units (SWMUs), or areas of concern (AOCs). Each investigation collects samples of the environmental medium of interest and the data are utilized to support site decisions. Corrective actions are complete at a site when LANL has demonstrated to the regulatory authority's satisfaction that the nature and extent of contamination are defined and the site poses no unacceptable risk or dose to humans, plants, and animals. Long-term stewardship activities, including surveillance and monitoring, might be implemented where contamination remains in place to ensure that there are no changes in potential risk/dose and concentrations.

1. Programs

The Corrective Action Program investigates consolidated units, SWMUs, and AOCs intermixed with active Laboratory operations as well as sites located within the Los Alamos town site (property currently owned by private citizens, businesses, or Los Alamos County) and property administered by the U.S. Forest Service (USFS), the National Park Service, and the U.S. Department of Energy (DOE). The Corrective Action Program also includes the canyons investigations, the groundwater monitoring program (implemented through the annual Interim Facility-Wide Groundwater Monitoring Plan), storm water and surface water monitoring, and the implementation of best management practices to minimize erosion.

The Technical Area (TA-) 21 Closure Program involves all of the sites associated with TA-21 and includes Material Disposal Areas (MDAs) A, B, T, U, and V; various process waste lines; a radioactive waste treatment system; and the Delta Prime (DP) Site Aggregate Area sumps, outfalls, leach fields, historic container storage areas, and other former facilities. The Laboratory received additional funding for environmental cleanup projects as part of the American Recovery and Reinvestment Act, which includes the decontamination and demolition of most of the buildings at TA-21, removal and disposal of waste from MDA B, and the installation of groundwater monitoring wells.

The TA-54 Closure Program involves all of the sites associated with TA-54 and includes MDAs G, H, and L. Activities involve periodic monitoring of the groundwater and vadose zone as well as the development and implementation of corrective measures for the MDAs.

2. Work Plans and Reports

The EP Directorate programs developed and/or revised 22 work plans and 37 reports, which were submitted to the New Mexico Environment Department (NMED) during 2010. A work plan proposes investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, and/or canyons.

Samples are collected from approved locations and depths and analyzed for some or all of the following analytical suites/analytes: target analyte list metals, cyanide, perchlorate, nitrate, volatile organic compounds (VOCs), semivolatile organic compounds, polychlorinated biphenyls (PCBs), dioxins and furans, explosive compounds, total petroleum hydrocarbons, isotopic uranium, americium-241, isotopic plutonium, gamma-emitting radionuclides, strontium-90, and tritium. The data are presented in an investigation report, which presents and evaluates the sampling results, and recommends additional investigation, remediation, monitoring, or no further action, as appropriate.

Tables 9-1 and 9-2 summarize the work plans and reports submitted and approved in 2010, the work plans and reports submitted prior to 2010 but approved in 2010, and the work plans and reports submitted in 2010 but not yet approved. Table 9-3 summarizes other reports, plans, and documents submitted in 2010. NMED granted Certificates of Completion for 34 SWMUs and AOCs in 2010 (Table 9-4). The remainder of this chapter presents summaries of the investigations for which activities were started, continued, and/or completed in 2010 and those investigations for which reports were submitted in 2010. Figures 9-1 and 9-2 show the locations where significant environmental characterization and/or remediation work was performed in 2010.

Table 9-1
Work Plans Submitted and/or Approved in 2010

Document Title	Date Submitted	Date Approved[a]	Status
Work Plan for Supplemental Soil Vapor Extraction Pilot Test Implementation/Reporting at Material Disposal Area G, Technical Area 54, Revision 1	1/11/2010	1/29/2010	The supplemental soil vapor extraction pilot test was conducted and a report provided
Lower Mortandad/Cedro Canyons Aggregate Area Investigation Work Plan, Revision 1	1/13/2010	1/22/2010	Conduct investigations and submit report in 2011
Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99	2/1/2010	5/20/2010	Submitted a tracer test work plan and schedule for proposed pumping test
Investigation Work Plan for Twomile Canyon Aggregate Area[b]	2/1/2010	n/a[c]	Revised
Historical Investigation Report for Twomile Canyon Aggregate Area	2/1/2010	n/a	n/a
Phase III Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50	2/5/2010	n/a	Revised
Work Plan to Plug and Abandon the Existing Deep-Extraction Borehole as Part of the Supplemental Soil-Vapor Extraction Pilot Test at Material Disposal Area G	4/1/2010	4/19/2010	Borehole plugged and abandoned according to standard operating procedures
Long-Term Monitoring and Maintenance Plan for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99	4/23/2010	—[d]	Pending review by NMED in 2011
Phase III Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50, Revision 1	4/28/2010	5/11/2010	One groundwater well and three vapor wells installed
Sampling and Analysis Plan for Post-Remediation Borehole Drilling at Material Disposal Area B, Solid Waste Management Unit 21-015, Technical Area 21	4/28/2010	—	Pending review by NMED in 2011
Delta Prime East Building Footprints Letter Work Plan for Delta Prime Site Aggregate Area	5/11/2010	n/a	Revised
Investigation Work Plan for Twomile Canyon Aggregate Area, Revision 1	5/12/2010	6/3/2010	Investigation planned to be implemented in 2012
Delta Prime East Building Footprints Letter Work Plan for Delta Prime Site Aggregate Area, Revision 1	7/19/2010	7/26/2010	Investigation planned to be implemented in 2011
Investigation Work Plan for Lower Pajarito Canyon Aggregate Area	7/28/2010	n/a	Revised

Table 9-1 (continued)

Document Title	Date Submitted	Date Approved[a]	Status
Historical Investigation Report for Lower Pajarito Canyon Aggregate Area	7/28/2010	n/a	n/a
Phase II Investigation Work Plan for Sandia Canyon	7/30/2010	1/4/2011	Investigation planned to be implemented in 2011–2012
Investigation Work Plan for Upper Water Canyon Aggregate Area	8/31/2010	n/a	Revised
Historical Investigation Report for Upper Water Canyon Aggregate Area	8/31/2010	n/a	n/a
Investigation Work Plan for Starmer/Upper Pajarito Canyon Aggregate Area	9/30/2010	n/a	Revised in 2011
Historical Investigation Report for Starmer/Upper Pajarito Canyon Aggregate Area	9/30/2010	n/a	n/a
Historical Investigation Report for Frijoles Canyon Aggregate Area	10/12/2010	12/6/2010	No investigation required
Phase II Investigation Work Plan for Upper Los Alamos Canyon Aggregate Area	10/21/2010	—	Pending review by NMED in 2011
Investigation Work Plan for Chaquehui Canyon Aggregate Area, Revision 1	10/29/2010	—	Revised in 2011
Investigation Work Plan for Lower Pajarito Canyon Aggregate Area, Revision 1	11/19/2010	12/8/2010	Investigation planned to be implemented in 2011–2012
Phase II Investigation Work Plan for Upper Mortandad Canyon Aggregate Area	12/3/2010	—	Pending review by NMED in 2011
Phase II Investigation Work Plan for North Ancho Canyon Aggregate Area[b]	12/10/2010	—	Pending review by NMED in 2011
Work Plan for Determining Background Concentrations of Inorganic Chemicals in Bandelier Tuff Unit 4	12/15/2010	1/12/2011	Investigation planned to be implemented in 2011

[a] Work plans typically approved with modifications or directions.
[b] A stipulated penalty document for 2010 under the Consent Order.
[c] n/a = Not applicable.
[d] — = Approval not received or required.

Table 9-2
Reports Submitted and/or Approved in 2010

Document Title	Date Submitted	Date Approved[a]	Status
Supplemental Investigation Report for Consolidated Units 16-007(a)-99 and 16-008(a)-99	1/7/2010	2/16/2010	Conduct inspections of erosion controls in drainages and periodic collection of sediment samples from pond; monitor groundwater for two quarters
Investigation Report for North Ancho Canyon Aggregate Area, Revision 1	1/18/2010	1/28/2010	Phase II work plan submitted
Report for the Self-Implementation of On-Site Cleanup and Disposal of Polychlorinated Biphenyl Remediation for Consolidated Unit 21-003-99 and Solid Waste Management Unit 21-024(c)	1/29/2010	n/a[b]	Phase III work plan to be submitted
Investigation Report for Upper Los Alamos Canyon Aggregate Area, Revision 1	2/2/2010	4/21/2010	Phase II work plan submitted
Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99[c]	3/1/2010	—[d]	Pending review by NMED in 2011

Table 9-2 (continued)

Document Title	Date Submitted	Date Approved[a]	Status
Results of Sediment Monitoring in the Pajarito Canyon Watershed	3/17/2010	6/3/2010	Monitoring of sediment continues
Phase II Investigation Report for Delta Prime Site Aggregate Area[c]	3/31/2010	n/a	Revised
Investigation Report for Upper Mortandad Canyon Aggregate Area, Revision 1	4/15/2010	6/4/2010	Phase II work plan submitted
Interim Measure Report for Solid Waste Management Unit 01-001(f) and Los Alamos Site Monitoring Area 2[c]	5/3/2010	—	Pending review by NMED in 2011
Investigation Report for Sites at Technical Area 49 Outside of the Nuclear Environmental Site Boundary[c]	5/18/2010	n/a	Revised
Investigation Report for Material Disposal Area B, Areas 9 and 10, Solid Waste Management Unit 21-015, Technical Area 21	5/26/2010	—	Pending review by NMED in 2011
Investigation Report for Sites at Technical Area 49 Inside of the Nuclear Environmental Site Boundary[c]	5/27/2010	n/a	Revised
Investigation Report for Upper Sandia Canyon Aggregate Area	6/1/2010	n/a	Revised
Soil Vapor Extraction Pilot Test Implementation/Reporting at Material Disposal Area G, Technical Area 54 (Summary Report)	6/1/2010	—	n/a
Completion Report for Pueblo Canyon Grade Control Structure[c]	6/3/2010	11/5/2010	Monitoring continues
Completion Report for Gage Stations E039.1 and E060.1[c]	6/3/2010	11/5/2010	Monitoring continues
Completion Report for DP Canyon Grade Control Structure[c]	6/3/2010	11/5/2010	Monitoring continues
Investigation Report for Threemile Canyon Aggregate Area	6/30/2010	n/a	Revised
Voluntary Corrective Action Completion Report for the Investigation and Remediation of Solid Waste Management Units 33-002(a-c) at Technical Area 33	7/30/2010	—	Revised
Addendum to the Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99	8/30/2010	—	Pending review by NMED in 2011
Investigation Report for S-Site Aggregate Area	8/31/2010	n/a	Revised in 2011
Nest Box Monitoring Report for the Upper Pajarito Canyon Watershed	8/31/2010	n/a	Revised
Investigation Report for Sites at Technical Area 49 Outside of the Nuclear Environmental Site Boundary, Revision 1	9/13/2010	11/12/2010	Phase II work plan to be submitted
Investigation Report for Sites at Technical Area 49 Inside of the Nuclear Environmental Site Boundary, Revision 1	9/14/2010	11/12/2010	Phase II work plan to be submitted
Supplemental Interim Measure Report for Solid Waste Management Unit 01-001(f)	9/29/2010	—	Pending review by NMED in 2011
Phase II Investigation Report for Delta Prime Site Aggregate Area, Revision 1	9/30/2010	—	Phase III work plan to be submitted
Phase II Investigation Report for Pueblo Canyon Aggregate Area[c]	9/30/2010	12/23/2010	Additional assessments planned to be completed in 2011
Corrective Measures Evaluation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Revision 1[c]	9/30/2010	—	Revised in 2011
Investigation Report for Upper Sandia Canyon Aggregate Area, Revision 1	10/1/2010	11/12/2010	Phase II work plan to be submitted
Remedy Completion Report for Upper Los Alamos Canyon Aggregate Area, Former Technical Area 32[c]	10/29/2010	—	Revised in 2011
Voluntary Corrective Action Completion Report for the Investigation and Remediation of Solid Waste Management Units 33-002(a-c) at Technical Area 33, Revision 1	10/29/2010	—	Revised in 2011
Interim Assessment to Report Storm Damage to Sediment Control Structures and Monitoring Stations in Los Alamos and Pueblo Canyons	10/29/2010	—	Pending review by NMED in 2011
Investigation Report for Threemile Canyon Aggregate Area, Revision 1	11/3/2010	12/8/2010	Phase II work plan to be submitted

Table 9-2 (continued)

Document Title	Date Submitted	Date Approved[a]	Status
Nest Box Monitoring Report for the Upper Pajarito Canyon Watershed, Revision 1	11/8/2010	1/14/2010	Additional monitoring required
Investigation Report for Upper Cañada del Buey Aggregate Area[c]	11/19/2010	—	Pending review by NMED in 2011
Corrective Measures Evaluation Report for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, at Technical Area 54, Revision 2	11/30/2010	—	Pending review by NMED in 2011
Investigation Report for Potrillo and Fence Canyons	12/21/2010	—	Revised in 2011
Corrective Measures Evaluation Report for Material Disposal Area H, Solid Waste Management Unit 54-004, at Technical Area 54[c]	12/21/2010	—	Pending review by NMED in 2011

[a] Work plans typically approved with modifications or directions.
[b] n/a = Not applicable.
[c] A stipulated penalty document for 2010 under the Consent Order.
[d] — = Approval not received or required.

Table 9-3
Additional Plans and Reports Submitted in 2010

Document Title	Date Submitted
Periodic Monitoring Reports	
Pajarito Watershed	2/26/2010
White Rock Watershed	2/26/2010
Mortandad Watershed	2/26/2010
Sandia Watershed	2/26/2010
Water Canyon/Cañon de Valle Watershed	2/26/2010
Ancho Watershed	2/26/2010
Mortandad Watershed	5/25/2010
Sandia Watershed	5/25/2010
Los Alamos Watershed	5/25/2010
Pajarito Watershed	5/25/2010
Mortandad Watershed	8/19/2010
Sandia Watershed	8/19/2010
Pajarito Watershed	8/19/2010
Water Canyon/Cañon de Valle Watershed	8/19/2010
White Rock Watershed	8/19/2010
Ancho Watershed	8/19/2010
Mortandad Watershed	11/29/2010
Sandia Watershed	11/29/2010
Pajarito Watershed	11/29/2010
Groundwater Data Reviews	Monthly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54	Quarterly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area H, Solid Waste Management Unit 54-004, at Technical Area 54	Quarterly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21*	Quarterly

Table 9-3 (continued)

Document Title	Date Submitted
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area V, Consolidated Unit 21-018(a)-99, at Technical Area 21	Quarterly
Well Work Plans and Reports	
Completion Report for Regional Well R-40, Revision 1	1/19/2010
Fact Sheets for CdV-37-1i	1/21/2010
Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99	2/1/2010
Completion Report for Well R-48	2/23/2010
Completion Report for Intermediate Aquifer Well R-47i	4/15/2010
Work Plan to Conduct Reliability Assessment of Multi-Screened West Bay Wells	5/27/2010
Work Plan for Replacement Well R-25r and Proposed Disposition of Scheduled Well R-47	6/15/2010
Technical Area 21 Groundwater and Vadose-Zone Monitoring Well Network Evaluation and Recommendations	7/1/2010
Los Alamos National Laboratory Site-Wide Monitoring Program Drinking Water Results for the City of Santa Fe Buckman Water Supply Wells	7/28/2010
Work Plan for Alternate Monitoring at the Buckman Well Field	7/30/2010
Drilling Work Plan for Intermediate Well R-55i	8/13/2010
Completion Report for Regional Aquifer Well R-37, Revision 1	8/30/2010
Completion Report for Intermediate Aquifer Well PCI-2, Revision 1	9/10/2010
Work Plan for Well R-61	10/15/2010
Work Plan for Well R-62	10/29/2010
Work Plan for Plug and Abandon Wells and Boreholes at Los Alamos National Laboratory	10/29/2010
Drilling Work Plan for Regional Aquifer Well R-56	2/1/2010
Notice of Demolition, Los Alamos National Laboratory Delta Prime Site, Building 21-155	2/1/2010
Material Disposal Area B Direct-Push Sampling Data Maps	2/4/2010
R-54 Fact Sheets	3/1/2010
Drilling Work Plan for Regional Aquifer Well R-57	3/4/2010
R-51 Fact Sheets	3/10/2010
Completion Report for Intermediate Aquifer Well R-27i	3/15/2010
Summary Report for Plugging and Abandonment of Test Wells TW-2, TW-2A, TW-2B	3/15/2010
R-50 Fact Sheets	3/15/2010
Work Plan to Plug and Abandon Well TW-4	3/25/2010
Fact Sheet TW-2Ar	4/1/2010
Fact Sheet R-29	4/12/2010
Drilling Work Plan for Perched-Intermediate Well CdV-16-4ip	4/27/2010
Fact Sheet R-53	4/27/2010
Summary Report for Plugging and Abandonment of Test Well-1 and Test Well-1A	4/27/2010
Completion Report for Intermediate Well CdV-37-1i	4/29/2010
Drilling Work Plan for Regional Aquifer Well R-55	5/3/2010
Fact Sheets for R-30	5/3/2010
Fact Sheets for R-52	5/3/2010
Notice of Demolition, Los Alamos National Laboratory Delta Prime Site, Buildings 21-213, 21-2, 21-3, 21-314, 21-4, 21-315, 21-1167, 21-5, and Demolition Resumption, Building 21-312	5/20/2010
Drilling Work Plan for Regional Aquifer Well R-60	6/1/2010

Table 9-3 (continued)

Document Title	Date Submitted
Completion Report for Regional Aquifer Well R-54	6/25/2010
Fact Sheets for R-57	6/25/2010
Completion Report for Regional Aquifer Well R-51	7/8/2010
Notice of Demolition, Los Alamos National Laboratory Delta Prime Site, Buildings 21-152 and 21-150	7/8/2010
Notice of Demolition, Los Alamos National Laboratory Delta Prime Site, Buildings 21-149 and 21-150	7/13/2010
Completion Report for Regional Aquifer Well R-50	7/13/2010
Summary Report for Plugging and Abandonment of TW-4	7/13/2010
Fact Sheets for R-3	7/21/2010
Completion Report for Intermediate TW-2Ar	7/21/2010
Fact Sheet for R-56	8/4/2010
Completion Report for Regional Aquifer Well R-29	8/5/2010
Completion Report for Regional Aquifer Well R-53	8/25/2010
Completion Report for Regional Aquifer Well R-30	8/25/2010
Completion Report for Regional Aquifer Well R-52	9/2/2010
Fact Sheets for CdV-16-4ip	9/17/2010
Fact Sheets for R-55	9/20/2010
Fourth Quarter Report, Fiscal Year 2010, Cleanup Activities at Material Disposal Area B, Solid Waste Management Unit 21-015	9/27/2010
Notice of Demolition, Los Alamos National Laboratory Delta Prime Site, Buildings 21-31, 21-212, 21-355, and 21-357	9/29/2010
Drilling Work Plan for Regional Well R-59	9/30/2010
Completion Report for Well R-57	11/5/2010
Fact Sheets for R-60	11/12/2010
Completion Report for Well R-3	11/18/2010
Completion Report for Regional Well R-56	12/14/2010
Progress Report for Cleanup Activities at Material Disposal Area B, Solid Waste Management Unit 21-015, Technical Area 21, First Quarter of Fiscal Year 2011	12/17/2010
Miscellaneous Reports/Plans	
Documentation of Borehole 16-608154 Abandonment	2/26/2010
Status of Inflatable Packer Systems and Assessment of Cross Flow in Monitoring Wells at Los Alamos National Laboratory	2/26/2010
Results of 2009 Sediment Monitoring in the Pajarito Canyon Watershed (Annual Update)	3/17/2010
Demolition Documentation Report for the Bayo Canyon Wastewater Treatment Plant, AOC 00-018(b)	4/13/2010
Documentation of Completion of Cross-Vane Structure Corrective Maintenance Actions In Pueblo Canyon	5/17/2010
Completion Documentation for Stream Bank Stabilization in the South Fork of Acid Canyon	4/23/2010
Baseline Geomorphic Conditions at Sediment Transport Mitigation Sites in Los Alamos/Pueblo Canyons Watershed	6/1/2010
Annual Inspection of Erosion Controls in Drainages to the 90s Line Pond at Technical Area 16	11/19/2010
Erosion Controls Associated with Fishladder Canyon [Solid Waste Management Unit 16-003(o)]	12/6/2010
General Facility Information (Annual Update)	3/31/2010
Interim Facility-Wide Groundwater Monitoring Plan (Annual Update)	6/29/2010
Groundwater Background Investigation Report, Revision 4	8/31/2010
Corrective Measure Study Progress Reports [16-021(c)-99 the 260 Outfall]	Monthly

*Periodic monitoring report for October to December 2009 is a stipulated penalty document for 2010 under the Consent Order.

Table 9-4
SWMUs and AOCs Granted Certificates of Completion in 2010

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
SWMU 39-001(b)		X	4/6/2010
AOC 39-002(c)		X	4/6/2010
AOC 39-002(d)		X	4/6/2010
AOC 39-002(e)		X	4/6/2010
AOC 39-002(f)		X	4/6/2010
SWMU 39-005		X	4/6/2010
AOC 39-007(d)		X	4/6/2010
AOC 03-041		X	9/7/2010
AOC 48-002(e)		X	9/7/2010
SWMU 48-007(a)	X		9/7/2010
SWMU 48-007(d)	X		9/7/2010
SWMU 48-010	X		9/7/2010
AOC 48-012	X		9/7/2010
AOC 00-031(a)		X	9/10/2010
AOC 00-034(b)		X	9/10/2010
SWMU 01-001(t)		X	9/10/2010
SWMU 01-001(u)		X	9/10/2010
SWMU 01-006(o)		X	9/10/2010
SWMU 01-007(d)		X	9/10/2010
SWMU 01-007(e)		X	9/10/2010
AOC 01-003(c)		X	9/10/2010
AOC 01-006(g)		X	9/10/2010
SWMU 03-009(j)		X	9/10/2010
SWMU 32-001		X	9/10/2010
SWMU 41-001		X	9/10/2010
SWMU 01-001(b)	X		9/10/2010
SWMU 01-001(c)	X		9/10/2010
SWMU 01-001(e)	X		9/10/2010
SWMU 01-003(e)	X		9/10/2010
SWMU 01-006(d)	X		9/10/2010
SWMU 01-007(j)	X		9/10/2010
AOC 01-007(k)	X		9/10/2010
AOC 03-008(a)	X		9/10/2010
AOC 43-001(b2)	X		9/10/2010

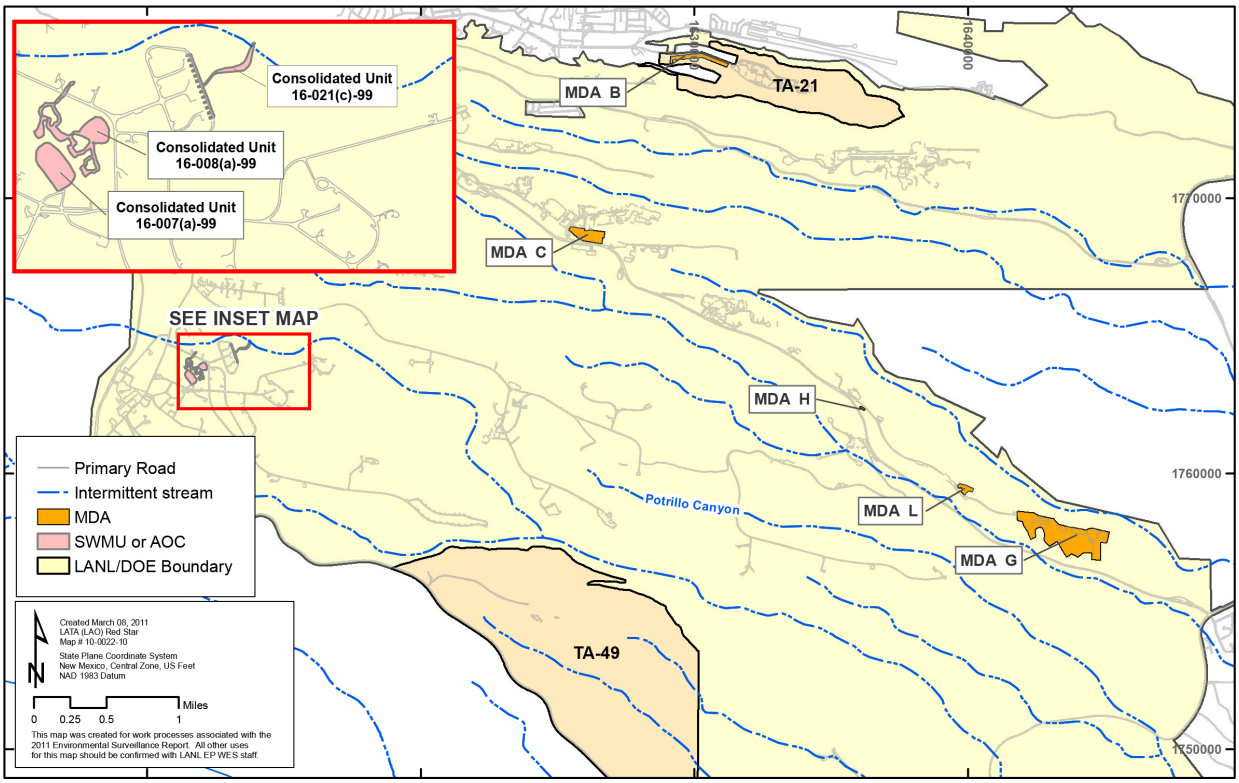

Figure 9-1 **Location of MDAs and other SWMUs or AOCs where remediation and/or characterization work was performed in 2010.**

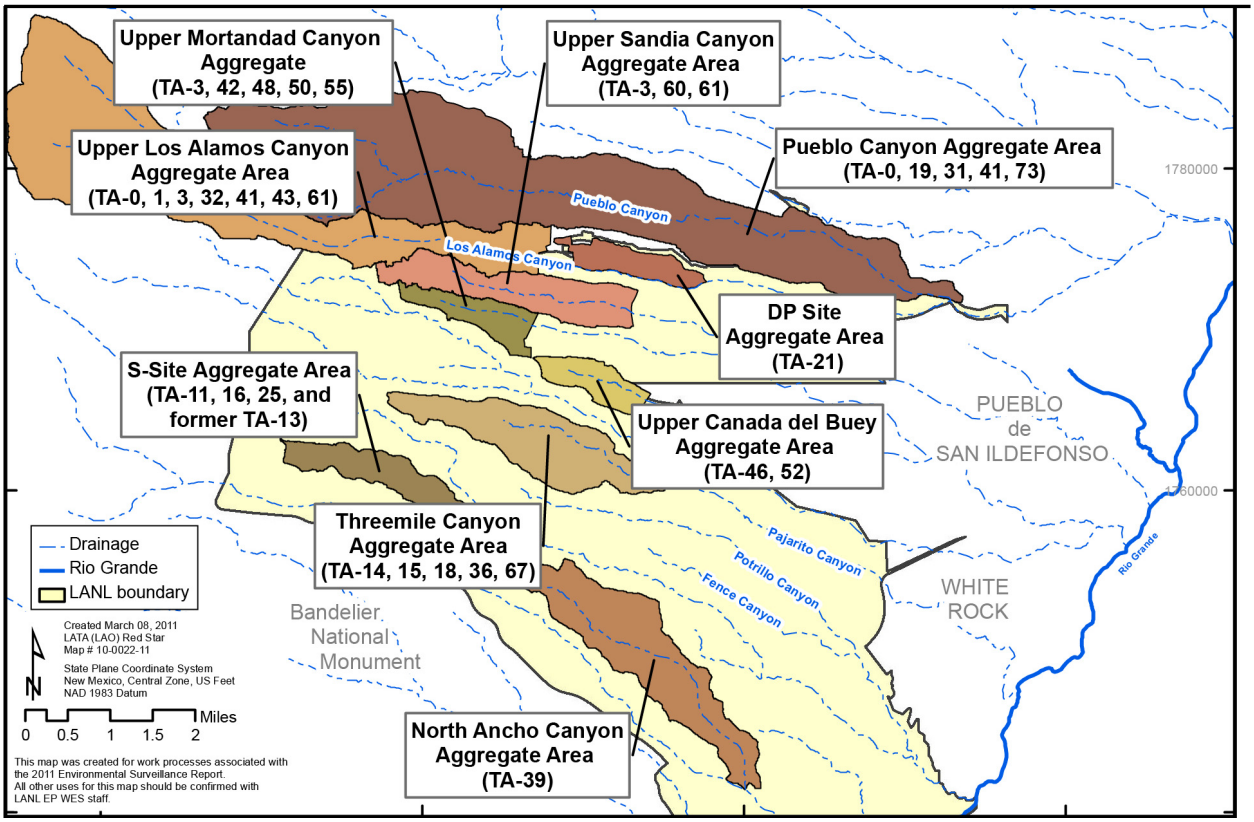

Figure 9-2 **Location of canyons and aggregate areas where remediation and/or characterization work was performed in 2010**

B. CORRECTIVE ACTIONS PROGRAM ACCOMPLISHMENTS

1. Upper Los Alamos Canyon Aggregate Area

a. Site Description and History

The Upper Los Alamos Canyon Aggregate Area is located within and south of the Los Alamos town site in TA-0, TA-1, TA-3, TA-32, TA-41, TA-43, and TA-61 and includes a total of 115 SWMUs and AOCs. Of the 115 sites in the Upper Los Alamos Canyon Aggregate Area, 47 sites underwent sampling in 2008–2009 and six sites were approved for delayed investigation pending cessation of operations. Sites include septic tanks and outfalls; sanitary waste lines and sewage treatment facilities; industrial waste lines, drains, and outfalls; storm drains and outfalls; soil contamination areas from Laboratory operations; landfills and surface disposal areas; transformer sites; and incinerators.

b. Remediation and Sampling Activities

A Phase II investigation work plan (LANL 2010a) was developed to complete the activities recommended in the investigation report (LANL 2010b). The primary activities at the 28 sites associated with the Phase II investigation are (1) surface and subsurface soil and tuff sampling and (2) excavation of soil and/or tuff in limited areas with elevated contaminant concentrations.

