

Los Alamos National Laboratory Environmental Report 2012



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- ▶ We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.



Abert's squirrel (*Sciurus aberti*) in Los Alamos



Male mule deer (*Odocoileus hemionus*) in Los Alamos



Three Cooper's Hawk (*Accipiter cooperii*) chicks in White Rock

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Los Alamos National Laboratory Environmental Report 2012

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Los Alamos National Laboratory Environmental Reports are prepared annually by the Los Alamos National Laboratory (LANL or the Laboratory) environmental organizations, as required by U.S. Department of Energy Order 450.1, Environmental Protection Program, and 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 as well as continued impacts from the Las Conchas Fire and the recently adopted Long-Term Strategy for Environmental Stewardship and Sustainability for Los Alamos National Laboratory. Chapter 2 reports the Laboratory's compliance status for 2012. 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, and foodstuffs and biota in Chapter 8) in a format to meet the needs of a general and scientific audience. Chapter 9 provides a summary of the status of environmental restoration work around LANL. Chapter 10 provides an overview of the performance of the analytical chemistry laboratories that provide sample analyses to the Laboratory. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurement 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, and Appendix G provides elemental and chemical nomenclature.

The posting of this report and its supplemental tables will be available on the Intellus New Mexico website: <http://www.intellusnmdata.com/>.

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LOS ALAMOS NATIONAL LABORATORY ENVIRONMENTAL REPORT 2012

This year's report incorporates some changes to the format and content, including a change in the report's organization and a summary of the Long-Term Strategy for Environmental Stewardship and Sustainability. Each chapter contains a summary of the primary objectives of the environmental monitoring discussed in the chapter. Additionally, each chapter supports one of Los Alamos National Laboratory's seven Environmental Grand Challenges. We will again post this report on the Intellus New Mexico website: <http://www.intellusnmdata.com/>.

REPORT ORGANIZATION

This year, vapor monitoring is presented in Chapter 9, Environmental Restoration, because of limited vadose-zone monitoring in 2012.

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Los Alamos National Laboratory (the Laboratory) is located in Los Alamos County in north-central New Mexico, approximately 60 mi north-northeast of Albuquerque and 25 mi northwest of Santa Fe. The 36-square-mile Laboratory is situated on the Pajarito Plateau, a series of mesas separated by deep east-to-west-oriented canyons. The mission of the Laboratory is to develop and apply science and technology to (1) ensure the safety and reliability of the U.S. 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 the Laboratory's commitment is to report on its environmental performance, and as such, this report does the following:



- characterizes the Laboratory'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.

As reflected by the nearly 70-yr history of Los Alamos National Laboratory, the next 50 yr will bring significant changes to the mission and operations of the Laboratory. Regardless of inevitable changes in mission and environmental requirements, the Laboratory is committed to operating the site sustainably. In 2012, the Laboratory developed the Long-Term Strategy Environmental Stewardship and Sustainability (Long-Term Strategy). The intent of the Long-Term Strategy for Los Alamos National Laboratory is fourfold:

- to clearly define Laboratory environmental policy and strategies to execute that policy;
- to set goals and objectives for environmental stewardship and establish metrics to accurately monitor and measure environmental performance;
- to integrate stewardship efforts across organizations and programs to ensure that the entire life cycle of work at the Laboratory is designed and executed in a manner that is protective of human health and the environment; and
- to provide transparent and relevant communication about the Laboratory's environmental stewardship performance to surrounding neighbors, regulators, and the public.

For the Long-Term Strategy, environmental stewardship focuses principally on the cleanup or stabilization of legacy contamination, waste management, control of emissions from existing operations while managing the landscape to protect human and environmental health, and lastly but importantly, environmental sampling.

The Long-Term Strategy sets forth the following long-term environmental grand challenges and objectives, which the Laboratory will achieve through integration of its environmental and operational programs, providing a coordinated approach to environmental stewardship. Each goal is accompanied by a series of objectives and strategies that will enable successful attainment:

- Grand Challenge 1: Collaborate with our stakeholders and tribal governments to ensure that the Laboratory's impact on the environment is as low as reasonably achievable.
- Grand Challenge 2: Remove or stabilize pollutants from the Manhattan Project and Cold War eras.
- Grand Challenge 3: Protect water resource quality and reduce water use.
- Grand Challenge 4: Eliminate industrial emissions, discharges, and releases to the environment.
- Grand Challenge 5: Protect human and environmental health by managing and restoring lands.
- Grand Challenge 6: Produce zero radioactive, hazardous, liquid, or solid wastes.
- Grand Challenge 7: Use energy efficiently while creating sustainable energy resources.

Environmental stewardship requires an active management system to provide environmental policy, planning, implementation, corrective actions, and management review. The Laboratory uses an Environmental Management System (EMS), compliant with U.S. Department of Energy Order 436.1, Departmental Sustainability, to accomplish this. The Laboratory has been certified to the International Organization for Standardization 14001:2004 standard for EMS since April 2006.

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. Laboratory monitoring includes the radiological ambient air sampling network; groundwater, soil, foodstuffs, and biota (plants and animals) sampling as far away as Dixon, New Mexico (40 direct miles away); and sediment and storm water monitoring in watersheds crossing the Laboratory and along the Rio Grande, as far upriver as Abiquiu Reservoir, and as far downriver as Cochiti Reservoir. The Laboratory's environmental compliance and surveillance programs monitor for environmental hazards and impacts by regularly collecting samples and comparing results with previous results and applicable regulatory standards. During 2012, the Laboratory collected samples from air, water, soil, sediment, foodstuffs, and associated biota at approximately 1800 locations. The Laboratory also works with and assists neighboring communities and pueblos in performing environmental monitoring.

The Laboratory maintained its record of environmental excellence in 2012, with operations resulting in minimal impact to the public and the environment. The site's radioactive and chemical discharges to air and water were well below regulatory standards, and the potential radiation doses from Laboratory operations were significantly less than national dose standards.

To Read About

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We at Los Alamos National Laboratory (LANL or the Laboratory) are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements. We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

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 3000 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 in 1981. Through May 2006, the Laboratory was managed by the Regents of the University of California through the Los Alamos Field Office of the U.S. Department of Energy (DOE). In June 2006, a new organization, Los Alamos National Security, 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 and energy challenges.

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 an International Organization for Standardization (ISO) 14001:2004–registered Environmental Management System (EMS) to focus on environmental performance, protection, and stewardship. The foundation of the EMS and the demonstrated commitment of the Laboratory combine to inform the LANL environmental policy:

- We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements.
- We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public.
- We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

2. Report Purpose

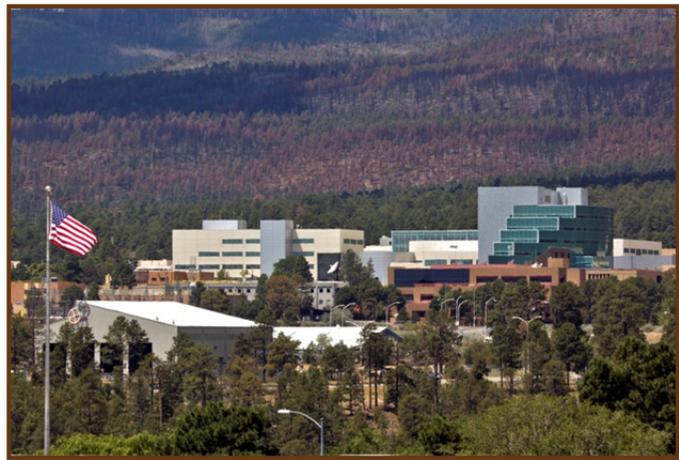
As part of the Laboratory's commitment to our environmental policy, we monitor and report on how Laboratory activities are affecting the environment. The objectives of this environmental report, as directed by DOE Order 231.1B (DOE 2011a), are to

- 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; and
- 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 mi north-northeast of Albuquerque and 25 mi northwest of Santa Fe (direct distance, see 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 7800 ft on the flanks of the Jemez Mountains to about 6200 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 U.S. Bureau of Land Management, Bandelier National Monument, the U.S. General Services Administration (GSA), 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. A local fault system, composed of a master fault and three subsidiary faults, constitutes the modern rift boundary in the Los Alamos area. Studies have investigated the seismic surface rupture hazard associated with these faults (LANL 2007). Most of the finger-like mesas in the Los Alamos area (Figure 1-2) are formed from Bandelier Tuff, which includes ash fall, pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains volcanic center 1.2 to 1.6 million years ago, the tuff is more than 1000 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. In the central Pajarito Plateau and near the Rio Grande, the Bandelier Tuff is underlain by the Puye Formation. The Cerros del Rio basalts interfinger with the Puye Formation along the river and extend beneath the Bandelier Tuff to the west. These formations overlie the sediments of the Santa Fe Group, which extend across the basin between the Laboratory and the Sangre de Cristo mountains and are more than 3300 ft thick.

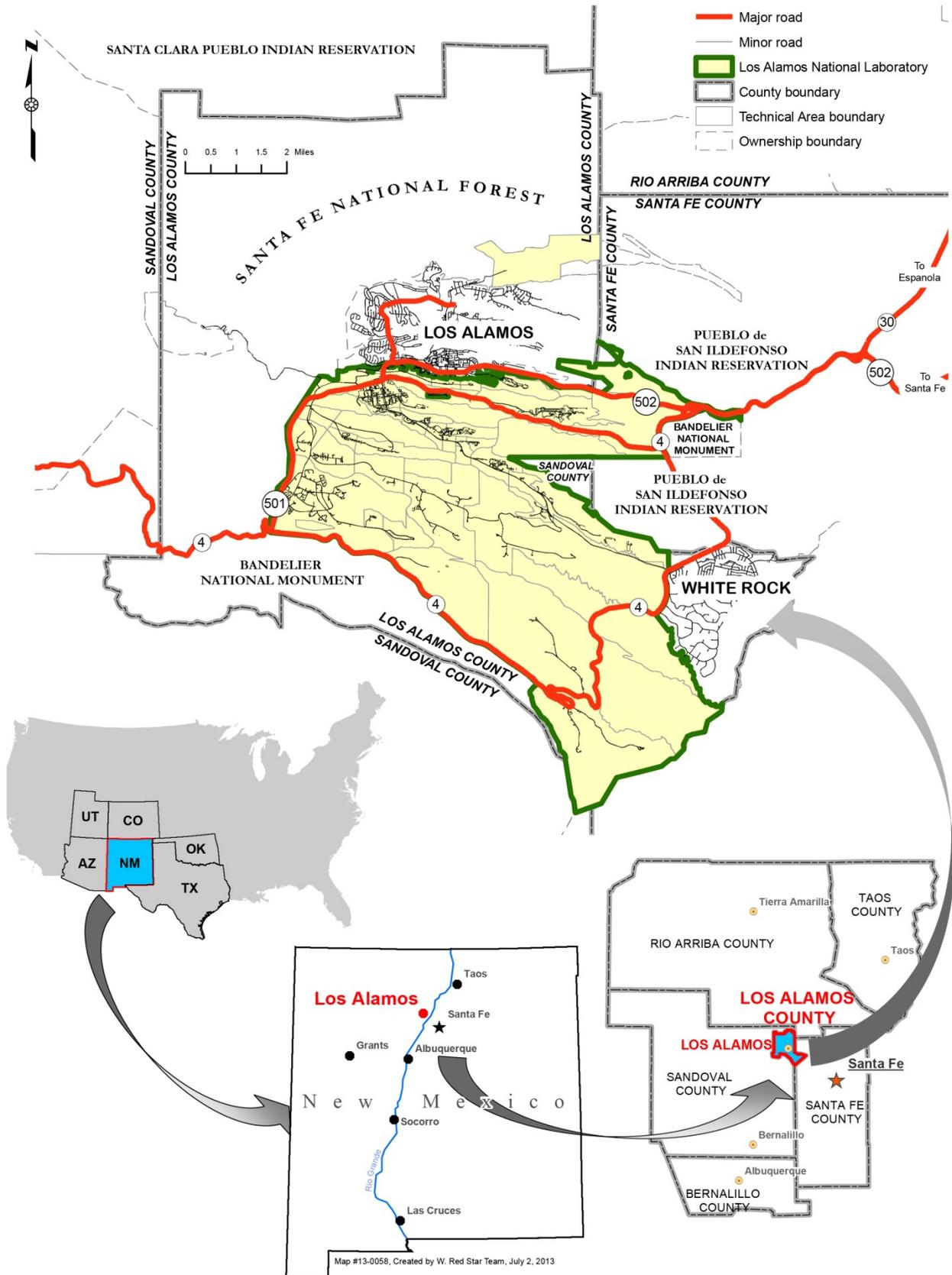


Figure 1-1 Regional location of LANL

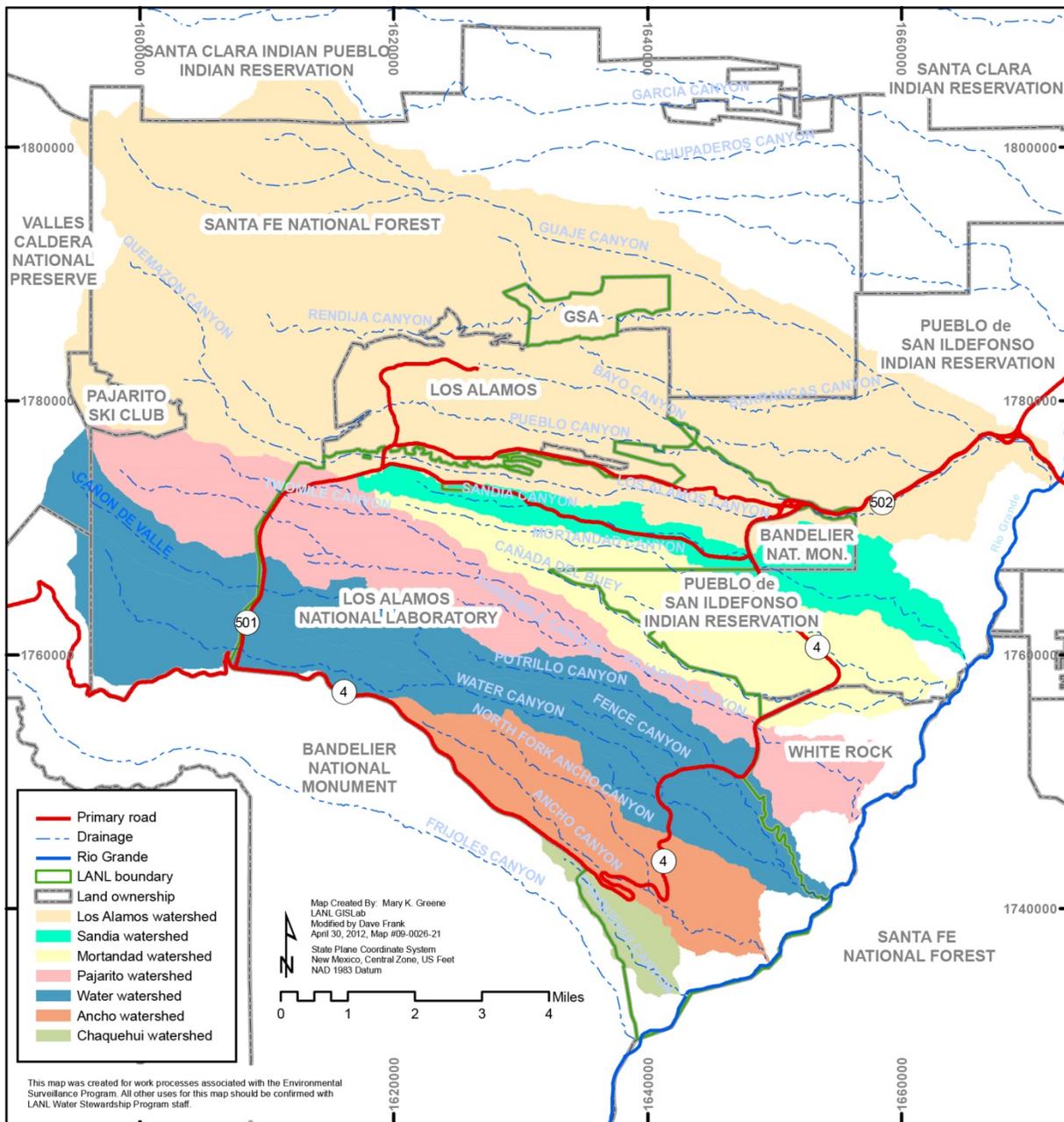


Figure 1-2 Primary watersheds at LANL

Surface water in the Los Alamos region occurs primarily as ephemeral 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 flow across the Laboratory property before the water is lost to evaporation, transpiration, and infiltration.

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 and under phreatic conditions beneath most of the Pajarito Plateau (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. A secondary

source is localized infiltration in canyons on the Pajarito Plateau (Birdsell et al. 2005). The upper portion of the regional aquifer beneath the Laboratory discharges into the Rio Grande through springs in White Rock Canyon.

3. Biological Resources

The Pajarito Plateau, including the Los Alamos area, is biologically diverse. This diversity of ecosystems is partly because of the dramatic 5000-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 because of the many steep canyons that dissect the area. Five major vegetative cover types are found in Los Alamos County. The juniper- (*Juniperus monosperma*-) 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 5600 and 6200 ft. The piñon- (*Pinus edulis*-) juniper cover type, generally between 6200 to 6900 ft in elevation, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine (*Pinus ponderosa*) communities are found in the western portion of the plateau between 6900 and 7500 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 7500 to 9500 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 9500 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 acres of forest in and around LANL. Most of the habitat damage occurred on U.S. Forest Service property to the west and north of LANL. Approximately 7684 acres, 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 there will be an appreciable increase in tree species until current climate trends improve (Munson et al. 2011).

In 2012, the Laboratory and region were still recovering from the Las Conchas Fire that burned approximately 133 acres (52 hectares) of LANL/DOE/National Nuclear Security Administration (NNSA) property in June and July 2011. Following the fire, high-priority areas in the canyons were armored to protect against potential flood damage. To protect the site from future wildfire, LANL operates a program to reduce wildfire fuels and manage forest health throughout forested areas on LANL and DOE property. Defensible space is created and maintained around facilities and other high-priority areas. Areas not designated as defensible space are managed for a combination of wildfire fuel reduction and forest health.

4. Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 88% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1800 sites have been recorded. Nearly 73% 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 77% located between 5800 and 7100 ft. A majority (59%) 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 300 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.

a. The National Park Service National Historical Park Study and Los Alamos Properties

In 2004, congressional legislation directed the National Park Service to examine historical areas associated with the Manhattan Project and to make recommendations concerning the possibility of establishing a new national park (see the Manhattan Project National Historical Park Study Act or Public Law 108-340). Potential Los Alamos park properties include buildings in the town of Los Alamos associated with the Manhattan Project but built as part of the Los Alamos Ranch School (circa 1921–1942). Six areas (nine individual properties in total) located at LANL are also part of the proposed park unit at Los Alamos. These include buildings and structures associated with the design and assembly of the “Gadget” (tested at Trinity Site), the “Little Boy” weapon (the gun-assembled device detonated over Hiroshima), and the “Fat Man” weapon (the implosion device detonated over Nagasaki), as well as two buildings that supported Laboratory work and an experimental plutonium recovery structure. Additional Manhattan Project–era properties at LANL that may be part of the proposed park include several under consideration for inclusion in the revised Los Alamos Scientific Laboratory National Historic Landmark District. New National Park Service legislation usually stipulates the development of a general management plan that identifies roles and responsibilities. In the case of the proposed Manhattan Project National Historical Park, this document would be prepared by the National Park Service with DOE participation. Legislation to establish the Manhattan Project National Historical Park in Oak Ridge, Tennessee; Los Alamos, New Mexico; and Hanford, Washington, was introduced in June 2012.

5. Climate

Los Alamos County has a temperate, semiarid mountain climate. Large differences in locally observed temperature and precipitation exist because of the 1000-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 snow 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 (with a range of 23°F). 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 18.97 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 convectively 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 are 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 midlatitude westerly winds.

The climatology of Los Alamos County is summarized in Chapter 4.

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 and their Associated Programs). 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 2800 structures, with approximately 8.6 million square feet under roof, spread over an area of approximately 36 square miles.

DOE/NNSA issued a Site-Wide Environmental Impact Statement (SWEIS) in May 2008 (DOE 2008a) and two Records of Decision in September 2008 (DOE 2008b) and June 2009 (DOE 2009). In the 2008 SWEIS, 15 Laboratory facilities are identified 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.

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; the National Security Sciences Building, which is the main administration building; and the TA-46 sewage treatment facility.

Table 1-1
Key Facilities*

Facility	TAs
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	TA-35
Machine shops	TA-03
Nicholas C. Metropolis Center for Modeling and Simulation	TA-03
High-explosives processing	TA-08, TA-09, TA-11, TA-16, TA-22, TA-37
High-explosives testing	TA-14, TA-15, TA-36, TA-39, TA-40
Los Alamos Neutron Science Center (LANSCE)	TA-53
Biosciences Facilities (formerly Health Research Laboratory)	TA-43, TA-03, TA-16, TA-35, TA-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.

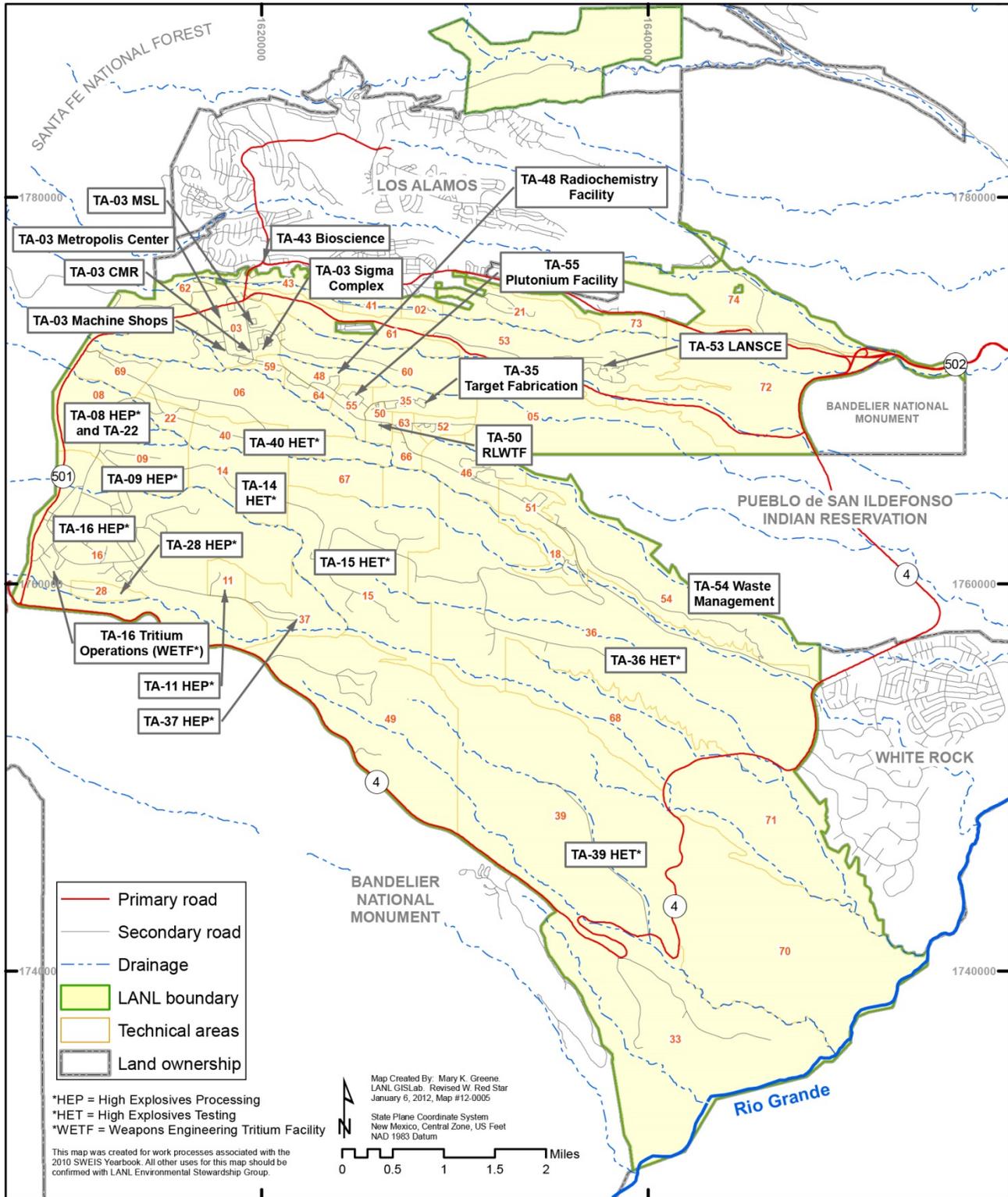


Figure 1-3 TAs and key facilities of the Laboratory in relation to surrounding landholdings

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Safety, environmental protection, and compliance with environmental, safety, and health laws and regulations are underlying values of all Laboratory work. The Laboratory uses integrated safety management to create a worker-based safety and environmental compliance culture in which all workers commit to safety, security, 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 that performance is within the context of the Laboratory's values and mission. Laboratory managers establish and manage environmental initiatives, determine and communicate expectations, allocate resources, assess performance, and are held accountable for safety performance.

The EMS, compliance, surveillance, and waste management operational support are managed within the Associate Directorate for Environment, Safety, and Health (ADESH). Environmental characterization, remediation, and waste management programs are part of the Associate Directorate for Environmental Programs. An organizational chart and description is available at <http://www.lanl.gov/resources/organizations.php>. The major environmental programs and management system are described below.

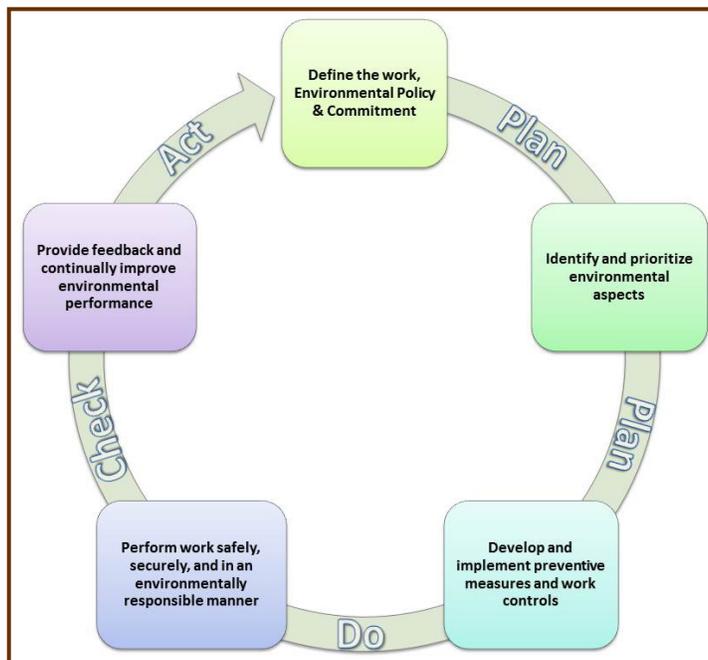
1. Environmental Management System

LANL maintains an EMS that meets the DOE Order 436.1 requirement to have an EMS "...certified to or conforming to the International Organization for Standardization's (ISO) 14001:2004...." An EMS is a systematic method for assessing mission activities, managing controls, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. LANL pursued and initially achieved registration to the ISO 14001:2004 standard in April 2006 and successfully renewed this registration at 3-yr intervals in 2009 and 2012.

A key feature of the Laboratory EMS is a focus on integrating environmental management with similar systems where possible. Integrated work management and integrated safeguards and security management both provide a framework for implementation of the five core elements of the EMS Laboratory wide:

1. Policy and commitment
2. Planning
3. Implementation and operation
4. Checking and corrective action
5. Management review

Meeting the international standard of quality for EMSs confirms LANL's commitment to ensuring regulatory compliance and protective operational management regarding all of its areas of environmental risk and responsibility, including air quality, water management, waste management, cultural and historical resource protection, biota and wildlife management, pollution prevention, and long-term site sustainability. More information about the EMS is available at <http://www.lanl.gov/community-environment/environmental-stewardship/protection/environmental-management-system.php>.



2. Waste Management Program

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

- Resource Conservation and Recovery Act–regulated nonradioactive hazardous waste;
- Toxic Substances Control Act–regulated waste (primarily polychlorinated biphenyl–contaminated waste);
- low-level radioactive waste (LLW), both solid and liquid;
- mixed LLW;
- transuranic waste;
- mixed transuranic waste;
- administratively controlled waste;
- medical waste;
- New Mexico Special Waste; and
- sanitary solid and liquid waste.

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

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

3. Pollution Prevention Program

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

“Sustainable acquisition” 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 Laboratory is characterizing and remediating, as necessary, sites to ensure that chemicals and radionuclides in the environment associated with past operations do not pose a potential unacceptable risk or dose to human health or the environment. The corrective actions at the Laboratory are subject to the requirements of a Compliance Order on Consent (Consent Order). Certificates of Completion are granted to indicate corrective actions were complete with or without controls, meaning either (1) no further corrective actions are needed, but some type of institutional controls (e.g., land use) must be in place to maintain current conditions (with controls), or (2) no additional corrective actions or conditions are necessary (without controls).

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

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

Program accomplishments for calendar year 2012 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 approximately 1000 locations (Table 1-2). Results for each of these monitoring programs are presented in Chapters 4 through 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 2012

Sample Type or Media	No. of Locations	Frequency of Sampling*	No. of Analytes or Measurements
Ambient air	46	Biweekly	6612
Stack monitoring	29	Weekly	23,577
Vegetation	57	Annually	1382
Sediment	79	Annually	15,621
Animal	12	Annually	3927
Groundwater	187	Quarterly/semiannually/annually	53,883
National Pollutant Discharge Elimination System outfalls	9	Weekly	1381
Surface water base flow	11	Quarterly/semiannually/annually	2400
Surface water storm runoff	69	Following rains	30,629
Neutron radiation	47	Quarterly	188
Gamma radiation	98	Quarterly	392
Environmental restoration soil/rock investigation sampling	308	Annually	20,739
Subsurface vapor monitoring	19	Monthly/quarterly/annually	10,917
Totals	971		171,648

Notes: 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. Sampling frequency is location-dependent when more than one frequency is listed.

* 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 are available through the Intellus New Mexico database (<http://www.intellusnmdata.com>). This tool was developed to provide public access to the same data that the New Mexico Environment Department (NMED) and LANL use in making remediation and other environmental management decisions.

The Laboratory is regulated under 27 separate environmental regulatory permits issued by NMED and the U.S. Environmental Protection Agency. These permits govern air emissions; liquid effluents; waste generation, treatment, storage, and disposal; and environmental restoration. The Laboratory's environmental compliance programs and results are presented in Chapter 2.

6. Continued Impacts from the 2011 Las Conchas Fire

The Las Conchas wildfire started on June 26, 2011, in the Jemez Mountains, approximately 10 mi west of the Laboratory. The fire ultimately burned approximately 156,600 acres, making it the largest wildfire in New Mexico history at the time; the fire was not 100% contained until August 1, 2011. Fire damage in the

upper portions of these watersheds greatly increased the risk of flash floods and flood damage in the downstream canyons. In response to this increased flood risk, the Laboratory implemented mitigation actions in 2011 and 2012 to lessen the potential for flood damage and to control the potential for mobilization of contamination.

a. Flood Damage and Mitigations

In 2012 there was no significant flooding, and thus no flood damage occurred and no mitigations were necessary. A low-head weir was installed in Los Alamos Canyon near the downstream boundary of the Laboratory after the Cerro Grande Fire in 2001 to collect sediment mobilized by flooding. In anticipation of increased sediment load following the Las Conchas Fire, sediment was removed from the basins upstream of the weir to provide additional storage capacity. During 2011 and 2012, after the Las Conchas Fire, approximately 6000 cubic yards of sediment was collected in the weir, and from March to May 2012, this sediment was removed and staged in Los Alamos Canyon in a borrow pit well above the active stream channel and floodplain. Flooding since the Las Conchas Fire has resulted in partial erosion and redistribution of sediment in Los Alamos, Pajarito, and Water Canyons and Cañon de Valle. As a result, the current distribution of contaminants in sediment in these canyons may be different from that reported in prior investigation reports. In Pajarito Canyon, silver that had not been identified as a concern in a particular reach before the Las Conchas Fire was detected above background values in 2012, indicating post-Las Conchas Fire floods likely transported some silver contamination downcanyon from source areas. In general, contaminants of potential concern detected in sediment have a primary source in the Las Conchas Fire burn area and are associated with the transport of ash. Transport of some contaminated sediment is not expected to result in deposits with higher than pre-fire concentrations because of the mixing of sediment from different sources; therefore, the potential risk or dose associated with sediment contamination would not have increased.

c. Fire Mitigation

Tree thinning and mastication was performed in Los Alamos Canyon to reduce the potential for fire spreading downcanyon toward the Los Alamos townsite. Thinning was performed from the Los Alamos County ice rink west to the Laboratory boundary.

Potential fuels in Pajarito Canyon were removed from along each side of Pajarito Road in the vicinity of TA-54. Fuel reduction was accomplished by removing trees and by mowing to provide additional fire protection to TA-54. Fuel reduction was also performed beneath power lines near the western Laboratory boundary along the eastern side of NM 501.

7. The Long-Term Strategy for Environmental Stewardship and Sustainability for Los Alamos National Laboratory

As reflected by the nearly 70-yr history of LANL, the next 50 yr will bring significant changes to the mission and operations of the Laboratory. Regardless of inevitable changes in mission and environmental requirements, the Laboratory is committed to operating the site sustainably. In 2012, the Laboratory adopted the Long-Term Strategy for Environmental Stewardship and Sustainability (Long-Term Strategy). The foundation of the Long-Term Strategy is fourfold:

- To clearly define our strategies to support environmental stewardship and restoration
- To implement actions to achieve our goals and objectives for environmental stewardship



- To involve every Laboratory employee in taking actions to protect and restore the environment
- To communicate transparently

The Long-Term Strategy looks at a 50-yr time frame (2012–2062) to consider the nature of environmental stewardship after cleanup activities focused on the environmental legacy of the Manhattan Project and Cold War have been completed. For this strategy, environmental stewardship focuses on the cleanup or stabilization of legacy contamination, waste management, control of emissions from existing mission operations, and the development and implementation of approaches to site sustainability.

a. Environmental Grand Challenges

The Long-Term Strategy sets forth the following long-term environmental grand challenges, a set of goals and objectives that the Laboratory will strive to achieve through integration of the Laboratory’s environmental and operational programs, providing a coordinated approach to environmental stewardship and sustainability (Figure 1-4):



Figure 1-4 Environmental Grand Challenges—Our goals to live a sustainable future

b. Policy

Environmental stewardship requires an active management system to provide a framework for setting environmental policy, planning, implementation, corrective actions, and management review. To manage these processes, the Laboratory uses an EMS that is compliant with DOE Order 436.1, Departmental Sustainability (DOE 2011b). The Laboratory has been certified to the ISO 14001:2004 standard for EMS since April 2006.

The first element of an ISO 14001 EMS is to define the institution’s senior management commitment as expressed in a policy communicated to all workers and the public. The Laboratory’s environmental policy is the following:

We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements. We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

c. Overarching Strategies

The Long-Term Strategy provides a set of long-term goals and supporting objectives for effective environmental stewardship at the Laboratory. Key strategies described in the Long-Term Strategy include the following:

- “Defenses-in-Depth”: This strategy is implemented through an extensive monitoring system coupled with a series of administrative and physical controls that restrict access and movement of potential contaminants off-site.
- Environmental ALARA (as low as reasonably achievable): The Laboratory evaluates all new and modified operations that involve radioactive materials and ensures that impacts to human health are ALARA. This concept will also be applied to environmental stewardship and sustainability.
- Off-Site Disposal: The Laboratory will discontinue on-site disposal of wastes whenever possible.
- Pollution Prevention: A Laboratory strategy is to prevent pollution whenever and wherever possible. This approach not only serves to protect the environment, it is a sound business strategy to improve mission processes and safety as well as to avoid significant waste management costs.
- Management Integration: An integrated schedule of projects is presented that, in support of the Long-Term Strategy’s objectives, addresses legacy issues and current operations to achieve the future Laboratory goals of zero-waste strategies and environmental sustainability.

d. Communications and Decision Support

To provide the public with a comprehensive picture of the Laboratory’s integrated environmental strategy and performance, the Laboratory uses multiple communication tools that provide information on our environmental protection actions and results and address the public’s major concerns about past, present, and future Laboratory operations. Specifically, the Laboratory maintains a website with information about cleaning up contamination from the past, controlling today’s mission impacts, and planning for future environmental stewardship (<http://www.lanl.gov/community-environment/environmental-stewardship/index.php>). Environmental stewardship leaders and subject-matter experts frequently go out into the community to provide information and solicit input for future decision-making. Further, local tribal environment departments meet regularly with the Laboratory to learn about projects and contribute to planning.

In addition, a decision-support application has been developed that provides spatial and analytical information to decision makers to compare alternatives and to keep environmental impacts ALARA. Specifically, the Decision Support Application can

- identify potential resource impacts;
- assist with siting decisions, project land-use preplanning, and identification of environmental requirements by showing selected opportunities and constraints on a particular site;
- search for potential environmental issues with seismic, soils, geology, migration, and infrastructure parameters;
- identify brownfield locations and potential lower-impact and/or lower-risk areas for future construction or development projects; and
- identify conflicts in land use.

E. REFERENCES

- Birdsell et al. 2005: Birdsell, K.H., B.D. Newman, D.E. Broxton, and B.A. Robinson, “Conceptual Models of Vadose Zone Flow and Transport beneath the Pajarito Plateau, Los Alamos, New Mexico,” *Vadose Zone Journal*, Vol. 4, pp. 620–636. (2005).
- DOE 2008a: “Final Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico,” DOE/EIS-0380 (May 16, 2008).
- DOE 2008b: “Record of Decision: Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico,” Federal Register Vol. 73, No. 188, pp. 55833–55840. (September 26, 2008).
- DOE 2009. “Record of Decision: Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory in the State of New Mexico,” Federal Register Vol. 74, No. 131, pp. 33232–33235. (July 10, 2009).
- DOE 2011a: “Environment Safety and Health Reporting,” U.S. Department of Energy Order 231.1B (June 27, 2011).
- DOE 2011b: “Departmental Sustainability,” U.S. Department of Energy Order 436.1 (May 2011).
- LANL 2007: “Update of the Probabilistic Seismic Hazard Analysis and Development of Seismic Design Ground Motions at the Los Alamos National Laboratory,” prepared for Los Alamos National Laboratory by URS Corporation and Pacific Engineering and Analysis (May 25, 2007).
- LANL 2010: “SWEIS Yearbook – 2008,” Los Alamos National Laboratory report LA-UR-10-03049 (June 2008).
- Munson et al. 2011: Munson, S.M., J. Belnap, and G. Okin, “Responses of Wind Erosion to Climate-Induced Vegetation Changes on the Colorado Plateau.” *Proceedings of the National Academy of Sciences*, 108, 3854-3859 (March 8, 2011).
- Purtymun and Johansen 1974: Purtymun, W.D., and S. Johansen, “General Geohydrology of the Pajarito Plateau,” in *New Mexico Geological Society Guidebook (25th Field Conference, Ghost Ranch, New Mexico, 1974)*.
- WMO 1984: World Meteorological Organization, *Technical Regulations*, Vol. I, WMO No. 49, Geneva, Switzerland (1984).

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Compliance with environmental regulations and policies is part of the foundation of Los Alamos National Laboratory's (LANL's or the Laboratory's) environmental stewardship program and helps the Laboratory attain its overall goal of environmental sustainability.

A. INTRODUCTION

Many operations at the Laboratory use or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. These operations, emissions, and effluents are regulated by U.S. 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 U.S. Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. Los Alamos National Security, LLC (LANS) 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 231.1B, Environment, Safety, and Health Reporting

DOE Order 231.1B, 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 2011a). This Environmental Report fulfills DOE Order 231.1B requirements to publish an annual site environmental report. The objectives of this report are to

- characterize site environmental management performance, including effluent releases, environmental monitoring, types and quantities of radioactive materials emitted, and radiological doses to the public;
- 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; and
- summarize property clearance activities.

The Laboratory began environmental monitoring in 1945 and published the first comprehensive environmental monitoring report in 1970.

2. DOE Order 436.1, Departmental Sustainability

DOE Order 436.1, Departmental Sustainability (DOE 2011b), requires all DOE sites to manage

sustainability within the DOE to (1) ensure the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future, (2) institute wholesale cultural change to factor sustainability and greenhouse gas (GHG) reductions into all DOE corporate management decisions, and (3) ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan (SSPP) pursuant to applicable laws, regulations and Executive Orders (EO), related performance scorecards, and sustainability initiatives.

The order further states that these objectives must be accomplished within the framework of the site Environmental Management System (EMS), which must be compliant with International Standards Organization (ISO) 14001:2004.

LANL pursued and achieved registration to the ISO 14001:2004 standard in April 2006. In 2012, there were two audits: one recertification audit and one routine surveillance external audit of the LANL EMS program. The 3-yr cycle recertification external audit was held early in 2012 with no major findings and a determination to extend LANL’s 14001:2004 certification.

The LANL EMS promotes regulatory compliance and operations management for all of its environmental requirements and risks across a wide range of environmental areas, including air, water, waste, cultural resources, biota, and wildlife, to name a few. Institutional programs are in place for each of these environmental areas. In response to DOE Order 436.1, LANL also creates and manages an annual, fiscal-year based site sustainability plan (SSP) to focus on energy and long-term sustainability milestones (see Section B2.b, below, for more detail). In 2012, at the request of DOE’s Los Alamos Field Office (formerly the Los Alamos Site Office [LASO]), LANL completed a long-term environmental stewardship and sustainability strategy plan to assist managers in identifying longer-term stewardship goals and initiatives (LANL 2012a).

In addition, multidisciplinary teams from each LANL directorate annually identify the environmental impacts associated with their work scope, prioritize these risks, and develop an environmental action plan to manage those risks. Combined, all of the above activities supported the Laboratory in meeting several milestones during fiscal year (FY) 2012 (October 2011 to September 2012) and calendar year (CY) 2012. LANL identified three high-level objectives to support its goal of establishing excellence in environmental stewardship during FY12. These objectives and FY12 accomplishments associated with them are presented in Table 2-1. Many additional accomplishments are cited in the following sections in greater detail. The Laboratory maintained a high level of environmental compliance performance in FY12 and maintained a fully compliant EMS.

**Table 2-1
FY12 Environmental Objectives and Accomplishments**

Objective	Example Accomplishments
Clean the Past	LANL’s transuranic (TRU) waste program shipped a record 920 m ³ of TRU waste to the Waste Isolation Pilot Plant (WIPP) in FY12.
Control the Present	LANL has been performing well in sustainable acquisition. In 2012, LANL won a GreenBuy award from DOE for purchasing sustainable products.
Create a Sustainable Future	The Sanitary Effluent Reclamation Facility (SERF) treats effluent from LANL’s sanitary wastewater plant to be used in various cooling towers at LANL. The effluent is cleaned to higher standards than even drinking water, and less groundwater needs to be pumped to provide water for the cooling towers. Less wastewater is generated because it can be reused in the cooling towers.

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 FY12 yielded millions of dollars in cost avoidances to the Laboratory and allowed hundreds of hours of labor to be spent more productively. Waste generation is tracked in four categories, including hazardous waste, low-level waste (LLW), mixed low-level waste (MLLW), and TRU/mixed TRU (MTRU) waste. LANL also tracks its recycling percentage and weight of sanitary trash generated per person. In FY12, LANL generated less routine LLW waste than in FY11 but more routine waste of all other types. In FY12, the amount of routine sanitary waste generated per person increased over FY11 levels, and the recycling percentage of solid waste increased. The differences in routine waste generation and recycling percentage are shown in Table 2-2.

Sustainable acquisition refers to the practice of purchasing items that contain recycled content. The EPA designated seven categories of products that are known to include 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 nonpaper office products. DOE requires LANL to review new contract actions each year and to have a plan that ensures 95% of new contract actions, including task and delivery orders under new contracts and existing contracts, require the supply or use of products and services that are energy efficient, water efficient, bio-based, environmentally preferable, non-ozone depleting, contain recycled content, or are nontoxic or less-toxic alternatives.

Table 2-2
Comparison of FY11 and FY12 Routine
Waste Generation and Recycling Percentage

LANL P2 Performance Index	FY11 Generation	FY12 Generation
Routine hazardous waste	8.3 metric tons	12.3 metric tons
Routine LLW	975 m ³	726.8 m ³
Routine MLLW	2.5 m ³	5.9 m ³
Routine sanitary waste	142 kg/person	145 kg/person
Routine TRU/MTRU waste	82.1 m ³	88.9 m ³
Recycling	50% of solid waste	81% of solid waste

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; Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management; and Executive Order 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 (GHG) reduction strategies and provide for implementation of an SSP. Site sustainability seeks to reduce consumption of natural resources so that LANL 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.

The Laboratory's SSP identifies appropriate projects that will contribute to meeting 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, 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 SERF expansion, High Performance Sustainable Building (HPSB) implementation, communication and outreach in conjunction with metering efforts, building automation system night setback scheduling, and the associated footprint reduction efforts to achieve our energy, water, and GHG management goals.

DOE required its subcontractors to publish SSPs as part of meeting the requirements set forth in its Strategic Sustainability Performance Plan. The Laboratory published an FY12 SSP (LANL 2011a), and Table 2-3 shows the Laboratory’s performance status toward meeting the sustainability goals.

**Table 2-3
Sustainability Performance Status**

DOE/NNSA Goal	Performance Status	Planned Actions and Contribution
28% Scope 1 and 2 GHG reduction by FY20 from an FY08 baseline	LANL has achieved a 7% reduction in Scope 1 and 2 GHG emissions compared with the FY08 baseline.	LANL will purchase Renewable Energy Certificates (RECs) and continue to pursue and implement lower carbon electricity resources and energy reduction projects to reduce GHG emissions as part of an overall strategy to reach the 28% reduction goal.
30% energy intensity reduction by FY15 from an FY03 baseline	The ESPC lighting and heating, ventilation, and air conditioning (HVAC) upgrades project was completed during FY12. In FY12, LANL calculated and tracked a rolling 12-mo energy intensity based on an FY03 baseline. A year-end net energy intensity reduction of 6.5% was reported. Year-end projections reflect an increase in base load electrical energy use and continued footprint reduction yielding the observed energy intensity trends.	In FY13, LANL plans to strategically invest \$2.3M to reduce energy consumption in facilities. This investment is estimated to yield an energy reduction percentage of approximately 3%.
Individual buildings or processes metering for 90% of electricity (by October 1, 2012) and for 90% of steam, natural gas, and chilled water (by October 1, 2015) where life cycle cost effective. The site may also report on potable water and chilled water as applicable.	LANL used the same evaluation methodology and justification determination designed for electric meters for thermal metering. In 2012, LANL installed electric meters to account for 91% electricity at the building level.	LANL will complete 65% of gas and 15% of steam meter installations in FY13 and will meet the DOE metering goals by the end of FY14 as defined in the LANL metering plan.
Use of cool roofs, unless uneconomical, for roof replacements unless project already has Critical Decision 2 approval. New roofs must have thermal resistance of at least R-30.	All new roofs meet cool roof requirements per engineering standards. In FY12, there was 75,566 ft ² of cool roofing installed.	The Roof Assets Management Program has designed replacement of approximately 280,000 ft ² of roofing for 2013. Every roof will be replaced within the parameters established at an R-value of 30 or above, and the membranes will meet the cool roof initiatives.
7.5% of annual electricity consumption from renewable sources by FY13 and thereafter (5% FY10–FY12)	LANL exceeded the 7.5% renewable energy goal. LANL purchased 48,683 RECs in FY12. With the allowable double credit for federal site production using the Abiquiu Dam low-flow turbine, LANL is reporting a total of 86,033 megawatt-hour (MWh) of renewable energy. The Laboratory used approximately 480,959 MWh of electricity in FY12, including on-site renewable generation. The purchased RECs and on-site renewable energy compose approximately 18% of the annual electricity consumption.	LANL will continue to support economically feasible on-site renewable energy and purchase RECs to meet this goal.
10% annual increase in fleet alternative fuel consumption by FY15 relative to an FY05 baseline	In FY12, alternative fuel consumption was a total of 46,227 gal., 23,481 gal. of E-85 and 22,746 gal. of B5 biodiesel fuel, which is an annual increase of 65% and a 420% increase compared with the FY05 baseline.	LANL will continue to purchase and increase utilization of alternative fuel for vehicles by 10% for E-85 and B5 in FY13. LANL plans to increase the percentage of biodiesel within the blend over time based on operational performance.
2% annual reduction in fleet petroleum consumption by FY20 relative to an FY05 baseline	Fleet petroleum use was reduced by 9.7% in FY12. LANL has reduced fleet petroleum by 25.6% compared with the FY05 baseline.	LANL will continue to right-size the fleet and expand alternative fuel use to reduce petroleum consumption by 2% in FY13.

Table 2-3 (continued)

DOE/NNSA Goal	Performance Status	Planned Actions and Contribution
100% of light-duty vehicle purchases must consist of alternative fuel vehicles (AFVs) by FY15 and thereafter.	68% of LANL's light-duty vehicles are considered AFVs. In FY12, LANL added 13.6%, or 112, new light-duty AFVs to the fleet. Availability of AFVs in the General Services Administration (GSA) schedule of replacements is limited, and replacement vehicle requirements constrain AFV alternatives.	LANL will continue to replace vehicles with AFVs and expand fleet utilization to achieve 100% AFV purchases by the 2015 cycle.
Reduce fleet inventory of non-mission-critical vehicles by 35% by FY13 to an FY05 baseline	A reduction of 1.3% is estimated for all vehicles compared with the FY05 baseline. Utilization rates averaged over the last 35 mo have been used to determine leases that will not be renewed.	Utilization rates averaged over the last 35 mo have been used to determine leases that will not be renewed in FY13. LANL plans to review and determine non-mission-critical status for the fleet and estimates reducing the non-mission-critical vehicles by 20% in FY13 and will develop a plan to reduce non-mission-critical vehicles by a net of 35%. Vehicle reductions in FY13 may be constrained by GSA lease requirements.
13% Scope 3 GHG reduction by FY20 from an FY08 baseline	The top three contributors to LANL's Scope 3 GHG emissions are travel, commuting, and losses associated with transmission and distribution lines. LANL did not take any credit for Park and Ride, vanpool, or carpool activities. This metric is updated annually each November. LANL achieved a 4% reduction in Scope 3 GHG emissions because of decreased air and ground travel and employee commuting.	LANL recognizes that the most practical way to reduce Scope 3 GHG emissions is by reducing commuting. LANL is exploring options for reducing commuting, e.g., changing work schedules to a 4-day by 10-h work week, promoting large-scale telecommuting, and relocating administrative and transactional functions to a satellite location.
15% of existing buildings greater than 5000 gross square feet are compliant with the guiding principles of HPSB by FY15	Overall, LANL has implemented 38% of the HPSB guiding principles within 31 facilities.	LANL plans to continue implementing the guiding principles within selected HPSBs, focusing on HVAC and building automation system recommissioning, and plans to increase the average guiding principle implementation rate to 60% within FY13 as measured in the EPA's Portfolio Manager. LANL is investing approximately \$1.3 million in HPSBs in FY13 as part of the overall funding to reduce energy use in facilities. HPSB program evaluations are underway to better quantify the challenges to achieve the FY15 goal.
All new construction, major renovations, and alterations of buildings greater than 5000 gross square feet must comply with the HPSB guiding principles, and where the work exceeds \$5 million, each is certified as Leadership in Energy and Environmental Design (LEED) – New Construction Gold or equivalent.	The Radiological Laboratory, Utility, and Office Building (RLUOB) obtained Gold Certification in FY13. DOE recently awarded the Laboratory an Environmental Sustainability (EStar) Award for integrating sustainable practices in the RLUOB design.	Over 600,000 ft ² of major new projects currently in the planning stages are being formulated to be certified as LEED Gold Projects. LANL will continue to implement and manage efforts to address the requirements of achieving LEED Gold status and 35% improvement over American Society of Heating, Refrigeration, and Air-Conditioning Engineers standards for new projects using cost-effective capital outlay strategies to achieve long-range operational benefits.

Table 2-3 (continued)

DOE/NNSA Goal	Performance Status	Planned Actions and Contribution
26% potable water intensity (gallons per gross square foot) reduction by FY20 from an FY07 baseline	LANL's water-use reduction was dependent in FY12 on SERF operations and industrial water reuse at the Strategic Computing Complex (SCC). Completion of the SERF project and meeting the criteria of the National Pollutant Discharge Elimination System (NPDES) required significant effort for the Laboratory in FY12. LANL's total water intensity has increased by approximately 39% because of cooling towers supporting increased supercomputing.	LANL will continue to operate SERF to reduce potable water use within the SCC. In addition, LANL will continue to implement some of the low-cost/no-cost recommendations in the Science Program Office-funded water analysis and report, including once-through cooling in the steam plant. LANL is also investing in a new chemical treatment system to increase cycles of concentration in LANL cooling towers that could reduce water consumption in cooling towers by approximately 35%. LANL estimates it will reduce potable water consumption by 33 million gallons in FY13. Water reduction milestones in FY13 are estimated to change goal performance from +39% to +16%.
20% water consumption (in gallons) reduction of industrial, landscaping, and agricultural water by FY20 from an FY10 baseline	LANL has written and implemented a Landscape Implementation Plan to decrease water used for landscape irrigation.	Currently, all of LANL's water use is potable water and is, therefore, considered part of the 26% water intensity reduction goal reporting.
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, by FY15	LANL diverted 47% of solid, nonhazardous waste (1275 metric tons of 2726 metric tons).	LANL will continue to identify and implement opportunities for improvement in nonhazardous solid waste recycling/diversion in FY13–FY15.
Divert at least 50% of construction and demolition materials and debris by FY15	In FY12, LANL recycled or diverted 93% of construction and demolition waste (6993 metric tons of 7480 metric tons). In FY12, LANL completed installation of the clean fill yard at Technical Area 60 (TA-60) and documented shipping savings of over \$400,000 in its first 2 mo. The on-site clean fill yard recycles construction and demolition material and reduces shipping distances versus off-site disposal.	LANL will continue diverting construction and demolition waste.
Procurements meet requirements by including necessary provisions and clauses (sustainable procurements/bio-based procurements)	LANL successfully purchased 11 designated priority products with leadership-level sustainable attributes in 5 categories and eliminated Styrofoam products from cafeterias.	LANL will work to increase procurement of environmentally preferable products while increasing visibility and reporting capability for those procurements. The Laboratory will analyze subcontracts to determine a sub-target population of large-volume environmentally preferable product contractors and will evaluate supporting subcontract content and language.
All data centers are metered to measure a monthly power utilization effectiveness (PUE) (100% by FY15).	LANL installed an Environmental and Power Monitoring System at the Laboratory Data Communications Center (LDCC) and can measure environmental conditions and power in real time. Similar to the system within the SCC, this system enables LANL to continually trend power and temperature measurements and systematically optimize efficiencies in the data centers.	LANL has assembled a Data Center Evaluation Team to identify and evaluate the extent of metering required. LANL will install metering in the 3-132 data center to increase the data center metering to account for approximately 45% of the unclassified non-high-performance computing on-site.
Maximum annual weighted average PUE of 1.4 by FY15	The PUE at the SCC is currently averaging at 1.35, and this number can be improved. The PUE at the LDCC is averaging 1.65.	LANL will continue to use the environmental monitoring systems at both the SCC and the LDCC to achieve this goal.
100% of eligible personal computers, laptops, and monitors with power management actively implemented and in use by FY12	LANL completed a pilot in implementing central management of Windows desktops and laptops using Microsoft System Center Configuration Manager (SCCM).	LANL will upgrade to SCCM 2012 in FY13. Power settings will be configured via SCCM on all new eligible Windows workstations.

3. DOE Orders 5400.5 and 458.1, Radiation Protection of the Public and the Environment

During 2012, the Laboratory implemented DOE Order 458.1, which replaced 5400.5, Radiation Protection of the Public and the Environment (DOE 2011c). Both of these orders establish the requirements to protect the public and the environment against undue risk from radiation associated with activities conducted by DOE facilities. Protections include 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 458.1 during 2012. Public and biota dose assessments, ALARA assessments, and the clearance of real and personal property are presented in Chapter 3, Radiological and Nonradiological Dose Assessment.

4. DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of radioactive wastes: LLW, MLLW, TRU waste, and MTRU waste. (Note: LLW and TRU waste definitions are provided in the glossary.) MLLW is LLW that also contains a hazardous (Resource Conservation and Recovery Act– [RCRA–] regulated) component, and MTRU waste is TRU waste with a hazardous component. Only LLW is disposed of 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 435.1-1 and DOE Manual 435.1-1 (DOE 1999, 2001). The hazardous component of MLLW and MTRU 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 of radioactive waste must have a DOE–Los Alamos Field Office–approved Radioactive Waste Management Basis (RWMB). The Los Alamos Field Office approved the most recent RWMB on February 29, 2012, 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 (1) will meet the acceptance requirements for a disposal facility, (2) will meet LANL on-site storage requirements, and (3) 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.

b. Low-Level Waste

The Laboratory disposes of LLW off-site at the Nevada National Security Site (NNSS) at a commercial site located near Clive, Utah, and on-site at TA-54, Area G. To dispose of LLW at Area G, DOE Order 435.1 requires the Laboratory to have an approved operational closure plan and performance assessment (PA)/composite analysis (CA). The closure plan demonstrates the Laboratory’s plan for decommissioning LLW disposal operations at TA-54, Area G. The TA-54, Area G PA 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 1000-yr period after closure. The TA-54 Area G CA accounts for all sources of radioactive material that are planned to remain on-site at LANL that may interact with the LLW disposal facility and contribute to the dose projected to a hypothetical member of the public from Area G. As with the Area G PA, the CA 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 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-Headquarters) 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 James J. McConnell and Randal S. Scott (DOE-Headquarters) to Donald L. Winchell (DOE-LASO)

During 2012, LANL generated approximately 3700 m³ of LLW. This amount includes waste generated during routine operations and during campaigns, such as environmental restoration cleanups. During 2012, LLW generation was much lower than in previous years because of the completion of American Recovery and Reinvestment Act-funded decontamination and decommissioning (D&D) of TA-21 buildings in 2011 (Figure 2-1). In 2012, approximately 10,657 m³ of LLW was buried at TA-54, Area G. During 2012, LANL generated approximately 40 m³ of MLLW and shipped these wastes to approved disposal facilities at the NNSS and near Clive, Utah. LANL maintained compliance with all aspects of its RWMB during 2012.

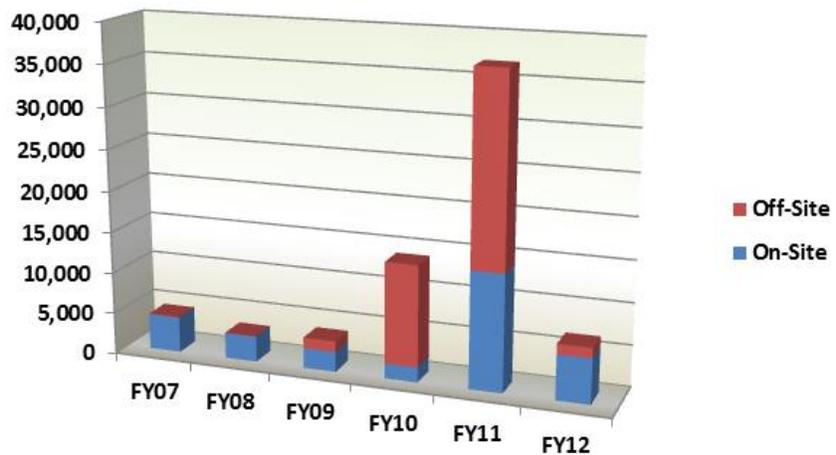


Figure 2-1 LANL LLW disposition

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 LANL TRU Program manages disposition of TRU waste in storage and newly generated TRU waste to WIPP, which is located east of Carlsbad, New Mexico. The program also ensures appropriate facilities and equipment are available to prepare legacy and current TRU waste for disposal at WIPP.

Figure 2-2 presents the cumulative inventory of TRU wastes that have been shipped from Los Alamos. Most of this TRU waste was shipped to WIPP, but some TRU waste was reclassified to MLLW after radioassay showed the waste did not meet the current definition of TRU waste. The waste was shipped to commercial treatment facilities. During FY12, 845.3 m³ of TRU waste (including MTRU waste) was shipped to WIPP, and 74.7 m³ of TRU waste that was reclassified to MLLW waste

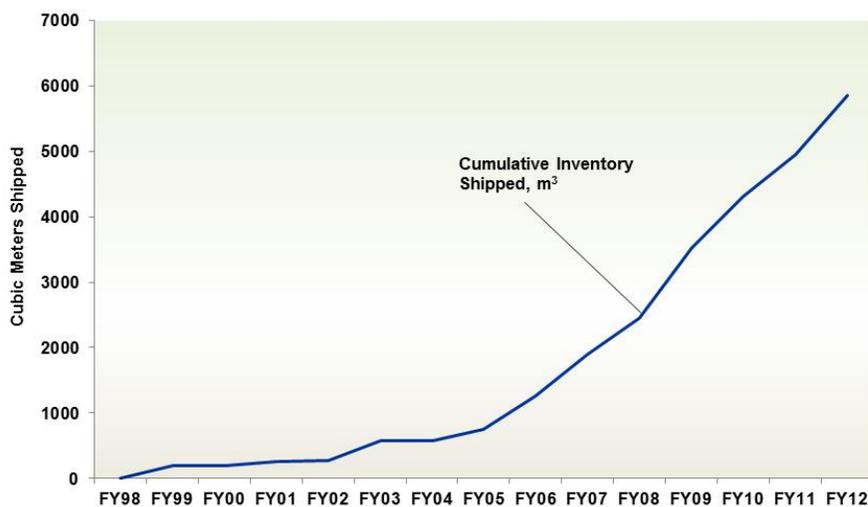


Figure 2-2 TRU waste shipping profile

was shipped. The DOE/NNSA and NMED announced a Framework Agreement for Realignment of Environmental Priorities in early January 2012 that contains several important commitments for TRU waste at LANL. These commitments include (1) complete removal of all noncemented aboveground TRU waste stored at Area G as of October 1, 2011 (defined as a total of 3706 m³ of waste material) by no later than June 30, 2014; (2) complete removal of all newly generated TRU waste received at Area G during FY12 and FY13 by no later than December 31, 2014; and (3) based on projected funding profiles, a schedule with pacing milestones for disposition of the belowground TRU waste requiring retrieval at Area G, developed by December 31, 2012. DOE/NNSA also committed to complete removal of the aboveground cemented TRU waste in an efficient and effective manner protective of the health and safety of workers and the public.

C. COMPLIANCE STATUS

The EPA and NMED regulate Laboratory operations under various environmental statutes (e.g., Clean Air Act, Clean Water Act [CWA]) through operating permits, construction approvals, and the Compliance Order on Consent (the Consent Order). These permits are designed by the regulatory agencies to allow Laboratory operations to be conducted while ensuring 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 2012 and the specific operations and/or sites affected. Table 2-6 lists the various environmental inspections and audits conducted at the Laboratory during 2012. The following sections summarize the Laboratory's regulatory compliance performance during 2012.

**Table 2-5
Environmental Permits or Approvals under which the Laboratory Operated during 2012**

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA Permit	Hazardous Waste Facility Permit, permitted hazardous waste storage units: TA-03, TA-50, TA-54, and TA-55	November 1989, renewed November 2010	December 2020	NMED
	40 CFR ^a 265 standards, interim status hazardous waste storage and treatment facilities: TA-14, TA-16, TA-36, TA-39, and TA-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 October 29, 2012	September 20, 2015	NMED
CWA/NPDES	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012 (administratively continued through 2012 [continued until a new permit is issued])	EPA
	MSGP ^b 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 ^c and AOCs ^d	November 1, 2010	October 31, 2015	EPA
	Construction general permits (17) for the discharge of storm water from construction activities	February 16, 2012	February 16, 2017	EPA
CWA Sections 404/401	USACE ^e nationwide permits (2)	March 19, 2012/ April 13, 2012	March 18, 2017	USACE/NMED
Groundwater Discharge Permit, TA-46 SWWS ^f Plant, DP-857	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998 Renewal application submitted July 2, 2010	January 7, 2003 ^g	NMED
Groundwater Discharge Plan, TA-50, RLWTF ^h , DP-1132	Discharge to groundwater	Application submitted August 20, 1996 Application resubmitted February 16, 2012	Approval pending	NMED
Groundwater Discharge Plan, Domestic Septic Tank/Leachfield Systems, DP-1589	Discharge to groundwater	Application submitted April 27, 2006 Application resubmitted June 25, 2010	Approval pending	NMED
Groundwater Discharge Plan, Land Application of Treated Groundwater from a Pumping Test at Well R-28, DP-1793	Discharge to groundwater	Submitted December 20, 2011 Supplemental Information March 13, 2012	Approval pending	NMED

Table 2-5 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC ^c)	LANL air emissions (P100) Renewal 1, modification 1	August 7, 2009 (initial) June 15, 2012 (current)	August 7, 2014	NMED
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher (2195) Retired and removed from operating permit Permit number will remain active to track exempt sources at LANL	June 16, 1999 (initial) June 15, 2006	None	NMED
	TA-03 power plant (2195-B) Permit modification 2	September 27, 2000 (initial) November 1, 2011 (current)	None	NMED
	1600-kW ^j generator at TA-33 (2195-F) Permit revision 3	October 10, 2002 (initial) May 28, 2008 (current)	None None	NMED NMED
	Two 20-kW generators and one 225-kW generator at TA-33 (2195-P)	August 8, 2007	None	NMED
	Asphalt plant at TA-60 (2195-G) Permit revision 1	October 29, 2002 (initial) September 12, 2006 (current)	None None	NMED NMED
	Data disintegrator (2195-H) CMRR ^k , RLUOB (2195-N) Permit revision 2	October 22, 2003 September 16, 2005 (initial) September 25, 2012 (current)	None None	NMED NMED
Air Quality (Beryllium NESHAP ^l)	Beryllium machining at TA-3-141 Beryllium machining at TA-35-213 Beryllium machining at TA-55-4	October 30, 1998 December 26, 1985 February 11, 2000	None None None	NMED NMED NMED

^a CFR = Code of Federal Regulations.

^b MSGP = Multi-Sector General Permit.

^c SWMU = Solid waste management unit.

^d AOC = Area of concern.

^e USACE = U.S. Army Corps of Engineers.

^f SWWS = Sanitary Wastewater Systems (Plant).

^g Permit was administratively continued through 2012.

^h RLWTF = Radioactive Liquid Waste Treatment Facility.

ⁱ NMAC = New Mexico Administrative Code.

^j kW = Kilowatt.

^k CMRR = Chemistry and Metallurgy Research Replacement (facility).

^l NESHAP = National Emission Standards for Hazardous Air Pollutants.

**Table 2-6
Environmental Inspections and Audits Conducted at the Laboratory during 2012**

Date	Purpose	Performing Entity
2/13/12–2/17/12	Environmental Management System reassessment	Third-party certifier
3/20/12	TA-50 RLWTF Groundwater Discharge Plan, DP-1132	NMED
3/20/12	TA-46 SWWS Plant, TA-03 SERF, TA-60 SERF Evaporation Basins Groundwater Discharge Permit, DP-857	NMED
4/10/12–4/17/12	RCRA compliance evaluation inspection	NMED
9/25/12	Title V Operating Permit compliance inspection	NMED
10/30/12–11/1/12	Environmental Management System audit	Third-party certifier
12/6/12	Construction Storm Water NPDES Compliance Evaluation Inspection	NMED

1. Resource 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 (R&D) activities, processing and recovery operations, D&D projects, and environmental restoration activities. Most of these waste streams are of 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 20.4.1 NMAC, as revised.

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 and was renewed in 2010.

b. RCRA Permitting Activities

The LANL Hazardous Waste Facility Permit was issued by NMED on November 30, 2010, and became effective December 30, 2010. The Permit, which regulates 22 container storage units, 1 storage tank system, and 1 stabilization unit, included new operating requirements for the units, as well as increased reporting and notification requirements to NMED's Hazardous Waste Bureau (NMED-HWB) and the public.

Notification to NMED-HWB and the public was transmitted in May 2012 that the location of the physical information repository required by the LANL Hazardous Waste Facility Permit, also known as the LANL Hardcopy Public Reading Room, was moved to the Northern New Mexico Citizens' Advisory Board Office in Pojoaque, New Mexico. Annual training on use and access to documents within the Electronic Public Reading Rooms was conducted in October 2012, and public notice was given via electronic mail, newspaper, and postal mail.

As required by the Hazardous Waste Facility Permit, Section 1.17, four quarterly and one annual demolition activity notifications were submitted to NMED-HWB in 2012. Responses to comments that arose during NMED-HWB review of the notifications also occurred on two occasions. These reviews included requests for 30-day notification on demolition activities for buildings, requests for SWMU reference information, and corrections of errors. Three expedited notifications for demolition were also submitted to NMED-HWB in 2012.

Reporting requirements associated with the permit included the submittal in November 2012 of a summary of instances of noncompliance and releases during FY12 and a waste minimization report for FY12 at LANL. A Community Relations Plan was also revised as annually required and published on the LANL environmental web page after comments were solicited and incorporated from the public.