Accelerated corrective action (ACA) activities were conducted at former TA-32 in the Upper Los Alamos Canyon Aggregate Area for four sites in accordance with the ACA work plan approved by NMED (LANL 2009a; NMED 2010a). The objectives of the ACA were to (1) conduct limited soil removal and (2) collect samples to finalize the determination of the extent of contamination. Additional samples were collected and a total volume of approximately 5.5 yd^3 was excavated at one site.

Interim measure activities were conducted in the drainage downgradient of a former septic system, referred to as the Los Alamos Site Monitoring Area 2 (LA-SMA-2) drainage. The interim measure activities were implemented to mitigate contaminant migration to and within Los Alamos Canyon and included removal of contaminated environmental media from the downgradient drainage; installation of best management practices to prevent contaminants from the mesa top from migrating into the downgradient drainage; construction of surface water retention and sediment deposition basins in Los Alamos Canyon below the drainage; and characterization and disposal of waste generated during removal activities in accordance with applicable regulatory requirements (LANL 2010c).

A total of 594 yd^3 of PCB-contaminated media were removed from the outfall and drainage during the interim measure activities. At the base of the drainage, where a large body of sediment had accumulated, 2,290 yd^3 of PCB-contaminated sediment has been removed. Following the removal of contaminated sediment and rock, a total of 107 confirmation samples were collected from the site (LANL 2010c; LANL 2010d). Supplemental interim measure activities included additional removal of contaminated environmental media and collection of confirmation samples from the downgradient drainage; inspection of the two surface water retention and sediment deposition basins in Los Alamos Canyon below the drainage; and characterization and disposal of waste generated during removal activities in accordance with applicable regulatory requirements.

c. Conclusions and Recommendations

The results of the Upper Los Alamos Canyon Aggregate Area investigation were provided in an investigation report (LANL 2009b), which was revised in 2010 (LANL 2010b).

The data indicated the nature and extent of contamination are defined at three former TA-32 sites and no potential unacceptable risks or doses to human and ecological receptors from Laboratory releases are present (LANL 2010e). Sampling results show that the extent of contamination has not been defined at one site (LANL 2010e). Additional sampling will be implemented as part of the Phase II investigation of the Upper Los Alamos Canyon Aggregate Area. No further investigation or remediation activities are warranted at the other sites.

Implementation of the interim measures achieved the desired objectives of reducing the contaminant inventory in the drainage system below the former septic tank and controlling contaminant migration. Additional removal, stabilization, and sampling activities are recommended for the mesa-top portion of the site and will be implemented as part of the Phase II investigation for Upper Los Alamos Canyon Aggregate Area. A risk assessment to ensure no potential unacceptable risks are present will also be performed as part of the Phase II investigation.

NMED approved the report (NMED 2010b) and granted Certificates of Completion for 21 sites in the Upper Los Alamos Canyon Aggregate Area (NMED 2010c).

2. Upper Mortandad Canyon Aggregate Area

a. Site Description and History

The Upper Mortandad Canyon Aggregate Area is located in TA-3, former TA-42, TA-48, TA-50, and TA-55 and consists of 119 sites, 58 of which have been previously investigated and/or remediated and have been approved for no further action. The remaining SWMUs and AOCs were evaluated by the investigation.

b. Remediation and Sampling Activities

Thirty-one sites require additional sampling to define the extent of contamination. A Phase II investigation work plan (LANL 2010f) was developed and presents the proposed sampling and analyses needed to define the extent of contamination at each of the 31 sites.

c. Conclusions and Recommendations

The investigation report describing the sampling, analyses, and evaluation of the data was submitted (LANL 2009c) and revised in 2010 (LANL 2010g). The extent of contamination has not been defined at 31 sites. Additional sampling is needed to define the vertical and/or lateral extent of one or more chemicals of potential concern (COPCs) at each of these sites. NMED approved the revised report (NMED 2010d) and granted Certificates of Completion for six sites in the Upper Mortandad Canyon Aggregate Area (NMED 2010e).

3. North Ancho Canyon Aggregate Area

a. Site Description and History

The North Ancho Canyon Aggregate Area includes TA-39 and portions of TA-49. The aggregate area includes 44 individual SWMUs and AOCs. The 18 sites within TA-49 sites are addressed in separate work plans and investigation reports. The North Ancho Canyon Aggregate Area that encompasses TA-39 consists of 26 sites and is primarily composed of firing sites for testing of high explosives (HE), support facilities, and waste disposal areas. Active facilities include firing sites, storage areas, administrative offices, workshops, sewage disposal facilities, and supporting infrastructure. Inactive facilities include firing sites, storage areas, waste disposal areas, and sewage and chemical disposal facilities.

b. Remediation and Sampling Activities

Six sites require additional sampling to define the extent of contamination, one of which also requires additional remediation. A Phase II investigation work plan (LANL 2010h) was developed and describes the activities needed to complete the investigation and/or remediation of the remaining five SWMUs and one AOC. The Phase II investigation work plan also includes the abandonment of five shallow wells and 12 angled boreholes, and the final removal of remaining waste and contaminated media at two landfill sites.

c. Conclusions and Recommendations

The investigation report was completed and submitted in 2009 (LANL 2009d) and subsequently revised in 2010 (LANL 2010i). NMED approved the revised report (NMED 2010f) and granted Certificates of Completion for seven sites in the North Ancho Canyon Aggregate Area (NMED 2010g).

4. TA-49

a. Site Description and History

TA-49, also known as the Frijoles Mesa site, occupies approximately 1280 acres along the south-central boundary of the Laboratory and is located within the Ancho, North Ancho, and Water Canyon watersheds.

A period of intense experimental activity at TA-49 took place from late 1959 to mid-1961, during which hydronuclear and related experiments deposited significant amounts of plutonium, uranium, lead, and beryllium in underground shafts. These experiments were conducted in subsurface shafts located at MDA AB (Areas 2, 2A, and 2B) and Areas 1, 3, and 4. Facilities in Areas 5 and 10 were used to support the experiments at the test shaft areas. Uncontaminated materials generated at these facilities were deposited into a landfill and burn site in Area 6. Additionally, general site cleanups conducted in 1971 and 1984 resulted in the disposal of uncontaminated structure debris and materials into the Area 6 landfill and the creation of small landfills at Areas 5 and 10. Area 11 is the site of a former radiochemistry laboratory, associated leach field, and subsurface test-shot area. Area 12 includes the former Bottle House and Cable Pull Test Facility.

b. Remediation and Sampling Activities

The investigation of TA-49 was separated into two investigation work plans; one plan addressed the sampling of sites outside of the nuclear environmental site (NES) boundary (LANL 2008a) and the other work plan addressed the sampling of sites inside the NES boundary (LANL 2008b). The TA-49 sites outside the NES boundary consist of nine SWMUs and AOCs, two of which have been previously investigated and/or remediated and have been approved for no further action. The investigation of one AOC and one SWMU is deferred per Table IV-2 of the Consent Order; however, samples were collected around former transformer pads located within the AOC. The TA-49 sites inside the NES boundary consist of 11 SWMUs and AOCs, one of which has been approved for no further action. The surface investigation at one AOC is deferred per Table IV-2 of the Consent Order; however, subsurface samples from boreholes were collected within the AOC.

The investigation activities included collection of 2438 surface and shallow subsurface soil samples from 1,219 locations for gross-alpha and -beta radiological screening. Of these screening samples, 1,058 samples from 569 locations were submitted for laboratory analyses. In addition to the surface sampling, 144 soil and tuff samples were collected from 41 boreholes with a maximum depth of 192 ft below ground surface. Pore-gas samples were collected from at least one borehole at each area and analyzed for VOCs and tritium.

c. Conclusions and Recommendations

The investigation reports for outside and inside the NES boundary at TA-49 were submitted and subsequently revised in 2010 (LANL 2010j; LANL 2010k). Both revised reports were approved by NMED (NMED 2010h; NMED 2010i).

The extent of contamination has been defined at Area 5. These sites have been determined to pose no potential unacceptable risk or dose to human health or the environment. No further investigation or remediation activities are warranted at Area 5 (LANL 2010j). Certificates of Completion were requested for one AOC and one SWMU. Extent of contamination at Area 6 West is defined, but additional sampling is necessary to determine whether potential contamination from dioxins and furans is present.

The extent of contamination has not been defined at Area 1, MDA AB (Area 2, 2A, 2B), Area 3, Area 4, Area 10, Area 11, and Area 12 (LANL 2010k). Additional sampling is necessary to define the lateral and vertical extent of one or more contaminants at each of these sites. Phase II investigation work plans will be prepared to address the additional sampling and the required data analysis will be conducted to define extent at the sites inside and outside the NES boundary will be prepared. In addition, a separate work plan has been developed to address the inorganic background concentrations for Unit 4 of the Tshirege Member of the Bandelier Tuff (LANL 2010l).

The VOC pore-gas data were compared with screening values based on equilibrium partitioning of vapor with groundwater standards or screening levels to evaluate the potential for the reported VOC concentrations to result in contamination of groundwater. Pore-gas data indicate that VOCs in subsurface pore gas are not a

potential source of groundwater contamination. Tritium pore-gas data were compared with the groundwater maximum contaminant level (MCL) for tritium. For the most part, tritium activities in vapor samples were low. However, tritium activities in one borehole located at Area 12 exceeded the groundwater MCL for tritium and may represent a potential source of groundwater contamination. The Phase II investigation work plan for sites inside the NES boundary will propose that this borehole be re-sampled to confirm the results.

5. Upper Sandia Canyon Aggregate Area

a. Site Description and History

The Upper Sandia Canyon Aggregate Area is located in TA-3, TA-60, and TA-61 at the Laboratory. The Upper Sandia Canyon Aggregate Area includes only part of TA-3. Other parts of TA-3 are included in the Upper Los Alamos Canyon Aggregate Area, the Upper Mortandad Canyon Aggregate Area, and the Twomile Canyon Aggregate Area. The Upper Sandia Canyon Aggregate Area includes 180 SWMUs and AOCs, 91 of which have been previously investigated and/or remediated and have been approved for no further action. The remaining 89 SWMUs or AOCs were investigated in 2009–2010.

b. Remediation and Sampling Activities

Six hundred eight (608) surface samples, shallow subsurface samples (<10 ft below ground surface [bgs]), and deep subsurface samples (10 to 65 ft bgs) were collected from 256 locations and submitted for laboratory analyses. The sampling included drilling 56 boreholes to 10 to 61 ft bgs.

A septic tank was removed and confirmation samples were collected in accordance with the approved work plan (LANL 2008c; NMED 2008). The 6-in. inlet drainline to the septic tank was plugged with concrete and the outlet drainline to the seepage pit was removed.

c. Conclusions and Recommendations

The investigation report for the Upper Sandia Canyon Aggregate Area was submitted and subsequently revised in 2010 (LANL 2010m; LANL 2010n). The revised report was approved by NMED (NMED 2010j).

The nature and extent of contamination have been defined for 24 sites previously investigated or investigated during 2009. The nature and extent of contamination have not been defined for 41 sites. A total of 22 sites are proposed for delayed characterization pending decontamination and decommissioning (D&D) of certain buildings and structures within the aggregate area. Two additional sites are addressed under other regulatory programs and require no further action.

The 24 sites for which nature and extent are defined have been determined to pose no potential unacceptable risk or dose to human and ecological receptors from Laboratory releases. The Laboratory requested Certificates of Completion for the 24 sites in the Upper Sandia Canyon Aggregate Area.

A Phase II work plan to address the remaining 41 sites was developed and submitted to NMED in 2011 (LANL 2011a).

6. S-Site Aggregate Area

a. Site Description and History

The S-Site Aggregate Area consists of 105 SWMUs and AOCs in TA-11, former TA-13, TA-16, and TA-25. Thirty-seven sites have either been approved for no further action, are pending no further action, were addressed by other investigations, or were deferred from investigation pursuant to Table IV-2 of the Consent Order. The aggregate area has been subdivided into four subaggregates according to their location and operational histories: K-Site Subaggregate, P-Site Subaggregate, 300s Line Subaggregate, and V-Site Subaggregate.

i. K-Site Subaggregate

The TA-11 firing sites were constructed in 1944 for research on implosion symmetry using x-rays and the magnetic method. K-Site has also been home to photofission experiments, an air gun firing facility, a mortar impact area, a burning ground, laboratories, and storage buildings.

ii. P-Site Subaggregate

The subaggregate consists of inactive sites at TA-16 and former TA-13, which included a firing site, a firing site debris area, control bunkers, firing bunkers, storage buildings, purported burn pits, and a former wastewater treatment plant (WWTP). Former TA-13 was constructed in 1944 to support the HE portion of the Manhattan Project. Manhattan Project activities conducted included counter x-ray diagnostics of HE lens configurations, testing of initiator assemblies, and HE assembly and research in the magnetic method program. Because of its remote location, the area was also used to machine toxic or extremely sensitive explosives.

iii. 300s Line Subaggregate

The 300s Line Subaggregate consists of HE processing buildings along with their associated rest houses. Construction of the 300s Line began at the end of 1951 and was completed in 1953. The primary function of this facility was casting HE such as 2,4,6-trinitrotoluene, Composition B, and Baratol. In 1958, the 300s Line facility changed from casting HE to developing plastic-bonded explosives.

iv. V-Site Subaggregate

The V-Site Subaggregate is a historic site located at the eastern edge of the World War II–era complex. V-Site was used for the processing, machining, and casting of HE and included operations buildings, HE magazines, material storage buildings, and an assembly building.

b. Remediation and Sampling Activities

Sixty-eight SWMUs and AOCs are included in the investigation conducted in 2009–2010 (LANL 2007). Of these, three sites required no additional investigation and were proposed for no further investigation or remediation, two sites were sampled with nearby sites, and two sites were not sampled because of historic preservation constraints. The remaining 61 sites were sampled to determine the nature and extent of contamination. Additional locations were sampled in the drainages to determine if there is off-site transport of contaminants into Fishladder Canyon and Martin Spring Canyon.

A total of 3288 samples of soil, sediment, and rock samples from the surface, shallow subsurface, and deep subsurface were collected during the 2009-2010 investigations. Drilling operations included 26 boreholes at the V-Site Subaggregate, 10 boreholes at the 300s Line Subaggregate, and 12 boreholes at the P-Site Subaggregate to a maximum depth of 30 ft bgs (LANL 2007).

c. Conclusions and Recommendations

The investigation report for the S-Site Aggregate Area was submitted (LANL 2010o). The report was subsequently revised in early 2011 (LANL 2011b).

The extent of contamination has been defined at six sites. Human health and ecological risk assessments were performed for these sites. Five sites do not pose a potential unacceptable risk to human health and the environment and are recommended for corrective action complete. One site was found to pose potential unacceptable risk to human health, and corrective actions are recommended. Three sites were also recommended for corrective action complete on the basis that there is no history or evidence of releases of hazardous constituents.

The nature and extent of contamination have not been defined for 59 sites. Additional sampling is needed to define the lateral and/or vertical extent of contamination at each of these sites. The Laboratory will provide a Phase II investigation work plan to address the additional sampling required to complete the characterization of these sites.

The V-Site Courtyard Area is of historical significance because of its association with the Manhattan Project. In this area, the Trinity test device was assembled and tests of Fat Man and Little Boy weapon components were conducted. Historic preservation restrictions prohibit the Laboratory from sampling within this historically protected area, thereby preventing the determination of the nature and extent of contamination for the sites that lie within the V-Site Courtyard Area. However, the Courtyard Periphery Area has been found not to pose a potential unacceptable risk to human health (under the recreational scenario) and the environment (LANL 2010o; LANL 2011b).

7. Upper Cañada del Buey Aggregate Area

a. Site Description and History

The Upper Cañada del Buey Aggregate Area is located in TA-46 and TA-52 (which includes two sites associated with former TA-4 but now lie within the boundary of TA-52) and consists of 83 SWMUs and AOCs, 27 of which have been previously investigated and/or remediated and have been approved or recommended for no further action. The remaining 56 SWMUs or AOCs were addressed in the investigation. The sites include septic systems; outfalls and drainages; drain lines; stack emissions; potential soil contamination areas; surface impoundments; a landfill; storage areas; dry wells; a storage tank; and a surface disposal area.

b. Remediation and Sampling Activities

A total of 738 soil, sediment, and rock samples were collected from the surface, shallow subsurface, and deep subsurface. The sampling included 50 boreholes drilled to 10 to 26 ft bgs. Four inactive septic tanks were removed and confirmation samples were collected from each excavation following removal.

c. Conclusions and Recommendations

The investigation report was submitted to NMED in November 2010 (LANL 2010p).

The extent of contamination has been defined at six sites. Human health and ecological risk assessments were performed for four of these six sites. The human health risk-screening assessment results indicate no potential unacceptable risks from COPCs at the four sites evaluated. The ecological risk-screening assessment results indicate no potential unacceptable risks to any receptor at the evaluated sites. No COPCs were detected above background at one of the remaining two sites, and no COPCs were detected at depth intervals relevant to human health risk assessments at the other site.

The Laboratory recommended corrective actions complete without controls for the six sites for which the nature and extent of contamination have been defined. In addition, one site previously recommended for no further action was recommended for corrective actions complete with controls.

The extent of contamination has not been defined at 49 sites. Additional sampling is needed to define the vertical and/or lateral extent at each of these sites. The Laboratory will provide a Phase II investigation work plan to address the additional sampling required to complete characterization at these sites.

8. Pueblo Canyon Aggregate Area

a. Site Description and History

The Pueblo Canyon Aggregate Area (TA-0, TA-19, TA-31, TA-45, and TA-73) consists of 49 SWMUs and AOCs located within the watershed or sites that discharged directly to the canyon from the mesa top. These sites are located on former Laboratory property that is now part of the Los Alamos town site or in Pueblo Canyon. Transfer of the property on which these sites are located occurred historically either to Los Alamos County or to private landholders. Of the 49 sites, 19 were included in the Phase I investigation.

b. Remediation and Sampling Activities

Based on the results of Phase I characterization sampling, three SWMUs and three AOCs were recommended for additional sampling. The objectives of the Phase II investigation were to complete the characterization of the nature and extent of contamination at five sites and to complete the soil removal at one site.

The Phase II investigation included 31 surface and shallow subsurface samples collected from 18 locations at four sites and the drilling of 14 vertical boreholes and the collection of 28 samples at three sites. In addition, approximately 306 yd^3 of sediment, soil, and rock was excavated at one site. Confirmatory samples were collected and the excavation was backfilled with clean fill material delivered from off-site.

c. Conclusions and Recommendations

The Phase II investigation report was submitted to NMED in 2010 (LANL 2010q).

Based on the analytical results from the Phase I and Phase II investigations, the nature and extent of all COPCs are defined at the six sites. The human health risk-screening assessment results indicated no potential unacceptable risks at the six sites. The ecological risk-screening assessment results indicated no potential unacceptable risks to any receptor at the six sites. Additional evaluations are needed before corrective actions are completed.

9. Threemile Canyon Aggregate Area

a. Site Description and History

The Threemile Canyon Aggregate Area consists of sites within TA-14, TA-15, TA-18, TA-36, and TA-67. This aggregate area also includes sites associated with former TA-12 that lie within the boundaries of TA-15 and TA-67. The Threemile Canyon Aggregate Area includes 40 sites, 10 of which have been previously investigated and/or remediated and have been approved for no further action. Four sites have been deferred per Table IV-2 of the Consent Order. The remaining 26 sites were investigated in 2009–2010.

b. Remediation and Sampling Activities

A total of 764 surface and shallow subsurface soil, sediment, and rock samples were collected from 358 locations. Nine boreholes were drilled to depths ranging from 10–182.5 ft bgs.

Two septic tanks were removed during the 2009–2010 investigation. Following the removal of the septic tanks, confirmation samples were collected from each excavation.

c. Conclusions and Recommendations

The investigation report for the Threemile Canyon Aggregate Area was submitted and subsequently revised in 2010 (LANL 2010r; LANL 2010s). The revised report was approved by NMED (NMED 2010k).

The extent of contamination has not been defined at any of the 26 sites investigated. Additional sampling is needed to define the vertical and/or lateral extent of one or more contaminants at each of the sites. Remediation is recommended for six sites. The Laboratory will provide a Phase II investigation work plan to address the additional sampling required at the sites identified in this report.

10. 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, drain lines, ponds, and outfall systems (drainages). Historically, the 30s Line and the 90s Line 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.

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 Line 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 removed, which included the removal of sumps, blast shields, drain lines, earthen berms, and asphalt roadways.

b. Remediation and Sampling Activities

The following activities were completed in 2009 in accordance with the approved supplemental investigation work plan:

- A 300.5-ft borehole was drilled, logged, and sampled at the 90s Line; eight characterization samples were collected,
- HE and chromium VI contaminated soil was removed, and

- A groundwater-monitoring well (installed at the 90s Line Pond during the 2006–2007 ponds investigation) was developed for groundwater sampling. A transducer was installed to monitor water-level fluctuations on a continuous basis.

A total of 185 yd^3 of soil and tuff was excavated and removed at the 30s Line. Eight confirmation samples were collected from four locations within the excavated area. A total of 23 yd^3 of material was excavated at the 90s Line. Six confirmation samples were collected from three locations within the excavated area

c. Conclusions and Recommendations

A supplemental investigation report was submitted to NMED in 2010 (LANL 2010t) and approved (NMED 2010l).

Consolidated Units 16-007(a)-99 (the 30s Line) and 16-008(a)-99 (the 90s Line) have been characterized and remediated. Results of the drilling and sampling indicate the extent of contamination has been defined. The remediation of the HE-contaminated soil and tuff at the 30s Line and the chromium VI contaminated soil at the 90s Line were successfully completed. All established target cleanup levels for the HE and chromium VI remediation were met.

A groundwater-monitoring well was developed and will be sampled on a quarterly basis for one year as part of the groundwater monitoring in the Water Canyon/Cañon de Valle watershed, conducted under the annual Interim Facility-Wide Groundwater Monitoring Plan.

The Laboratory will continue to inspect erosion controls installed in the drainages to the 90s Line Pond and collect sediment samples from the 90s Line Pond.

11. Consolidated Unit 16-021(c)-99 (260 Outfall) Corrective Measures Implementation

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.

b. Remediation and Sampling Activities

The Laboratory implemented the corrective measure implementation (CMI) plan in 2009 and completed the plan's remediation and investigation actions in 2010. The CMI characterization and remediation activities included (1) removing the concrete trough outfall adjacent to building 16-260 at the 260 Outfall channel; (2) removing soil and sediment within the former settling pond within the 260 Outfall drainage channel; (3) replacing a low-permeability cap on the former settling pond; (4) removing soil and tuff from the 260 Outfall drainage channel; (5) sampling soil in the Sanitary Wastewater Systems Consolidation (SWSC) Cut of Cañon de Valle; (6) installing surge bed injection grouting within the former settling pond at the 260 Outfall channel; (7) installing carbon filter treatment systems of spring waters at SWSC and Burning Ground Springs in Cañon de Valle and modifying the existing carbon filter at Martin Spring in Martin Spring Canyon; and (8) installing a pilot permeable reactive barrier (PRB) for treatment of HE and barium in Cañon de Valle.

c. Conclusions and Recommendations

The CMI summary report and an addendum were completed and submitted in 2010 (LANL 2010u; LANL 2010v). The summary report presented most of the activities listed above, while the addendum reported the remaining activities, which included excavating soil and tuff and collecting a confirmation sample at the base of the cliff within the 260 Outfall drainage channel and re-sampling sediment for ecotoxicity at the SWSC Cut.

The removal activities and final confirmation sampling at the lower 260 Outfall drainage channel were conducted in April 2010. No potential unacceptable risks exist for the industrial, construction worker, and residential scenarios for the 260 Outfall drainage channel (LANL 2010v).

The SWSC Cut sediment toxicity testing of chironomids was completed in March 2010. The toxicity test results indicated no significant reductions in *Chironomus tentans* survival or growth occurred in the SWSC Cut sediment (LANL 2010v).

To confirm the effectiveness of the CMI characterization and remediation activities, the Laboratory submitted a CMI monitoring plan to NMED (LANL 2010w). The plan is designed to assess the performance of the four CMI treatment systems (a low-permeability cap, injection grouting of the surge bed, carbon filter treatment systems of spring waters, and PRB treatment system in Cañon de Valle) to determine whether the objectives of the treatment systems have been met, and to repair and/or adjust the treatment systems as necessary to ensure maximum effectiveness. The monitoring effectiveness will be evaluated following a one year period of activities.

The structural integrity of the low-permeability cap and surrounding stormwater control structures will be inspected and maintained. One alluvial well was installed in the vicinity of the former settling pond to monitor the performance of surge bed injection grouting within the former settling pond area. Treated spring water discharged from the carbon filter systems will be monitored to assess the performance of the carbon filter systems at SWSC, Burning Ground, and Martin Springs. Multiple upgradient and downgradient alluvial wells and vessel test ports will be monitored to test the effectiveness of the pilot PRB system and the effects of the system on the alluvial water in Cañon de Valle.

Data generated from the monitoring activities will assist the Laboratory and NMED in determining whether the goal of the CMI—to remediate HE and barium in the former settling pond within the 260 Outfall drainage channel and in the alluvial systems of Cañon de Valle and Martin Spring Canyon—has been met.

12. 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. 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

The Laboratory developed a Phase III investigation work plan (LANL 2010x; LANL 2010y), which was subsequently approved by NMED (NMED 2010m). Phase III investigation activities will be conducted to better define the lateral and vertical extent of subsurface VOC and tritium pore gas contamination at MDA C, install two downgradient regional groundwater monitoring wells, and characterize background concentrations of inorganic chemicals detected in dacite rocks. The data collected during the Phase III investigation will be used to support future corrective action decisions for MDA C.

c. Conclusions and Recommendations

Regional aquifer well R-60 was installed downgradient of MDA C. The R-60 borehole was drilled to a total depth of 1418 ft bgs. The primary objective of the R-60 well is to provide hydrogeologic and groundwater data on the regional aquifer below the MDA. Secondary objectives were to collect drill-cutting samples, conduct borehole geophysical logging, and investigate potential perched groundwater zones.

Post-installation activities included well development, aquifer testing, surface completion, geodetic surveying, and installing a dedicated sampling system. Groundwater characterization samples will be collected from the completed well and results will be included in the appropriate periodic monitoring report.

In order to optimize the location, the second regional groundwater monitoring well proposed in the Phase III work plan will be sited and drilled following two rounds of sampling of the new deep vapor wells.

Three of the four new vapor monitoring wells have been installed. The fourth well will be located outside of the MDA C fence and will be installed in early 2011. The borehole cuttings for the two vapor monitoring wells located outside of the fenced area of MDA C will be used to characterize background concentrations of inorganic chemicals detected in dacite rocks. This work should be completed in 2011.

13. Los Alamos and Pueblo Canyons

a. Site Description and History

The portion of the canyon watershed investigated as the Los Alamos and Pueblo Canyons watershed includes Los Alamos, Pueblo, DP, and Acid Canyons (inclusive of the South Fork of Acid Canyon). The Los Alamos and Pueblo Canyons watershed heads on USFS land in the Sierra de los Valles west and northwest of the Laboratory. The watershed extends eastward from the headwaters across the Pajarito Plateau for approximately 30.4 km to the confluence with the Rio Grande.

The Los Alamos and Pueblo Canyons watershed includes several TAs (primarily TA-0, TA-1, TA-2, TA-21, TA-41, TA-45, TA-53, and TA-73) and non-Laboratory sources in the Los Alamos town site, such as roads and other paved areas, application of pesticides in headwater areas in the Santa Fe National Forest and within the town site, and atmospheric fallout of radionuclides. Regardless of the source(s), the contaminants have been dispersed down canyon in sediment, surface water, and alluvial groundwater. Many constituents found naturally or derived from anthropogenic sources were concentrated in ash during the Cerro Grande fire in May 2000 and also were dispersed down canyon.

b. Remediation and Sampling Activities

The geomorphic conditions were surveyed above and below sediment transport mitigation sites in the Los Alamos and Pueblo Canyon watersheds as specified in the approved monitoring plan (LANL 2009e; NMED 2010n). Surveys were conducted at all sediment transport mitigation sites specified in the plan and at the LA-SMA-2 retention basins. These surveys were repeated after the 2010 monsoon season and the results will be presented in a report to NMED in 2011. The report will include estimates of net sediment deposition in each area since the previous surveys and will evaluate if any unintended geomorphic changes have occurred, such as net sediment erosion.

c. Conclusions and Recommendations

Los Alamos and Pueblo Canyons were subject to a series of storm events in August 2010 that resulted in significant damage to some of the sediment control structures and gages installed as part of the mitigation project plan. An interim assessment was conducted to provide documentation of all bank and channel erosion, channel scour or undercutting, and deposition related to the sediment control structures; conduct an evaluation of any newly created flow paths; and determine any other changes that could affect the performance of the structures and monitoring stations. The interim assessment summarizes the impact of the storms and provides a schedule for repairing damages that require interim actions (LANL 2010z).

14. 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 and Threemile Canyons 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 TA-3, TA-8, TA-9, TA-12, TA-15, TA-18, TA-23, TA-27, TA-48, TA-54, TA-55, TA-59, TA-64, and TA-69.

b. Remediation and Sampling Activities

The approved sampling and analysis plan specified that seven active stream channel samples would be collected each year in the Pajarito Canyon watershed, and up to an additional eight fine-grained sediment samples were identified as "contingency" samples to be collected in the event large floods occurred (LANL 2009f). Because no large floods occurred in 2010 in this watershed, the fine-grained contingency samples were not collected. In addition, because no flow was recorded at the E250 stream gage in Pajarito Canyon above NM 4, no samples were collected from the two active stream channel locations below E250. Also, there was insufficient sediment to sample at the lower retention pond in the MDA G-6 drainage. Therefore, a total of four active channel sediment samples were collected in the Pajarito Canyon watershed in 2010.

The bird nest box monitoring plan was revised (LANL 2010aa) and approved (NMED 2010o). Insects collected from occupied nest boxes were analyzed for key chemicals of potential ecological concern (COPECs), as allowed by available sample mass and target detection limits. These samples provide a comparison between reaches close to contaminant sources with relatively high COPEC concentrations. In addition, insect samples were collected from nest boxes on an adjacent mesa in TA-14, which serves as a local reference area. Insects from each reach were composited to increase sample mass before they are submitted to analytical laboratories.

The insects collected from bird nest boxes in the three reaches and the TA-14 reference area had sufficient mass for analyses of metals. In addition, there was sufficient sample mass to analyze the insects collected from one reach for PCBs.

c. Conclusions and Recommendations

The results of the 2010 sediment monitoring in the Pajarito Canyon Watershed are presented and discussed in Chapter 6.

The analytical data indicated elevated cadmium and lead in insects in one reach, which also has higher concentrations in sediment samples than the other reaches sampled for insects (LANL 2010bb). The concentrations of cadmium and lead in insects represent a potential for adverse ecological effects, and their distribution is consistent with a Laboratory source.

Other lines of evidence for evaluating risks to cavity-nesting birds include field measures of nest success. Such studies have not identified any potential for ecological risk in the Pajarito watershed. Overall, the weight-of-evidence indicates that COPECs in the Pajarito reaches do not pose a potential risk to population abundance or persistence and species diversity of avian ground invertivore feeding guild species (LANL 2010bb).

Submission of additional insect samples for analysis of metals, PCBs, and dioxins and furans is proposed. The Laboratory will submit insects collected in 2010 from nest boxes in the upper Pajarito Canyon watershed reaches for these analyses if sufficient sample mass is available (LANL 2010bb). These data and an evaluation of the associated field nest monitoring observations will be reported in 2011, if sufficient sample mass is available.

15. Potrillo and Fence Canyons

a. Site Description and History

Potrillo and Fence Canyons are located within the Water Canyon watershed. The Potrillo Canyon watershed heads on the Pajarito Plateau in TA-15. Potrillo Canyon extends approximately 7.0 mi to Water Canyon, approximately 1.0 mi above the Rio Grande. Fence Canyon is a major tributary to Potrillo Canyon that has its headwaters in TA-36. Its watershed extends approximately 4.0 mi to Potrillo Canyon. The combined watershed of Potrillo and Fence Canyons has a drainage area of 4.5 mi^2, of which 95% is on Laboratory land and 5% is on private land and Los Alamos County land in and adjacent to the community of White Rock.

Releases from SWMUs and AOCs within the Potrillo and Fence watershed have occurred as a result of dispersal from firing sites and related activities in TA-15 and TA-36. These canyons also receive stormwater runoff from roads, parking lots, and other developed areas in these TAs. Previous sampling results from

within these canyons indicated contamination from inorganic chemicals, organic chemicals, and radionuclides.

b. Remediation and Sampling Activities

The sediment investigations focus on characterizing the nature, extent, and concentrations of COPCs in post-1942 sediment deposits in a series of reaches in the Potrillo and Fence watershed. The scope of this investigation included characterization of seven reaches and two additional reaches requested by NMED. Sediment investigations in the Potrillo and Fence watershed included detailed geomorphic characterization and sediment sampling.

The surface water investigations include the presentation and summary of stormwater analyses obtained at one gaging station in Potrillo Canyon, E267, as part of the Laboratory's Environmental Surveillance Program. Stormwater samples have been collected from an additional gage in the Potrillo Canyon watershed, E269, along a tributary east of NM 4. Because this location is not downgradient of any SWMUs or AOCs, the E269 data are not evaluated for potential contamination, although they provide useful information on stormwater composition from a background location.

The investigations of potential shallow groundwater include observations from six boreholes drilled in Potrillo Canyon and one borehole drilled in Fence Canyon. Two of the Potrillo Canyon holes and the Fence Canyon borehole were completed as monitoring wells, but only the Fence Canyon borehole, FCO-1, has been maintained as a monitoring well. A transducer was installed in well FCO-1 in 2008 to measure any transient groundwater, but water levels have remained below the screen since the installation. No shallow groundwater has been observed, and therefore no groundwater samples have been collected from the Potrillo and Fence watershed. Because well FCO-1 has been dry since installation, it was removed from the Interim Facility-Wide Groundwater Monitoring Plan in 2010.

c. Conclusions and Recommendations

The investigation report was submitted to NMED in December 2010 (LANL 2010cc).

Sediment COPCs in Potrillo and Fence Canyons include 14 inorganic chemicals, 24 organic chemicals, and six radionuclides. These COPCs are derived from a variety of sources, including Laboratory SWMUs and AOCs and natural sources such as uncontaminated soil, sediment, and bedrock.

No persistent surface water occurs in Potrillo or Fence Canyons; therefore, surface water does not present potential ecological or human health risks, and no surface water COPCs were identified. Stormwater comparison values were exceeded by aluminum and by gross-alpha radiation in samples from Potrillo Canyon. However, the results represent natural background conditions.

The human health risk assessment for Potrillo and Fence Canyons indicates no unacceptable risks or doses from COPCs in sediment under a recreational scenario. The COPECs identified in the ecological risk screening assessment were compared with results from other watersheds where more detailed biota investigations have been conducted. This comparison indicated concentrations of COPECs in Potrillo and Fence Canyons are not likely to produce adverse ecological impacts, and no additional biota investigations, mitigation, or monitoring is required.

The conditions for sediment are likely to stay the same or improve because of decreases in contaminant concentrations after peak releases; therefore, no further monitoring of sediments is necessary. However, several firing sites in the watershed remain active, and additional releases are possible. SWMUs and AOCs present in the watershed will be characterized as part of the Potrillo and Fence Canyons Aggregate Area investigation. Potential contaminant transport will be monitored under the requirements of the National Pollutant Discharge Elimination System Individual Permit for Stormwater Discharges from certain SWMUs and AOCs at Los Alamos National Laboratory.

C. TA-54 CLOSURE PROGRAM ACCOMPLISHMENTS

1. MDA G

a. Site Description and History

MDA G is located in the east-central portion of the Laboratory at TA-54, Area G, on Mesita del Buey. MDA G is a decommissioned (removed from service) subsurface site established for disposition of low-level waste, certain radioactively contaminated infectious waste, asbestos-contaminated material, and PCBs. The MDA was also used for the retrievable storage of transuranic waste and consists of inactive subsurface units that include 32 pits, 194 shafts, and four trenches. When operations ceased, the remaining capacity of the pits, shafts, and trenches was backfilled with clean, crushed, compacted tuff, and the pits, shafts, and trenches were closed. The disposal shafts were capped with a concrete plug. Portions of the disposal units at MDA G are covered with concrete to allow ongoing waste management activities to be conducted on the surface at Area G. Surface runoff from the site is controlled and discharges into drainages to the north (towards Cañada del Buey) and the south (towards Pajarito Canyon).

b. Remediation and Sampling Activities

The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDA G. The Laboratory reports these monitoring results in periodic monitoring reports.

Groundwater-quality monitoring is conducted in accordance with the annual Interim Facility-Wide Groundwater Monitoring Plan. This monitoring supports the corrective measures process for solid waste management units at TA-54, the Resource Conservation and Recovery Act permit for operating units within TA-54, and DOE regulations. The groundwater monitoring network for TA-54 includes both perched-intermediate and regional wells. The monitoring at TA-54 provides the basis for accurately describing the groundwater conditions beneath TA-54, including MDA G. The monitoring well network at MDA G includes new wells drilled in 2010 that are part of the overall effort to further characterize the groundwater conditions. The TA-54 monitoring network wells, including those specific to MDA G, will continue to be sampled on a quarterly basis, consistent with the Interim Facility-Wide Groundwater Monitoring Plan.

The Laboratory submitted a work plan for the implementation of a supplemental soil vapor extraction (SVE) pilot study (LANL 2009g; LANL 2010dd). NMED approved the work plan in early 2010 (NMED 2010p). The objectives of the supplemental pilot study were (1) to determine the capabilities and optimal design for a full-scale active SVE system at MDA G and (2) to further demonstrate that active SVE has the potential to be an effective part of remediation of hazardous constituents at MDA G. The 2010 SVE pilot test was designed to target the permeable zones identified in the Tshirege Member of the Bandelier Tuff, the contacts between the stratigraphic units, and any permeable layers in the geologic column. It was also designed to assess the ability of major stratigraphic units, such as the Cerro Toledo unit and Otowi Member, to act as either a barrier to contaminant migration or as an effective extraction interval.

c. Conclusions and Recommendations

Data from the groundwater monitoring network around TA-54 show sporadic detections of a variety of contaminants including, most notably, several VOCs. The temporal and spatial nature of the occurrences does not, however, clearly indicate the presence of a discernable plume or a source related to MDA G or other sources at TA-54. The results of the screening and evaluation of the groundwater data indicate that there is no compelling evidence for the presence of contamination from MDA G in wells downgradient of MDA G. The majority of the organic compounds that have been detected are generally associated with the first year of sampling following well completion or redevelopment. These organic compounds are not persistent after the first few rounds of sampling at a well, or they are detected only sporadically and near their respective detection limits.

The supplemental SVE pilot study report was submitted in 2010 (LANL 2010ee). The results of the 2010 SVE pilot test, as well as previous testing at MDAs G and L, further demonstrated that active SVE would be an effective remedial technology for removing VOCs from the subsurface at MDA G.

The Laboratory submitted a second revision of the corrective measure evaluation (CME) report to NMED in 2010 (LANL 2010ff). Technologies were first screened for applicability to MDA G and then combined into corrective measure alternatives. The alternatives were screened against balancing criteria and combined by source area into a recommended alternative. The recommended alternative includes constructing an evapotranspiration cover over the pits and shafts and constructing and operating a soil-vapor extraction system to achieve remedial action objectives. The recommended alternative assumes removing all existing surface structures, including concrete foundations and asphalt, before the selected remedy is implemented.

The recommended alternative meets the remedial action objectives. The remedy selected was based on the ability of the recommended alternative to (1) achieve cleanup objectives in a timely manner, (2) protect human and ecological receptors, (3) control or eliminate the sources of contaminants, (4) control migration of released contaminants, and (5) manage remediation waste in accordance with state and federal regulations.

2. MDA H

a. Site Description and History

MDA H is a 70 ft by 200 ft (0.3-acre) fenced area located within TA-54 on Mesita del Buey, a small mesa that lies between Pajarito Canyon and Cañada del Buey. The MDA consists of nine inactive vertical disposal shafts arranged in a line approximately 15 ft inside the southern fence. Each shaft is cylindrical with a diameter of 6 ft and a depth of 60 ft. When filled to within 6 ft of the surface, the space above the waste in Shafts 1 through 8 was capped with 3 ft of concrete, over which an additional 3 ft of crushed tuff was placed. The space above the waste in Shaft 9 was capped with 6 ft of concrete.

From May 1960 until August 1986, MDA H was the Laboratory's primary disposal area for classified, solid-form waste. Disposal of solid-form waste materials at MDA H was restricted to items or materials that were determined by authorized personnel to be both classified and no longer required for their intended use. Liquids were prohibited from disposal.

b. Remediation and Sampling Activities

The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDA H. The Laboratory reports these monitoring results in periodic monitoring reports.

Groundwater monitoring at the Laboratory is currently conducted in accordance with the annual Interim Facility-Wide Groundwater Monitoring Plan. The monitoring at TA-54 provides the basis for accurately describing the groundwater conditions beneath TA-54, including MDA H. The groundwater monitoring network for TA-54 includes both perched-intermediate and regional wells. The monitoring well network at MDA H includes one new regional well, R-52, drilled in 2010, that is part of the overall effort to further characterize the groundwater conditions.

TA-54 monitoring network wells, including those specific to MDA H, will continue to be sampled on a quarterly basis, consistent with the annual Interim Facility-Wide Groundwater Monitoring Plan.

c. Conclusions and Recommendations

Data from the groundwater monitoring network at TA-54 show sporadic detections of a variety of potential contaminants, including several VOCs, general inorganic chemicals, trace metals, and tritium. The temporal and spatial nature of the occurrences does not, however, clearly indicate the presence of a discernable plume or a source related to MDA H.

In 2010, the Laboratory submitted a CME report for MDA H to NMED (LANL 2010gg). Technologies were screened for applicability to MDA H and then combined into corrective measure alternatives. The alternatives were screened against balancing criteria and combined by source area into a recommended alternative.

The recommended alternative includes constructing an evapotranspiration cover over the shafts and implementing institutional controls to prevent human intrusion. Implementation of the recommended alternative satisfies all remedial action objectives.

3. MDA L

a. Site Description and History

MDA L is located at TA-54 in the east-central portion of the Laboratory on Mesita del Buey, within an 1,100 ft by 3,000 ft (2.5-acre) fenced area known as Area L. MDA L is a decommissioned (removed from service) area established for disposing of nonradiological liquid chemical waste, including containerized and uncontainerized liquid wastes; bulk quantities of treated aqueous waste; batch-treated salt solutions; electroplating wastes, including precipitated heavy metals; and small-batch quantities of treated lithium hydride.

The MDA consists of one inactive subsurface disposal pit (Pit A); three inactive subsurface treatment and disposal impoundments (Impoundments B, C, and D); and 34 inactive disposal shafts (Shafts 1 through 34). When the shafts were filled to within approximately 3 ft of the surface, they were capped with a 3-ft concrete plug. Upon decommissioning, the pit and impoundments were filled and covered with clean, crushed, consolidated tuff.

b. Remediation and Sampling Activities

The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDA L. The Laboratory reports these monitoring results in periodic monitoring reports.

Borehole 54-610786 was drilled and installed with a stainless-steel, pore-gas sampling system to measure the pore-gas plume at MDA L as a replacement for borehole 54-24244. The new borehole is located approximately 17 ft south of borehole 54-24244. Borehole 54-24244 was subsequently abandoned once borehole 54-610786 was completed.

c. Conclusions and Recommendations

The Laboratory submitted a revised CME report to NMED in 2010 (LANL 2010hh). Technologies were first screened for applicability to MDA L and then combined into corrective measure alternatives. The alternatives were screened against balancing criteria and combined by source area into a recommended alternative.

The recommended alternative includes constructing an engineered erosion-resistant vegetative cover over the pit, impoundments, and shafts and constructing and operating an SVE system to achieve remedial action objectives. The recommended alternative assumes removing all existing surface structures, including concrete foundations and asphalt before the selected remedy is implemented.

The recommended alternative meets the remedial action objectives. The remedy selected was based on the ability of the recommended alternative to (1) achieve cleanup objectives in a timely manner; (2) protect human and ecological receptors; (3) control or eliminate the sources of contaminants; (4) control migration of released contaminants; and (5) manage remediation waste in accordance with state and federal regulations. SVE also meets the preference for a remedy that uses treatment.

D. TA-21 CLOSURE PROGRAM ACCOMPLISHMENTS

1. DP Site Aggregate Area

a. Site Description and History

TA-21 is located on Delta Prime (DP) Mesa on the northern boundary of LANL and is immediately east-southeast of the Los Alamos town site. From 1945 to 1978, TA-21 was used primarily for plutonium research and metal production. Since 1978, various administrative and research activities have been conducted at TA-21. The DP Site Aggregate Area includes container storage areas, surface disposal areas, a PCB storage area, septic systems, sumps, drain lines, outfalls, a waste treatment laboratory, a sewage treatment plant, and seepage pits.

b. Remediation and Sampling Activities

Phase II investigation activities were conducted at 19 SWMUs, one AOC, and six consolidated units within the DP Site Aggregate Area. The objectives of the Phase II investigation were to define the nature and extent

of contamination and to determine whether the sites pose potential unacceptable risk or dose to human health or the environment.

The Phase II investigation activities included collecting 226 surface and subsurface soil and tuff samples from 175 locations to define the extent of contamination. Data from the samples collected during the Phase II investigation were combined with data presented in the Phase I investigation report that meet current Laboratory data-quality requirements. Two boreholes were drilled to a depth of 200 ft bgs in the area of diesel tank 21-57, which defined the extent of diesel contamination. Remediation activities at the PCB site removed all material contaminated with 1 mg/kg or greater of total PCBs within 10 ft bgs. Approximately 1,400 yd^3 of PCB-contaminated material were removed and a total of 300 confirmation samples were collected and analyzed for PCBs.

c. Conclusions and Recommendations

The Laboratory submitted the Phase II investigation report (LANL 2010ii) to NMED, which was subsequently revised (LANL 2010jj). The extent of contamination has been defined for 15 sites and has not been defined at 11 sites. The 11 sites at which extent was not defined will be addressed in a Phase III work plan.

Sixteen sites have been determined to pose no potential unacceptable risk or dose to human health or to the environment. Corrective actions are complete for 12 sites. Five sites within the DP Site Aggregate Area were determined to pose potential unacceptable risk or dose to human health, and one site also poses potential risk to ecological receptors. Limited soil removal and confirmation sampling will be conducted at these sites as part of Phase III.

2. American Recovery and Reinvestment Act At TA-21

a. Site Description and History

TA-21 is located on DP Mesa on the northern boundary of LANL and is immediately east-southeast of the Los Alamos town site. In 1945, plutonium research and metal production activities were transferred to the newly built facilities at TA-21.

b. Remediation and Sampling Activities

The Laboratory received $212 million for environmental cleanup projects as part of the American Recovery and Reinvestment Act of 2009. The Laboratory's Recovery Act projects include the following:

- Decontamination and demolition of 24 buildings at TA-21;
- Removal and remediation of early Laboratory waste from MDA B; and
- Installation of 16 groundwater monitoring wells.

c. Conclusions and Recommendations

The status of the Recovery Act projects as of January 2011 is as follows:

- The D&D and subsequent demolition of 24 buildings at TA-21 has been completed. The last building was demolished in December 2010.
- The excavation activities at the MDA B site commenced on June 30, 2010 (see below). The objective is to remediate the site to residential cleanup levels.
- The installation of 16 groundwater monitoring wells has been completed. The wells range in depth from 850 feet to 1,400 feet. Six existing wells were plugged and abandoned.

3. MDA B

a. Site Description and History

MDA B is an inactive subsurface disposal site that occupies approximately six acres. The site runs along the fence line on DP Road and is located about 1,600 ft east of the intersection of DP Road and Trinity Drive. MDA B consists of several disposal trenches approximately 300 ft long, 15 ft wide, and 12 ft deep and

includes at least one smaller, shallower trench on the eastern end of the site. From 1944 until it closed in 1948, MDA B received process wastes from operations within TA-21 at DP East and DP West. The wastes disposed of at MDA B were highly heterogeneous, primarily radioactively contaminated laboratory wastes and debris, and limited liquid chemical waste. MDA B will be completely excavated.

b. Remediation and Sampling Activities

Excavation activities at MDA B commenced on June 30, 2010. Remediation activities included the removal of an asphalt cover that was present over 75% of MDA B and removal of soil overburden from the east end of MDA B. MDA B was split into a grid of cells, each measuring 10 ft long by 10 ft wide. Remedial action progress through December 2010 included excavation of 201 grid cells. Excavation operations generally consisted of overburden removal, contaminated soil and waste removal, and confirmation sampling.