Revised closure plans for the TA-14-23 open-burning/open-detonation units and the TA-39-57 open detonation unit were submitted in February 2012. Responses to comments on disapproval letters for a permit modification request for a container storage unit proposed at TA-63 and a closure plan for the TA-16-399 open-burning treatment unit were conducted throughout 2012. The Laboratory submitted 10 Class 1 permit modification packages to the LANL Hazardous Waste Facility Permit. The modifications revised the emergency equipment lists, clarified permit conditions, clarified inspection activities, added and removed structures from permitted units, corrected errors within the permit, and included revised figures and text associated with these modifications. Public notices were sent via the NMED-maintained LANL facility mailing list. In October, the Laboratory also requested a temporary authorization for a minor waste treatment and storage operation at TA-55 that was subsequently withdrawn. No hazardous waste management units at the Laboratory underwent full closure activities in 2012.

c. RCRA Compliance Inspections and Notices of Violation

From April 10, 2012, to April 17, 2012, NMED conducted a hazardous waste compliance inspection at the Laboratory. NMED noted seven potential violations and seven best management practice recommendations from this inspection. In March 2013, NMED-HWB issued LANS and DOE a Notice of Violation and Resolution identifying four violations that were noted during the April 2012 inspection. Settlement on the penalties assessed for these violations was finalized on May 13, 2013.

d. Site Treatment Plan

In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to DOE and the University of California requiring compliance with the Site Treatment Plan (STP). On June 1, 2006, LANS replaced the University of California 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 1 yr. In FY12, the Laboratory shipped approximately 62 m³ of STP-covered MLLW and approximately 476 m³ of covered MTRU waste for treatment and disposal.

e. Hazardous Waste Report

The Hazardous Waste Report submitted in February 2012 covers hazardous and mixed waste generation, treatment, and storage activities performed at LANL during CY11 as required by RCRA, under 40 CFR 262.41, Biennial Report. In 2011, the Laboratory generated about 145,870 kg of RCRA hazardous waste, approximately 107,086 kg of which was MTRU waste sent to WIPP. Data was recorded for more than 10,000 waste movements, treatment, or storage actions and resulted in 360 Waste Generation and Management forms in the Hazardous Waste Report. The entire report is available online at <http://permalink.lanl.gov/object/tr?what=info:lanl-repo/eprr/ERID-213280>.

f. Compliance Order on Consent

The Consent Order is an enforcement document that prescribes the requirements for corrective action at the Laboratory. The purposes of the Consent Order are to (1) define the nature and extent of releases of contaminants at, or from, the facility; (2) 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) 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 SWMUs and 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 2012 is presented in Chapter 9 of this report.

In 2012, the Laboratory submitted 16 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 measure 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, investigation reports are being prepared or finalized, or where investigation work plans have been approved but not yet implemented. Aggregate areas listed as pending include sites or areas where work plan preparation has not yet started. As of December 2012, scheduled investigation activities are complete at 8 aggregate areas, in progress at 19 aggregate areas, and pending at 2 aggregate areas.

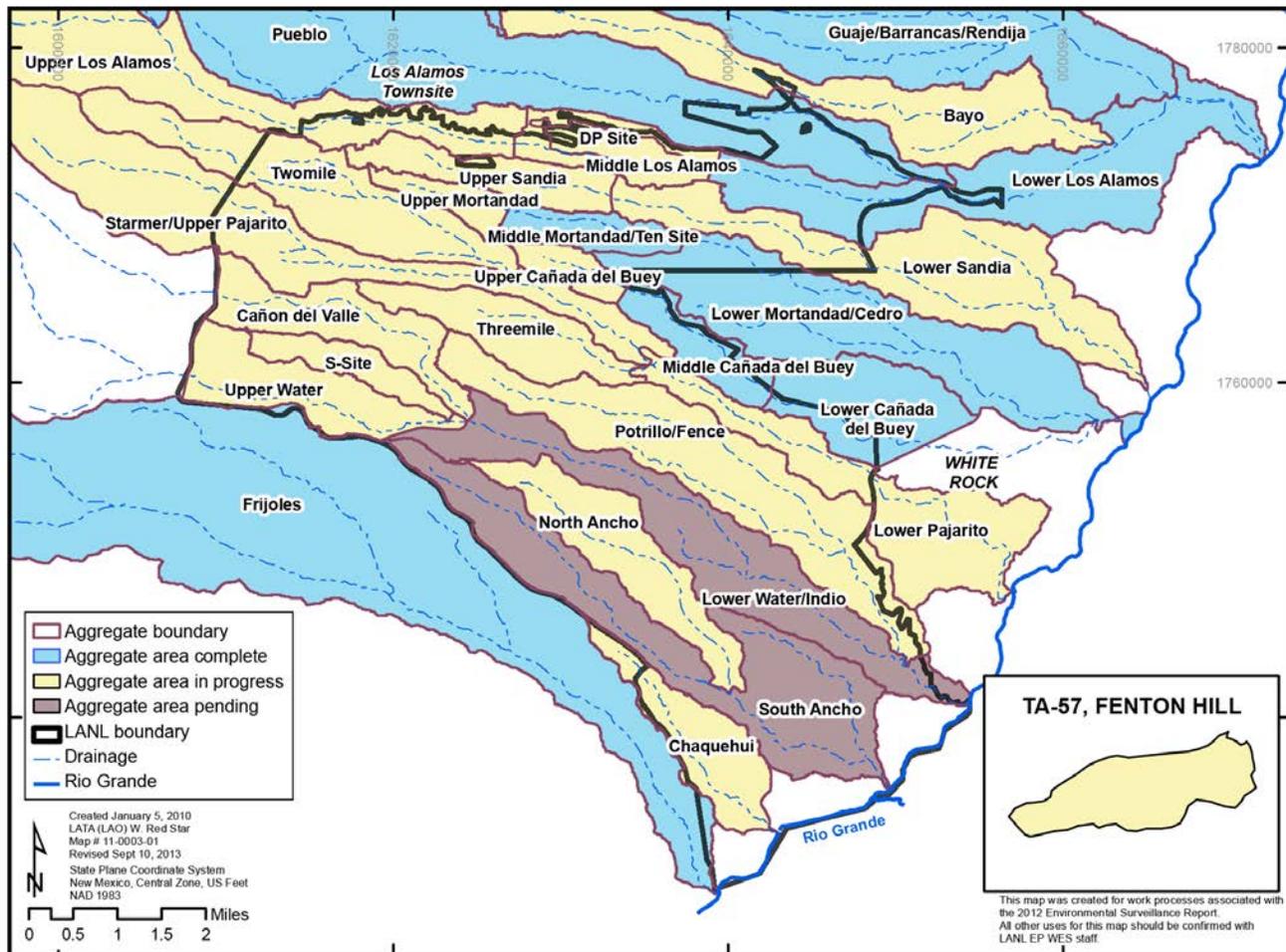


Figure 2-3 Aggregate areas as defined for the Consent Order and their status. Status is shown as aggregate area activities complete, activities in progress, or activities pending.

g. Solid Waste Disposal

LANL sends sanitary solid waste (trash) and construction and demolition debris for transfer to municipal landfills through the Los Alamos County Eco-Station on East Jemez Road. 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 2012

included 1400 metric tons of trash and 481 metric tons of construction and demolition debris. Through LANL's recycling efforts in 2012, 1294 metric tons of material was recycled and did not go to a landfill.

h. Other RCRA Noncompliances

In November 2012, an annual noncompliance report required by Section 1.9.14 of the LANL Hazardous Waste Facility Permit was submitted to NMED-HWB. The report listed instances of noncompliance with the permit and any releases from, or at, a permitted unit that did not pose a threat to human health or the environment. From October 1, 2011, through September 30, 2012, there were no releases of hazardous waste or hazardous waste constituents from, or at, a permitted unit. The report detailed 14 instances of noncompliance that were recorded during FY12 from the effective date of the permit through September 30, 2012. The majority of the occurrences of noncompliance were associated with documentation and record-keeping requirements, such as missing information on inspection record forms and late additions to the LANL information repositories. Other noncompliance occurrences were for physical permit conditions, such as aisle spacing, secondary containment requirements, and failure to mitigate compromised containers within 24 h. None of these incidents resulted 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.

2. 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 small quantities of chemical substances used in R&D. The PCB regulations govern substances containing greater than 50 parts per million (ppm) of PCBs, 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 2012, the Laboratory shipped 31 containers of PCB waste (>50 ppm) off-site for disposal or recycling. The quantities of waste disposed of included 12,324 lb (5589 kg) of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 CFR 761 for manifesting, record keeping, and disposal requirements. PCB wastes go to EPA-permitted treatment or disposal facilities. Light ballasts go off-site for recycling or destruction. The primary compliance document related to 40 CFR 761.180 is the PCB Annual Records/Document Log that the Laboratory maintains on file for possible inspection by EPA Region 6. LANL stopped disposing of PCB waste (>50 ppm) on-site in 2006. During 2012, EPA did not perform a PCB site inspection. Six TSCA reviews were conducted in 2012 on imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office.

3. Comprehensive Environmental Response, Compensation, and Liability Act

a. Land Transfer

Three land tracts were conveyed or transferred in CY12 (Figure 2-4). Tract A-8-B was conveyed to the Los Alamos School Board, Tract A-10 was conveyed to Los Alamos County, and Tract B-3 was transferred to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso. DOE and LANS have implemented DOE Order 458.1, Radiation Protection of the Public and the Environment, and tracts are sampled in accordance with this order prior to their release.



Figure 2-4 Land transfer tract A-8-B

b. Natural Resource Damage Assessment

Under a memorandum of agreement established in 2008, DOE and several other federal, state, and tribal entities in the region continued in 2012 to work towards completing a Natural Resource Damage Assessment (NRDA) for LANL. Participating entities include DOE, the Department of Agriculture, the State of New Mexico, Pueblo de San Ildefonso, Santa Clara Pueblo, and Jemez Pueblo (collectively known as the Trustee Council).

The Trustee Council assesses injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances from LANL. The final objective of the NRDA process is to restore, rehabilitate, or replace services provided by injured natural resources.

The LANL Natural Resource Trustee Council released a preassessment screen in January 2010. In September 2010, 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 2013.

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

a. Emergency Planning Notification

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. 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 2012.

b. 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 2012.

c. Material Safety Data Sheet/Chemical Inventory Reporting

Title III, Sections 311 to 312, of EPCRA require facilities to provide an annual inventory of the quantities and locations 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 13 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2012.

d. 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. LANL operations exceeded the threshold for use of lead in 2012 and, therefore, LANL 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 2-7 summarizes the reported releases in 2012.

**Table 2-7
Summary of 2012
Reported Releases under EPCRA Section 313**

Reported Release	Lead (lb)
Air emissions	5.4
Water discharges	0.37
On-site land disposal	3659
Off-site waste transfers	2377

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act 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 2012.

Table 2-8 shows the amounts of pesticides and herbicides the Laboratory used in 2012.

6. Clean Air Act

On June 15, 2012, a revision to the Title V Operating Permit was issued to LANL. The revision incorporated conditions from the New Source Review (NSR) Permit 2195-N, the construction permit for RLUOB, which is part of CMRR. The operating permit has a new NMED-standardized format, so all sections within the permit have been revised. Also included in the revision were permit conditions from NSR Permit 2195B-M2 for the TA-03 power plant and combustion turbine generator. Permit 2195B-M2 was issued on November 1, 2011.

The Title V Operating Permit requires the Laboratory to submit an Annual Compliance Certification to NMED. As the name implies, the report is signed by Laboratory management certifying compliance with the Title V Operating Permit. As part of this report, any permit deviations are also included. In 2012, the Laboratory had no operating permit deviations.

No excess emissions occurred from any of the Laboratory-permitted sources, and LANL met all required reporting deadlines during 2012.

In 2012, LANL was not required to provide the annual GHG emissions report to NMED. The previous requirement found in 20.2.87 NMAC was repealed on January 1, 2011. Instead of providing a report, NMED accepts GHG emission reports submitted to EPA pursuant to 40 CFR 98 as a method of complying with 20.2.73 NMAC, Notice of Intent and Emissions Inventory Requirements.

The 2012 EPA Greenhouse Gas Emission Report was submitted on March 7, 2013. The report provided emissions of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) for CY12. The amount of these gases emitted during 2012 was approximately 59,726 metric tons of CO₂ equivalents from the combustion of fossil fuels. The report for 2012 was the third annual GHG emission report submitted to EPA by the Laboratory. The first required report provided emissions during CY10. DOE has set aggressive goals to reduce GHG 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 nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs).

Table 2-8
Herbicides and Pesticides Used at LANL in 2012

Herbicide	Amount (gal.)
Ranger	1.1
Roundup	2.03
Telar	0.1
Velossa	143
Velpar	21
Insecticide	Amount
Advion Ant Gel	2.7 g
Bait House	2 bait houses
Contact P.I. Treatment	9 oz
Demand C.S.	96 mL
Max Force Bait	22 oz
Suspend S.C.	0.7 oz
Tempo	1 oz
Tempo 20 WP	5 g
Wasp Freeze	32 oz
Water Treatment Chemical	Amount (lb)
Garratt-Callahan 316-T	10.5
Houghton Purobrom (granular)	4880
Sump Buddy	50

In 2012, the TA-03 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, NO_x emissions were approximately 23% of the permit limit, CO emissions were 16%, and PM emissions were 4%. R&D activities were responsible for most of the VOC and hazardous air pollutant (HAP) emissions. Table 2-9 summarizes these data.

**Table 2-9
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2012**

Emission Unit	Pollutants (tons)					
	NO _x	SO _x ^a	PM	CO	VOCs	HAPs
Asphalt Plant	0.03	0.002	0.02	1.13	0.003	0.003
TA-03 Power Plant (3 boilers)	12.2	0.13	1.6	8.4	1.2	0.4
TA-03 Power Plant (combustion turbine)	4.0	0.28	0.54	0.84	0.18	0.1
Regulated Boilers	3.0	0.21	0.32	1.92	0.24	0.07
R&D Chemical Use	n/a ^b	n/a	n/a	n/a	8.8	6.2
Degreaser	n/a	n/a	n/a	n/a	0.007	0.007
Data Disintegrator	n/a	n/a	0.008	n/a	n/a	n/a
Stationary Standby Generators ^c	7.0	0.35	0.39	1.56	0.39	0.002
Miscellaneous Small Boilers ^c	25	0.15	1.99	20.4	1.45	0.48
TA-33 Generators (4 units)	0.16	0.02	0.01	0.13	0.0	<0.001
TOTAL	51.39	1.142	4.88	34.38	12.27	7.263

^a SO_x = Sulfur oxides.

^b n/a = Not applicable.

^c Emission units in these categories are exempt from construction permitting and annual emission inventory reporting requirements and are not included in Figure 2-5.

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 20.2.73 NMAC, Notice of Intent and Emissions Inventory Requirements, and the Title V Operating Permit, LANL submits an annual emissions inventory report and semiannual emissions reports, respectively, to NMED. Figure 2-5 depicts a 5-yr history of criteria pollutant emissions. Emissions from 2008 through 2012 are very similar and remain relatively constant.

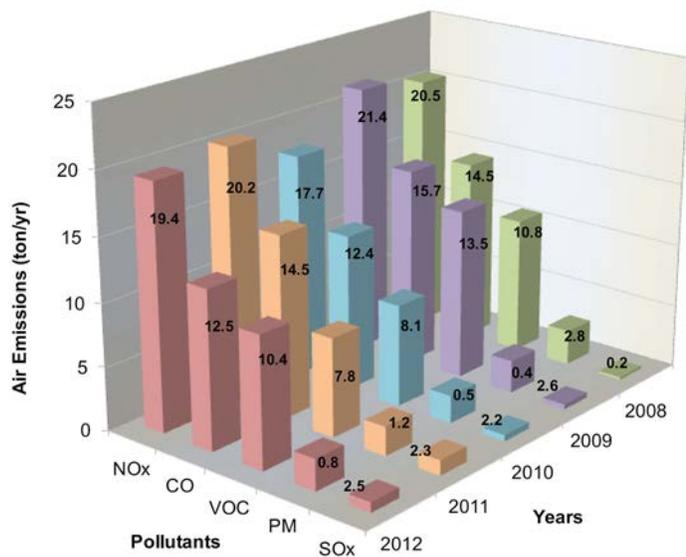


Figure 2-5 LANL criteria pollutant emissions from 2008 through 2012 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.

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 2012, the Laboratory was issued a Title V Operating Permit revision. The permit revision included

requirements from the CMRR-RLUOB NSR permit as well as conditions from the TA-03 power plant NSR permit, which was revised and issued in 2011. LANL submitted seven exemption notifications to NMED during 2012. The exemptions were for boilers, heaters, a cooling tower, and two small electrical generators. During 2012, 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 2012.

iii. Asbestos

The 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 2012, 47 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 Clean Air Act contains specific sections that establish regulations and requirements for ozone-depleting substances (ODS), such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting 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 eliminate 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 2012, the Laboratory removed approximately 462 lb of Class I ODS and 778 lb of Class II ODS from the active inventory.

ii. Radionuclides

Emissions of airborne radionuclides are regulated under Subpart H of 40 CFR 61 (EPA 1986), which sets a dose limit of 10 millirem per year (mrem/yr) to any member of the public. The 2012 air-pathway dose to the maximally exposed individual (MEI) was 0.58 mrem (see Chapter 3, Section B.3.b.i.). Other MEI cases are regulated by DOE Order 458.1 (DOE 2011c) and are described in Chapter 3, Section B.3.b. For all these cases, the annual doses are less than 0.58 mrem/yr and are far below the DOE limit of 100 mrem/yr. In summary, the doses from radionuclides were far below the regulatory limits in 2012.

7. Clean Water Act

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 issues and enforces the permit. NMED certifies the EPA-issued permit and performs some compliance evaluation inspections and monitoring for the EPA. From January 1, 2010, through October 10, 2011, the Laboratory's point-source NPDES permit contained 15 permitted outfalls that include 1 sanitary outfall and 14 industrial outfalls. EPA deleted 4 outfalls from the permit on October 11, 2011, bringing the total to 11 (Table 2-10). 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/community-environment/environmental-stewardship/protection/compliance/permits.php>. Outfalls listed on the current permit that did not discharge in CY12 include the following.

- *Outfall 05A055*: The High Explosives Wastewater Treatment Facility currently uses a thermal evaporator.
- *Outfall 051*: The RLWTF currently uses a thermal evaporator.

Table 2-10
Volume of Effluent Discharge from NPDES-Permitted Outfalls in 2012

Outfall Number	Building No.	Description	Watershed (Canyon)	2012 Discharge (gal.)
03A048	53-963/978	LANSCE ^a Cooling Tower	Los Alamos	16,919,960
051	50-1	TA-50 RLWTF	Mortandad	0
03A022	3-2238	Sigma Cooling Tower	Mortandad	36,000
03A160	35-124	National High Magnetic Field Laboratory Cooling Tower	Mortandad	286,702
03A181	55-6	Plutonium Facility Cooling Tower	Mortandad	1,336,554
13S	46-347	Sanitary Wastewater Treatment Plant	Sandia	see outfall 001 ^b
001	3-22	Power Plant (includes treated effluent from outfall 13S)	Sandia	97,882,000
03A027	3-2327	Strategic Computing Complex Cooling Tower	Sandia	21,627,900
03A113	53-293/952	LANSCE Cooling Tower	Sandia	632,151
03A199	3-1837	Laboratory Data Communications Center	Sandia	15,067,900
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
2012 Total:				153,789,167

^a LANSCE = Los Alamos Neutron Science Center.

^b The discharge amount for outfall 13S is included in the total for outfall 001.

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 2012, none of the 76 samples collected from the SWWS Plant's outfall exceeded effluent limits; however, 5 of the 937 samples collected from industrial outfalls exceeded effluent limits (described below).

The following is a summary of the corrective actions the Laboratory took during 2012 to address the NPDES outfall permit noncompliances cited above:

- *03A048 April 11, 2012, Total Residual Chlorine (TRC) = 0.11 mg/L*: The treatment system controller failed to activate the chemical pump (which injects chlorine neutralizer) during the cooling tower blowdown. All wiring and relays that control the chemical pump were inspected, and the blowdown/chemical pump interlock was tested numerous times with no adverse results.

Corrective actions:

1. Set up a paging system to alert facility personnel (24 h/day) when the chlorine monitor alarms. Document alarms and actions taken, including blowdown shutdown and restart.

2. Perform on-going operational sampling to ensure chlorine monitoring system is functioning properly.
 3. Facility personnel will perform routine checks of (and write a procedure for) the blowdown portion of the system to ensure the chlorine analyzer responds accurately to a sample spiked with a known concentration of chlorine, the backup neutralizer pump activates, and the paging system is engaged when the alarm is activated.
- *03A199 May 30, 2012, TRC = 1.13 mg/L:* The cause was a trapped air bubble in the suction line of the chlorine neutralizer pump, and when combined with a low stroke and speed setting on the pump, resulted in no chlorine neutralizer being introduced into the blowdown. All air was purged from the suction line of the chlorine neutralizer pump. Facility personnel increased the speed and stroke of the pump per the recommendation of their chemical equipment vendor.
 - *03A113 June 27, 2012, TRC = >2.2 mg/L:* The check valve on the neutralizer pump was clogged. The check valve was cleaned and the pump returned to service. The check valve will be cleaned weekly.
 - *03A181 July 11, 2012, pH = 9.1 standard units:* The cooling tower blowdown control panel had a firmware corruption, causing a timeout error, resulting in reduced blowdown duration and a misreading of the actual conductivity. Scale buildup or clogs in the blowdown piping and valves may have reduced system capabilities. Facility personnel reinstalled the firmware and verified it was performing properly. A master of the control panel firmware will be kept on-site to correct issues of suspect programming.
 - *03A022 November 26, 2012, total copper = 0.604 mg/L:* The cause of the exceedence was a stuck make-up water float valve that maintains the level of the water in the circulating water tank inside the building. Overflow from this system discharged to outfall 03A022 without treatment. The make-up water float valve was fixed the evening of November 26, 2012.

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 2012, the SWWS Plant generated approximately 27.9 dry tons (55,805 dry lb) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material.

c. NPDES 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. An 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.

The 2012 CGP was issued and became effective on February 16, 2012. SWPPPs for existing sites were revised to meet the new requirements, and notices of intent (NOIs) were submitted. All existing projects needed to have SWPPPs revised and NOIs submitted by May 16, 2012. Some of the new requirements included inspections of sites within 24 h of a 0.25-in. or greater precipitation event. Other new requirements included weekly inspections for sites that discharge into sensitive waters and that routine maintenance be performed by the end of the next business day after the inspection.

During 2012, the Laboratory implemented and maintained 42 construction site SWPPPs and SWPPP addendums and performed 749 storm water inspections at construction sites. Of the 749 site inspections performed, 711 inspections were compliant, for an overall compliance rate of 94.9%.

d. NPDES Industrial Storm Water Program

The NPDES MSGP Program regulates storm water discharges from identified industrial activities and their associated facilities. The intent of the 2008 MSGP is to authorize storm water discharges from permitted industrial facilities and minimize the discharge of potential pollutants. The types of industrial activities conducted at LANL covered under the 2008 MSGP include metal and ceramic fabrication, hazardous waste treatment and storage, vehicle and equipment maintenance, recycling activities, electricity generation, warehousing activities, and asphalt manufacturing.

LANL submitted its Notice of Intent to Discharge under the 2008 MSGP in December 2008 and received coverage in January 2009. The LANL permit tracking number under the 2008 MSGP is NMR05GB21. LANL's authorization to discharge expires at midnight on September 29, 2013. At that time, EPA will either publish a new permit or administratively continue the existing permit.

The 2008 MSGP requires the implementation of control measures, development of SWPPPs, and monitoring of storm water discharges from permitted sites. LANL implemented and maintained 11 SWPPPs covering 13 facilities in CY12.

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 stand-alone samplers for industrial sector-specific benchmark parameters, impaired water constituents, and effluent limitations
- Visually inspecting storm water runoff to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution

Results of the CY12 MSGP monitoring are summarized below. The average concentration of magnesium was mathematically certain to exceed benchmark at outfalls 54-G-1 and 54-G-2. In addition, zinc was mathematically certain to exceed benchmark at outfall 3-TS-1. However, because magnesium and zinc were present at a concentration solely attributable to natural storm water background, LANL was not required to perform corrective action or additional benchmark monitoring for these constituents.

Based on the average concentration for the four most recent samples at outfall 54-G-4, chemical oxygen demand (COD) exceeded benchmark. As a result, sand/sediment was cleaned out of a trench drain leading to the outfall.

At the Material Recycling Facility (MRF) located within TA-60, the average concentration from the most recent monitoring samples exceeded benchmark for total suspended solids (TSS), copper, zinc, and COD. Although the average zinc concentration is less than the LANL-specific background in storm water, the

concentration of zinc in one of the samples was greater than background. Therefore, LANL will continue to monitor for zinc at this location. Copper was present at a concentration solely attributable to natural background in storm water. Thus, LANL is not required to perform corrective action or benchmark monitoring for copper at outfall 60-MRF-1. As follow-up for the COD and TSS exceedances, the MRF pond was drained, filters were replaced, and sediment and base course were removed. Natural vegetation from foliage in the area routinely blows onto the concrete apron where the intake tubing for the automated sampler at outfall 60-MRF-1 is located. This may be contributing to the COD exceedance, so the tubing was moved to within the corrugated metal pipe where storm water discharges from the MRF.

Evaluation of data associated with the most recent monitoring samples obtained at the TA-3-38 Metals Fabrication Shop indicates the average concentration of zinc exceeded benchmark at outfall 3-MFS-1. Although the average concentration of zinc in the samples did not exceed LANL-specific background, two individual results exceeded background. Therefore, benchmark monitoring for zinc at this facility will continue.

The State of New Mexico water quality criteria was exceeded for aluminum in the annual impaired water monitoring sample collected from outfall 54-G-2 at TA-54 Area G and for copper at outfall 3-PSP-1 at the TA-3-22 Power and Steam Plant. The concentrations of aluminum and copper were solely attributable to natural background in storm water; therefore, LANL was not required to perform corrective action or additional impaired water monitoring.

LANL has completed 4 of the 5 yr of required storm water monitoring in accordance with the 2008 MSGP. Since LANL started monitoring under the 2008 MSGP in April 2009, the analytical monitoring requirements have been fulfilled (i.e., monitoring is no longer required) for most of the individual constituents. The permit allows discontinuation of monitoring under the following circumstances:

- constituents are found to not be present,
- constituents/parameters are found to be present below permit defined levels, or
- changes are made to impaired water constituents (i.e., no longer requiring specific constituent monitoring for impaired water).

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

On February 13, 2009, EPA Region 6 issued NPDES Individual Permit (IP) No. NM0030759 to co-permittees LANS and DOE. Immediately following issuance of the IP by the EPA, the IP was appealed. Following permit modification negotiations in 2009, the EPA issued a new modified IP that was effective on November 1, 2010. The IP authorizes discharges of storm water from certain SWMUs and AOCs (sites) at the Laboratory.

The IP lists 405 permitted sites that must be managed to prevent the transport of contaminants to surface waters via storm water runoff. Potential contaminants of concern within these sites are metals, organic chemicals, 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 a technology-based permit and relies, in part, on nonnumeric technology-based effluent limits (storm water control measures). 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 in storm water. These control measures include run-on, runoff, erosion, and sedimentation controls, which are routinely inspected and maintained as required.

For purposes of monitoring and management, sites are grouped into small watersheds called Site Monitoring Areas (SMAs). The SMAs have sampling locations identified to most effectively sample storm water runoff. Storm water 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 enhanced controls for corrective actions; and (5) certification of corrective action complete or application for alternative compliance.

In 2012, the Laboratory completed the following tasks:

- Developed an annual update to the Site Discharge Pollution Prevention Plan, Revision 1, that describes three main objectives: identification of pollutant sources, description of control measures, and monitoring that determines the effectiveness of controls at all regulated SWMUs/AOCs
- Completed more than 1000 control measure inspections on all 250 SMAs
- Conducted BMP maintenance at 109 SMAs
- Completed installation of additional controls at 21 SMAs
- Collected baseline confirmation monitoring samples at 15 SMAs
- Collected corrective action enhanced control confirmation samples at 5 SMAs
- No further monitoring based on no TAL exceedances during baseline monitoring at 3 SMAs
- Initiated corrective action based on TAL exceedances at 63 SMAs associated with 105 sites
- Completed installation of enhanced control measures at 42 SMAs associated with 67 sites
- Completed corrective action at 12 sites
- Held 3 public and 2 technical meetings
- Completed website updates and public notifications

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 112) and NMED's Petroleum Storage Tank Bureau (PSTB) Regulations (20.5 NMAC). During 2012, 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 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 112). New regulations required 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 two modifications to existing and new SPCC Plans, and implementation of those modifications is in process. In 2012, ENV-RCRA conducted approximately 34 annual inspections/assessments of facilities with SPCC Plans.

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 13 tank systems (17 ASTs) that are operational pursuant to 20.5 NMAC. One remaining tank system is under permanent closure status pursuant to 20.5 NMAC. In 2012, 10 additional tank systems were registered with NMED because of a New Mexico Environmental Improvement Board (NMEIB) regulation change that removed a previous exemption from regulation for ASTs associated with emergency generator systems.

During 2012, the Laboratory continued to work on removing and decommissioning ASTs that are no longer in service. Three closed systems had tanks and piping removed in 2012.

g. Dredge and Fill Permit Program

Section 404 of the Clean Water Act requires the Laboratory to obtain permits from USACE 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 2012, Section 404/401 permits were issued for two construction projects at the Laboratory:

- Installation of a new stream gage, E229.7, in Cañada del Buey (Nationwide Permit No. 5, Scientific Measurement Devices)
- Water Canyon Storm Drain Reconstruction Project (Nationwide Permit No. 43, Stormwater Management Facilities)

In addition, LANL reviewed 91 project profiles for potential impacts to watercourses, floodplains, or wetlands. Two Floodplain/Wetland Assessments were prepared in 2012 for proposed work at the TA-72 Live Fire Range. No violations of the DOE Floodplain/Wetland Environmental Review Requirements were recorded in 2012. NMED and the Corps of Engineers did not inspect any sites permitted under the Section 404/401 regulations during 2012.

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 2012, 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 in the online Intellus New Mexico Environmental Database (<http://www.intellusnmdata.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 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 2012, the Laboratory had one discharge permit and three 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 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 NMED quarterly. During 2012, none of the samples collected exceeded NMWQCC groundwater standards. Monitoring data are available online in the Intellus New Mexico Environmental Database (<http://www.intellusnmdata.com>). On April 6, 2010, NMED requested an application for renewal and modification of discharge permit DP-857. The Laboratory submitted a renewal application on July 2, 2010. On August 30, 2012, NMED issued a working draft of discharge permit DP-857 for the Laboratory's review. Issuance of a final discharge permit was pending at the end of 2012. NMED conducted a site inspection of the TA-46 SWWS Plant, SERF, and the SERF evaporation basins on March 20, 2012.

ii. TA-50 RLWTF Discharge Plan DP-1132

On August 20, 1996, at NMED's request, the Laboratory submitted a discharge plan application for the RLWTF at TA-50. On November 18, 2011, NMED requested a new, comprehensive, and up-to-date discharge plan application for the TA-50 RLWTF and the TA-52 Solar Evaporative Tank. An application was submitted by the Laboratory on February 16, 2012. On November 21, 2012, NMED issued a preliminary draft of discharge permit DP-1132 for the Laboratory's review. Issuance of a final discharge permit was pending at the end of 2012.

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, total dissolved solids, and perchlorate. The Laboratory reports the analytical results to NMED quarterly. During 2012, none of the quarterly groundwater samples exceeded NMWQCC groundwater standards. No effluent samples were collected in 2012 because the TA-50 RLWTF did not discharge any treated effluent to Mortandad Canyon; all treated effluent was evaporated on-site. Monitoring data are available online in the Intellus New Mexico Environmental Database (<http://www.intellusnmdata.com>). NMED conducted an inspection of the TA-50 RLWTF on March 20, 2012.

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

On April 27, 2006, at 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, NMED requested that LANL submit a new, up-to-date septic tank/leachfield systems discharge plan application. Accordingly, on June 25, 2010, the Laboratory submitted an updated discharge plan application for 15 septic tank/leachfield systems. Issuance of a final discharge permit was pending at the end of 2012.

iv. Land Application of Treated Groundwater from a Pumping Test at R-28 Discharge Plan DP-1793

On December 20, 2011, at NMED's request, the Laboratory submitted a discharge plan application for the discharge of treated groundwater produced during a 10-day pumping test at regional aquifer monitoring well R-28. Subsequently, on March 13, 2012, at NMED's request, the Laboratory submitted supplemental information to broaden the scope of the original discharge plan. The broader scope will capture activities beyond the R-28 pumping test to include, but not be limited to, pumping tests, aquifer tests, and well rehabilitation. Included in the plan is produced groundwater that requires treatment prior to discharge. Issuance of a final discharge permit was pending at the end of 2012.

b. Groundwater Monitoring Activities

The Laboratory performed significant groundwater compliance work in 2012 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and installation of monitoring wells in support of various groundwater investigations and corrective measures evaluations. However, the

Laboratory installed no new monitoring wells in 2012. Maps of all monitoring well locations can be found in Chapter 5.

10. National Environmental Policy Act

Under the National Environmental Policy Act (NEPA) (42 United States Code 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 reported to NNSA.

The current Site-Wide Environmental Impact Statement (SWEIS) was issued in May 2008 (DOE 2008a). Two Records of Decision (RODs) have been issued to date; the first in September 2008 (DOE 2008b) and another in June 2009 (DOE 2009a). In both RODs, DOE/NNSA decided to implement the No Action Alternative with the addition of some elements of the Expanded Operations Alternative analyzed in the SWEIS.

The first Supplement Analysis (SA) to the 2008 SWEIS was issued by DOE in October 2009 (DOE 2009b). This SA was prepared to determine if the 2008 SWEIS adequately bounded the off-site transportation of low-specific-activity and low-level waste by a combination of truck and rail to EnergySolutions in Clive, Utah. DOE/NNSA concluded that the proposed shipments of waste to EnergySolutions by truck and rail were bounded by 2008 SWEIS transportation analysis. The second SA was issued by DOE in April 2011 (DOE 2011a). It was prepared to assess DOE/NNSA activities of the Off-Site Source Recovery Project (OSRP) to recover and manage high-activity beta/gamma sealed sources from Uruguay and other locations. DOE/NNSA issued an amended SWEIS ROD in response to the SA on OSRP in July 2011.

During 2012, LANL began the data collection process for the 2008 SWEIS SA. DOE/NNSA is required to prepare an SA to determine whether a supplemental or new SWEIS should be prepared pursuant to regulations from the President's Council on Environmental Quality. The SA is on a 5-yr cycle that reviews existing NEPA coverage to determine if the current SWEIS would still bound proposed Laboratory operations and activities over the next 5 to 10 yr.

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. While there were no Environmental Assessments prepared in CY12, there were five categorical exclusions issued by DOE/NNSA during CY12: Construction of Interagency Fire Center at TA-49 (DOE 2012a); Domestic Source Recovery – FY 2012 (DOE 2012b); Storm Water Control Measures at Individual Permit Site, TA-72 (DOE 2012c); Domestic Source Recovery – FY 2013 (DOE 2012d); and Foreign Location Source Recovery – FY 2013 (DOE 2012e).

In October 2012, LANL submitted the draft FY12 Mitigation Action Plan Annual Report for the 2008 SWEIS to DOE/NNSA. The annual report was revised and resubmitted in December 2012 (LANL 2012b). This fulfilled the FY12 annual reporting requirements under the LANS prime contract.

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 2011b).

The Laboratory contains potential habitat for one federally endangered species (Southwestern Willow Flycatcher, *Empidonax traillii extimus*), 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 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 2-12).

Table 2-12
Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL

Scientific Name	Common Name	Protected Status ^a	Potential to Occur ^b
<i>Empidonax traillii extimus</i>	Southwestern Willow Flycatcher	E	Moderate
<i>Mustela nigripes</i>	Black-footed Ferret	E	Low
<i>Strix occidentalis lucida</i>	Mexican Spotted Owl	T	High
<i>Coccyzus americanus</i>	Yellow-Billed Cuckoo	C, NMS	Moderate
<i>Zapus hudsonius luteus</i>	New Mexico Meadow Jumping Mouse	C, NME	Moderate
<i>Haliaeetus leucocephalus</i>	Bald Eagle	NMT, S1	High
<i>Cyananthus latirostris magicus</i>	Broad-billed Hummingbird	NMT	Low
<i>Gila pandora</i>	Rio Grande Chub	NMS	Moderate
<i>Plethodon neomexicanus</i>	Jemez Mountains Salamander	C, NME	High
<i>Falco peregrinus anatum</i>	American Peregrine Falcon	NMT, FSOC	High
<i>Falco peregrinus tundrius</i>	Arctic Peregrine Falcon	NMT, FSOC	Moderate
<i>Accipiter gentiles</i>	Northern Goshawk	NMS, FSOC	High
<i>Lanius ludovicianus</i>	Loggerhead Shrike	NMS	High
<i>Vireo vicinior</i>	Gray Vireo	NMT	Moderate
<i>Myotis ciliolabrum melanorhinus</i>	Western Small-footed Myotis Bat	NMS	High
<i>Myotis volans interior</i>	Long-legged Bat	NMS	High
<i>Euderma maculatum</i>	Spotted Bat	NMT	High
<i>Corynorhinus townsendii pallascens</i>	Townsend's Pale Big-eared Bat	NMS, FSOC	High
<i>Nyctinomops macrotis</i>	Big Free-tailed Bat	NMS	High
<i>Bassariscus astutus</i>	Ringtail	NMS	High
<i>Vulpes vulpes</i>	Red Fox	NMS	Moderate
<i>Ochotona princeps nigrescens</i>	Goat Peak Pika	NMS, FSOC	Low
<i>Cynomys gunnisoni</i>	Gunnison's Prairie Dog	C, NMS	Low
<i>Lilium philadelphicum var. andinum</i>	Wood Lily	NME	High
<i>Cypripedium calceolus var. pubescens</i>	Greater Yellow Lady's Slipper	NME	Moderate
<i>Speyeria Nokomis nitocris</i>	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 2012, LANL reviewed 572 excavation permits, 130 project profiles in the Permits Requirements Identification process, and 15 storm water profiles for potential impacts to threatened or endangered species. The Laboratory conducted surveys for the Mexican Spotted Owl, Southwestern Willow Flycatcher, Jemez Mountains salamander (to be federally listed as Endangered in September 2013), and Gray Vireo. Mexican Spotted Owl and Jemez mountain salamander surveys by LANL biologists had positive results. Willow Flycatchers were not found during surveys. However, during an unrelated migratory bird monitoring project, a Willow Flycatcher was captured

(Hathcock et al. 2013). This bird was not nesting, so it could not be determined if it was the Southwestern endangered subspecies.

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 U.S. 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 2012, LANL biologists continued annual surveys in all major habitat types in each season. In addition, biologists completed a third year of bird netting to monitor the bird populations during fall migration in Pajarito Canyon.

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 (<http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-04-8964>).

In FY12, the Laboratory conducted 24 projects that required some field verification of previous cultural surveys. Two new archaeological sites were identified in FY12. Thirty-five archaeological sites 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). During the last quarter of CY12, the DOE/NNSA conveyed and transferred approximately 4000 acres of excess DOE lands to Los Alamos County and to the Bureau of Indian Affairs to be held in trust for Pueblo de San Ildefonso under Public Law 105-119. The Resources Management Team continued to conduct the annual inspection of the curation facility (Museum of Indian Arts and Culture in Santa Fe, New Mexico) in 2012 where the artifacts from the excavation of 39 C&T archaeological sites, along with collections from other earlier projects conducted at LANL, are housed.

In support of LANL’s 2012 D&D program, square footage reduction, and Laboratory consolidation, the Laboratory completed a final documentation report for one D&D project and continued work on another project as required under the provisions of the NHPA. Buildings included in these projects are located at TA-03 and TA-18. 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 2012, consultations with the Pueblo de San Ildefonso continued regarding the culturally affiliated human remains discovered at TA-54 during 2011.

D. UNPLANNED RELEASES

1. Air Releases

No unplanned air releases occurred at LANL during 2012.

2. Water Releases

No unplanned releases of radioactive liquids occurred on Laboratory lands in 2012. There were 11 unplanned releases of nonradioactive liquids in 2012 that were reported to NMED pursuant to 20.6.2.1203 NMAC (Table 2-13). In addition, there were 4 reports for groundwater detections in excess of New Mexico Groundwater Quality Standards and one well packer failure that were reported pursuant to 20.6.2.1203 NMAC.

The Laboratory investigated all unplanned releases of liquids as required by the NMWQCC Regulations in 20.6.2.1203 NMAC. Upon cleanup, NMED’s DOE Oversight Bureau inspected the unplanned release sites as required to ensure adequate cleanup. In 2012, the Laboratory was in the process of administratively closing all releases with NMED’s DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

**Table 2-13
2012 Unplanned Nonradioactive Releases**

Material Released	Instances	Approximate Total Release (gal.)
Potable water	8	68,500
Diesel fuel	1	60
Partially retreated SERF effluent	1	1300
Cooling tower water	1	54,000

E. REFERENCES

DOE 1999: “Radioactive Waste Management Manual,” U.S. Department of Energy Manual 435.1-1 (July 9, 1999).

DOE 2001: “Radioactive Waste Management, Change 1,” U.S. Department of Energy Order 435.1-1 (August 28, 2001).

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

DOE 2008b: “Record of Decision: Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico,” U.S. Department of Energy, NNSA (September 19, 2008).

DOE 2009a: “Record of Decision: Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico,” U.S. Department of Energy, NNSA (June 29, 2009).

DOE 2009b: “Supplement Analysis: Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory—Proposed Transport of Low Level Radioactive Waste by Truck and Rail from Los Alamos National Laboratory (LANL) for Disposal at EnergySolutions at Clive Utah,” U.S. Department of Energy report DOE/EIS-0380-SA-01 (October 2009).

DOE 2011a: “Supplement Analysis: Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory—Transport and Storage of High-Activity Sealed Sources from Uruguay and Other Locations,” U.S. Department of Energy report DOE/EIS-0380-SA-02 (April 2011).

DOE 2011a: “Environment, Safety, and Health Reporting,” U.S. Department of Energy Order 231.1B (June 2011).

DOE 2011b: “Departmental Sustainability,” U.S. Department of Energy Order 436.1 (May 2011).

DOE 2011c: “Radiation Protection of the Public and the Environment,” U.S. Department of Energy Order 458.1 (June 2011).

DOE 2012a: “Categorical Exclusion for the Construction of Interagency Fire Center at TA-49,” LAN-12-002, Accession Number 15280, Los Alamos, NM (January 2012).

- DOE 2012b: “Categorical Exclusion for Domestic Source Recovery - FY 2012,” LAN-12-003, Accession Number 17555, Los Alamos, NM (April 2012).
- DOE 2012c: “Categorical Exclusion for Storm Water Control Measures at Individual Permit Site, TA-72,” LAN-13-001, Accession Number 18072, Los Alamos, NM (November 2012).
- DOE 2012d: “Categorical Exclusion for Domestic Source Recovery - FY 2013,” LAN-13-002, Accession Number 18162, Los Alamos, NM (November 2012)
- DOE 2012e: “Categorical Exclusion for Foreign Location Source Recovery - FY 2013,” LAN-13-003, Accession Number 18161, Los Alamos, NM (November 2012)
- EPA 1986: “National Emission Standards for Hazardous Air Pollutants,” Environmental Protection Agency, Code of Federal Regulations, Title 40, Part 61 (1986).
- Hathcock et al. 2013: Hathcock, C.D., H.B. Mahowald, and D.C. Keller, “Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2010-12,” Los Alamos National Laboratory document LA-UR-13-20413 (2013)
- 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 (2004), <http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-04-8964>
- LANL 2007: “Biological Resources Management Plan for Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-07-2595 (2011), http://www.lanl.gov/environment/bio/docs/BRMP_LA-UR-07-2595.pdf
- LANL 2011a. “Fiscal Year 2012 Site Sustainability Plan,” Los Alamos National Laboratory document UI-PLAN-20 (December 2011)
- LANL 2011b: “Threatened and Endangered Species Habitat Management Plan for Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-11-02582 (2011), <http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-11-02582>
- LANL 2012a: “Long-Term Strategy for Environmental Stewardship & Sustainability,” Los Alamos National Laboratory document LA-UR-12-24845
- LANL 2012b: Fiscal Year 2012 Mitigation Action Plan Annual Report for the 2008 Los Alamos National Laboratory Site-Wide Environmental Impact Statement,” Los Alamos National Laboratory document LA-UR-12-26410, U.S. Department of Energy report DOE/EIS-0380 (December 2012).
- 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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Radiological and nonradiological doses are the primary measures of harm and risk from radiation and chemicals. The objective of the Los Alamos National Laboratory (LANL or the Laboratory) dose programs is to use environmental sampling data collected from air, water, soil, foodstuffs, and biota to answer the question, “What is the potential dose and risk to various populations from the Laboratory’s operations?” The Laboratory’s work in environmental sampling and dose calculations supports the following three Environmental Grand Challenges—*protect water resource quality; eliminate industrial emissions, discharges, and releases into the environment; and protect human and environmental health by managing and restoring lands.*

A. INTRODUCTION

In this chapter, we assess the dose and risk to the public and to biota to ensure they are well protected and to demonstrate compliance with U.S. Department of Energy (DOE) Order 458.1 (DOE 2011). Section B addresses radiological dose to the public, Section C addresses radiological dose to biota, and Section D addresses nonradiological materials.

In all cases, the actual and potential doses from LANL operations are much smaller than the regulatory limits and the naturally occurring background. The data indicate that there is no measurable harm either to the public or to biota.

B. RADIOLOGICAL DOSE ASSESSMENT FOR THE PUBLIC

1. Overview of Radiological Dose

Radiological dose is the primary measure of harm or risk from radiation and radioactive materials. It is calculated using the standard methods specified in guidance documents (DOE 1988a, 1988b, 1991, 2011; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). The final result is measured in millirems (mrem). The estimated risk of contracting cancer is 8×10^{-7} per mrem received (DOE 2003, BEIR 2006).

DOE regulations (DOE 2011) limit the total annual dose to the public from LANL operations to 100 mrem. Furthermore, doses must be “as low as reasonably achievable” (ALARA) (LANL 2008) and not exceed 25 mrem from any one pathway (DOE 1999) or from storage of waste (DOE 2011). The annual dose received by the public from airborne emissions of radionuclides is limited to 10 mrem by the National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides (Rad-NESHAP) (EPA 1986) dose limit. Annual doses from community drinking water supplies are limited by the Clean Water Act to 4 mrem (EPA 2004).

2. Exposure Pathways

Radiation doses to the public are evaluated for three principal exposure pathways: direct radiation, inhalation, and ingestion.

a. Direct Radiation Pathway

LANL monitors direct external radiation from gamma photons and neutrons at about 100 locations in and around LANL (see Chapter 4, Section C). To receive a measurable dose from direct external radiation, a member of the public must be within 1 km of the source of radiation at LANL. Dose decreases with increasing distance from the source. At distances more than 1 km, the inverse-square law, scattering, and absorption reduce the annual dose to much less than 0.1 mrem, which cannot be distinguished from natural

background radiation. The only significant above-background doses from direct radiation are measured near Technical Area 53 (TA-53) and TA-54.

b. Airborne Radioactivity (Inhalation Pathway)

At distances of more than 1 km from LANL sources, any LANL-generated dose to the public is almost entirely from airborne radioactive emissions. Whenever possible, we use the measurements of airborne radioactivity concentrations measured by the air-sampling network (AIRNET) reported in Chapter 4, Section A. Where local concentrations are too small to measure or are not measured by AIRNET, we calculate the doses using a model called CAP88 (Clean Air Act Assessment Package-1988, PC Version 3.0) (EPA 2013). CAP88 is an atmospheric dispersion and dose calculation computer code that combines stack emissions with meteorological data to estimate the dose.

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 min or less).

c. Water (Ingestion Pathway)

We report measurements of radionuclide concentrations in water in Chapters 5 and 6. The majority of radionuclides detected in water samples collected from potential drinking water sources (Los Alamos County drinking water supply wells, Buckman wells, and natural springs) resulted from natural radioactivity. These radionuclides include natural uranium and its decay products, such as radium-226.

Generally, ingestion of water can occur through the drinking water systems or indirectly via irrigation, livestock watering, consumption of fish, or consumption of other animals or plants. Near Los Alamos, these pathways are limited because of the absence of fish, water fowl, and aquatic habitats and limited irrigation and livestock watering. In Los Alamos County, irrigation of domestic gardens and water for domestic animals are from the regional aquifer, which feeds the local drinking water system. Farther downstream, the Rio Grande has been extensively studied, as reported in previous annual environmental reports, and it has been shown that water contributes less than 0.1 mrem per year (mrem/yr) to the public dose.

d. Soil (Direct Exposure and Ingestion Pathways)

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 every 3 yr.

Soil can contribute to the direct exposure pathway because of the ingestion of soil or dust. It also contributes indirectly by consumption of food grown on contaminated soil and indirectly by consumption of animals that ingest contaminated material. In practice, the public dose from these pathways is less than 0.1 mrem/yr because public access to contaminated soil is very limited.

e. Food (Ingestion Pathway)

We report measurements of the radioactive content of food and native vegetation in Chapter 8. No contamination from the Laboratory has been detected in food, and the individual LANL-generated dose from food ingestion is less than 0.1 mrem/yr.

f. Release of Items and Real Property

The Laboratory releases salvageable office and scientific equipment to the general public following Laboratory requirements (LANL 2011). All items are screened for radioactive contamination in accordance with the procedures of LANL's Health Physics Operations Group. In addition, items are not released if they are from a known or potentially contaminated area that cannot be completely surveyed. These procedures are designed to ensure that the public dose from these items, if any, is too small to measure.

The Land Conveyance and Transfer Project is a DOE project for which LANL provides technical and project management support. Prior to any land transfer, the land is remediated as necessary and the potential

dose is calculated using procedures (LANL 2008, DOE 2000) that demonstrate the dose is ALARA and does not exceed 15 mrem/yr (DOE 2000).

3. Dose Calculations and Results

The objective is to calculate doses from LANL operations. Therefore, we do not include contributions from naturally occurring radioactive material, from global fallout, from consumer products, or from medical sources.

We calculate doses for the following cases:

1. The population within 80 km of the Laboratory
2. The maximally exposed individual (MEI) for the inhalation pathway
3. The on-site and off-site MEI for all pathways

a. Collective Dose to the Population within 80 km

The collective population dose from Laboratory operations is the sum of the doses for each member of the public within an 80-km radius of LANL. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88.

The 2012 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory is 0.27 person-rem. Averaged over the 343,000 people who live within 80 km (McNaughton 2012), the dose is less than 0.001 mrem per person. Tritium contributed about 50% of the dose, and short-lived activation products, such as carbon-11 from LANSCE, contributed about 40% of the dose. Collective population doses for the past 10 yr are shown in Figure 3-1.

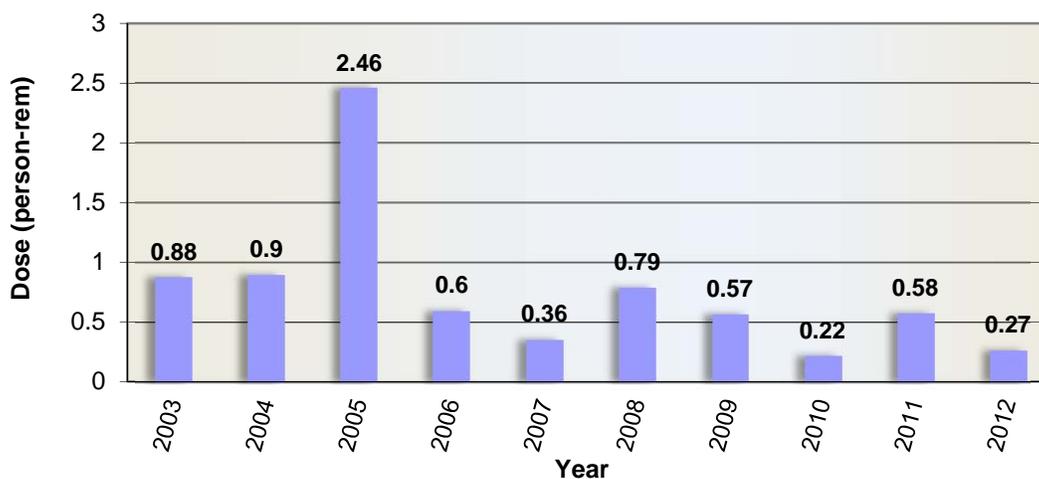


Figure 3-1 Annual collective dose (person-rem) to the population within 80 km of LANL over the past 10 yr

b. Dose to the MEI

The MEI is a hypothetical member of the public who receives the greatest dose from LANL operations. In Sections 3.b.i through 3.b.iv, we consider the air-pathway case, the all-pathway case, on-site locations, and off-site locations. In Section 3.b.v, we conclude that the air-pathway dose was the largest in 2012.

i. Air-Pathway (Rad-NESHAP) MEI

The air-pathway dose is reported in detail in the annual Rad-NESHAP report (Fuehne 2013). For 2012, the LA-Inn-South AIRNET location was the Rad-NESHAP MEI location, with a total dose of 0.58 mrem (Fuehne 2013, Green 2013). At this location in 1944 and 1945, plutonium-239 from the Manhattan Project was deposited on a steep hillside on DOE land protected by a boundary fence. The americium-241 activity is about 1% of the plutonium activity, indicating that this is Manhattan-Project plutonium.

This material is resuspended by high winds and can be detected within a few hundred meters of the source. At the AIRNET station 600 m downwind, the dose is 2% of that at the LA-Inn-South station, indicating that the resuspended dust settles within a short distance. Beyond 600 m, the dose is too small to measure.

The airborne-pathway MEI doses for the past 10 yr are shown in Figure 3-2.

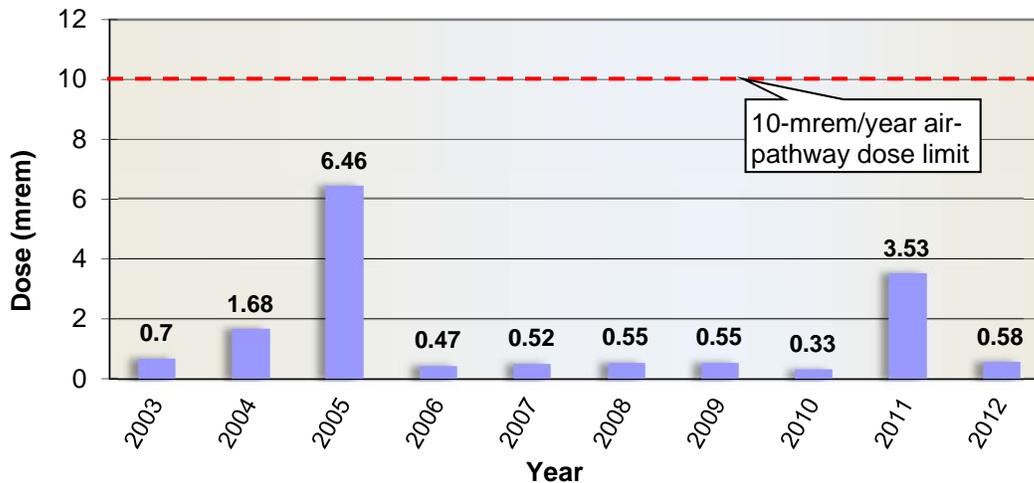


Figure 3-2 Annual airborne pathway (Rad-NESHAP) dose (mrem) to the MEI over the past 10 yr

ii. All-Pathways MEI

For the all-pathways MEI, we consider both off-site and on-site locations. The off-site locations are near the LANL perimeter, while the on-site locations are on or near the publicly accessible roads and hiking trails.

iii. On-Site MEI

The on-site locations are described in McNaughton et al. (2013). The only location with a measurable LANL-generated dose is at East Jemez Road near TA-53. As reported in Chapter 4, Section C.4, at this location in 2012 the neutron dose was 0.34 mrem and the gamma dose was 0.20 mrem. These are the doses that would be received by a hypothetical individual at this location 24 hr per day and 365 days per year. Members of the public such as a bus driver or cyclist spend less than 15 min per day at this location, so the on-site MEI dose is much less than 0.1 mrem and is also much less than the off-site MEI dose.

iv. Off-Site MEI

For the off-site MEI, we begin with the location with the highest direct-radiation dose and compare it with the air-pathway MEI location. The location with the highest direct-radiation dose was 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 neutron dose measurements are described in Chapter 4, Section C.5. After subtracting background, the measured neutron dose at the Laboratory boundary near TA-54 was 5.3 mrem. After applying the standard factor of 1/16 for occasional occupancy (NCRP 1976), the individual neutron dose was $5.3/16 = 0.33$ mrem. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as $0.01 \text{ mrem}/16 = 0.001$ mrem. We added the dose derived from measurements at the highest-dose AIRNET station along the northern boundary of Area G (0.35 mrem) close to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.02 mrem. The ingestion pathway was much less than 0.1 mrem and was too small to measure. The total MEI dose at this location in 2012 was measured as 0.35 mrem, which is less than the 0.58-mrem air-pathway MEI dose, so the air-pathway MEI was also the all-pathway MEI.

v. *MEI Summary*

The MEI dose of 0.58 mrem in 2012 is far below the 10-mrem air-pathway limit (EPA 1986) and the 100-mrem all-pathway limit (DOE 1993, DOE 1999, DOE 2011).

c. **Other Pathways**

Direct-penetrating radiation and airborne radioactivity contribute small but measurable doses to the public, as discussed above. The annual dose from other pathways is much less than 0.1 mrem. These other pathways are discussed below.

i. *Water (Ingestion Pathway)*

Measurements of radioactivity in water are reported in Chapters 5 and 6. The local drinking water contains no measurable radionuclides from LANL operations, and the annual dose, if any, is much less than 0.1 mrem. For further information regarding Los Alamos County drinking water quality, refer to the Los Alamos Department of Public Utilities “Drinking Water Quality Report 2012” (Los Alamos County 2013). Similarly, for further information regarding the City of Santa Fe drinking water quality, refer to the City of Santa Fe Water Division “2012 Annual Water Report” (City of Santa Fe 2013).

ii. *Soil and Sediment*

Radioactivity in soil and sediment can contribute to dose by several pathways: direct radiation, inhalation, and ingestion. At all publicly accessible locations, the LANL-generated doses from these pathways are all indistinguishable from background (Chapter 7) and are much less than 0.1 mrem.

iii. *Food (Ingestion Pathway)*

In 2012, there were no new measurements of food; agriculture-related resources (crops, milk, eggs, and honey) and fish from the Rio Grande are collected every 3 yr. The next measurements of agriculture-related foodstuffs are scheduled to occur in 2013, and measurements in fish are scheduled to occur in 2014. Based on previous work reported in Chapter 8, the annual dose from food is much less than 0.1 mrem.

iv. *Release of Items and Real Property*

Two tracts of real property off of DP Road, A-8-b and A-10, were conveyed to Los Alamos County in the latter half of 2012. The dose assessment for land tract A-8-b indicated an estimated average dose of 0.6 mrem/yr for soil samples collected on the surface and at depth based on a residential scenario. With regard to land tract A-10, the estimated dose for a residential scenario was approximately 2.2 mrem/year. In neither case did the estimated dose exceed the authorized release limit of 15 mrem/yr (DOE 2000). At present, these tracts are not occupied. When they are occupied, the actual dose will be calculated using appropriate scenarios.

4. **Dose from Naturally Occurring Radiation**

The annual dose from naturally occurring radioactivity is approximately 450 mrem; see Figure 3-3. Additional man-made sources of radiation, such as medical/dental uses of radiation and building products such as stone walls, raise the total annual dose to about 800 mrem (NCRP 1975, 1987a, 1987b, 2009). Generally, any additional dose of less than 0.1 mrem/yr cannot be distinguished from natural background radiation.

External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from naturally occurring radionuclides. Annual doses from cosmic radiation range from 50 mrem at lower elevations near the Rio Grande to about 90 mrem in the higher elevations west of Los Alamos (Bouville and Lowder 1988). In addition, annual background doses from terrestrial radiation range from about 50 to 150 mrem.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products. Nationwide, the average annual dose from radon is about 200 to 300 mrem (NCRP 1987b.) In Los Alamos County, the average residential radon concentration results in an annual dose of 270 mrem and is within the range of the national average (Whicker 2009a and 2009b). An additional 30 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 U.S. population receive an average annual dose of 300 mrem from medical and dental uses of radiation (NCRP 2009). Another 10 mrem/yr comes from man-made products, such as stone or adobe walls. Therefore, the average total annual dose from sources other than LANL operations is 780 mrem for a typical Los Alamos resident. Figure 3-3 compares the average radiation background in Los Alamos with the average background dose in the United States. The LANL-attributable MEI dose is about 0.1% of the average U.S. background radiation dose from all sources.

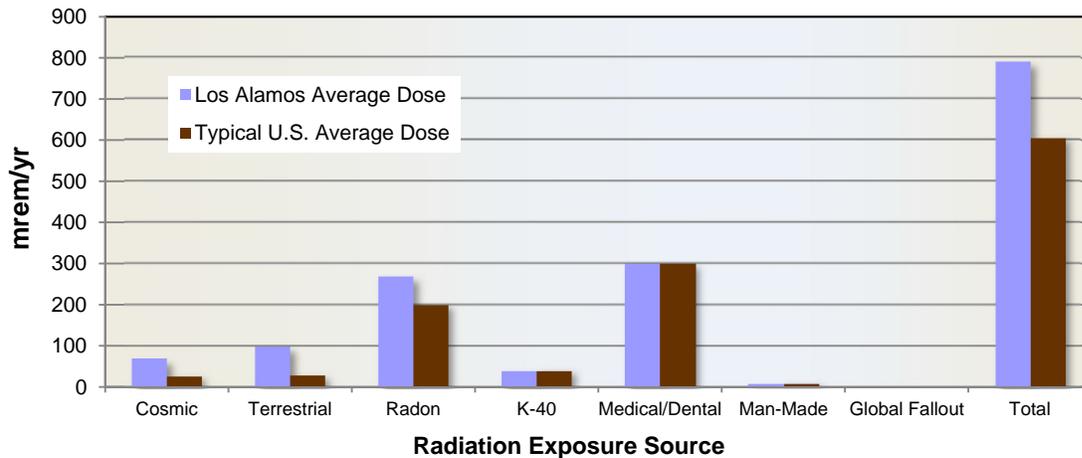


Figure 3-3 Average Los Alamos County radiation background dose compared with average U.S. radiation background dose. Los Alamos County background doses for potassium-40 (K-40), man-made radiation, and global fallout are assumed to be the same as the U.S. average.

5. Conclusion

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem). However, doses to the public from LANL operations are much smaller (Table 3-1) and are far below all regulations and standards. The doses from LANL operations described in this chapter do not cause observable human health effects.

**Table 3-1
LANL Radiological Doses for Calendar Year 2012**

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	0.58 ^a	0.6%	0.27	n/a ^b	n/a
Water	<0.1	<0.1%	0	n/a	n/a
Other Pathways (foodstuffs, soils, etc.)	<0.1	<0.1%	0	n/a	n/a
All Pathways	0.58 ^c	0.6%	0.27	~343,000	~268,000 ^d

^a Rad-NESHAP MEI dose.

^b n/a = Not applicable.

^c The all-pathways MEI is the same as the Rad-NESHAP MEI.

^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, 30 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 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 site-representative parameters to be adjusted according to local conditions. The methods used at LANL are specified in the Quality Assurance Project Plan for the Biota Dose Assessment (available at <http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php>), and McNaughton (2005) describes in detail the application of these methods to specific locations at LANL.

b. Biota Dose Limits

The biota dose limits (DOE 2002) are applied to biota populations rather than to individuals.

The DOE dose limits to biota populations are

- Terrestrial animals: 0.1 rad/day (100 mrad/day)
- Terrestrial plants: 1 rad/day (1000 mrad/day)
- Aquatic animals: 1 rad/day (1000 mrad/day)

c. Methods

Annually, the environmental teams measure more than 100,000 analytes from thousands of locations (Table 1-2 in Chapter 1), so we begin with a screening process to focus on the locations where the biota dose could approach the DOE limits. According to the DOE standard, the biota concentration guide (BCG) “provides users with a place to start” and “Exceedance of BCGs leads the user to the more-detailed tiers of analysis as needed in a stepwise manner.”

We use screening levels that are a small fraction of the BCGs to ensure we do not overlook unusual combinations of data that might be significant. Water is initially screened against the U.S. Environmental Protection Agency (EPA) drinking water standards for humans and further screened against 10% of the applicable BCGs. Soil is screened against 10% of the BCGs, and biota samples are screened against 10% of the values in Module 3 of the DOE standard (DOE 2002.)

2. Biota Dose Results

As summarized in Table 1-2 and described in subsequent chapters, we collected water, soil, and biota samples from many locations in 2012. Most were well below all applicable screening levels. Data that were above a screening level are discussed below.

As reported in Chapter 5, the concentration of strontium-90 in the alluvial groundwater of DP Canyon was 29 picocuries per liter (pCi/L), which is above the EPA drinking water standard for humans, and is approximately 10% of the generic BCG for aquatic systems. However, this location is not part of an aquatic system, so the applicable BCG is 50,000 pCi/L for terrestrial systems. The measured concentration is less than 0.1% of the applicable BCG and therefore does not need further evaluation.

As a result of the Las Conchas Fire, concentrations in suspended sediment in storm water were above screening levels at some locations. The highest concentrations consisted of natural uranium and global fallout in ephemeral storm water. Detailed analysis using RESRAD-BIOTA includes consideration of maximum and mean concentrations; natural radioactive material, global fallout, and material from LANL; terrestrial, riparian, and aquatic habitats; and bioaccumulation factors. These considerations are described in a detailed report (McNaughton and Brock 2013) that concludes biota doses were below the DOE limits.

All the concentrations in soil samples reported in Chapter 7 were far below screening levels. As discussed in the McNaughton 2005 report, previous concentrations in soil samples at isolated locations have, in the past, exceeded the screening levels, but the more detailed tiers of analysis corresponding to level 2 and level 3 of

RESRAD-BIOTA showed that the biota dose is far below the DOE limits (McNaughton 2005, 2008, 2013, McNaughton and Brock 2013).

Chapter 8 reports measurements of radionuclides in the tissue and on the surfaces of biota. These data provide direct confirmation of biota doses, either by comparing with Table 2.4 of Module 3 of the DOE standard (DOE 2002), or by entering tissue concentrations into the latest versions of RESRAD-BIOTA. These data confirm the conclusions based on the underlying media (ground water, surface water, soil, and sediment) and show that biota doses are far below the DOE limits.

3. Conclusion

In conclusion, the extensive data reported in Chapters 6 through 9 demonstrate that biota doses at LANL are well below the DOE limits.

D. NONRADIOLOGICAL RISK

1. Overview

This section assesses the potential human health risk from nonradiological materials released from LANL during 2012 and, in some cases, during the previous 70 yr of operations at LANL. The Clean Air Act regulates nonradiological air pollutants, as discussed in Chapter 2, Section C.6. The applicable standards for other media are summarized in Table 5-1 (Chapter 5), Table 6-1 (Chapter 6), Table 7-1 (Chapter 7), Table 8-1 (Chapter 8), 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 nonradiological 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 are summarized below.

i. Air (Inhalation Pathway)

Assessments of ambient air quality of nonradiological constituents, as reported in Chapter 4, Section D, indicate that releases from LANL operations are below the applicable standards. 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 2% of the National Emission Standards for Hazardous Air Pollutants—recommended concentration of 10 ng/m³, and the PM-10 and PM-2.5 concentrations are lower than applicable EPA limits (Chapter 4, Section D.3).

ii. Groundwater (Ingestion)

The details and a summary of the results of all groundwater measurements are provided in Chapter 5.

Regarding drinking water supplies, LANL collected water samples from Los Alamos County water supply wells. These wells supply water for county residents and the Laboratory. These samples showed no impact from past LANL operations, and the water meets all applicable New Mexico Environment Department (NMED) and EPA drinking water standards.

Additional well water sampling was done in the City of Santa Fe's Buckman well field. No evidence of LANL impact was found in this drinking water supply.

In nondrinking groundwater within Laboratory boundaries, LANL has detected hexavalent chromium in Mortandad Canyon regional aquifer monitoring well samples at 20 times the New Mexico groundwater standard (50 µg/L of any dissolved form of chromium). However, hexavalent chromium has not been detected in any Los Alamos County or Santa Fe Buckman drinking water supply wells above natural background levels.

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 because of LANL operational releases.

iv. Soil

Soil concentrations are reported in Chapter 7. The contaminant concentrations are below all soil screening levels.

v. Foodstuffs (Ingestion)

There was no measurement of nonradioactive materials in foods in 2012; agriculture-related resources (crops, milk, eggs, and honey) and fish from the Rio Grande are collected every 3 yr. The next measurements of agriculture-related foodstuffs are scheduled to occur in 2013, and measurements in fish are scheduled to occur in 2014. As reported in Chapter 8, no risks from nonradioactive materials have been detected in foods in the past years.

vi. Biota Sampling

Metal concentrations were measured in indicator species to assess potential impacts of LANL operations. Specifically, mice and bees were sampled near the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility (Chapter 8, Section B.4.b), and the concentrations were below the screening levels. Also, no significant concentrations of dioxins or furans congeners were found in field mice near DARHT.

Additionally, overstory vegetation was sampled and analyzed for metals, and concentrations were less than the regional reference levels (Supplemental Table S8-6). Polychlorinated biphenyl concentrations in mice around the Los Alamos Canyon Weir were at their lowest since surveys began (Figure 8-9) and suggest that engineering controls are working.

3. Conclusion

The environmental data collected in 2012 show that there is no measurable risk to the public or biota from materials released from LANL operations.