Seventeen confirmation samples were collected from the four enclosures. Additional excavation was conducted and additional confirmation samples were collected in locations where results exceeded residential soil screening levels (SSLs) for chemicals or residential screening action levels (SALs) for radionuclides. Approximately 7,265 yd^3 and 388 yd^3 of waste and overburden, respectively, have been removed from MDA B.

Eight air-monitoring network (AIRNET) stations are located along the northern boundary of MDA B. Each AIRNET station collects airborne radionuclides, such as plutonium, americium, and uranium, on a particulate filter and a water vapor sample (for measuring tritium) in a silica gel cartridge. The particulate filters and silica gel cartridges are changed every 2 weeks, and the sample media are sent to a commercial laboratory for analysis using U.S. Environmental Protection Agency (EPA) approved methods. Each calendar quarter, six or seven of the biweekly filters from a given station are assembled into a single composite sample and prepared for isotopic analysis by dissolution and radiochemical separation techniques. Annual emissions reporting and compliance evaluations for a station are based on the sum of the four quarterly composite samples (for particulate matter) and the sum of biweekly tritium analyses.

c. Conclusions and Recommendations

Nine exploratory trenches were excavated in 2010 to determine whether waste was present in Areas 9 and 10. The investigation activities concluded that no waste was buried in Areas 9 and 10 (LANL 2010kk). As a result, remediation and further investigation are not required for Areas 9 and 10 of MDA B, not only because no operational waste was found buried there, but because soil and fill in those areas do not contain contaminants that exceed residential screening levels.

The 17 confirmation samples collected from four of the enclosures had no detected concentrations of organic chemicals that exceeded residential SSLs (LANL 2010ll). Two of the seven confirmation samples from enclosure 3 had arsenic results exceeding residential SSLs, but all other inorganic and organic chemical results from those samples were below SSLs, and all the radionuclide results from those samples were below residential SALs (LANL 2010ll). One of three confirmation samples from enclosure 1 had plutonium-239/240 results that exceeded residential SALs; thus additional excavation was conducted and four additional confirmation samples were collected at various depths within that grid cell. None of the subsequent results exceeded the residential SSLs or SALs (LANL 2010ll). The SAL for plutonium-239/240 was also exceeded in the one confirmation sample collected from the bottom of the trench in enclosure 2. No additional tuff removal is planned because excavation in that trench has reached a depth at which continued excavation is impractical (LANL 2010ll). Three confirmation samples were collected from the trench in enclosure 7. The SAL for plutonium-239/240 was exceeded in the sample collected from the bottom of the enclosure 7 trench; excavation will continue to deeper levels (LANL 2010kk). No other confirmation sample results exceeded SSLs or SALs. No confirmation samples have been collected from the trench in enclosure 12 to date.

Air sampling along the northern boundary of MDA B indicated a maximum dose of 0.9 mrem to the public for 2010. These measurements are significantly lower than the EPA air pathway limit of 10 mrem per year.

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, and 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 LANL Quality Management Plan establishes the principles, requirements, and practices necessary to implement an effective quality assurance program.

The use of a graded approach in accordance with DOE Order 414.1C 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 of sample collection activities is maintained through the rigorous use of carefully documented procedures that govern all aspects of these activities. These procedures are reviewed on a regular basis and updated as required to ensure up-to-date processes are used.

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-cleaned sampling containers in a secure and clean area for shipment. The Laboratory delivers samples to analytical laboratories under full chain-of-custody, including secure FedEx shipment to all external vendors, and tracks the samples at all stages of their collection and analysis.

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A. INTRODUCTION

Subsurface vapor (pore gas) monitoring is currently implemented as part of corrective action investigations at Los Alamos National Laboratory (LANL). Vapor monitoring is conducted beneath and surrounding several historic material disposal areas (MDAs) at the Laboratory. The data collected from vapor monitoring wells is used to help characterize the nature and extent of volatile organic compounds (VOCs) and tritium in the vadose zone. Analysis of pore gas also assists in evaluating whether VOCs and tritium may be a potential threat to the groundwater.

Periodic monitoring of pore gas was required in 2010 by the New Mexico Environment Department (NMED) Order on Consent (Consent Order) at MDAs H, G, L, T, and V (Figure 10-1). The results of the pore gas sampling are provided in periodic monitoring reports (PMRs) submitted to the NMED on a quarterly or annual basis as required by the Consent Order. In addition, pore gas monitoring was conducted at MDA C for investigation purposes (Figure 10-1). The analytical data are also available on the online Risk Analysis, Communication, Evaluation and Reduction (RACER) Data Analysis Tool (http://www.racernm.com) and the Los Alamos National Laboratory's electronic public reading room (http://eprr.lanl.gov/oppie/service).

Because no regulatory criteria currently exist for vapor-phase contaminants in soil, LANL evaluates VOC pore gas data for the potential to contaminate groundwater above standards. A Tier I screening analysis is routinely presented in the vapor PMRs; the analysis evaluates the pore water concentration that would be in equilibrium with the maximum pore gas concentration of each VOC detected at a given site. The equilibrium relationship between pore gas and water concentrations is explained in the various PMRs for vapor sampling (LANL 2010a; LANL 2010b; LANL 2011c). The Tier I screening value (SV) is the ratio of the measured VOC pore gas concentration to the concentration corresponding to that VOC's groundwater standard; if the SV exceeds 1, the VOC may have the potential to impact groundwater. This Tier I screening process yields conservative SVs because the maximum vapor concentrations are located in the unsaturated zone several hundred feet above the regional groundwater at each of the MDAs. In addition, the screening evaluation does not account for aquifer dilution.

In the Corrective Measures Evaluation (CME) reports for MDAs G and L, a Tier II screening process was developed (LANL 2010d; LANL 2010e). The Tier II screening accounts for migration of VOCs through the unsaturated zone to the regional aquifer and subsequent dilution within the aquifer to provide a more realistic estimate of the potential impact that the vapor plume may ultimately have on groundwater. The calculated groundwater concentrations are compared with groundwater standards to produce a more realistic prediction of the potential for the vapor-phase VOCs to impact groundwater. Additional analysis was included in the CME reports for those constituents that exceeded the Tier II screening limits.

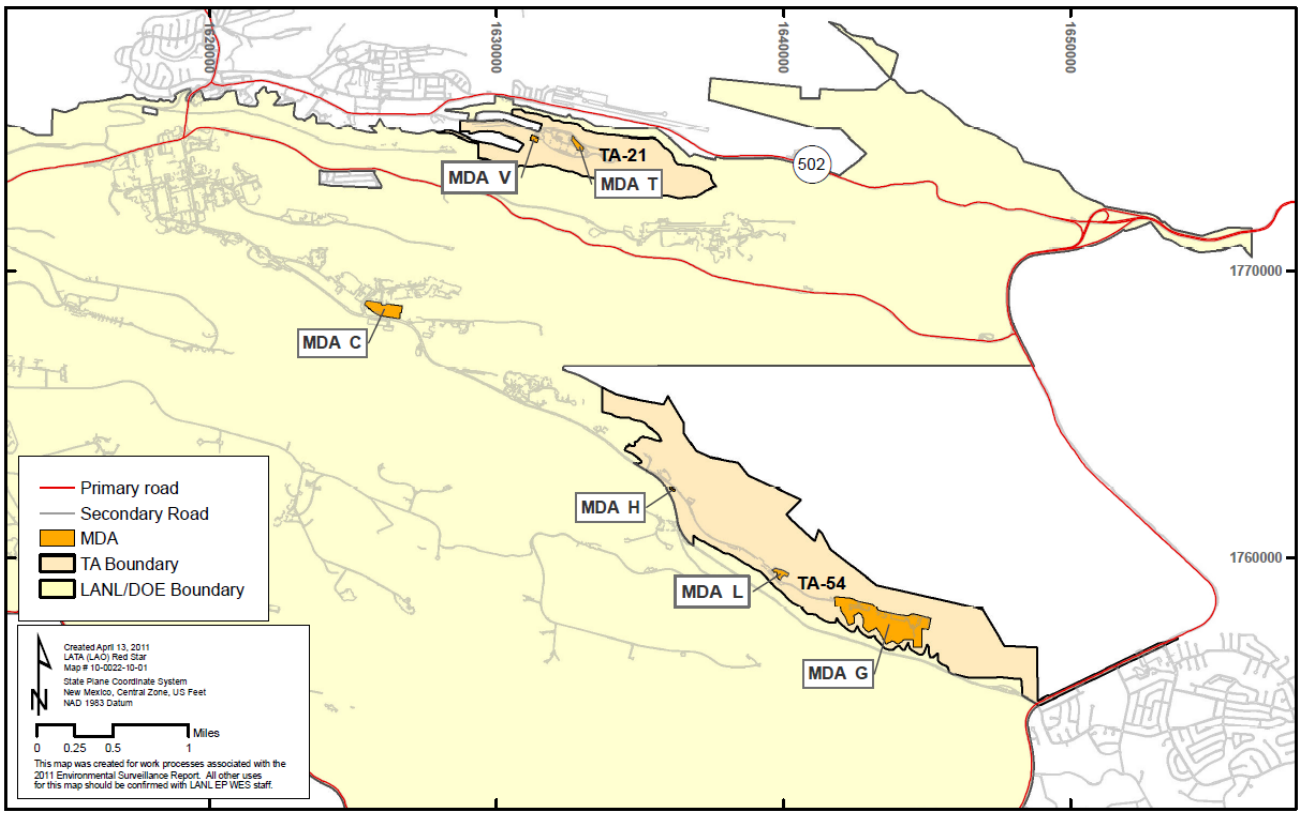

Figure 10-1 Location of MDAs where subsurface vapor monitoring was performed in 2010

B. FIELD SCREENING AND SAMPLING

Vapor monitoring during 2010 consisted of field screening and sample collection. Field screening included purging a specific sample interval, isolated at depth, within a vapor monitoring well with a gas monitor until pore gas concentrations stabilize, signifying that subsurface air was being collected. In addition to purging, VOC field screening included obtaining field measurements of organic vapors using a photoionization detector at MDAs H, L and G. A Breül and Krajer multi-gas analyzer was also used at MDA L and G that estimated several VOC concentrations at more wells and depths than were sampled and submitted for laboratory analysis.

Sample collection was carried out using one of three different sampling systems. VOC and tritium samples were collected with stainless steel tubing, down-hole packers, or a Flexible Liner Underground Technologies (FLUTe) sampling system. Each system is capable of isolating a specific depth interval from which pore gas is collected by applying a vacuum at the receiving end. VOC samples were collected in "SUMMA" canisters that capture and contain the air sample for transport to the analytical laboratory for analysis. Tritium samples were obtained by capturing subsurface water vapor in silica gel cartridges.

The analytical laboratory analyzed vapor samples according to U.S. Environmental Protection Agency (EPA) Method TO-15 for VOCs and EPA Method 906.0 for tritium.

C. FACILITY MONITORING

Table 10-1 includes the number of vapor monitoring wells, number of depth intervals sampled and/or field screened, type of sampling systems implemented, and the depth to groundwater at each MDA during the 2010 monitoring period. Vapor-monitoring wells and sampled depth intervals are determined by NMED-approved work plans.

Table 10-1
Vapor Monitoring Locations

Material Disposal Area	Number of Vapor Monitoring Wells	Number of Sampling Intervals	Type of Sampling System[a]	Approximate Depth to Groundwater[b] (ft bgs)
C	14	129	F/SS	1,182
G	21	39	SS/P	930
H	4	28	SS	1,040
L	25	86	SS/P	950
T	5	34	SS	1,300
V	1	9	SS/P	1,300

[a] SS = stainless steel, P = Packer, F = FLUTe

[b] Based on nearest groundwater monitoring well

VOC and tritium data analyses are discussed below and in other Laboratory reports available on the LANL public Website (http://www.lanl.gov/environment/all/reports.shtml/).

D. ANALYTIC DATA COMPARISON AND TRENDS

At MDAs G, H, and L vapor monitoring has been required for several years, and consequently a large data set exists. The data provide information on the nature and extent of subsurface VOC and tritium contamination. In 2010, contour views of the VOC vapor plumes under MDAs G and L were developed as part of the CME reports (LANL 2010d; LANL 2010e). At MDAs T and V, preliminary plots help to determine data trends. Data collection at MDA C has recently started; however, no comparison or trending was completed in 2010. Analyses of the data will be included in the Phase III investigation report for MDA C to be submitted to NMED in June 2011. Table 10-2 lists the VOCs for which the SVs exceeded 1 during 2010 for MDAs G, L, and T using the Tier I screening analysis. The maximum Tier I SVs calculated for these VOCs are also listed. Table 10-2 also indicates the VOCs at MDAs G and L that exceeded the more realistic Tier II screening analyses performed in the CME reports. SVs were not exceeded for VOCs at MDA H in 2010. Only tritium samples were collected at MDA V; thus, the Tier I screening evaluation does not apply.

Table 10-2
VOCs that Exceeded Tier I and Tier II Screening Values during 2010

Location	VOC	Maximum Pore Gas Concentration ($\mu g/m^3$)	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard ($\mu g/m^3$)	Tier I Screening Value (unitless)
MDA G	Dichloroethane[1,1-]	35,000	5,750	6.1
	Dichloroethane[1,2-]	340	240	1.4
	Dichloroethene[1,1-]*	33,000	5,500	6
	Dichloroethene[cis-1,2-]	46,000	11,900	3.9
	Methylene chloride	1,900	650	2.9
	PCE*	220,000	3,600	61
	1,1,1-TCA*	720,000	42,300	17
	1,1,2-TCA	600	170	3.5
	TCE*	1,600,000	2,000	800

Table 10-2 (continued)

Location	VOC	Maximum Pore Gas Concentration (µg/m³)	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard (µg/m³)	Tier I Screening Value (unitless)
MDA L	Benzene	4,400	1,140	3.86
	Carbon tetrachloride	19,000	5,500	3.45
	Chloroform	82,000	15,000	5.47
	Dichloroethane [1,1-]	94,000	5,750	16.4
	Dichloroethane [1,2-]*	740,000	240	3,083
	Dichloroethene [1,1-]*	130,000	5,500	23.6
	Dichloropropane [1,2-]*	400,000	600	666
	Dioxane [1,4-]	6,700	12.2	548
	Methylene chloride*	240,000	650	369
	PCE*	780,000	3,600	217
	1,1,1-TCA*	3,900,000	42,300	92.2
	1,1,2-TCA	2,100	170	12.4
	TCE*	1,300,000	2,000	650
MDA T	Methylene chloride	3,100	650	4.77
	PCE	3,700	3,600	1.03
	1,1,2-TCA	240	170	1.41

*Denotes the VOC exceeded the Tier II screening limits; analysis performed for MDAs G and L only.

Mass estimates of VOCs were also calculated for the CMEs at MDA G, H, and L in 2010 (LANL 2010d; LANL 2010e; LANL 2010f). The data used for these calculations are from 2009 and 2010. The following sections summarize these data as well as discuss data trends and comparisons.

1. MDA G

Figure 10-2 illustrates the 20 vapor monitoring wells sampled at MDA G during 2010. MDA G is currently sampled on an annual basis. Subsurface vapor monitoring data has been collected since 1985. Vapor monitoring data collected indicate VOCs are present in the subsurface. The screening evaluation identified nine VOCs above a Tier I SV of 1 and four VOCs that exceeded the more realistic Tier II screening limits at MDA G in 2010 (Table 10-2).

Trichloroethane-1,1,1 (TCA) and trichloroethene (TCE) are two VOCs of particular interest due to the consistency in detected concentrations and because their concentrations consistently exceed Tier II screening limits. As part of the MDA G CME (LANL 2010d) submitted to NMED in November 2010, contour views of the VOC plumes for both TCA and TCE were interpolated and are presented in Figures 10-3 and 10-4, respectively. These plots are based on data collected in August and September, 2009, because the 2010 data were not yet available for that evaluation. The extent of each VOC plume is defined by contour lines that represent multiples of (10 to 30 times) the TCA and TCE Tier I screening levels of 42,3000 µg/m^3 and 2,000 µg/m^3, respectively (Table 10-2). These contour lines reflect the extent of the different plumes in terms of their potential risk to groundwater rather than as absolute concentrations. An east-west cross section was developed for the same contaminants and presented in Figures 10-3 and 10-4. The concentration contours identified two plumes for TCA and three plumes for TCE at MDA G. The plumes are associated with disposal pits and shafts that contain wastes where VOCs are a secondary component of the waste, rather than a primary waste form. These areas are considered to be potentially ongoing sources of VOC vapors.

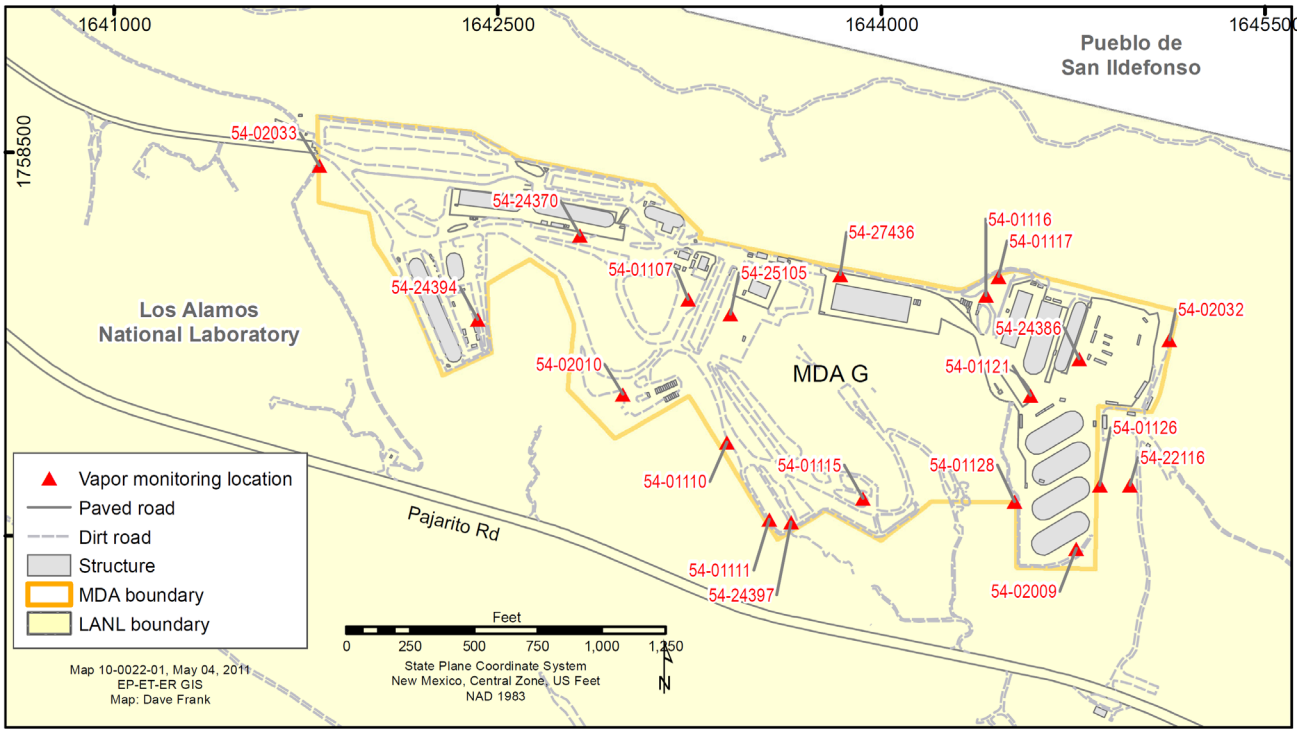

Figure 10-2 MDA G vapor monitoring wells

The estimated masses of TCA and TCE are 210 kg and 79 kg, respectively (LANL 2010g). These estimates are for mass contained within the areas defined by 10 times the respective Tier I SVs. These estimates account for mass in the vapor phase, dissolved phase, and adsorbed to solids. The analysis indicates the majority of the mass to be TCA. In addition, most of the mass is contained within the Bandelier Tuff as indicated by the vertical extent shown in Figures 10-3 and 10-4. However, there is uncertainty related to the long-term transport of VOC vapors to groundwater through the fractured basalts that are present beneath the tuff units at MDA G, and therefore, corrective measures related to VOCs were recommended as a precautionary measure in the MDA G CME (LANL 2010g).

Tritium activity is also detected in vapor samples collected at MDA G. MDA G contains the highest detected tritium activities in pore gas observed at Laboratory with a maximum in 2010 of 486,635,000 pCi/L. Reported activities have been similar during each annual sampling event, and the greatest activities are consistently reported in vapor monitoring well 54-01111 (Figure 10-2), which is located near the tritium disposal shafts in the south-central portion of MDA G.

2. MDA H

Figure 10-5 illustrates the four vapor monitoring wells sampled at MDA H during 2010. Vapor monitoring is currently conducted on a quarterly basis at MDA H. Subsurface vapor monitoring data has been collected since 2005. Vapor monitoring data indicate that VOC concentrations are low and frequently reported as not detected. No VOC concentrations exceeded Tier I screening values during 2010.

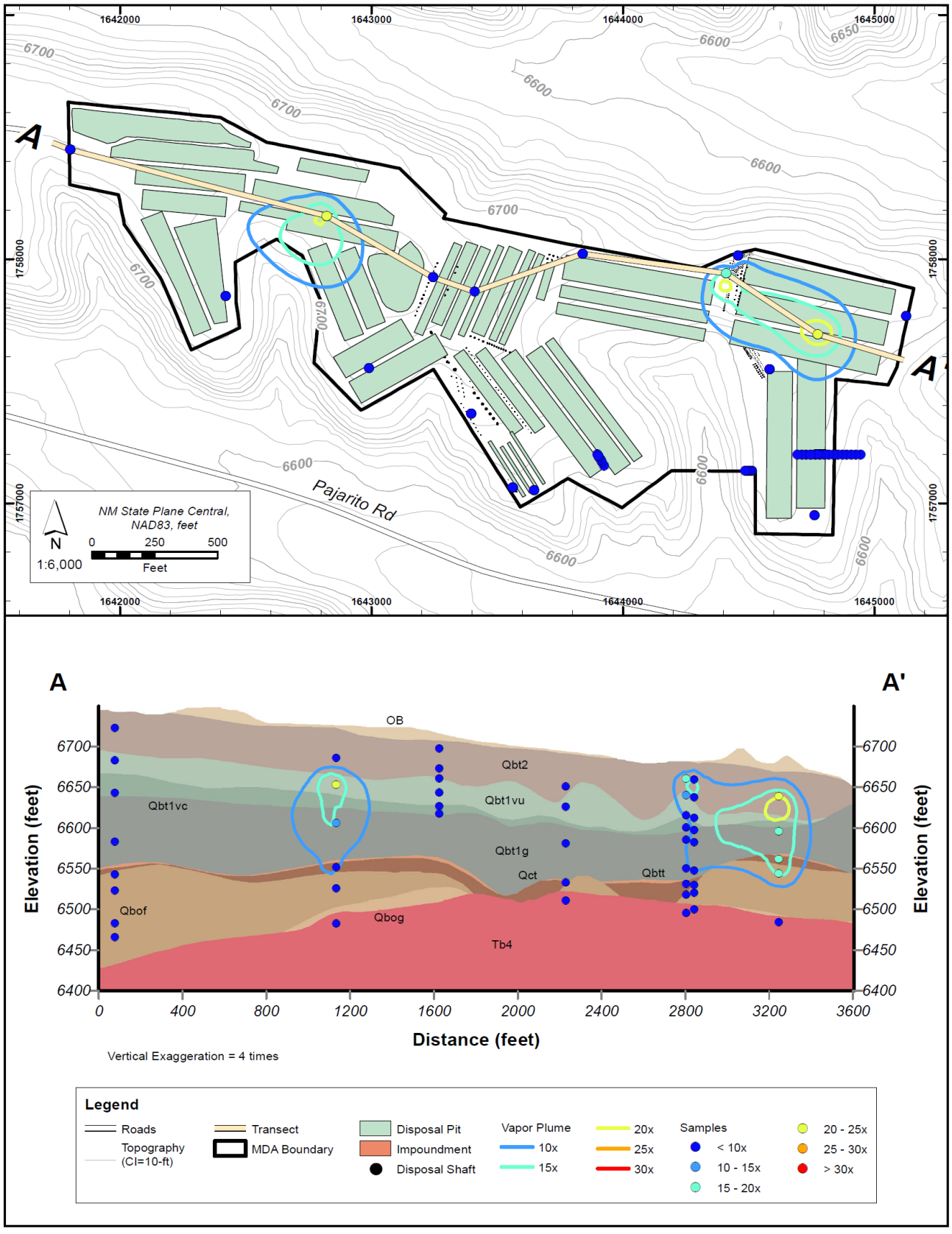

Figure 10-3 **Interpolated vapor plumes with cross section at MDA G for 1,1,1-TCA, based on 2009 data. Contour lines show concentration levels that are multiples of (10 to 30 times) the 1,1,1-TCA screening concentration.**