E. REFERENCES

- BEIR 2006: "Health Effects of Exposure to Low Levels of Ionizing Radiation," National Research Council, Biological Effects of Ionizing Radiation (BEIR) VII Phase 2 (2006).
- Bouville and Lowder 1988: Bouville, A., and W.M. Lowder, "Human Population Exposure to Cosmic Radiation," *Radiation Protection Dosimetry* 24:293–299 (1988).
- City of Santa Fe 2013: "2012 Annual Water Report," City of Santa Fe Water Division (April 2013). <http://www.santafenm.gov/DocumentCenter/View/40782>
- DOE 1988a: "External Dose Conversion Factors for Calculating Dose to the Public," U.S. Department of Energy report DOE/EP-0070 (July 1988).
- DOE 1988b: "Internal Dose Conversion Factors for Calculating Dose to the Public," U.S. Department of Energy report DOE/EP-0071 (July 1988).
- DOE 1991: "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," U.S. Department of Energy report DOE/EH-0173T (January 1991).
- DOE 1993: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 5400.5 (January 1993).
- DOE 1999: "The Long-Term Control of Property: Overview of Requirements in DOE Orders 5400.1 and DOE 5400.5," U.S. Department of Energy Information Brief, Office of Environmental Policy and Assistance, EH-412-0014/1099 (October 1999).

- DOE 2000: "Procedure for the Release of Residual Radioactive Material from Real Property," Letter and Attached Procedure from Constance L. Soden, Director, Environment, Safety, and Health Division, U.S. Department of Energy, Albuquerque Operations Office, to Area Office Managers, (June 2000).
- DOE 2002: "A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota," U.S. Department of Energy Technical Standard 1153-2002 (August 2000).
<http://www.hss.doe.gov/nuclearsafety/ns/techstds/docs/standard/1153.htm>
- DOE 2003: "Estimating Radiation Risk from Total Effective Dose Equivalent (TEDE)," Interagency Steering Committee on Radiation Standards (ISCORS) Technical Report No. 1, U.S. Department of Energy DOE/EH-412/0015/0802, Rev. 1 (January 2003).
- DOE 2011: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 458.1 (June 2011).
- EPA 1986: "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, Code of Federal Regulations, Title 40, Part 61 (1986).
- EPA 1988: "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," U.S. Environmental Protection Agency, EPA-520/1-88-020, Federal Guidance Report No. 11 (September 1988).
- EPA 1993: "External Exposure to Radionuclides in the Air, Water, and Soil," U.S. Environmental Protection Agency, EPA-402-R-93-081, Federal Guidance Report No. 12 (September 1993).
- EPA 1997: "Exposure Factors Handbook," U.S. Environmental Protection Agency, EPA/600/C-99/001 (August 1997).
- EPA 1999: "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," U.S. Environmental Protection Agency, EPA-402-R-99-001, Federal Guidance Report No. 13 (September 1999).
- EPA 2004: "Primary Drinking Water Regulations; Radionuclides; Final Rule," U.S. Environmental Protection Agency, Code of Federal Regulations, Title 40, Parts 141 and 142 (June 2004).
- EPA 2013: "CAP88-PC Version 3.0 User Guide," Trinity Engineering Associates, Inc., U.S. Environmental Protection Agency (February 2013).
- Fuehne 2013: Fuehne, D.P., "2012 LANL Radionuclide Air Emissions," Los Alamos National Laboratory report LA-14469 (June 2013).
- Green 2013: Green, A., "Air Monitoring Compliance Network Report for 2013," Los Alamos National Laboratory memorandum to David Fuehne, ENV-ES-13-0131 (May 16, 2013).
- ICRP 1996: "Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients," Annals of the International Commission on Radiological Protection, ICRP Publication 72, 26:1, Pergamon Press (1996).
- LANL 2008: "Los Alamos National Laboratory Environmental ALARA Program," Los Alamos National Laboratory document, Program Description (PD) 410 (August 2008).
- LANL 2011: "Radiation Protection," Los Alamos National Laboratory procedure P121, Rev. 2 (June 2011).
- Los Alamos County 2013: "Drinking Water Quality Report 2012," Los Alamos Department of Public Utilities (2013).
http://www.losalamosnm.us/utilities/DPUDocuments/DPU_BR130617WaterReport.pdf
- McNaughton 2005: McNaughton, M.W., "Biota Dose Assessment at LANL," Los Alamos National Laboratory document LA-UR-05-4699 (2005).

- McNaughton 2008: McNaughton, M.W., “Notes on the Mortandad Canyon Biota Dose Assessment,” Los Alamos National Laboratory document LA-UR-08-2947 (2008).
- McNaughton 2012: McNaughton, M.W., and B.R. Brock, “Population Files for use with CAP88 at Los Alamos,” Los Alamos National Laboratory document LA-UR-12-22801 (July 2012).
- McNaughton 2013: McNaughton, M.W., “Site-Representative Biota Concentration Guides at Los Alamos,” Los Alamos National Laboratory document LA-UR-13-20095 (2013).
- McNaughton and Brock 2013: McNaughton, M.W., and B.R. Brock, “Biota Dose Assessment at LANL for 2012,” Los Alamos National Laboratory document LA-UR-13-26044 (2013).
- McNaughton et al. 2013: McNaughton, M.W., B.R. Brock, W.F. Eisele, and J.J. Whicker, “On-site Measurements and Calculations of the Maximally Exposed Individual (MEI) at LANL,” Los Alamos National Laboratory document LA-UR-13-25871 (2013).
- NCRP 1975: “Natural Background Radiation in the United States,” National Council on Radiation Protection and Measurements report 45 (November 1975).
- NCRP 1976: “Structural Shielding and Evaluation for Medical Use of X-rays and Gamma Rays of Energies up to 10 MeV, Recommendations of the National Council on Radiation Protection and Measurements,” National Council on Radiation Protection and Measurements report 49 (1976).
- NCRP 1987a: “Ionizing Radiation Exposure of the Population of the United States,” National Council on Radiation Protection and Measurements report 93 (September 1987).
- NCRP 1987b: “Exposure of the Population in the United States and Canada from Natural Background Radiation,” National Council on Radiation Protection and Measurements report 94 (December 1987).
- NCRP 2009: “Ionizing Radiation Exposure of the Population of the United States,” National Council on Radiation Protection and Measurements report 160 (March 2009).
- NMED 2009: “Technical Background Document for Development of Soil Screening Levels, Revision 5.0,” with revised Table A-1, New Mexico Environment Department, Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program (December 2009).
- NRC 1977: “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I,” Nuclear Regulatory Commission report, Regulatory Guide 1.109 (October 1977).
- Whicker 2009a: Whicker, J.J., “Estimated Effective Dose Rates from Radon Exposure in Workplaces and Residences within Los Alamos County in New Mexico,” Los Alamos National Laboratory document LA-UR-09-00149 (2009).
- Whicker 2009b: Whicker, J.J., “Work to save dose: Contrasting effective dose rates from radon exposure in workplaces and residences against the backdrop of public and occupational regulatory limits,” *Health Physics* 97:248-256 (2009).

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The Los Alamos National Laboratory (LANL or the Laboratory) air-monitoring and meteorology programs support dose assessment, emergency response, and safety basis accident analysis. Both air quality measurements and meteorology are important surveillance programs that support the following Environmental Grand Challenges—*eliminate industrial emissions, discharges, and releases into the environment* and *protect human and environmental health by managing and restoring lands*.

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 5 yr.

Table 4-1
Average Background Radionuclide Concentrations in the Regional^a Atmosphere

Analyte	Units ^b	EPA Concentration Limit ^c	Annual Averages				
			2008	2009	2010	2011	2012
Tritium ^d	pCi/m ³	1500	0.8	0.2	-0.2	1.3	-0.2
Am-241	aCi/m ³	1900	-0.3 ^e	-0.6 ^e	-0.4 ^e	0.5	0.2
Pu-238	aCi/m ³	2100	0.1	0.4	1.2	1.5	1.6
Pu-239	aCi/m ³	2000	-0.1	1.0	0.0	0.3	1.2
U-234	aCi/m ³	7700	18	17	16	16	18
U-235	aCi/m ³	7100	1.3	0.7	0.6	0.9	1.0
U-238	aCi/m ³	8300	17	16	15	16	17

^a Regional air-sampling stations operated by LANL; locations can vary by year.

^b pCi/m³ = Picocuries per cubic meter; aCi/m³ = attocuries per cubic meter.

^c Each U.S. Environmental Protection Agency (EPA) concentration limit is from 40 Code of Federal Regulations (CFR) 61 and corresponds to 10 millirems/year (mrem/yr).

^d Tritium values have been corrected for the tritium lost to bound water in the silica gel.

^e Negative values occur because of subtraction of radioactivity found in sample filter media and in tracers used in the analytical chemistry process.

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 with the EPA (EPA 1989) 10-mrem annual dose equivalent concentration limit. On-site air concentrations and resulting dose equivalents are compared with the U.S. Department of Energy (DOE) 100-mrem annual dose equivalent concentration limit (DOE 1993).

2. Air-Monitoring Network

During 2012, LANL operated 59 environmental air stations to sample radionuclides by collecting particulate matter. Thirty-five of these stations also collected water vapor for tritium analysis. A network evaluation was conducted during 2012 that identified 12 stations that were no longer required to meet environmental surveillance objectives. These 12 stations were taken out of operation during 2012 and were not sampled for the entire year. AIRNET sampling locations (Figures 4-1 through 4-4) are categorized as “regional,” “pueblo,” “perimeter,” “waste site” (Technical Area 54 [TA-54]), “decontamination and decommissioning” (D&D) at Material Disposal Area (MDA) B, or “on-site.”

3. Quality Assurance

The AIRNET quality assurance project plan and implementing procedures specify the requirements and implementation of sample collection, sample management, chemical analysis, and data management. The requirements follow EPA methods for sample handling, chain-of-custody, analytical chemistry, and statistical analyses of data.

AIRNET stations are operated continuously; samples are changed out every 2 wk. Field sampling completeness in AIRNET is assessed for each 2-wk collection period. The AIRNET run time for compliance stations averaged 99.5% for the year.

Filters are grouped by geographical location into “clumps” and screened for gamma-emitting radionuclides every 2 wk. For analysis of alpha-emitting isotopes at the end of the quarter, a composite for each station is made up of six or seven half-filters. AIRNET maintains a quality assurance program that satisfies 40 CFR 61, Appendix B, Method 114. Analytical data completeness was 100% for filters and 99.3% for silica gel.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-7 summarize measured 2012 ambient air concentrations. Concentrations are not reduced by background amounts but are corrected for blank measurements 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 interval (within two standard deviations of the mean). Because 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 because their omission would bias averages.

Concentrations farther from the mean than three standard deviations are used to identify samples of interest or detected concentrations. The control limit of three standard deviations is widely used for statistical quality control charts (Duncan 1986, Gilbert 1987).

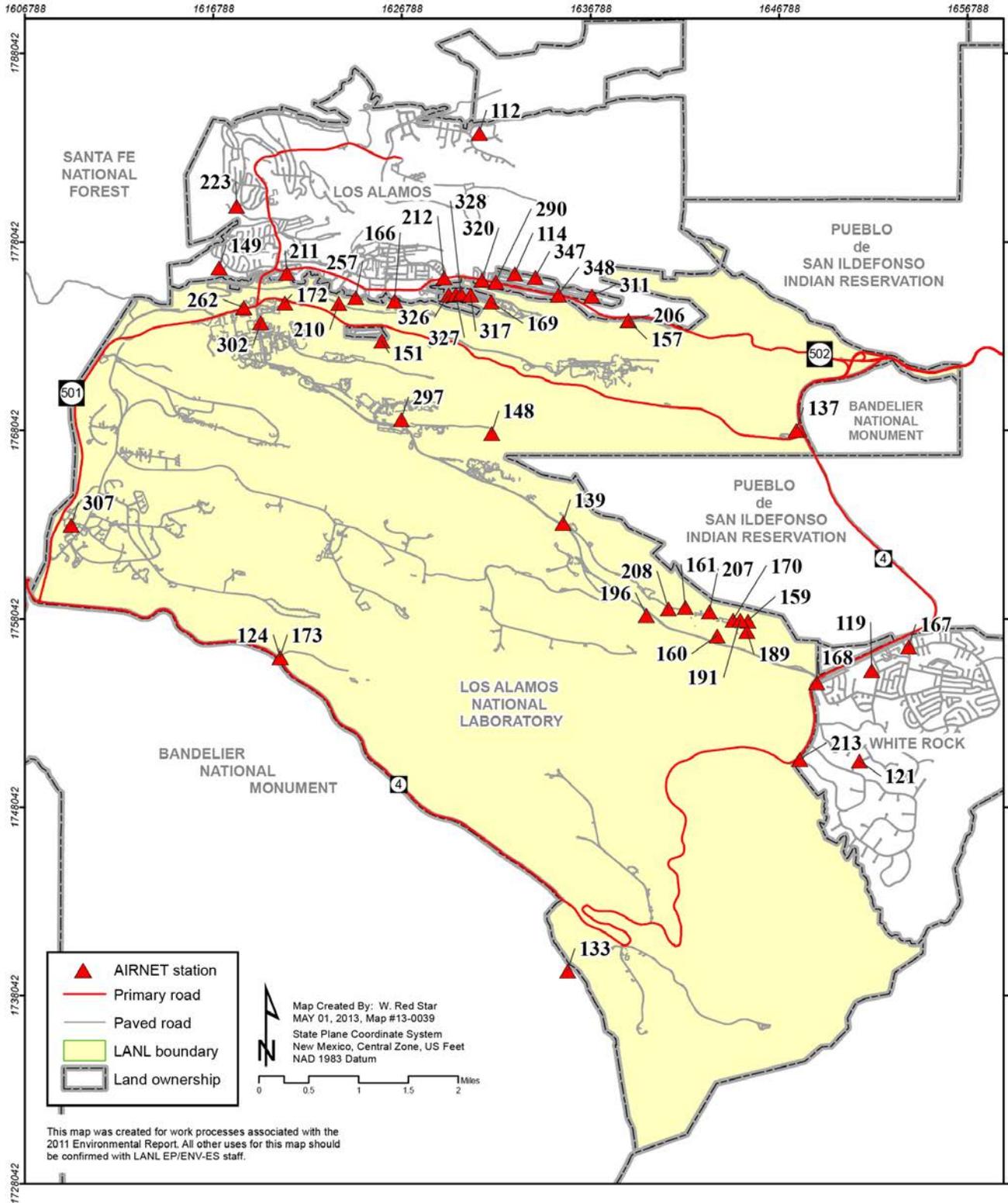


Figure 4-1 AIRNET station locations at and near LANL

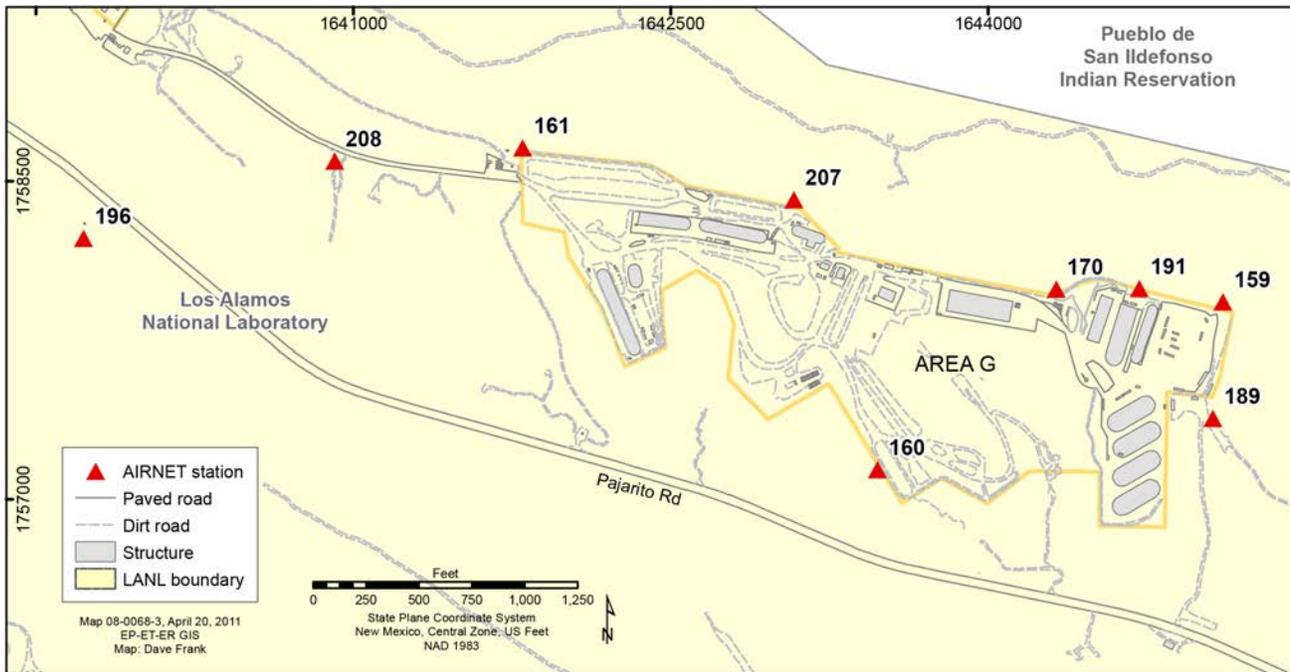


Figure 4-2 AIRNET station locations at TA-54, Area G, LANL

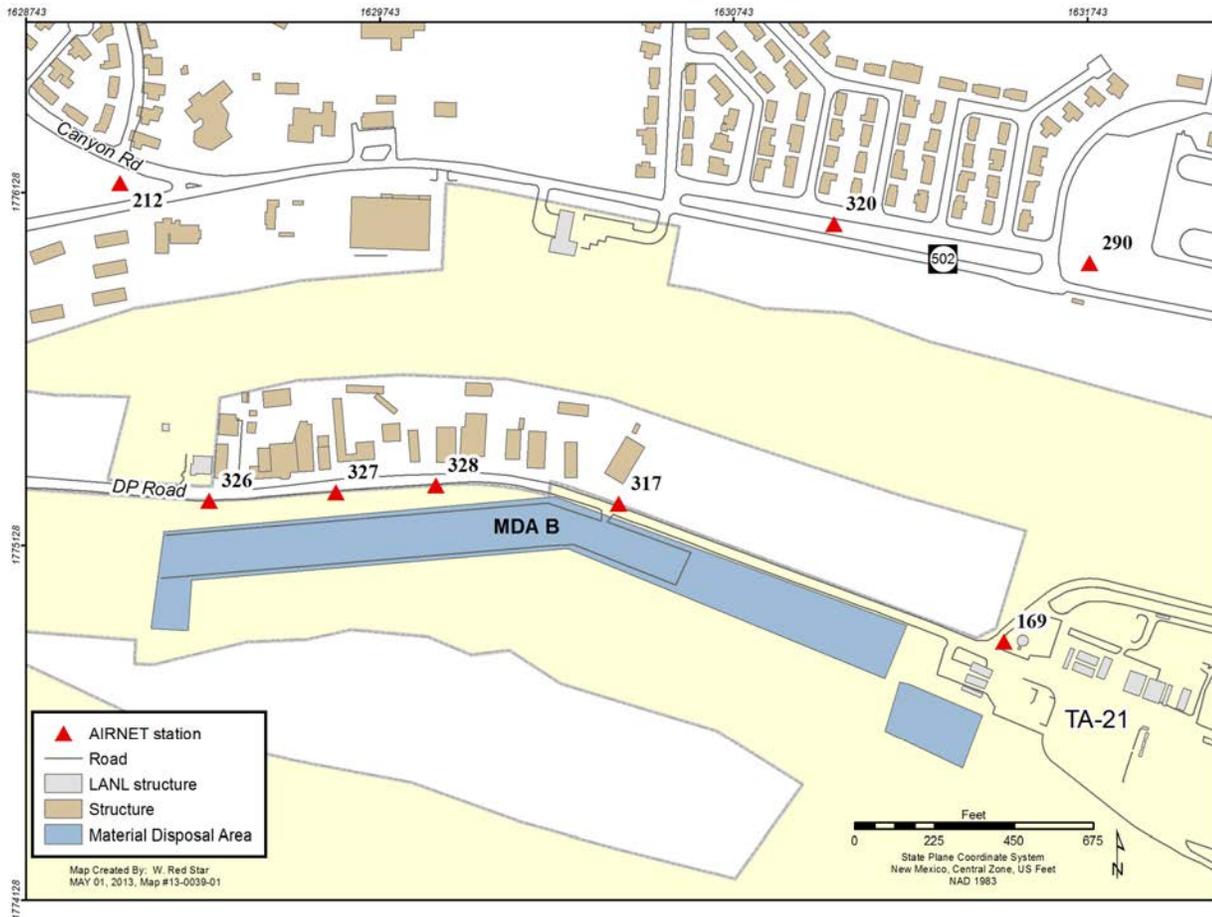


Figure 4-3 AIRNET station locations near TA-21, MDA B

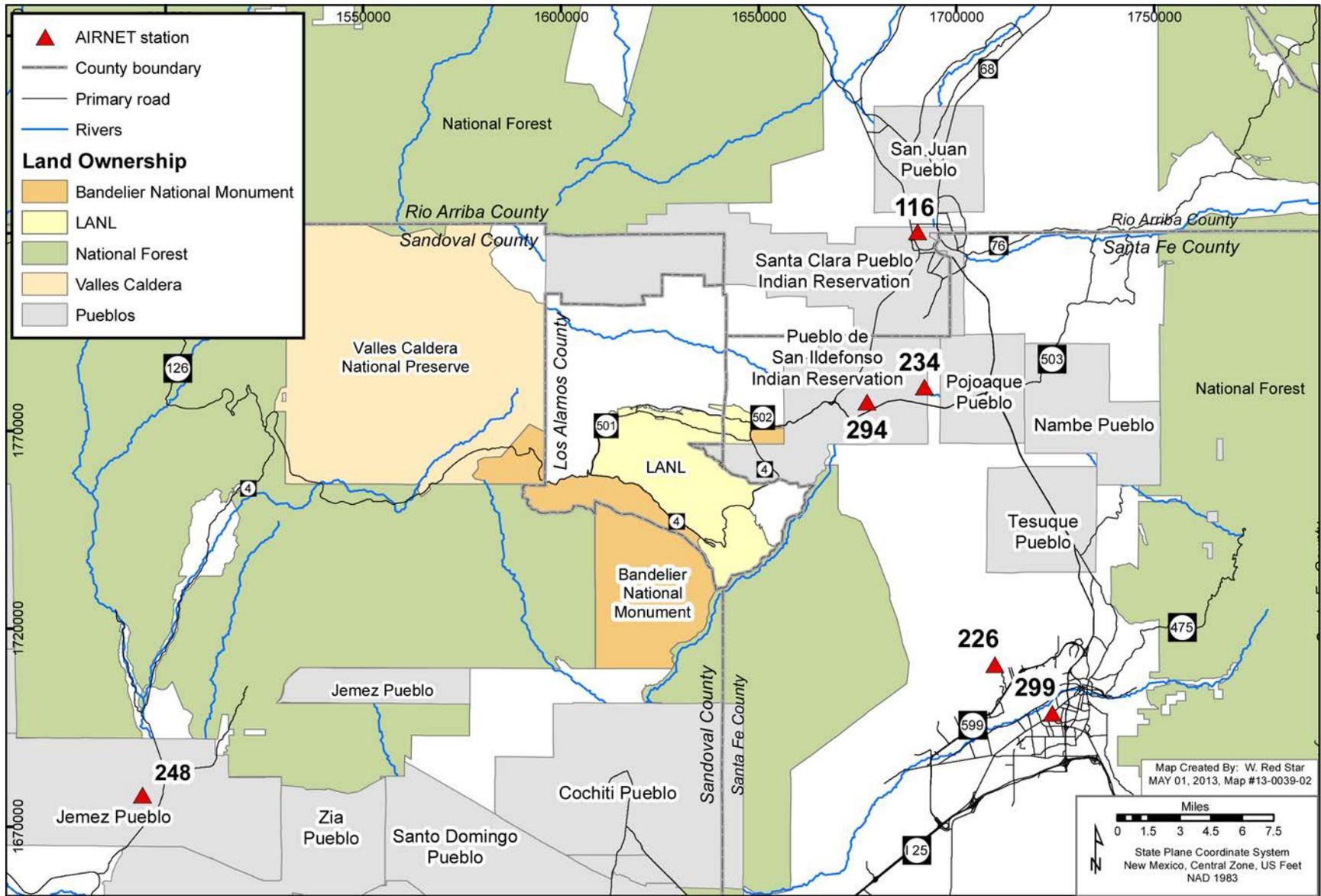


Figure 4-4 Regional and pueblo AIRNET station locations

Table 4-2
Airborne Tritium as Tritiated Water Concentrations for 2012—Group Summaries

Station Grouping ^a	Number of Biweekly Samples	Mean ± 3s ^b Uncertainty (pCi/m ³)	Maximum Annual Station Concentration (pCi/m ³)
Regional	108	-0.2 ±0.5	0.0
Pueblo	79	0.4 ±0.6	2.0
Perimeter	578	0.3 ±0.2	1.9
D&D	69	0.0 ±0.7	0.5

^a EPA 40 CFR 61, Appendix E, public concentration limit is 1500 pCi/m³.

^b 3s = Three standard deviations.

Table 4-3
Airborne Americium-241 Concentrations for 2012—Group Summaries

Station Grouping	Number of Quarterly Samples	Mean ± 3s (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	0.2 ±0.4	1.0
Pueblo ^a	8	1.7 ±3.0	2.0
Perimeter ^a	92	0.2 ±0.4	1.0
Waste site ^b	32	0.6 ±0.8	1.6
On-site ^b	16	0.2 ±0.9	0.8
D&D ^a	20	0.2 ±0.9	0.8

^a EPA 40 CFR 61, Appendix E, public concentration limit is 1900 aCi/m³.

^b Worker concentration limit is 19,000 aCi/m³.

Table 4-4
Airborne Plutonium-238 and Plutonium-239/240 Concentrations for 2012—Group Summaries

Station Grouping	Number of Samples	Group Mean ± 3s (aCi/m ³)		Maximum Annual Station Concentration (aCi/m ³)	
		Pu-238	Pu-239/240	Pu-238	Pu-239/240
Regional ^a	16	1.6 ±1.1	1.2 ±0.9	2.0	1.8
Pueblo ^a	8	1.4 ±2.4	2.3 ±2.4	2.3	2.4
Perimeter ^a	92	1.0 ±0.4	5.3 ±0.9	1.8	97
Waste site ^b	32	1.3 ±0.9	20 ±3.2	2.0	67
On-site ^b	16	0.9 ±0.9	1.1 ±0.9	1.3	3.4
D&D ^a	20	1.9 ±0.9	13 ±1.9	3.8	24

^a EPA 40 CFR 61, Appendix E, public concentration limit is 2100 aCi/m³ for Pu-238 and 2000 aCi/m³ for Pu-239/240.

^b Worker concentration limit is 21,000 aCi/m³ for Pu-238 and 20,000 aCi/m³ for Pu-239/240.

Table 4-5
Airborne Uranium-234, -235, and -238 Concentrations for 2012—Group Summaries

Station Grouping	Number of Samples	Group Mean \pm 3s (aCi/m ³)		
		U-234	U-235	U-238
Regional ^a	16	18 \pm 3	1.0 \pm 1.2	17 \pm 3
Pueblo ^a	8	23 \pm 6	1.4 \pm 2.3	22 \pm 5
Perimeter ^a	92	12 \pm 1	0.8 \pm 0.5	12 \pm 1
Waste site ^b	32	19 \pm 3	0.9 \pm 0.9	19 \pm 2
On-site ^b	16	12 \pm 2	0.7 \pm 1.0	12 \pm 2
D&D ^a	20	16 \pm 2	1.3 \pm 1.0	16 \pm 2

^a EPA 40 CFR 61, Appendix E, public concentration limit is 7700 aCi/m³ for U-234, 7100 aCi/m³ for U-235, and 8300 aCi/m³ for U-238.

^b Worker concentration limit is 77,000 aCi/m³ for U-234; 71,000 aCi/m³ for U-235; and 83,000 aCi/m³ for U-238.

b. Investigation of Elevated Air Concentration Measurements

Two air concentration thresholds have been established to determine when further action is warranted. The “investigation” action level, or screening level, is triggered when an air concentration exceeds a 5-yr average plus three standard deviations at that location. “Alert” action levels 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 measurements are valid and recur, the air-monitoring team works with LANL operations personnel to assess potential sources and implement possible mitigation plans.

During the year, investigation levels for americium-241; plutonium-238 and -239; uranium-234, -235 and -238; tritium; and select gamma-emitters were exceeded in a statistically significant manner 30 times (sometimes only barely so). Of these exceedances, about 40% were at or near LANL’s solid waste site Area G at TA-54, another 43% were at or near the remediation site at MDA B, and about 7% were near a legacy waste site. None of these concentrations pose a long-term health risk.

c. Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and natural cosmogenic processes (Eisenbud and Gesell 1997). We measure tritiated water (HTO) because the dose impact is about 25,000 times higher than from gaseous tritium, HT or T₂ (ICRP 1978). We used water-vapor concentrations in the air and tritium concentrations in the water vapor to calculate ambient levels of tritium, which are corrected for blanks, bound water in the silica gel, and isotopic distillation effects.

During 2012, all annual mean concentrations were well below EPA and DOE guidelines (Table 4-2). The highest off-site annual tritium concentration at any station was about 0.13% 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 about 3.5% of the on-site worker exposure limit. Concentrations reflect variability in operations and show no distinctive trends (Figure 4-5).

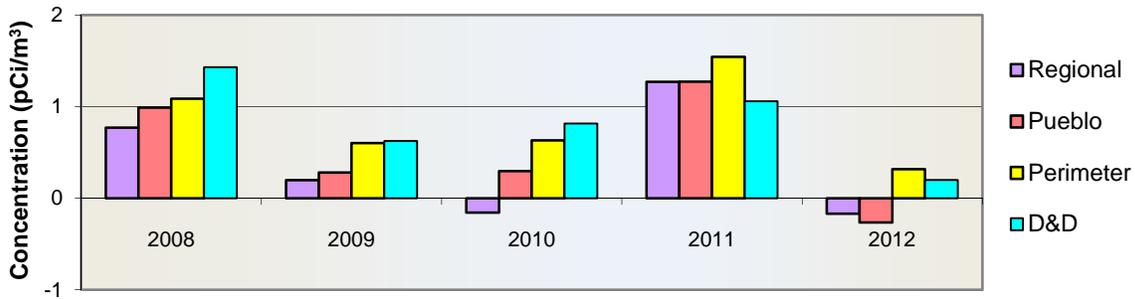


Figure 4-5 Annual average concentrations of tritium by group

d. Americium-241

Americium is present in very low concentrations in the environment. Table 4-3 summarizes 2012 sampling data. The highest annual off-site and on-site averages for any station were about 0.1% and 0.01% of the public and worker limits, respectively. Concentrations show no distinctive trends (Figure 4-6).

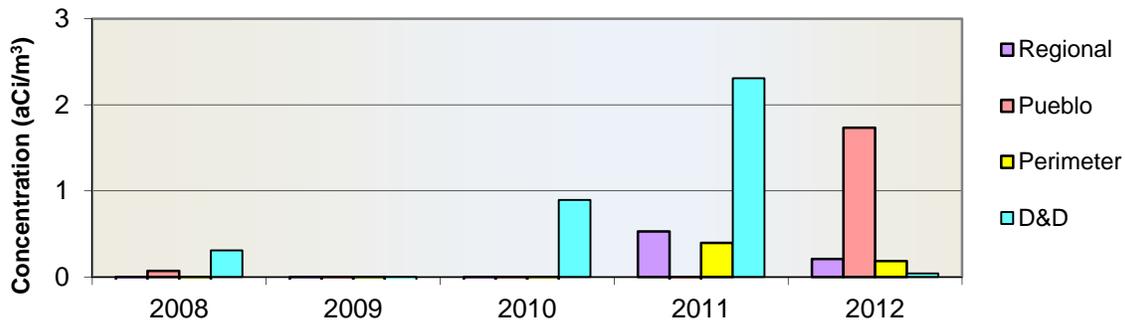


Figure 4-6 Annual average concentrations of americium-241 by group

e. 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 from 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 and plutonium-239/240 data for 2012. The highest annual plutonium-238 off-site and on-site averages were about 0.5% and 0.02% of the public and worker limits, respectively. The highest annual plutonium-239/240 off-site and on-site averages were about 5% and 0.3% of the public and worker limits, respectively.

Figures 4-7 and 4-8 show the annual grouping average concentrations. The increased concentration of plutonium-239 in 2012 was likely because of MDA B cleanup and associated operations.

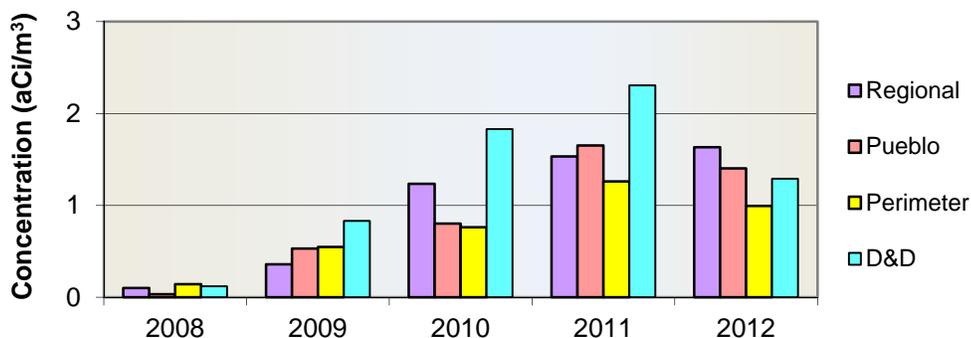


Figure 4-7 Annual average concentrations of plutonium-238 by group

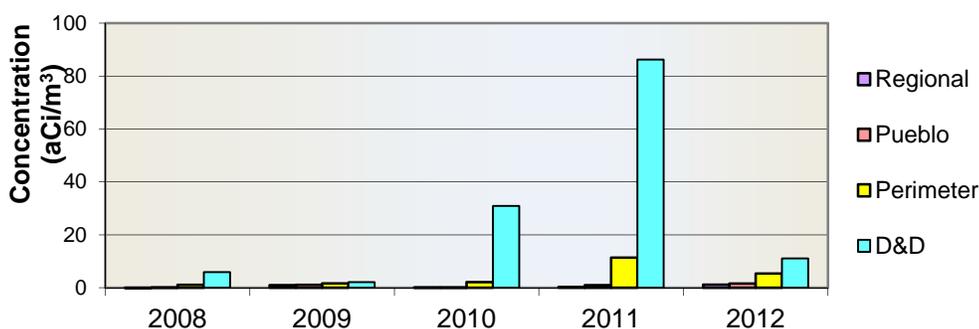


Figure 4-8 Annual average concentrations of plutonium-239/240 by group

f. Uranium

Uranium-234, -235, and -238 are found in nature. Natural uranium has constant and known relative isotopic abundances. Uranium-238 activity is generally equal to uranium-234 (Walker et al. 1989). LANL emissions over the past 60 yr have been either enriched uranium (EU) (uranium-234 and uranium-235) or depleted uranium (DU). If uranium-234 and -238 concentrations differ by more than three standard deviations, we note an EU or DU presence. No EU or DU was detected in 2012. Off-site annual mean concentrations of uranium isotopes (Table 4-5) were below 0.5% of the EPA guidelines; the on-site concentrations were below 0.1% of the EPA guidelines. The highest annual uranium concentrations are typically at dusty locations. The highest annual off-site concentrations of uranium-234, -235, and -238 were all below 35 aCi/m³.

g. Gamma Spectroscopy Measurements

For gamma screening, we group filters across sites in “clumps” for each sampling period and analyze for the following: actinium-228, americium-241, beryllium-7, bismuth-212 and -214, cobalt-60, cesium-134 and -137, iodine-131, potassium-40, sodium-22, protactinium-234m, lead-212 and -214, thorium-234, and thallium-208. We investigate any measurement of these analytes above its minimum detectable activity, which we use as a screening level.

We analyze for the naturally occurring radionuclides beryllium-7, potassium-40, and lead-210. None were detected during 2012.

5. Special Monitoring

During emergencies or unusual events, the routine monitoring systems described in this chapter are supplemented by special monitoring. There were no such events during 2012.

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 that there are no emission controls in place, such as the high-efficiency particulate air filters that 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 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (Rad-NESHAP) (EPA 1989). During 2012, we identified 28 stacks meeting this criterion.

2. Sampling Methodology

In 2012, 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 (CMR) 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 6 mo, the analytical laboratory composites these samples and analyzes them to determine the cumulative activity in 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 6-mo 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 CMR 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 medium before vapor sampling. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present in 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 collect the vials of ethylene glycol weekly and send 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 a historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling for 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 2012 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 their quantities. 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). 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. Before 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 1 wk (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 6 mo 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; plutonium-238 and -239/240; etc.) identify all significant activity in the composites.

For particulate filters from the LANSCE accelerator facility and TA-48 radiochemistry hot-cell facilities, 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 before shipping them to the off-site analytical laboratory.

c. Vaporous Activation Product Emissions

We remove and replace the charcoal canisters weekly at facilities with the potential for significant vaporous activation product 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 collect 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 Analysis Laboratory. The Health Physics Analysis 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 Emissions

To record and report GMAP emissions, we use 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 that 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 2012 totaled approximately 217 curies (Ci) (compared with 328 Ci in 2011). Of this total, tritium emissions contributed approximately 98 Ci (compared with 101 Ci in 2011), and air activation products from LANSCE stacks contributed nearly 119 Ci (compared with nearly 228 Ci in 2011). LANSCE diffuse emissions of air activation products contributed another 9.8 Ci of GMAP. Combined airborne emissions of particulate materials such as plutonium, uranium, americium, and thorium were less than 0.00001 Ci. Emissions of particulate matter plus vapor activation products (P/VAP) were about 0.023 Ci, which is about the same as recent years (short-lived progeny are included in the P/VAP sum).

Table 4-6 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-7 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP. Table 4-8 presents the half-lives of the radionuclides typically emitted by LANL. During 2012, the LANSCE facility nonpoint source emissions of activated air comprised approximately 9 Ci of carbon-11 and less than 1 Ci of argon-41.

**Table 4-6
Airborne Radioactive Emissions (Ci) from LANL Buildings with Sampled Stacks in 2012**

Building No.	H-3 ^a	Am-241	Pu ^b	U ^c	Th ^d	P/VAP ^e	GMAP	Sr-90 ^f
TA-03-029		4.85E-07	3.59E-06	4.32E-06	5.59E-07	7.96E-05		1.88E-07
TA-03-102								
TA-16-205/450	7.50E+01							
TA-48-001				1.48E-08		1.07E-02		
TA-50-001			6.34E-09	1.79E-07				5.61E-08
TA-50-037				2.00E-08	9.97E-09			
TA-50-069	1.50E+00		1.95E-10	1.95E-09	3.99E-10			8.71E-10
TA-53-003	1.53E+01					1.62E-04	4.46E+01	
TA-53-007	1.62E+00					1.39E-03	7.43E+01	
TA-54-231			2.23E-10	6.51E-09	1.53E-09			1.79E-09
TA-54-412				4.84E-09	2.43E-10			
TA-55-004	4.70E+00		3.68E-09	1.54E-07	2.55E-08			
TA-55-400								
Total ^g	9.81E+01	4.85E-07	3.60E-06	4.70E-06	5.97E-07	2.33E-02	1.29E+02 ^h	2.46E-07

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 Includes measured radionuclides and short-lived radioactive progeny.

^f Strontium-90 values do not include short-lived radioactive progeny of Y-90.

^g Totals may reflect rounding.

^h Total for GMAP includes 9.8 Ci released from diffuse sources at TA-53.

Table 4-7
Detailed Results of Activation Products
Sampling from LANL Stacks in 2012

Building No.	Nuclide	Emission (Ci)
TA-3-0029	Ge-68	0
TA-3-0029	Ga-68	0
TA-48-0001	As-72	0
TA-48-0001	As-73	0
TA-48-0001	As-74	0.00000358
TA-48-0001	Br-76	0
TA-48-0001	Br-77	0.000010
TA-48-0001	Ge-68	0.0106
TA-48-0001	Ga-68	0.0106
TA-48-0001	Hg-197	0
TA-48-0001	Hg-197m	0
TA-48-0001	Mn-54	0
TA-48-0001	Se-75	0.000106
TA-53-0003	Ar-41	1.79
TA-53-0003	As-73	0
TA-53-0003	Be-7	0.0000482
TA-53-0003	Br-76	0.00000296
TA-53-0003	Br-77	0.00000430
TA-53-0003	Br-82	0.000103
TA-53-0003	C-11	42.9
TA-53-0003	Na-24	0.00000293
TA-53-0003	Os-191	0.0000000821
TA-53-0007	Ar-41	5.73
TA-53-0007	As-73	0.0000114
TA-53-0007	Be-7	0.00000278
TA-53-0007	Br-76	0.000149
TA-53-0007	Br-77	0
TA-53-0007	Br-82	0.000939
TA-53-0007	C-10	0.132
TA-53-0007	C-11	37.7
TA-53-0007	Hg-197m	0.000283
TA-53-0007	Hg-197	0.00283
TA-53-0007	N-13	12.1
TA-53-0007	N-16	0.279
TA-53-0007	Na-24	0.00000331
TA-53-0007	O-14	0.203
TA-53-0007	O-15	18.1
TA-53-0007	Os-191	0.00000338
TA-53-0007	Se-75	0

Table 4-8
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

*d = Day; s = second; h = hour.

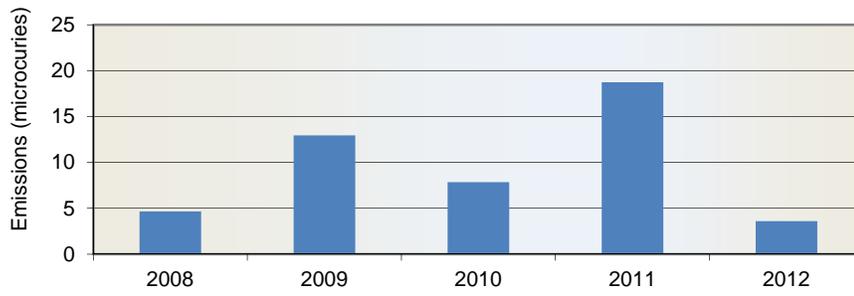


Figure 4-9 Plutonium emissions from sampled LANL stacks

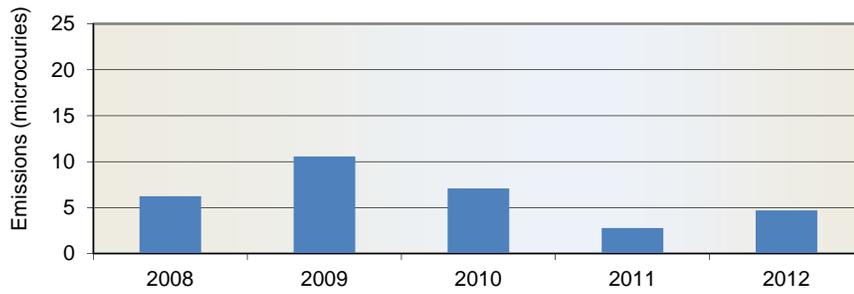


Figure 4-10 Uranium emissions from sampled LANL stacks

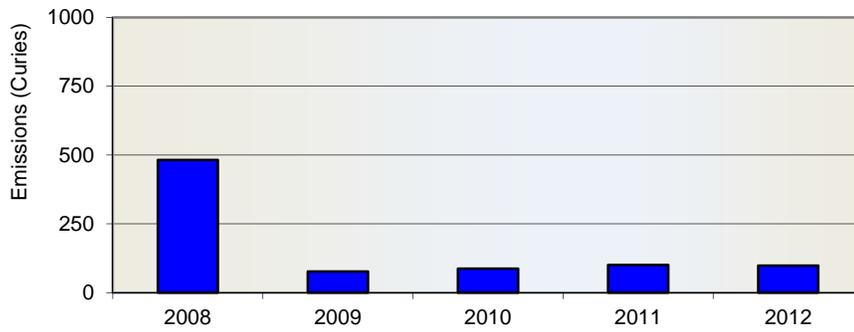


Figure 4-11 Tritium emissions from sampled LANL stacks

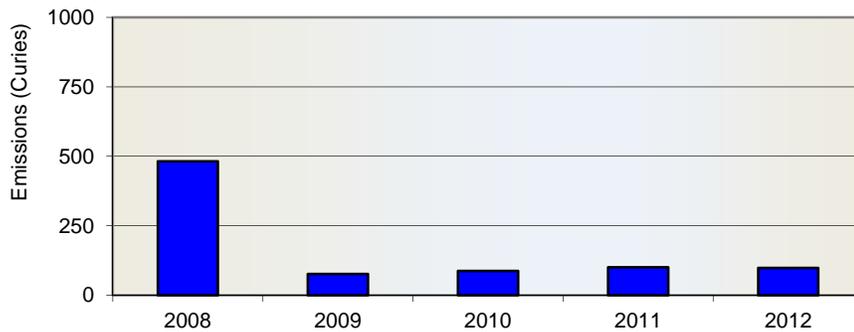


Figure 4-12 GMAP emissions from sampled LANL stacks

5. Long-Term Trends

Figures 4-9 to 4-12 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 remained low as in recent years, reflecting minimal operations taking place at the main tritium facility during the year. In 2012, emissions of GMAP were lower than those measured in 2011, reflecting reduced operational hours in 2012 compared with 2010 and 2011. GMAP levels dropped dramatically from 2009 levels because of a change-out of the primary beam irradiation target at TA-53, Building 7, before the 2010 run cycle at LANSCE.

The LANSCE facility operated in the same configuration as recent years, with the majority of radioactive air emissions being generated by continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center. Operations to the 1L Target in January and February of 2012 were followed by an extended maintenance outage. Normal operations to most facility areas resumed in August and continued through December 2012. There was a contamination incident in August of 2012 in the 1L Target experimental areas, which did not result in any airborne emissions. Investigation and cleanup of this incident in the last half of 2012 resulted in lower beam current and a reduced operating schedule for much of the fall, which in turn lowered the levels of routine air emissions from the 1L Target operations. Full-power beam operations did not resume at the 1L Target until November.

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 of the stack. This time interval allows decay of the short-lived radionuclides to nonradioactive components. As mentioned, the primary beam irradiation target at TA-53, Building 7, was changed out before the 2010 run cycle. This resulted in a more controlled irradiation environment and less generation of activated air or other particulates and vapors.

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM

1. Introduction

The objective of the Direct Penetrating Radiation Monitoring Network (DPRNET) and the Neighborhood Environmental Watch Network (NEWNET) is to monitor gamma and neutron radiation in the environment, outside of the workplace, as required by DOE Order 458.1, Section 4.e, and as described in McNaughton et al. (2000), to demonstrate compliance with the DOE all-pathway dose limit of 100 mrem/yr.

Significant observations during 2012 are as follows:

- The doses near Area G continue to decrease as a result of shipments to the Waste Isolation Pilot Plant (WIPP).
- At all locations, the DPRNET dose to the public from LANL operations was much less than 1 mrem/yr.

In northern New Mexico, naturally occurring radiation varies from approximately 100 to 200 mrem/yr, so it is difficult to measure the much smaller radiation from LANL. To meet the objectives, measurements are made both at public locations and close to potential sources, and the data are compared with models of radiation as a function of distance (McNaughton 2013). Thus, radiation from LANL is distinguished by higher levels close to the source and also from the trend of the radiation levels with distance from the source.

Sources that are constant with time are monitored with thermoluminescent dosimeters (TLDs). Time-varying sources are monitored by NEWNET. For example, radiation from LANSCE depends on whether the accelerator is on or off, and short-lived activation products such as carbon-11 are only detected when the wind is directed from the source to the detector. These fluctuations are apparent in the real-time NEWNET displays at <http://environweb.lanl.gov/newnet/>.

For the past 10 yr, neutron radiation has been a significant contributor to the all-pathway maximally exposed individual (MEI) near Area G. However, in 2012, DPRNET showed that dose rates near Area G decreased significantly (see Figures 4-13 and 4-14). These decreases are a result of waste being shipped off-site to WIPP.

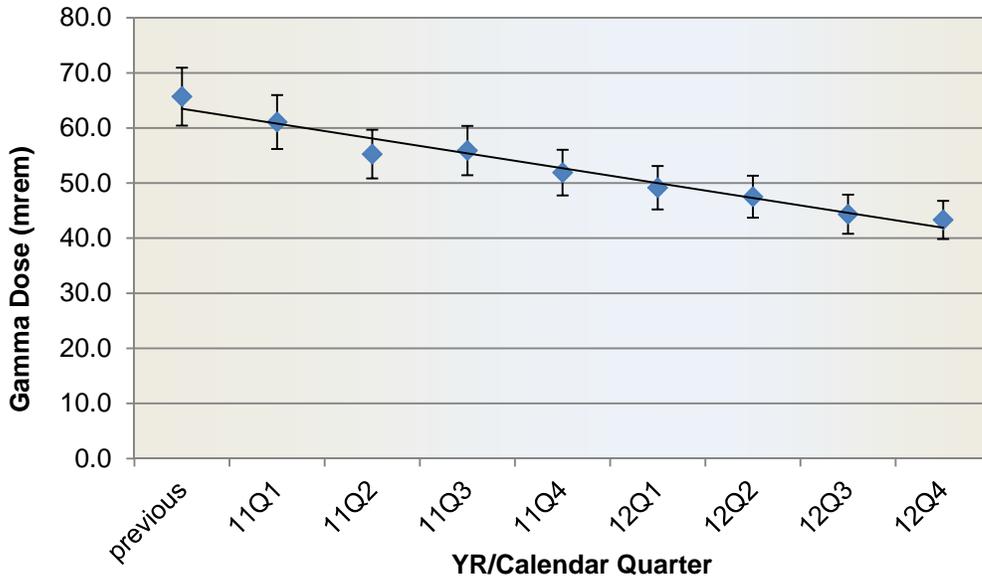


Figure 4-13 Average quarterly gamma doses around the perimeter of Area G for the calendar quarters of 2011 (11Q1 to 11Q4) and 2012 (12Q1 to 12Q4). The first point, at 66 ± 4 mrem, is the average of the previous 36 calendar quarters, during which the quarterly doses were approximately constant.

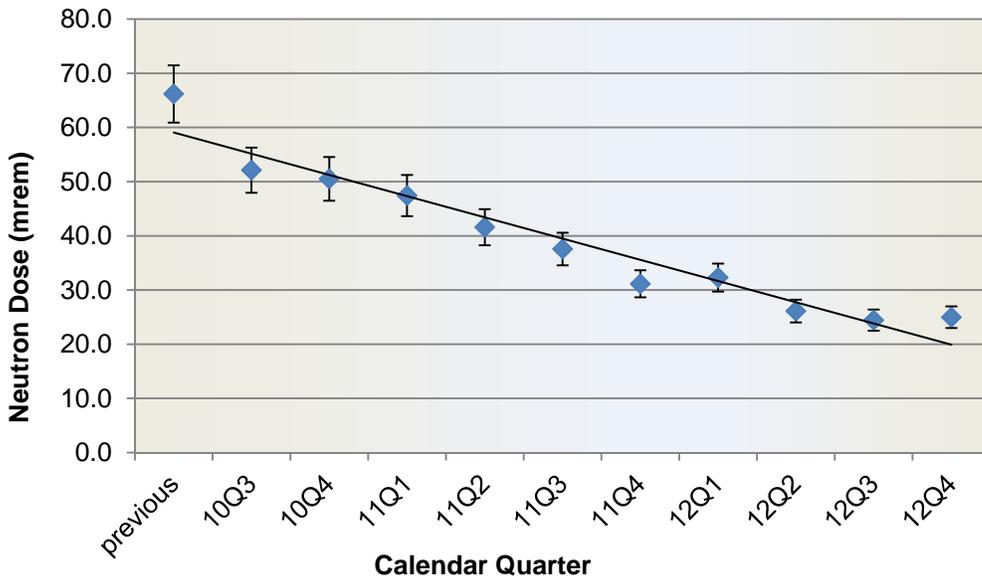


Figure 4-14 Average quarterly neutron doses (mrem) around the perimeter of Area G from the third quarter of 2010 (10Q3) to the fourth quarter of 2012 (12Q4). The first point, at 63 mrem, is the average of the preceding 14 calendar quarters. Natural background contributes less than 1 mrem to each point.

a. Dosimeter Locations

We placed 98 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). Additional stations are around TA-54, Area G (shown in Figure 4-15); at TA-53, LANSCE (8 stations); at Santa Clara Pueblo (5 stations); and inside the Pueblo de San Ildefonso sacred area (2 stations).

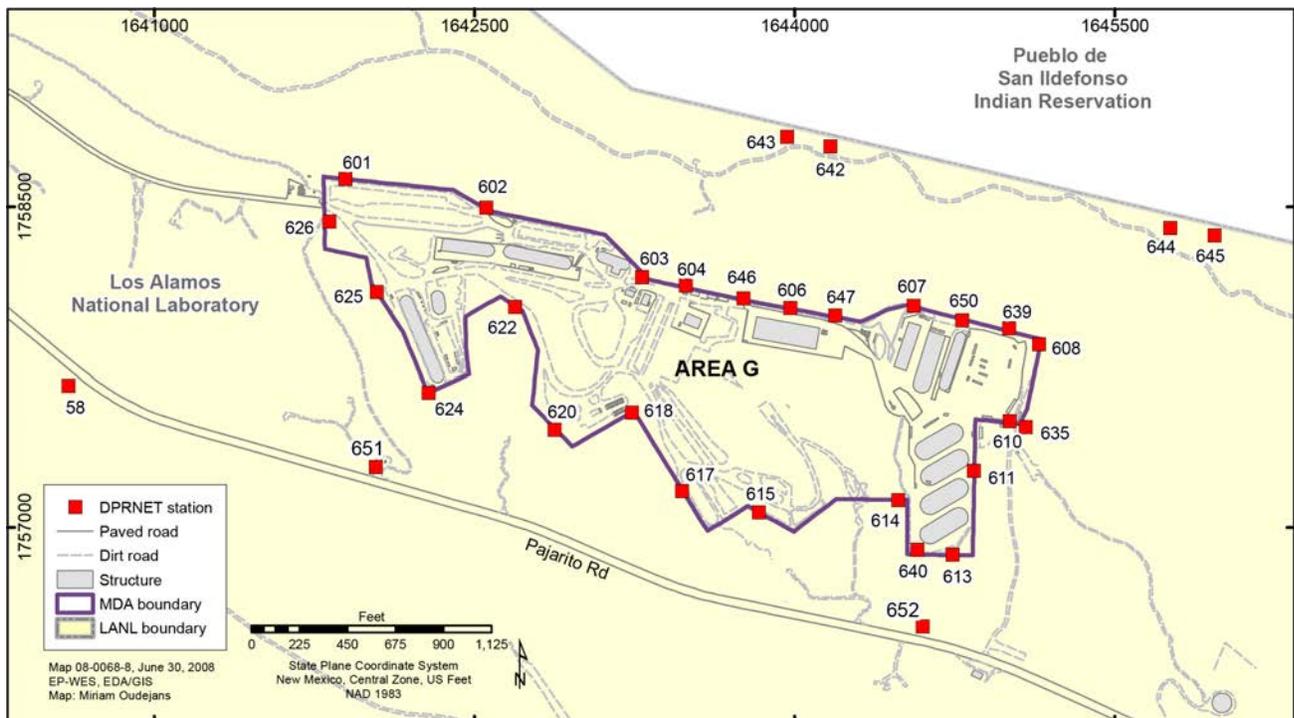


Figure 4-15 TLD locations at TA-54, Area G, as part of DPRNET

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 station 101 in Santa Fe. The average neutron background at these two stations is 2 ± 1 mrem/yr.

2. 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 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%.

3. 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. The only locations with a measurable contribution from LANL operations are near TA-53 (LANSCE) and TA-54 (Area G), as discussed below.

a. TA-53

DOE Order 458.1 requires determination of the doses to the MEI members of the public, both on-site and off-site [DOE 2011, Section 4.e(1)(a)2]. The only on-site location where a member of the public could receive a measurable dose is along Jemez Road as it passes TA-53 (McNaughton 2013), so we use the TLDs at TA-53 to determine this dose.

At TA-53, the only TLD that measures above-background gamma dose is at location 115, 100 m from the tanks at the east end of TA-53, where the dose was 249 mrem/yr, 99 mrem/yr above the background of 150 mrem/yr. Jemez Road is in Sandia Canyon, so it does not receive direct radiation from these tanks. However, Jemez Road receives photons that are scattered from the air, known as "sky shine." The Monte-

Carlo N-Particle (MCNP) program calculates that the dose at Jemez Road, 500 m south of the tanks, is 0.2% of the dose at location 155, 100 m north of the tanks (McNaughton 2013). Therefore, during 2012, the gamma dose at Jemez Road from the tanks was 0.2% of 99 mrem/yr, which is 0.2 mrem/yr. This is the dose that would be received by a person who is at this location 24 h/day, 365 days/yr.

Six of the eight TLDs at TA-53 measured neutron doses of 5 ± 1 mrem/yr, which is greater than the background of 2 ± 1 mrem/yr. These measurements indicate there are several sources at TA-53, including the isotope production facility to the west, Areas B and C to the north, and Line D to the south. As mentioned in the previous paragraph, Jemez Road is in Sandia Canyon, so it only receives neutrons that are scattered from the air. MCNP calculates that the dose at Jemez Road, 350 m south of the Line-D targets, is 10% of the dose at location 124, 200 m south of the targets (McNaughton 2013). During 2012, the neutron dose at location 124 was 5.4 mrem/yr, 3.4 mrem/yr above the background of 2 mrem/yr, so the neutron dose at Jemez Road was 10% of 3.4, which is 0.34 mrem/yr. This is the dose that would be received by a person who is at this location 24 h/day, 365 days/yr.

b. TA-54

Figure 4-15 shows the locations of the stations at TA-54, Area G. Situated south of the line of TLDs 601 to 608, Area G is a controlled-access area, so the Area G 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 neutron doses measured by TLDs 134, 642, and 643 were 5.3 mrem, 4.7 mrem, and 5.2 mrem, respectively. These are the doses that would be received by a person who is at the location of the TLDs 24 h/day, 365 days/yr. 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 $5.3/16 = 0.33$ mrem/yr, which is less than previous years.

4. NEWNET

During 2012, NEWNET did not record any doses above the normal background, which indicates that the public dose from gamma-emitting radionuclides was well below 1 mrem/yr.

5. Conclusion

Generally, the data are similar to previous years, except for a decreasing trend at and near Area G, as shown in Figures 4-13 and 4-14. The results are far below the applicable limits; when an occupancy factor is included, the largest doses at public locations are all less than 1 mrem/yr.

D. NONRADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

The nonradioactive ambient air-monitoring network consists of two types of measurements: (1) AIRNET total suspended particulate matter samples analyzed for selected nonradiological species and (2) results from tapered-element oscillating microbalance samplers, which directly measure particulate matter smaller than 10 micrometers (μm) in diameter (PM-10) and particulate matter smaller than $2.5 \mu\text{m}$ (PM-2.5). We do not measure other regulated nonradiological species. See Chapter 2 for a full discussion of the nonradiological compliance program.

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 PM-10 and one for PM-2.5 particles. 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 98%. Annual averages, 24-h maxima, and EPA standards are shown in Table 4-9.

4. Detonation and Burning of Explosives

LANL uses explosives at firing sites but also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2012, LANL consumed roughly 6093 kg of high explosives. An assessment of the ambient impacts of high-explosives testing (DOE 1999) suggests no adverse air quality impacts from this usage quantity.

5. Beryllium Sampling

We analyzed quarterly composite samples from 27 stations either in nearby communities or near potential beryllium sources at LANL. New Mexico has no ambient air quality standard for beryllium. All concentrations measured this year were below 2% of the NESHAP standard of 10 nanograms per cubic meter from 40 CFR 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 plan is available online at 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-06, TA-49, TA-53, and TA-54), two are in canyons (TA-41 in Los Alamos Canyon and one in Mortandad Canyon [MDCN]), and one is on top of Pajarito Mountain (PJMT). A precipitation gage is also located in North Community (NCOM) of the Los Alamos townsite. The TA-06 station is the official meteorological measurement site for the Laboratory.

Table 4-9
PM-2.5 and PM-10 Concentration Summary for 2012

Station Location	Constituent	24-h Maximum (µg/m ³)	Annual Average (µg/m ³)
Los Alamos Medical Center	PM-10	116	16
	PM-2.5	23	8
White Rock Fire Station	PM-10	103	17
	PM-2.5	20	7
EPA standard ^a	PM-10	150	n/a ^b
	PM-2.5	35	15

^a EPA 40 CFR 50 and www.epa.gov/air/criteria.html.

^b n/a = None applicable.

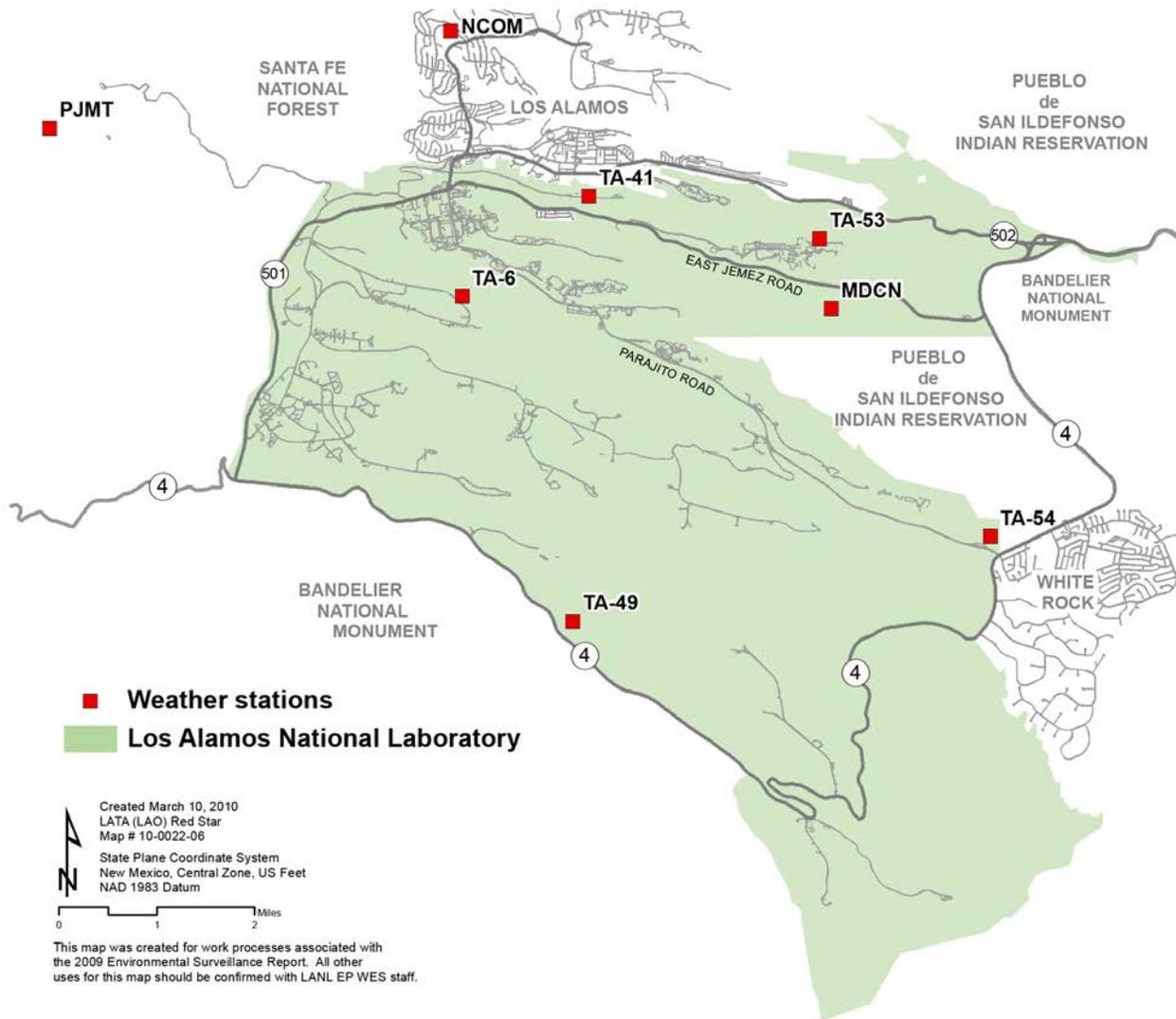


Figure 4-16 Location of meteorological monitoring towers and rain gages

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-06, 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 MDCN station includes a 10-m tripod tower that measures wind at a single level (tower top). In addition, temperature and humidity are measured at ground level at all stations except the NCOM station, 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 modem or cell phone to a UNIX workstation. 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 yr, we have provided

these daily weather statistics to the National Weather Service. In addition, cloud type and percentage cloud cover are logged daily.

We calibrate all meteorological instruments on an annual basis, with the exception of solar radiation sensors, which are calibrated every 5 yr according to manufacturer's specifications. An external audit of the instrumentation and methods is performed periodically. 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 www.weather.lanl.gov/. An external subcontractor inspects and performs maintenance on the station network structures and hoists on an annual basis.

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 (WMO), the standard should be 1961 to 1990, until 2021, when 1991 to 2020 will become the standard, and so on for every 30 yr (WMO 1984). In practice, however, normals are computed every decade, and so 1981 to 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 midafternoon, 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. 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. During these months, 90% of minimum temperatures range from 45°F to 61°F.

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 in., 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 1986–1987.

Precipitation in July and August accounts for 36% of the annual precipitation and encompasses 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 convectively 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. Winds on the Pajarito Plateau are faster during the day than at night. This is because of 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.

5. 2012 in Perspective

Figure 4-17 presents a graphical summary of Los Alamos weather for 2012. 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 4-10 presents a tabular perspective of Los Alamos weather during 2012.

The year 2012 was much warmer and much drier than normal, with a Pacific La Niña pattern governing the weather during the first half of the year. The year was the second warmest and second driest on record in Los Alamos. The average annual temperature in 2012 of 51.6°F exceeded the normal annual average of 48.4°F by 3.2°F. The total precipitation of 9.59 in. was 51% of normal (18.97 in.). With the exception of February and December, the entire year had above-normal temperatures.

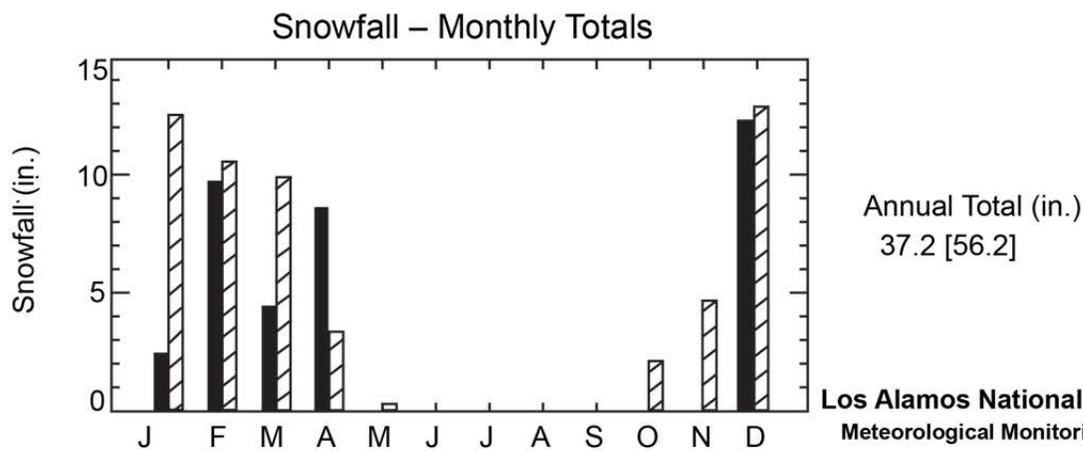
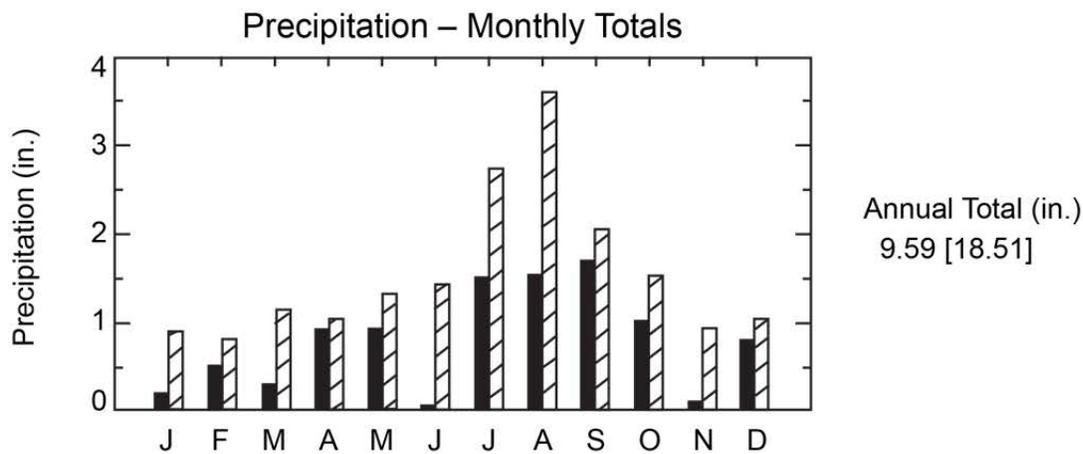
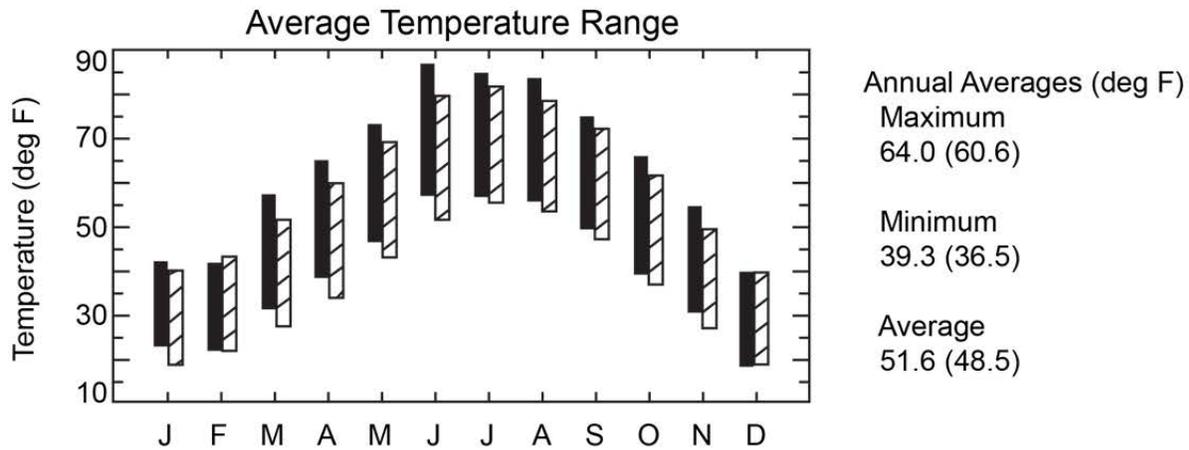
Below-average precipitation was recorded for each month of 2012. The summer monsoon, which typically produces 40% of the annual Los Alamos precipitation, was located over Arizona and Nevada during much of the summer. Thus the summertime rainfall was 48% of normal. Five snowstorms hit Los Alamos during December, giving Los Alamos an average December snowfall total of 12.2 in. Even with average December snowfall amounts, low snowfall totals during the first 3 mo of the year resulted in a year-end snowfall total of 37.2 in., 66% of average.

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 2012. 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 5-yr running mean is also shown. With 5-yr averaging, for example, it appears that the warm spell during the past decade is almost as extreme as the warm spell during the early-to-mid 1950s and is longer-lived. The summertime temperature (June, July, August) during 2012 was the second highest on record, at 70.7°F. The highest summertime average temperature on record was 71.1°F, recorded during 2011.

2012 Weather Summary

Los Alamos, New Mexico – TA-6 Station, Elevation 7424 ft

■ 2012 Values □ [Normal Values] 1981–2012



Los Alamos National Laboratory
 Meteorological Monitoring Program
 (505) 667-7079
<http://weather.lanl.gov>

Figure 4-17 Weather summary for Los Alamos for 2012 at the TA-06 meteorology station

Table 4-10
Monthly and Annual Climatological Data for 2012 at Los Alamos

Month	Temperatures (°F) ^a								Precipitation (in.) ^a				12-m wind (miles per hour) ^a				
	Averages				Extremes				Total	Departure ^b	Snowfall		Average Speed	Departure ^c	Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure ^b	Highest	Date	Lowest	Date			Total	Departure ^b			Speed	From	Date
January	42.0	23.2	32.6	3.2	49	19 th	14	12 th	0.22	-0.73	2.4	-10.9	5.4	0.4	65	WNW	22 nd
February	41.9	21.9	31.9	-1.0	53	25 th	-15	20 th	0.53	-0.33	9.7	-1.2	6.5	0.7	51	WSW	27 th
March	57.2	31.6	44.4	5.0	74	31 st	11	3 rd	0.16	-1.04	0.6	-9.8	7.2	0.7	56	SSW	18 th
April	64.8	38.8	51.8	5.0	78	24 th	25	3 rd	0.90	-0.16	8.5	5.2	8.0	0.4	49	S	26 th
May	72.9	46.5	59.7	3.7	82	22 nd	37	9 th	0.93	-0.46	0.0	-0.3	8.7	1.3	45	WNW	24 th
June	86.7	56.9	71.8	5.7	93	24 th	48	5 th	0.05	-1.46	0	0	8.2	1.1	39	NW	19 th
July	84.2	57.2	70.7	2.5	91	2 nd	53	6 th	1.51	-1.31	0	0	6.1	0.5	36	NW	24 th
August	83.4	56.1	69.7	3.9	92	11 th	51	4 th	1.52	-2.09	0	0	6.5	0.8	43	W	1 st
September	74.7	49.3	62.0	2.2	86	6 th	40	14 th	1.69	-0.32	0	0	5.9	0.2	48	NW	25 th
October	65.6	39.6	52.6	3.4	78	3 rd	21	27 th	1.02	-0.53	0	-2.2	6.6	0.6	51	NNW	17 th
November	54.3	31.0	42.6	4.7	66	1 st	11	12 th	0.12	-0.86	0	-4.9	5.3	0.0	41	W	10 th
December	39.5	19.0	29.2	-0.2	58	6 th	-4	20 th	0.80	-0.21	12.2	0	5.3	0.4	53	WNW	14 th
Year	64.0	39.3	51.6	3.1	93	Jun 23 th	-15	Feb 20 th	9.59	-8.92	37.2	-29.0	6.6	0.6	65	WNW	Jan 22 nd

^a Data from TA-06, the official Los Alamos weather station.

^b Departure column indicates positive or negative departure from 1981–2010 (30-yr) climatological average.

^c Departure column indicates positive or negative departure from 1990–2010 (21-yr) climatological average.

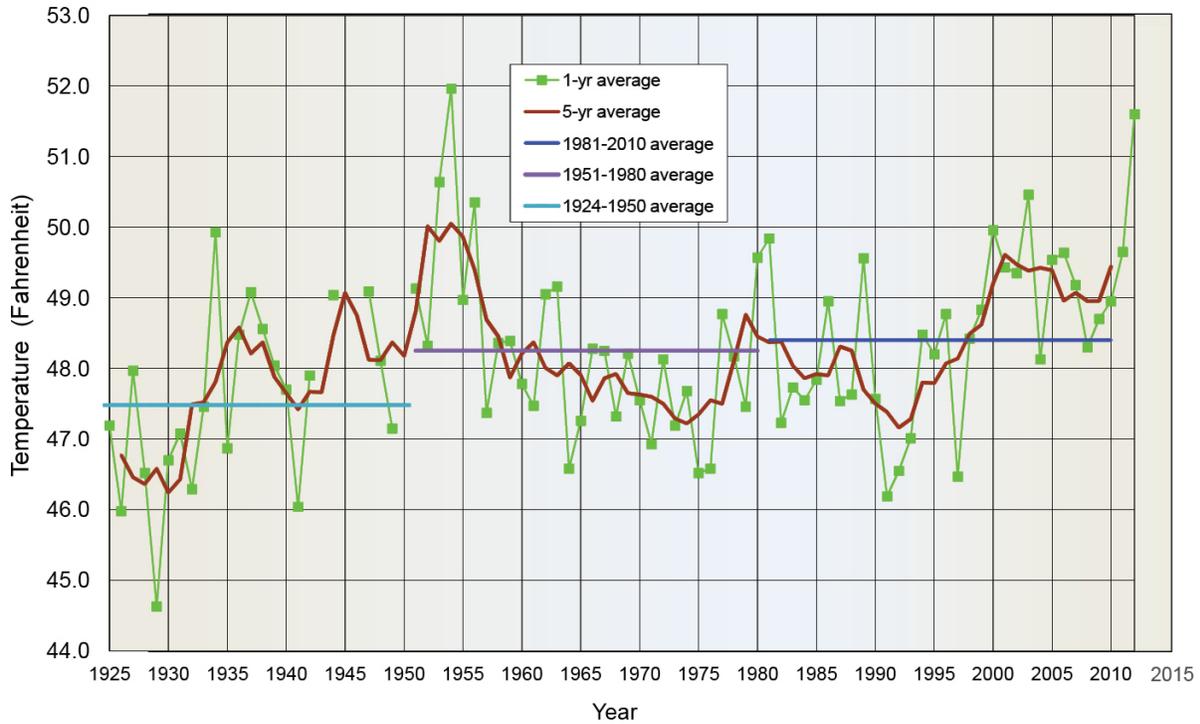


Figure 4-18 Temperature history for Los Alamos

Figure 4-19 shows the historical record of the annually summed total precipitation. The most recent drought has essentially spanned the years 1998 through 2012, with near-average precipitation years occurring from 2004 to 2010. With a total of 9.59 in., 2012 was the second driest year on record. As with the historical temperature profile, the 5-yr running mean is also shown.

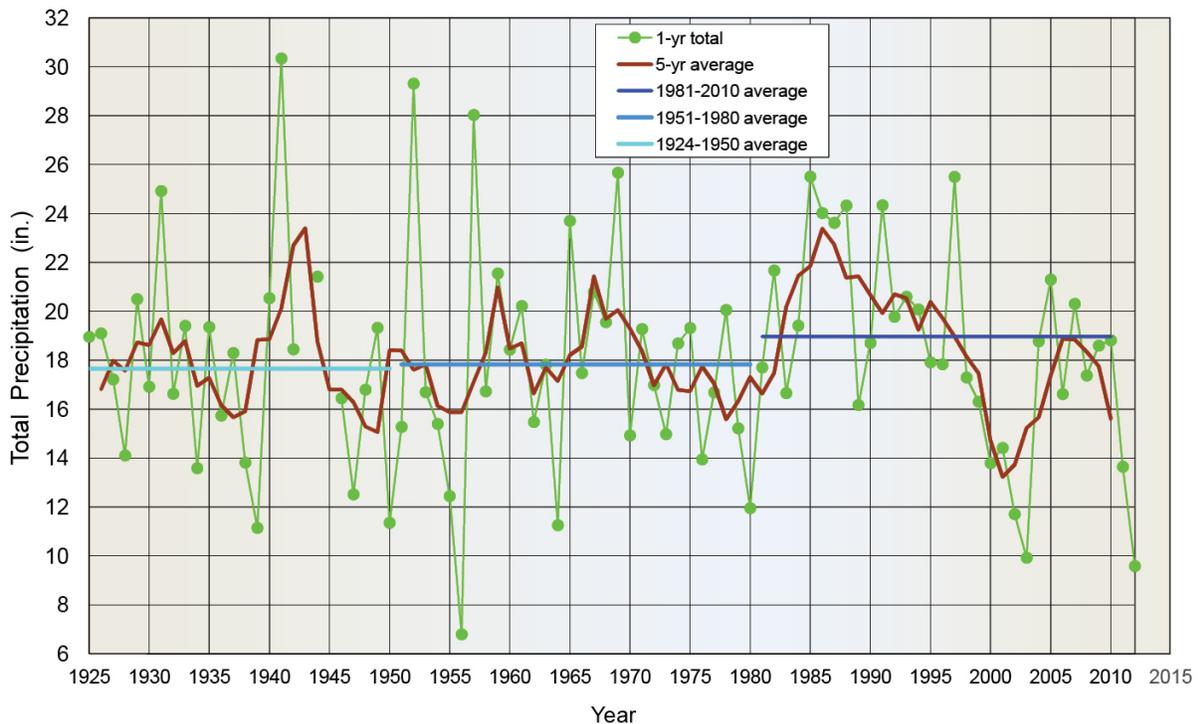


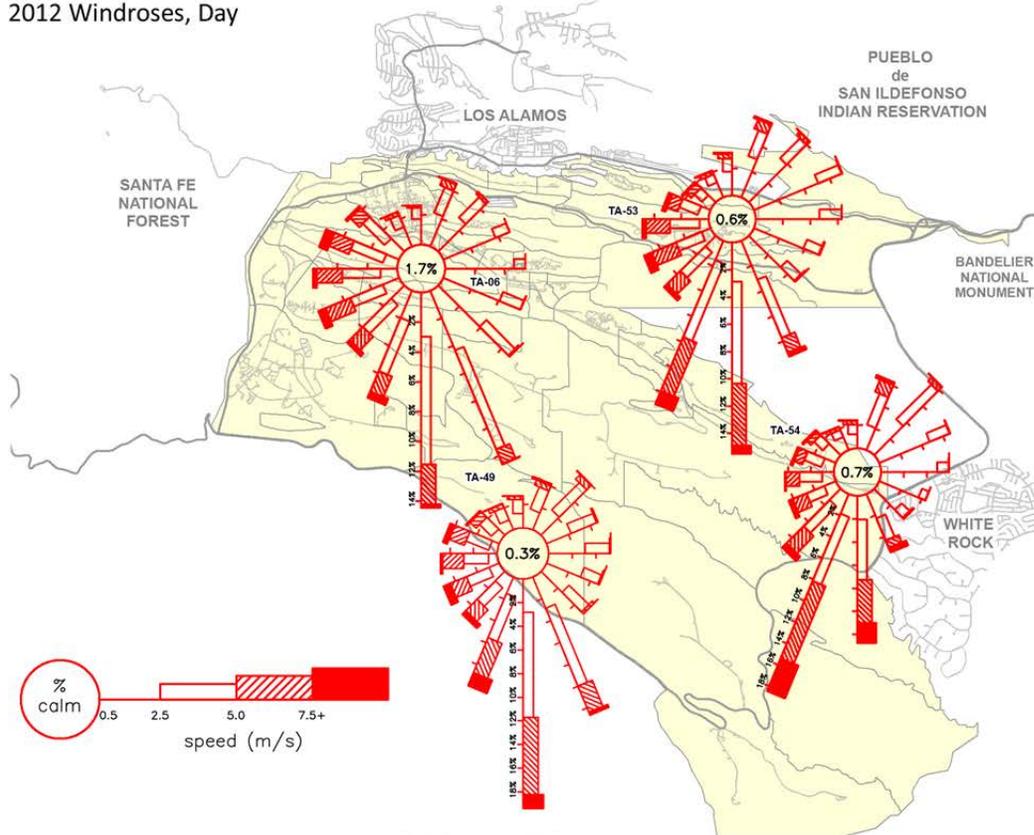
Figure 4-19 Total precipitation history for Los Alamos

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-06 over 14% of the time during the day in 2012. Winds are directly from the north just over 2% of the time during the day. Wind roses also show the distribution of wind speed. For approximately 8% of the time, for example, winds at TA-06 are from the south and range from 2.5 to 5 meters per second (m/s). Winds from the south at TA-06 exceed 7.5 m/s only a fraction of 1% of the time, and winds are calm 1.7% of the time.

Similar to 2011, higher-than-average wind speeds were recorded in 2012 (Table 4-10). Winds during May and June were the highest, with average wind speeds in May being 18% above normal.

The wind roses are based on 15-min-averaged wind observations for 2012 at the four Pajarito Plateau stations. Although not shown here, wind roses from different years are almost identical, indicating that wind patterns are constant when averaged over a year.

2012 Windroses, Day



2012 Windroses, Night

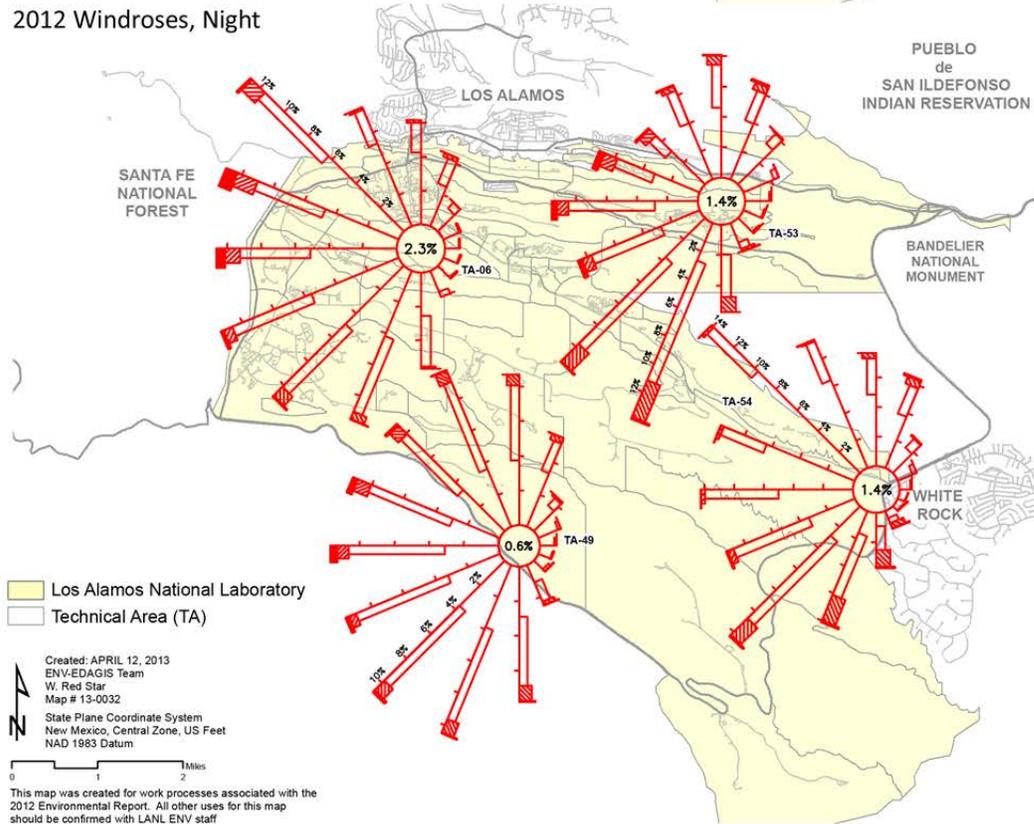


Figure 4-20 Daytime and nighttime wind roses for 2012. Wind data for TA-49 are from 2010.

F. REFERENCES

- Bowen 1990: Bowen, B.M., "Los Alamos Climatology," Los Alamos National Laboratory document LA-11735-MS (1990).
- Bowen 1992: Bowen, B.M., "Los Alamos Climatology Summary," Los Alamos National Laboratory document LA-12232-MS (1992).
- DOE 1993: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 5400.5 (1993).
- DOE 1999: "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory," DOE/EIS-0238 (1999).
- DOE 2011: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 458.1 (June 2011).
- Duncan 1986: Duncan, A.J., *Quality Control and Industrial Statistics*, 5th ed., Irwin, Homewood, Illinois (1986), 1123 pp.
- Eisenbud and Gesell 1997: Eisenbud, M., and T. Gesell, *Environmental Radioactivity from Natural, Industrial, and Military Sources*, 4th ed., Academic Press, San Diego, California (1997).
- EPA 1989: "National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities," Code of Federal Regulations, Title 40, Part 61, Subpart H (1989).
- Gilbert 1987: Gilbert, R.O., *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York (1987), 320 pp.
- ICRP 1978: "Limits for Intakes of Radionuclides by Workers," Publication 30, Supplement to Part 1, International Commission on Radiological Protection, Pergamon Press (1979).
- Johnson and Young 2008: Johnson, S.D., and D.L. Young, "Meteorological Monitoring at Los Alamos," Los Alamos National Laboratory document LA-UR-08-3032 (2008).
- McNaughton et al. 2000: McNaughton, M.W., D.H. Kraig, and J.C. Lochamy, "Siting of Environmental Direct-Penetrating-Radiation Dosimeters," Los Alamos National Laboratory document LA-UR-00-1168 (2000).
- McNaughton 2013: "On-site MEI Measurements and Calculations," Los Alamos National Laboratory document LA-UR-13-25871 (2013).
- NCRP 1976: "Structural Shielding and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies up to 10 MeV, Recommendations of the National Council on Radiation Protection and Measurements," National Council on Radiation Protection and Measurements report 49 (1976).
- Walker et al. 1989: Walker, F.W., J.R. Parrington, and F. Feiner, *Nuclides and Isotopes*, 14th ed., General Electric Company (1989).
- WMO 1984: World Meteorological Organization, *Technical Regulations, Vol. I*, WMO No. 49, Geneva, Switzerland (1984).

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Los Alamos National Laboratory (LANL or the Laboratory) conducts groundwater characterization and monitoring to ensure groundwater protection. Characterization activities are conducted to define the nature and extent of known contaminants and to determine their fate and transport within groundwater to guide remedial actions. Other wells are used to monitor for potential impacts of ongoing operations. These activities are also conducted to determine compliance with the requirements of the U.S. Department of Energy (DOE) orders and New Mexico and federal regulations. The Laboratory collects and analyzes hundreds of samples per year for a wide range of organic and inorganic constituents and radionuclides. The Laboratory’s groundwater sampling supports the Environmental Grand Challenge to *protect water resource quality and reduce water use*.

A. INTRODUCTION

The Laboratory routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and the surrounding area. Because of the Laboratory’s semiarid, mountainside setting, significant groundwater is found only at depths greater than several hundred feet. This regional aquifer is found beneath the Laboratory at depths ranging from 600 to 1200 ft. The Los Alamos County public water supply comes from supply wells that draw water from the regional aquifer. 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 2012 was carried out according to the Interim Facility-Wide Groundwater Monitoring Plans (IFGMPs; LANL 2011a, 2011b, 2012a) approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (the Consent Order). The LANL Environmental Programs Directorate collects 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://www.lanl.gov/community-environment/environmental-stewardship/public-reading-room.php>.

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 1000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

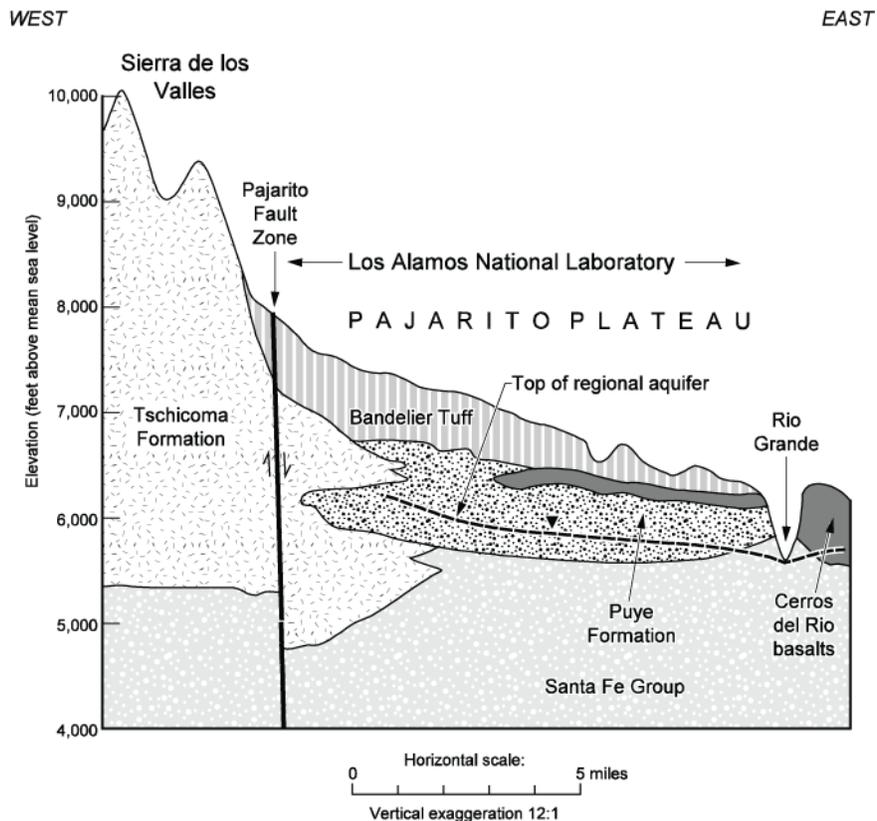


Figure 5-1 Generalized geologic cross-section of the Pajarito Plateau

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 3300 ft thick.

2. Groundwater Occurrence

Because of 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 1200 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.

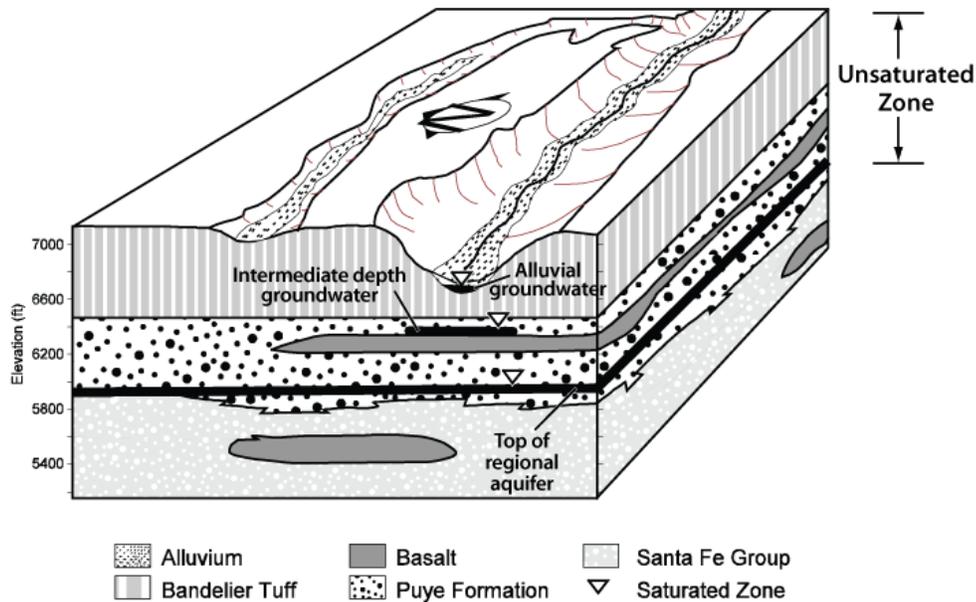


Figure 5-2 Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence

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 to 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 water table occurs at a depth of 1200 ft along the western edge of the plateau and 600 ft along the eastern edge (Figures 5-1 and 5-3). In the central part of the plateau, the regional aquifer lies about 1000 ft beneath the mesa tops. 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, which is 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.

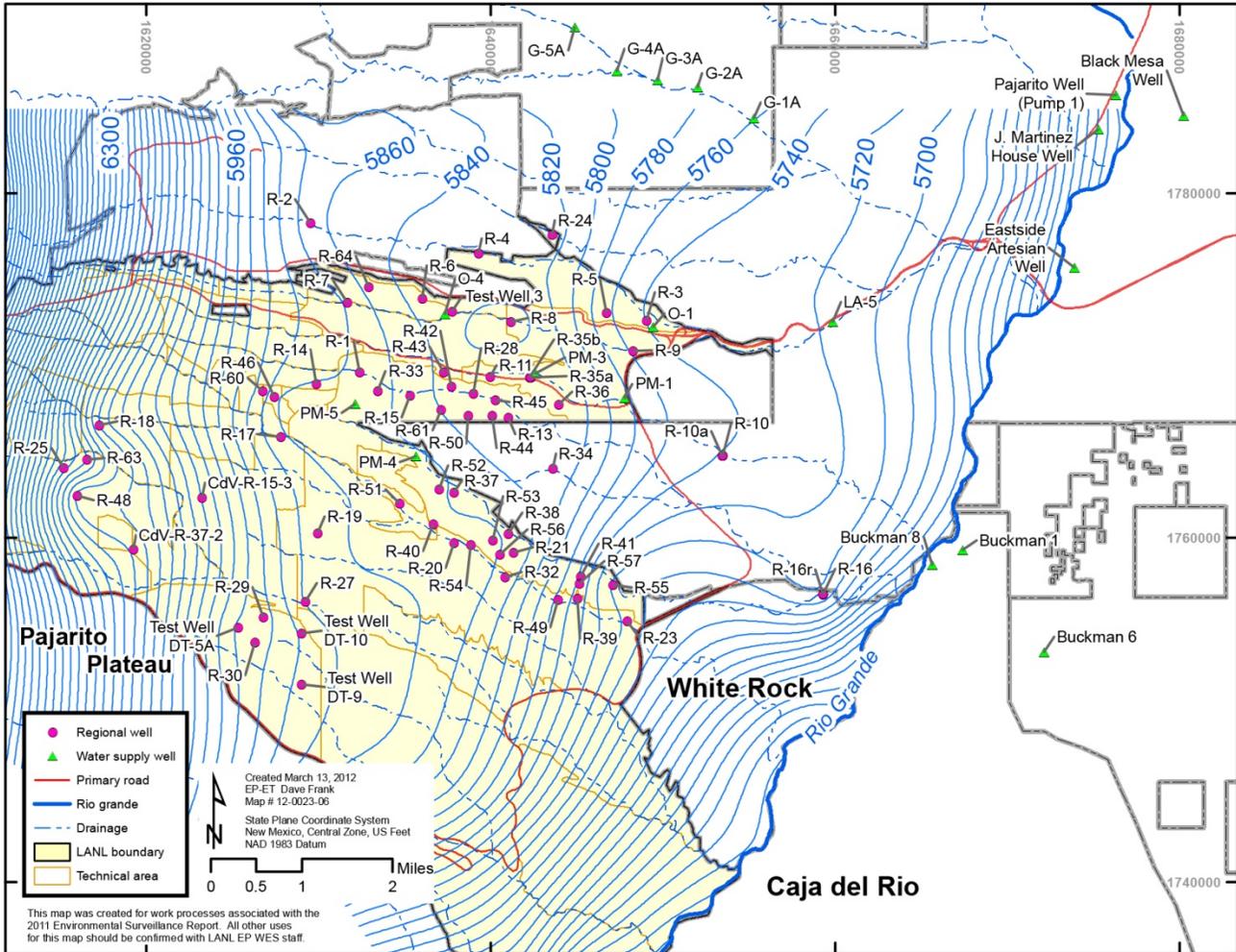


Figure 5-3 Contour map of average water table elevations for the regional aquifer (based on a map in a LANL report [2012a]). This map represents a generalization of the data; other interpretations are possible.

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, that 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.

C. GROUNDWATER STANDARDS AND SCREENING LEVELS

1. Regulatory Overview

The regulatory standards and screening levels listed in Table 5-1 are used to evaluate groundwater samples in this chapter.

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

Sample Type	Constituent	Standard	Screening Level	Reference	Notes
Water supply wells	Radionuclides	EPA ^a MCLs ^b	DOE 4-mrem ^c /yr DCGs ^d	40 CFR ^e 141–143, DOE Order 5400.5	4-mrem/yr DCGs apply to water provided by DOE-owned drinking water systems. EPA MCLs apply to drinking water systems.
Water supply wells	Nonradionuclides	EPA MCLs, NM groundwater standards, EPA regional screening levels for tap water	None	40 CFR 141–143, 20.6.2 NMAC [†] , http://www.epa.gov/reg3hwmd/ris/k/human/rb-concentration_table/index.htm	EPA MCLs apply to drinking water systems.
Non-water-supply groundwater samples	Radionuclides	NM groundwater standards	4-mrem/yr DCGs, EPA MCLs	20.6.2 NMAC, DOE Order 5400.5, 40 CFR 141–143	NM groundwater standards apply to all groundwater. The 4-mrem/yr DCGs and EPA MCLs are for comparison because they apply only to drinking water systems.
Non-water-supply groundwater samples	Nonradionuclides	NM groundwater standards, EPA regional screening levels for tap water	EPA MCLs	40 CFR 141–143, 20.6.2 NMAC, http://www.epa.gov/reg3hwmd/ris/k/human/rb-concentration_table/index.htm	NM groundwater standards and EPA regional screening levels for tap water apply to all groundwater. EPA MCLs apply to drinking water systems.
Effluent samples	Radionuclides	DOE 100-mrem/yr DCGs	None	DOE Order 5400.5	DOE 100-mrem/yr public dose limit applies to effluent discharges.

^a EPA = U.S. Environmental Protection Agency.

^b MCL = Maximum contaminant level.

^c mrem/yr = Millirems per year.

^d DCG = Derived concentration guide.

^e CFR = Code of Federal Regulations.

[†] NMAC = New Mexico Administrative Code.

Groundwater standards are established by three regulatory agencies. Radionuclides related to national security uses are regulated by DOE. EPA and the New Mexico Water Quality Control Commission (NMWQCC) regulate all other constituents. DOE has authority under the Atomic Energy Act (42 U.S. Code, Sections 2011 to 2259) to establish standards governing possession and use of nuclear materials deemed necessary by the Nuclear Regulatory Commission to promote the common defense and security. This allows DOE to set radiation protection standards for itself and its contractors for nuclear materials related to nuclear weapon production. DOE has regulatory authority over nuclear source materials, including ores, nuclear materials enriched for use in nuclear weapons, and radioactive byproduct materials from nuclear weapon production.

DOE Order 5400.5, Radiation Protection of the Public and the Environment, establishes dose limits for radiation protection and provides DCGs for radionuclides in media, such as drinking water, that are based on the dose limits. DOE has two dose limits for radioactivity in water. The DCGs for the 100-millirem per year (mrem/yr) public dose limit apply as effluent release guidelines. For ingested water, DCGs are calculated for DOE's 4-mrem/yr drinking water dose limit. Effective November 2, 2012, DOE Order 5400.5 was replaced by DOE Order 458.1, Radiation Protection of the Public and the Environment. DOE Order 458.1 establishes derived concentration standards, which are similar to, and replace, DCGs. Most of the data discussed in this chapter were collected during the period that DOE Order 5400.5 was in effect, so the new derived concentration standards were not used in this report.

Public drinking water systems are regulated by EPA under the Safe Drinking Water Act and by states and tribes when authority is delegated by EPA. The operator of the drinking water system must demonstrate

compliance with drinking water regulations. 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.

NMWQCC groundwater standards (20.6.2 NMAC) apply to all groundwater. These standards include numeric criteria for many contaminants and a list of toxic pollutants for which numeric criteria are determined using EPA regional screening levels for tap water (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). The regional screening levels for tap water are for either a cancer or noncancer risk type. The Consent Order and NMWQCC groundwater standards specify screening at a 10^{-5} excess cancer risk. The EPA screening levels are for 10^{-6} excess cancer risk, so in this report, values 10 times the EPA 10^{-6} screening values are used for screening. These screening levels are updated several times each year; the November 2012 values were used to prepare this chapter.

Section VIII.A of the Consent Order identifies NMWQCC groundwater standards and EPA MCLs as cleanup levels for groundwater when corrective action is implemented. NMWQCC groundwater standards, MCLs, and EPA regional screening levels for tap water are used as screening levels for monitoring data. Documents submitted to NMED by LANL use these values for evaluation of groundwater results.

The Consent Order groundwater cleanup level for an individual substance is the lesser of the EPA MCL or the NMWQCC groundwater standard. The groundwater cleanup level for perchlorate is the 4-micrograms per liter ($\mu\text{g/L}$) screening level established in Section VIII.A.1.a of the Consent Order.

Section VIII.A.1 of the Consent Order requires that if no NMWQCC standard or MCL has been established for a specific substance for which toxicological information is published, the EPA regional screening level (adjusted to a 10^{-5} excess cancer risk) for tap water is used as the groundwater cleanup level. This language extends the list of substances that have cleanup levels beyond the list of toxic pollutants in the NMWQCC groundwater standards.

The NMWQCC groundwater standards apply to the dissolved (filtered) portion of specified contaminants; however, the standards for mercury, organic compounds, and nonaqueous phase liquids apply to the total unfiltered concentrations of the contaminants. EPA MCLs and regional screening levels for tap water are applied to both filtered and unfiltered sample results.

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 may be higher than the filtered concentrations. The EPA MCLs and regional screening levels for tap water are intended for application to water supply samples that generally have low turbidity.

2. Evaluation of Groundwater Results

For water supply wells, which draw water from the regional aquifer, concentrations of radionuclides in samples were compared with the EPA MCLs. The DCGs for ingested water calculated from DOE's 4-mrem/yr drinking water dose limit are used as screening levels. For nonradioactive chemical quality parameters in water supply samples, the EPA MCLs apply as regulatory standards.

For radioactivity in groundwater other than drinking water, there are NMWQCC groundwater standards for uranium and radium. For 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. When used in this chapter for assessing water samples from sources other than water supply wells, these DCGs and EPA MCLs are referred to as screening levels.

The NMWQCC groundwater standards (including the toxic pollutants and their EPA regional screening levels for tap water) apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples. For nonradioactive chemical quality parameters in groundwater other than drinking water, the EPA MCLs may be used as screening levels.

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 (20.6.4 NMAC), including the wildlife habitat standards, also apply to this surface water. (For a discussion of surface water, see Chapter 6.)

D. OVERVIEW OF GROUNDWATER QUALITY

All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards. 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 2012 at concentrations up to 0.76 µg/L. This concentration is now about twice that found in other water supply wells; it is 19% of the 4-µg/L Consent Order screening level and 5% of the EPA's interim health advisory of 15 µg/L for perchlorate in drinking water.

Since the 1940s, liquid effluent discharge by the Laboratory has affected the shallow perched alluvial groundwater that lies beneath the floor of a few canyons (Table 5-2). Liquid effluent discharge is also the primary means by which Laboratory operations have affected 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.

Table 5-2
Alluvial Groundwater Contaminants above Screening Levels in 2012

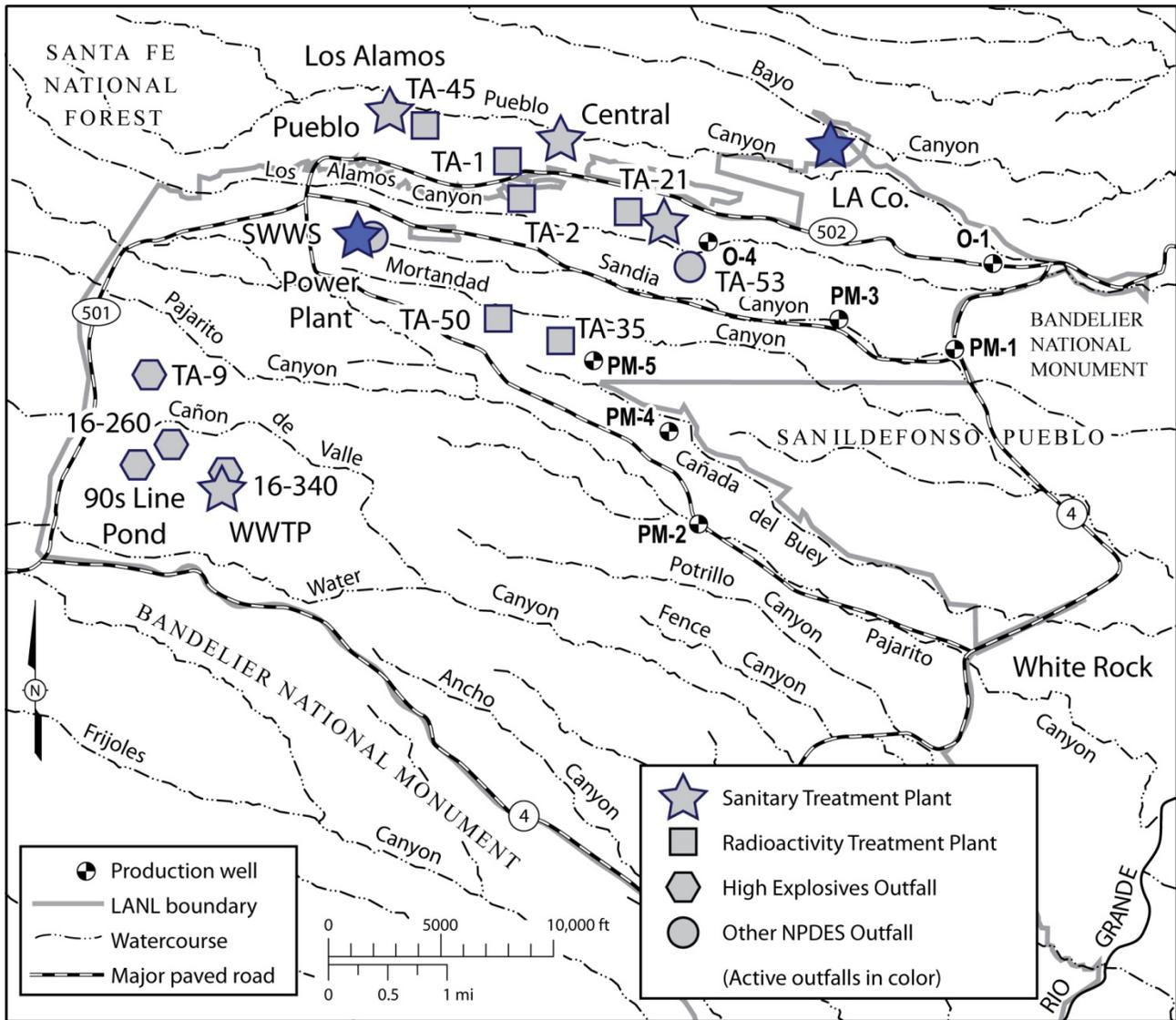
Chemical	Location	Result	Trends
Strontium-90	DP and Los Alamos Canyons	Up to 29 picocuries per liter (pCi/L), above 8-pCi/L EPA MCL screening level	Steady for decades in several wells, including LAO-3a
Chloride	Pajarito Canyon	Up to 354 milligrams per liter (mg/L), above 250-mg/L NM groundwater standard (for domestic water supply)	Above standard in winter and spring for a decade because of road salt runoff
Perchlorate	Mortandad Canyon	Up to 7.5 µg/L, above 4-µg/L Consent Order screening level	Variable in several wells, decreased from >200 µg/L in 2000
Barium	Cañon de Valle	Up to 21,200 µg/L, above 1000-µg/L NM groundwater standard	Steady for decades in several wells
RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	Cañon de Valle	Up to 8.5 µg/L, above 6.1-µg/L EPA tap water screening level	Present at similar levels for years in several wells

The 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 during past decades 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.

Sandia Canyon has received discharges of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems (SWWS) Plant. Water Canyon and its tributary Cañon de Valle have received effluents produced by high explosives (HE) processing and experimentation (LANL 1993a, 1993b).

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



NPDES = National Pollutant Discharge Elimination System.

Figure 5-4 Major liquid release outfalls (effluent discharge) potentially affecting groundwater; most outfalls shown are inactive

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls and the volume of water. The quality of the remaining discharges has been improved through treatment process improvements so that they meet applicable standards.

The intermediate groundwater in various locations shows localized contamination (Table 5-3). Hexavalent chromium and perchlorate have been found in regional aquifer monitoring wells (Table 5-4). In regional aquifer monitoring wells in Mortandad Canyon, hexavalent chromium is found at concentrations above the 50- $\mu\text{g}/\text{L}$ NM groundwater standard. At a few wells, perchlorate concentrations are above the 4- $\mu\text{g}/\text{L}$ Consent Order screening level (Table 5-4).

Table 5-3
Intermediate Groundwater Contaminants above Screening Levels in 2012

Chemical	Location	Result	Trends
Perchlorate	DP and Los Alamos Canyons	Up to 7.6 µg/L, above 4-µg/L Consent Order screening level	Generally steady in three wells for 7 yr, rising in LAOI-3.2a for 3 yr
Perchlorate	Lower Los Alamos Canyon	Up to 5.4 µg/L, above 4-µg/L Consent Order screening level	Rising in Basalt and Vine Tree Springs for 5 yr
Chromium	Sandia Canyon	Up to 491 µg/L, above 50-µg/L NM groundwater standard	Steady for 5 yr in SCI-2
Chromium	Mortandad Canyon	Up to 65 µg/L, above 50-µg/L NM groundwater standard	Increasing for 6 yr in MCOI-6
Perchlorate	Mortandad Canyon	Up to 75 µg/L, above 4-µg/L Consent Order screening level	Fairly steady over 4 yr in two wells
Dioxane[1,4-]	Mortandad Canyon	Up to 11 µg/L, above 6.7-µg/L EPA tap water screening level	>50% decline in MCOI-6 over 6 yr
Dioxane[1,4-], trichloroethane[1,1,1-]	Upper Pajarito Canyon	Dioxane >69 times EPA tap water screening level, trichloroethane above NM groundwater standard	Highly variable concentrations in isolated perched zone for 7 yr
Boron	Tributary of Cañon de Valle	Up to 1310 µg/L, above 750-µg/L NM groundwater standard (for irrigation)	Steady for more than 6 yr in Martin Spring
RDX	Cañon de Valle	Up to 154 µg/L, above 6.1-µg/L EPA tap water screening level	Present at steady levels for years in several wells and springs

Table 5-4
Regional Aquifer Groundwater Contaminants above Screening Levels in 2012

Chemical	Location	Result	Trends
Perchlorate	Pueblo Canyon	Up to 4.8 µg/L, above 4-µg/L Consent Order screening level	Steady for 5 yr in R-4
Chromium	Sandia Canyon	Up to 198 µg/L, above 50-µg/L NM groundwater standard	First year of sampling at R-62, increasing for 4 yr in R-43 S1, now just below standard
Chromium	Mortandad Canyon	Up to 1070 µg/L, above 50-µg/L NM groundwater standard	Steady for 8 yr in R-28 and R-42, increasing for 2 yr in R-50 S1
Perchlorate	Mortandad Canyon	Up to 7.9 µg/L, above 4-µg/L Consent Order screening level	Slight increase over several years in R-15, second year of samples in R-61 S1

Nitrate and traces of tritium are also found in the regional aquifer. Nitrate (as nitrogen [as N]) concentrations in regional aquifer monitoring wells R-43 S1 (that is, the first screen of R-43) and R-11 in Sandia Canyon and R-42 in Mortandad Canyon were detected at levels of up to 60% of the 10-mg/L NM groundwater standard. Tritium activities are far below the EPA MCL of 20,000 pCi/L.

Beginning in late 2008, trichloroethene was detected at 1147 ft in Pajarito Canyon regional aquifer monitoring well R-20 S2 (the second screen of R-20) and continued to be detected in every sampling event through 2011. The concentrations rose to 60% of the 5-µg/L EPA MCL screening level in late 2009 but decreased afterwards. Trichloroethene was detected in only one of two sampling events in 2012, at a concentration just above the 0.3-µg/L method detection limit (MDL).

In 2012, the HE compound RDX continued to be detected in the regional aquifer at Pajarito Canyon monitoring well R-18. The RDX concentration was at 18% of the EPA tap water screening level (adjusted to a 10^{-5} excess cancer risk) of 6.1 µg/L. RDX was also detected in a new Cañon de Valle regional aquifer well, R-63 (to the south of R-18), at 24% of the screening level.

E. MONITORING NETWORK

In 2005, DOE, DOE's 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 IFGMP to NMED for its approval. Groundwater monitoring conducted during calendar year 2012 was carried out according to two IFGMPs and a revision (LANL 2011a, 2011b, 2012a). The monitoring locations, analytical suites, and frequency of monitoring reflect the technical and regulatory status of each area and are updated annually in the IFGMP. In some cases, when monitoring results demonstrate little change or no impacts, sampling frequency has decreased.

The 2011 IFGMP submitted in August 2011 was modified to address the realigned environmental priorities presented in the framework agreement between DOE/National Nuclear Security Administration and NMED (http://www.nmenv.state.nm.us/documents/LANL_Framework_Agreement.pdf). The revised 2011 IFGMP (LANL 2011b) was submitted to NMED in December 2011.

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.

Most of the monitoring wells discussed in the IFGMP are assigned to area-specific monitoring groups related to project areas that may be located in more than one watershed (Figures 5-5a and b). Area-specific monitoring groups are defined for Technical Area 54 (TA-54) in Pajarito and Mortandad Canyons; TA-21, primarily in Los Alamos Canyon; Material Disposal Area (MDA) AB, primarily in Ancho Canyon; MDA C, primarily in Mortandad Canyon; the chromium investigation area in Sandia and Mortandad Canyons; and the TA-16 260 Outfall in Water Canyon and Cañon de Valle. Locations that are not included within one of these six area-specific monitoring groups are assigned to the General Surveillance monitoring group (Figure 5-6). This report uses monitoring group assignments in the 2013 IFGMP (LANL 2012a).

Monitoring outside the Laboratory boundaries is conducted in areas (1) where Laboratory operations have been conducted in the past (e.g., Guaje and Rendija Canyons) or (2) that have not been affected by Laboratory operations. To ensure water leaving the Laboratory does not pose an unacceptable risk to human and ecological receptors, the IFGMP also includes monitoring of areas downgradient of the Laboratory and outside Laboratory boundaries, for example, the springs in White Rock Canyon (Figure 5-7).

To document the potential impact of Laboratory operations on Pueblo de San Ildefonso land, 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 5-7 and mainly sample the regional aquifer. Vine Tree Spring (near former sampling location Basalt Spring) and Los Alamos Spring are intermediate groundwater sampling points, and wells LLAO-1b and LLAO-4 sample alluvial groundwater. The Laboratory also monitors Los Alamos County water supply wells and three City of Santa Fe supply wells.

In 2012, LANL sampled 186 groundwater wells, well screens, and springs in 326 separate sampling events.

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 no new wells to the monitoring well network in 2012.

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 (Figure 5-7). 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. This chapter reports on supplemental sampling of those wells by the Laboratory.

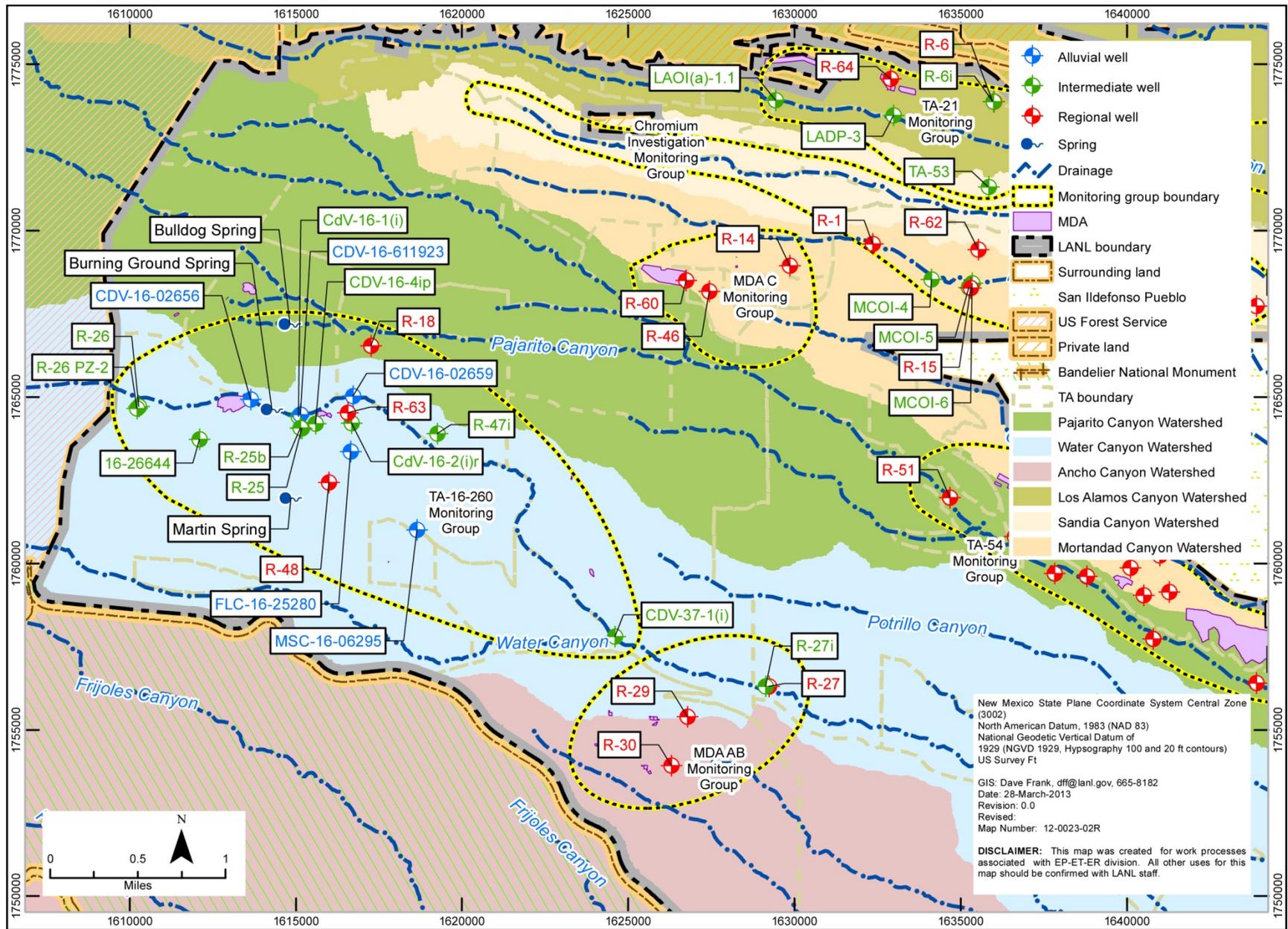


Figure 5-5b Groundwater monitoring wells and springs assigned to area-specific monitoring groups

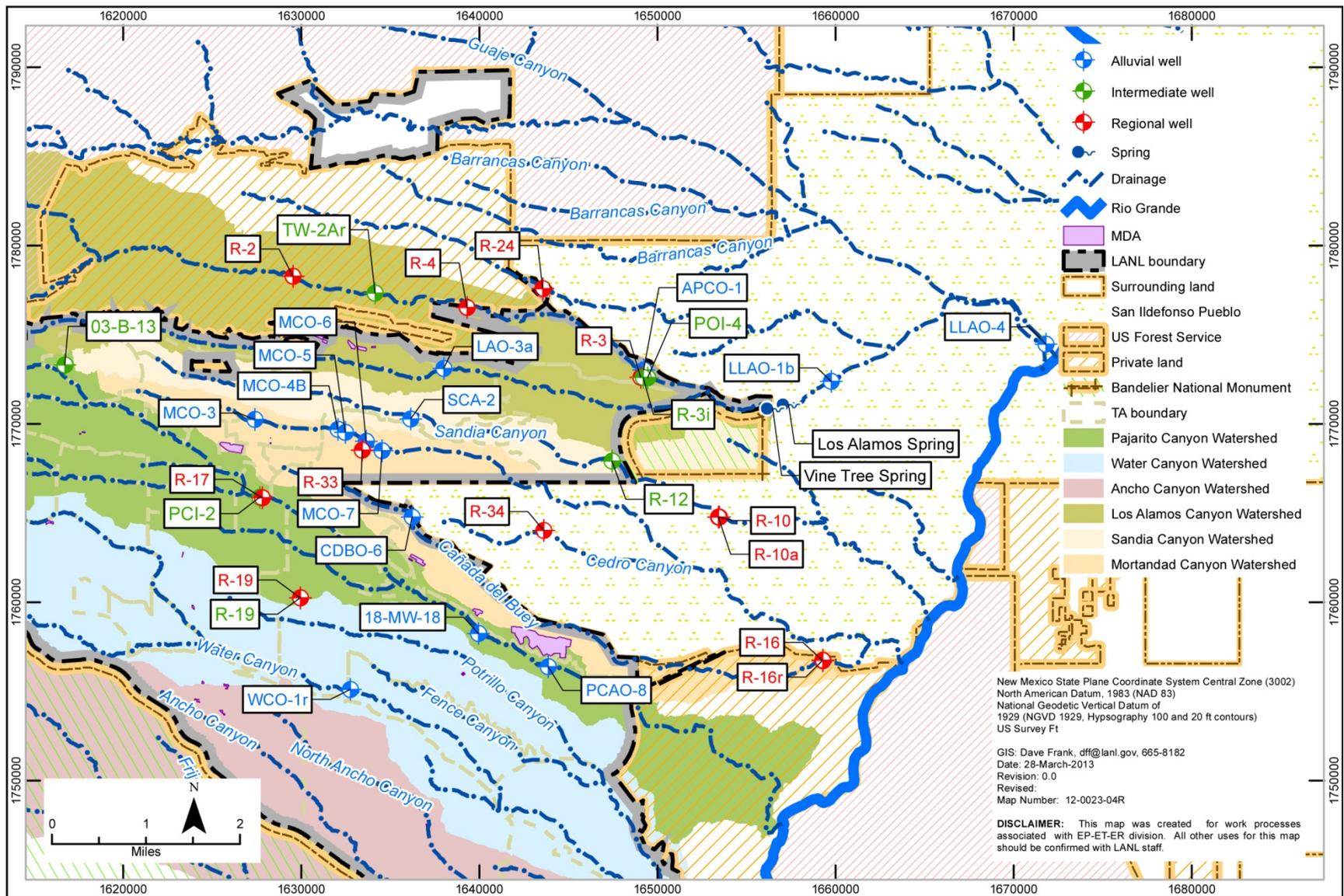


Figure 5-6 Groundwater monitoring wells and springs assigned to general surveillance monitoring

LANL also samples numerous springs near the Rio Grande (Figure 5-7) because they represent natural discharge from the regional aquifer (Purtymun et al. 1980). Sampling the springs allows detection of 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, the Laboratory 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. Monitoring Network Modifications

Plugging and abandonment was completed in early 2012 for Seismic Hazard Borehole 4, Test Hole 6 in Pajarito Canyon, Borehole H-19, Beta Hole in Water Canyon, TA-21 Distillation Hole, and Test Well 3 (LANL 2012c).

No new monitoring wells were drilled in 2012.

G. GROUNDWATER SAMPLING RESULTS BY CONSTITUENT

The groundwater quality monitoring data for 2012 are available at <http://www.intellusnmdata.com>.

1. Organic Chemicals in Groundwater

In 2012, the Laboratory analyzed samples from selected springs and monitoring wells for organic chemicals. These samples were analyzed for some or all of the following organic chemical suites: volatile organic compounds (VOCs), semivolatile organic compounds, polychlorinated biphenyls (PCBs), diesel and gasoline range organics, dioxins and furans, and HE.

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). Other compounds sporadically detected in samples as a result of cross-contamination include PCBs and polycyclic aromatic hydrocarbon compounds (such as benzo[a]pyrene).

Bis(2-ethylhexyl)phthalate is a component of 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- $\mu\text{g}/\text{L}$ EPA MCL. Concentrations generally have fallen significantly during the years following initial well sampling. Based on the history of concentrations of bis(2-ethylhexyl)phthalate for these wells, it appears that the compound initially leaches from some material used during drilling or well construction.

Only one well had bis(2-ethylhexyl)phthalate detections in 2012. Two samples from MDA C monitoring group regional aquifer well R-46 in Mortandad Canyon had bis(2-ethylhexyl)phthalate concentrations of up to 3.8 $\mu\text{g}/\text{L}$. The highest concentration at the well, just after it was constructed in 2009, was 96 $\mu\text{g}/\text{L}$; concentrations have declined steadily since.

2. Radioactivity in Groundwater

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at elevated 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.

No 2012 activity or concentration value for a radioactivity measurement in a Los Alamos County water supply well exceeded any regulatory standard, including the 4-mrem/yr DOE DCGs applicable to drinking water.

The 2012 samples from water supply wells used by the City of Santa Fe and Pueblo de San Ildefonso had uranium and gross-alpha results near or above screening levels, as described in a later section.

A gross-alpha result of 62.8 pCi/L in MDA C regional aquifer well R-60 was above the 15-pCi/L EPA MCL (which excludes uranium and radon). One result of 3.6 pCi/L from a year earlier was a detection, and four other previous results were nondetects. A radium-226 result of 4.86 pCi/L in R-47i was just below the 5-pCi/L MCL. One earlier radium-226 result and two measurements for radium-228 were nondetects. Otherwise, no 2012 radioactivity results for intermediate groundwater or regional aquifer wells within or immediately adjacent to LANL were above screening levels.

Results for strontium-90 from alluvial groundwater in Los Alamos Canyon were below the 4-mrem/yr DOE DCG and above the EPA MCL screening level (Table 5-5). Strontium-90 contributed most of the dose in alluvial groundwater for samples taken in 2012; other radioactive analytes contributed little.

Table 5-5
Radioactivity Results above Screening Levels in Alluvial Groundwater for 2012

Chemical	Location	Result	Trends
Strontium-90	One well in Los Alamos Canyon	29 pCi/L, above EPA MCL screening level of 8 pCi/L, below 40-pCi/L, 4-mrem/yr DOE DCG screening level	Fairly stable for 10 yr because of retention on alluvium
Gross beta	One well in Los Alamos Canyon	78 pCi/L, above EPA drinking water screening level of 50 pCi/L	Present because of strontium-90 content

3. Metals in Groundwater

Some metals are found in groundwater samples at concentrations near or above screening levels because they occur naturally or because of well sampling and well construction issues, rather than LANL releases. For this reason, such results are not discussed in detail in this report.

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, Revision 2 (LANL 2007a). When such wells are identified, LANL has removed them from the monitoring program and taken steps to improve well performance.

Addition of the organic matter in drilling fluids into the aquifer near a well stimulates bacterial activity, consuming available dissolved oxygen and changing chemical behavior of several constituents found in groundwater and adjacent aquifer material. With reducing conditions (absence of dissolved 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 are possibly dissolved 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 the use of 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.

Despite better development and construction practices, a few new wells have shown elevated iron and manganese concentrations in filtered samples. In 2012, samples from R-61 S1 and S2 (screens at 1125 ft and 1220 ft) and R-55i had unusually high iron or manganese concentrations. No samples were collected in 2012 from R-54 S1 (the 830-ft screen) because of high iron and manganese observed in earlier samples from the screen. The performance of these wells was evaluated to determine what actions might improve their water sample quality. R-61 was redeveloped during 2012 (LANL 2013a).

In addition to the effect of drilling fluids, well samples may have relatively elevated 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 or natural colloid content on water quality are also seen in many samples from alluvial wells and springs. This occurs in samples from springs because samples may incorporate surrounding soil material.

H. GROUNDWATER SAMPLING RESULTS BY MONITORING GROUP

The following sections discuss groundwater quality results for water supply well monitoring, the six area-specific monitoring groups, and the General Surveillance monitoring group. The tables and discussions are grouped according to groundwater mode, proceeding from the regional aquifer to the alluvial groundwater.

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 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. Water Supply Monitoring

a. Los Alamos County

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. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards. The water supply wells have screened lengths up to 1600 ft within the regional aquifer and 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 section reports on supplemental sampling of those wells by the Laboratory.

With one exception, drinking water wells in the Los Alamos area have not been impacted by Laboratory discharges. For supply well O-1 in Pueblo Canyon, the 2012 perchlorate concentrations (with a maximum of 0.76 $\mu\text{g}/\text{L}$) were up to 19% of the 4- $\mu\text{g}/\text{L}$ Consent Order screening level, or 5% of the EPA's interim health advisory of 15 $\mu\text{g}/\text{L}$ (Figure 5-8). This perchlorate concentration is about twice that found in other supply wells. Even though the perchlorate levels are below regulatory limits, this well is not used by Los Alamos County for water supply. The levels of tritium and perchlorate 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 5-6). Well O-4, the second well in the Otowi well field, showed no evidence of Laboratory impact in 2012.

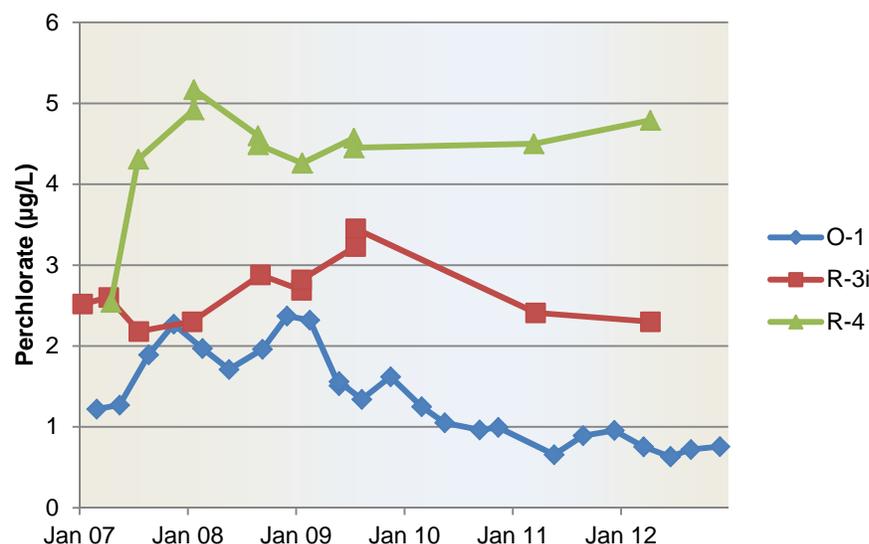


Figure 5-8 Perchlorate at general surveillance and water supply (well O-1) monitoring locations in Pueblo Canyon intermediate and regional aquifer groundwater. The Consent Order screening level is 4 $\mu\text{g}/\text{L}$.

Table 5-6
Groundwater Quality in Los Alamos Water Supply Wells

Chemical	Location	Result	Trends
Arsenic	Water supply wells G-1A and G-2A	9.07 µg/L to 9.39 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
Total lead	Water supply well PM-2	22.5 µg/L, above EPA drinking water system action level of 15 µg/L	Prior results are 0.3 µg/L to 2.0 µg/L since 2004
Tritium	Water supply well O-1	6.1 pCi/L, below EPA MCL of 20,000 pCi/L; field duplicate was nondetect	Results are variable, between nondetect and 58 pCi/L since 2000, and have declined since 2004.
Perchlorate	Water supply well O-1	0.63 µg/L to 0.76 µg/L, below Consent Order screening level of 4 µg/L	Results are variable, up to 3 µg/L since 2001, and have declined since 2008.

The Guaje well field, located northeast of the Laboratory, contains five water supply wells. Naturally occurring arsenic has often been found in this well field at concentrations above the 10-µg/L EPA MCL since the field was developed in the early 1950s. In 2012, arsenic was detected at four of the wells (Table 5-6) at concentrations ranging from 3.6 µg/L to 9.4 µg/L.

Lead was detected in unfiltered samples from nine of the wells at concentrations from 0.95 µg/L to 22.5 µg/L. A sample from PM-2 had a total lead concentration above the 15-µg/L EPA drinking water action level. Lead is not mobile in groundwater, so the lead may be derived from materials within the well.

b. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near the Rio Grande (Table 5-7). Except for LA-5, which was part of the former Los Alamos well field, these wells are located north of LANL along the Rio Grande; some are east of the river. As a result, the wells do not lie along groundwater flow paths emanating from LANL. Other Pueblo de San Ildefonso wells and springs are covered in later sections.

Table 5-7
Groundwater Quality in San Ildefonso Water Supply Wells

Chemical	Location	Result	Trends
Uranium	Black Mesa Well, J. Martinez House Well, and Pajarito Well (Pump 1)	Up to 17.1 µg/L in Black Mesa Well, below NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	Black Mesa Well, J. Martinez House Well, and Pajarito Well (Pump 1)	Up to 10.5 pCi/L in Black Mesa Well, below EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; these values were not corrected for this)	Naturally occurring because of uranium
Fluoride	Eastside Artesian Well, Pajarito Well (Pump 1)	Up to 1.08 mg/L in Pajarito Well (Pump 1), below NM groundwater standard of 1.6 mg/L	Naturally occurring
Boron	Pajarito Well (Pump 1)	692 µg/L, below NM groundwater standard (for irrigation) of 750 µg/L	Naturally occurring
Arsenic	J. Martinez House Well, Pajarito Well (Pump 1), and two other wells	5.2 µg/L to 20.2 µg/L, above EPA MCL of 10 µg/L	Naturally occurring

The groundwater quality 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 5-7). 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. Elevated gross-alpha values for these wells reflect the presence of uranium. The 15-pCi/L gross-alpha EPA MCL excludes the gross-alpha contribution from uranium; these gross-alpha results were not corrected for uranium. The wells also have elevated natural concentrations of boron, fluoride, and arsenic.

c. City of Santa Fe

In 2012, the Laboratory sampled three wells in the City of Santa Fe's Buckman well field (Table 5-8). As shown from past samples, these wells contain natural uranium near or above the NM groundwater standard of 30 µg/L. The elevated gross-alpha values for these wells also reflect the presence of uranium. The 15-pCi/L gross-alpha EPA MCL excludes the gross-alpha contribution from uranium; these gross-alpha results were not corrected for uranium. Naturally occurring arsenic is also elevated in some wells. Samples were also collected from four piezometers in the well field; those results are reported in a separate publication (LANL 2012d).

Table 5-8
Groundwater Quality in Buckman Well Field Supply Wells

Chemical	Location	Result	Trends
Uranium	Buckman Wells No. 1 and No. 8	16.8 µg/L to 27.6 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	Buckman Wells No. 1, No. 6, and No. 8	7.6 pCi/L to 18.4 pCi/L, above EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; these values were not corrected for this)	Naturally occurring, because of uranium
Arsenic	Buckman Wells No. 1 and No. 8	6.6 µg/L to 10 µg/L, above EPA MCL of 10 µg/L	Naturally occurring

2. Guaje Canyon (including Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that lies north of Laboratory land and heads in the Sierra de los Valles. The canyon has not received any effluents from LANL activities (Table 5-9). The Guaje well field, located northeast of the Laboratory, contains five 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 5-6).

Table 5-9
Summary of Groundwater Contamination in Guaje Canyon (includes Rendija and Barrancas Canyons)

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Guaje, Rendija, and Barrancas Canyons	Noneffluent sources	None, alluvial groundwater only in upper Guaje Canyon	No intermediate groundwater	Natural arsenic above EPA MCL

The tributaries 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.

3. TA-21 Monitoring Group (Los Alamos and DP Canyons) and Pueblo Canyon

The TA-21 monitoring group is located in and around TA-21 and is primarily located in upper Los Alamos Canyon (Table 5-10). The group includes monitoring wells completed in the perched-intermediate groundwater and in the regional aquifer. TA-21 is located on the mesa north of Los Alamos Canyon. DP Canyon borders the north side of the mesa and joins Los Alamos Canyon east of TA-21. TA-21 consists of two past operational areas, DP West and DP East, both of which produced liquid and solid radioactive wastes. The operations at DP West included plutonium processing, while the operations at DP East included the production of weapons initiators and tritium research.