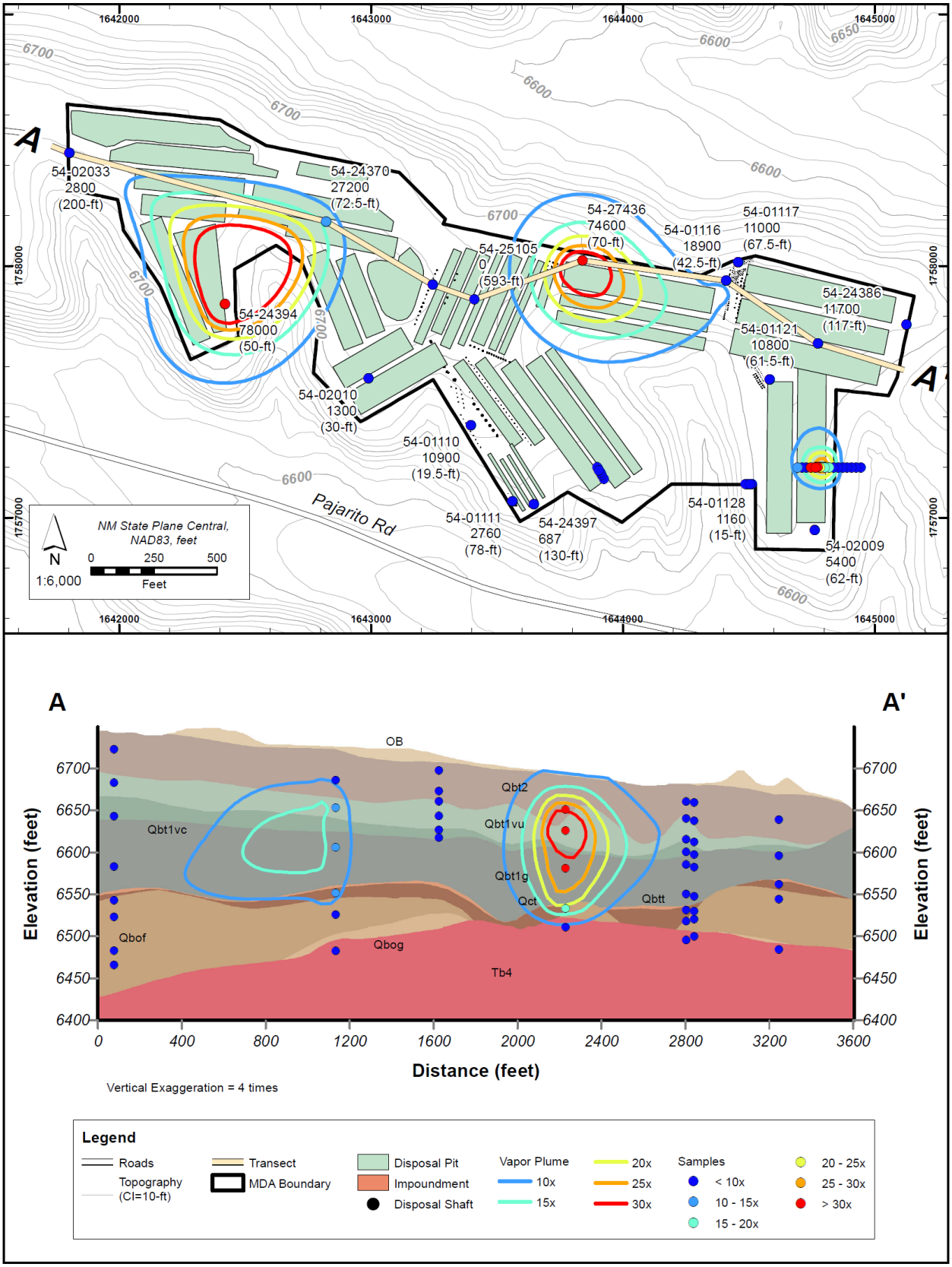

Figure 10-4 **Interpolated vapor plumes with cross section at MDA G for TCE, based on 2009 data. Contour lines show concentration levels that are multiples of (10 to 30 times) the TCE screening concentration.**

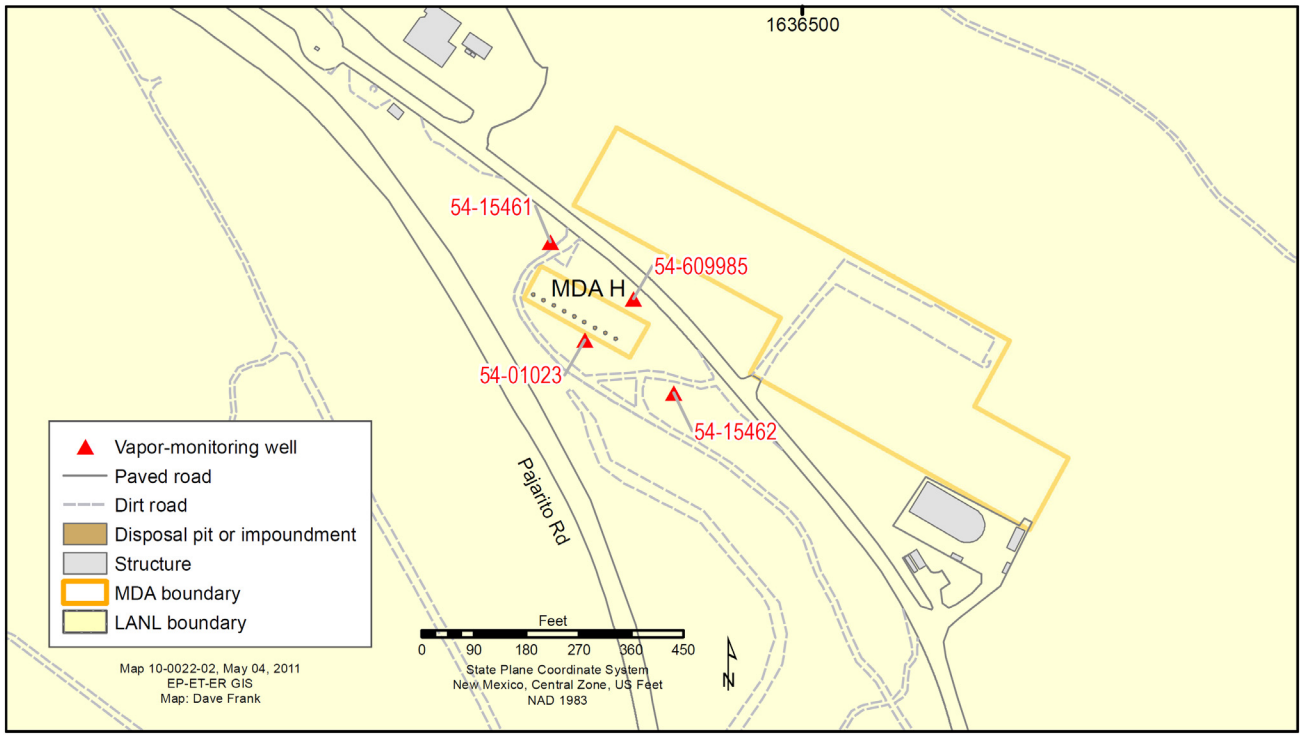

Figure 10-5 MDA H vapor monitoring wells

The MDA H CME (LANL 2010f) was submitted to NMED in December 2010. No VOC plume contours were created because reported VOC concentrations were very low or not detected, and no appreciable plume could be interpolated. Bulk estimates of VOC masses, however, were calculated based on an estimated volume of subsurface soil. The estimates were used to quantify the mass in the vapor phase, dissolved phase, and adsorbed to solids. The total VOC mass for all constituents detected at MDA H during vapor monitoring is estimated to be less than 2 kg; most of this mass is associated with alcohols and ketones (e.g., butanol and acetone) (LANL 2010f). Halogenated VOCs (e.g., TCA and TCE), which are generally of the most concern because of their potential to contaminate groundwater, comprise less than 5% of the total estimated mass (approximately 0.1 kg). This low estimate is consistent with the known sources of VOCs at MDA H, which does not include bulk chemical wastes. Based on the CME, VOCs measured in subsurface vapor at MDA H do not pose a potential threat to groundwater (LANL 2010f).

Tritium activity is also detected in vapor samples collected at MDA H. Reported activities are similar for each sampling event, and the greatest activities are consistently reported in vapor monitoring well 54-01023. The maximum activity reported during 2010 was 5,070,000 pCi/L in vapor monitoring well 54-01023.

3. MDA L

Figure 10-6 illustrates the 25 vapor monitoring wells sampled at MDA L during 2010. Vapor monitoring is currently conducted on a quarterly basis at MDA L. Subsurface vapor monitoring data has been collected since 1985. Vapor monitoring data show that MDA L contains the highest concentrations of VOCs in pore gas at the Laboratory. The screening evaluation identified 13 VOCs that exceeded a Tier I SV of 1 during 2010 and seven VOCs that exceeded the Tier II screening limits (Table 10-2). During 2010, six VOCs (1,2-dichloroethane, 1,2-dichloropropane, methylene chloride, tetrachloroethene [PCE], TCA, and TCE) were of particular interest due to the consistency in detected concentrations over time and because concentrations exceed Tier II limits. Vapor concentration data for each of the six VOCs were interpolated and are presented as contour plots in Figure 10-7 (LANL 2010e). The contour lines represent multiples of (50 times or 100 times) each constituent's Tier I screening level (see column 4 in Table 10-2 for the Tier I vapor screening level concentration of each VOC). These contour lines reflect the extent of the different plumes in terms of its potential risk to groundwater rather than as an absolute concentration. An east-west cross section for the

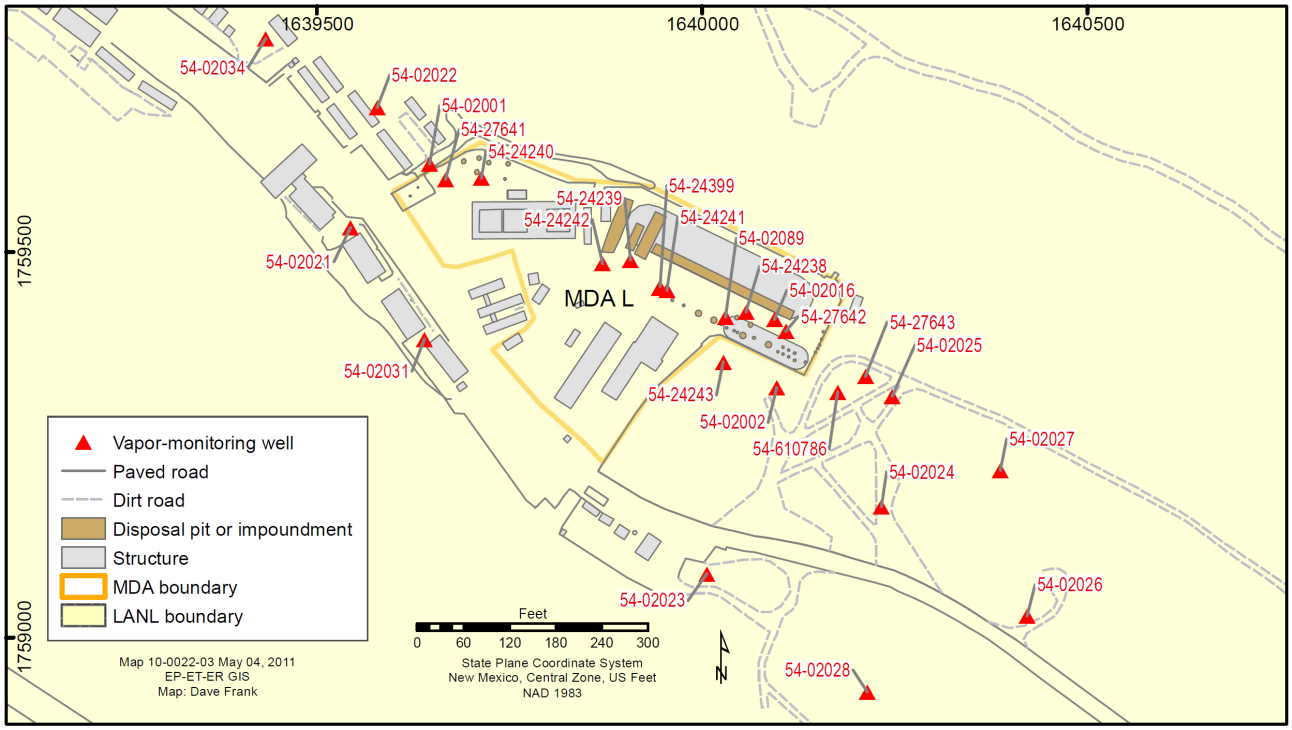

Figure 10-6 MDA L vapor monitoring wells

same VOCs is also presented in Figure 10-7. This cross section illustrates that the plumes are located within the upper 200 ft bgs; the regional aquifer is well below the plume at approximately 950 ft bgs. TCA and 1, 2-dichloroethane have the greatest lateral extent based on concentration contours representing 100 times their respective SVs (Figures 10-7). Additional information on the methodology used to develop contour views is available in Appendix B of the MDA L CME (LANL 2010e).

Mass estimates were calculated for TCA and TCE as part of the 2010 CME. The estimated masses of TCA and TCE are 428 kg and 245 kg, respectively. These two constituents are the dominant VOCs within the vapor plume at MDA L, making up more than 75% of the plume. Mass estimates were not calculated for the other four VOCs of interest. The estimated TCA and TCE contaminant masses are contained within areas defined by 10 times their respective SVs. Data for the TCA vapor plume at MDA L has been studied for over a decade, and the extent and concentrations within the plume are quite stable (Stauffer et al., 2005). However, because VOC concentrations substantially exceed Tier II screening limits at MDA L and because there is some uncertainty related to the transport of these vapors through the fractured basalts that are present beneath the tuff units at MDA L toward groundwater, corrective actions related to VOCs were recommended as a precautionary measure in the MDA L CME (LANL, 2010e).

Reported tritium activities in vapor samples collected at MDA L during 2010 were similar to previous year's data. Tritium is detected at various shallow depths in several vapor monitoring wells; however, most activities are relatively low compared to other sites (< 10,000 pCi/L). The highest tritium activities reported are in vapor monitoring well 54-24243 with a maximum activity reported in 2010 of 478,830 pCi/L.

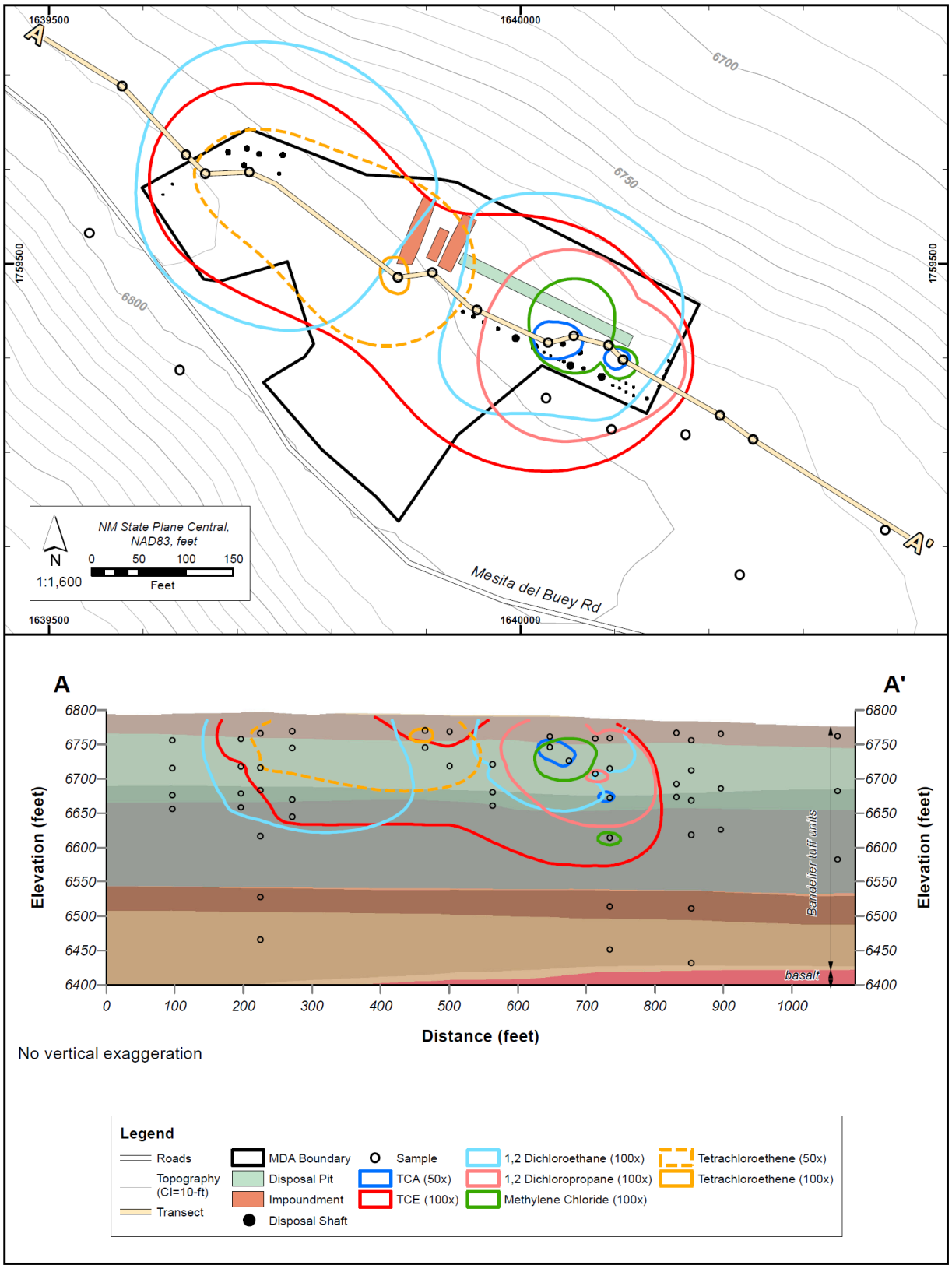

Figure 10-7 **Extent of VOC plume thresholds with cross section within the Bandelier Tuff at MDA L. VOCs include 1,2-dichloroethane; 1,2-dichloropropane; methylene chloride; PCE; TCA; and TCE. Contour lines show concentration levels that are multiples of (50 times or 100 times) each constituent's Tier I screening level.**

4. MDA T

Figure 10-8 illustrates the five vapor monitoring wells sampled at MDA T during 2010. Vapor monitoring is currently conducted on a quarterly basis at MDA T. Vapor monitoring data indicate that VOCs are present in the subsurface at MDA T. Three VOCs (methylene chloride, PCE, and 1,1,2-trichloroethane) exceed the Tier I screening values during 2010 (Table 10-2). PCE exceeds a Tier I SV of 1 in only one sample during 2010 while methylene chloride and 1,1,2-trichloroethane both exceeded an SV of 1 several times. The greatest Tier I SV reported at MDA T during 2010 was for methylene chloride with an SV of 4.77 (Table 10-2). Plots of concentrations versus depth are presented in the quarterly PMRs for the deeper vapor monitoring wells (locations 21-25262 and 21-607955) at MDA T to assist in evaluating trends. Plots for methylene chloride are presented in Figure 10-9. These plots indicate that methylene chloride concentrations consistently peak at a single depth; approximately 356 ft bgs in vapor monitoring well 21-607955 and 575 ft bgs in vapor monitoring well 21-25262. The data also indicate that concentrations decrease with depth. Current vapor data do not indicate a potential threat to groundwater; however, additional detailed data analysis and a Tier II screening analysis will be presented for the MDA T CME report.

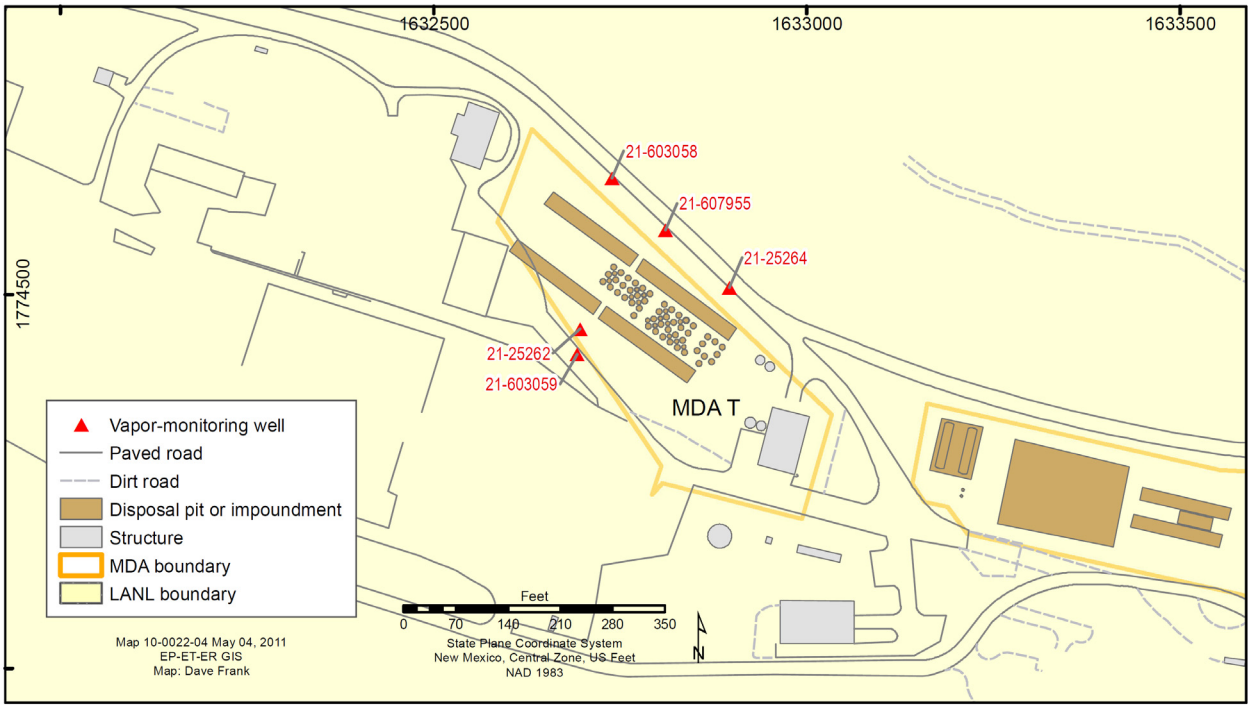

Figure 10-8 MDA T vapor monitoring wells

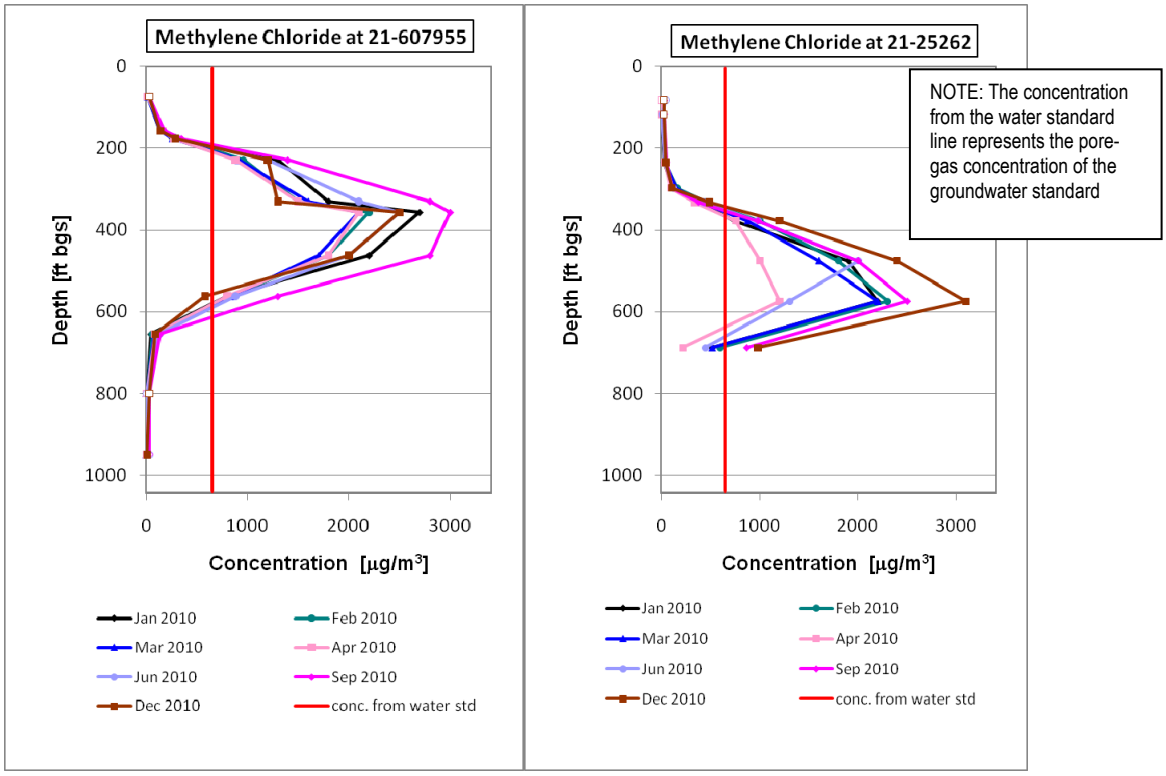

Figure 10-9 Vertical profiles of methylene chloride in vapor-monitoring wells 21-607955 and 21-25262 at MDA T

Tritium activity is detected in vapor samples collected at MDA T. Reported activities from each sampling event are similar, and the greatest activities are consistently reported in vapor monitoring well 21-25264. The maximum activity reported during 2010 was 191,460 pCi/L in vapor monitoring well 21-25264. Like methylene chloride, tritium activity peaks at a single depth (378 ft bgs) in vapor monitoring well 21-25262. In vapor monitoring well 21-607955, tritium activity generally peaks at a shallower depth of 156 ft bgs (Figure 10-10). Tritium data will be evaluated further in the MDA T CME report. In addition, results of monitoring for VOCs and tritium in nearby groundwater wells will be included in the CME report.

5. MDA V

LANL completed characterization and remediation activities at MDA V in 2005 related to potential contamination from both hazardous and radioactive chemicals. The activities included the removal of the absorption beds and contaminated soil. However, the extent of tritium in pore gas was not determined during characterization, thus continued monitoring for tritium in pore gas was required. A two part deep vapor monitoring well, 21-24524W and 21-24524S, collectively known as well 21-24524, were completed to assist in defining extent, and vapor monitoring has been ongoing for three years. Figure 10-11 illustrates the two wells sampled at MDA V and indicates where the absorption beds once existed. Figure 10-12 illustrates the last four quarters of tritium activity in pore gas in monitoring well 21-24524. The plot shows a consistent, prominent peak activity near 300 ft bgs. This peak may be attributed to the subsurface geologic feature known as the Tsankawi pumice bed. The higher permeability and porosity and lack of fractures in this bed compared with the units in the upper unsaturated zone may have created an effective geologic control on the downward transport of liquid following disposal operations at MDA V (LANL, 2011h).

Vapor monitoring for tritium continues on a quarterly basis. LANL requested and received certificates of completion from NMED for MDA V in 2010. Subsurface vapor monitoring is schedule to continue on a quarterly basis at vapor monitoring well 21-24524 until remediation activities are completed at nearby MDA B.