Table 5-10
Summary of Groundwater Contamination in Los Alamos Canyon
and the TA-21 Monitoring Group (includes Bayo, Acid, Pueblo, and DP Canyons)

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Bayo Canyon	Past dry and liquid sources	No alluvial groundwater	No intermediate groundwater	None
Pueblo and Acid Canyons	Past effluent discharges, current sanitary effluent	None	Perchlorate at 58% of Consent Order screening level	Perchlorate above Consent Order screening level, trace tritium and nitrate
Los Alamos and DP Canyons	Past effluent discharges	Strontium-90 above EPA MCL screening level, gross beta above EPA drinking water screening level	No monitoring locations	No monitoring locations
TA-21 monitoring group	Past effluent discharges	No monitoring locations	Fluoride at 63% of NM groundwater standard, perchlorate above Consent Order screening level, tritium up to 13% of EPA MCL screening level	None
Lower Los Alamos Canyon	Past effluent discharges	None	Perchlorate above Consent Order screening level	None

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. Primary potential sources of contaminants in the vicinity of the TA-21 monitoring group include the effluent outfall [Solid Waste Management Unit [SWMU] 21-011(k)], the adsorption beds and disposal shafts at MDA T, DP West, and waste lines and sumps. Other potential sources include DP East and a diesel spill. The monitoring objectives for the TA-21 monitoring group are based in part on the results and conclusions presented in the Los Alamos and Pueblo Canyons Investigation Report (LANL 2004) as well as on the NMED-approved Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1 (LANL 2008a).

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at TA-01 (1942–1945) and until 1993 from nuclear reactors at TA-02. 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 at TA-53. Except for strontium-90, contaminant concentrations in shallow groundwater have decreased dramatically in recent decades.

Bayo Canyon, a tributary of Los Alamos Canyon, contained a now-decommissioned firing site. The canyon has only ephemeral surface water and no known alluvial or intermediate groundwater.

Pueblo Canyon receives effluent from the new Los Alamos County WWTP (completed in 2007). Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Compared with past decades, little radioactivity is found in current groundwater samples. Perchlorate concentrations from one regional aquifer monitoring well in Pueblo 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 from past discharges of radioactive wastewater in Acid Canyon.

a. Pueblo Canyon General Surveillance Monitoring

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, has perchlorate values above the Consent Order screening level of 4 µg/L (Figures 5-8 and 5-9, Table 5-11).

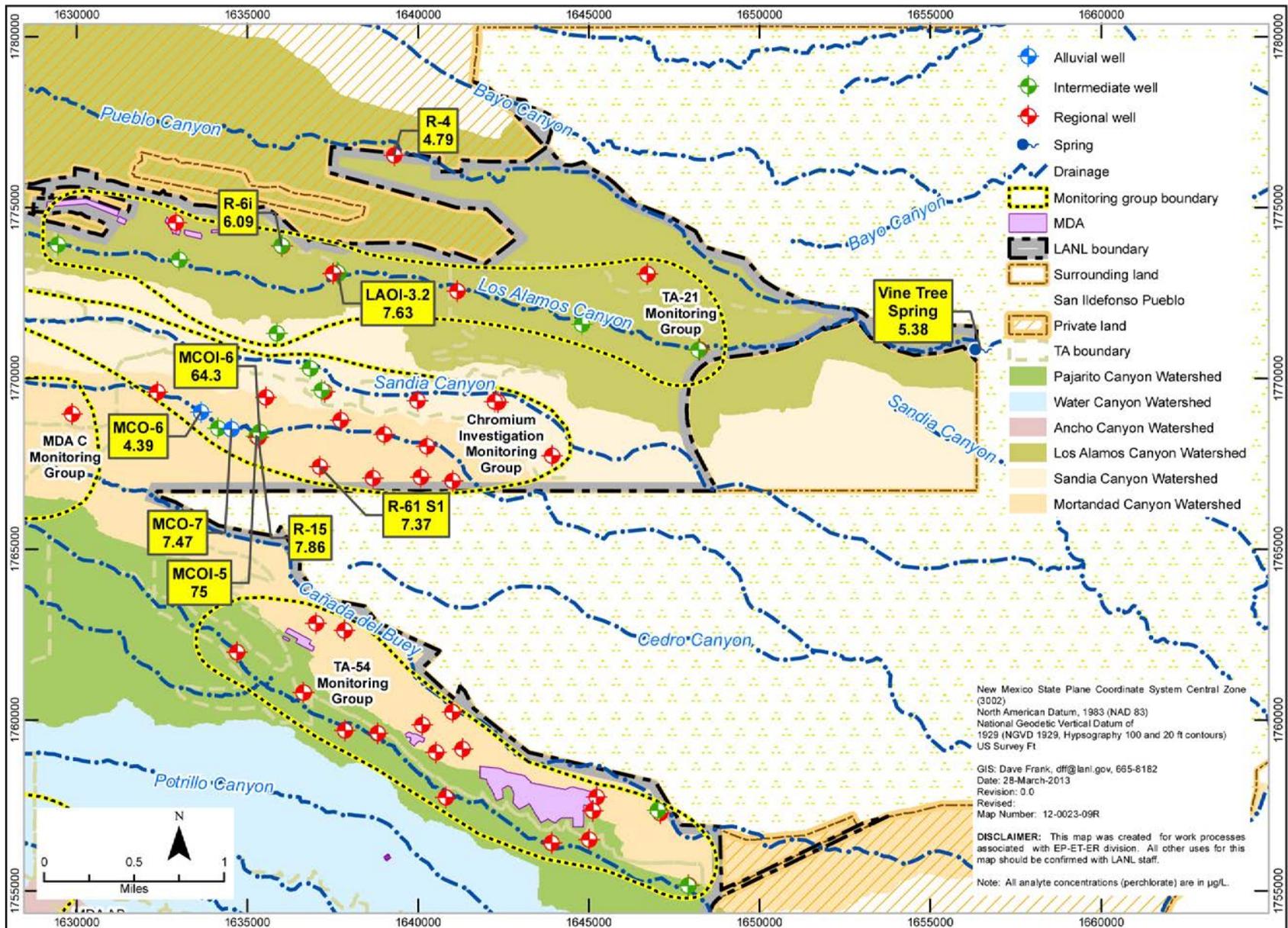


Figure 5-9 Wells and springs with 2012 perchlorate concentrations above the 4-µg/L Consent Order screening level. The maximum concentration for the year is shown in µg/L.

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

Chemical	Location	Result	Trends
Perchlorate	Regional aquifer well R-4	4.8 µg/L, above Consent Order screening level of 4 µg/L	Concentrations fairly steady since 2006
Perchlorate	Intermediate well R-3i	2.3 µg/L, below Consent Order screening level of 4 µg/L	Concentrations fairly steady since 2006

Intermediate groundwater samples have also shown concentrations near standards of perchlorate, fluoride, and nitrate (Figure 5-10, Table 5-11). The 2012 uranium concentration in a sample from Pueblo Canyon intermediate well R-3i was 9.3 µg/L, above levels in nearby wells but below the standard. The higher uranium concentrations may result from dissolution of uranium from surrounding bedrock by sanitary effluent (Teerlink 2007).

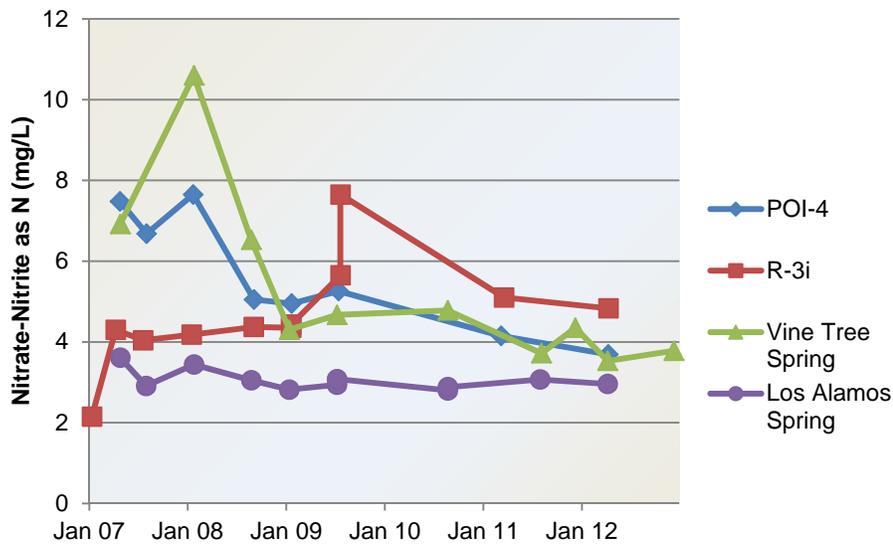


Figure 5-10 Nitrate (as N) at general surveillance monitoring locations in Pueblo Canyon and lower Los Alamos Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L.

b. TA-21 Monitoring Group (Los Alamos Canyon)

TA-21 is located on the mesa north of Los Alamos Canyon. The TA-21 monitoring group is primarily located in upper Los Alamos Canyon.

Several intermediate wells have elevated activities of tritium and high concentrations of perchlorate and 1,4-dioxane (Table 5-12, Figures 5-11 through 5-13). In 2012, 1,4-dioxane was not detected in R-6i for the first time since 2006. Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 2630 pCi/L of tritium. For comparison purposes, the EPA MCL (which applies to drinking water) is 20,000 pCi/L.

An intermediate screen in well R-5 S2 shows fluoride values higher than those in nearby wells, but the results are below the NM groundwater standard.

The 2012 perchlorate concentrations in R-6i, LAOI-3.2, and LAOI-3.2a ranged up to 7.6 µg/L, above the Consent Order screening level of 4 µg/L. The perchlorate concentrations in the deeper intermediate screen at R-9i since late 2008 have been between 2.0 µg/L and 2.4 µg/L (Figure 5-13).

In 2006, LANL measured and detected 1,4-dioxane for the first time in intermediate well R-6i. The compound was detected in nearly every sampling event until 2012.

Table 5-12
Groundwater Quality in TA-21 Monitoring Group

Chemical	Location	Result	Trends
Tritium	Intermediate wells R-6i, LAOI-3.2, and LAOI-3.2a	1410 pCi/L to 2630 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
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and R-9i	2.3 µg/L to 7.6 µg/L, above Consent Order screening level of 4 µg/L	Highest concentrations in LAOI-3.2, lowest concentrations but steady for 2 yr in R-9i
Fluoride	Intermediate well R-5 S2	1 mg/L, below NM groundwater standard of 1.6 µg/L	Concentrations fairly steady since 2004

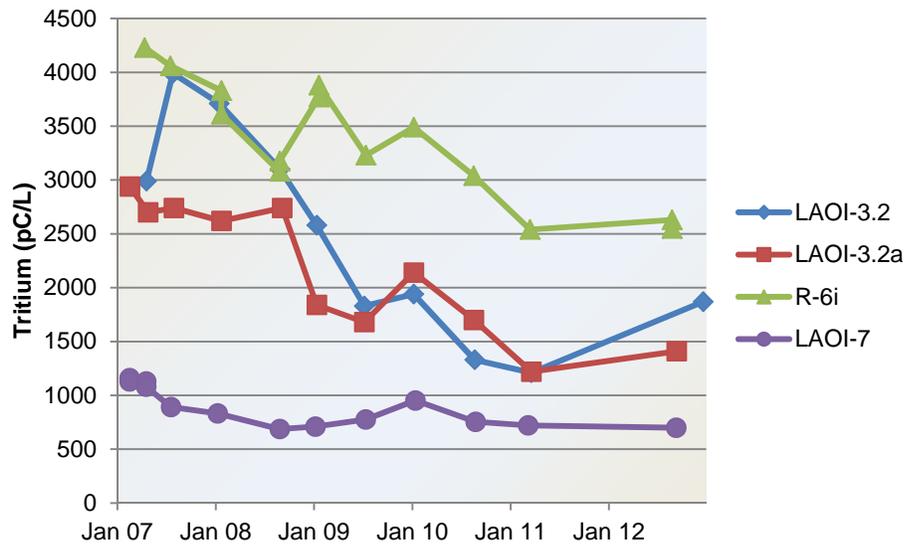


Figure 5-11 Tritium in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL (which does not apply to these samples) is 20,000 pCi/L.

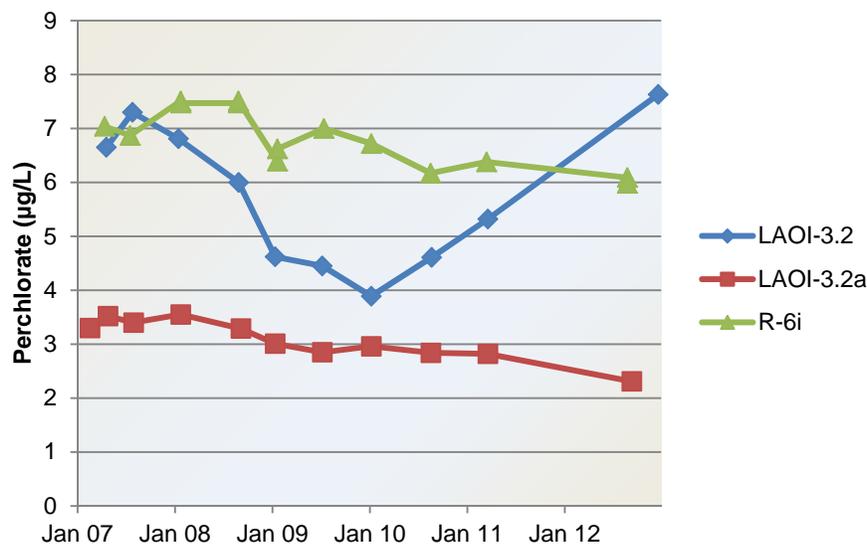


Figure 5-12 Perchlorate in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.

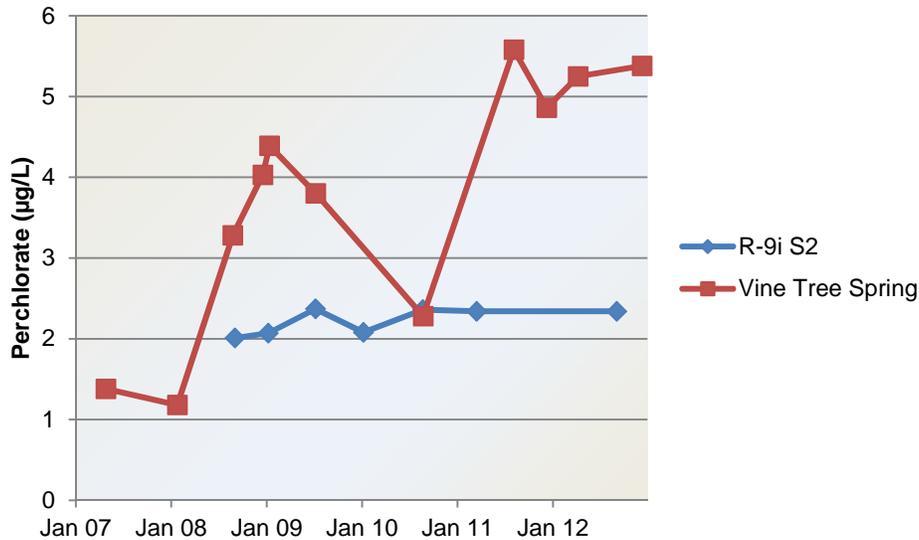


Figure 5-13 Perchlorate in the TA-21 monitoring group at R-9i and at general surveillance monitoring location Vine Tree Spring (combined with Basalt Spring) in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.

c. Los Alamos Canyon General Surveillance Monitoring

An alluvial well in Los Alamos Canyon continues to show strontium-90 activity above the 8-pCi/L EPA MCL screening level (Figure 5-14, Table 5-13). Results from filtered and unfiltered samples from the same date are usually similar, so both are shown in Figure 5-14. Strontium-90 continues to be found in groundwater samples because it has been retained on the alluvium by cation exchange.

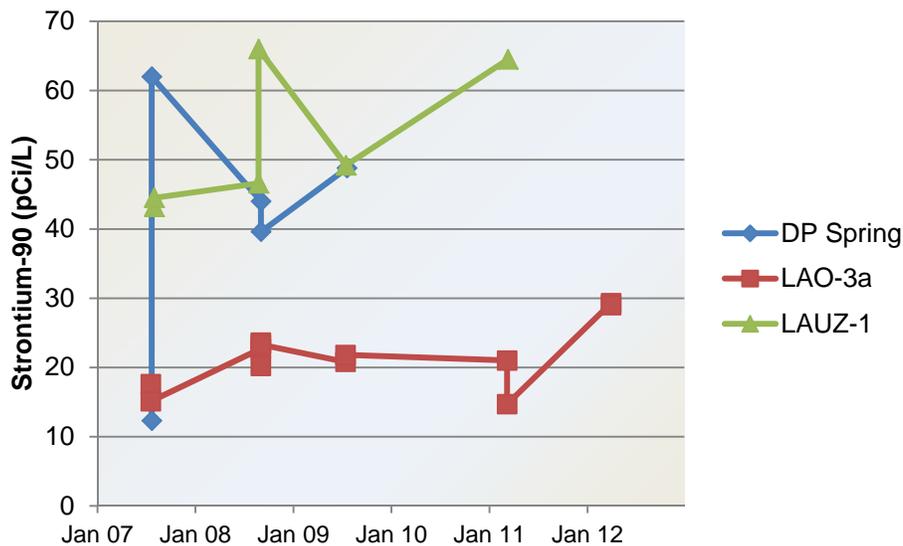


Figure 5-14 Strontium-90 at current and previous general surveillance monitoring locations in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results. For comparison purposes, the EPA MCL (which does not apply to these samples) is 8 pCi/L.

Table 5-13
Groundwater Quality in Los Alamos Canyon (includes DP Canyon)

Chemical	Location	Result	Trends
Strontium-90	Alluvial well LAO-3a	29 pCi/L, above 8-pCi/L EPA MCL screening level, below 40-pCi/L, 4-mrem/yr DOE DCG screening level	Decreased since cessation of discharges in 1986, remains elevated because of retention on alluvium
Gross beta	Alluvial well LAO-3a	78 pCi/L, above EPA drinking water system screening level of 50 pCi/L	Present because of strontium-90, decreased since cessation of discharges in 1986, remains elevated because of retention on alluvium

d. Lower Los Alamos Canyon General Surveillance Monitoring

Los Alamos Spring and Vine Tree Spring on Pueblo de San Ildefonso land are both fed by intermediate groundwater. Basalt Spring is a spring a few feet from Vine Tree Spring that has been monitored since the 1950s; it apparently dried up around 2010, and discharge moved to Vine Tree Spring where the 2012 samples were collected. The 2012 nitrate (as N) results in Los Alamos and Vine Tree Springs were up to 3.8 mg/L, below the NM groundwater standard of 10 mg/L. Past nitrate (as N) results from Basalt Spring were above the standard.

At Vine Tree Spring and Basalt Spring, the perchlorate concentrations since late 2008 have been near or above the Consent Order screening level of 4 µg/L (Table 5-14, Figure 5-13). The 2012 fluoride concentration at Los Alamos Spring was 48% of the 1.6-mg/L NM groundwater standard. Similar concentrations have been found in samples from the spring since the 1960s.

Table 5-14
Groundwater Quality in Lower Los Alamos Canyon

Chemical	Location	Result	Trends
Perchlorate	Vine Tree Spring (intermediate)	5.4 µg/L, above Consent Order screening level of 4 µg/L	Combined with results from nearby Basalt Spring, increasing since 2006
Fluoride	Los Alamos Spring (intermediate)	0.77 mg/L, below NM groundwater standard of 1.6 mg/L	Similar levels since 1960s
Lead	Alluvial well LLAO-4	23 µg/L, above EPA drinking water screening level of 15 µg/L	First filtered detection in 17 yr of sampling, only one prior total lead detection at 1.5 µg/L

4. Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. Monitoring focuses on the characterization and fate and transport of chromium contamination in intermediate-perched groundwater and within the regional aquifer. The distribution of wells in the monitoring group also addresses past releases from NPDES Outfall 051, which discharged from the Radioactive Liquid Waste Treatment Facility (RLWTF) in the Mortandad Canyon watershed.

The RLWTF discharged effluent containing radioactivity into Mortandad Canyon from 1963 through 2010 (Emelity 1996, Del Signore 2012). RLWTF effluent volumes were considerably reduced in 2010 and eliminated in 2011 because of process changes at the RLWTF (Del Signore 2011, 2012). Beginning in 2011, treated water went to a new effluent evaporator (Del Signore 2012).

Sandia Canyon has a small drainage area that heads at TA-03. The canyon receives sanitary effluent, releases from the steam plant, and cooling tower discharges from computing facilities and the TA-03 power plant (Table 5-15). Treated sanitary effluent from the TA-46 SWWS Plant has been routed to Sandia Canyon since 1992. Until 1972, chromate was used to treat cooling water at the power plant (LANL 1973). These earlier discharges are associated with the hexavalent chromium concentrations in intermediate groundwater

and the regional aquifer beneath Sandia and Mortandad Canyons (Figure 5-15). 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 before reaching the regional aquifer (LANL 2006a, 2008b).

Table 5-15
Summary of Groundwater Contamination in Sandia and
Mortandad Canyons and the Chromium Investigation Monitoring Group

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Sandia Canyon	Current and past effluent discharges	One location not sampled in 2012	None	None
Chromium Investigation monitoring group (Sandia Canyon)	Current and past effluent discharges	No monitoring locations	Chromium above NM groundwater standard	Chromium above and nitrate at 59% of NM groundwater standards
Chromium Investigation monitoring group (Mortandad Canyon)	Past effluent discharges	No monitoring locations	Tritium at 19% of EPA MCL screening level; perchlorate above Consent Order screening level; chromium above and nitrate up to 85% of NM groundwater standards; 1,4-dioxane above EPA regional screening level for tap water	Chromium above and nitrate at 61% of NM groundwater standards, perchlorate above Consent Order screening level
Mortandad and Ten Site Canyons	Past effluent discharges	Fluoride at 66% of NM groundwater standard, perchlorate above Consent Order screening level	No monitoring locations	None
Cañada del Buey	Dry and liquid sources	None, little alluvial groundwater	No intermediate groundwater	No monitoring locations

Mortandad Canyon also has a small drainage area that heads at TA-03. This drainage area receives inflow from natural precipitation and a number of NPDES outfalls, including (until 2010) one from the RLWTF at TA-50 (Table 5-15). Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35. Some Mortandad Canyon wells are part of the TA-54 and MDA C monitoring groups and are discussed in a later section.

The 2012 chromium concentrations exceeded the NM groundwater standard in four regional aquifer wells: R-28, R-42, R-62, and R-50 S1 (Figure 5-15). The 2012 chromium concentration was just below the standard in regional aquifer well R-43 S1. Two intermediate wells also had chromium concentrations above the standard: SCI-2 and MCOI-6. Other constituents detected at elevated concentrations or activities in wells in the monitoring group include nitrate, perchlorate, and tritium. A conceptual model for the sources and distribution of these contaminants is presented in the Investigation Report for Sandia Canyon (LANL 2009a).

The conceptual model hypothesizes that chromium originated from releases into Sandia Canyon and may have migrated along lateral pathways to locations beneath Mortandad Canyon. For this reason, intermediate-perched and regional wells beneath Mortandad Canyon are included in the Chromium Investigation monitoring group. Other areas of contamination beneath Sandia and Mortandad Canyons may be associated with Mortandad Canyon sources. These sources and the migration pathways are described in the Investigation Report for Sandia Canyon (LANL 2009a).

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 Plant 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.

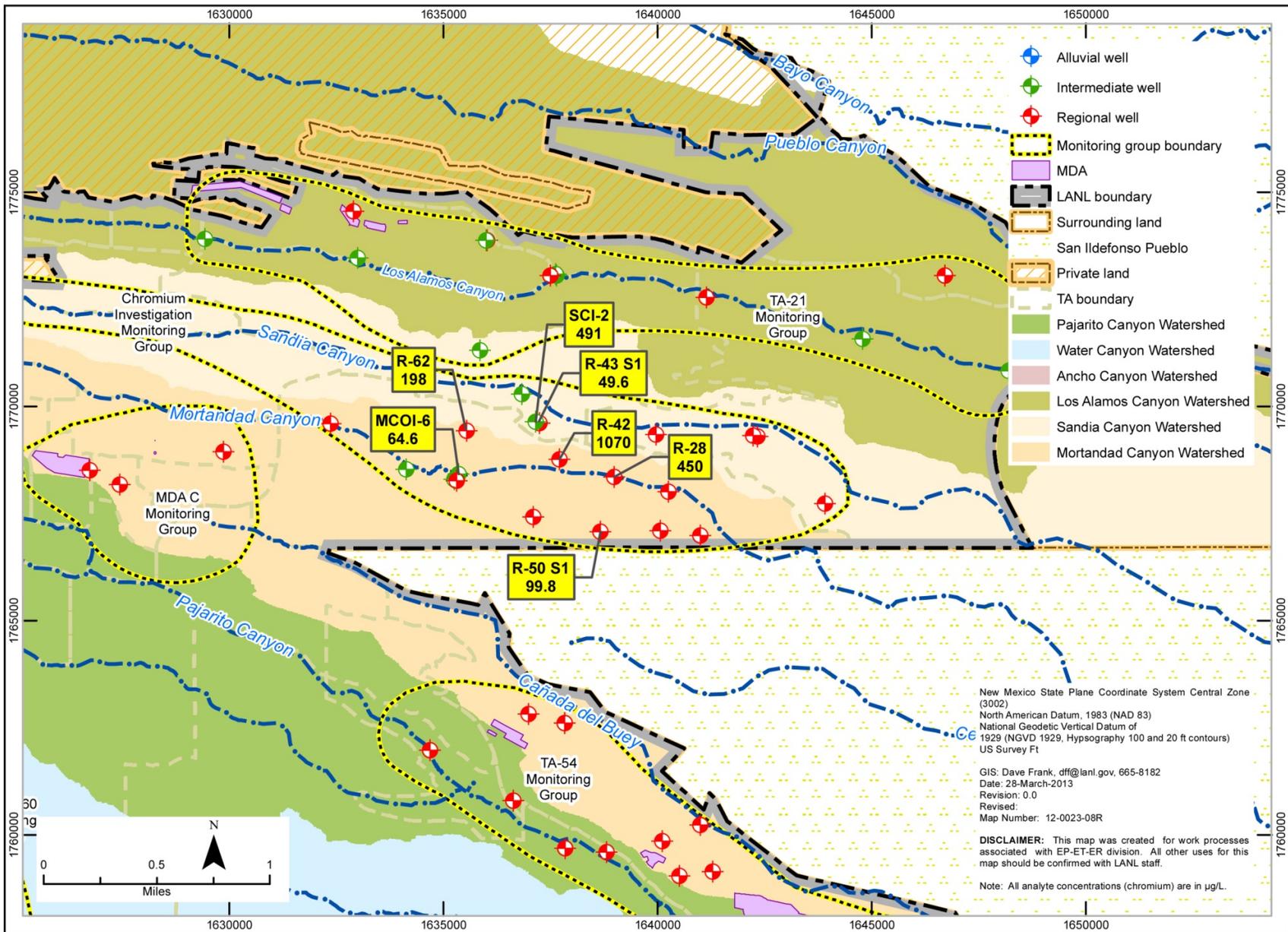


Figure 5-15 Wells with 2012 dissolved or hexavalent chromium concentrations above the 50-µg/L NM groundwater standard. The maximum concentration for the year is shown in µg/L.

a. Sandia Canyon General Surveillance Monitoring

The wells located in Sandia Canyon that are not part of the Chromium Investigation monitoring group include regional aquifer wells R-10, R-10a, and intermediate well R-12; the first two are on Pueblo de San Ildefonso land. No constituents were measured near or above standards in these wells during 2012. SCA-2, an alluvial well, was not sampled because of lack of water.

b. Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. Several regional aquifer wells had high filtered chromium concentrations that ranged from 49.6 µg/L in Sandia Canyon well R-43 S1 to 1070 µg/L in Mortandad Canyon well R-42 (Table 5-16, Figures 5-15 through 5-17). The NM groundwater standard is 50 µg/L.

Table 5-16**Groundwater Quality in the Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)**

Chemical	Location	Result	Trends
Chromium	Five regional aquifer wells in Sandia and Mortandad Canyons	34.5 µg/L to 1070 µg/L, above NM groundwater standard of 50 µg/L	Results at R-42 and R-28 in this range for several years of sampling, increasing at R-50 S1 and R-43 S1; R-62 is a new well
Nitrate (as N)	Three regional aquifer wells in Sandia and Mortandad Canyons	From 5 mg/L to 6.1 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over 4 yr of sampling, recent range is 4 mg/L to 6 mg/L
Perchlorate	Mortandad Canyon regional aquifer wells R-15 and R-61 S1	From 6.1 µg/L to 7.9 µg/L, above Consent Order screening level of 4 µg/L	Concentrations rising in R-15 over several years, R-61 first sampled in 2011
Tritium	Mortandad Canyon intermediate wells MCOI-5 and MCOI-6	2410 pCi/L to 3720 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values decreasing since 2008, the wells sample separate isolated perched zones
Chromium	Intermediate wells SCI-2 and MCOI-6	Average of 450 µg/L in SCI-2 and 61 µg/L in MCOI-6, above NM groundwater standard of 50 µg/L	Results in this range for several years in SCI-2, increasing since 2007 in MCOI-6
Nitrate (as N)	Intermediate wells SCI-2, MCOI-5, and MCOI-6	3.8 mg/L to 8.5 mg/L, below NM groundwater standard of 10 mg/L	Stable in two wells, decreasing in MCOI-6 for several years, the wells sample separate isolated perched zones
Perchlorate	Mortandad Canyon intermediate wells MCOI-5 and MCOI-6	59 µg/L to 75 µg/L, above Consent Order screening level of 4 µg/L	Results in MCOI-6 decreased substantially through 2009, less change in MCOI-5
Dioxane[1,4-]	Mortandad Canyon intermediate wells MCOI-5 and MCOI-6	4.5 µg/L to 11.2 µg/L, above EPA regional screening level for tap water of 6.7 µg/L	Fairly steady in MCOI-5, >50% decline at MCOI-6 since 2009

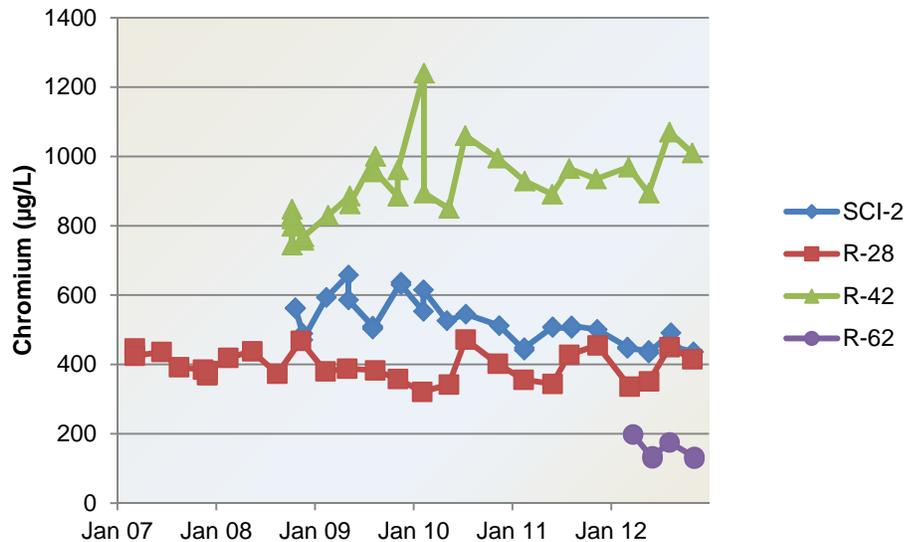


Figure 5-16 Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

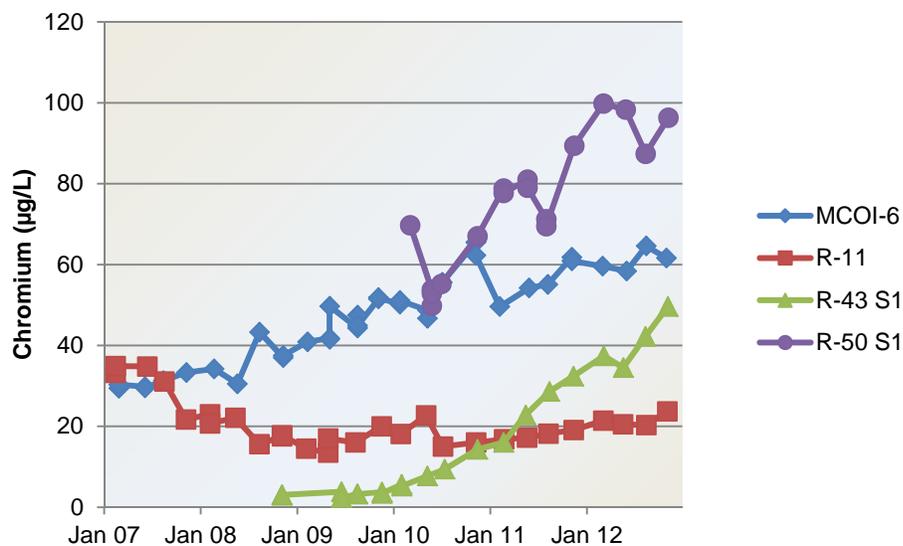


Figure 5-17 Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

Regional aquifer wells R-43 S1 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon had 2012 nitrate (as N) concentrations up to 61% of the 10-mg/L NM groundwater standard (Figures 5-18 and 5-19). Nitrate (as N) concentrations were also elevated (that is, above 2 mg/L) in samples from regional aquifer wells R-36 in Sandia Canyon and R-15, R-28, and R-45 in Mortandad Canyon. R-36 had one unusually elevated result on November 16, 2011, and R-11 had a corresponding low result, suggesting samples may have been switched. Reanalysis of the R-36 sample produced a result similar to other values at that well, and the original value was rejected.

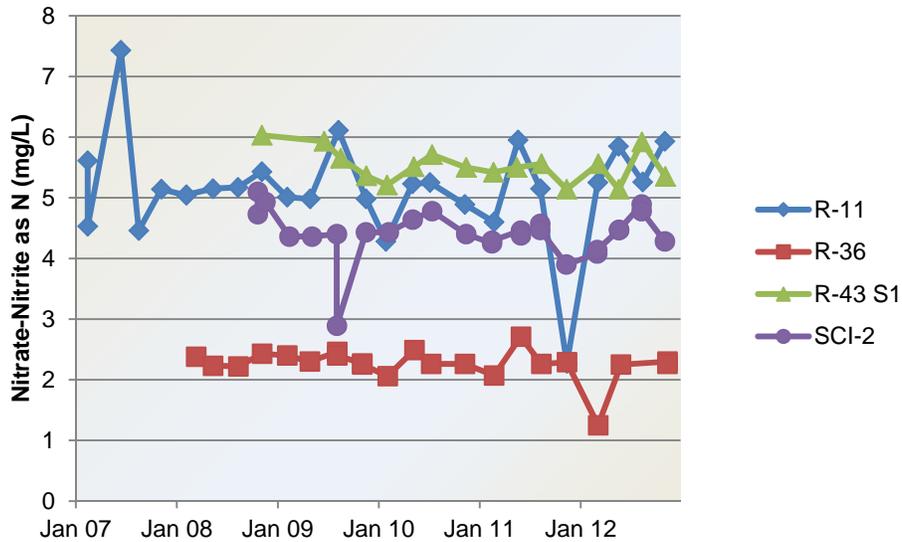


Figure 5-18 Nitrate (as N) in the Chromium Investigation monitoring group in Sandia Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Many of the results in 2007 and 2008 are estimated because of analytical quality issues.

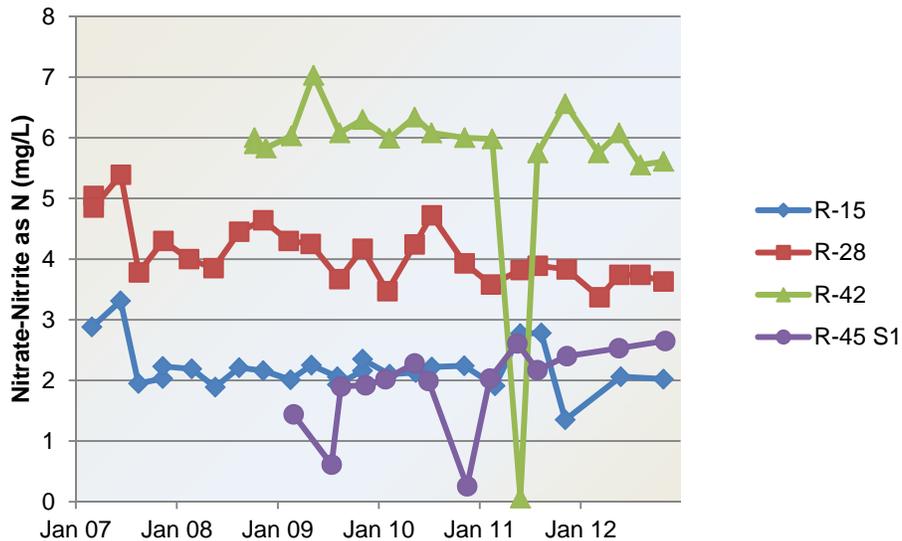


Figure 5-19 Nitrate (as N) in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Most of the 2007 and some of the 2009 results are estimated because of analytical quality issues.

The perchlorate concentration in R-15 was above the Consent Order screening level of 4 µg/L (Figures 5-9 and 5-20). Samples taken from R-61 S1 (the upper screen) were also above the screening level.

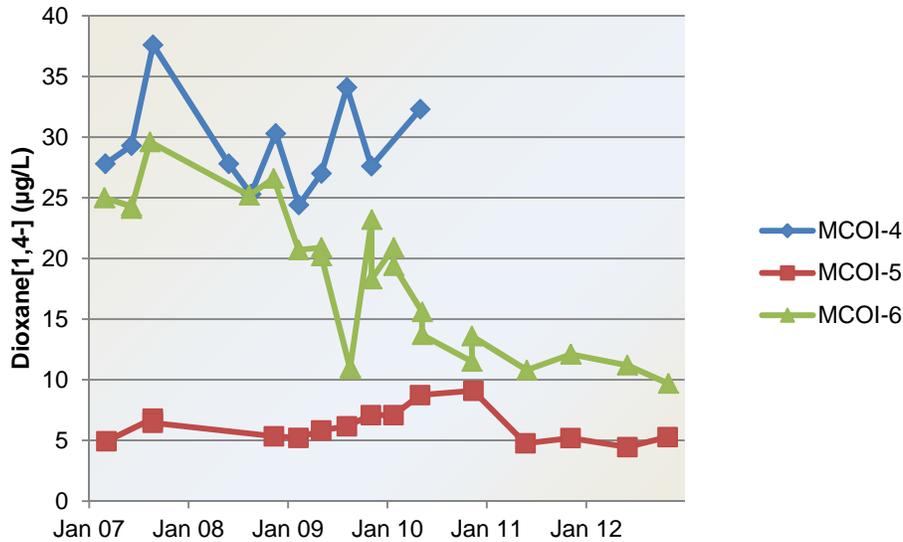


Figure 5-22 Concentrations of 1,4-dioxane in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. The EPA regional screening level for tap water is 6.7 µg/L. About half the results are estimated.

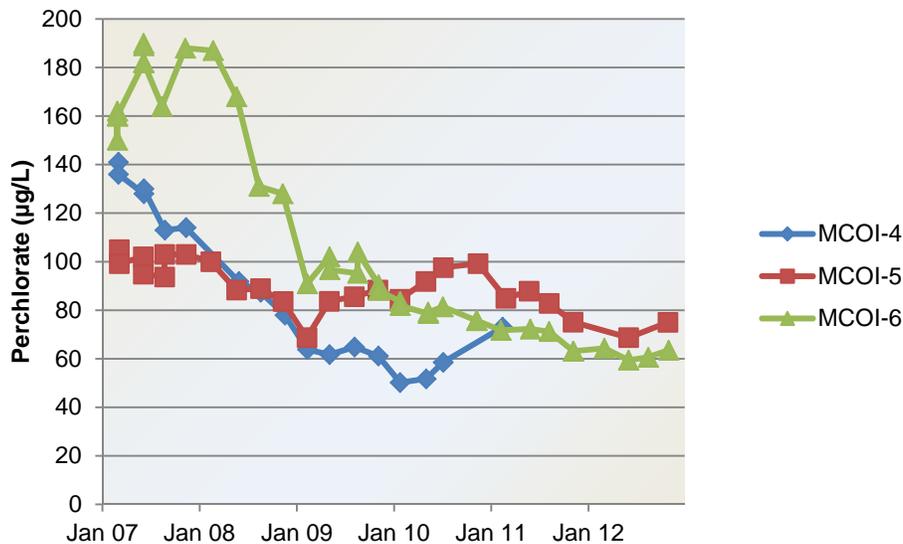


Figure 5-23 Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.

Intermediate wells MCOI-5 and MCOI-6 had tritium activities that ranged from 12% to 19% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-24). Tritium activities in these wells and MCOI-4 have decreased significantly since 2007.

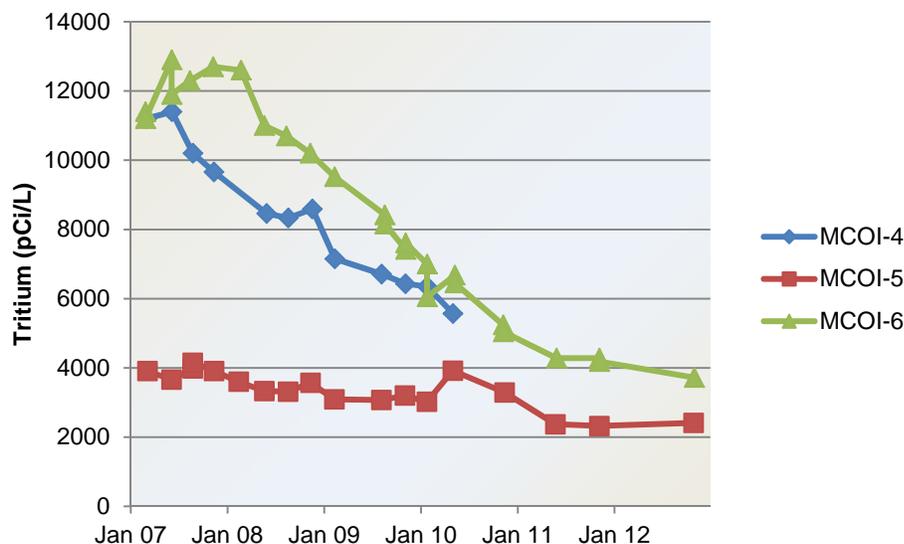


Figure 5-24 Tritium in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 20,000 pCi/L.

c. Mortandad Canyon General Surveillance Monitoring

Several regional aquifer wells in Mortandad Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above standards in these wells during 2012.

MCO-7, an alluvial well in Mortandad Canyon, was sampled during 2012 for radionuclides; the results were well below screening levels. Before effluent quality improvements were implemented 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. The inventory of strontium-90 in the alluvium is gradually declining because discharge amounts have decreased and the half-life of strontium-90 is 28.8 yr. 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.

Under the groundwater discharge plan application for the former RLWTF outfall, the Laboratory has collected additional quarterly samples since 1999 for nitrate, fluoride, perchlorate, and total dissolved solids (TDS) from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCO-3, MCO-4B, MCO-6, and MCO-7 (Table 5-17). Because of dry conditions during 2012, there was little runoff. As a result, alluvial wells in Mortandad Canyon were often dry.

Table 5-17
Groundwater Quality in Mortandad Canyon Alluvial Groundwater

Chemical	Location	Result	Trends
Fluoride	Alluvial wells MCO-6 and MCO-7	0.88 mg/L to 1.06 mg/L, below NM groundwater standard of 1.6 mg/L	Results decreasing below RLWTF outfall and generally below standard since 1999 effluent treatment upgrades
Perchlorate	Alluvial wells MCO-6 and MCO-7	3.2 µg/L to 7.5 µg/L, above Consent Order screening level of 4 µg/L	Results substantially decreasing since 2002 effluent treatment upgrades

Between 2006 and 2010, the chloride concentration in surface water and alluvial well samples in Effluent Canyon, a small tributary of Mortandad Canyon, approached or exceeded the 250-mg/L NM groundwater standard. These locations showed peaks in chloride concentrations mainly in early winter, evidently the result of runoff affected by road salting. Similar trends occur in sodium concentrations and TDS. The concentration peaks at monitoring locations farther downstream occurred later in the year.

In Mortandad Canyon, downstream of Effluent Canyon at alluvial well MCO-3, chloride values in 2008 through 2010 were highest each year during February through May, up to 144 mg/L (Figure 5-25). MCO-3 has been sampled since 1963. With the exception of a few chloride results in about 1971 and 1990, the chloride concentrations since 2006 at MCO-3 are the highest measured at the well over its monitoring history.

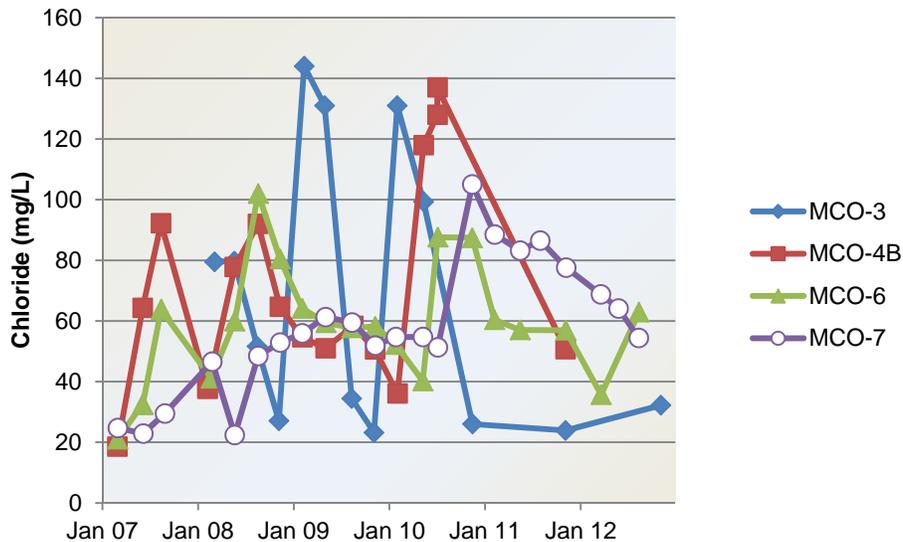


Figure 5-25 Chloride at general surveillance and groundwater discharge plan monitoring locations in Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

The chloride concentrations at MCO-3 and downstream alluvial groundwater wells have risen since 2003 and since 2006 are higher than most previous values. As RLWTF effluent discharge and total chloride mass discharge decreased after 1990 and ended in 2010, the average annual effluent chloride concentration also decreased. Accordingly, RLWTF effluent is not believed to be the cause of the increasing chloride concentration in recent downstream alluvial groundwater samples. These results suggest that increased application of road salt during the past few years has a greater impact on recent groundwater chloride concentrations than the past RLWTF effluent discharges.

The 2012 nitrate (as N) concentrations in these wells were below the NM groundwater standard of 10 mg/L; the maximum was 1.35 mg/L in MCO-7. The fluoride concentrations were below the NM groundwater standard of 1.6 mg/L, though many were above 50% of the standard. The highest 2012 groundwater fluoride concentration downstream of the former RLWTF outfall was 1.06 mg/L in MCO-7.

Mortandad Canyon alluvial groundwater samples from wells downstream of the RLWTF outfall had elevated perchlorate concentrations (Figures 5-9 and 5-26). The 2012 concentrations at two alluvial wells were above the Consent Order screening level of 4 µg/L. In 2000, the perchlorate concentrations in these wells were above 200 µg/L; they declined substantially following the removal of perchlorate from RLWTF effluent in March 2002.

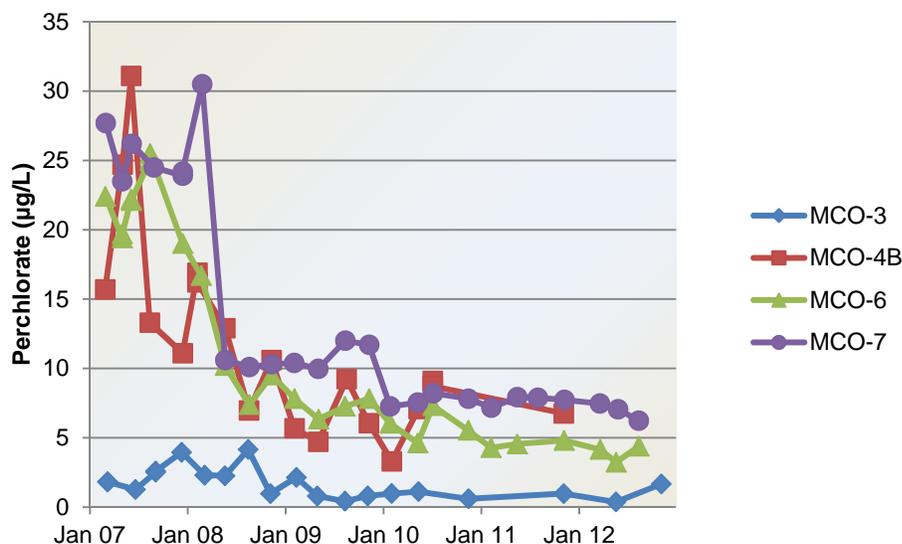


Figure 5-26 Perchlorate at general surveillance and groundwater discharge plan monitoring locations in Mortandad Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.

d. Cañada del Buey General Surveillance Monitoring

Alluvial well CDBO-6 in Cañada del Buey was dry and not sampled in 2012.

5. MDA C and TA-54 Monitoring Groups (Mortandad, Pajarito, 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-09 (Table 5-18). 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 area of shallow intermediate groundwater occurs behind a former Laboratory warehouse location at TA-03. The main groundwater impacts are from organic chemicals and from HE (Tables 5-19 and 5-20).

Table 5-18

Summary of Groundwater Contamination in Pajarito Canyon and the MDA C and TA-54 Monitoring Groups

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
MDA C monitoring group (Mortandad Canyon)	Noneffluent sources	No monitoring locations	No monitoring locations	Gross alpha above, bis(2-ethylhexyl)phthalate at 64%, and antimony at 75% of EPA MCL screening levels
TA-54 monitoring group (Mortandad and Pajarito Canyons)	Noneffluent sources	No monitoring locations	1,4-Dioxane at 53% of EPA regional screening level for tap water, nitrate (as N) up to 48% of NM groundwater standard	Trichloroethene at 8% of EPA MCL screening level
Pajarito, Twomile, and Threemile Canyons	Noneffluent sources, liquid sources major in the past but minor currently	Chloride above, TDS at 83%, and barium at 53% of NM groundwater standards	Chloride at 52%; 1,1-dichloroethene at 98%; and iron and 1,1,1-trichloroethane above NM groundwater standards. Trichloroethene at 35% of EPA MCL screening levels; 1,4-dioxane above EPA regional screening level for tap water	None

Table 5-19
Groundwater Quality in MDA C and TA-54 Monitoring Groups

Chemical	Location	Result	Trends
Gross alpha	MDA C regional aquifer well R-60	62.8 pCi/L, above EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; these values were not corrected for this)	One previous detection of 3.6 pCi/L, four other results were nondetects
Total antimony	MDA C regional aquifer well R-46	3.4 µg/L to 4.5 µg/L, below EPA MCL screening level of 6 µg/L	Results in this range since first samples in 2009
Bis(2-ethylhexyl) phthalate	MDA C regional aquifer well R-46	3.8 µg/L in R-46, above EPA MCL screening level of 6 µg/L	More than 20-fold decline since 2009
Trichloroethene	TA-54 regional aquifer well R-20 S2	One nondetect and one at 0.38 µg/L, below EPA MCL screening level of 5 µg/L	Until 2012, found in every sampling event since December 2008, concentrations decreasing since December 2009
Dioxane[1,4-]	TA-54 intermediate well R-37 S1	One nondetect and one at 3.5 µg/L, below EPA regional screening level for tap water of 6.7 µg/L	Detected in nearly every sampling event since 2009, all detections just above the 2-µg/L MDL and estimated
Nitrate (as N)	TA-54 intermediate well R-55i	4.8 mg/L, below NM groundwater standard of 10 mg/L	First sampled in 2011

Table 5-20
Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
Chloride	Intermediate well 03-B-13	130 mg/L, below NM groundwater standard of 250 mg/L	From road salt, previously above standard
Iron	Intermediate well 03-B-13	1930 µg/L, below NM groundwater standard of 1000 µg/L	Seasonally variable, caused by reducing conditions related to bacterial decomposition of solvents
Dichloroethene [1,1-]	Intermediate well 03-B-13	4.9 µg/L, below NM groundwater standard of 5 µg/L	Detected in every sample since 2006, seasonally variable with highest concentrations in 2008
Trichloroethane [1,1,1-]	Intermediate well 03-B-13	117 µg/L, above NM groundwater standard of 60 µg/L	Detected in every sample since 2006, seasonally variable
Trichloroethene	Intermediate well 03-B-13	1.74 µg/L, below EPA MCL screening level of 5 µg/L	Detected in every sample since 2006, seasonally variable
Dioxane[1,4-]	Intermediate well 03-B-13	462 µg/L, above EPA regional screening level for tap water of 6.7 µg/L	Detected since 2006, seasonally variable
Chloride	Alluvial wells 18-MW-18 and PCAO-8	128 mg/L to 354 mg/L, above NM groundwater standard of 250 mg/L	From road salt, elevated in several wells in past years
TDS	Alluvial well 18-MW-18	834 mg/L, below NM groundwater standard of 1000 mg/L	From road salt, elevated in several wells in past years
Barium	Alluvial well 18-MW-18	531 µg/L, below NM groundwater standard of 1000 µg/L	May be released from sediments by cation exchange caused by high sodium in road salt runoff

MDA C is located on Mesita del Buey in TA-50, at the head of Ten Site Canyon. The MDA C monitoring group includes nearby regional monitoring wells on the mesa top and in Mortandad Canyon. TA-50 is bounded on the north by Effluent and Mortandad Canyons, on the east by the upper reaches of Ten Site Canyon, on the south by Twomile Canyon, and on the west by TA-55.

MDA C is an inactive landfill where solid low-level radioactive wastes and chemical wastes were disposed of between 1948 and 1974. Vapor-phase VOCs and tritium are present in the upper 500 ft of the unsaturated zone beneath MDA C (LANL 2011c). The primary vapor-phase contaminants beneath MDA C are trichloroethene, tetrachloroethene, and tritium. There is no evidence of groundwater contamination in the

regional aquifer. MDA C is located on a mesa top above thick, unsaturated units of the Bandelier Tuff, and therefore, present-day aqueous-phase transport is generally believed to be minimal.

TA-54 is situated in the east-central portion of the Laboratory on Mesita del Buey. TA-54 includes four MDAs designated as G, H, J, and L; a waste characterization, container storage, and transfer facility (TA-54 West); active radioactive waste storage and disposal operations at Area G; hazardous and mixed-waste storage operations at Area L; and administrative and support areas. The transfer facility is located at the western end of TA-54.

At TA-54, groundwater monitoring is conducted to support both (1) the corrective measures process for SWMUs and areas of concern (AOCs) (particularly MDAs G, H, and L) under the Consent Order and (2) the Resource Conservation and Recovery Act permit. The TA-54 monitoring group was established to address the monitoring requirements for all portions and aspects of TA-54. The TA-54 monitoring group includes both intermediate-perched and regional wells in the near vicinity. Other downgradient wells have general relevance to TA-54 and other potential upgradient sources but are not considered part of the TA-54 monitoring network and are not included in the monitoring group.

Pore-gas monitoring data show vapor-phase organic compounds are present in the upper portion of the unsaturated zone beneath MDAs G and L. The primary contaminants in the vapor phase at TA-54 are 1,1,1-trichloroethane; trichloroethene; Freon-113; and tritium (LANL 2005b, 2006b, 2007b).

Data from the groundwater monitoring network around TA-54 show sporadic detections of a variety of contaminants, including several VOCs. The temporal and spatial nature of the occurrences does not, however, clearly indicate the presence of a release from potential sources at TA-54 (LANL 2009b). Further evaluations of existing groundwater data near TA-54 and detailed descriptions of organic and inorganic contaminants detected in intermediate-perched and regional groundwater at TA-54 are presented in the corrective measures evaluation reports for MDAs G, H, and L (LANL 2011d, 2011e, 2011f).

a. MDA C Monitoring Group

A gross-alpha result of 62.8 pCi/L in MDA C regional aquifer well R-60 was above the 15-pCi/L EPA MCL. One result of 3.6 pCi/L from a year earlier was a detection, and four other previous results were nondetects.

The total and filtered antimony concentrations at regional aquifer well R-46 ranged from 3.4 µg/L to 4.5 µg/L, below the EPA MCL screening level of 6 µg/L. Results for antimony have been in this range since the first samples were collected from the well in 2009. The source of antimony is uncertain; it may be from well drilling or construction materials.

The bis(2-ethylhexyl)phthalate concentration of 3.8 µg/L from regional aquifer well R-46 was below the 6-µg/L EPA MCL screening level. The concentration of this compound was 96 µg/L in samples taken after well construction in 2009 and has declined with time. The presence of bis(2-ethylhexyl)phthalate is apparently caused by drilling or well construction materials.

b. TA-54 Monitoring Group

Rehabilitation activities were conducted at regional aquifer well R-20 through December 2007 to improve sample quality (LANL 2008c). Beginning with a December 18, 2008, sample, trichloroethene was detected at R-20 S2, the 1147-ft regional aquifer screen, in every sampling event through May 1, 2012. Trichloroethene was not detected in the October 17, 2012, sample. Results from the first sampling events were near the detection limit of 0.25 µg/L and were estimated. Concentrations rose for the following sampling events, reaching 3.04 µg/L in December 2009. Sample concentrations then declined through early 2012. The EPA MCL (which does not apply to these samples) for trichloroethene is 5 µg/L. The NM groundwater standard is 100 µg/L. Trichloroethene has not been detected at the shallower 904-ft regional screen, R-20 S1, and was not detected at R-20 before rehabilitation. A source for trichloroethene has not been determined at this time, and additional wells are planned to help the investigation of water quality in the area.

Trichloroethene was also detected in two of the four annual sampling events during both 2010 and 2011 at R-40 S1, a 751-ft intermediate screen. This well is about 0.25 mi up Pajarito Canyon from R-20. The estimated concentrations were between 0.27 $\mu\text{g/L}$ and 0.81 $\mu\text{g/L}$. Trichloroethene was not detected in samples at this screen during 2012 or 2009. Trichloroethene has not been detected in the other intermediate screen (R-40 Si at 649 ft) or the regional screen R-40 S2 (at 849 ft). The R-40 S1 screen is difficult to sample because the perched zone has little water, and the screen is quickly pumped dry.

The chemical 1,4-dioxane was detected in one of two 2012 samples from R-37 S1, the 929-ft intermediate upper screen, located near the upper part of Cañada del Buey. The detected concentration was 53% of the EPA regional screening level for tap water. This 3.5- $\mu\text{g/L}$ result was estimated because it was near the 3.2- $\mu\text{g/L}$ MDL. Concentrations of 1,4-dioxane have been found in nearly every sampling event at this screen since the well was constructed in 2009.

The nitrate (as N) concentration in samples from intermediate well R-55i ranged from 4.69 mg/L to 4.80 mg/L, below the 10-mg/L NM groundwater standard (Figure 5-21). The well was first sampled in 2011. The nitrate concentrations are unusually elevated and unlike any nearby wells.

c. Pajarito Canyon General Surveillance Monitoring

SWMU 03-010(a) is the outfall area from a former vacuum repair shop and is currently under investigation (DOE 2005). 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). 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.

This perched groundwater is tapped at a depth of 21 ft 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 in past years had chloride (Figure 5-27) and TDS results that were elevated, with chloride sometimes above the groundwater standard. The seasonal pattern of sodium and chloride concentrations, with elevated 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 5-20). The concentrations of several organic chemicals have exceeded NM groundwater standards or other screening levels. Compounds found in well samples included 1,1-dichloroethane; 1,1-dichloroethene; trichloroethene; 1,1,1-trichloroethane; and 1,4-dioxane.

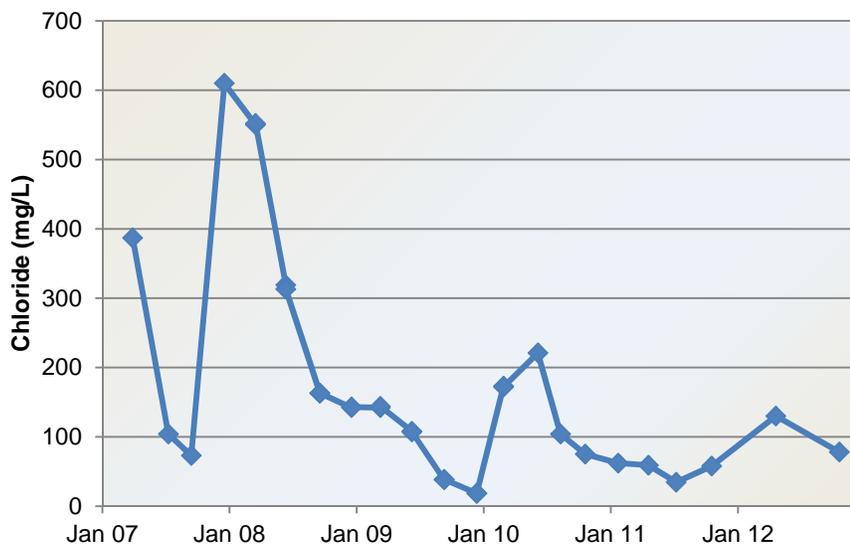


Figure 5-27 Chloride in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 250 mg/L.

Seasonal variation is shown by several field parameters and concentrations of other chemical compounds measured in water samples from wells 03-B-10 and 03-B-13 (LANL 2009c). Variation in oxidation-reduction potential and total organic carbon indicates changes in reducing conditions. Oxidation-reduction potential changes, for example, with a change in the amount of oxygen dissolved in the water. Changes in oxidation-reduction potential lead to observed seasonal changes in turbidity and concentrations of dissolved iron and manganese; under more reducing conditions (e.g., less oxygen), iron and manganese are more soluble.

Figures 5-28 through 5-30 show 1,1-dichloroethene; 1,1,1-trichloroethane; and 1,4-dioxane histories for 03-B-13. For some solvents, retention on solid surfaces is lower in higher ionic strength solutions (solutions with higher concentrations). Thus, increases in concentrations of 1,1-dichloroethene and 1,1,1-trichloroethane could result from increasing concentrations of sodium and chloride (because of infiltration of snowmelt containing dissolved road salt), which releases these compounds from the aquifer matrix. For example, the elevated chloride (Figure 5-27) and TDS observed in the groundwater in December 2007 might have caused release of 1,1,1-trichloroethane during the following months (Figure 5-29).

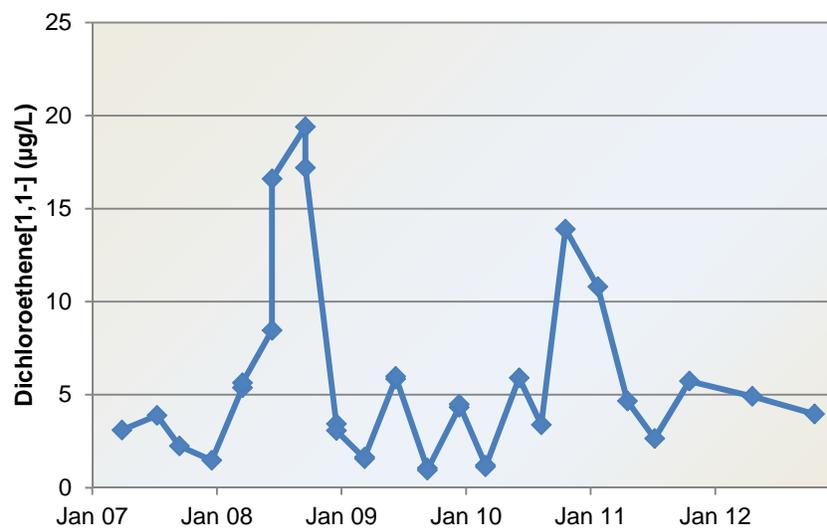


Figure 5-28 Concentrations of 1,1-dichloroethene in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 5 µg/L.

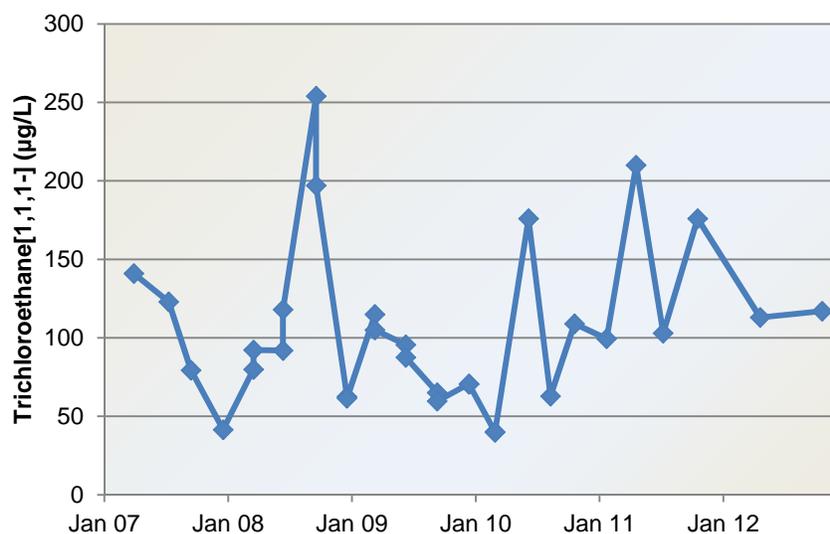


Figure 5-29 Concentrations of 1,1,1-trichloroethane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 60 µg/L.

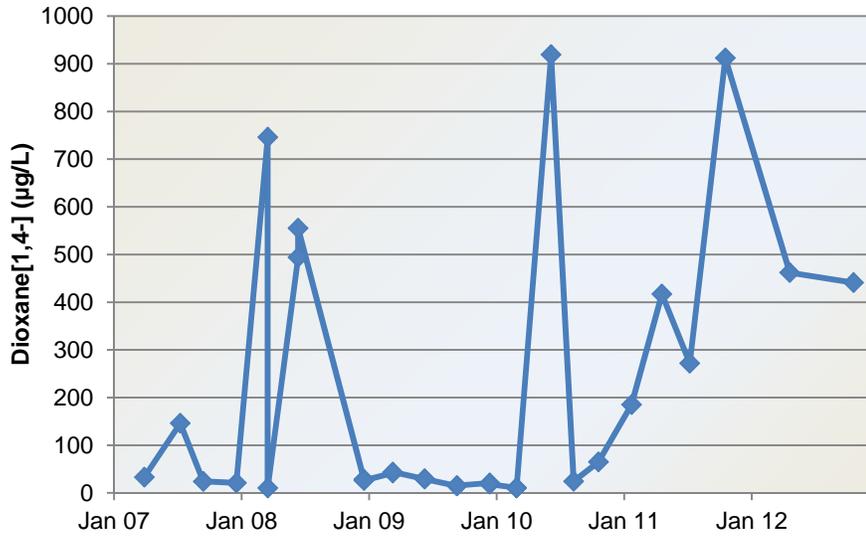


Figure 5-30 Concentrations of 1,4-dioxane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. For comparison purposes, the EPA regional screening level for tap water is 6.7 µg/L.

Several alluvial groundwater wells along Pajarito Road have shown high chloride (Figure 5-31) and TDS concentrations since 2007. 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 2012 chloride concentration at 18-MW-18 was above the NM groundwater standard of 250 mg/L.

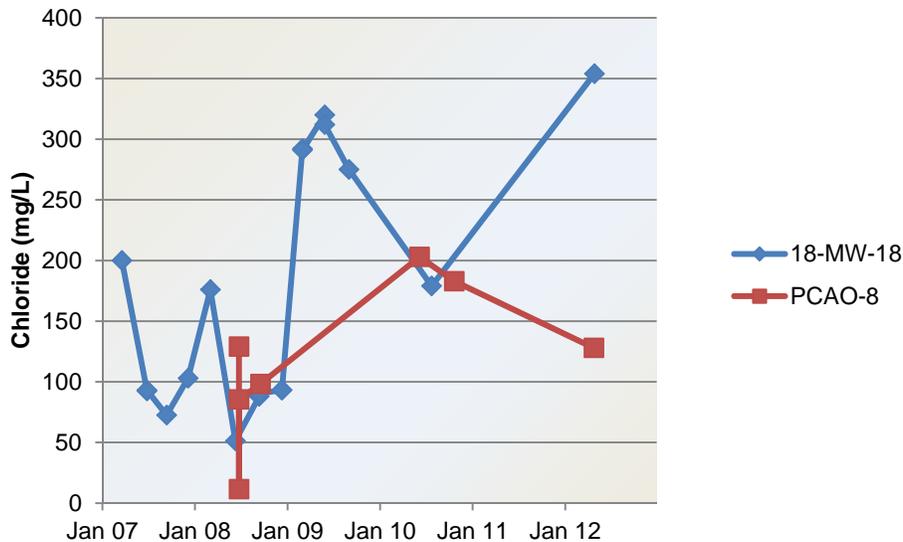


Figure 5-31 Chloride in Pajarito Canyon alluvial groundwater at general surveillance monitoring wells 18-MW-18 and PCAO-8. The NM groundwater standard is 250 mg/L.

Barium concentrations are elevated in several alluvial wells; the concentration of 531 µg/L at 18-MW-18 is below the NM groundwater standard of 1000 µg/L. Barium concentrations have shown seasonal fluctuations; high sodium concentrations in road salt runoff apparently cause cation exchange replacement of barium bound to sediments, increasing the groundwater barium concentration.

6. TA-16 260 Monitoring Group (Pajarito Canyon, Water Canyon, and Cañon de Valle)

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-09 (Table 5-21). 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 than the previous outfalls and generally meets NPDES permit requirements.