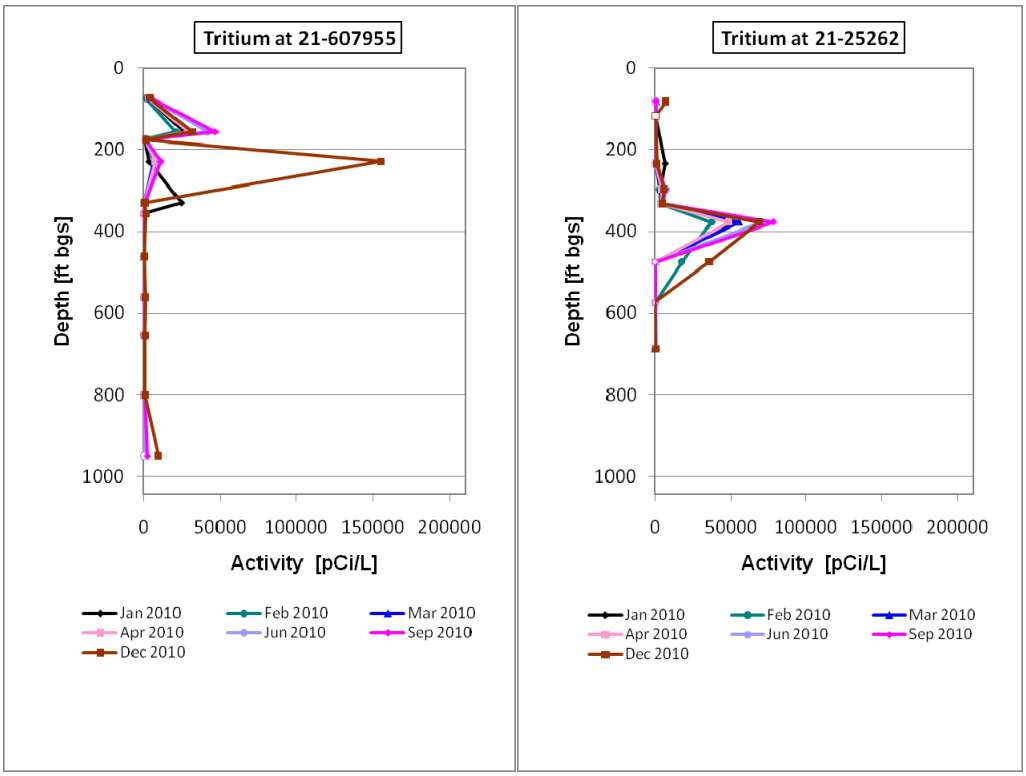

Figure 10-10 Vertical profiles of tritium in vapor-monitoring wells 21-607955 and 21-25262 at MDA T

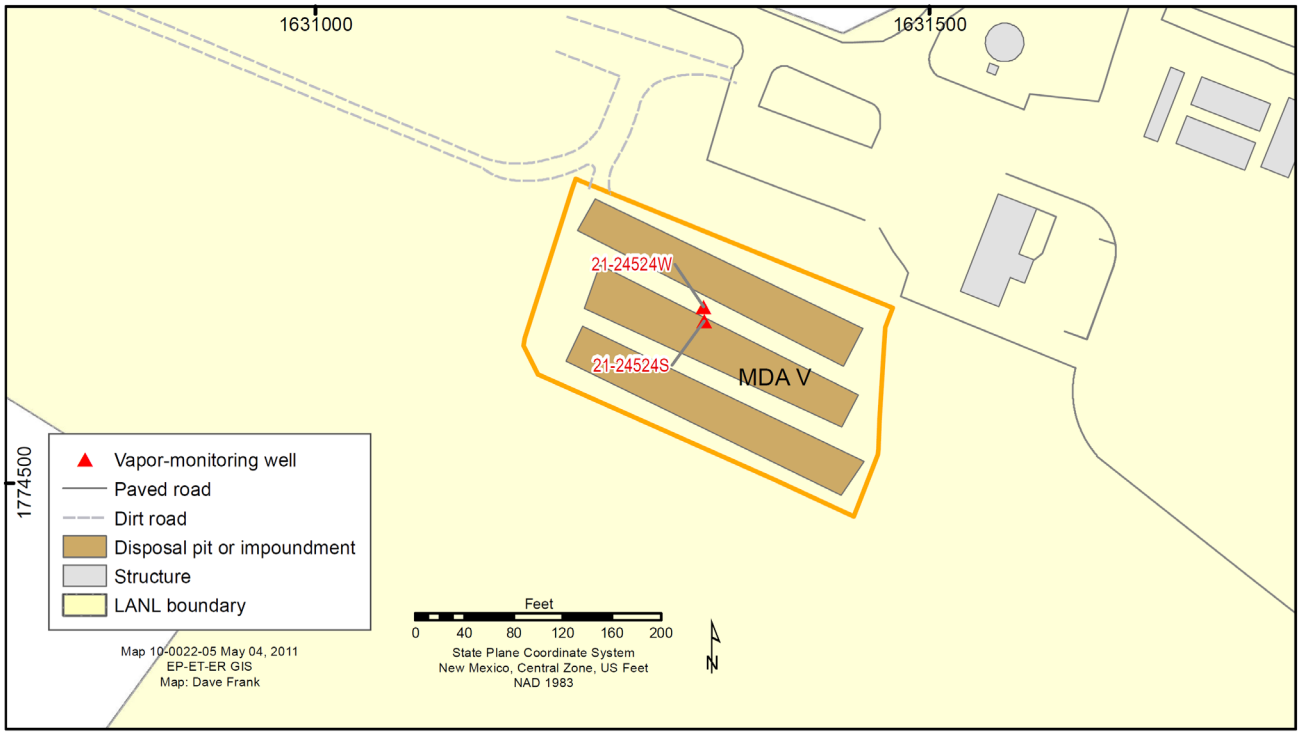

Figure 10-11 MDA V vapor monitoring wells

E. SUMMARY

Vapor (pore gas) monitoring is an important method for evaluating subsurface contamination of VOCs and tritium. Monitoring data has been used to determine the nature and extent of VOCs and the associated vapor plumes as well as to estimate masses of VOCs in the vadose zone. Similarly, monitoring data has been used to help determine the nature and extent of tritium contamination. These data have assisted in determining whether corrective measures are warranted at MDAs L and G to decrease subsurface vapor concentrations. In addition, analysis of subsurface VOC data from MDAs H and T indicate that VOCs do not pose a potential threat to groundwater; however, additional detailed data analyses will be presented for MDA T in the CME report. Because corrective actions have been completed at MDA V, LANL will request corrective action complete without controls for this site.

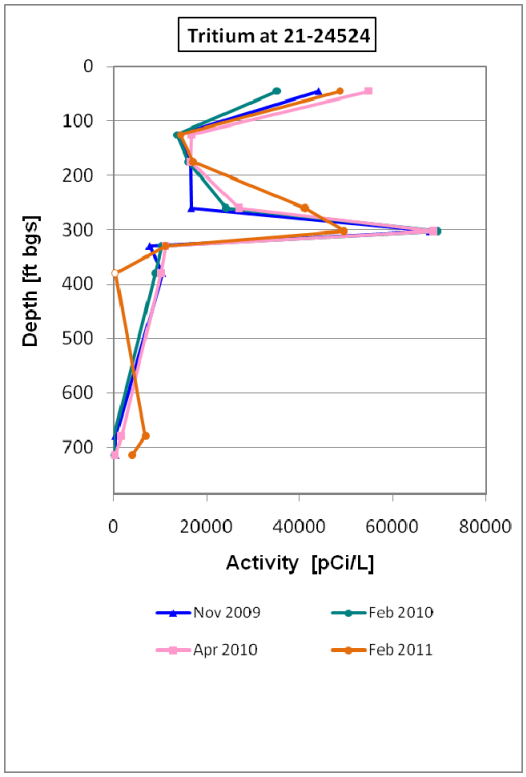

Figure 10-12 Vertical profile of tritium vapor-port samples from vapor-monitoring wells 21-24524 and 21-24524S

F. REFERENCES

LANL 2010a: "Periodic Monitoring Report for Vapor-Sampling Activities at Material Disposal Area H, Solid Waste Management Unit 54-004, at Technical Area 54, Fourth Quarter Fiscal Year 2010," Los Alamos National Laboratory document LA-UR-10-7589 (November 2010).

LANL 2010b: "Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Fourth Quarter Fiscal Year 2010," Los Alamos National Laboratory document LA-UR-10-8098 (2010).

LANL 2011c: "Sampling Activities at Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21, July to September 2010," Los Alamos National Laboratory document LA-UR-11-0396 (2011).

LANL 2010d: "Corrective Measures Evaluation Report for Material Disposal Area G at Technical Area 54," Los Alamos National Laboratory document LA-UR-10-7868 (November 2010).

LANL 2010e: "Corrective Measures Evaluation Report for Material Disposal Area L at Technical Area 54," Los Alamos National Laboratory document LA-UR-10-6506 (2010).

LANL 2010f: "Corrective Measures Evaluation Report for Material Disposal Area H at Technical Area 54," Los Alamos National Laboratory document LA-UR-10-8097 (December 2010)

LANL 2010g: "Report for Supplemental Soil-Vapor Extraction Pilot Test at Material Disposal Area G, Technical Area 54," Los Alamos National Laboratory document LA-UR-10-3409 (May 2010)

LANL 2011h: "Supplemental Tritium Report for Material Disposal Area V," Los Alamos National Laboratory document LA-UR-11-8366 (January 2011)

Stauffer, P.H., K.H. Birdsell, M.S. Witkowski, and J.K. Hopkins, 2005. "Vadose Zone Transport of 1,1,1-Trichloroethane: Conceptual Model Validation through Numerical Simulation," *Vadose Zone Journal,* Vol. 4, pp. 760–773. (Stauffer et al. 2005, 090537)

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A. INTRODUCTION

The 2010 environmental sampling incorporated a graded approach to quality assurance (QA) in accordance with DOE Order 414.1C, which determines the scope, depth, and rigor of implementing the QA criteria for a specific activity. To maximize effective resource use, this process promotes the selective application of QA and management controls based on the quality requirements, risk, and hazards associated with each activity. In this chapter, we present the analytical laboratories quality performance of LANL environmental data across all media. Overall, our analytical laboratories' performance meets our high quality standards.

All sampling, data reviews, and data package validations are conducted using standard operating procedures (SOPs), which are part of LANL's comprehensive QA program. The LANL quality program and SOPs may be viewed at http://www.lanl.gov/environment/all/qa.shtml. Completed chain-of-custody forms serve as the 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, bottle sizes, and preservatives for each analysis requested.

All analytical laboratory results undergo validation following the guidelines in the National Nuclear Security Administration (NNSA) Model Data Validation Procedure (NNSA 2006) and US EPA Contract Laboratory Program National Functional Guidelines for Data Review (EPA 2004, EPA 2005, EPA 2008). This process includes review of the data quality and the documentation's correctness and completeness. An independent DOE contractor, Analytical Quality Associates, Inc. (AQA), in Albuquerque, NM, performs the data validation and applies data qualifiers to the data according to LANL validation SOPs.

Field QA procedures and the quality plan documents were followed during 2010 sampling. Together, these plans and procedures describe or prescribe all the planned and systematic activities necessary to provide adequate confidence that sampling processes are performed satisfactorily.

The LANL data are available as part of the RACER database (http://www.racernm.com/) which contains all the air, surface water, sediment, soils, and groundwater analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results are inconsistent with prior data, LANL investigates 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.

See Supplemental Table S11-1 for the analytes and analytical methods used for analysis of air, surface water, soil, sediment, and groundwater samples during 2010. Tables S11-2, -3, and -4 present the laboratory qualifier codes, secondary validation flags, and validation reason codes.

B. QUALITY CONTROL FOR SAMPLES, DATA VALIDATION, AND ANALYTICAL RESULTS REVIEW

All samples are analyzed at analytical laboratories authorized by the LANL Analytical Services Statement of Work (SOW) for General Inorganic, Organic, Radiochemical, and Asbestos Analytical Laboratory Service. LANL requires all laboratories to produce legally, defensible data packages, which include the following types of quality control (QC) samples and data: instrument raw data, initial and continuing calibration verifications, method blanks, internal standards, laboratory duplicates, laboratory control samples (LCS), surrogate

samples, tracers, and matrix spike (MS) samples. The results from the laboratory QC samples are used to check the accuracy and precision of the analytical data. Field QC samples are also submitted along with environmental samples so that field and analytical laboratory contamination can be tracked and analytical laboratory performance can be assessed. Field QC samples collected include equipment blanks, field blanks, field duplicates, field trip blanks, and performance evaluation blanks.

LANL verifies and validates all analytical data used to support environmental activities to ensure they are defensible and of known quality. Analytical data packages sent to LANL by the analytical laboratories undergo a secondary validation review by AQA. When documentation or contract-compliance problems are identified during data validation, the analytical laboratory is contacted and attempts to resolve or clarify the related issues are established in Validation Corrective Action Reports submitted by AQA to LANL. The analytical laboratory reissues the corrected, modified documentation for re-validation. The majority of the issues of concern involve minor documentation and typographical errors, missing pages, and clarification of data results. Associated sample results are generally not affected. All 2010 Validation Corrective Action Reports are addressed and resolved appropriately by the analytical laboratory. AQA validated all of the 2010 data packages. Table S11-2 include the qualifiers and validation reason codes used to qualify the 2010 data.

After data validation by AQA, approximately 98% of all results are of good quality and are usable; AQA R-qualified (rejected) approximately 2% of the 2010 data. Overall, approximately 16% of the accepted results are qualified during data validation based on data quality issues such as surrogate, LCS, duplicates, tracer, and MS recoveries that do not meet specification; calibration of internal standards that are not met; or holding times that have expired. Less than 1% of the 2010 data are qualified as not detected (U) based on method blank and/or field blank contamination. The analytical laboratory assigned J qualifiers to approximately 2% of the data, indicating that the results represent a detection, but the value is estimated. The analytical laboratory confirmed 13% of the analytes as detected. Even after validation, 67% of the data are qualified as non-detect with no quality control issues. Table 11-1 displays the overall quality of the 2010 samples.

Table 11-1
Overall Quality of 2010 Samples

Qualifiers Affecting Quality Control	Percent of 2010 Data
U, U_LAB – qualified not detected by lab with No QC issues	67
J, J_LAB – qualified detected between method detection limit (MDL) and estimated quantitation limit (EQL)	2
NQ – Detected above the reporting limit with No QC issues	13
REJECTED in validation	2
Qualified as UJ [estimated non-detect] or J due to quality control issues discover in validation	16

Table 11-2 shows the percentage of data qualified based on AQA's secondary data validation of laboratory QC samples. Two percent of all 2010 data were qualified as Rejected (R).

Table 11-2
Routine Validation Summary for 2010 Data

QC Sample Type	Number of Analytes Qualified as Estimated (J)	Percent 2010 Data
Blanks	3,646	0.29
Holding Times	1,154	0.09
Initial Calibration Verifications or Continuing Calibration Verifications	1,982	0.16
Interference Check Samples	20	0.002
Internal Standards or Surrogates	740	0.06
Laboratory Control Samples	465	0.04
Laboratory Duplicates	3,317	0.27
Matrix Spike Samples	11,942	0.96
Serial Dilutions	228	0.02
Tracers (rad only)	352	0.03
QC Sample Type	**Number of Analytes Qualified as Rejected (R)**	**Percent 2010 Data**
Holding Times	218	0.02
Initial Calibration Verifications or Continuing Calibration Verifications	7,616	0.61
Internal Standards or Surrogates	3,210	0.27
Laboratory Control Samples	516	0.04
Laboratory Duplicates	38	0.003
Matrix Spike Samples	332	0.03
Spectra not match	11,427	0.91
Professional Judgment	50	0.004
Blank rejection	21	0.001

In addition to data validation, in order to determine the overall quality of the reported results, LANL performs data review of analytical results to assess and identify issues with data quality that require action. The data quality issues identified and addressed in 2010 include the following:

- LANL directed AQA to conduct a Data Package Assessment (DPA) for TestAmerica, Inc., St. Louis (TA-STL). The assessment included data package completeness, documentation of the analytical work performed, instrument calibration and calibration checks, method quality control, secondary reviews and quality assurance 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. This DPA included data packages that are assessed for organics, inorganics, and radiochemistry analyses. TA-STL worked closely with LANL and AQA to resolve the 109 issues noted in the DPA Report, as well as additional "validation time-saving" requests. TA-STL, LANL and AQA worked together to ensure that the corrective actions proposed adequately addressed all issues outlined in the DPA. Throughout the DPA reconciliation process, TA-STL exhibited a willingness to cooperate and an eagerness to resolve the issues. TA-STL submitted a comprehensive Corrective Action Plan (CAP) to LANL, and all 109 issues have been resolved.
- Elevated selenium results were obtained from soil samples. After review of the raw data, it was determined the analytical laboratory used a different mass for the Se on its instrumentation. LANL is in the process of working with the analytical laboratories to preclude non-detects above background.

- In 2010, LANL changed analytical laboratories from University of Miami to ARSL for low-level tritium analyses. Due to the minor differences in analytical methods at the two laboratories, the more recent data are not directly comparable to earlier values.
- Samples were improperly preserved with nitric acid for several samples collected for three wells. Samples displayed high nitrate (as nitrogen) results in contrast to low TDS concentrations. These issues have been resolved.
- LANL chromium results in groundwater showed an increasing Practical Quantitation Limits (PQL) and Method Detection Limits (MDL). This issue was brought to GEL Laboratories, which had identified the causes of the elevated chromium results in reported samples. Specifically, the equations that correct for isobaric polyatomic ion interferences for this element have not been revised at the same frequency as in the past. This is due to the elevation of GEL's current MDLs and PQLs from an MDL of 1 ppb and PQL of 3 ppb to revised values of 2.5 ppb and 10 ppb, respectively. While the frequency of the revision to the equation changed, the laboratory continued to comply with method requirements. GEL admitted to reporting LANL chromium samples with higher bias than what had been previously reported at or near the detection limit. The majority of the samples could not be reevaluated due to lack of availability of sample media and past holding times. The analytical lab performed re-digestion and reanalysis on only a few samples. GEL re-reported chromium results to LANL and these updated data are in the database.
- On July 12, 2006, LANL collected a groundwater sample from Buckman Well #1 as part of routine quarterly sampling conducted by LANL at three water-supply wells in the Buckman Well Field. The samples are sent to GEL Laboratories for radiochemistry analysis. GEL's data package indicated that they qualified a Pu-238 result from Buckman Well #1 as a detected analyte. However, following recent reviews of legacy data by LANL and further discussions with the analytical laboratory, GEL now concludes that Pu-238 was not present in the sample from Buckman Well #1. GEL found insufficient counts of alpha activity at the location of the spectrum that would be indicative of Pu-238. The original computer analysis of the results used the total number of counts, including background, within a specified "region of interest," but the analysis did not evaluate the data fully. Subsequent examination of the data by experts shows that the counts were the result of random processes and were not from Pu-238. Consequently, the results for the analysis of Pu-238 have been formally changed and flagged in the database as undetected. The updated flag is in RACER.
- The detection of several compounds in well samples was likely the result of analytical contamination rather than their presence in groundwater. Two Aroclor (PCB) compounds were found in a field duplicate from R-16 but not in the primary sample or any previous sample. Several PAH compounds (such as benzo(a)pyrene) were found in samples from MCOI-6, PCI-2, R-27, R-60 and R-55. In these cases, some compounds were found in a primary sample or field duplicate sample, but not both. The presence of diethylphthalate contamination in water samples was caused by contaminated sample bottles. The sample bottle supplier was changed to a supplier that provides higher quality certified 300 Series bottles.
- In 2010, we changed analytical laboratories for low-level tritium analyses. In August 2011 investigation revealed that results from the new provider (ARSL) were subject to calculation errors. At the time of this report, these data had not been corrected.

C. QUALIFICATION AND PERFORMANCE ASSESSMENT OF ANALYTICAL LABORATORIES

The Laboratory is responsible for acquiring analytical services that support environmental activities. The SOW for analytical services follows the Department of Energy (DOE) NNSA Service Center Model Statement of Work for Analytical Laboratories (NNSA 2010). The SOW provides the contract analytical laboratories the general QA guidelines and includes specific requirements and guidelines for analyzing air, surface water, groundwater, soil, and sediment samples.

In 2010, the majority of the analyses were performed by GEL Laboratories, Charleston, South Carolina; TestAmerica, Inc.- St. Louis, Earth City, Missouri; ALS Laboratory Group (formally Paragon), Fort Collins, Colorado; Southwest Research Institute, San Antonio, Texas; and American Radiation Services, Inc, Baton Rouge, Louisiana. Vista Analytical Laboratory in El Dorado Hills, California, is used as an additional laboratory to analyze samples for dioxins and furans.

Analytical laboratories undergo a pre-award assessment to evaluate their ability to perform the required analyses. The Laboratories must be certified by the National Environmental Laboratory Accreditation Program (NELAP) for the required analytical methods.

LANL requires analytical laboratories to participate in independent national performance evaluation (PE) programs. These PE studies address a majority of the parameters for which the analytical laboratories conduct analyses in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP), Water Study (WS), proficiency testing, and other pertinent programs offered by Environmental Resource Associates and state-sponsored certification programs as available for the analytical methods they conduct for LANL.

The vast majority of the results of these studies were within acceptance limits. Acceptance limits are the range of percent recoveries that indicate sufficient accuracy of the analyses and results in data not being qualified. If the results for an analyte or group of analytes did not pass, the laboratories implemented corrective actions and acceptable results are reported for 2010.

The 2010 performance evaluation programs at five analytical laboratories are summarized here:

- GEL Laboratories analyzed and reported results for PE samples in accordance with the NELAP requirements. These PE sample analyses resulted in the reporting of 129 analytes outside of the acceptance limits, out of 5,798 total PE results submitted (97.8% acceptable results). Eleven of the 129 are either reported as false negative or false positive results. The laboratory reported two consecutive Pu-238 failures due the ramifications of a worldwide shortage of the Pu-242 tracer, which resulted in a Priority I finding by the DOE Contract Analytical Program (DOECAP) audit team in 2011. However, only three out 8,000 Pu-238 results published by the lab for all its clients are affected. The laboratory has completed and submitted a corrective action for the Pu failures, and the finding was closed before the end of the audit. The laboratory has performed Pu-238 analyses with acceptable results since completion of the corrective action. Although the laboratory did not find an apparent cause for all of the 129 PE result failures, the laboratory investigated and addressed all of the failures. None of these failures affected Los Alamos samples.
- TestAmerica, Inc. - St. Louis analyzed and reported results for PE samples in accordance with the NELAP requirements. These PE sample analyses resulted in the reporting of 52 analytes outside of the acceptance limits, out of 3,043 total results submitted (98.3% acceptable results). Five of the 52 failures are either reported as false negative or false positive results. A failure of o-phosphate performance testing sample was also captured with the DOECAP audit. Although the laboratory did not find an apparent cause for all of the 52 PE result failures, the laboratory investigated and addressed all of the failures.
- ALS Laboratory Group analyzed and reported results for PE samples in accordance with NELAP requirements. These PE sample analyses resulted in the reporting of 37 analytes outside of the acceptance limits, out of 1,482 total results submitted (97.5% acceptable). Eight of the 37 failures are either reported as false negative or false positive results. Although the laboratory did not find an apparent cause for all of the 37 PE result failures, the laboratory investigated and addressed all of the failures.
- Southwest Research Institute analyzed and reported results for PE samples in accordance with NELAP requirements. These PE sample analyses resulted in the reporting of 12 analytes outside of the acceptance limits, out of 889 total results reported (92.7% acceptable). Three of the 12 failures are either reported as false negative or false positive results. Although the laboratory did not find an

apparent cause for all of the 12 PE result failures, the laboratory investigated and addressed all PE failures.

- American Radiation Services analyzed and reported results for PE samples in accordance with NELAP requirements. These PE sample analyses resulted in the reporting of seven analytes outside of the acceptance limits, out of 174 total results submitted (96.0% acceptable). A failure in radiochemistry due to a low bias observed in performance testing water samples for Am-241 was also captured in the DOECAP audit. The laboratory did not report any false negative or positive results. Although the laboratory did not find an apparent cause for all of the seven PE result failures, the laboratory investigated and addressed all PE failures.

There are no performance evaluation programs for the specialty analyses conducted at Vista Analytical Laboratory; therefore, performances on samples at Vista Analytical Laboratory are not assessed through performance evaluation programs.

All of the laboratories provided detailed analytical laboratory performance evaluation studies, investigation reports, and correction action plans to LANL for review. In addition, each laboratory conducts internal audits of their procedures, instrumentation and reporting practices on a regular basis. When issues are found, each laboratory documents the issues and performs and records corrective actions.

D. DEPARTMENT OF ENERGY CONTRACT ANALYTICAL PROGRAM AUDITS

The DOE Office of Environmental Management mandates participation in the DOE Contract Analytical Program (DOECAP; https://doecap.oro.doe.gov/). DOECAP is a consolidated, uniform 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 and other industry standard-setting groups, such as the National Environmental Laboratory Accreditation Conference. LANL requires participation in DOECAP for all major analytical providers. In 2010, DOECAP audits were conducted at five laboratory facilities which provide air, water, soil, and sediment data to LANL: GEL Laboratories; TestAmerica, Inc. - STL; ALS Laboratory Group; Southwest Research Institute, and American Radiation Services, Inc.

DOECAP audits result in *Findings and Observations* when there are items of concern that need to be addressed in the audit report. DOECAP audits found that the laboratories meet established requirements necessary to produce data of acceptable and documented quality through analytical operations that follow approved and technically sound methods. The corrective action plans resulting from the five audits, listed below, have been approved and are available from the DOECAP website.

- GEL Laboratories, April 27–29, 2010. There were seven findings and one observation identified. The findings were issued in the quality assurance area and involved the lack of defined protocol for production and use of control charts throughout the laboratory. All findings and observations were addressed and a corrective action plan has been accepted by DOECAP.
- TestAmerica, Inc. - STL, March 11–13, 2010. There were four findings and 15 observations identified. There were findings in organics due to lack of traceability for organic internal standards; in inorganics due to lack of root cause analysis associated with the corrective action for a failed o-phosphate performance testing sample; and in hazardous and radioactive materials management for lack of implementation of the eye protection requirements detailed in the laboratory safety documentation. A recurring finding from 2009 was the lack of defined acceptable uncertainty for daily balance check weights. All findings and observations were addressed and a corrective action plan was accepted by DOECAP.
- ALS, March 23–25, 2010. There were 10 findings and nine observations identified. Five findings were issued in quality assurance were poor document control practices, lack of document and record

review, and lack of designation for deputies for key management positions. A recurring finding from 2009 was the use of a thermometer that did not bracket the monitoring range required for the method in use. A finding was issued in radiochemistry for non-compliance with the laboratory's internal operating procedure. A finding was issued in Laboratory Information Management Systems (LIMs) due to lack of password maintenance. A finding was issued in hazardous and radioactive materials management for a continuing lack of attention by laboratory personnel to protective equipment requirements (lab coats and eye protection). All findings and observations were addressed and a corrective action plan was accepted by DOECAP.