Table 5-21
Summary of Groundwater Contamination in Water
and Pajarito Canyons and the TA-16 260 Monitoring Group

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
TA-16 260 monitoring group (Cañon de Valle and Pajarito Canyon)	Dry and past effluent sources	Barium above NM groundwater standard and RDX above EPA regional screening level for tap water	Nickel, cobalt, iron, and manganese above NM groundwater standard in R-25 because of well damage; boron above NM groundwater standard; tetrachloroethene at 57%, trichloroethene at 43%, and natural radium isotopes up to 97% of EPA MCL screening level; RDX above EPA regional screening level for tap water	RDX at 24% of EPA regional screening level for tap water
Cañon de Valle	Dry and past effluent sources	No monitoring locations	No monitoring locations	No monitoring locations
Water Canyon	Dry and past effluent sources	None, little alluvial groundwater	No monitoring locations	No monitoring locations
Potrillo, Fence, and Indio Canyons	Minor noneffluent sources	No alluvial groundwater	No intermediate groundwater	No monitoring locations

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.

The TA-16 260 monitoring group was established for the upper Water Canyon/Cañon de Valle watershed to monitor contaminants released from Consolidated Unit 16-021(c)-99, the TA-16 260 Outfall (hereafter, the 260 Outfall), and other sites at TA-16. The 260 Outfall is a former HE-machining outfall that discharged HE-bearing water to Cañon de Valle for almost 50 yr.

Results of the 260 Outfall corrective measures evaluation (LANL 2007c) show the drainage channel below the outfall and the canyon bottom as well as surface water, alluvial groundwater, and intermediate-perched groundwater contain explosive compounds, including RDX (Figure 5-32), HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), TNT (2,4,6-trinitrotoluene), and barium. In addition, the VOCs tetrachloroethene and trichloroethene have been detected in springs, alluvial groundwater, and intermediate-perched groundwater.

a. TA-16 260 Monitoring Group

RDX was detected at Pajarito Canyon regional well R-18 at a concentration that is 18% of the 6.1- $\mu\text{g/L}$ EPA regional screening level for tap water. RDX has been detected at this well since August 2006 in every sample at increasing concentrations.

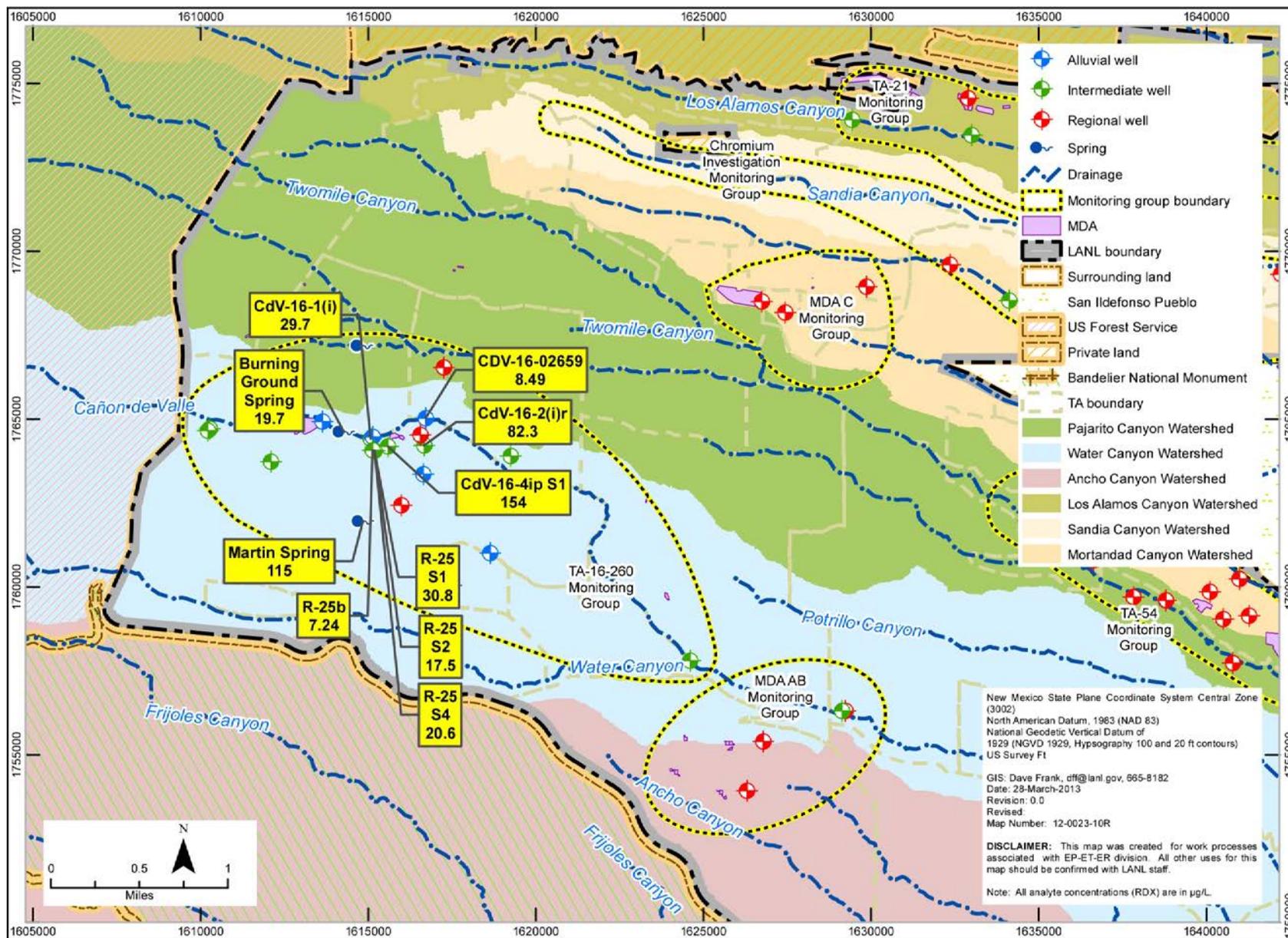


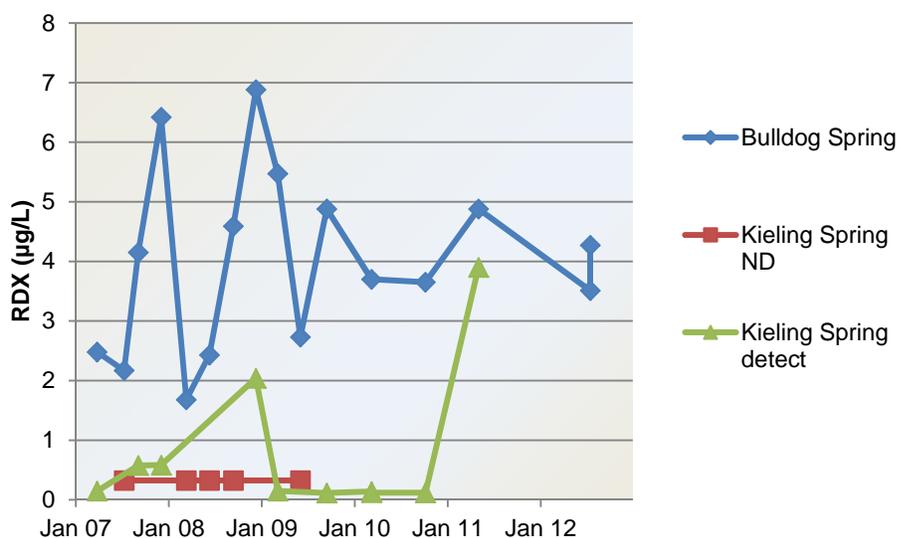
Figure 5-32 Wells and springs with 2012 RDX concentrations above the 6.1-µg/L EPA tap water screening level. The maximum concentration for the year is shown in µg/L.

Regional well R-63 was first sampled in 2011. The 2012 RDX concentrations ranged from 1.25 µg/L to 1.47 µg/L, up to 24% of the 6.1-µg/L EPA regional screening level for tap water. The shallowest two regional aquifer screens at well R-25 had 2012 RDX concentrations of 0.21 µg/L to 0.38 µg/L, also below the 6.1-µg/L EPA regional screening level for tap water. RDX has been found at R-25 since the well was first sampled in 2000. Initial concentrations were higher, possibly because of a delay in installing the sampling system that allowed water from shallower screens to enter the regional aquifer screens.

A radium-226 result of 4.86 pCi/L in intermediate well R-47i was just below the 5-pCi/L MCL. One earlier radium-226 result and two measurements for radium-228 were nondetects. Intermediate well CDV-37-1(i) had a radium-228 detection of 2.66 pCi/L, 53% of the MCL. One earlier sample was nondetect and radium-226 was not detected in either sampling event. These isotopes occur naturally.

The shallowest two screens at well R-25 (which sample intermediate groundwater) have shown elevated concentrations of metals such as nickel and chromium for several years. The elevated concentrations were caused by damage to the screens during well construction. In 2008, new wells were drilled to replace some of the upper R-25 screens.

Samples from intermediate Bulldog Spring in upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. The RDX result from Bulldog Spring was 70% of the EPA regional screening level for tap water (Figure 5-33).



ND = Nondetect.

Figure 5-33 RDX in Pajarito Canyon intermediate groundwater at the TA-16 260 monitoring group location Bulldog Spring and a previous general surveillance monitoring location Kieling Spring. The EPA tap water screening level is 6.1 µg/L. Nondetects are reported at the practical quantitation limit.

Samples from seven intermediate-perched zone wells or well screens contained RDX above the 6.1-µg/L EPA regional screening level for tap water (Figures 5-32 and 5-34 through 5-36). As seen in Figure 5-36, samples from the shallowest two screens at well R-25, which sample intermediate groundwater, show variability that may be because of switching of samples or drilling of new nearby wells (LANL 2009d).

Samples from intermediate groundwater at Martin Spring and Burning Ground Spring contained several HE compounds. RDX was present at the highest concentrations relative to the screening levels, above the 6.1-µg/L EPA regional screening level for tap water (Figures 5-34 and 5-35). The RDX levels have been fairly steady at both of these springs.

The chlorinated solvents tetrachloroethene and trichloroethene continue to be found in several intermediate wells and springs at concentrations below the EPA MCL screening levels (Table 5-22).

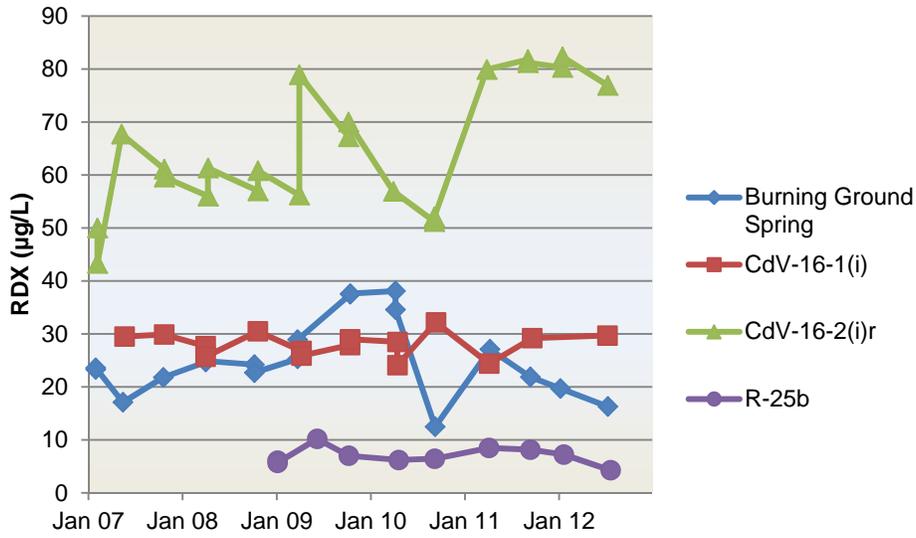


Figure 5-34 RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA tap water screening level is 6.1 µg/L.

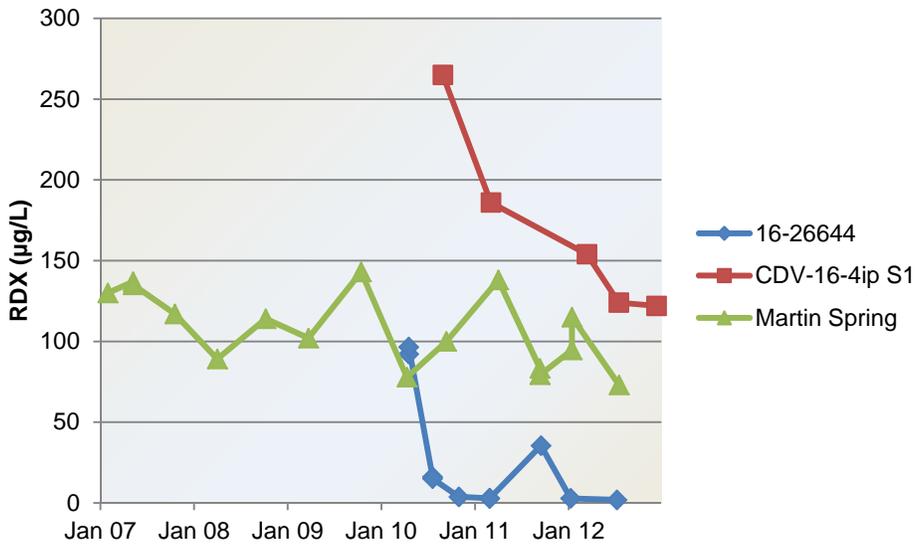


Figure 5-35 RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA tap water screening level is 6.1 µg/L.

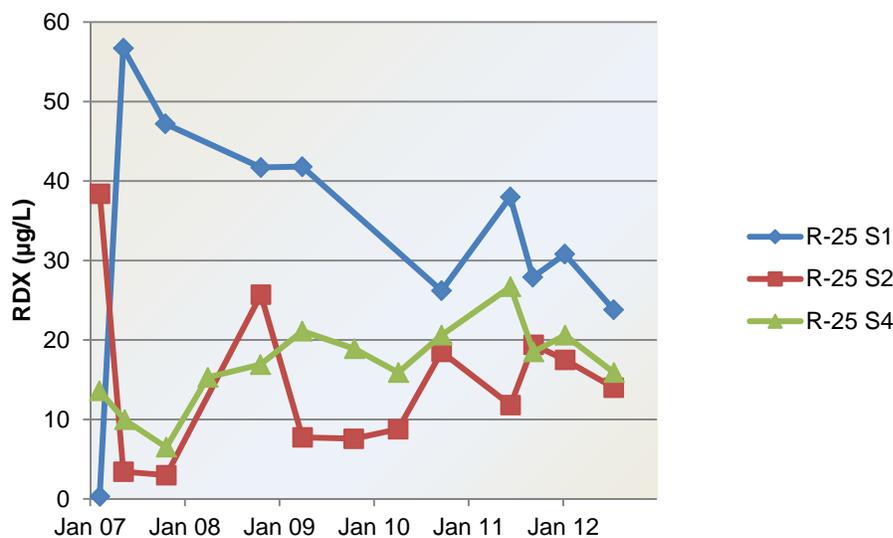


Figure 5-36 RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA regional screening level for tap water is 6.1 µg/L.

Table 5-22
Groundwater Quality in the TA-16 260 Monitoring Group

Chemical	Location	Result	Trends
RDX	Regional aquifer wells R-18, R-25, and R-63	Up to 1.47 µg/L, below EPA regional screening level for tap water of 6.1 µg/L	Concentrations increasing in R-18, steady in past few years for other wells
Radium-228 and radium-226	Intermediate wells CDV-37-1(i) and R-47i	Up to 4.9 pCi/L, below EPA MCL screening level of 5 pCi/L	Naturally occurring isotopes, two samples at each well with only one detection
Nickel	Intermediate well R-25 S2	4770 µg/L, above NM groundwater standard of 200 µg/L	Similar results in shallowest screen since 2001 because of construction damage; cobalt, iron, and manganese also above standards
Boron	Intermediate Martin Spring	1310 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected since 1995, approximate 40% decrease since 2003
RDX	Seven intermediate wells or well screens	Up to 154 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Present during several years of sampling of wells
RDX	Intermediate Bulldog, Martin, and Burning Ground Springs	Up to 115 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Highest in Martin Spring, present at these levels for several years
Tetrachloroethene	Eight intermediate wells or well screens	Up to 2.85 µg/L, below EPA MCL screening level of 5 µg/L	Present during several years of sampling of wells
Tetrachloroethene	Intermediate Burning Ground Spring	Up to 1.67 µg/L, below EPA MCL screening level of 5 µg/L	Present at these levels since 1996
Trichloroethene	Six intermediate wells or well screens	Up to 2.13 µg/L, below EPA MCL screening level of 5 µg/L	Present during several years of sampling of wells
Trichloroethene	Intermediate Martin and Burning Ground Springs	Up to 1.78 µg/L, below EPA MCL screening level of 5 µg/L	Higher in Burning Ground Spring, present at these levels since 1996
Barium	Three alluvial wells in Cañon de Valle	3870 µg/L to 21,200 µg/L, above NM groundwater standard of 1000 µg/L	Present at these levels for several years of sampling
RDX	Two alluvial wells in Cañon de Valle	Up to 8.5 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Present at these levels for several years of sampling

Boron was found in samples from intermediate groundwater at Martin Spring at concentrations above the NM groundwater standard for irrigation use (Figure 5-37); however, this spring is not used for irrigation. Boron is also present at elevated levels in downstream alluvial wells.

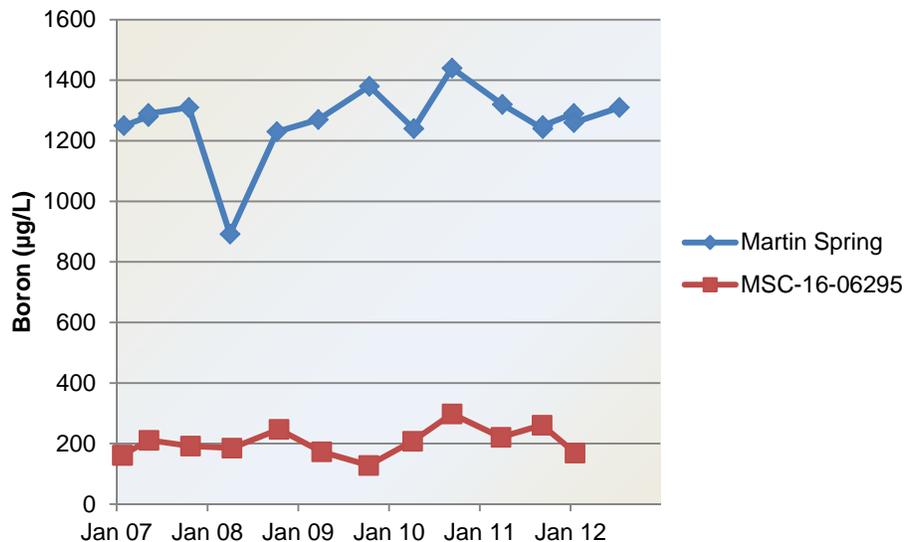


Figure 5-37 Boron in Martin Spring Canyon (a Cañon de Valle tributary) intermediate groundwater at the TA-16 260 monitoring group location Martin Spring and in alluvial groundwater at a previous general surveillance monitoring location. The NM groundwater standard for irrigation use is 750 µg/L.

Barium exceeded the NM groundwater standard in several alluvial wells in Cañon de Valle (Figures 5-38 and 5-39). 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 relative to the screening levels, with some sample results above the 6.1-µg/L EPA regional screening level for tap water (Figures 5-32 and 5-40).

b. Water Canyon General Surveillance Monitoring

Water Canyon has only one general surveillance monitoring location, alluvial well WCO-1r. This well was dry in 2012.

7. MDA AB Monitoring Group (Ancho and Water Canyons)

The MDA AB monitoring group is located in TA-49. TA-49, also known as the Frijoles Mesa Site, is located on a mesa in the upper part of the Ancho Canyon drainage, and part of the MDA drains into Water Canyon. The canyons in the Ancho watershed are mainly dry with little alluvial and no known intermediate groundwater.

Area AB was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987, LANL 1988). The testing produced large inventories of radioactive and hazardous materials: isotopes of uranium and plutonium, lead, and beryllium; explosives such as TNT, RDX, and HMX; and barium nitrate. Some of this material remains in shafts on the mesa top. Further information about activities, SWMUs, and AOCs at TA-49 can be found in recent Laboratory reports (LANL 2010a, 2010b).

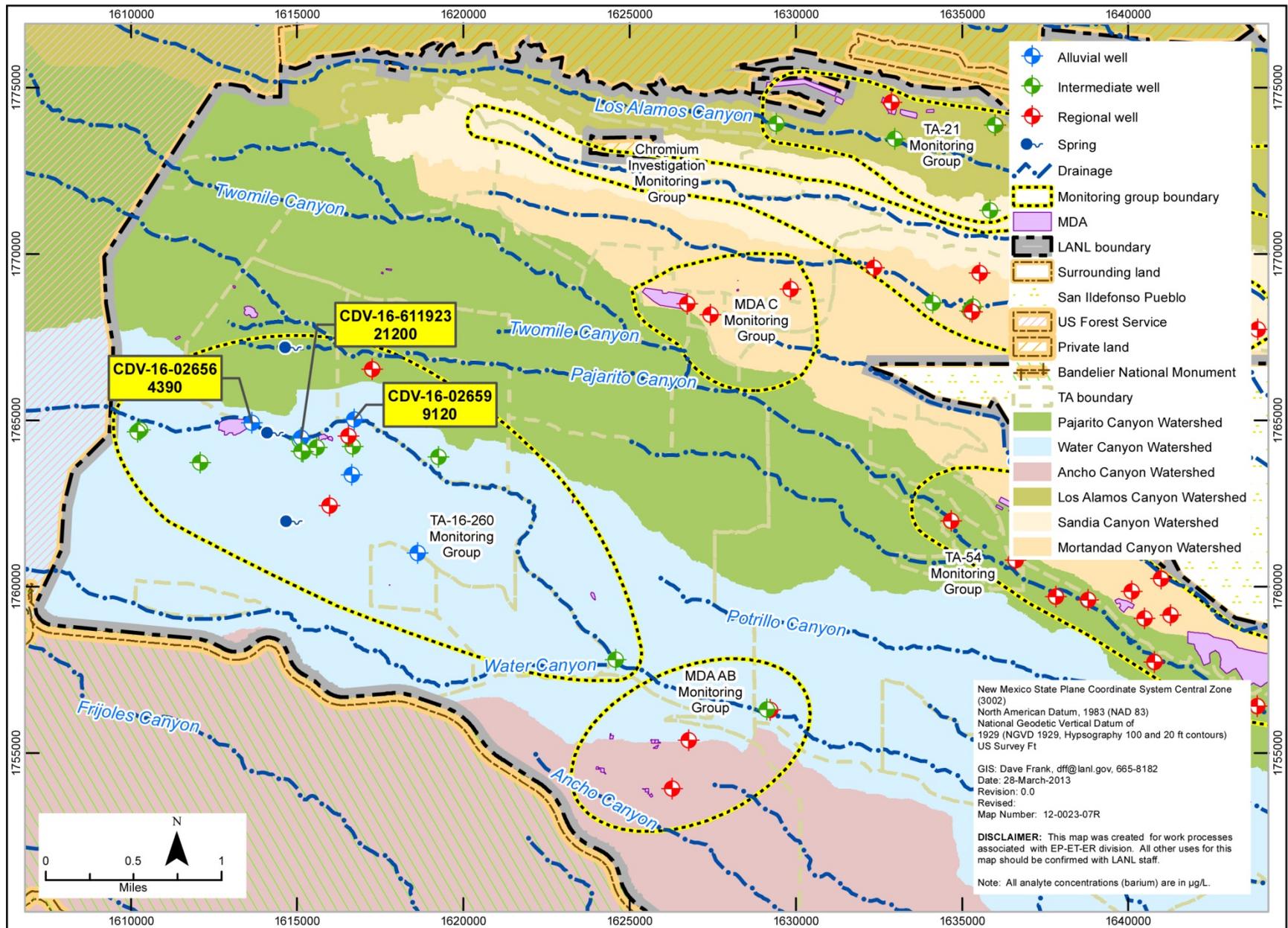


Figure 5-38 Wells with 2012 barium concentrations above the 1000-µg/L NM groundwater MDA standard. The maximum concentration for the year is shown in µg/L.

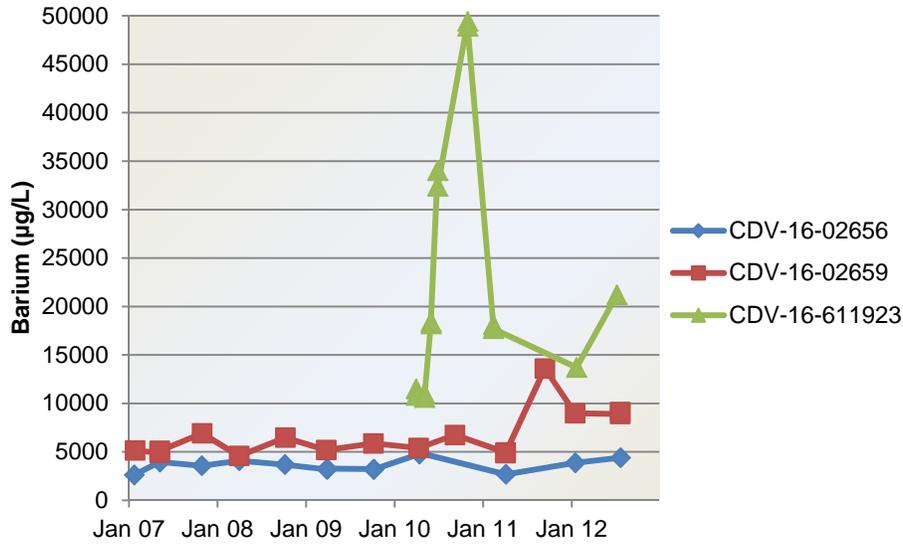


Figure 5-39 Barium in the TA-16 260 monitoring group in Cañon de Valle alluvial groundwater. The NM groundwater standard is 1000 µg/L.

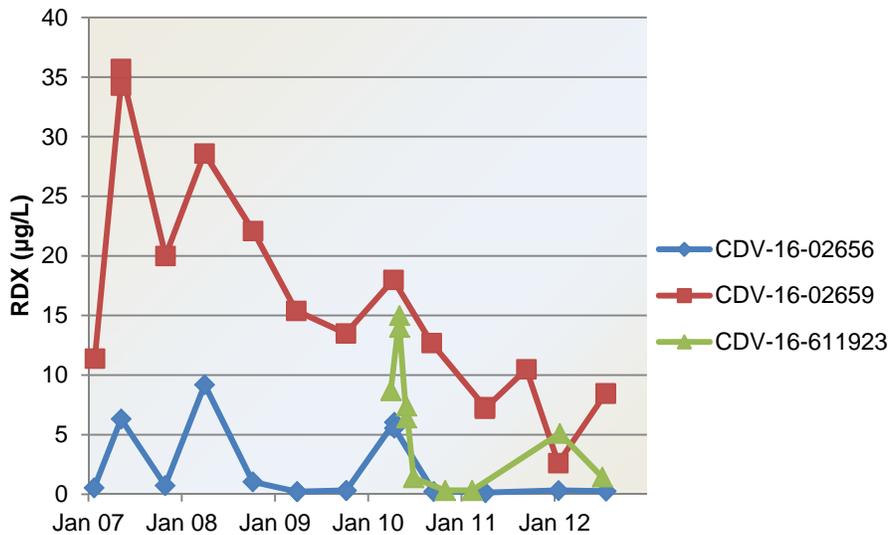


Figure 5-40 RDX in the TA-16 260 monitoring group in Cañon de Valle alluvial groundwater. The EPA tap water screening level is 6.1 µg/L.

No contaminants were found in MDA AB wells at concentrations near or above standards (Table 5-23).

Table 5-23
Summary of Groundwater Contamination in Ancho Canyon and the MDA AB Monitoring Group

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
MDA AB monitoring group (Water and Ancho Canyons)	Noneffluent sources and past effluent sources	Little or no alluvial groundwater	None	None

8. White Rock Canyon General Surveillance Monitoring

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 5-24). A few springs appear to represent discharge of intermediate-perched groundwater. The water discharging at other springs may be a mixture of regional aquifer groundwater, intermediate-perched groundwater, and percolation of recent precipitation (Longmire et al. 2007).

Table 5-24
Summary of Groundwater Contamination in White Rock Canyon Springs

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, arsenic, and uranium

The only radioactivity detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring (Table 5-25). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs.

Table 5-25
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)	10.6 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Total arsenic	Regional aquifer Spring 2 (Pueblo de San Ildefonso)	Up to 10.7 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 2012 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 0.896 µg/L. This spring also shows elevated nitrate (2.32 mg/L, below the 10-mg/L NM groundwater standard) and uranium (10.6 µg/L, below the 30-µg/L NM groundwater standard) values; it is not located near any apparent sources of contamination. Springs in the Spring 4 series had perchlorate values of 0.50 µg/L to 0.59 µg/L. Several springs have elevated arsenic, with Spring 2 showing the highest concentrations.

I. REFERENCES

- Del Signore 2011: Del Signore, J.C., "Radioactive Liquid Waste Treatment Facility Discharges in 2010," Los Alamos National Laboratory document LA-UR-11-1632 (2011).
- Del Signore 2012: Del Signore, J.C. "Radioactive Liquid Waste Treatment Facility Discharges in 2011," Los Alamos National Laboratory document LA-UR-12-21423 (2012).
- DOE 2005: "Investigation Report for Solid Waste Management Units 03-010(a) and 03-001(e) at Technical Area 3," U.S. Department of Energy report (August 2005).
- Emelity 1996: Emelity, L.A., "A History of Radioactive Liquid Waste Management at Los Alamos," Los Alamos National Laboratory document LA-UR-96-1283 (1996).
- Fetter 1993: Fetter, C.W., *Contaminant Hydrology* (Macmillan Publishing Co., New York, 1993), p. 334.

- LANL 1973: "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, Calendar Year 1972," Los Alamos National Laboratory document LA-5184 (March 1973).
- LANL 1981: "Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant (TA-45) and the Effluent Receiving Areas of Acid, Pueblo, and Los Alamos Canyons, Los Alamos, New Mexico, Final Report," Los Alamos National Laboratory document LA-8890-ENV, U.S. Department of Energy report DOE/EV-0005/30 (May 1981).
- LANL 1988: "Environmental Surveillance at Los Alamos during 1987," Los Alamos National Laboratory document LA-11306-MS (May 1988).
- LANL 1993a: "RFI Work Plan for Operable Unit 1157," Los Alamos National Laboratory document LA-UR-93-1230 (July 1993).
- LANL 1993b: "RFI Work Plan for Operable Unit 1082" Los Alamos National Laboratory document LA-UR-93-1196 (July 1993).
- LANL 1998: "Hydrogeologic Workplan," Los Alamos National Laboratory document LA-UR-01-6511, (May 1998).
- LANL 2004: "Los Alamos and Pueblo Canyons Investigation Report," Los Alamos National Laboratory document LA-UR-04-2714 (April 2004).
- LANL 2005a: "Los Alamos National Laboratory's Hydrogeologic Studies of the Pajarito Plateau: A Synthesis of Hydrogeologic Workplan Activities (1998–2004)," Los Alamos National Laboratory document LA-14263-MS (December 2005).
- LANL 2005b: "Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54," Los Alamos National Laboratory document LA-UR-05-6398 (September 2005).
- LANL 2006a: "Interim Measures Work Plan for Chromium Contamination in Groundwater," Los Alamos National Laboratory document LA-UR-06-1961 (March 2006).
- LANL 2006b: "Investigation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Revision 1," Los Alamos National Laboratory document LA-UR-06-1564 (March 2006).
- LANL 2007a: "Well Screen Analysis Report, Revision 2", Los Alamos National Laboratory document LA-UR-07-2852 (May 2007).
- LANL 2007b: "Addendum to the Investigation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54," Los Alamos National Laboratory document LA-UR-07-3214 (May 2007).
- LANL 2007c: "Corrective Measures Evaluation Report, Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-07-5426 (August 2007).
- LANL 2008a: "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1," Los Alamos National Laboratory document LA-UR-08-1105 (February 2008).
- LANL 2008b: "Fate and Transport Investigations Update for Chromium Contamination from Sandia Canyon," Los Alamos National Laboratory document LA-UR-08-4702 (July 2008).
- LANL 2008c: "Well R-20 Rehabilitation and Conversion Summary Report," Los Alamos National Laboratory document LA-UR-08-0056 (January 2008).

- LANL 2009a: "Investigation Report for Sandia Canyon," Los Alamos National Laboratory document LA-UR-09-6450, Los Alamos, New Mexico. (October 2009)
- LANL 2009b: "Pajarito Canyon Investigation Report, Revision 1," Los Alamos National Laboratory document LA-UR-09-4670 (August 2009).
- LANL 2009c: "Plugging and Abandonment Summary Report for Wells 03-B-09 and 03-B-10," Los Alamos National Laboratory document LA-UR-09-6791 (October 2009).
- LANL 2009d: "Environmental Surveillance at Los Alamos During 2008," Los Alamos National Laboratory document LA-14407-ENV (September 2009).
- LANL 2010a: "Investigation Report for Sites at Technical Area 49 Outside the Nuclear Environmental Site Boundary," Los Alamos National Laboratory document LA-UR-10-3095 (May 2010).
- LANL 2010b: "Investigation Report for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary," Los Alamos National Laboratory document LA-UR-10-3304 (May 2010).
- LANL 2011a: "2011 Interim Facility-Wide Groundwater Monitoring Plan," Los Alamos National Laboratory document LA-UR-11-2183 (August 2011).
- LANL 2011b: "2011 Interim Facility-Wide Groundwater Monitoring Plan, Revision 1," Los Alamos National Laboratory document LA-UR-11-6958 (December 2011).
- LANL 2011c: "Phase III Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50," Los Alamos National Laboratory document LA-UR-11-3429 (June 2011).
- LANL 2011d: "Corrective Measures Evaluation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Revision 2," Los Alamos National Laboratory document LA-UR-11-4798 (September 2011).
- LANL 2011e: "Corrective Measures Evaluation Report for Material Disposal Area H, Solid Waste Management Unit 54-004, at Technical Area 54, Revision 1," Los Alamos National Laboratory document LA-UR-11-5079 (September 2011).
- LANL 2011f: "Corrective Measures Evaluation Report for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, at Technical Area 54, Revision 3," Los Alamos National Laboratory document LA-UR-11-4910 (September 2011).
- LANL 2012a: "Interim Facility-Wide Groundwater Monitoring Plan for the 2013 Monitoring Year, October 2012–September 2013," Los Alamos National Laboratory document LA-UR-12-21331 (August 2012).
- LANL 2012b: "Technical Area 16 Well Network Evaluation and Recommendations," Los Alamos National Laboratory document LA-UR-12-1082 (March 2012).
- LANL 2012c: "Plugging and Abandonment Summary Report for Wells and Boreholes SHB-1, SHB-3, HB-4, TH-5, TH-6, Beta Hole, H-19, TA-21 Distillation Hole, TW-3, and USGS Test Hole," Los Alamos National Laboratory document LA-UR-12-1084 (March 2012).
- LANL 2012d: "Report for the Pilot Investigation of the Buckman Well Field Piezometers," Los Alamos National Laboratory document LA-UR-12-20640 (May 2012).
- LANL 2013a: "Summary Report for Redevelopment of Regional Well R-61," Los Alamos National Laboratory document LA-UR-13-20807 (March 2013).

- Longmire et al. 2007: Longmire, P., M. Dale, D. Counce, A. Manning, T. Larson, K. Granzow, R. Gray, and B. Newman, "Radiogenic and Stable Isotope and Hydrogeochemical Investigation of Groundwater, Pajarito Plateau and Surrounding Areas, New Mexico," Los Alamos National Laboratory document LA-14333 (July 2007).
- Plummer et al. 2006: Plummer, L.N., J.K. Bohlke, and M.W. Doughten, "Perchlorate in Pleistocene and Holocene Groundwater in North-Central New Mexico," *Environmental Science and Technology*, 40, 1757–1763 (2006).
- Purtymun and Stoker 1987: Purtymun, W.D., and A.K. Stoker, "Environmental Status of Technical Area 49, Los Alamos, New Mexico," Los Alamos National Laboratory document LA-11135-MS (November 1987).
- Purtymun et al. 1980: Purtymun, W.D., R.J. Peters, and J.W. Owens, "Geohydrology of White Rock Canyon from Otowi to Frijoles Canyon," Los Alamos Scientific Laboratory document LA-8635-MS (December 1980).
- Rogers 2001: Rogers, D.B., "Impact of Sr-90 on Surface Water and Groundwater at Los Alamos National Laboratory through 2000," Los Alamos National Laboratory document LA-13855-MS (December 2001).
- Teerlink 2007: Teerlink, J., "Why is there Uranium in Pine Rock Spring?" Los Alamos National Laboratory document LA-UR-07-5694 (August 2007).

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Los Alamos National Laboratory (LANL or the Laboratory) monitors the quality of surface water, including storm water, and canyon-bottom sediment to evaluate the potential effects associated with transport of legacy contaminants and ongoing Laboratory operations. The Laboratory collects and analyzes samples for a variety of constituents, including radionuclides and inorganic and organic chemicals. The sampling results for the spatial and temporal aspects of storm water and sediment data are compared with various screening criteria to determine if different mitigation actions are effective at protecting human health and the environment. The Laboratory’s work in watershed sampling supports the following three Environmental Grand Challenges—*protect water resource quality and reduce water use; eliminate industrial emissions, discharges, and releases into the environment; and protect human and environmental health by managing and restoring lands.*

A. INTRODUCTION

The Laboratory monitors the quality of surface water, including storm water, and canyon-bottom sediment to evaluate effects associated with transport of legacy contaminants and ongoing Laboratory operations. The Laboratory collects and analyzes samples for a variety of constituents, including radionuclides and inorganic and organic chemicals. In this chapter, spatial and temporal aspects of storm water and sediment data are evaluated. The sampling results are compared with various screening criteria based on protection of 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 channels, overbank-flow sediment deposition on floodplains, and other settings and is intended to evaluate changes in constituent concentrations at specific locations over time and potential changes in risk estimates for locations receiving floodwaters. Detailed evaluations of constituents in sediment across LANL have indicated that concentrations are within regulatory acceptable risks and dose limits (e.g., the Canyons Investigation Reports [IRs]: LANL 2004, 2005a, 2006, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b, 2011c). Ongoing monitoring is designed to confirm that constituent concentrations are not increasing because of changing conditions in the watersheds, including the 2011 Las Conchas Fire, and 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, 2011d, 2012a, 2013a).

Sediment and surface water monitoring and assessments at the Laboratory in 2012 occurred under several tasks. Sediment monitoring in 2012 occurred following the annual summer monsoon season, and this work is described in a sampling and analysis plan (LANL 2012b). 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 2012c). Control and monitoring of storm water discharges associated with solid waste management units (SWMUs) and areas of concern (AOCs) occurred under the Individual Permit (IP) with the U.S. Environmental Protection Agency (EPA). Sampling of storm water at gage stations occurred as part of LANL’s Environmental Surveillance Program. These data are presented in this chapter.

Not included in this chapter are data from the following programs for the following reasons: the Storm Water General Permit for Construction Activities is used to control storm water discharges from projects that impact 1 acre or greater that are cleared, graded, or excavated; storm water sampling to monitor industrial

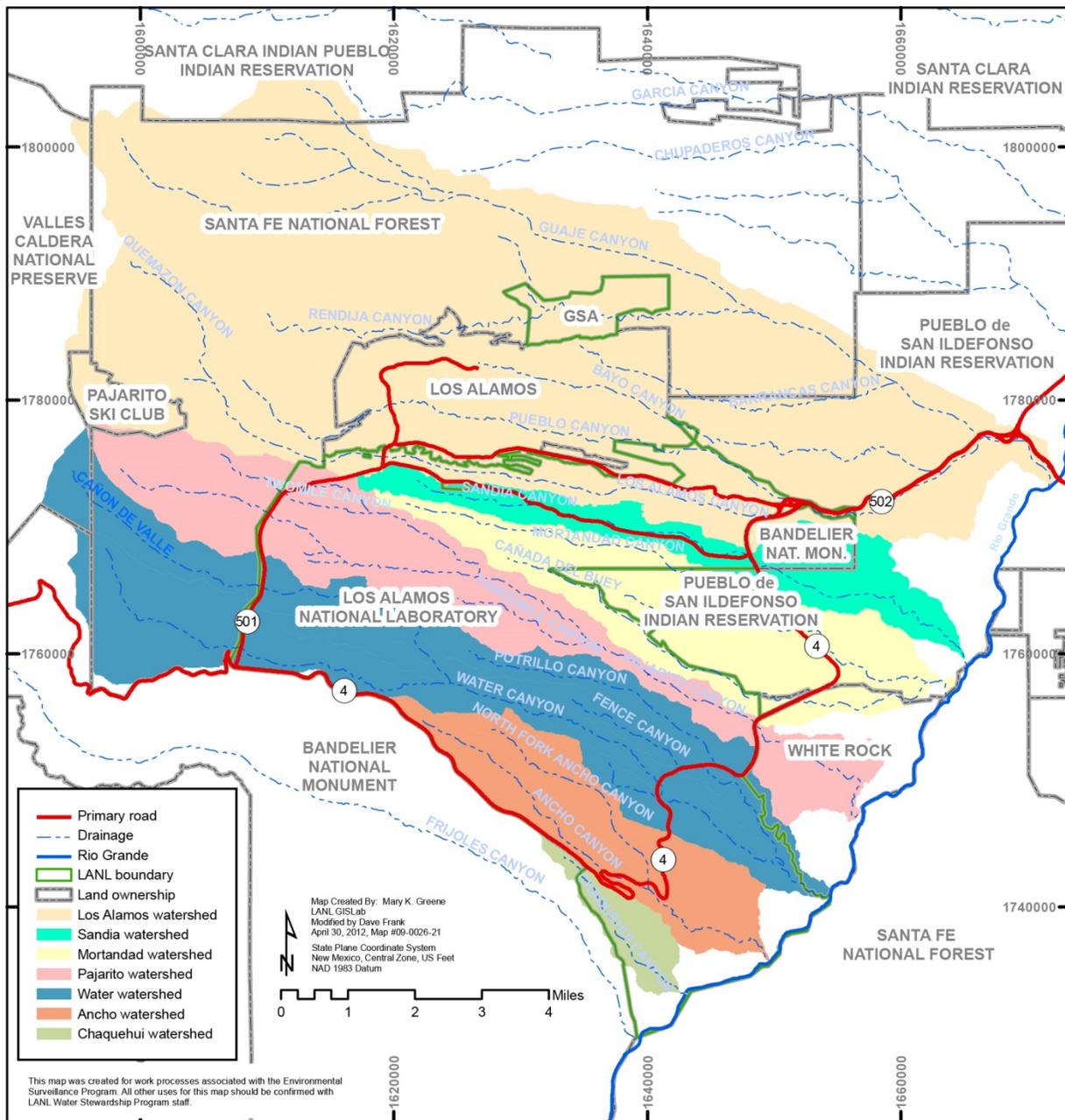
activities occurred under the Multi-Sector General Permit (MSGP) regulated by the EPA; and the annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2011e, 2012d) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels for an extensive list of constituents. In addition, 2012 sampling of storm water occurred in watersheds along the western boundary of LANL and in urban, developed landscapes in the Los Alamos townsite and on LANL property. The results were included in a report evaluating background and baseline concentrations of particular metals, weak acid dissociable cyanide, gross-alpha radioactivity, and radium isotopes (LANL 2013b).

B. HYDROLOGIC SETTING

Laboratory lands contain all or parts 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 in areas burned in the Las Conchas Fire. The remainder of the primary watersheds head on the Pajarito Plateau, in areas not burned by the Las Conchas Fire. Only the Ancho Canyon watershed is entirely located on Laboratory land.

In 2012, there was no snowmelt runoff that crossed the eastern boundary of the Laboratory; however, a total of 3.2 acre-feet (ac-ft) of runoff through E060.1 in Pueblo Canyon was effluent from the Los Alamos County Waste Water Treatment Plant. Continuous runoff was present at E060.1 for 11 days in January. Total storm water runoff at downstream gages in the canyons leaving the Laboratory is estimated at 47 ac-ft, approximately 90.3% of this occurring in Los Alamos Canyon, 8.9% in Water Canyon, and the remaining 0.8% in Pajarito Canyon.

Figure 6-2 shows the estimated storm water runoff volume at LANL for June through October from 2010 to 2012 and the seasonal precipitation from 1995 to 2012, indicating that the total storm water runoff of the 5-mo period in 2012 (47 ac-ft) was two times less than in 2011 (97 ac-ft), which corresponds to a significant decrease (42%) in 2012 precipitation from 2011. During 2012, increased runoff volumes and times to peak discharge because of the Las Conchas Fire effects were present but moderated because of the reduced precipitation. Figure 6-3 shows the 1995 to 2011 mean monthly total precipitation (snow water equivalent and monsoonal precipitation) across the Pajarito Plateau throughout the year and the 2012 mean monthly total precipitation. Aside from a small spring snowstorm in April, a few showers in May, and minimal snow in December, all of 2012 was drier than normal. Figure 6-4 shows the 1995 to 2011 monthly mean of the daily maximum and minimum temperatures across the Pajarito Plateau throughout the year and the monthly mean of the daily maximum and minimum temperatures during 2012. The 2012 temperatures were above normal with the exception of February, July, September, and December, which were normal.



GSA = General Services Administration.

Figure 6-1 Primary watersheds at LANL

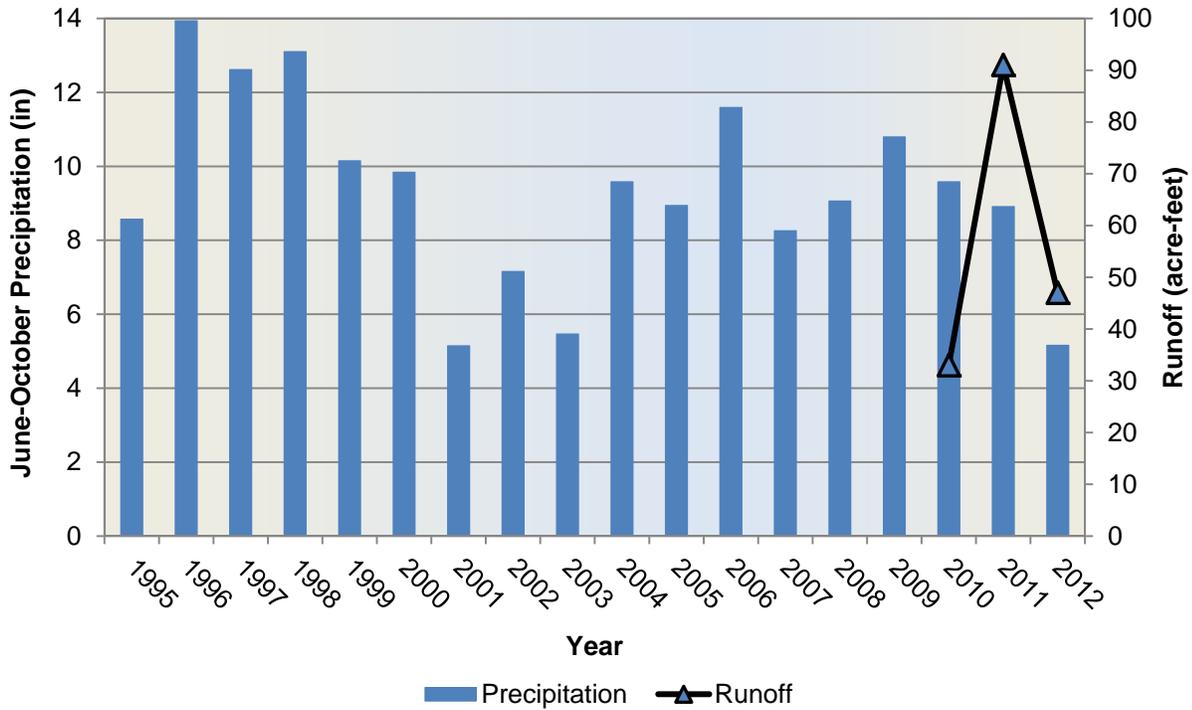


Figure 6-2 Estimated storm water runoff volume in LANL canyons from 2010 to 2012 and total June through October precipitation from 1995 to 2012 averaged across LANL’s meteorological tower network (TA-06, TA-49, TA-53, TA-54, and northern community)

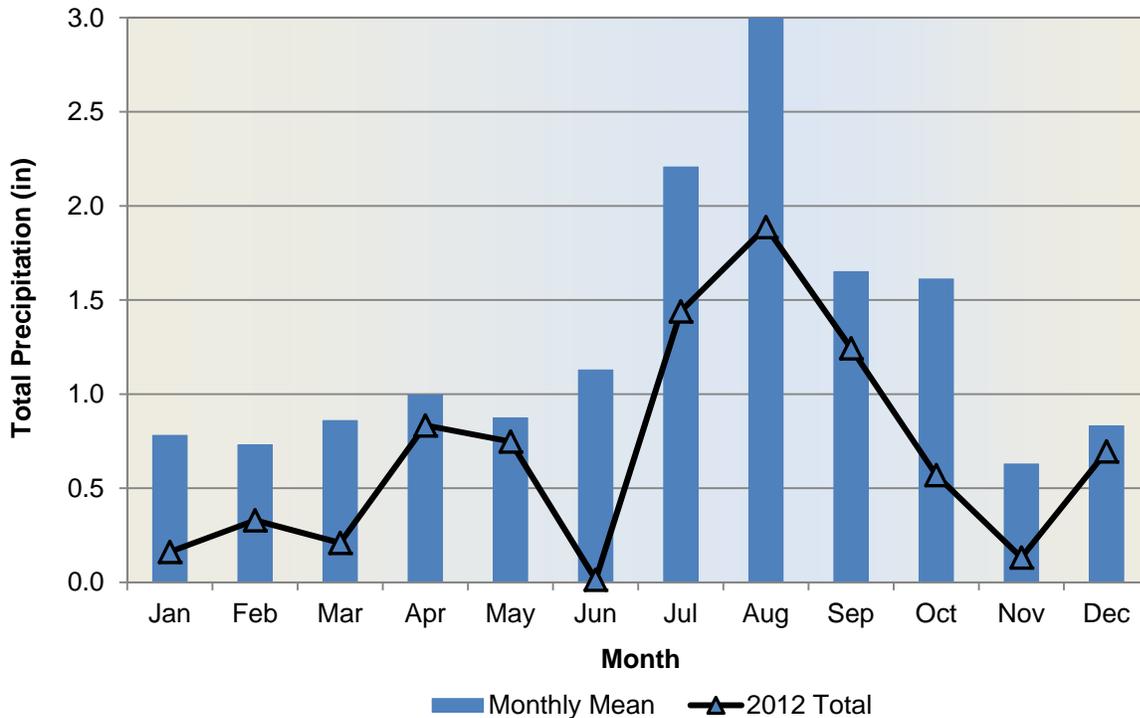


Figure 6-3 Mean of the monthly total precipitation from LANL’s meteorological tower network (TA-06, TA-49, TA-53, TA-54, and northern community) over the period of record 1995 to 2011 and the mean of the monthly total precipitation during 2012

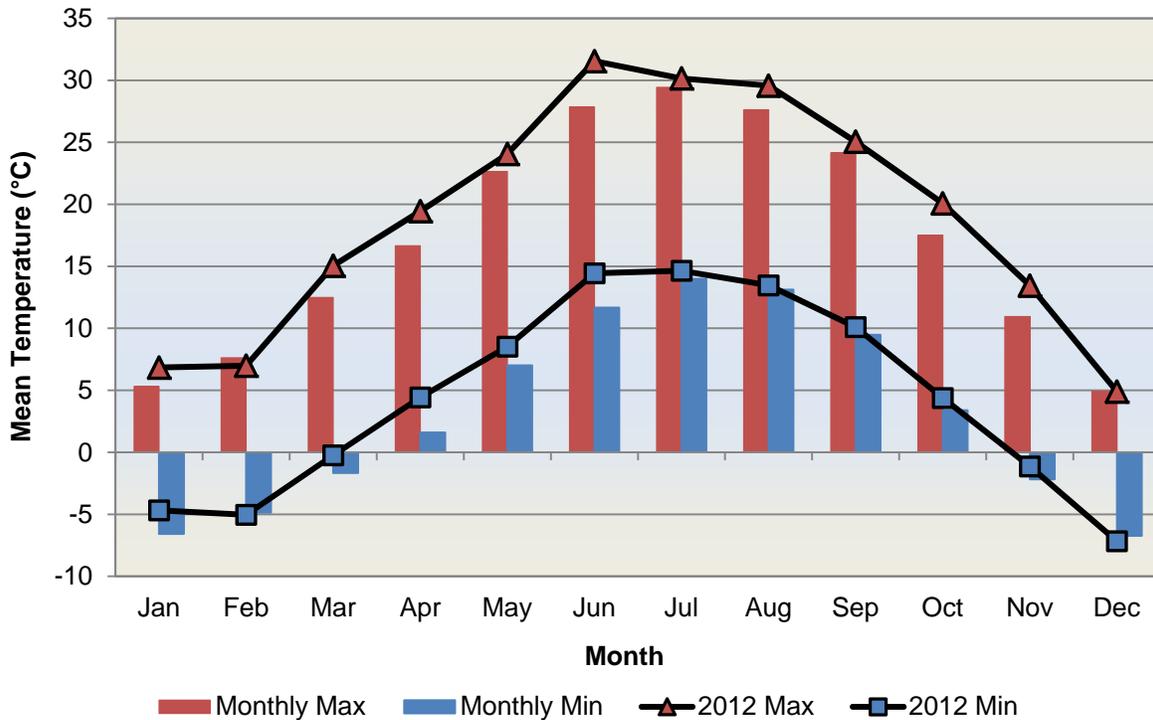


Figure 6-4 Monthly mean of the daily maximum and minimum temperatures averaged from LANL's meteorological tower network (TA-06, TA-49, TA-53, and TA-54) over the period of record 1995 to 2011 and the monthly mean of the daily maximum and minimum temperatures during 2012

The Laboratory has installed various sediment-control structures to minimize the erosive nature of storm water runoff and to enhance deposition of sediment (Figure 6-5). In Pueblo Canyon (LANL 2008a and 2008b), the central focus of the mitigations is to maintain a physically, hydrologically, and biologically functioning wetland that can reduce peak discharge and trap suspended sediment; thus, a grade-control structure was installed to prevent headcutting at the terminus of the wetland, a wing ditch was installed to reduce flood peaks and enhance channel/floodplain interaction before floods reach the wetland, and willows were planted to potentially promote the establishment of additional riparian or wetland vegetation that will also dampen flood peaks and slow floods resulting in sediment deposition. In DP Canyon, a grade-control structure was installed to stabilize and potentially bury the channel and adjacent floodplains where LANL-derived substances are entrained in floods originating from a portion of the Los Alamos townsite. In Los Alamos Canyon, a detention basin/low-head weir was built after the Cerro Grande Fire to trap ash, sediment, and debris in floods and has performed in the same manner after the Las Conchas Fire. Two detention basins were constructed below the SWMU 01-001(f) drainage to capture polychlorinated biphenyl- (PCB-) contaminated sediment in runoff into the canyon. In Mortandad Canyon, three sediment traps were constructed in 1976/1980 to trap sediment suspended in storm water. In Pajarito Canyon, a large flood-control structure was built after the Cerro Grande Fire to reduce the potential for large flood peaks impacting downcanyon facilities and has functioned in the same manner after the Las Conchas Fire. In lower Pajarito Canyon, the wetland reduces peak discharge and traps suspended sediment.

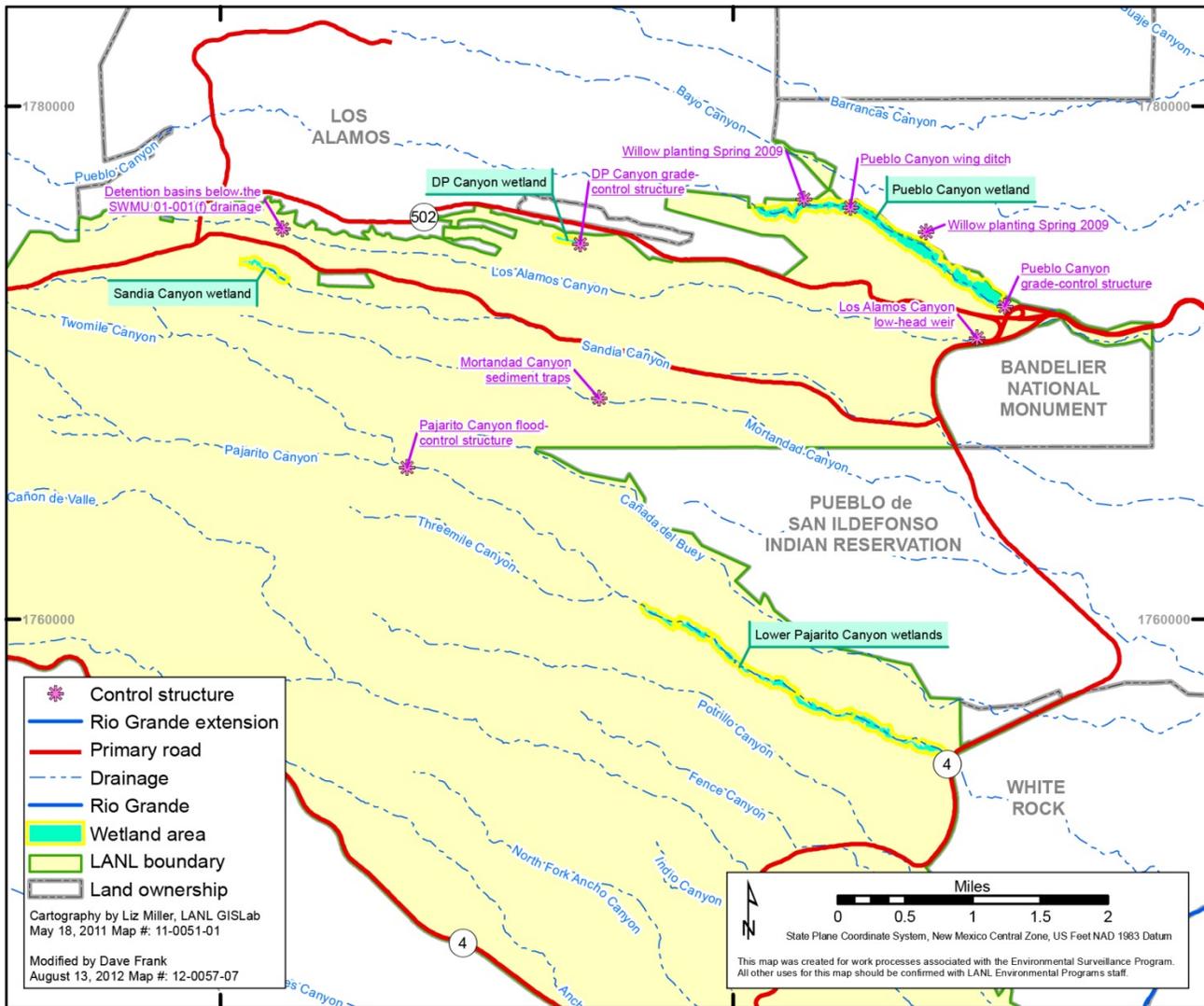


Figure 6-5 Sediment-control structures installed by LANL

C. SURFACE WATER AND SEDIMENT STANDARDS AND SCREENING LEVELS

The effects of disturbances, including drought, construction, fire, fire suppression, global atmospheric fallout and Laboratory operations, on watersheds are monitored using results of surface water and sediment sampling. Monitoring results are compared with published standards and screening levels applicable to LANL. 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 water quality standards for surface water for adjusted gross alpha radioactivity, radium-226, and radium-228		New Mexico Water Quality Control Commission (NMWQCC) (2013)	Based on the protection of livestock watering for adjusted gross-alpha, radium-226, and radium-228 radiation. NMWQCC standards are not specific about exposure frequency or duration, and single sample results are compared with numeric criteria. The adjusted gross-alpha standard excludes alpha radioactivity 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. At those locations, the standards are applied as screening levels in this report.
Surface water, nonradionuclides	New Mexico water quality standards for surface water		NMWQCC (2013)	Single sample results are compared with applicable segment-specific water quality standards. Standards for livestock watering, wildlife habitat, and acute (limited) and chronic (cold water) aquatic life criteria apply to all stream segments, excluding samples from 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. Standards for human health criteria, including PCBs, apply to all stream segments.
Surface water, radionuclides, and radioactivity		Biota Concentration Guides (BCGs)	DOE (2002, 2004) and McNaughton et al. (2008)	Surface water is generally present ephemerally 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 the 1 rad/day (10 milligray per day [mGy/day]) exposure limit for aquatic animals and 0.1 rad/day (1 mGy/day) for riparian or terrestrial animals.
Surface water, nonradionuclides, radionuclides, and radioactivity		Background	LANL (2012e, 2013b)	Sample results from Pajarito Plateau water sampling are compared with plateau-specific urban and Bandelier Tuff background levels for particular metals, weak acid dissociable cyanide, gross alpha, radium-226, radium-228, and total PCBs.
Sediment, radionuclides		BCGs	DOE (2002, 2004) and McNaughton et al. (2008)	Dose limit to biota is the same as for surface water. Results are compared with BCGs obtained from RESRAD-BIOTA 1.5.
Sediment, radionuclides		Background	Ryti et al. (1998) and McLin and Lyons (2002)	Results from samples from Pajarito Plateau sampling are compared with plateau-specific background values (natural background and fallout) 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, nonradionuclides		Background	Ryti et al. (1998)	Results for inorganic chemicals from Pajarito Plateau sampling are compared with plateau-specific background levels. There are no established background levels for organic chemicals on or off the Pajarito Plateau, and all detected organic chemicals are considered as contaminants.
Sediment, nonradionuclides		Soil screening levels (SSLs)	New Mexico Environment Department (NMED) (2012)	Results are compared with residential SSLs for particular metals, PCBs, HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine).
Sediment, radionuclides, and radioactivity		Screening action levels (SALs)	LANL (2009e)	Results are compared with residential SALs.

1. Surface Water

The NMWQCC establishes surface water standards for New Mexico in its Standards for Interstate and Intrastate Surface Waters, presented in 20.6.4 of the New Mexico Administrative Code (NMAC) (Figure 6-6, Table 6-2, and NMWQCC 2013). The current standards were approved by EPA on February 14, 2013, and can be found on NMED's website at <http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.pdf>. New Mexico water quality standards do not apply to surface waters on Native American lands, and in this report, these standards are used as screening levels for comparison with surface water data from Pueblo de San Ildefonso land. Surface water within the Laboratory is not a source of drinking, municipal, industrial, or irrigation water. As described below, under the NMWQCC standards, surface waters within the Laboratory are not considered a drinking water source for humans. 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).

Under the NMWQCC standards, all surface waters within LANL boundaries are assigned specified designated uses, ranging from coldwater aquatic life to limited aquatic life, livestock watering, wildlife habitat, and secondary contact. Perennial surface waters within LANL boundaries are assigned the designated uses under 20.6.4.126 NMAC. Intermittent and ephemeral portions of channels managed by DOE are assigned the designated uses under 20.6.4.128 NMAC. Portions of watersheds scheduled for land transfer from LANL to Los Alamos County and portions of streams off of LANL property are assigned designated uses under 20.6.4.97 and 20.6.4.98 NMAC.

Samples of storm water from Site Monitoring Areas (SMAs) associated with SWMUs and AOCs regulated under the IP (NM0030759) are compared with target action levels (TALs) contained in the IP to assess the effectiveness of storm water controls. Storm water samples collected from gage stations under the LANL Environmental Surveillance Program are compared with NMWQCC standards and established Pajarito Plateau background concentrations from "Polychlorinated Biphenyls in Precipitation and Stormwater within the Upper Rio Grande Watershed" (LANL2012e) and "Background Metals Concentrations and Radioactivity in Storm Water on the Pajarito Plateau, Northern New Mexico" (LANL 2013b). These comparisons, however, are for informational purposes only and are not indicative of regulatory compliance. Hardness-dependent aquatic life numeric criteria are calculated using water hardness values of the particular sample, where available, and 30 milligrams calcium carbonate per liter (mg CaCO₃/L) where hardness values of the particular sample are not available (EPA 2006, NMWQCC 2013). 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 water quality standards attainment for the State of New Mexico (NMED 2011).

2. Radionuclides in Surface Water

DOE Order 5400.5 (DOE 2003) 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 compared with BCGs to identify if radionuclides at a location pose a potential risk to biota. For water samples from in or near designated perennial stream segments, BCGs for aquatic or riparian animals are used for evaluation, and for samples from ephemeral or intermittent segments, BCGs for terrestrial animals are used.

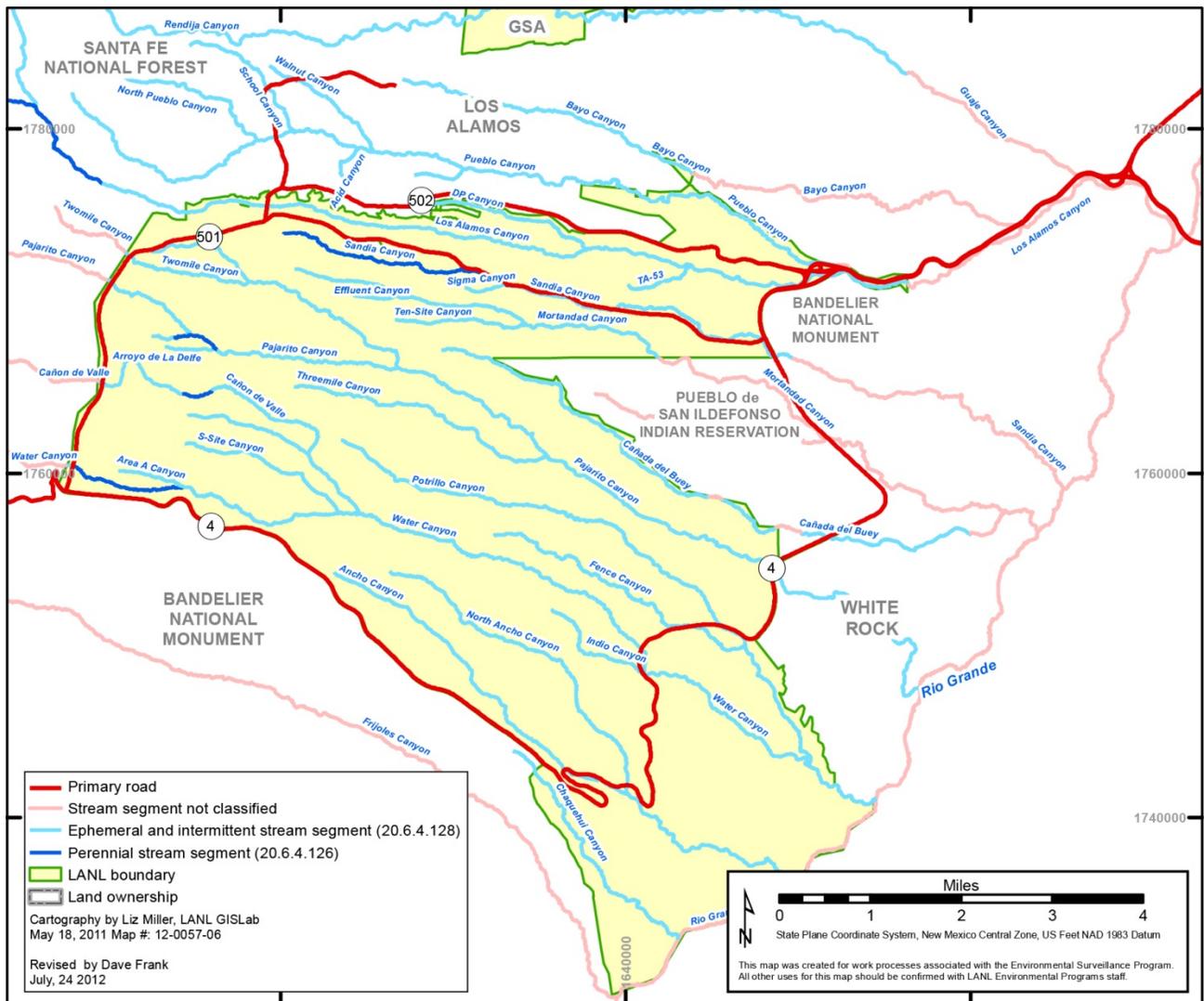


Figure 6-6 Major drainages within Laboratory land showing designated stream segments

Table 6-2
NMWQCC-Designated Uses for LANL Surface Waters

Stream Segment	Designated Uses	Description of Associated Users
<p>20.6.4.126 NMAC – “Perennial portions of Cañon de Valle from Los Alamos national laboratory (LANL) stream gage E256 upstream to Burning Ground spring, Sandia canyon from Sigma canyon upstream to LANL NPDES* outfall 001, Pajarito Canyon from Arroyo de La Delfe upstream into Starmers gulch and Starmers spring and Water canyon from Area-A canyon upstream to State Route 501.”</p> <p>Designated perennial segments on LANL property, including parts of Cañon de Valle, Pajarito, Water, and Sandia Canyons</p>	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact
	Coldwater aquatic life (i.e., chronic aquatic life standard)	Fish, aquatic invertebrates, etc.
<p>20.6.4.97 NMAC – “Ephemeral unclassified waters of the state as identified below [in NMWQCC (2013)] and additional ephemeral waters as identified on the department’s water quality standards website pursuant to Subsection C of 20.6.4.15 NMAC.”</p> <p>20.6.4.128 NMAC – “Ephemeral and intermittent portions of watercourses within lands managed by U.S. department of energy (DOE) within LANL, including but not limited to: Mortandad canyon, Cañada del Buey, Ancho canyon, Chaquehui canyon, Indio canyon, Fence canyon, Potrillo canyon and portions of Cañon de Valle, Los Alamos canyon, Sandia canyon, Pajarito canyon and Water canyon not specifically identified in 20.6.4.126 NMAC. (Surface waters within lands scheduled for transfer from DOE to tribal, state or local authorities are specifically excluded.)”</p> <p>Ephemeral and intermittent segments on LANL property and all of Pueblo Canyon</p>	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Limited aquatic life (i.e., acute aquatic life standard)	Aquatic invertebrates, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact
<p>20.6.4.98 NMAC – “All non-perennial unclassified waters of the state, except those ephemeral waters included under 20.6.4.97 NMAC.”</p> <p>Intermittent segments not on LANL property</p>	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Marginal warm water aquatic life	Limited ability for stream to sustain a natural aquatic life population on a continuous annual basis
	Primary contact	Recreational or other water use in which there is prolonged and intimate human contact with the water, such as swimming and water skiing, involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard. Primary contact also means any use of surface waters of the state for cultural, religious, or ceremonial purposes in which there is intimate human contact with the water, including but not limited to ingestion or immersion, that could pose a significant health hazard

*NPDES = National Pollutant Discharge Elimination System.