- Southwest Research Institute, March 2–4, 2010. There were seven findings and eight observations. The findings identified in quality assurance involved lack of defined training requirements for each position, lack of gravimetric daily verification of pipettes, and improper logbook maintenance. A Priority 1 and a Priority 2 finding were issued in radiochemistry due to repeated performance testing failures. A new finding was issued in the LIMs due to lack of preservation of the original chromatogram when manual integration is performed. A finding was issued in hazardous and radioactive materials management for a safety shower that is located too far from the laboratory it is meant to service. All findings and observations were addressed and a corrective action plan was accepted by DOECAP.
- American Radiation Services, July 20–22, 2010. There were four findings and 4 observations identified. A finding was issued in quality assurance due to lack of periodic logbook review. A finding was issued in radiochemistry due to a low bias observed in performance testing water samples for Am-241. Two findings were issued in hazardous and radioactive materials management. A finding was issued for improper radiation scanning of samples upon receipt, and a finding was issued for lack of a policy or procedures for evaluation of waste brokering and Treatment, Storage and Disposal Facilities (TSDF) used by the laboratory. All findings and observations were addressed and a corrective action plan was accepted by DOECAP.

E. REFERENCES

EPA 2004: US EPA Contract Laboratory Program, "National Functional Guidelines for Inorganic Data Review," OSWER 9240.1-45, EPA 540-R-04-004 (October 2004).

EPA 2005: US EPA Contract Laboratory Program, "National Functional Guidelines for Chlorinated Dioxin/Furan Data Review," EPA-540-R-05-001 (September 2005).

EPA 2008: US EPA Contract Laboratory Program, "National Functional Guidelines for Superfund Organic Methods Data Review," EPA-540-R-08-01 (June 2008).

NNSA 2006: U.S. Department of Energy National Nuclear Security Administration (NNSA) Service Center, "Model Data Validation Procedure," Rev 4.1 (August 2006).

NNSA 2010: U.S Department of Energy NNSA Service Center, "Model Statement of Work for Analytical Laboratories" (August 2010).

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A. INTRODUCTION

In this chapter, we present environmental topics at Los Alamos National Laboratory (LANL or the Laboratory) that are not strictly defined by media type or compliance program. In this year's report, we present (a) environmental monitoring and assessment information for geographical areas of interest to stakeholders and (b) Laboratory efforts at risk reduction.

Some environment subjects of interest to stakeholders do not fall into single environmental categories (water, sediments, air, foodstuffs, etc.), following the current organization of this report. One of these subjects of interest is the Rio Grande; another area is the Valles Caldera/Jemez Mountain region. LANL is not presenting new environmental monitoring projects or environmental assessments in this section, but rather summarizing environmental data presented in Chapters 5 through 8 of this report applicable to these regions and summarizing recent risk assessments for these two areas.

The DOE Order 450.1, Environmental Protection, establishes Department of Energy (DOE) sustainable environmental stewardship goals to reduce or eliminate environmental hazards. In this chapter, we present summary information on the environmental risk reduction efforts associated with Laboratory programs, including the environmental restoration program, groundwater program, surface water program, wildfire mitigation program, and the transuranic (TRU) waste management program.

B. MONITORING OF THE RIO GRANDE

1. Monitoring Information

Water quality, sediments, and biota/foodstuffs have been monitored for many years in and along the Rio Grande to assess LANL impacts. Annually, these data are presented in Chapters 5 through 8 of this report. Individual measurements are available in Supplemental tables of this report and on the RACER database (www.racerdat.com). Environmental samples may not be collected every year when contaminant values are not above standards and do not demonstrate an upward trend over time. When trends are identified, sample locations may change (e.g., sediments) to gain more information. Stations located along the Rio Grande above Los Alamos Canyon (e.g., Otowi Bridge and Abiquiu Reservoir) are considered upstream or background locations.

2. Water Quality in the Rio Grande

Surface water samples were collected from three locations along the Rio Grande in 2010: upriver of Los Alamos Canyon and LANL at Otowi Bridge, at the Buckman Direct Diversion (BDD) Project surface water diversion site (at the mouth of Cañada Ancha, downriver from Los Alamos, Sandia, and Mortandad Canyons), and at the mouth of Frijoles Canyon in Bandelier National Monument (downriver from all canyons draining LANL) (see Figure 6-5).

Nine radionuclides were detected in the Rio Grande water samples: radium-226, radium-228, thorium-228, thorium-230, thorium-232, tritium, uranium-234, uranium-235/236, and uranium-238. As described in the report of the Buckman Direct Diversion Project Independent Peer Review (ChemRisk 2010), these are all natural, as demonstrated by their ratios and the consistency of the data upstream and downstream of LANL. Furthermore, as discussed in Chapter 3, the annual dose from these radionuclides is less than 0.1 mrem. As discussed in Chapter 3, doses less than 0.1 mrem cannot be distinguished from natural background radiation.

For inorganic chemicals, two results from the Rio Grande were above screening levels in 2010. A non-filtered sample collected at Otowi Bridge, above Los Alamos Canyon, had ammonia slightly above the New Mexico

Water Quality Control Commission (NMWQCC) chronic aquatic life standard of 179 µg/L, at 184 µg/L. A filtered sample collected at Frijoles Canyon had copper slightly above the NMWQCC chronic aquatic life standard of 9.0 µg/L, at 9.71 µg/L. These data indicate that water quality in the Rio Grande in the vicinity of the Laboratory is good, with average values for these constituents being below chronic aquatic life standards.

For organic chemicals, samples from the Rio Grande were analyzed for explosive compounds, pesticides, PCBs (by both the Aroclor and the congener methods), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). PCB congeners were detected in one sample, collected from Otowi Bridge on July 13, below the NMWQCC human health standard of 0.00064 µg/L at 0.0000385 µg/L. All other results were non-detects.

3. Sediments in the Rio Grande

Past analyses and studies have detected radionuclides and other contaminants that have been transported by flood events down Los Alamos Canyon to the Rio Grande near Otowi Bridge (Graf 1994, 1996; Reneau et al., 1998; LANL 2004). Using sensitive isotopic analytical methods, we have traced plutonium-239/240 from historic Acid Canyon discharges in sediment more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002). However, the dose that might result from these radionuclides is much less than 0.1 mrem (see Chapter 3).

Natural stream flow and sediment loading in the Rio Grande are quite large compared with Los Alamos area streams. These factors limit impacts from the Laboratory in the Rio Grande. In 2010, we collected sets of five sediment samples each for analysis of isotopic plutonium, gamma spectroscopy radionuclides, and PCB congeners from five areas along the Rio Grande. The five areas were: (1) upriver from Otowi Bridge, which is upriver from all LANL sources; (2) upriver from Buckman and the BDD Project surface water intake for the City and County of Santa Fe; (3) below the White Rock Overlook, downriver from Los Alamos, Sandia and Mortandad canyons; (4) between Chaquehui and Frijoles Canyons, downriver from all canyons draining LANL, and the bottom of Cochiti Reservoir.

In four sediment samples collected at Cochiti in 2010, Pu-239/240 was detected above background. These results are consistent with previous data from Cochiti Reservoir (see Figure 6-36). Previous fish monitoring results demonstrate no difference in plutonium concentrations between fish caught in Abiquiu Reservoir, upriver of all LANL sources, and Cochiti Reservoir.

Total detected PCB congener concentrations in Rio Grande sediment samples in 2010 are similar to concentrations measured in 2008 and 2009. Data from the 1980s-vintage Cochiti Reservoir sediments indicate that PCB concentrations were significantly higher at that time. Total detected PCB congeners in 1980s samples ranged from 350 to 1660 ng/kg, averaging 1,063 ng/kg (Figure 6-37). This decrease in PCB concentrations between the 1980s and present is consistent with the discontinuation of use of PCBs that began in 1979, when the U.S. Congress banned their production because of concerns about their toxicity and persistence in the environment.

We estimate the long-term average PCB flux in the Rio Grande to be 0.27 kg/year, based on the average annual river flow past Otowi Bridge and average PCB concentrations in sediments near Otowi Bridge. A preliminary estimate of PCB flux in lower Los Alamos Canyon into the Rio Grande is 0.003 - 0.005 kg/yr, which is 1% to 3% of the total estimated long-term flux in the Rio Grande. These estimates support the conclusion based on PCB congener patterns that there is little LANL impact on PCBs in the river (see Chapter 6).

4. Crayfish in the Rio Grande

Crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp.) samples were collected from the Rio Grande within two reaches relative to the location of LANL: upstream and downstream (see Figure 8-4). Upstream (or background) samples were collected starting from the Otowi Bridge north to the Black Mesa area (about a three-mile stretch) and downstream samples were collected from the Los Alamos Canyon confluence south (about a one-mile stretch). The samples were separated into edible (meat) and non-edible (claws, shell, etc.) portions and analyzed for target analyte list (TAL) elements.

All TAL elements, including mercury, in the edible portions of crayfish collected from the downstream reach were similar to the edible portions collected from the upstream reach (less than the regional statistical reference levels [RSRLs]) (Table S8-7). Also, all concentrations of mercury in the edible portion of crayfish collected from both reaches were an order of magnitude below the Environmental Protection Agency (EPA) screening level of 0.30 mg/kg (EPA 2001). Mercury sources and contamination in fish inhabiting the Rio Grande upstream and downstream of LANL are well documented (see Chapter 8); however, the amount of mercury in crayfish compared with the amount of mercury in bottom-feeding fish within these same reaches is an order of magnitude lower and does not appear to be a significant risk factor to humans if ingested.

5. Irrigation with Rio Grande Waters

In 2010, LANL sampled fruits and vegetables irrigated with Rio Grande water collected downstream (south) of the Laboratory. In general, contaminants in all produce samples were very low (pCi range) and most were either not detected or detected below the RSRLs.

6. Risk Assessments

Due to concern about potential LANL impacts to the Rio Grande, a number of risk assessments have been conducted over the past 10 years. Two areas of emphasis have been evaluated: LANL impacts to the Rio Grande following the May 2000 Cerro Grande fire and LANL impacts to the Rio Grande that may affect the BDD Project.

a. Cerro Grande Fire

An independent subcontractor, estimated the potential risk to the public from chemicals and radioactive materials released from the Cerro Grande fire in May 2000 (RAC 2002). They estimated the potential annual cancer risk to be less than 3 in 1 million for exposure to any LANL-derived chemical or radioactive material that may have been carried in the surface water and sediments to the Rio Grande and Cochiti Reservoir. This value is well below EPA target excess cancer risk level of one in 100,000 for environmental cleanup.

b. Buckman Direct Diversion Project

The City of Santa Fe and Santa Fe County completed the construction of the BDD Project in December 2010. The project accesses surface water from the Rio Grande and then treats and distributes these waters to the City and the County through their drinking water distribution systems.

The BDD Project hired an independent peer reviewer to prepare an independent risk assessment, regarding LANL contaminants, of potential exposure through the drinking water pathway, based on existing information, data, and studies. The risk assessment was published on December 3, 2010 and concluded that there is no health risk to people drinking BDD tap water (ChemRisk, 2010). The BDD Project began routine operations during 2011.

A discussion of Laboratory risk reduction activities related to the BDD Project is presented in Section D.d., below.

C. MONITORING IN THE JEMEZ MOUNTAINS AND VALLES CALDERA

This section provides the reader with a consolidated review of all LANL monitoring of areas west and southwest of the Laboratory, namely in the Valles Caldera, the Fenton Hill Site at Technical Area (TA-57), and in the Jemez River drainage. The Laboratory is not presenting new data or environmental assessments in this section, but instead summarizing the historical record of monitoring over a period of the last 35 years, from Environmental Surveillance Reports dating from 1980 and from reports on Fenton Hill as far back as 1973. This review was developed from Simmons (2011).

Since the 1970s, the Laboratory has been measuring the concentrations of chemical constituents in environmental media at locations west and southwest of the Laboratory, including surface water, ground water, soils, biota, and foodstuffs. Jemez Pueblo and a Jemez River location have served as regional (background) monitoring sites over this period of time because their distance from the Laboratory (>20 km) is such that they should not be affected by Laboratory operations.

Monitoring of surface water, well water, circulation-loop pond water, and vegetation at the Fenton Hill hot dry rock experimental site from 1973 to 1994 showed no long-term downstream effects to water quality or vegetation. Elevated concentrations of trace elements in vegetation receiving episodic discharge downstream of the ponds dissipated when discharges became less frequent and ended, with the completion of the hot dry rock project.

Thermal waters originate from the Valles Caldera geothermal region discharge in springs along the Jemez Fault at the Jemez River. The presence of higher arsenic, boron, fluoride, cadmium, and lithium at and downstream of these springs along the Jemez River can be attributed to geothermal sources. The higher concentrations are not evident below the confluence with the Rio Grande because of the higher discharge rate of the Rio Grande.

A very few sporadic detections of radionuclides have been measured in air, surface water, sediment, soil, and biota and foodstuffs over the period of record. The detections appear to be isolated instances and show no spatial or temporal trends. Above all, the detections cannot be attributed to Laboratory operations or influences. For this reason, the Jemez Pueblo and Jemez River locations remain as excellent background locations free of Laboratory influences.

D. RISK REDUCTION

The Laboratory is committed to reducing environmental hazards and the associated risk to people and the environment. In some cases the risk is directly related to dose, which results from actual exposure to a radiological or chemical hazard released from routine operations. The risk is reduced by keeping the dose as low as reasonably achievable (ALARA) through operational work practices. In other cases the risk depends on the probability of exposure in the future. For example, a contaminant in the regional aquifer may not currently be found in drinking water systems, but it may move over time and enter the drinking water systems. Another example of future risk is the potential for accidents from routine operations to release radioactive materials or chemicals into the environment.

The following are examples of where the Laboratory is working to reduce risks to the public and the environment.

1. TRU Waste Program

The TRU waste disposition program expedites the disposal of legacy transuranic waste to Waste Isolation Pilot Project (WIPP) in Carlsbad, NM. TRU waste processing facilities are located at TA-50 and TA-54. TA-54 Area G stores radioactively contaminated waste and other contaminated materials in aboveground storage.

As discussed in Chapter 3, the dose to the all-pathway maximally exposed individual (MEI) was about 1 mrem/yr in 2010. One method used 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. The Laboratory shipped approximately 700 m^3 of TRU to WIPP in 2010. The DOE/LANL goal is to ship all legacy LANL TRU waste to WIPP by the end of 2015. After 2015, all newly generated TRU waste (~85 m^3 per year) will be shipped to WIPP within one year of generation.

The Site-Wide Environmental Impact Statement (DOE 2008) identifies the exposures to the public from potential accidents from Laboratory operations and facilities. The potential accidents having the greatest off-site consequences are postulated to occur at TRU processing (TA-50 and TA-54) and TRU storage facilities (TA-54). The Laboratory will begin design of a new TRU waste staging facility at TA-63 in 2011 to replace the existing facilities at TA-50 and TA-54. Final construction at TA-63 is to be completed in 2015. This facility will replace the buildings and fabric domes currently used to process TRU waste, and thus reduce the consequences from potential accidents.

2. Environmental Restoration

The objective of the Laboratory's environmental restoration program is to determine the types and extent (horizontal and vertical) of legacy environmental contamination (created prior to 1989), whether or not it

requires remediation, and what type of remediation is appropriate. The environmental restoration program requirements and schedule of work are defined in a Consent Order, signed by the Laboratory, DOE, and NMED in 2005. Approximately 2,100 sites were originally identified for evaluation (Figure 12-1). At the end of 2010, investigation work plans have been written for 99% of these sites. Sampling to determine the types and extent of contamination has been reported on approximately 64% of all sites. Approximately 40% of all sites have been approved by EPA and/or the New Mexico Environment Department (NMED) as corrective action complete, requiring no further remedial actions or ongoing monitoring.

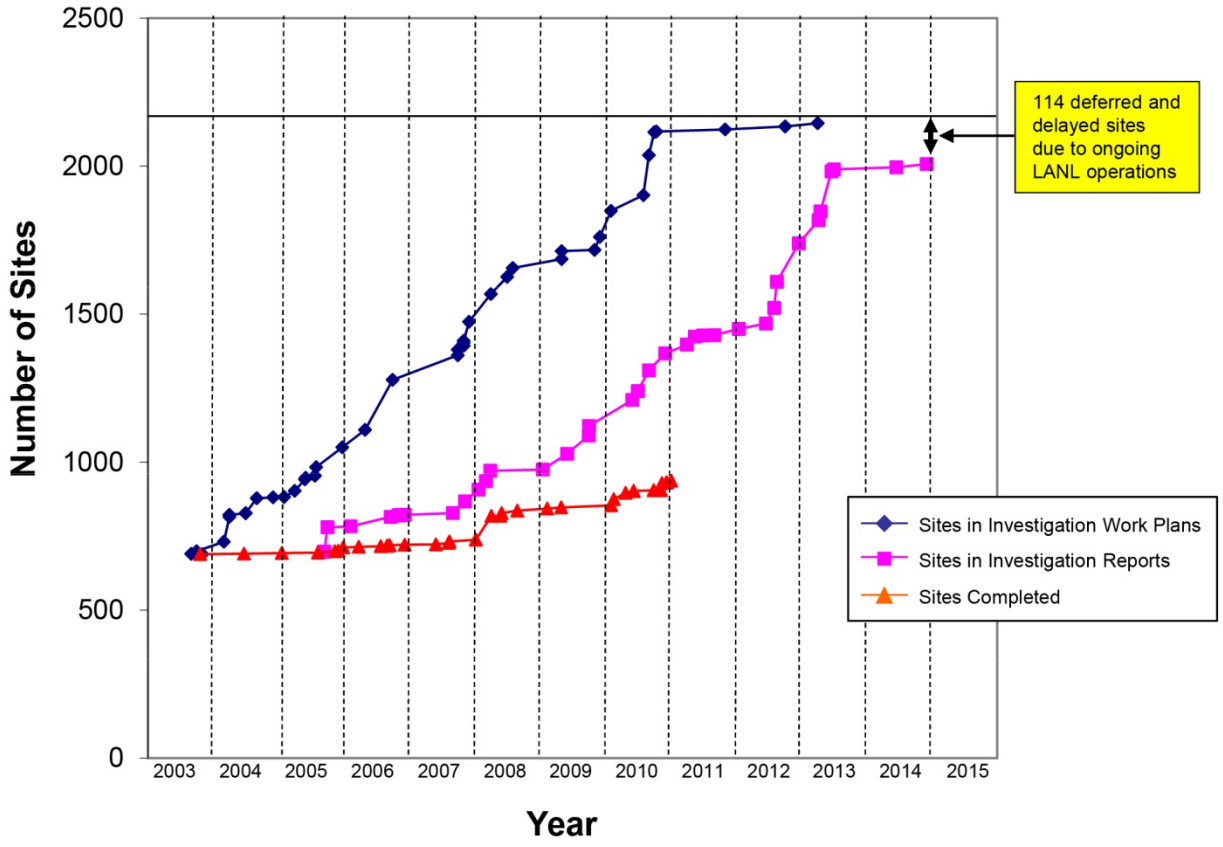

Figure 12-1 Consent Order Site Status

Chapter 9 provides information about all environmental investigation and cleanup activities in 2010. Major risk reduction activities conducted during 2010 included decontamination and decommissioning (D&D) and clean-up activities at TA-21.

TA-21 was the site of plutonium processing from 1945 to the early 1970s. It was also the site of a tritium processing and handling facility, and several material disposal areas (MDAs). The buildings at TA-21 were built as long ago as the 1940s and housed labs, offices and production facilities from the Manhattan Project and Cold War eras. Due to its location on the north side of Los Alamos canyon and its proximity to the Los Alamos townsite, TA-21 has been designated for future transfer to Los Alamos County. Prior to transfer to Los Alamos County, buildings, utilities, and MDAs must be demolished or remediated and the site must meet residential clean-up standards. The Laboratory received American Recovery and Reinvestment Act (ARRA) funding in 2009, and by the end of 2010, all TA-21 buildings, totaling more than 175,000 square feet, were demolished.

TA-21 MDA-B (Figure 4-3), was used from 1944-48 and is the Lab's oldest waste disposal site. MDA-B consists of a number of trenches that were dug to dispose of equipment, clothing and other waste. A great challenge in performing this work is that the inventories of hazardous and radioactive material at the TA-21 MDAs are not well characterized because few records of waste disposal exist from the 1940s and the Manhattan Project. To address those challenges and to ensure safety, the excavation of MDA-B has occurred inside large metal structures that resemble airplane hangars. These structures were built on the site and contain a number of safeguards, including dust and fire suppression systems and high efficiency particulate air (HEPA) filtering. In addition, the excavation has been monitored by closed circuit television cameras. The MDA B clean up was also conducted with ARRA funding. Approximately 50% of the excavation was completed by the end of 2010.

3. Groundwater

As discussed in Chapter 5, Groundwater Monitoring, Laboratory-derived impacts to groundwater have been detected in some monitoring wells. At present, there is no measurable LANL-derived contamination in the Los Alamos County or neighboring community's drinking water systems, but there may be a prospective risk because of the potential for contamination to migrate to the drinking water supply wells. For the past several years, efforts have been underway 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. These investigations will help determine the actions to reduce the prospective risk.

To characterize the extent of contamination in the groundwater, the Laboratory completed 14 intermediate or regional aquifer wells in 2010. Eleven wells were designed to monitor potential contamination from TA-54, TA-49 MDA AB, and TA-50 MDA C. One regional aquifer well was installed to further characterize chromium in Mortandad Canyon. The one intermediate well was installed to evaluate perched intermediate hydrologic properties in the vicinity of the TA-16 260 high explosives facility outfall. One regional aquifer well was installed in Los Alamos Canyon to monitor for potential contamination near the Los Alamos County municipal production well Otowi 1. Results of groundwater monitoring are found in Chapter 5.

4. Surface Water

The Laboratory has established a long term environmental stewardship goal of Zero Liquid Discharge (ZLD) from liquid effluent outfalls. The goal includes reducing the total number of outfalls and reducing the amount of water discharged from remaining outfalls. Reducing the LANL discharge of water into canyons will limit the driver of existing contaminants into downstream surface waters and downward movement into alluvial and intermediate waters and to the regional aquifer. This will reduce the long term risk of contamination to the regional aquifer and protects drinking water resources.

As part of the ZLD effort, the Laboratory is designing new concrete evaporation tanks at TA-52 to receive fully treated radioactive liquid effluent from the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF). These tanks are being constructed to reduce the volume of treated effluent being discharged through the National Pollutant Discharge Elimination System (NPDES) Outfall 051. The construction will also allow for passive evaporation of treated RLWTF effluent. The Laboratory submitted a Notice of Planned Change to EPA in May 2007 regarding the construction of the ZLD Tanks. The estimated completion for the date for the ZLD Tanks Project is March 28, 2012.

Additionally, the Laboratory eliminated discharges from NPDES Outfall 03A021 (TA-3 Chemistry and Metallurgy Research [CMR] Facility Cooling Tower), NPDES Outfall 03A130 (TA-11 Cooling Tower), and NPDES Outfall 03A185 (TA-15 DARHT Cooling Tower) in 2010. These actions were taken by LANL instead of adding new/additional treatment to meet new copper and zinc effluent limits that became effective on August 1, 2010. The TA-21 Steam Plant wastewater discharge (NPDES Outfall 02A129) has been eliminated a result of the facility closure and is currently undergoing D&D.

The BDD Project and the DOE signed a Memorandum of Understanding (MOU) in May 2010, documenting DOE/LANL continuing actions to assure protection of surface water accessed by the BDD Project. LANL upgraded an existing storm water monitoring system in lower Los Alamos Canyon near the Rio Grande. Through the use of remote telemetry, the monitoring system automatically notifies the BDDP

of storm water flows entering the Rio Grande through the use of remote telemetry. The BDDP can then temporarily discontinue water intake from the Rio Grande. Stormwater flows entered the Rio Grande from Los Alamos and Pueblo Canyons on two occasions and from Guaje Canyon on three occasions during 2010. In The system successfully notified the BDD Project in each case.

In addition, LANL completed construction in 2010 of two grade control structures in Pueblo and DP Canyons, both part of the Los Alamos Canyon watershed. These structures mitigate erosion processes during storm water runoff events to stabilize sediments and contaminants in place. Through the reduction of erosion in the canyon (known as headcutting), vegetative growth is enhanced and riparian areas are improved. The effectiveness of these projects will be measured and reported on an annual basis to NMED beginning in November 2011. In addition, 10,000 willows were planted in Pueblo Canyon during 2005 to 2009 to help slow flood waters and aid sediment deposition.

The MOU calls for funding five years of the storm water monitoring in lower Los Alamos Canyon, Rio Grande sampling at the BDD Project location, and one year of intensive measurements of BDD Project diverted water, sand return, and treated drinking water. Detailed sampling plans were under development during 2010. Reporting on these sampling efforts will occur in future editions of this report.

5. Wildland Fires

LANL is located in a fire-prone region and there will always be a high potential for wildfires. The Laboratory maintains a Wildland Fire Management Plan to protect the public and the environment from catastrophic wildfires. On an annual basis, the condition of the Laboratory forests is evaluated and mitigation actions are implemented. The locations of cultural resources and sensitive species habitats are also specifically identified for fire protection measures. These actions include tree thinning, maintenance of LANL fire roads, and erosion controls. During FY10, the Laboratory performed tree thinning operations on 380 acres of LANL property on the western Laboratory boundary on West Jemez Road, TA-49 along State Route 4, on the west side of State Route 4 adjacent to White Rock, and interior to LANL at TAs -39, -52, and -5. These mitigation actions were extremely important in minimizing the amount of LANL lands burned (only 2 acres of wild fires) during the 2011 Las Conchas fire (additional details to be presented in the 2011 report).

E. REFERENCES

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General Formation of a Standard

Standards are created to protect a target group from a variety of contaminants in a given exposure pathway for a specific time frame. A target group may refer to the general public, animals, or a sensitive population like adolescents, the elderly, or asthmatics. Contaminants of concern are addressed by a governing body, such as the EPA, which takes into consideration occurrence in the environment, human exposure and risks of adverse health effects, available methods of detection, cost of implementation, geographic location, and public health. After a contaminant of concern has been identified, all exposure pathways are considered to determine the most probable instances and the need for regulation. Pathways of exposure include air, water, soil, biota, and foodstuffs that can be ingested, absorbed, or inhaled. Time of exposure is also an important factor in the formation of standards because prolonged exposure to low levels of a contaminant can have similar health effects as a short exposure to a high level of a contaminant.