Surface water analytical results for gross-alpha radioactivity and radium isotopes 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. (Note: There are no livestock at the Laboratory except for a small number of trespassing cows grazing at low elevations near the west bank of the Rio Grande.) Concentrations of gross-alpha radioactivity and radium isotopes in storm water are also compared with established Pajarito Plateau background concentrations (LANL 2013b). NMWQCC standards and Pajarito Plateau background values (BV's) 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/screening level does not apply to source, special nuclear, or byproduct material regulated by DOE

under the Atomic Energy Act, and the gross-alpha radioactivity 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 global atmospheric fallout (Ryti et al. 1998, McDonald et al. 2003). 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). Background concentrations have been established for PCBs in precipitation and storm water within the upper Rio Grande watershed (LANL 2012e). There are no established background levels for other organic chemicals.

Organic and inorganic analytical results from sediment are compared with NMED's risk-based residential SSLs, and radionuclide analytical results from sediment are compared with LANL's risk-based residential SALs. SSLs for inorganic and organic chemicals and SALs for radionuclides are media-specific concentrations derived for residential exposures. If environmental concentrations of contaminants are below SALs or SSLs, then the potential for adverse human health effects is considered highly unlikely. Human health risk screening assessments for chemicals of potential concern are conducted using SSLs for residential scenarios obtained from NMED guidance (NMED 2012). Residential SALs are calculated using both adult and child receptors as described in LANL's Derivation and Use of Radionuclide Screening Action Levels, Revision 1 (LANL 2009e).

For protection of biota, concentrations of radionuclides in sediment are compared with the DOE BCGs (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2008). Dose limit to biota is the same as for surface water. For screening purposes, single sample results are compared with BCGs to identify if radionuclides at a location pose a potential risk to biota. For sediment samples from in or near designated perennial stream segments, BCGs for riparian animals are used for evaluation, and for samples from ephemeral or intermittent segments, BCGs for terrestrial animals are used.

D. SAMPLING LOCATIONS AND METHODS

Surface water and sediment are sampled in all major canyons that cross current or former LANL lands and are also sampled along some short tributary drainages. Canyon-bottom channel and floodplain sediment is sampled to evaluate the accumulation of LANL-derived substances (DOE 1991), to evaluate trends over time, and to monitor effects on the canyon systems from disturbances such as construction and the Las Conchas Fire. 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 sources of Laboratory-derived substances, such as at the downstream Laboratory boundary or NM 4. These samples include base-flow samples from particular locations where effluent discharges maintain stream flow and storm water samples collected using automated samplers.

Figure 6-7 shows surface water locations sampled in 2012 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/Pueblo Canyon watershed. These locations are mostly at stream gages but also include grab samples at sediment detention basins in upper Los Alamos Canyon and locations at a tributary to Pueblo Canyon in Graduation Canyon. Figure 6-8 shows locations of IP SMAs where storm water runoff samples were collected in 2012.

Figure 6-9 shows sediment locations sampled in 2012 as part of the Environmental Surveillance Program. The Laboratory collected sediment samples from stream channels and adjacent flood plains on the Pajarito Plateau to a depth of 0 to 19 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 channel were also sampled to variable depths in hand-dug holes.

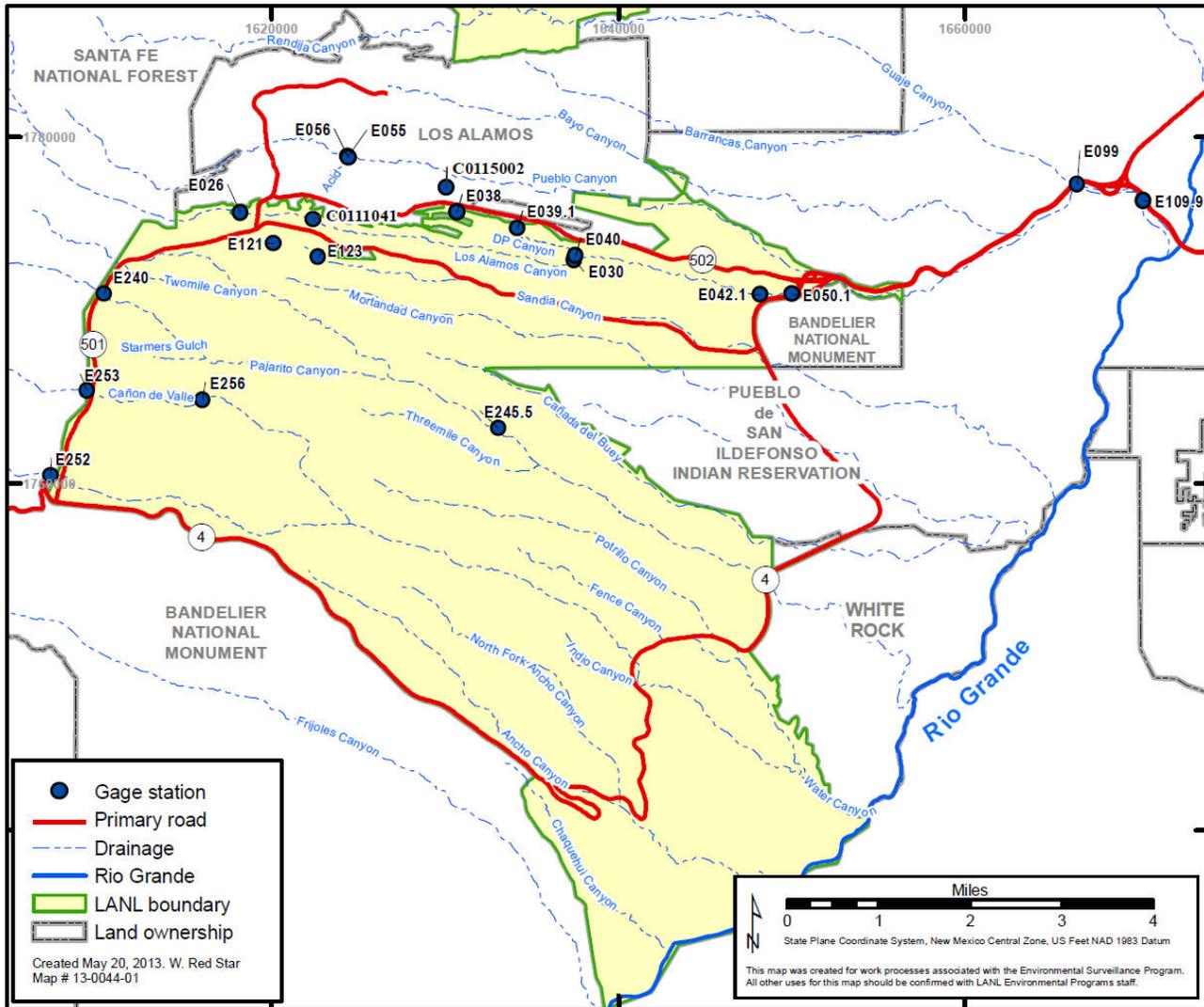


Figure 6-7 Surface water locations sampled in 2012 as part of the Environmental Surveillance Program and the Los Alamos and Pueblo Canyons monitoring plan (location CO111041 is run-on into the sediment detention basins in upper Los Alamos Canyon, and location CO115002 is in Graduation Canyon)

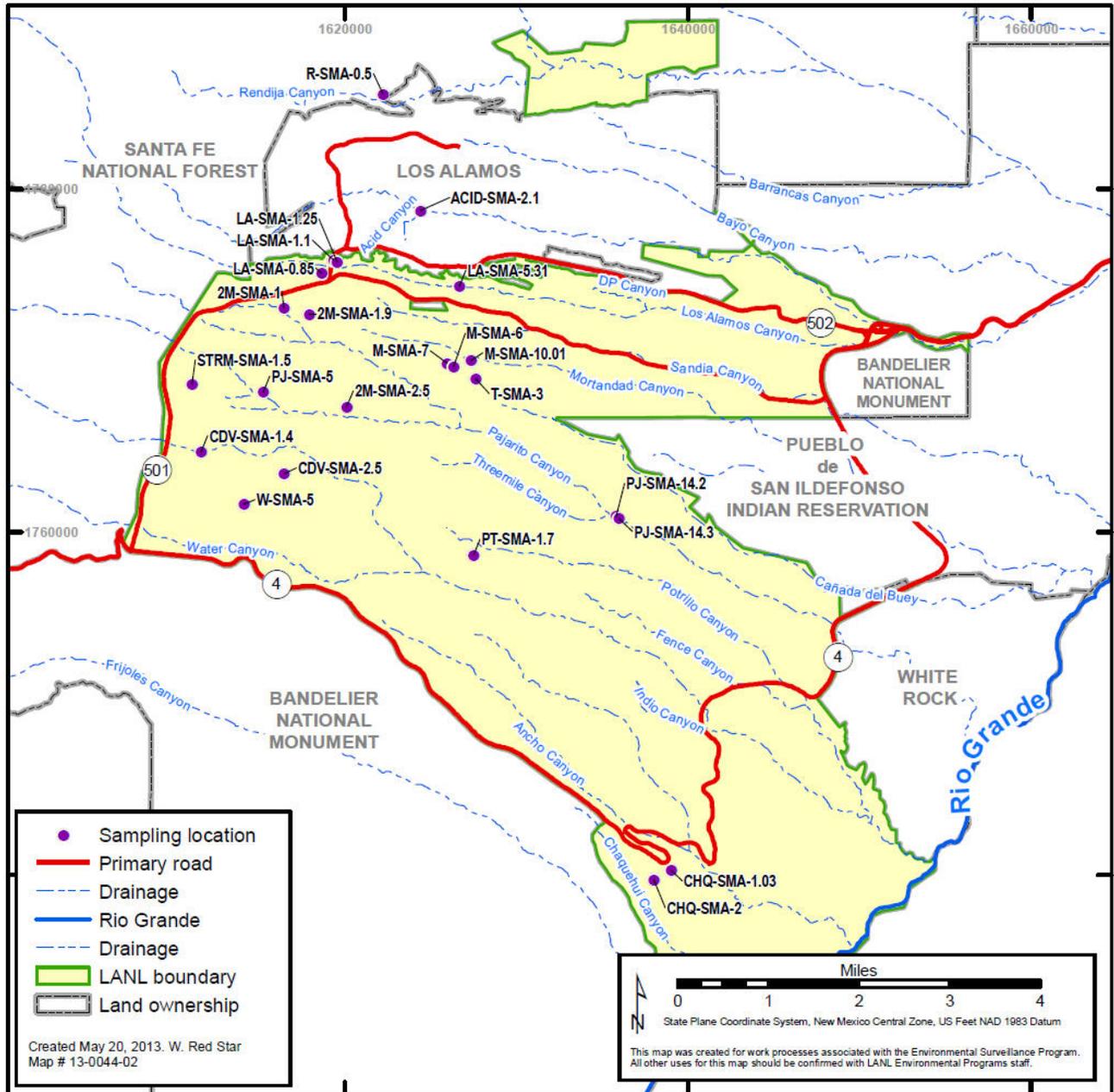
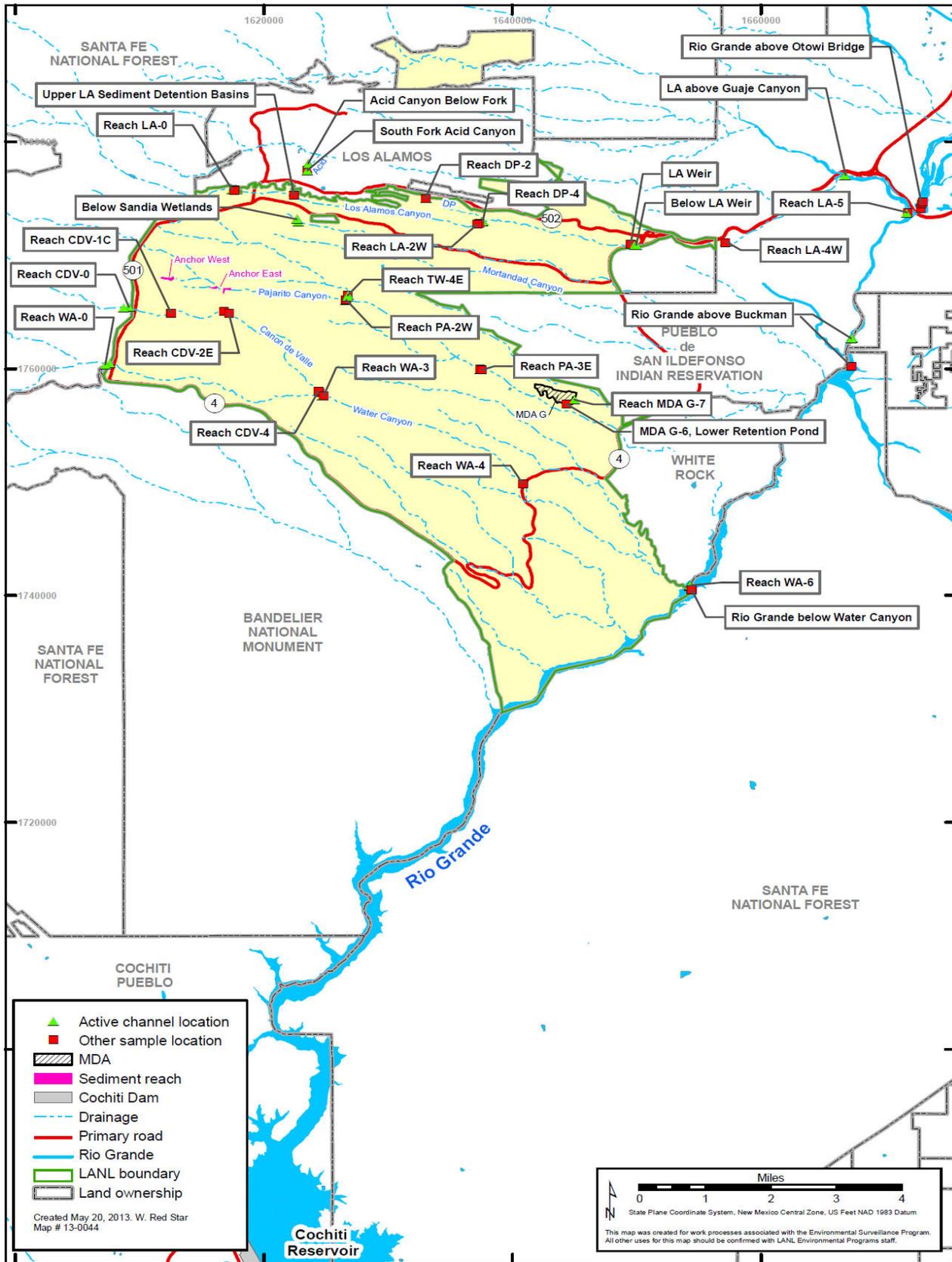


Figure 6-8 Surface water locations sampled in 2012 at IP SMAs



MDA = Material disposal area.

Figure 6-9 Sediment locations sampled in 2012 as part of the Environmental Surveillance Program

The procedures for surface water sampling depend on the type of stream flow and location. Grab samples of base flow 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 storm water runoff events. All automated samplers collect water from the peak of the runoff event to sample water near the leading edge of the hydrograph, also called the “first flush.” The year 2012 was the ninth year that the first flush of storm water was sampled at many stations, and it is a significant change from previous years (2003 and earlier) when samples were collected continuously over a two-hour period and composited. Higher suspended sediment concentrations (SSCs) tend to occur in the first flush compared with the average concentration over a runoff event because the SSC is generally greatest near the leading edge of the hydrograph (Malmon et al. 2004, 2007). As a result, these post-2003 storm water data are not directly comparable with data from previous years. Beginning in 2010, LANL also collected multiple storm water samples throughout individual runoff events to evaluate variations in suspended sediment and contaminant concentrations within the hydrograph. All storm water samples are filtered and preserved in LANL’s storm water processing facility. These samples are then shipped to commercial analytical laboratories without compositing or splitting.

E. SAMPLING RESULTS BY CONSTITUENTS

LANL releases to Pajarito Plateau watersheds were initiated in the first years of LANL operations when effluents containing radionuclides, metals, and organic chemicals were discharged to canyons. Treatment to reduce contaminants in effluents prior to discharge began in the 1950s and has continued to increase in intensity since that time. Effluent discharges at LANL have been permitted since 1978. Permitted outfalls have been reduced from 141 in 1993 to 11 permitted outfalls in 2012. LANL’s outfall reduction efforts are still underway. Storm water runoff from SWMUs and AOCs is managed under the IP. Storm water runoff from construction sites is managed under the construction general permit. Large watershed-scale and small drainage-scale approaches to control sediment are being implemented to reduce sediment transport.

During 2012, storm water runoff overtopped stream banks in Los Alamos, Pajarito, Sandia, and Water Canyon watersheds, resulting in new sediment deposits onto adjacent floodplains that were sampled. Storm water runoff in Ancho, Chaquehui, and Mortandad Canyon watersheds stayed within existing channels, did not deposit new sediment onto floodplains, thus sediment was not sampled. Tables 6-3 and 6-4 present summaries of results for radionuclides and inorganic/organic chemicals, respectively, in Pajarito Plateau sediment samples from 2012 as compared with the standards/screening levels discussed in Table 6-1. Tables 6-5 and 6-6 present summaries of results for radionuclides and inorganic/organic chemicals, respectively, in Pajarito Plateau storm water samples collected at gage stations in 2012 as compared with the standards/screening levels discussed in Table 6-1. All analytes above the standards/screening levels are discussed further in this report. Also discussed are the radionuclides americium-241, cesium-137, plutonium-238, plutonium-239/240, and strontium-90, which are associated with LANL activities and global atmospheric fallout. Uranium-234 and uranium-238 are included in the discussion as associated with LANL activities and regional background. Additionally, barium and the explosive compound RDX are discussed in Water Canyon in association with LANL activities and, for barium, the regional background.

Human health and ecological risk assessments have been performed as part of each of the Canyons IRs conducted under the Compliance Order on Consent (Consent Order). The human health risk assessments in those reports have concluded that concentrations of contaminants present in canyons media are within acceptable limits for applicable exposure scenarios. Sediment data presented in this report are used to verify the conceptual model that the scale of storm-water-related contaminant transport observed in LANL canyons generally results in lower concentrations of contaminants in the new sediment deposits than previously existed in deposits in a given reach. The results of the comparisons of sediment data collected in 2012 verify the conceptual model and support the premise that the risk assessments presented in the Canyons IRs represent an upper bound of potential risks in the canyons. Health effects from exposure to storm water are evaluated in Chapter 3, Dose Assessment.

Table 6-3
Summary of Results for Radionuclides in Pajarito Plateau Sediment Samples from 2012

Analyte	Sediment BV, SAL, or BCG ^a (pCi/g ^b)	Percentage of Samples with Detected Results above BV, SAL, or BCG	Number of Detected Results above BV, SAL, or BCG	Number of Samples Analyzed	Canyons with Detected Results above BV, SAL, or BCG	Notes
Americium-241	0.04 (BV)^c 30 (SAL) 4000 (BCG)	17% (BV) 0% (SAL) 0% (BCG)	12 (BV) 0 (SAL) 0 (BCG)	69	Acid, Los Alamos, MDA G-6 lower retention pond, MDA G-7	Maximum result (0.85 pCi/g) is from DP Canyon reach DP-4.
Cesium-137	0.9 (BV) 5.6 (SAL) 2000 (BCG)	13% (BV) 0% (SAL) 0% (BCG)	4 (BV) 0 (SAL) 0 (BCG)	30	Los Alamos	Maximum result (3.33 pCi/g) is from DP Canyon reach DP-4.
Plutonium-238	0.006 (BV) 37 (SAL)	10% (BV) 0% (SAL)	5 (BV) 0 (SAL)	50	Acid, Los Alamos, MDA G-7	Maximum result (0.0624 pCi/g) is from DP Canyon reach DP-4.
Plutonium-239/240	0.068 (BV) 33 (SAL) 6000 (BCG)	38% (BV) 0% (SAL) 0% (BCG)	19 (BV) 0 (SAL) 0 (BCG)	50	Acid, Los Alamos, Pajarito, Twomile, MDA G-6 lower retention pond, MDA G-7	Maximum result (12 pCi/g) is from south fork of Acid Canyon.
Potassium-40	36.8 (BV)	0% (BV)	0 (BV)	30	None	Maximum result (32 pCi/g) is from DP Canyon reach DP-4.
Strontium-90	1.04 (BV) 5.7 (SAL) 300 (BCG)	0% (BV) 0% (SAL) 0% (BCG)	0 (BV) 0 (SAL) 0 (BCG)	21	None	Maximum result (0.751 pCi/g) is from DP Canyon reach DP-4.
Uranium-234	2.59 (BV) 170 (SAL) 5000 (BCG)	0% (BV) 0% (SAL) 0% (BCG)	0 (BV) 0 (SAL) 0 (BCG)	12	None	Maximum result (1.34 pCi/g) is from MDA G-6 lower retention pond.
Uranium-235/236	0.2 (BV) 17 (SAL) 4000 (BCG)	0% (BV) 0% (SAL) 0% (BCG)	0 (BV) 0 (SAL) 0 (BCG)	41	None	Maximum result (0.0751 pCi/g) is from MDA G-7.
Uranium-238	2.29 (BV) 87 (SAL) 2000 (BCG)	0% (BV) 0% (SAL) 0% (BCG)	0 (BV) 0 (SAL) 0 (BCG)	12	None	Maximum result (1.32 pCi/g) is from MDA G-6 lower retention pond.

^a DOE BCG (terrestrial animal and site-adjusted for Cs-137 and Sr-90).

^b pCi/g = Picocuries per gram.

^c Bold text denotes samples with concentrations above the standard or screening level.

Table 6-4
Summary of Results for Inorganic and Organic Chemicals in Pajarito Plateau Sediment Samples from 2012

Analyte	Sediment BV or SSL (mg/kg ^a)	Percentage of Samples with Detected Results above BV or SSL	Number of Detected Results above BV or SSL	Number of Samples Analyzed	Canyons with Detected Results above BV or SSL	Notes
Aluminum	15,400 (BV) 78,000 (SSL)	0% (BV) 0% (SSL)	0 (BV) 0 (SSL)	61	None	Maximum result (13,200 mg/kg) is from Cañon de Valle reach CDV-4 in a sample containing ash.
Antimony	0.83 (BV) 31.3 (SSL)	0% (BV) 0% (SSL)	0 (BV) 0 (SSL)	61	None	Maximum result (0.688 mg/kg) is from MDA G-7.
Arsenic	3.98 (BV) 3.9 (SSL)	0% (BV) 0% (SSL)	0 (BV) 0 (SSL)	61	None	Maximum result (2.94 mg/kg) is from Cañon de Valle reach CDV-4 in a sample containing ash.
Barium	127 (BV)^d 15,600 (SSL)	56% (BV) 0% (SSL)	34 (BV) 0 (SSL)	61	Cañon de Valle, Los Alamos, Pajarito, Rio Grande, Sandia, Twomile, Water	Maximum result (844 mg/kg) is from Cañon de Valle reach CDV-2E.
Beryllium	1.31 (BV) 156 (SSL)	3% (BV) 0% (SSL)	2 (BV) 0 (SSL)	61	Los Alamos	Maximum result (1.85 mg/kg) is from Los Alamos Canyon low-head weir in a sample containing ash.
Cadmium	0.4 (BV) 70.3 (SSL)	21% (BV) 0% (SSL)	13 (BV) 0 (SSL)	61	Acid, Cañon de Valle, Pajarito, Sandia, Twomile	Maximum result (1.01 mg/kg) is from Sandia Canyon below the wetlands.
Calcium	4420 (BV)	43% (BV)	26 (BV)	61	Cañon de Valle, Los Alamos, Pajarito, Rio Grande, Twomile, Water	Maximum result (18,100 mg/kg) is from Rio Grande below Water Canyon.
Chromium	10.5 (BV) 117,000 (SSL)	8% (BV) 0% (SSL)	5 (BV) 0 (SSL)	61	Los Alamos, Pajarito, Sandia, Water	Maximum result (568 mg/kg) is from Sandia Canyon below the wetlands. SSL is for trivalent chromium.
Cobalt	4.73 (BV)	25% (BV)	15 (BV)	61	Cañon de Valle, Los Alamos, Pajarito, Twomile, Water	Maximum result (7.05 mg/kg) is from Cañon de Valle reach CDV-4 in a sample containing ash.
Copper	11.2 (BV) 3130 (SSL)	31% (BV) 0% (SSL)	19 (BV) 0 (SSL)	61	Acid, Cañon de Valle, Los Alamos, Pajarito, Sandia, Twomile, Water	Maximum result (42.8 mg/kg) is from Sandia Canyon below the wetlands.
Iron	13,800 (BV) 54,800 (SSL)	7% (BV) 0% (SSL)	4 (BV) 0 (SSL)	61	Cañon de Valle, Pajarito, Water	Maximum result (15,200 mg/kg) is from Water Canyon reach WA-6.
Lead	19.7 (BV) 400 (SSL)	26% (BV) 0% (SSL)	16 (BV) 0 (SSL)	61	Acid, Cañon de Valle, Los Alamos, Pajarito, Sandia, Twomile, Water	Maximum result (43.3 mg/kg) is from south fork of Acid Canyon.
Magnesium	2370 (BV)	8% (BV)	5 (BV)	61	Cañon de Valle, Rio Grande, Water	Maximum result (3570 mg/kg) is from Water Canyon reach WA-6.
Manganese	543 (BV) 1860 (SSL)	41% (BV) 0% (SSL)	25 (BV) 0 (SSL)	61	Cañon de Valle, Los Alamos, Pajarito, Sandia, Twomile, Water	Maximum result (1440 mg/kg) is from Twomile Canyon reach TW-4E in a sample containing ash.
Mercury	0.1 (BV) 23.5 (SSL)	3% (BV) 0% (SSL)	2 (BV) 0 (SSL)	61	Los Alamos, Sandia	Maximum result (0.416 mg/kg) is from Sandia Canyon below the wetlands. SSL is for mercury salts.

Table 6-4 (continued)

Analyte	Sediment BV or SSL (mg/kg ^a)	Percentage of Samples with Detected Results above BV or SSL	Number of Detected Results above BV or SSL	Number of Samples Analyzed	Canyons with Detected Results above BV or SSL	Notes
Nickel	9.38 (BV) 1560 (SSL)	13% (BV) 0% (SSL)	8 (BV) 0 (SSL)	61	Cañon de Valle, Los Alamos, Water	Maximum result (88.8 mg/kg) is from Cañon de Valle reach CDV-1C.
Potassium	2690 (BV)	0% (BV)	0 (BV)	61	None	Maximum result (2460 mg/kg) is from Pajarito Canyon reach PA-3E in a sample containing ash.
Selenium	0.3 (BV) 391 (SSL)	10% (BV) 0% (SSL)	6 (BV) 0 (SSL)	61	Cañon de Valle, Los Alamos, Sandia, Twomile	Maximum result (0.579 mg/kg) is from Cañon de Valle reach CDV-4 in a sample containing ash.
Silver	1 (BV) 391 (SSL)	28% (BV) 0% (SSL)	17 (BV) 0 (SSL)	61	Cañon de Valle, Pajarito, Sandia, Water, MDA G-6 lower retention pond	Maximum result (63.9 mg/kg) is from Cañon de Valle reach CDV-1C.
Sodium	1470 (BV)	0% (BV)	0 (BV)	61	None	Maximum result (717 mg/kg) is from DP Canyon reach DP-2.
Thallium	0.73 (BV) 0.782 (SSL)	0% (BV) 0% (SSL)	0 (BV) 0 (SSL)	61	None	Maximum result (0.456 mg/kg) is from Los Alamos Canyon low-head weir in a sample containing ash.
Vanadium	19.7 (BV) 391 (SSL)	16% (BV) 0% (SSL)	10 (BV) 0 (SSL)	61	Cañon de Valle, Pajarito, Rio Grande, Twomile, Water	Maximum result (30.4 mg/kg) is from Water Canyon reach WA-6.
Zinc	60.2 (BV) 23,500 (SSL)	21% (BV) 0% (SSL)	13 (BV) 0 (SSL)	61	Acid, Cañon de Valle, Los Alamos, Pajarito, Sandia, Twomile, MDA G-6 lower retention pond, MDA G-7	Maximum result (169 mg/kg) is from Sandia Canyon below the wetlands.
HMX	3910 (SSL)	0% (SSL)	0 (SSL)	30	None	Maximum result (2.92 mg/kg) is from Cañon de Valle reach CDV-4.
RDX	58.2 (SSL)	0% (SSL)	0 (SSL)	30	None	Maximum result (2.18 mg/kg) is from Cañon de Valle reach CDV-4.
PCB-105	1.14 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.0314 mg/kg) is from upper Los Alamos Canyon sediment detention basins.
PCB-114	1.14 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.000685 mg/kg) is from upper Los Alamos Canyon sediment detention basins.
PCB-118	1.14 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.0804 mg/kg) is from upper Los Alamos Canyon sediment detention basins.
PCB-123	1.14 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.00064 mg/kg) is from upper Los Alamos Canyon sediment detention basins.
PCB-126	0.000341 (SSL)	2% (SSL)	1 (SSL)	62	Los Alamos	Maximum result (0.000962 mg/kg) is from upper Los Alamos Canyon sediment detention basins.
PCB-167	1.14 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.00451 mg/kg) is from upper Los Alamos Canyon sediment detention basins.

Table 6-4 (continued)

Analyte	Sediment BV or SSL (mg/kg ^a)	Percentage of Samples with Detected Results above BV or SSL	Number of Detected Results above BV or SSL	Number of Samples Analyzed	Canyons with Detected Results above BV or SSL	Notes
PCB-170	0.341 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.0308 mg/kg) is from Sandia Canyon below the wetlands.
PCB-189	1.14 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.00114 mg/kg) is from Sandia Canyon below the wetlands.
PCB-77	0.341 (SSL)	0% (SSL)	0 (SSL)	62	None	Maximum result (0.00126 mg/kg) is from upper Los Alamos Canyon sediment detention basins.

^a mg/kg = Milligrams per kilogram.

^b Bold text denotes samples with concentrations above the standard or screening level.

Table 6-5
Summary of Results for Radionuclides in Pajarito Plateau Storm Water Samples Collected at Gage Stations from 2012

Analyte	Standard or Screening Level ^a (pCi/L ^b)	Percentage of Samples with Detected Results above Standard or Screening Level	Number of Detected Results above Standard or Screening Level	Number of Samples Analyzed	Canyons with Detected Results above Standard or Screening Level	Notes
Gross-alpha radioactivity	15 (LW)^c 1490 (BT-BV) 32.5 (UA-BV)	100% (LW) 0% (BT-BV) 100% (UA-BV)	2 (LW) 0 (BT-BV) 2 (UA-BV)	2	Los Alamos	Maximum result (1260 pCi/L) is from Los Alamos Canyon above Rio Grande at E109.9.
Americium-241	400 (aBCG) 200,000 (tBCG) 438 (laBCG) 1460 (lrBCG) 202,000 (ltBCG)	0% (aBCG) 0% (tBCG) 0% (laBCG) 0% (lrBCG) 0% (ltBCG)	0 (aBCG) 0 (tBCG) 0 (laBCG) 0 (lrBCG) 0 (ltBCG)	42	None	Maximum result (30.6 pCi/L) is from Los Alamos Canyon above low-head weir at E042.1.
Cesium-137	40 (aBCG) 20,000 (sBCG) 600,000 (tBCG)	11% (aBCG) 0% (sBCG) 0% (tBCG)	4 (aBCG) 0 (sBCG) 0 (tBCG)	38	Los Alamos, Pajarito	Maximum result (259 pCi/L) is from Los Alamos Canyon above Rio Grande at E109.9.
Plutonium-238	200 (aBCG) 200,000 (tBCG) 176 (laBCG) 551 (lrBCG) 189,000 (ltBCG)	0% (aBCG) 0% (tBCG) 0% (laBCG) 0% (lrBCG) 0% (ltBCG)	0 (aBCG) 0 (tBCG) 0 (laBCG) 0 (lrBCG) 0 (ltBCG)	59	None	Maximum result (2.41 pCi/L) is from Los Alamos Canyon above Rio Grande at E109.9.
Plutonium-239/240	200 (aBCG) 200,000 (tBCG) 187 (laBCG) 622 (lrBCG) 201,000 (ltBCG)	0% (aBCG) 0% (tBCG) 0% (laBCG) 0% (lrBCG) 0% (ltBCG)	0 (aBCG) 0 (tBCG) 0 (laBCG) 0 (lrBCG) 0 (ltBCG)	59	None	Maximum result (93.5 pCi/L) is from Los Alamos Canyon above low-head weir at E042.1.
Radium-226 + Radium-228	30 (LW) 52.7 (BT-BV)	100% (LW) 100% (BT-BV)	1 (LW) 1 (BT-BV)	1	Los Alamos	Maximum result (122 pCi/L) is from Los Alamos Canyon above Rio Grande at E109.9.
Strontium-90	300 (aBCG) 30,000 (sBCG) 50,000 (tBCG)	0% (aBCG) 0% (sBCG) 0% (tBCG)	0 (aBCG) 0 (sBCG) 0 (tBCG)	24	None	Maximum result (73.6 pCi/L) is from Los Alamos Canyon above low-head weir at E042.1.

Table 6-5 (continued)

Analyte	Standard or Screening Level ^a (pCi/L ^b)	Percentage of Samples with Detected Results above Standard or Screening Level	Number of Detected Results above Standard or Screening Level	Number of Samples Analyzed	Canyon with Detected Results above Standard or Screening Level	Notes
Uranium-234	200 (aBCG) 400,000 (tBCG)	20% (aBCG) 0% (tBCG)	9 (aBCG) 0 (tBCG)	46	Guaje, Los Alamos	Maximum result (365 pCi/L) is from Los Alamos Canyon above Rio Grande at E109.9.
	202 (laBCG) 684 (lrBCG)	20% (laBCG) 0% (lrBCG)	9 (laBCG) 0 (lrBCG)			
	405,000 (ltBCG)	0% (ltBCG)	0 (ltBCG)			
Uranium-235/236	200 (aBCG) 400,000 (tBCG)	0% (aBCG) 0% (tBCG)	0 (aBCG) 0 (tBCG)	46	None	Maximum result (22.9 pCi/L) is from Los Alamos Canyon below Ice Rink at E026.
	218 (laBCG)	0% (laBCG)	0 (laBCG)			
	737 (lrBCG)	0% (lrBCG)	0 (lrBCG)			
	420,000 (ltBCG)	0% (ltBCG)	0 (ltBCG)			
Uranium-238	200 (aBCG) 400,000 (tBCG)	17% (aBCG) 0% (tBCG)	8 (aBCG) 0 (tBCG)	46	Guaje, Los Alamos	Maximum result (345 pCi/L) is from Los Alamos Canyon above Rio Grande at E109.9.
	224 (laBCG) 757 (lrBCG)	15% (laBCG) 0% (lrBCG)	7 (laBCG) 0 (lrBCG)			
	406,000 (ltBCG)	0% (ltBCG)	0 (ltBCG)			

^a LW = Livestock watering standard; BT-BV = Bandelier Tuff background value; UA-BV = urban area background value; aBCG = DOE BCG for aquatic animals; sBCG = LANL site-adjusted (McNaughton et al. 2008) BCG; tBCG = DOE BCG for terrestrial animals; laBCG = LANL BCG for aquatic animals; lrBCG = LANL BCG for riparian animals; ltBCG = LANL BCG for terrestrial animals.

^b pCi/L = Picocuries per liter.

^c Bold text denotes samples with concentrations above the standard or screening level.

Table 6-6
Summary of Results for Inorganic and Organic Chemicals in Pajarito Plateau Storm Water Samples Collected at Gage Stations from 2012

Analyte	Sample Preparation	Standard or Screening Level ^a (µg/L ^b)	Percentage of Samples with Detected Results above Standard or Screening Level	Number of Detected Results above Standard or Screening Level	Number of Samples Analyzed	Canyons with Detected Results above Standard or Screening Level	Notes
Aluminum ^c	Filtered	5000 (IRR)	0% (IRR)	0 (IRR)	44	Cañon de Valle, DP, Guaje, Los Alamos, Pajarito, Sandia, Water	Maximum result (1390 µg/L) is from Guaje Canyon at NM 502 at E099.
		471 to 10,100 (AA)^d	10%^d (AA)	4^e (AA)	39^e		
		161 to 4030 (CA)	40%^d (CA)	2^e (CA)	5^e		
		2241 (BT-BV)	0% (BT-BV)	0 (BT-BV)	44		
		245 (UA-BV)	68% (UA-BV)	30 (UA-BV)	44		
Antimony	Filtered	640 (HH)	0% (HH)	0 (HH)	44	None	Maximum result (4.21 µg/L) is from upper Los Alamos Canyon sediment detention basin run-on.
		9.25 (UA-BV)	0% (UA-BV)	0 (UA-BV)	44		
Arsenic	Filtered	100 (IRR)	0% (IRR)	0 (IRR)	44	Guaje, Los Alamos, Pajarito	Maximum result (6.14 µg/L) is from Pajarito Canyon above Threemile Canyon at E245.5.
		200 (LW)	0% (LW)	0 (LW)	44		
		340 (AA)	0% (AA)	0 (AA)	39		
		150 (CA)	0% (CA)	0 (CA)	5		
		9 (HH)	0% (HH)	0 (HH)	44		
		2.55 (UA-BV)	25% (UA-BV)	11 (UA-BV)	44		
Barium	Filtered	Not available	n/a [†]	n/a	42	n/a	Maximum result (1840 µg/L) is from Los Alamos Canyon above low-head weir at E042.1.
Beryllium	Filtered	Not available	n/a	n/a	37	n/a	Maximum result (0.202 µg/L) is from Guaje Canyon at NM 502 at E099.
Boron	Filtered	750 (IRR)	0% (IRR)	0 (IRR)	44	Cañon de Valle, Guaje Los Alamos, Pajarito	Maximum result (592 µg/L) is from Los Alamos Canyon above low-head weir at E042.1.
		5000 (LW)	0% (LW)	0 (LW)	44		
		47.3 (UA-BV)	23% (UA-BV)	10 (UA-BV)	44		
Cadmium ^c	Filtered	10 (IRR)	0% (IRR)	0 (IRR)	44	None	Maximum result (0.139 µg/L) is from Cañon de Valle above NM 501 at E253.
		50 (LW)	0% (LW)	0 (LW)	44		
		0.48 to 5.38 (AA)	0% (AA)	0 (AA)	39		
		0.19 (CA)	0% (CA)	0 (CA)	5		
		0.36 (UA-BV)	0% (UA-BV)	0 (UA-BV)	44		
Chromium	Filtered	100 (IRR)	0% (IRR)	0 (IRR)	44	Sandia	Maximum result (5.16 µg/L) is from Sandia Canyon right fork at Power Plant at E121.
		1000 (LW)	0% (LW)	0 (LW)	44		
		4.07 (UA-BV)	2% (UA-BV)	1 (UA-BV)	44		

Table 6-6 (continued)

Analyte	Sample Preparation	Standard or Screening Level ^a (µg/L ^b)	Percentage of Samples with Detected Results above Standard or Screening Level	Number of Detected Results above Standard or Screening Level	Number of Samples Analyzed	Canyons with Detected Results above Standard or Screening Level	Notes
Cobalt	Filtered	50 (IRR)	2% (IRR)	1 (IRR)	44	Los Alamos, Sandia	Maximum result (81.3 µg/L) is from Los Alamos Canyon above low-head weir at E042.1.
		1000 (LW)	0% (LW)	0 (LW)	44		
		7.53 (BT-BV)	11% (BT-BV)	5 (BT-BV)	44		
		9.2 (UA-BV)	11% (UA-BV)	5 (UA-BV)	44		
Copper ^c	Filtered	200 (IRR)	0% (IRR)	0 (IRR)	44	Acid, DP, Los Alamos, Pajarito, Sandia	Maximum result (20.4 µg/L) is from Sandia Canyon right fork at Power Plant at E121.
		500 (LW)	0% (LW)	0 (LW)	44		
		3.43 to 49.6 (AA)	13% (AA)	5 (AA)	39		
		2.35 to 24.3 (CA)	80% (CA)	4 (CA)	5		
		3.43 (BT-BV)	36% (BT-BV)	16 (BT-BV)	44		
		32.3 (UA-BV)	0% (UA-BV)	0 (UA-BV)	44		
Cyanide (Total)	Unfiltered	5.2 (WH)	81% (WH)	17 (WH)	21	Guaje, Los Alamos, Pajarito, Water	Maximum result (0.446 mg/L) is from Los Alamos Canyon above Rio Grande at E109.9.
		22 (AA)	50% (AA)	10 (AA)	20		
		5.2 (CA)	0% (CA)	0 (CA)	1		
		140 (HH)	5% (HH)	1 (HH)	21		
Lead ^b	Filtered	5000 (IRR)	0% (IRR)	0 (IRR)	39	Sandia	Maximum result (0.567 µg/L) is from Sandia Canyon below wetlands at E123.
		100 (LW)	0% (LW)	0 (LW)	39		
		12.9 to 281 (AA)	0% (AA)	0 (AA)	35		
		0.442 to 8.72 (CA)	25% (CA)	1 (CA)	4		
		3.3 (UA-BV)	0% (UA-BV)	0 (UA-BV)	39		
Manganese ^c	Filtered	1840 to 4470 (AA)	11% (AA)	4 (AA)	37	Los Alamos	Maximum result (28,900 µg/L) is from Los Alamos Canyon above low-head weir at E042.1.
		979 to 2430 (CA)	0% (CA)	0 (CA)	5		
Mercury	Unfiltered	10 (LW)	0% (LW)	0 (LW)	45	Guaje, Los Alamos, Pajarito, Water	Maximum result (5.99 µg/L) is from Los Alamos Canyon above low-head weir at E042.1.
		0.77 (WH)	29% (WH)	13 (WH)	45		
Nickel ^c	Filtered	138 to 1510 (AA)	0% (AA)	0 (AA)	39	Guaje, Los Alamos, Pajarito	Maximum result (5.78 µg/L) is from Los Alamos Canyon above DP Canyon at E030.
		13.8 to 139 (CA)	0% (CA)	0 (CA)	5		
		4600 (HH)	0% (HH)	0 (HH)	44		
		3.53 (BT-BV)	16% (BT-BV)	7 (BT-BV)	44		
		7.57 (UA-BV)	0% (UA-BV)	0 (UA-BV)	44		
Selenium	Unfiltered	5 (WH)	29% (WH)	13 (WH)	45	Guaje, Los Alamos, Pajarito	Maximum result (106 µg/L) is from Los Alamos Canyon above Rio Grande at E109.9.
		20 (AA)	20% (AA)	8 (AA)	40		
		5 (CA)	0% (CA)	0 (CA)	5		

Table 6-6 (continued)

Analyte	Sample Preparation	Standard or Screening Level ^a (µg/L ^b)	Percentage of Samples with Detected Results above Standard or Screening Level	Number of Detected Results above Standard or Screening Level	Number of Samples Analyzed	Canyons with Detected Results above Standard or Screening Level	Notes
Silver ^c	Filtered	0.266 to 34.9 (AA)	0% (AA)	0 (AA)	39	None	Maximum result (0.303 µg/L) is from Pajarito Canyon above Threemile at E245.5.
Vanadium	Filtered	100 (IRR)	0% (IRR)	0 (IRR)	44	Los Alamos, Sandia	Maximum result (36.9 µg/L) is from Sandia Canyon right fork at Power Plant at E121.
		100 (LW)	0% (LW)	0 (LW)	44		
		5.77 (BT-BV) 10.6 (UA-BV)	9% (BT-BV) 9% (UA-BV)	4 (BT-BV) 4 (UA-BV)	44 44		
Zinc ^c	Filtered	2,000 (IRR)	0% (IRR)	0 (IRR)	44	Los Alamos, Sandia	Maximum result (259 µg/L) is from Sandia Canyon right fork at Power Plant at E121.
		25,000 (LW)	0% (LW)	0 (LW)	44		
		42.9 to 564 (AA)	0% (AA)	0 (AA)	39		
		29.2 to 350 (CA)	20% (CA)	1 (CA)	5		
		26,000 (HH)	0% (HH)	0 (HH)	44		
		109 (BT-BV)	2% (BT-BV)	1 (BT-BV)	44		
		1120 (UA-BV)	0% (UA-BV)	0 (UA-BV)	44		
Dioxin ^g	Unfiltered	5.10E-08 (HH)	75% (HH)	9 (HH)	12	Acid, DP, Los Alamos	Maximum result (5.01E-06 µg/L) is from DP Canyon above TA-21 at E038.
Total PCBs	Unfiltered	0.014 (WH)	86% (WH)	32 (WH)	37	Acid, Cañon de Valle, DP, Los Alamos, Pajarito, Sandia	Maximum result (21.8 µg/L) is from upper Los Alamos Canyon sediment detention basin run-on.
		2 (AA)	9% (AA)	3 (AA)	32		
		0.014 (CA)	100% (CA)	5 (CA)	5		
		0.00064 (HH)	97% (HH)	36 (HH)	37		
		0.0117 (BT-BV)	86% (BT-BV)	32 (BT-BV)	37		
		0.098 (UA-BV)	32% (UA-BV)	12 (UA-BV)	37		

^a IRR = Irrigation standard; LW = livestock watering standard; WH = wildlife habitat standard; AA = acute aquatic life standard; CA = chronic aquatic life standard; HH = human health standard; BT-BV = Banelier Tuff background value; UA-BV = urban area background value.

^b µg/L = Micrograms per liter.

^c AA and CA life standards for particular metals are hardness-dependent, thus the standard is adjusted accordingly if a hardness value is available, and 30 mg CaCO₃/L is used if no hardness value is available (NMWQCC 2013). AA and CA standards are presented as a range if hardness-adjusted.

^d Bold text denotes samples with concentrations above the standard or screening level.

^e AA and CA life standards apply to different stream segments (see Table 6-2 and Figure 6-6), thus the percentage of samples with detected results above the standard, number of detected results above the standard, and number of samples analyzed varies accordingly.

^f n/a = Not applicable.

^g Dioxin is the sum of the dioxin toxicity equivalents expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin (EPA 2010). If there were no dioxin/furan results for a particular sample, 2,3,7,8-tetrachlorodibenzo-p-dioxin was not calculated.

1. Background-Related Constituents

Several constituents observed in storm water runoff and sediment are associated with both naturally occurring sources in soils and rock and anthropogenic sources upgradient of the Laboratory on the Pajarito Plateau.

Filtered storm water samples collected on the Pajarito Plateau in 2012 commonly contained aluminum concentrations above the NMWQCC acute aquatic life standard (658 $\mu\text{g/L}$ for a hardness of 30 mg CaCO_3/L). However, most or all of this aluminum is likely naturally occurring (e.g., Reneau et al. 2010). For example, samples from the upgradient boundary gage station in Cañon de Valle after the Cerro Grande Fire had aluminum concentrations of 19,900 $\mu\text{g/L}$ and 13,200 $\mu\text{g/L}$ in 2000 and 2001, respectively. Similarly, a sample from the upgradient boundary gage station in Pajarito Canyon had an aluminum concentration of 11,500 $\mu\text{g/L}$ in 2005. Aluminum is a natural component of soil and Bandelier Tuff and is not known to be derived from LANL 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 658 $\mu\text{g/L}$ in other parts of the Jemez area (NMED 2009). Aluminum concentrations in storm water were very similar at environmental surveillance report (ESR) gages and IP SMAs during 2012. For sampling conducted under the IP, the highest result for filtered aluminum was 1430 $\mu\text{g/L}$ at 2M-SMA-1 in upper Twomile Canyon (tributary of Pajarito Canyon). The highest aluminum result determined at a gage station in 2012 in Pajarito Canyon was 1010 $\mu\text{g/L}$ at Pajarito below NM 501 (E240), which is located at the Laboratory’s upper boundary. In 2012, aluminum concentrations in sediment were not detected above the residential SSL of 78,000 mg/kg or the regional BV of 15,400 mg/kg.

No filtered storm water samples collected on the Pajarito Plateau in 2012 had arsenic above the NMWQCC human health standard of 9 $\mu\text{g/L}$. Eleven of 44 storm water samples had arsenic above the urban area BV of 2.55 $\mu\text{g/L}$: 2 were collected at the upgradient boundary gage station in Pajarito Canyon with arsenic concentrations of 4.74 $\mu\text{g/L}$ and 2.78 $\mu\text{g/L}$, 1 was collected at the upgradient boundary gage station in Los Alamos Canyon with an arsenic concentration of 3.01 $\mu\text{g/L}$, 2 were collected in Guaje Canyon with arsenic concentrations of 3.13 $\mu\text{g/L}$ and 2.57 $\mu\text{g/L}$, and the remaining 6 were collected downstream of these gage stations. Arsenic did not exceed the IP TAL in samples collected in 2012. For sampling under the IP, the highest result for filtered arsenic was 3.43 $\mu\text{g/L}$. The highest filtered arsenic result detected at a gage station in 2012 was 6.14 $\mu\text{g/L}$ in Pajarito Canyon above Threemile Canyon. In 2012, arsenic concentrations in sediment were not detected above the residential SSL of 3.9 mg/kg or the regional BV of 3.98 mg/kg.

Elevated copper concentrations have been associated with firing sites, developed areas, and forest fires. In 2012, copper concentrations in filtered storm water were detected above the NMWQCC chronic aquatic life standard for copper in Sandia Canyon (4 of 5 samples) and the NMWQCC acute aquatic life standard for copper in Acid Canyon, DP Canyon, and at the upper Los Alamos sediment detention basins (5 of 39 samples). All of these locations receive a large percentage of runoff from developed areas. Also, 16 of 44 storm water samples had copper concentrations greater than the Bandelier Tuff BV (3.43 $\mu\text{g/L}$), but none of the 44 samples had concentrations greater than the urban area BV (32.3 $\mu\text{g/L}$). Prior to 2012, every watershed across the Laboratory had recorded elevated copper concentrations in storm water, including all of LANL’s upgradient boundary stations, indicating that copper most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. In addition, in 2011 through 2012, every watershed had maximum TAL (MTAL) exceedances of copper concentrations in IP-related storm water samples. However, the highest copper concentrations at IP SMAs are higher than copper concentrations at ESR gages, indicating a Laboratory contribution of copper to the canyons. For sampling under the IP, the highest result for filtered copper was 75.5 $\mu\text{g/L}$ at PJ-SMA-5 in Pajarito Canyon and is associated with Laboratory operations. The highest filtered copper result detected at a gage station in 2012 was 20.4 $\mu\text{g/L}$ in Sandia Canyon. In 2012, copper concentrations in sediment were not detected above the residential SSL of 3130 mg/kg.

Total cyanide concentrations in storm water samples collected in 2012 were detected above the NMWQCC wildlife habitat standard (5.2 $\mu\text{g/L}$) in all Las Conchas Fire-affected watersheds. In 2012, cyanide was not analyzed in sediment samples, but in 2011, cyanide was detected above the regional BV for sediment (0.83 mg/kg) in 41 of 58 samples collected, and no cyanide concentrations in sediment were above the

residential SSL (1220 mg/kg). Cyanide is observed in ash from forest fires as a result of incomplete combustion of cellulosic materials. Cyanide concentrations should decline over the next several years, as was observed following the Cerro Grande Fire in May 2000 (Gallaher and Koch 2004, 2005). Cyanide concentrations at IP SMAs are less than cyanide concentrations at ESR gages affected by the Las Conchas Fire. For sampling under the IP, the highest result for unfiltered cyanide (weak acid dissociable) was 0.0276 µg/L at STRM-SMA-1.5 in Starmer's Gulch, a subwatershed of the Pajarito Canyon watershed. The highest cyanide (total) result detected at a gage station in 2012 was 0.446 µg/L in Los Alamos Canyon watershed above the Rio Grande.

Filtered manganese concentrations were detected above the NMWQCC acute aquatic life standard in 4 of 37 ash-bearing storm water samples collected in 2012. Also in 2012, manganese concentrations in sediment were not above the residential SSL of 1860 mg/kg, but 25 of 61 samples were above the regional BV of 543 mg/kg, mostly in Las Conchas Fire-affected watersheds. Laboratory operations did not generate or release significant quantities of manganese. Manganese is not monitored as part of the IP. Dissolved manganese concentrations were elevated following the Cerro Grande Fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005).

Total selenium concentrations were detected above the NMWQCC wildlife habitat standard of 5 µg/L in 13 of 40 ash-bearing storm water samples collected in 2012. Selenium concentrations in storm water at IP SMAs are less than selenium concentrations at ESR gages affected by the Las Conchas Fire. Unfiltered selenium did not exceed the IP TAL in samples collected in 2012, and the highest result was 2.44 µg/L. The highest unfiltered selenium result detected at a gage station in 2012 was 106 µg/L in Los Alamos Canyon above the Rio Grande, which includes runoff from Guaje Canyon. In 2012, selenium concentrations in sediment were not detected above the residential SSL of 391 mg/kg, and selenium was detected above the regional BV for sediment of 0.3 mg/kg in 6 of 61 samples collected. Laboratory operations did not generate or release significant quantities of selenium. Total selenium concentrations were elevated following the Cerro Grande Fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005).

Elevated zinc concentrations are associated with developed areas, particularly compounds associated with tires and galvanized metals. In 2012, filtered zinc concentrations in storm water were above the NMWQCC chronic aquatic life standard in 1 of 5 samples in Sandia Canyon and above the Bandelier Tuff BV (109 µg/L) in 1 of 44 samples in Sandia Canyon but not above the urban area BV (1120 µg/L), thus indicating developed areas as sources. In 2011 through 2012, every watershed had MTAL exceedances (42 µg/L) of zinc concentrations in IP-related storm water samples. Prior to 2012, every watershed across the Laboratory, with the exception of Mortandad, had elevated zinc concentrations in storm water, including all of LANL's upgradient boundary stations, indicating that zinc most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. No 2012 zinc concentrations in sediment were above the residential SSL (23,500 mg/kg).

In 2012, only storm water samples collected at Los Alamos Canyon above the Rio Grande were analyzed for gross-alpha radioactivity levels. The 2 samples collected had concentrations (1260 pCi/L for both samples) above the NMWQCC livestock watering standard (15 pCi/L) and the urban area BV (32.5 pCi/L) but were less than the Bandelier Tuff BV (1490 pCi/L). In previous years, many storm water samples had gross-alpha radioactivity levels above the NMWQCC standard. For example, in 2011 the highest concentrations of gross alpha in storm water, 6200 pCi/L to 1100 pCi/L, were measured in samples containing ash from the Las Conchas Fire. For sampling under the IP in 2012, the highest detected gross-alpha concentration was 1270 pCi/L at STRM-SMA-1.5 in Starmer's Gulch, a subwatershed of Pajarito Canyon watershed. The analytical results from 2012 support earlier conclusions that the majority of the alpha radioactivity in storm water on the plateau is because of 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.

In 2012, only storm water samples collected at Los Alamos Canyon above the Rio Grande were analyzed for radium-226 and radium-228. The only sample collected had radium-226 and radium-228 concentrations (76.8 pCi/L and 45.3 pCi/L, respectively) above the NMWQCC livestock watering standard (30 pCi/L) and

the Bandelier Tuff BV (52.7 pCi/L). In previous years, many storm water samples had radium-226 and radium-228 levels above the NMWQCC standard. For example, in 2011 the highest concentration of radium-226 and radium-228 in storm water, 109 pCi/L, was measured in samples containing ash from the Las Conchas Fire at Los Alamos Canyon above the Rio Grande. For sampling under the IP in 2012, the highest detected radium-226 plus radium-228 concentration was 38.5 pCi/L at STRM-SMA-1.5 in Starmer's Gulch, a subwatershed of Pajarito Canyon watershed. The analytical results from 2012 support earlier conclusions that the majority of the radium-226 and radium-228 found in storm water on the plateau is because of 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).

2. LANL-Related Constituents

Several constituents were measured in storm water runoff and resultant sediment deposits that relate to historical LANL operations. The nature and extent of the constituents in sediment deposited from runoff are described in detail in the Canyons IRs referenced in this chapter's introduction. The following discussion describes the occurrences of key constituents in 2012 storm water and sediment samples and the relationship of their concentrations to pre-existing concentrations and spatial distributions.

Supplemental figures and Figures 6-10 and 6-11 illustrate the relationships between 2012 constituent concentrations in storm water and sediment to those prior to 2012. Plotted results were part of Canyons IRs, ESRs, or were results from IP SMAs. All results are plotted relative to their distance to the Rio Grande. Confluence points of each subwatershed, stream reaches of interest, and particular Laboratory areas are labeled on the upper x-axis for spatial reference. Pre-2012 results for each subwatershed are identified using a unique color, and results obtained in 2012 are in green. In the storm water figures, results collected as part of the IP are identified with a triangle, and canyon gage results are identified with an oval. In the sediment figures, results collected as part of Canyons IRs are identified with an oval, and environmental surveillance results are identified with a triangle. In some cases, the highest results for a watershed are not presented but are described in a figure note. Results from the sediment detention basins in upper Los Alamos Canyon are uniquely presented.

3. Inorganic and Organic Chemicals

a. Barium

There are no NMWQCC standards for barium, other than for drinking water. Concentrations of unfiltered barium in storm water collected in 2012 are highest in Los Alamos Canyon above the low-head weir (291,000 µg/L) and the upgradient Laboratory boundary above contaminant sources of barium in sediment in Water Canyon (LANL 2011c), indicating that barium also occurs naturally in rocks and soils on and upgradient of the Pajarito Plateau (Supplemental Figures S6-1a and b). Pre-2012 barium concentrations in sediment were above the residential SSL of 15,600 mg/kg in Cañon de Valle; however, 2012 barium concentrations in sediment were not above the residential SSL in Water Canyon watershed nor throughout the Laboratory. Concentrations of barium in storm water and sediment generally decreased from Cañon de Valle to the confluence with the Rio Grande.

b. Lead

In pre-2012 storm water data, filtered lead concentrations were above the NMWQCC acute aquatic life standard and MTAL (17 µg/L) in Pueblo, DP, and upper Los Alamos Canyons (Supplemental Figures S6-2a through f). In 2012, one result in Sandia Canyon was above the NMWQCC chronic aquatic life standard, and there were no IP TAL exceedances for lead. For samples collected under the IP in 2012, the highest result for filtered lead was 1.48 µg/L at LA-SMA-0.85 in Los Alamos Canyon. The highest unfiltered lead result at ESR gage stations in 2012 was 0.567 µg/L in Sandia Canyon below the wetlands. Concentrations of lead in storm water collected during 2012 were highest where lead had been detected in sediment associated with historical Laboratory operations in Acid, DP, Twomile, and S-Site Canyons and Cañon de Valle (LANL 2005a, 2009b, 2011c). Los Alamos, Pajarito, and Water Canyon watersheds had pre-2012 lead concentrations in sediment that were above the regional BV (19.7 mg/kg) but were below the residential SSL (400 mg/kg). No 2012 lead concentrations in sediment were above the residential SSL. Lead concentrations in sediment decreased to levels near background by the Laboratory boundary.