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. 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

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] Note: 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.

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-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.

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://int.lanl.gov/environment/h2o/cw_npdes.shtml.

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	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours	$\mu g/m^3$	150		
PM-10[a]	Annual	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
PM-2.5[b]	Annual	$\mu g/m^3$		15	15
	24 hours	$\mu g/m^3$		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	$\mu g/m^3$		1.5	1.5

[a] Particles ≤10 µm in diameter.
[b] Particles ≤2.5 µm in diameter.

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.

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.

Soils

If contaminant concentrations in soil exceed regional statistical reference levels, the concentrations are first compared to screening levels. The screening level for soils is the concentration that would produce (a) a dose of 15 mrem or greater to an individual, (b) a carcinogen risk of 10^{-5}, or (c) a hazard quotient greater than 1. Screening levels for radionuclides are found in LANL 2005; screening levels for non-radionuclides are found in NMED 2006. If radionuclide concentrations in soil exceed the screening levels, then a dose to a person is calculated using RESRAD and all of the measured radionuclide concentrations available for a given year (these data are presented in Table S7-1). This calculated dose is compared to the 25-mrem/yr DOE single pathway dose standard (DOE 1999). Doses, risk, or hazard quotients are calculated using a conservative residential scenario given the measured contaminant soil concentration.

Foodstuffs

Federal standards exist for radionuclides and selected non-radionuclides (e.g. mercury and Polychlorinated Biphenyls (PCBs) in foodstuffs. Federal screening levels exist for selected non-radionuclides; LANL has selected screening levels for radionuclides. If contaminant concentrations in foodstuffs exceed regional statistical reference levels, the concentrations are compared to screening levels. LANL has established a screening level of 1 mrem/year for concentrations of individual radionuclides in individual foodstuffs (e.g. fish, crops, etc), assuming a residential scenario. EPA has established screening levels for mercury (EPA 2001) and PCBs (EPA 2007) in fish.

If contaminant concentrations in foodstuffs exceed screening levels, contaminant concentrations are compared against Food and Drug Administration (FDA) standards (FDA 2000). In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured and compared with the 25 mrem/yr DOE single-pathway dose constraint (DOE 1999).

Biota

If contaminant concentrations in biota exceed regional statistical reference levels, the concentrations are compared to screening levels. For radionuclides in biota, SLs were set at 10% of the standard by LANL to identify the potential contaminants of concern (McNaughton 2006). For chemicals, there are no SLs based on biota tissue concentrations. Instead, if a chemical in biota tissue exceeds the RSRL, then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2008).

Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1-rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1-rad/day for terrestrial animals (DOE 2002).

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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-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-3 presents abbreviations for common measurements.

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.

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	.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)

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
Common Measurement Abbreviations and Measurement Symbols

Symbol	Abbreviation	Symbol	Abbreviation
aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu	British thermal unit	nCi	nanocurie
Ci	curie	nCi/dry g	nanocurie per dry gram
cm^3/s	cubic centimeters per second	nCi/L	nanocurie per liter
cpm/L	counts per minute per liter	ng/m^3	nanogram per cubic meter
fCi/g	femtocurie per gram	pCi/dry g	picocurie per dry gram
ft	foot or feet	pCi/g	picocurie per gram
ft^3/min	cubic feet per minute	pCi/L	picocurie per liter
ft^3/s	cubic feet per second	pCi/m^3	picocurie per cubic meter
kg	kilogram	pCi/mL	picocurie per milliliter
kg/h	kilogram per hour	pg/g	picogram per gram
m^3/s	cubic meter per second	pg/m^3	picogram per cubic meter
µCi/L	microcurie per liter	PM_{10}	small particulate matter (less than 10 µm diameter)
µCi/mL	microcurie per milliliter	$PM_{2.5}$	small particulate matter (less than 2.5 µm diameter)
µg/g	microgram per gram	R	roentgen
$\mu g/m^3$	microgram per cubic meter	*s*, SD, or σ	standard deviation
mL	milliliter	sq ft (ft^2)	square feet
mm	millimeter	>	greater than
µm	micrometer	<	less than
µmho/cm	micro mho per centimeter	≥	greater than or equal to
mCi	millicurie	≤	less than or equal to
mg	milligram	±	plus or minus
mR	milliroentgen	~	approximately
mrad	millirad		

Standard deviations for the AIRNET 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).

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-2. The main programs conducted at each of the areas are listed in this Appendix.

Technical Area	Activities
TA-0 (Offsite Facilities)	This TA designation is assigned to structures leased by DOE that are located outside LANL's boundaries in the Los Alamos townsite and White Rock.
TA-2 (Omega Site or Omega West Reactor)	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 or South Mesa Site)	This TA is LANL's core scientific and administrative area, with approximately half of LANL's employees and total floor space. It is the location of a number of the LANL's Key Facilities, including the Chemistry and Metallurgy Research Building, the Sigma Complex, the Machine Shops, the Material Sciences Laboratory, and the Nicholas C. Metropolis Center for Modeling and Simulation.
TA-5 (Beta Site)	This TA is largely undeveloped. Located between East Jemez Road and the San Ildefonso Pueblo, it contains physical support facilities, an electrical substation, and test wells.
TA-6 (Two-Mile Mesa Site)	This TA, located in the northwestern part of LANL, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, and aging vacant buildings that are awaiting demolition.
TA-8 (GT-Site [Anchor Site West])	This TA, located along West Jemez Road, is a testing site where nondestructive dynamic testing techniques are used for the purpose of ensuring the quality of materials in items ranging from test weapons components to high-pressure dies and molds. Techniques used include radiography, radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
TA-9 (Anchor Site East)	This TA is located on the western edge of LANL. Fabrication feasibility and the physical properties of explosives are explored at this TA, and new organic compounds are investigated for possible use as explosives.
TA-11 (K-Site)	This TA is used for testing explosives components and systems, including vibration analysis and drop-testing materials and components under a variety of extreme physical environments. Facilities are arranged so that testing may be controlled and observed remotely, allowing devices that contain explosives, radioactive materials, and nonhazardous materials to be safely tested and observed.
TA-14 (Q-Site)	This TA, located in the northwestern part of LANL, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high explosives machining, and permitted burning.
TA-15 (R-Site)	This TA, located in the central portion of LANL, is used for high explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. TA-15 is the location of two firing sites, the Dual Axis Radiographic Hydrodynamic Test Facility, which has an intense high-resolution, dual-machine radiographic capability, and Building 306, a multipurpose facility where primary diagnostics are performed.
TA-16 (S-Site)	TA-16, in the western part of LANL, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. The TA is also the location of high explosives research, development, and testing, and the High Explosives Wastewater Treatment Facility.
TA-18 (Pajarito Site)	This TA, located in Pajarito Canyon, is the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. It is the location of the Solution High-Energy Burst Assembly and is also used for teaching and training related to criticality safety and applications of radiation detection and instrumentation. All Security Category I and II materials and activities have been relocated to the Nevada Test Site.
TA-21 (DP-Site)	TA-21 is on the northern border of LANL, next to the Los Alamos townsite. In the western part of the TA is the former radioactive materials (including plutonium) processing facility that has been partially decontaminated and decommissioned. In the eastern part of the TA are the Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility. Operations from both facilities have been transferred elsewhere as of the end of 2006.
TA-22 (TD-Site)	This TA, located in the northwestern portion of LANL, houses the Los Alamos Detonator Facility. Construction of a new Detonator Production Facility began in 2003. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
TA-28 (Magazine Area A)	TA-28, located near the southern edge of LANL, was an explosives storage area. The TA contains five empty storage magazines that are being decontaminated and decommissioned.
TA-33 (HP-Site)	TA-33 is a remotely-located TA at the southeastern boundary of LANL. The TA is used for experiments that require isolation, but do not require daily oversight. The National Radioastronomy Observatory's Very Long Baseline Array telescope is located at this TA.

Technical Area	Activities
TA-35 (Ten Site)	This TA, located in the north central portion of LANL, is used for nuclear safeguards research and development, primarily in the areas of lasers, physics, fusion, materials development, and biochemistry and physical chemistry research and development. The Target Fabrication Facility, located at this TA, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at TA-35 include research in reactor safety, optical science, and pulsed-power systems, as well as metallurgy, ceramic technology, and chemical plating. Additionally, there are some Biosafety Level 1 and 2 laboratories at TA-35.
TA-36 (Kappa-Site)	TA-36, a remotely-located area in the eastern portion of LANL, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
TA-37 (Magazine Area C)	This TA is used as an explosives storage area. It is located at the eastern perimeter of TA-16.
TA-39 (Ancho Canyon Site)	TA-39 is located at the bottom of Ancho Canyon. This TA is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
TA-40 (DF-Site)	TA-40, centrally located within LANL, is used for general testing of explosives or other materials and development of special detonators for initiating high explosives systems.
TA-41 (W-Site)	TA-41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.
TA-43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	TA-43 is adjacent to the Los Alamos Medical Center at the northern border of LANL. Two facilities are located within this TA: the Bioscience Facilities (formerly called the Health Research Laboratory) and NNSA's local Site Office. The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at LANL. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.
TA-46 (WA-Site)	TA-46, located between Pajarito Road and the San Ildefonso Pueblo, is one of LANL's basic research sites. Activities have focused on applied photochemistry operations and have included development of technologies for laser isotope separation and laser enhancement of chemical processes. The Sanitary Wastewater Systems Plant is also located within this TA.
TA-48 (Radiochemistry Site)	TA-48, located in the north central portion of LANL, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
TA-49 (Frijoles Mesa Site)	TA-49, located near Bandelier National Monument, is used as a training area and for outdoor tests on materials and equipment components that involve generating and receiving short bursts of high-energy, broad-spectrum microwaves. A fire support building and helipad located near the entrance to the TA are operated by the U.S. Forest Service.
TA-50 (Waste Management Site)	TA-50, located near the center of LANL, is the location of waste management facilities including the Radioactive Liquid Waste Treatment Facility and the Waste Characterization, Reduction, and Repackaging Facility. The Actinide Research and Technology Instruction Center is also located in this TA.
TA-51 (Environmental Research Site)	TA-51, located on Pajarito Road in the eastern portion of LANL, is used for research and experimental studies on the long-term impacts of radioactive materials on the environment. Various types of waste storage and coverings are studied at this TA.
TA-52 (Reactor Development Site)	TA-52 is located in the north central portion of LANL. A wide variety of theoretical and computational research and development activities related to nuclear reactor performance and safety, as well as to several environmental, safety, and health activities, are carried out at this TA.
TA-53 (Los Alamos Neutron Science Center)	TA-53, located in the northern portion of LANL, includes the LANSCE. LANSCE houses one of the largest research linear accelerators in the world and supports both basic and applied research programs. Basic research includes studies of subatomic and particle physics, atomic physics, neutrinos, and the chemistry of subatomic interactions. Applied research includes materials science studies that use neutron spallation and contributes to defense programs. LANSCE has also produced medical isotopes for the past 20 years.
TA-54 (Waste Disposal Site)	TA-54, located on the eastern border of LANL, is one of the largest TAs at LANL. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage, treatment, decontamination, and disposal operations.
TA-55 (Plutonium Facility Complex Site)	TA-55, located in the center of LANL, is the location of the Plutonium Facility Complex and is the chosen location for the Chemistry and Metallurgy Research Building Replacement. The Plutonium Facility provides chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms. The Chemistry and Metallurgy Research Building Replacement, currently under construction, will provide chemistry and metallurgy research, actinide chemistry, and materials characterization capabilities.

Technical Area	Activities
TA-57 (Fenton Hill Site)	TA-57 is located about 20 miles (32 kilometers) west of LANL on land administered by the U.S. Forest Service. The primary purpose of the TA is observation of astronomical events. TA-57 houses the Milagro Gamma Ray Observatory and a suite of optical telescopes. Drilling technology research is also performed in this TA.
TA-58 (Twomile North Site)	TA-58, located near LANL's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to TA-3. The TA houses a few LANL-owned storage trailers and a temporary storage area.
TA-59 (Occupational Health Site)	This TA is located on the south side of Pajarito Road adjacent to TA-3. This is the location of staff who provide support services in health physics, risk management, industrial hygiene and safety, policy and program analysis, air quality, water quality and hydrology, hazardous and solid waste analysis, and radiation protection. The Medical Facility at TA-59 includes a clinical laboratory and provides bioassay sample analytical support.
TA-60 (Sigma Mesa)	TA-60 is located southeast of TA-3. The TA is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located here. Due to the moratorium on testing, these buildings have been placed in indefinite safe shutdown mode.
TA-61 (East Jemez Site)	TA-61, located in the northern portion of LANL, contains physical support and infrastructure facilities, including a sanitary landfill operated by Los Alamos County and sewer pump stations.
TA-62 (Northwest Site)	TA-62, located next to TA-3 and West Jemez Road in the northwest corner of LANL, serves as a forested buffer zone. This TA is reserved for future use.
TA-63 (Pajarito Service Area)	TA-63, located in the north central portion of LANL, contains physical support and infrastructure facilities. The facilities at this TA serve as localized storage and office space.
TA-64 (Central Guard Site)	This TA is located in the north central portion of LANL and provides offices and storage space.
TA-66 (Central Technical Support Site)	TA-66 is located on the southeast side of Pajarito Road in the center of LANL. The Advanced Technology Assessment Center, the only facility at this TA, provides office and technical space for technology transfer and other industrial partnership activities.
TA-67 (Pajarito Mesa Site)	TA-67 is a forested buffer zone located in the north central portion of LANL. No operations or facilities are currently located at the TA.
TA-68 (Water Canyon Site)	TA-68, located in the southern portion of LANL, is a testing area for dynamic experiments that also contains environmental study areas.
TA-69 (Anchor North Site)	TA-69, located in the northwestern corner of LANL, serves as a forested buffer area. The new Emergency Operations Center, completed in 2003, is located here.
TA-70 (Rio Grande Site)	TA-70 is located on the southeastern boundary of LANL and borders the Santa Fe National Forest. It is a forested TA that serves as a buffer zone.
TA-71 (Southeast Site)	TA-71 is located on the southeastern boundary of LANL and is adjacent to White Rock to the northeast. It is an undeveloped TA that serves as a buffer zone for the High Explosives Test Area.
TA-72 (East Entry Site)	TA-72, located along East Jemez Road on the northeastern boundary of LANL, is used by protective force personnel for required firearms training and practice purposes.
TA-73 (Airport Site)	TA-73 is located along the northern boundary of LANL, adjacent to Highway 502. The County of Los Alamos manages, operates, and maintains the community airport under a leasing arrangement with DOE. Use of the airport by private individuals is permitted with special restrictions.
TA-74 (Otowi Tract)	TA-74 is a forested area in the northeastern corner of LANL. A large portion of this TA has been conveyed to Los Alamos County or transferred to the Department of the Interior in trust for the Pueblo of San Ildefonso and is no longer part of LANL.

For more information on environmental topics at Los Alamos National Laboratory, access the following websites:

Environmental Surveillance reports and supplemental data tables	http://www.lanl.gov/environment/all/esr.shtml
Los Alamos National Laboratory web site	http://www.lanl.gov/
DOE/NNSA Los Alamos Site Office web site	http://www.doeal.gov/laso/default.aspx
Department of Energy web site	http://www.energy.gov/
LANL's air quality pages	http://www.lanl.gov/environment/air/index.shtml
LANL's water quality pages	http://www.lanl.gov/environment/h2o/index.shtml
LANL's waste pages	http://www.lanl.gov/environment/waste/index.shtml
LANL's biological resources pages	http://www.lanl.gov/environment/bio/index.shtml
LANL's risk reduction pages	http://www.lanl.gov/environment/risk/index.shtml
LANL's clean-up pages	http://www.lanl.gov/environment/cleanup/index.shtml
LANL's environmental database	http://www.lanl.gov/environment/all/racer.shtml
Comments and suggestions on this document	http://www.lanl.gov/environment/all/esr.shtml

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.
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 × 1010 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.
DCG	Derived Concentration Guides. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem. DCGs do not consider decay products when the parent radionuclide is the cause of the exposure (DCG values are presented in DOE Order 5400.5).
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).

TEDE	Total 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. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 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).
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.
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.
gallery	An underground collection basin for spring discharges.
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 constituent 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).
LANS	Los Alamos National Security. The limited liability corporation that took over management of LANL in June 2006.
LASO	Los Alamos Site Office. The Los Alamos office of the DOE's NNSA.
LLW	Low-level radioactive waste. Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the *Atomic Energy Act of 1954*, as amended), or naturally occurring radioactive material.
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	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.
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.
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.
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.
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 Level. 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.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
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.

Ac-ft	acre-feet
ACA	accelerated corrective action
AIRNET	Ambient Air Monitoring Network
ALARA	as low as reasonably achievable
AOC	area of concern
AQA	Analytical Quality Associates
ARRA	American Recovery and Reinvestment Act
AST	aboveground storage tank
BCG	Biota Concentration Guides
BDD	Buckman Direct Diversion Project
BMP	Best Management Practice
BOD	biological oxygen demand
BSRL	baseline statistical reference level
C&T	(Land) Conveyance and Transfer Project
CAA	Clean Air Act
CEM	Certified Energy Manager
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGP	Construction General Permit
Ci	curie
CME	corrective measure evaluation
CMI	corrective measure implementation
CMR	Chemistry and Metallurgy Research Facility
CMRR	Chemistry and Metallurgy Research Replacement Facility
COE	United States Army Corps of Engineers
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Consent Order	New Mexico Environment Department Compliance Order on Consent
COPC	chemical of potential concern
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DAC	derived air concentration

DARHT	Dual Axis Radiographic Hydrotest Facility
DCG	derived concentration guide
DOE	Department of Energy
DOECAP	Department of Energy Contract Analytical Program
DP	Delta Prime site
DPA	Data Package Assessment
DRO	diesel-range organic compound
DPRNET	Direct Penetrating Radiation Monitoring Network
DU	depleted uranium
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EMS	Environmental Management System
EP	Environmental Programs Directorate
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
ESH&Q	Environment, Safety, Health, and Quality Directorate
ESL	ecological screening level
ESPC	Energy Savings Performance Contract
EU	enriched uranium
FCRS	Flood Control Retention Structure
FDA	Food and Drug Administration
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FOD	Facility Operations Directorate
FY	fiscal year
GEL	General Environmental Laboratory
GHG	greenhouse gas
GMAP	gaseous mixed air activation products
GSAF	Generator Set-Aside Fee
GSA	General Services Administration

HAP	hazardous air pollutant
HE	high explosive
HEWTF	High Explosive Wastewater Treatment Facility
HPSB	High Performance Sustainable Building
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
IFWGMP	Interim Facility-Wide Groundwater Monitoring Plan
IP	Individual Permit
ISL	industrial screening level
ISM	Integrated Safety Management
ISO	International Standards Organization
JIT	just in time
LACW	Los Alamos Canyon Weir
LANL	Los Alamos National Laboratory (or the Laboratory)
LANS	Los Alamos National Security, LLC
LANSCE	Los Alamos Neutron Science Center (TA-53)
LASO	Los Alamos Site Office
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
LCS	laboratory control sample
LEED	Leadership in Energy and Environmental Design
LLW	low-level waste
MAP	Mitigation Action Plan
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	material disposal area
MDL	method detection limit
MEI	maximally exposed individual
MLLW	mixed low-level waste

MOU	memorandum of understanding
MREM	millirem
MS	matrix spike
MSGP	Multi-Sector General Permit
NCRP	National Council on Radiation Protection
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NISC	Nonproliferation and International Security Center
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NNSA	National Nuclear Security Administration
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NRDA	natural resources damage assessment
NSSB	National Security Sciences Building
NSR	New Source Review
NTS	Nevada Test Site
NTU	nephelometric turbidity units
ODS	Ozone-depleting substances
ORP	oxidation-reduction potential
P2	Pollution Prevention Program
PA/CA	performance assessment/composite analysis
PCB	polychlorinated biphenyls
PCFRS	Pajarito Canyon Flood Retention Structure
PE	performance evaluation
PM	particulate matter
ppb	parts per billion
PQL	Practical Quantitation Limit

PRS	Potential Release Site
PSTB	Petroleum Storage Tank Bureau
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
RAMP	Roof Assessment Management Program
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RLUOB	Radiological Laboratory/Utility/Office Building
RLWTF	Radioactive Liquid Waste Treatment Facility
ROD	Record of Decision
RSL	residential screening level
RSRL	regional statistical reference level
RWMB	Radioactive Waste Management Basis
SAL	screening action level
SDPPP	Site Discharge Pollution Prevention Plan
SDWA	Safe Drinking Water Act
SERF	Sanitary Effluent Reclamation Facility
SFB	soil, foodstuffs, and biota
SL	screening level
SMA	Site Monitoring Area
SMO	Sample Management Office
SOP	standard operating procedure
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SSL	soil screening level
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SWEIS	Site-Wide Environmental Impact Statement

SWPPP	Storm Water Pollution Prevention Plan
SWMU	solid waste management unit
SWWS	Sanitary Wastewater Systems Plant
TA	Technical Area
TAL	target analyte list
TCDD	tetrachlorodibenzodioxin
TCDF	tetrachlorodibenzofuran
TCE	trichloroethylene
TDS	total dissolved solids
TEQ_	toxicity equivalent quotient
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TOC	total organic carbon
TRC	total residual chlorine
TRU	transuranic
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, or disposal facility
UI	Utilities and Infrastructure Facilities
USFS	United States Forest Service
USGS	United States Geological Survey
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Project
WWTP	wastewater treatment plant
WY	water year
ZLD	Zero Liquid Discharge

Actinium	Ac	Erbium	Er
Aluminum	Al	Europium	Eu
Americium	Am	Fermium	Fm
Argon	Ar	Fluorine	F
Antimony	Sb	Francium	Fr
Arsenic	As	Gadolinium	Gd
Astatine	At	Gallium	Ga
Barium	Ba	Germanium	Ge
Berkelium	Bk	Gold	Au
Beryllium	Be	Hafnium	Hf
Bicarbonate	HCO_3	Helium	He
Bismuth	Bi	Holmium	Ho
Boron	B	Hydrogen	H
Bromine	Br	Hydrogen oxide	H_2O
Cadmium	Cd	Indium	In
Calcium	Ca	Iodine	I
Californium	Cf	Iridium	Ir
Carbon	C	Iron	Fe
Cerium	Ce	Krypton	Kr
Cesium	Cs	Lanthanum	La
Chlorine	Cl	Lawrencium	Lr (Lw)
Chromium	Cr	Lead	Pb
Cobalt	Co	Lithium	Li
Copper	Cu	Lithium fluoride	LiF
Curium	Cm	Lutetium	Lu
Cyanide	CN	Magnesium	Mg
Carbonate	CO_3	Manganese	Mn
Dysprosium	Dy	Mendelevium	Md
Einsteinium	Es	Mercury	Hg

Molybdenum	Mo	Samarium	Sm
Neodymium	Nd	Scandium	Sc
Neon	Ne	Selenium	Se
Neptunium	Np	Silicon	Si
Nickel	Ni	Silver	Ag
Niobium	Nb	Sodium	Na
Nitrate (as Nitrogen)	NO_3-N	Strontium	Sr
Nitrite (as Nitrogen)	NO_2-N	Sulfate	SO_4
Nitrogen	N	Sulfite	SO_3
Nitrogen dioxide	NO_2	Sulfur	S
Nobelium	No	Tantalum	Ta
Osmium	Os	Technetium	Tc
Oxygen	O	Tellurium	Te
Palladium	Pd	Terbium	Tb
Phosphorus	P	Thallium	Tl
Phosphate (as Phosphorus)	PO_4-P	Thorium	Th
Platinum	Pt	Thulium	Tm
Plutonium	Pu	Tin	Sn
Polonium	Po	Titanium	Ti
Potassium	K	Tritiated water	HTO
Praseodymium	Pr	Tritium	^3H
Promethium	Pm	Tungsten	W
Protactinium	Pa	Uranium	U
Radium	Ra	Vanadium	V
Radon	Rn	Xenon	Xe
Rhenium	Re	Ytterbium	Yb
Rhodium	Rh	Yttrium	Y
Rubidium	Rb	Zinc	Zn
Ruthenium	Ru	Zirconium	Zr

In the Report "Environmental Surveillance at Los Alamos During 2009," a number of errors were introduced during the final compositing of the report. These errors have been corrected in the on-line version http://int.lanl.gov/environment/all/esr.shtml. In the printed copies of the report, the following errors are found.

1. Chapter 1, page 40, Table 1-2, 2 corrections – both in the middle column: 1,6057 should be 1,605, and 4,882 should be 5,551.

2. Chapter 3, page 87 Figure 3-3: The caption of the figure should be "Los Alamos County radiation background compared with 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."

3. Chapter 5, page 148, Figure 5-10 should read, "Bis(2-ethylhexyl)phthalate concentration history for intermediate well MCOI-6. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. The EPA MCL is 6 µg/L."
   Chapter 5, page 150, Figure 5-16 should read, "Figure 5-16. Bis(2-ethylhexyl)phthalate concentration history for intermediate groundwater well TA-53i. The EPA MCL is 6 µg/L."

4. Chapter 6, pages 214 and 215, D.1 heading should be "On-Site and Perimeter Monitoring Locations," and D.2 should be "Regional Monitoring Locations."

5. Chapter 8, page 281, Table 8-1 should read, "Standards and Other Reference Levels Applied to Foodstuffs"
   Chapter 8, page 288, Table 8-2 should read, "Standards and Other Reference Levels Applied to Biota"
   Chapter 8, page 291, Figure 8-9, The unit measurements should read "Uranium-238 (pCi/g ash)"
   Chapter 8, page 292, Figure 8-10, The unit measurements should read "Uranium-238 (pCi/g ash)"

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Previous reports in this series are LA-14427-ENV, LA-13775-ENV, LA 13861 ENV, LA-13979-ENV, LA-14085 ENV, LA-14162-ENV, LA 14239 ENV, LA-14304-ENV, LA-14341-ENV, LA-14369-ENV, LA 14407 ENV, and LA-14427-ENV.

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An on-line survey form for providing comments, suggestions, and other input on this report is available at http://www.lanl.gov/environment/all/esr.shtml

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