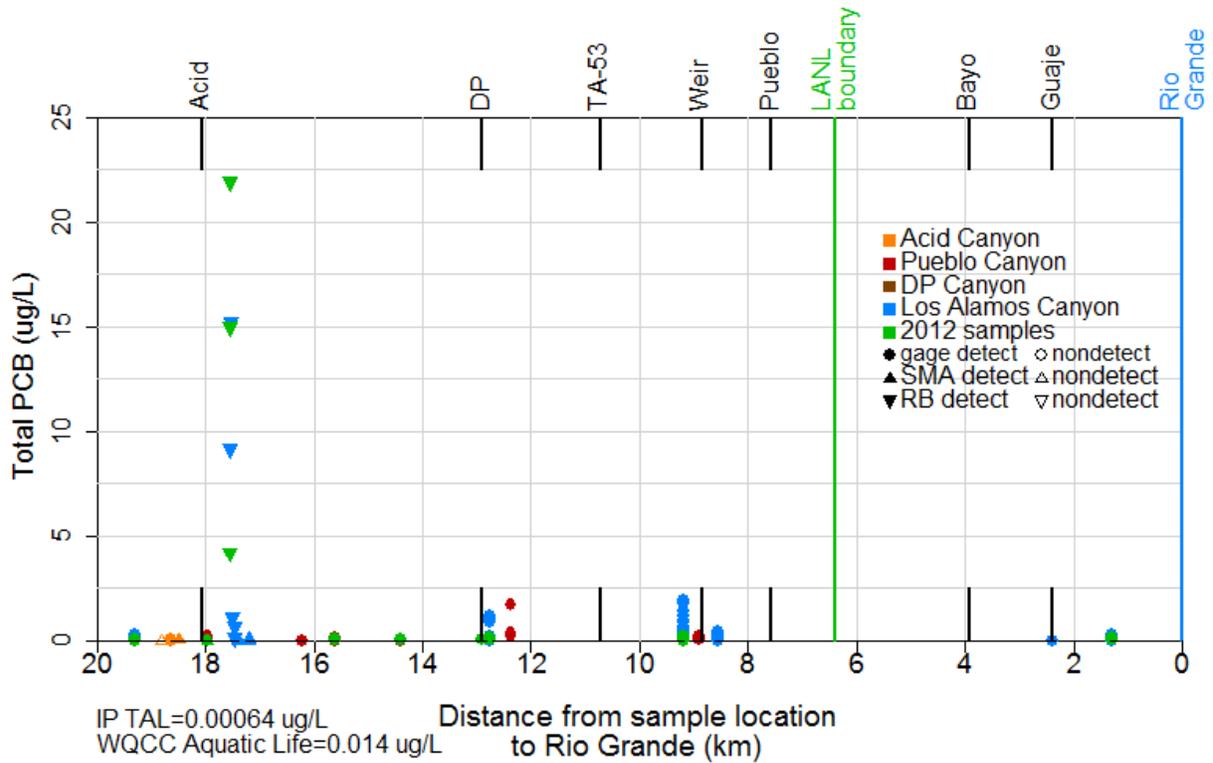


Figure 6-10a Los Alamos Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011–2012), gages (data from 2009–2012), and the sediment detention basins (RB)

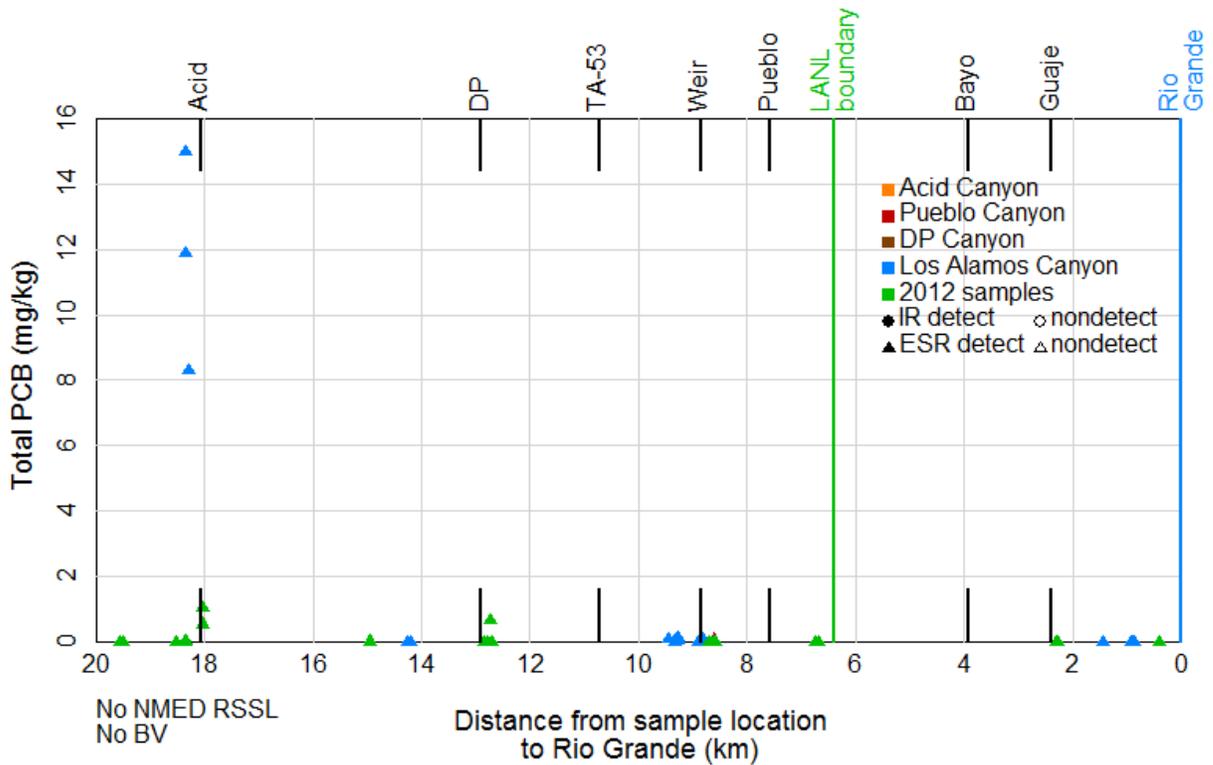


Figure 6-10b Los Alamos Canyon watershed total PCB concentrations in sediment from ESRs (data from 2009–2012), congeners not analyzed in Los Alamos Canyon before 2011

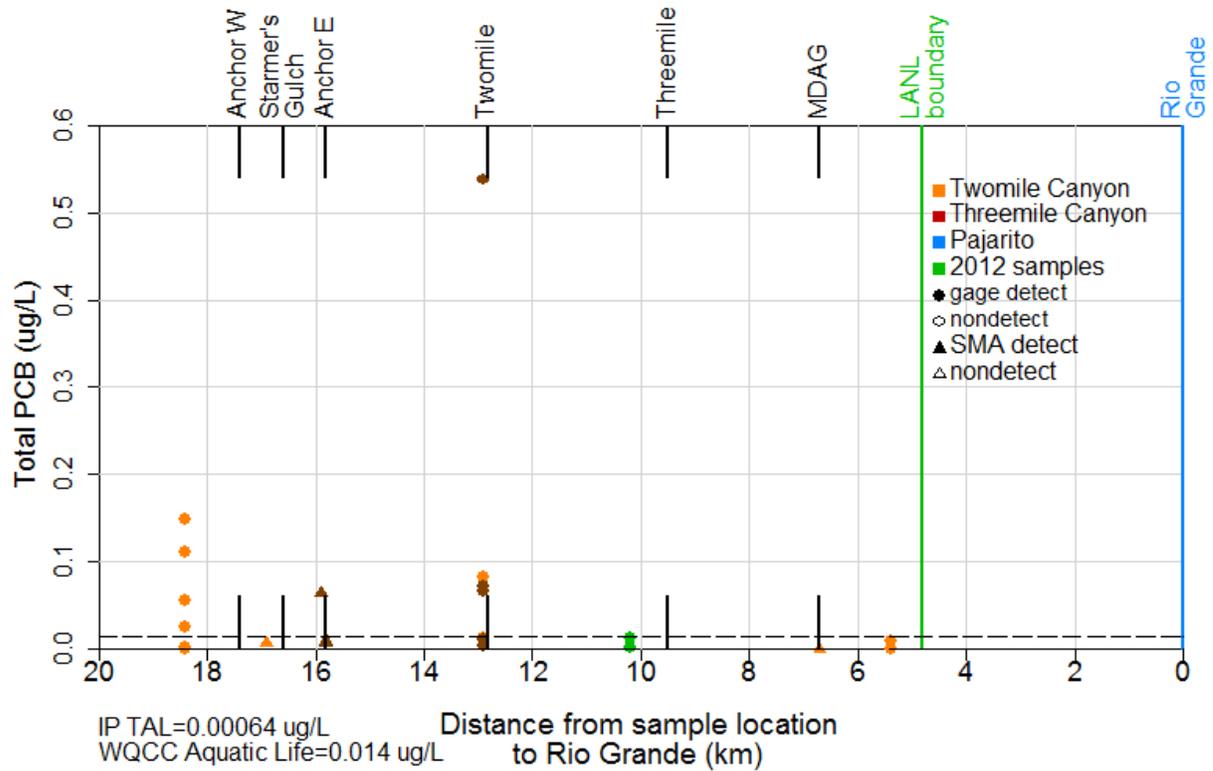


Figure 6-10c Pajarito Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011–2012) and gages (data from 2010–2012)

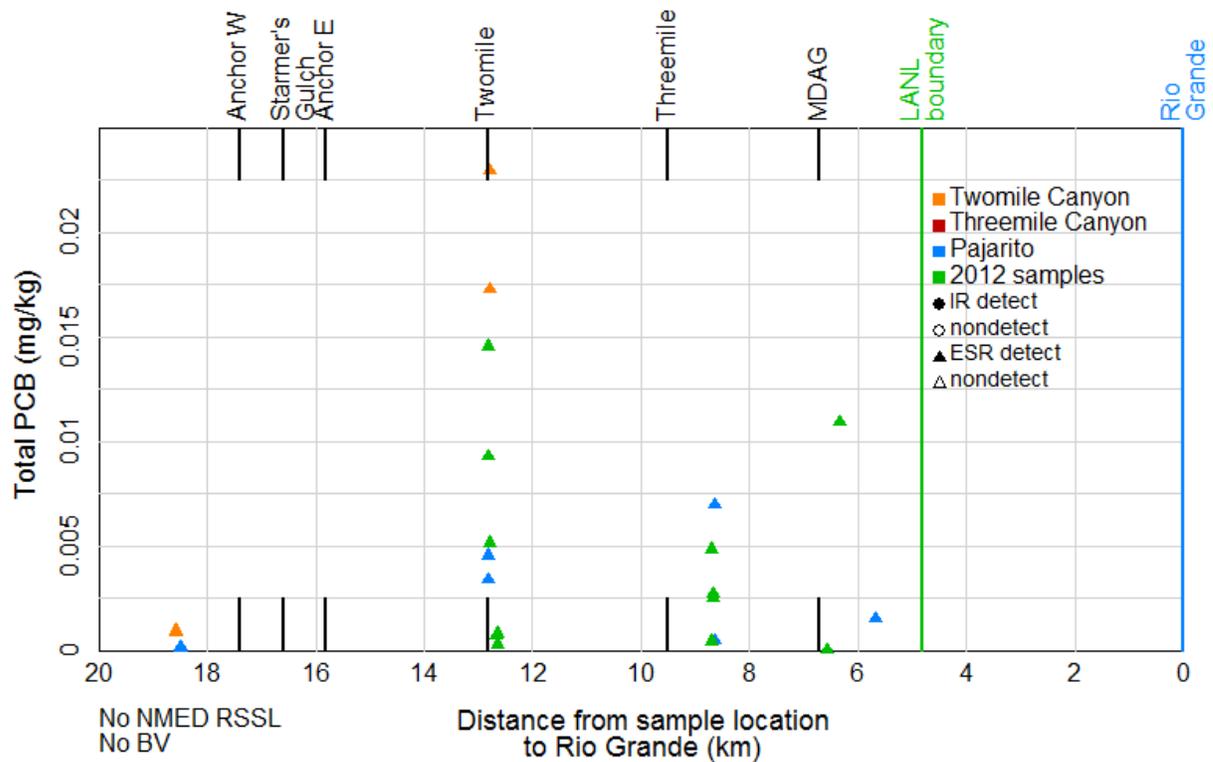


Figure 6-10d Pajarito Canyon watershed total PCB concentrations in sediment from ESR (data from 2012), congeners not analyzed in Pajarito Canyon before 2011

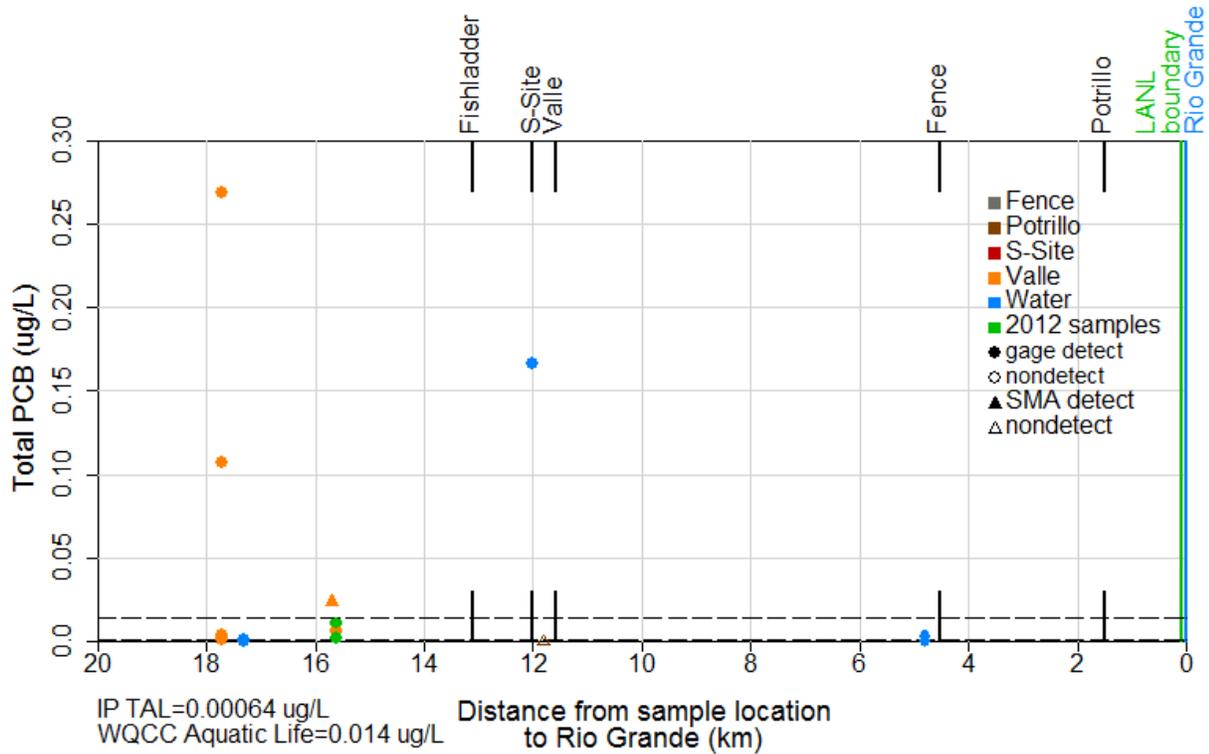


Figure 6-10e Water Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011–2012) and gages (data from 2010–2012)

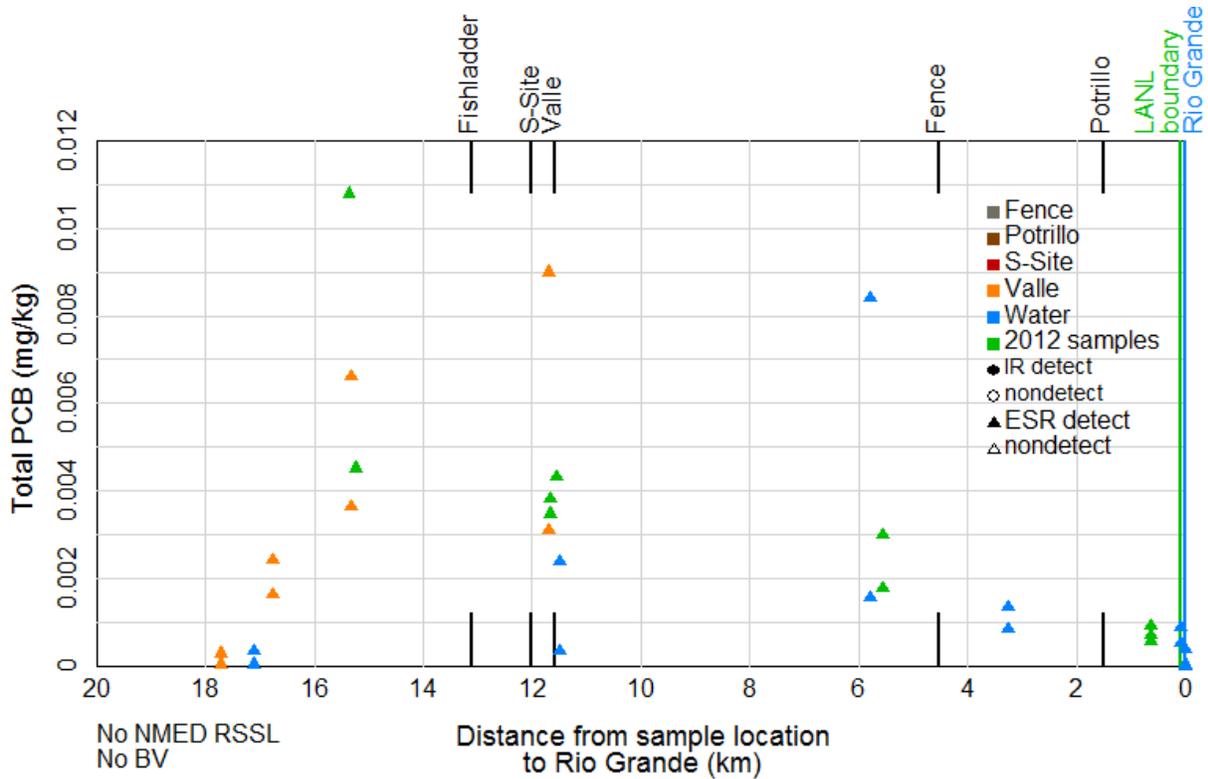


Figure 6-10f Water Canyon watershed total PCB concentrations in sediment from ESR (data from 2012), congeners not analyzed in Water Canyon before 2011

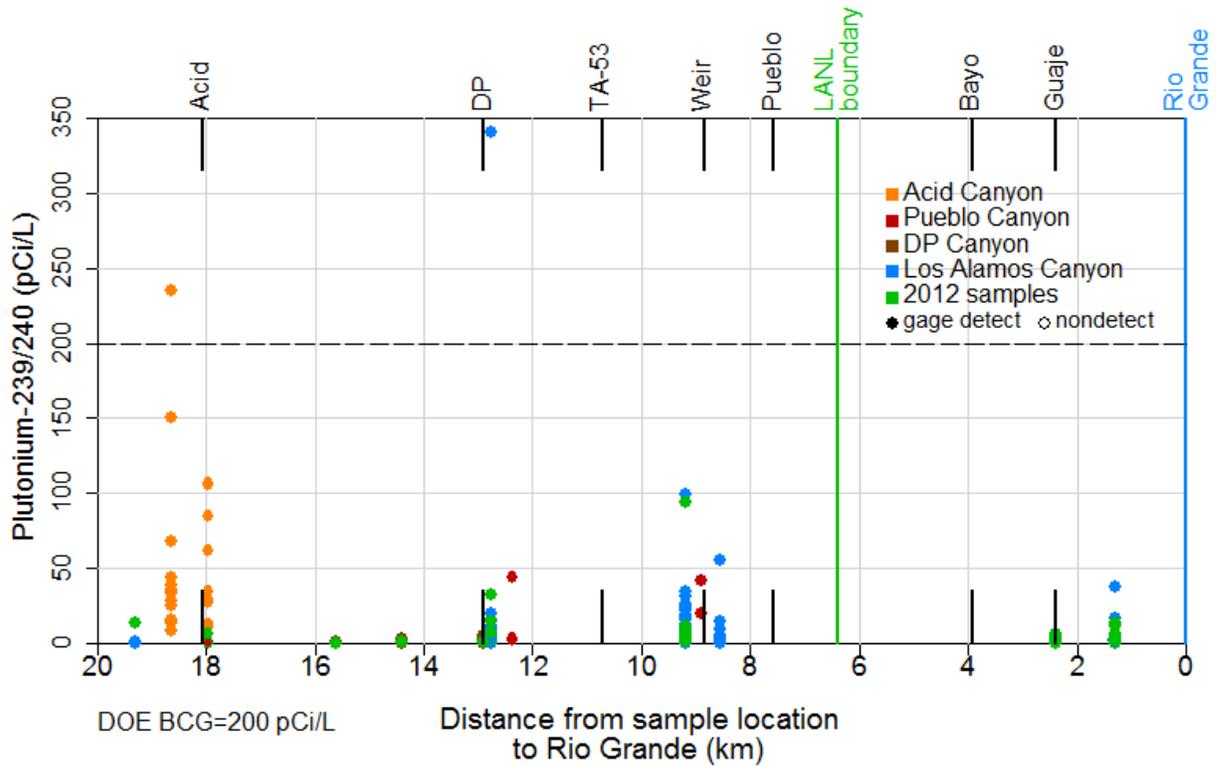


Figure 6-11a Los Alamos Canyon watershed plutonium-239/240 concentrations in storm water from gages (data from 2004–2012), no SMA samples analyzed

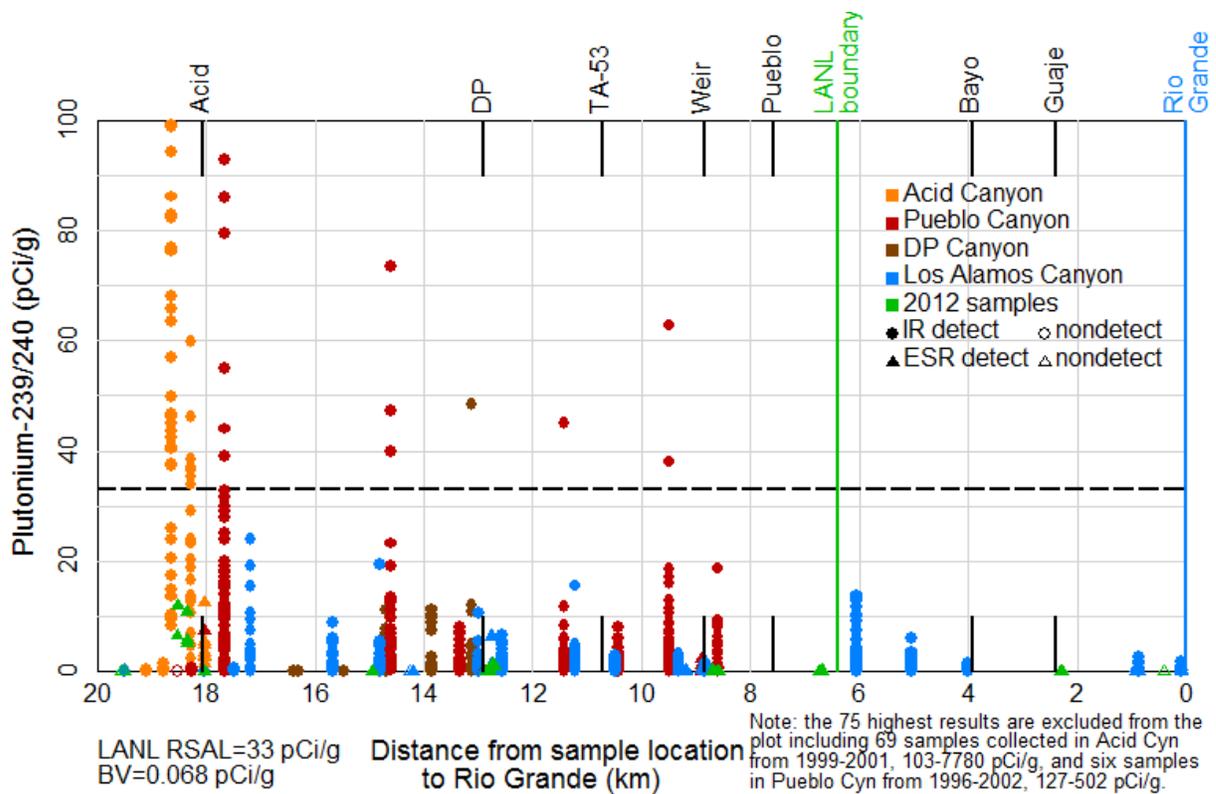


Figure 6-11b Los Alamos Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IRs (data from 1994–2003) and ESRs (data from 2003–2012)

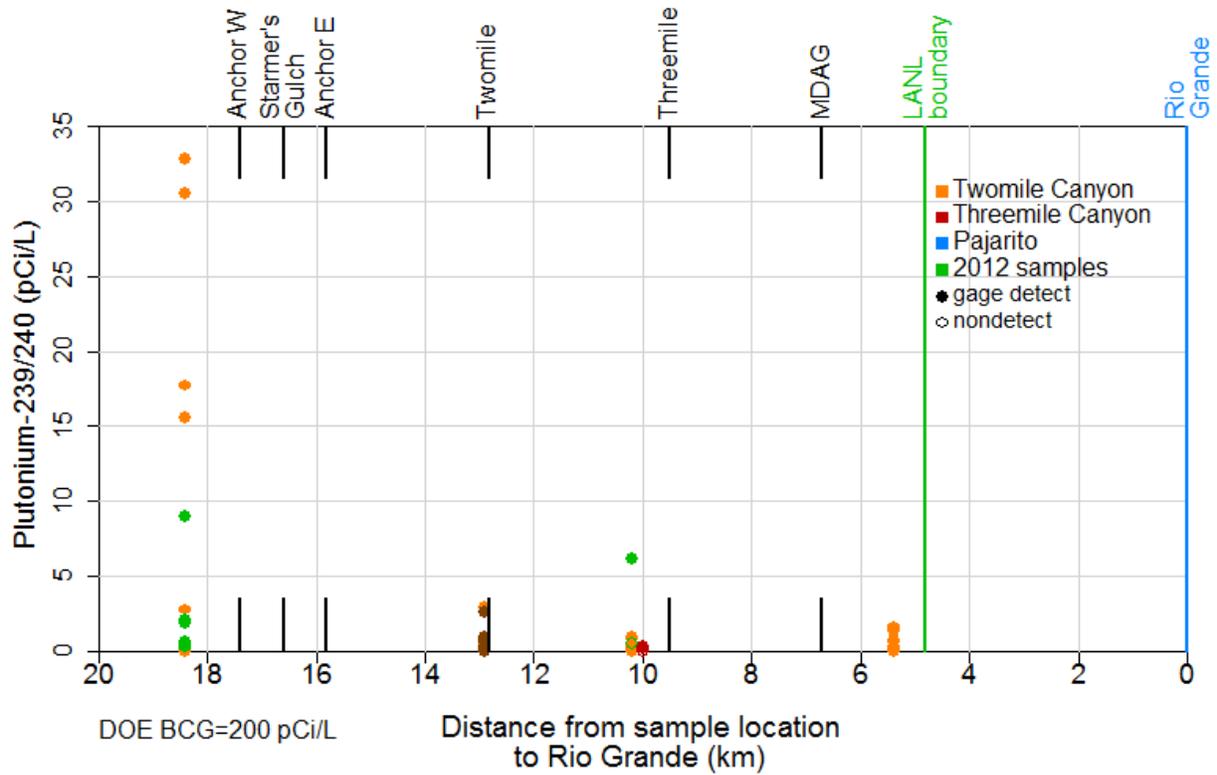


Figure 6-11c Pajarito Canyon watershed plutonium-239/240 concentrations in storm water from gages (data from 2004–2012), no SMA samples analyzed

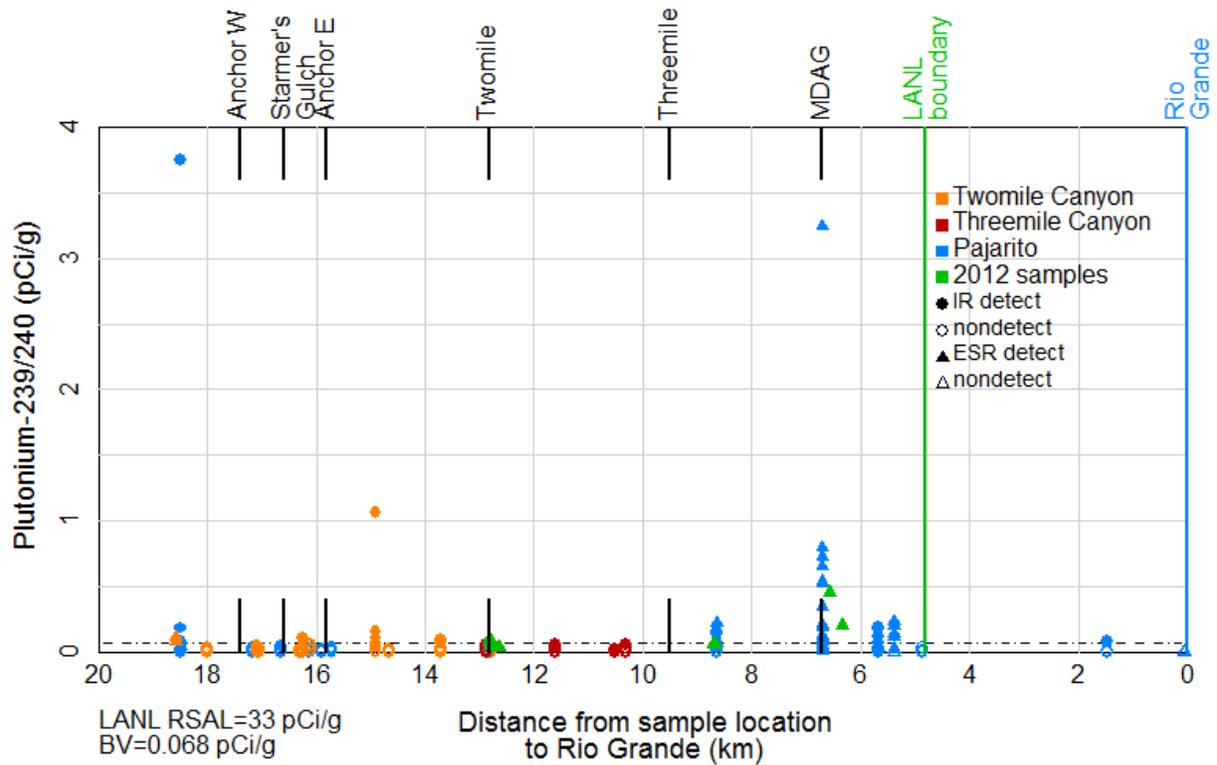


Figure 6-11d Pajarito Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IRs (data from 2000–2007) and ESRs (data from 2003–2012)

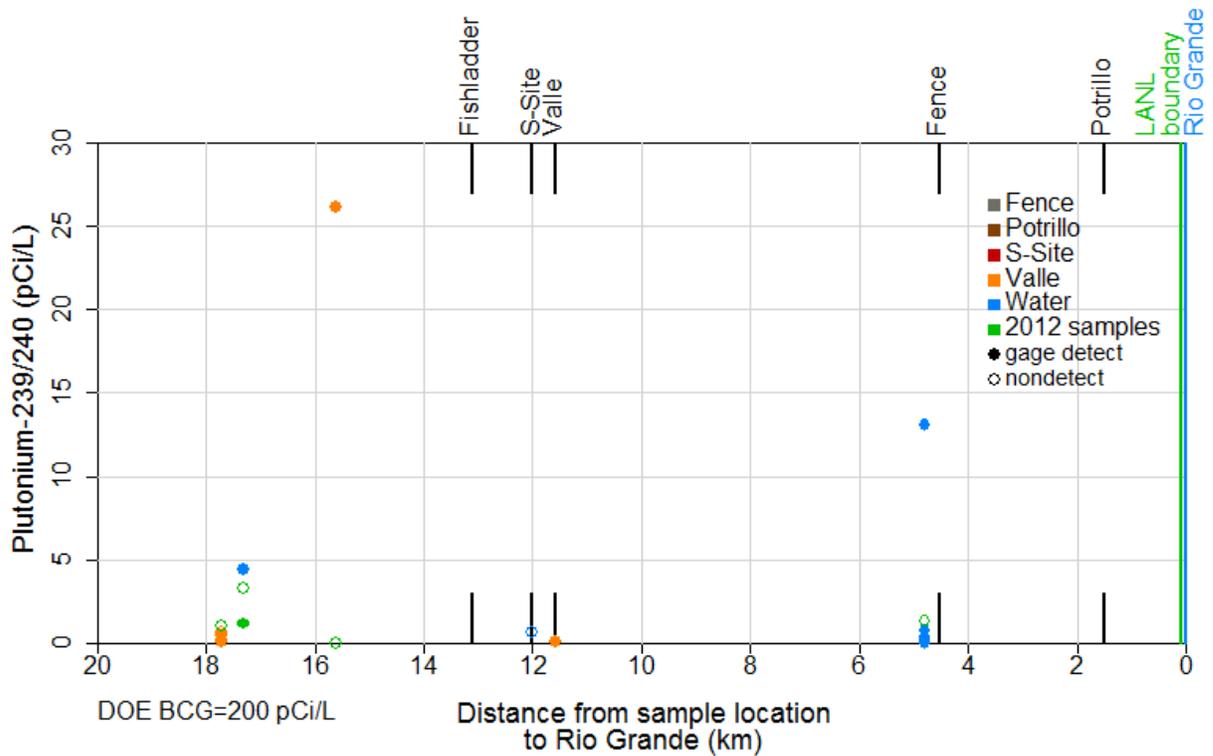


Figure 6-11e Water Canyon watershed plutonium-239/240 concentrations in storm water from gages (data from 2004–2012), no SMA samples analyzed

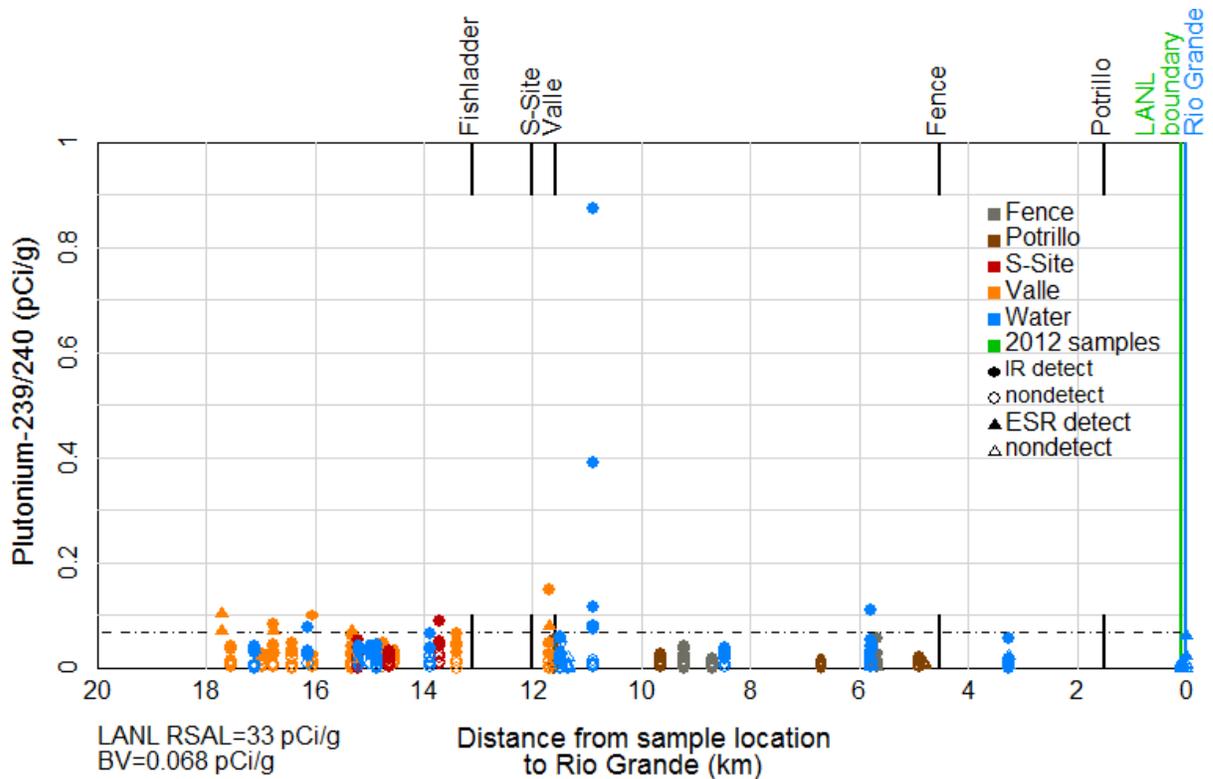


Figure 6-11f Water Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IRs (data from 2000–2007) and ESRs (data from 2003–2012)

c. Mercury

In pre-2012 storm water data, total mercury concentrations were above the NMWQCC wildlife habitat standard (0.77 µg/L) in Cañon de Valle and Acid, Los Alamos, Pajarito, and Water Canyons (Supplemental Figures S6-3a through d; Pajarito Canyon does not have a Laboratory source for mercury and concentrations are low, thus Pajarito Canyon is not shown in the figures). For 2012, unfiltered mercury concentrations in storm water were above the NMWQCC wildlife habitat standard in Guaje, Los Alamos, Pajarito, and Water Canyons and exceeded the average TAL (0.77 µg/L) in Pajarito Canyon. Mercury concentrations are similar at ESR gages and IP SMAs. For samples collected under the IP in 2012, the highest result for unfiltered mercury was 1.17 µg/L at STRM-SMA-1.5 in Starmer's Gulch, a subwatershed of Pajarito Canyon. The highest unfiltered mercury result determined at ESR gages in 2012 was 5.99 µg/L in Los Alamos Canyon above the low-head weir. Mercury concentrations decreased from their sources in Acid and S-Site Canyons (LANL 2005a, 2011c) to below background in sediment collected near the Laboratory boundary. One pre-2012 mercury concentration in sediment was above the residential SSL of 23.5 mg/kg in Threemile Canyon (LANL 2009b). No 2012 mercury concentrations in sediment were above the residential SSL.

d. Silver

In pre-2012 storm water data, filtered silver concentrations were above the NMWQCC acute aquatic life standard (0.4 µg/L) in Cañon de Valle and Acid, Pajarito, and Water Canyons (Supplemental Figures S6-4a through d; silver concentrations in Los Alamos Canyon are low with minimal spatial extent, thus it is not shown in the figures). In 2012, no storm water samples were above the NMWQCC standards for filtered silver, and the highest concentration at ESR gages in 2012 was 0.303 µg/L in Pajarito Canyon above Threemile Canyon. For samples collected under the IP in 2012, two exceeded the MTAL (0.5 µg/L): 7.86 µg/L at CDV-SMA-1.4 in Cañon de Valle and 0.589 µg/L at STRM-SMA-1.5 in Starmer's Gulch, a subwatershed of Pajarito Canyon. No pre-2012 or 2012 sediment concentrations of silver were above the residential SSL of 391 mg/kg; however, 2012 sediment samples collected in Twomile Canyon and just below Threemile Canyon had silver concentrations higher than pre-2012 concentrations, possibly indicating the movement of silver-laden sediment downstream. Nonetheless, silver concentrations in sediment decreased from their Laboratory sources in Cañon de Valle and Pajarito Canyon (LANL 2009a, 2011c) to below background in sediment collected near the Laboratory boundary.

e. Total PCBs

PCBs were detected in 97% of storm water samples collected in 2012 and within most LANL watersheds at concentrations above the NMWQCC human health standard of 0.00064 µg/L (Figures 6-10a through f). Data from storm water runoff from nonurban, nonindustrial areas on the Pajarito Plateau indicate that atmospheric deposition of PCBs can result in concentrations in storm water that are above the human health standard. These PCB detections are categorized into three statistically different categories in "Polychlorinated Biphenyls in Precipitation and Stormwater within the Upper Rio Grande Watershed" (LANL 2012e):

- 1) *Storm water runoff from nonurban, nonindustrial areas on the Pajarito Plateau.* Two of the 37 storm water samples collected at gage stations in 2012 fall into this category. In one sample, PCBs were not detected, and in the other, the total PCB concentration (0.0897 µg/L) was above the upper threshold limit (UTL) of 0.013 µg/L identified in the PCB background report (LANL 2012e). This indicates nonpoint sources of PCBs, including atmospheric deposition and Las Conchas Fire impacts.
- 2) *Storm water runoff from Los Alamos County townsites without point sources of PCBs.* Two of the 37 storm water samples collected at gage stations in 2012 fall into this category. The total PCB concentrations (0.0671 and 0.0501 µg/L) for both of these samples were below the UTL of 0.098 µg/L identified in the PCB background report (LANL 2012e), indicating an absence of point sources of PCBs.
- 3) *Storm water runoff from potential point sources of PCBs.* Thirty-three of the 37 storm water samples collected at gage stations in 2012 fall into this category. The total PCB concentrations in 12 of the 33 samples (36%) were above the UTL of 0.098 µg/L identified in the PCB background report (LANL 2012e), potentially indicating a presence of sources of PCBs. The other 21 samples (64%) were below the UTL, potentially indicating an absence of sources of PCBs.

The highest total PCB concentrations were detected in storm water runoff entering the sediment detention basins below SWMU 01-001(f) in Los Alamos Canyon. These detention basins function to capture PCB-contaminated sediments prior to runoff entering the main channel in Los Alamos Canyon. Total PCB concentrations for storm water samples collected at the inlet to the upper detention basin on July 6, September 12, and October 12, 2012, range from 4.09 µg/L to 21.8 µg/L, and no storm water was collected at the outlet of the lower retention basin in 2012. The maximum concentration in 2012 is higher than the 9.07 µg/L maximum in 2011. Concentrations of PCBs running onto the Laboratory from burned areas are as high as 0.0897 µg/L in Los Alamos Canyon and as high as 0.156 µg/L in Los Alamos Canyon above the Rio Grande (but below the Guaje Canyon confluence), indicating that PCBs are concentrated in forest fire ash, although these concentrations are less than in 2011. Concentrations of PCB Aroclor mixtures do not directly correspond to PCB congener concentrations and thus are not presented here.

f. RDX

No pre-2012 or 2012 RDX concentrations exceeded the TALs for IP-related sampling. In Cañon de Valle, pre-2012 RDX concentrations in sediment were above the residential SSL of 58.2 mg/kg and are associated with the former high-explosives-machining facility, including MDAs, burning grounds, and settling ponds (LANL 2011c). In 2012, no RDX concentrations in sediment were above the residential SSL.

g. Radionuclides

Storm water runoff from Las Conchas burn areas contains naturally occurring uranium and radionuclides present in global fallout: americium-241, cesium-137, plutonium-238, plutonium-239/240, and strontium-90. The uranium is likely associated with soil erosion in post-fire runoff (Gallaher and Koch 2004, 2005), and the other radionuclides are likely from global fallout concentrated in ash.

h. Plutonium-238 and Plutonium-239/240

No storm water samples collected in Los Alamos, Pajarito, and Water Canyons from 2004 to 2011 had plutonium-238 (Supplemental Figures S6-5a through f) or plutonium-239/240 (Figures 6-11a through f) concentrations above the DOE BCG of 200 pCi/L (Figures 6-16a through f and Figures 6-17a through f, respectively) with the exception of two storm water samples, one in Acid Canyon and one in Los Alamos Canyon below the DP Canyon confluence. In 2012, no storm water samples collected on the Pajarito Plateau had plutonium-238 or plutonium-239/240 concentrations above the DOE BCG. The highest concentration of plutonium-238 in storm water (2.41 pCi/L) was in Los Alamos Canyon above the Rio Grande (containing Guaje Canyon runoff), and the highest concentration of plutonium-239/240 in storm water (93.5 pCi/L) was in Los Alamos Canyon above the low-head weir.

In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), slightly elevated concentrations of plutonium-238 and plutonium-239/240 in storm water at the upgradient boundary stations are related to ongoing ash and sediment in runoff from Las Conchas Fire burn areas. Slightly elevated concentrations of plutonium-238 and plutonium-239/240 in storm water at the lower boundary of Los Alamos Canyon are associated with Guaje Canyon runoff, which also contains ash and sediment. In addition, the Los Alamos Canyon low-head weir significantly reduced the slightly elevated concentrations of plutonium-238 and plutonium-239/240 in ash and sediment-laden storm water. Overall, fire-related effects on concentrations of plutonium-238 and plutonium-239/240 in storm water were reduced from 2011 to 2012.

In Los Alamos Canyon, only one pre-2012 sediment sample in Acid Canyon had plutonium-238 concentrations that were above the LANL residential SAL (37 pCi/g). From the historical Laboratory sources in Acid Canyon (LANL 2005a), downcanyon to Pueblo Canyon, then to Los Alamos Canyon, and from the historical Laboratory sources in DP Canyon and TA-53 (LANL 2005a), downcanyon to Los Alamos Canyon, pre-2012 and 2012 plutonium-238 concentrations in sediment decreased to near regional background (0.006 pCi/g) or nondetectable levels before reaching the confluence with the Rio Grande. Pre-2012 plutonium-239/240 concentrations in Los Alamos Canyon watershed were above the LANL residential SAL (33 pCi/g) in Acid, Pueblo, and DP Canyons, yet decreased from these historical source sites to near regional background levels (0.068 pCi/g) at the confluence with the Rio Grande.

In Pajarito Canyon, no pre-2012 concentrations of plutonium-238 and plutonium-239/240 in sediment were above the LANL residential SALs, although MDA G had concentrations above regional BVs. However, both pre-2012 and 2012 plutonium-238 and plutonium-239/240 concentrations in sediment decreased from the LANL historical source at MDA G (LANL 2009b) to near regional BVs before the LANL boundary and were at nondetectable levels at the confluence with the Rio Grande.

In Water Canyon, only one pre-2012 sediment sample in Cañon de Valle had plutonium-238 concentrations above the LANL residential SAL, and no pre-2012 sediment samples had plutonium-239/240 concentrations above the LANL residential SAL. From the historical Laboratory source in Cañon de Valle (LANL 2011c) downstream, the concentrations of plutonium-238 and plutonium-239/240 in sediment decreased to near regional background or nondetectable levels before reaching the confluence with the Rio Grande.

In sediment samples collected in Los Alamos, Pajarito, and Water Canyons in 2012, plutonium-238 and plutonium-239/240 concentrations were not above the LANL residential SALs. In Los Alamos and Pajarito Canyons, plutonium-238 and plutonium-239/240 concentrations in sediment were above BVs; however, most samples contained ash and sediment from Las Conchas burn areas or were from the historical source at MDA G. In Water Canyon, no 2012 plutonium-238 or plutonium-239/240 concentrations in sediment were above BVs. The highest plutonium-238 concentration in sediment (0.0624 pCi/g) was in DP Canyon just above the Los Alamos Canyon confluence, and the highest plutonium-239/240 concentration in sediment (12 pCi/g) was at the south fork of Acid Canyon.

i. Uranium-234 and Uranium-238

No storm water samples collected in Los Alamos, Pajarito, and Water Canyons from 2004 to 2010 had uranium-234 (Supplemental Figures S6-6a through f) or uranium-238 (Supplemental Figures S6-7a through f) concentrations above the DOE BCG of 200 pCi/L (Figures 6-18a through f and Figures 6-19a through f, respectively). Only in Las Conchas Fire-affected canyons, where storm water was laden with ash and sediment in 2011 and 2012, were uranium-234 and uranium-238 concentrations in storm water above the DOE BCG (Guaje, Los Alamos, Pajarito, and Water Canyons). Note that BCG screening levels are based on chronic exposure, thus comparing them with a one-time, acute event will overestimate risk. In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), elevated concentrations of uranium-234 and uranium-238 in storm water were found at the upgradient boundary stations in 2011 and 2012. Elevated concentrations of uranium-234 and uranium-238 in storm water at the lower boundary of Los Alamos Canyon are associated with Guaje Canyon runoff. In addition, the Los Alamos Canyon low-head weir significantly reduced the concentrations of uranium-234 and uranium-238 in storm water with ash and sediment.

In Los Alamos, Pajarito, and Water Canyons, no pre-2011 sediment samples had uranium-234 or uranium-238 concentrations above the LANL residential SALs of 170 pCi/g and 87 pCi/g, respectively. In fact, almost all sediment samples had uranium-234 and uranium-238 concentrations below or near background levels (2.59 pCi/g and 2.29 pCi/g, respectively), with the exception of samples from Acid, Threemile, and Potrillo Canyons. However, all pre-2011 uranium-234 and uranium-238 sediment concentrations in Los Alamos, Pajarito, and Water Canyons originating from the historical LANL sources in Acid (LANL 2005a), Threemile (LANL 2009b), and Potrillo Canyons (LANL 2011c) were below background at the LANL boundary and the confluence with the Rio Grande. In sediment samples collected in Los Alamos, Pajarito, and Water Canyons in 2011 and 2012, uranium-234 and uranium-238 concentrations were below the LANL residential SALs and below to near regional BVs. All post-fire uranium-234 and uranium-238 concentrations in sediment decreased to below background before the LANL boundary and the confluence with the Rio Grande.

j. Americium-241, Cesium-137, and Strontium-90

No storm water samples collected in Los Alamos Canyon from 2004 to 2011 had americium-241 (Supplemental Figures S6-8a and b) or strontium-90 (Supplemental Figures S6-9a and b) concentrations above the DOE BCGs of 400 pCi/L and 300 pCi/L, respectively. In Los Alamos Canyon prior to 2011, two storm water samples collected above and below the low-head weir contained cesium-137 at concentrations

above the DOE BCG of 40 pCi/L (Supplemental Figures S6-10a and b). Note that BCG screening levels are based on chronic exposure, thus comparing them with a one-time, acute event will overestimate risk.

In 2011 and 2012, elevated concentrations of americium-241 and strontium-90 in storm water samples are associated with runoff from Las Conchas Fire burn areas. Indeed, elevated concentrations of americium-241 and strontium-90 in storm water samples at the upgradient LANL boundary of Los Alamos Canyon and throughout Los Alamos Canyon, particularly after the Guaje Canyon confluence, are associated with ash and sediment. Four samples collected in 2012 had cesium-137 concentrations above the DOE BCG, two at the upgradient Pajarito Canyon boundary station, one in Los Alamos Canyon above the low-head weir, and one in Los Alamos Canyon below the Rio Grande, all of which receive runoff from burn areas. In 2012, the highest concentrations of americium-241 and strontium-90 in storm water (30.6 pCi/L and 73.6 pCi/L, respectively) were from Los Alamos Canyon above the low-head weir, and the highest concentration of cesium-137 in storm water (259 pCi/L) was from Los Alamos Canyon above the Rio Grande, below the Guaje Canyon confluence. In addition, the Los Alamos Canyon low-head weir significantly reduced the elevated concentrations of americium-241, cesium-137, and strontium-90 in storm water.

In Los Alamos Canyon, pre-2011 americium-241 concentrations in sediment were above the LANL residential SAL (30 pCi/g) in Acid and DP Canyons because of historical Laboratory sources (LANL 2005a), yet decreased to near regional background levels (0.04 pCi/g) before the confluence with the Rio Grande. Pre-2011 cesium-137 concentrations in sediment were above the LANL residential SAL (5.6 pCi/g) in Acid, DP, and downstream Los Alamos Canyons because of historical Laboratory sources (LANL 2005a), yet decreased to below regional background levels (0.9 pCi/g) near the LANL boundary and before the confluence with the Rio Grande. Pre-2011 strontium-90 concentrations in sediment were above the LANL residential SAL (5.7 pCi/g) in Acid, DP, and downstream Los Alamos Canyons because of historical Laboratory sources (LANL 2005a), yet decreased to below background levels (1.04 pCi/g) near the LANL boundary and before the confluence with the Rio Grande.

In sediment samples collected in Los Alamos Canyon in 2011 and 2012, americium-241, cesium-137, and strontium-90 concentrations were below the LANL residential SALs and were near background levels with the exception of one sediment sample collected in 2011. The 2011 sample from Los Alamos Canyon above the low-head weir had a strontium-90 concentration above the LANL residential SAL and is associated with ash and sediment from burn areas. All other 2011 and 2012 sediment samples collected in Los Alamos Canyon had strontium-90 concentrations below background levels.

F. CONCLUSIONS

The Las Conchas Fire burned areas of Santa Fe National Forest upgradient of Laboratory property, resulting in increased ash and sediment transport into Water, Pajarito, and Los Alamos Canyon watersheds in 2011 and 2012. Ash and sediment accumulate in storm water during active flooding and in floodplain deposits after monsoonal rains have ended. Following the Cerro Grande Fire in May 2000, ash and sediment transport returned to pre-fire levels in 3 to 5 years (Gallaher and Koch 2004, 2005). A similar return to pre-fire conditions is expected for the Las Conchas Fire.

Storm water samples collected in 2012 downgradient of burned areas contained increased concentrations of ash and sediment. These samples contained correspondingly increased concentrations of background and fallout constituents transported with ash and sediment in storm water. Elevated concentrations of inorganic and organic chemicals and radionuclides in storm water were observed, including: aluminum, arsenic, barium, copper, cyanide, manganese, selenium, zinc, PCBs, gross alpha, radium-226, radium-228, americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, and uranium-238.

Concentrations of constituents in storm water decrease as ash and sediment are deposited on floodplains and at other LANL-constructed and -maintained flood- and sediment-control features such as wetlands, detention basins, sediment traps, and weirs. In 2012, the Pueblo Canyon wetland reduced storm water discharge such that the gage station downstream of the wetland and grade-control structure did not measure any discharge. The Los Alamos Canyon low-head weir reduced peak discharges and storm water

concentrations of almost all constituents, particularly those elevated because of ash and sediment from Las Conchas burn areas. Ash and sediment were trapped upstream of the Pajarito Canyon flood-control structure, reducing sediment transport downstream.

Human health and ecological risk assessments have been performed as part of each of the Canyons IRs conducted under the Consent Order. The human health risk assessments in those reports have concluded that concentrations of contaminants present in canyons media are within acceptable limits for applicable exposure scenarios. The sediment data presented in this report are used to verify the conceptual model that the scale of storm-water-related contaminant transport observed in LANL canyons generally results in lower concentrations of contaminants in the new sediment deposits than previously existed in deposits in a given reach. The results of the sediment data comparisons collected from flood-affected canyons in 2012 verify the conceptual model and support the premise that the risk assessments presented in the Canyons IRs represent an upper bound of potential risks in the canyons.

G. REFERENCES

- DOE 1991: "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," U.S. Department of Energy document DOE/EH-0173 (January 1991).
- DOE 2002: "A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota," U.S. Department of Energy Standard, DOE-STD-1153-2002 (2002).
- DOE 2003: "Strategy for Evaluation of Surface Water Quality Relative to DOE Order 5400.5," U.S. Department of Energy memorandum from R.J. Borders, Albuquerque Operations Office, to G. Turner, Los Alamos Site Office (January 9, 2003).
- DOE 2004: "RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation, User's Guide, Version 1," Interagency Steering Committee on Radiation Standards Technical Report 2004-02, DOE/EH-0676 (2004).
- DOE 2008: "Environmental Protection Program," U.S. Department of Energy Order 450.1A (June 4, 2008).
- EPA 2006: "National Recommended Water Quality Criteria," U.S. Environmental Protection Agency, Office of Water, <http://www.epa.gov/waterscience/criteria/wqctable> (2006).
- EPA 2010: "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin and Dioxin-Like Compounds," U.S. Environmental Protection Agency, Office of Science Advisor, Risk Assessment Forum, <http://www.epa.gov/raf/files/tefs-for-dioxin-epa-00-r-10-005-final.pdf> (2010).
- Gallaher 2007: Gallaher, B.M., "Watershed Monitoring," in *Environmental Surveillance at Los Alamos During 2006*, Los Alamos National Laboratory document LA-14341-ENV, pp. 195–230 (September 2007).
- Gallaher and Koch 2004: Gallaher, B.M., and R.J. Koch, "Cerro Grande Fire Impacts to Water Quality and Stream Flow near Los Alamos National Laboratory: Results of Four Years of Monitoring," Los Alamos National Laboratory document LA-14177 (September 2004).
- Gallaher and Koch 2005: Gallaher, B.M., and R.J. Koch, "Water Quality and Stream Flow After the Cerro Grande Fire: A Summary," Los Alamos National Laboratory document LALP-05-009 (2005).
- LANL 2004: "Los Alamos and Pueblo Canyons Investigation Report," Los Alamos National Laboratory document LA-UR-04-2714 (April 2004).
- LANL 2005a: "Los Alamos and Pueblo Canyons Supplemental Investigation Report," Los Alamos National Laboratory document LA-UR-05-9230 (December 2005).
- LANL 2006: "Mortandad Canyon Investigation Report," Los Alamos National Laboratory document LA-UR-06-6752 (October 2006).

- LANL 2008a: "Interim Measure Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons," Los Alamos National Laboratory document LA-UR-08-1071 (February 2008).
- LANL 2008b: "Supplemental Interim Measures Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons," Los Alamos National Laboratory document LA-UR-08-6588 (October 2008).
- LANL 2009a: "Pajarito Canyon Investigation Report, Revision 1," Los Alamos National Laboratory document LA-UR-09-4670 (August 2009).
- LANL 2009b: "Investigation Report for Sandia Canyon," Los Alamos National Laboratory document LA-UR-09-6450 (October 2009).
- LANL 2009c: "North Canyons Investigation Report, Revision 1," Los Alamos National Laboratory document LA-UR-09-6794 (October 2009).
- LANL 2009d: "Cañada del Buey Investigation Report, Revision 1," Los Alamos National Laboratory document LA-UR-09-7317 (November 2009).
- LANL 2009e: "Radionuclide Screening Action Levels (SALs) from RESRAD, Version 6.5," Los Alamos National Laboratory document LA-UR-09-8111 (December 2009).
- LANL 2011a: "Investigation Report for Potrillo and Fence Canyons, Revision 1," Los Alamos National Laboratory document LA-UR-11-1820 (March 2011).
- LANL 2011b: "Investigation Report for Ancho, Chaquehui, and Indio Canyons, Revision 1," Los Alamos National Laboratory document LA-UR-11-3305 (June 2011).
- LANL 2011c: "Investigation Report for Water Canyon/Cañon de Valle," Los Alamos National Laboratory document LA-UR-11-5478 (September 2011).
- LANL 2011d: "2010 Geomorphic Changes at Sediment Transport Mitigation Sites in the Los Alamos and Pueblo Canyon Watersheds," Los Alamos National Laboratory document LA-UR-11-2970 (May 2011).
- LANL 2011e: "2011 Interim Facility-Wide Groundwater Monitoring Plan, Revision 1," Los Alamos National Laboratory document LA-UR-11-6958 (December 2011).
- LANL 2012a: "2011 Geomorphic Changes at Sediment Transport Mitigation Sites in the Los Alamos and Pueblo Canyon Watersheds," Los Alamos National Laboratory document LA-UR-12-21330 (May 2012).
- LANL 2012b: "Los Alamos National Laboratory Environmental Surveillance Program Sampling and Analysis Plan for Sediment, 2012," Los Alamos National Laboratory document LA-UR-12-1132 (March 2012).
- LANL 2012c: "2012 Monitoring Plan for Los Alamos and Pueblo Canyons Sediment Transport Mitigation Project, Revision 2," Los Alamos National Laboratory document LA-UR-12-24779 (September 2012).
- LANL 2012d: "Interim Facility-Wide Groundwater Monitoring Plan for the 2013 Monitoring Year, October 2012–September 2013," Los Alamos National Laboratory document LA-UR-12-21331 (August 2012).
- LANL 2012e: "Polychlorinated Biphenyls in Precipitation and Stormwater within the Upper Rio Grande Watershed," Los Alamos National Laboratory document LA-UR-12-1081 (May 2012).
- LANL 2013a: "2012 Geomorphic Changes at Sediment Transport Mitigation Sites in the Los Alamos and Pueblo Canyon Watersheds," Appendix A in *Storm Water Performance Monitoring in the Los*

- Alamos/Pueblo Watershed during 2012*, Los Alamos National Laboratory document LA-UR-13-22113 (March 2013).
- LANL 2013b: “Background Metals Concentrations and Radioactivity in Storm Water on the Pajarito Plateau, Northern New Mexico,” Los Alamos National Laboratory document LA-UR-13-22841 (April 2013).
- Malmon et al. 2004: Malmon, D.V., S.L. Reneau, and T. Dunne, “Sediment Sorting and Transport by Flash Floods,” *Journal of Geophysical Research: Earth Surface* 109, F02005 (June 2004).
- Malmon et al. 2007: Malmon, D.V., S.L. Reneau, D. Katzman, A. Lavine, and J. Lyman, “Suspended Sediment Transport in an Ephemeral Stream Following Wildfire,” *Journal of Geophysical Research: Earth Surface* 112, F02006 (June 2007).
- McLin and Lyons 2002: McLin, S.G., and D.W. Lyons, “Background Radioactivity in River and Reservoir Sediments near Los Alamos, New Mexico,” Los Alamos National Laboratory document LA-13603-MS (May 2002).
- McLin 2004: McLin, S.G., “Background Radioactivity in Sediments near Los Alamos, New Mexico,” *Science of the Total Environment* 328, 143–159 (2004).
- McDonald et al. 2003: McDonald, E.V., R.T. Ryti, S.L. Reneau, and D. Carlson, “Natural Background Geochemistry of Sediments, Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-03-2661 (May 2003).
- McNaughton et al. 2008: McNaughton, M., P. Fresquez, and B. Eisele, “Site-Representative Biota Concentration Guides at Los Alamos,” Los Alamos National Laboratory document LA-UR-08-2783 (2008).
- NMED 2009: “Surface Water Quality Bureau, Monitoring and Assessment Section, Pajarito Plateau Assessment for the 2010–2012 Integrated List,” New Mexico Environment Department, <http://www.nmenv.state.nm.us/swqb/303d-305b/2010-2012/Pajarito/index.html>, accessed December 18, 2009.
- NMED 2011: “Procedures for Assessing Standards Attainment for Section §303(d)/§305(b) Integrated Report: Assessment Protocol,” New Mexico Environment Department, Surface Water Quality Bureau <ftp://ftp.nmenv.state.nm.us/www/swqb/MAS/Protocols/AssessmentProtocol+Appendices.pdf>, accessed August 2, 2011.
- NMED 2012: “Risk Assessment Guidance for Site Investigations and Remediation,” New Mexico Environment Department, Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program (February 2012, updated June 2012).
- NMWQCC 2013: “State of New Mexico Standards for Interstate and Intrastate Surface Waters,” New Mexico Water Quality Control Commission, 20.6.4 NMAC (as amended by the WQCC through February 14, 2013), at <http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.pdf> (2013).
- Reneau et al. 2010: Reneau, S.L., P.G. Drakos, A.R. Groffman, J. Linville, R.T. Ryti, K.B. Schilling, E.S. Schultz-Fellenz, W.L. Swanson, and S.J. Veenis, “Watershed Monitoring,” in *Environmental Surveillance at Los Alamos During 2009*, Los Alamos National Laboratory document LA-14427-ENV, pp. 207–252 (September 2010).
- Ryti et al. 1998: Ryti, R.T., P.A. Longmire, D.E. Broxton, S.L. Reneau, and E.V. McDonald, “Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-98-4847 (September 1998).

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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. Soil is an integrating medium that may receive substances released to the atmosphere, particles resuspended and transported by wind, and substances in water used for irrigation. Consequently, soil contaminant data may provide information about potential pathways that could deliver radioactive materials or chemicals to humans and biota. Environmental soil monitoring was conducted in 2012 at Los Alamos National Laboratory (LANL or the Laboratory) with the primary objective of measuring chemicals and radionuclides and then comparing measurements with human health screening levels. The soil monitoring program at the Laboratory supports the following Environmental Grand Challenges—*eliminate industrial emissions, discharges, and releases into the environment* and *protect human and environmental health by managing and restoring lands*.

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 may receive substances released to the atmosphere, particles resuspended and transported by wind, and substances in water used for irrigation. Consequently, soil contaminant data may provide information about potential pathways (e.g., soil ingestion, food ingestion, resuspension 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, at the Laboratory consists of the following:

- 1) An institutional component that monitors surface soil within and around the perimeter of LANL in accordance with U.S. Department of Energy (DOE) Orders 436.1 (DOE 2011a) and 458.1 (DOE 2011b)
- 2) A facility component that monitors surface soil (and sediment) within and around the perimeter of two Laboratory sites:
 - The principal radioactive waste disposal area (Area G) in accordance with DOE Order 435.1 (DOE 1999a) and DOE Manual 435.1-1 (DOE 1999b)
 - The principal explosive test facility (Dual-Axis Radiographic Hydrodynamic Test [DARHT] facility) in accordance with the mitigation action plan (DOE 1996).
- 3) A special studies component that investigates cases where there may be an absence of data in areas that have the potential to impact human health and/or the environment as mandated from mitigation action plans, the Laboratory's Environmental Surveillance Program, or public concern.

The objectives of LANL's soil surveillance program are to monitor for new operational releases of radionuclides and chemicals, to assess trends in concentrations that resulted from historic operational releases, and to provide data for dose and risk assessments. The program

- 1) measures concentrations of radionuclides and other chemicals that have had a history of use at LANL in soil from on-site and perimeter locations and compares those concentrations with regional background locations and data from previous years,
- 2) assesses radionuclides and/or chemical concentrations in soil over time (i.e., are concentrations increasing or decreasing?), and
- 3) collects samples needed to estimate the committed effective dose equivalent from radionuclides 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 determines the likelihood of risk to residents and biota from metal and organic chemical exposures.

B. SOIL COMPARISON LEVELS

To evaluate the presence and potential effects of Laboratory-derived radionuclides and chemicals in surface soil, we first compare the analytical (detected) results of samples collected from the Laboratory's on-site and perimeter areas with regional statistical reference levels (RSRLs). If the detected results exceed these regional background levels, we then compare the concentrations with human health– (dose-) based screening levels (SLs) and finally, if needed, with the appropriate regulatory standard, if available. More detailed descriptions of the RSRLs, the SLs, and the regulatory standard used to evaluate the sampling results 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) of the activities of radionuclides or the concentrations of nonradioactive chemicals in surface soil collected from background locations away from the influence of the Laboratory (>9 mi) (DOE 1991). RSRLs, which represent natural and fallout levels (or anthropogenic sources not from the Laboratory), 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 at levels below the DOE single-pathway protective dose constraint of 25 millirems per year (mrem/yr) (DOE 1999c, 2011b), so that potential human health concerns may be identified in advance. If a radionuclide exceeds the SL, we investigate the basis for the higher amount, 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 multiple exposure scenarios (residential or industrial) (LANL 2009) using the residual radioactivity (RESRAD) computer model (Yu et al. 1995).

For other chemicals (inorganic and organic), we compare concentrations with 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 1 for noncarcinogens (NMED 2009).

To evaluate radionuclides 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.

- **Regulatory Standards:** 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 based on a residential exposure scenario. (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 et al. (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 BSRL = 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 6 regional background locations on a triennial basis (every third year) (Figure 7-1). Most locations have been sampled for radionuclides since the early 1970s (Purtymun et al. 1980, 1987). The last comprehensive soil survey, which included the analysis of radionuclides, target analyte list (TAL) inorganic elements (mostly metals), polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and high explosives (HE), occurred in 2009 (Fresquez 2010).

Areas sampled at LANL are not from areas referred to as solid waste management units (SWMUs) or areas of concern (AOCs). Instead, the majority of on-site soil sampling stations are located on undisturbed mesa tops close to and, if possible, downwind from major facilities or operations at LANL in an effort to assess soil that may have been contaminated from stack emissions and fugitive dust (the resuspension of dust from SWMUs/AOCs and active firing sites).

On-site samples were collected from Technical Area 16 (TA-16) (S-Site), TA-21 (DP Site), near TA-33, north of TA-50/TA-35 at TA-60, TA-51, west of TA-53, east of TA-53, east of TA-54, Potrillo Drive at TA-36, near Test Well DT-9 at TA-49, R-Site Road east at TA-15, and Two-Mile Mesa at TA-06. We also collected four additional samples from along the south side of NM 502 within the TA-73 boundary; these points are downwind of TA-21 (the former plutonium processing facility) and associated SWMUs/AOCs, including Material Disposal Areas (MDAs) A, B, and T.

The 11 perimeter stations, located within 2.5 mi of the Laboratory, were sampled to determine the soil conditions of the inhabited areas to the north (North Mesa, Sportsman's Club, Quemazon Trail, west airport, and east airport) and east of the Laboratory (White Rock, San Ildefonso, Otowi, and Tsankawi/PM-1). Additional samples were collected west of U.S. Forest Service property (across from TA-08) and south on Bandelier National Monument property (near TA-49) to provide comprehensive coverage.

Soil sample (analysis) data from on-site and perimeter stations were compared with RSRLs. These RSRLs are derived from samples collected from northern New Mexico regional 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 DOE, all locations are at elevations similar to LANL elevations, are more than 20 mi away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (>9 mi) (DOE 1991).

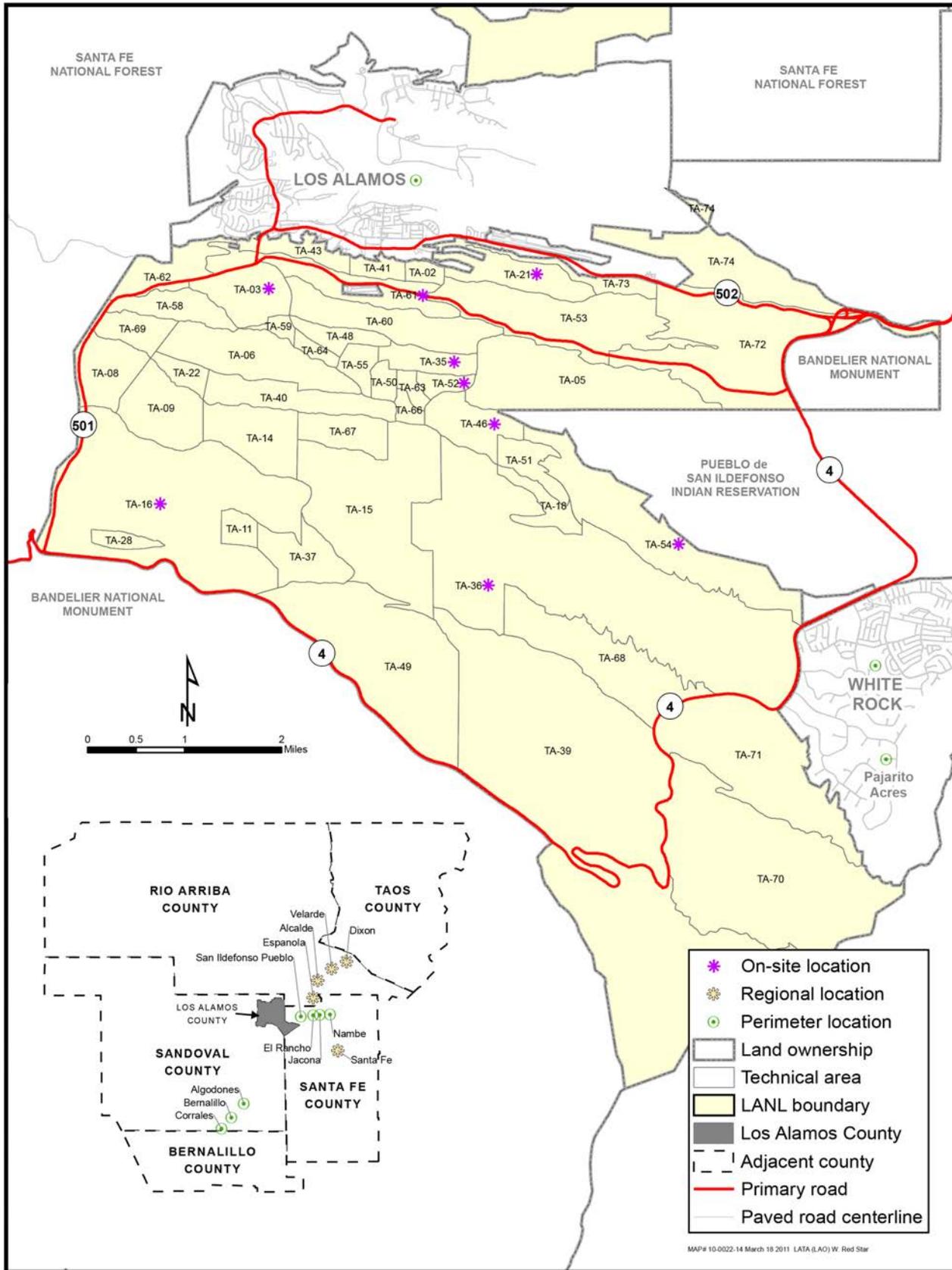


Figure 7-1 On-site, perimeter, and regional soil-sampling locations. The Otowi perimeter station is not shown but is about 5 mi east of LANL near the confluence of Los Alamos Canyon and the Rio Grande.

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 in. in diameter pushed 2 in. 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 inorganic 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).

In addition, soil grab samples from each site were collected from the 0 to 6-in. depth with disposable polystyrene scoops for the analysis of 7 PCB Aroclors, 65 SVOCs, and 20 HE compounds. Each individual sample was placed into a pre-labeled 500-mL amber-colored glass jar, sealed with chain-of-custody tape, placed into a Ziploc bag, and immediately cooled to 4°C. All samples were handled and shipped under full chain-of-custody procedures to GEL (General Engineering Laboratory) Analytics, Inc., for analysis.

The results from these sample analyses are presented in supplemental Tables S7-1 through S7-5. (Note: We report on the analyses of radionuclides and TAL elements in vegetation collected from these same sites in Chapter 8, Section B.3.)

3. Radionuclides

All radionuclide concentrations (activities) in soil collected from perimeter and on-site areas in 2012 were very low (the picocuries per gram [pCi/g] range), and most were either not detected or similar to RSRLs (based on 2002–2012 data; $n = 25$) (Table S7-1). A nondetected value is one in which the result is less than the minimum detectable activity or lower than three times the counting uncertainty ($\alpha = 0.01$, or 99% confidence level) (Keith 1991, Corely et al. 1981).

The only radionuclide detected in perimeter and on-site soils that was significantly higher than the RSRL was plutonium-239/240. Plutonium-239/240 was higher than the RSRL in soil collected from the Otowi and Airport West perimeter sites and from the East of TA-54 and TA-73/SR (State Road) 502 (middle and east) on-site locations. All plutonium-239/240 concentrations, however, in these areas were far below the RSL of 33 pCi/g dry. Plutonium-239/240 concentrations in these areas are not increasing over time (Figure 7-2). In general, plutonium-239/240 in soil from the Otowi site may be attributed to sediment migration from the Los Alamos Canyon watershed (Gallagher and Efurud 2002a, 2002b); plutonium-239/240 in soil from the Airport West site and all of the TA-73/SR 502 sites may be attributed to the former plutonium processing facility at TA-21; and plutonium-239/240 in soil from the East of TA-54 site may be attributed to Area G at TA-54 (see Section D.2.a for a more detailed analysis of soil samples collected directly around the perimeter of Area G).

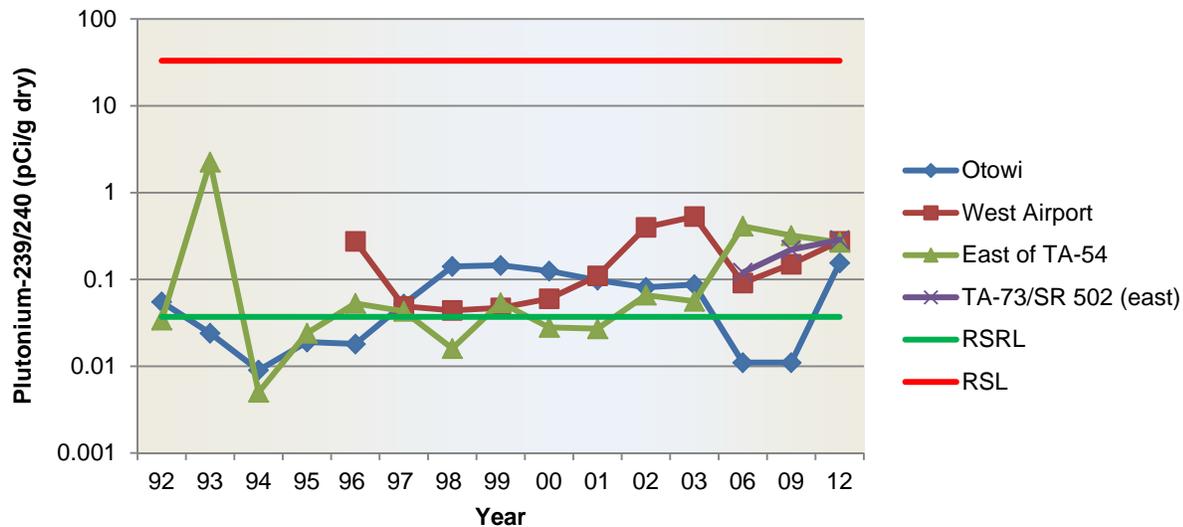


Figure 7-2 Plutonium-239/240 (detected and nondetected) concentrations in soil samples collected from perimeter (Otowi and West Airport) and on-site (East of TA-54 and TA-73/SR 502) lands from 1992 through 2012 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

4. TAL Elements

Table S7-2 shows the results of the TAL element analyses in surface soil collected from regional, perimeter, and on-site areas in 2012. All metal concentrations, including beryllium and mercury, in perimeter and on-site locations were either not detected or were not different from RSRLs (based on 2002–2012 data; n = 18).

5. HE, PCBs, and SVOC Chemicals

Concentrations of HE, PCBs (Aroclors), and SVOCs in soils collected from regional, perimeter, and on-site locations can be found in Tables S7-3, S7-4, and S7-5, respectively.

No concentrations of HE were detected in any of the regional, perimeter, or on-site soils.

Trace amounts of PCB Aroclor-1254 and/or -1260 were detected in one regional, two perimeter, and six on-site areas (Table S7-4). All were far below residential (1.1 milligrams per kilogram [mg/kg]) or industrial (8.3 mg/kg) SLs.

Most SVOCs in regional, perimeter, and on-site soils were not detected above the method detection limit (MDL). There were a few trace amounts (above the MDL but below the detection limit [DL]) of SVOCs, including some in regional soils, but the majority of detectable (>DL) SVOCs of any significance were found in soils associated with the TA-73/SR 502 sampling sites across from the Los Alamos Airport (Table S7-5). These SVOCs (mostly polycyclic aromatic hydrocarbons) detected at two (east and west ends) of the four TA-73/SR 502 sites are probably from common asphalt (tar) materials (Kitto et al. 1997). In the past year, a walking/biking path was constructed out of asphalt for public use along the length of the Los Alamos Canyon rim adjacent to the sampling sites. In other words, the SVOCs detected were probably associated with common townsite road materials and not associated with any Laboratory activities.

With the exception of benzo(a)pyrene (<5.4 mg/kg), all other SVOCs, particularly anthracene (<2.5 mg/kg) benzo(a)anthracene (<3.9 mg/kg), benzo(b)fluoranthene (<6.2 mg/kg), benzo(g,h,i)perylene (<2.0 mg/kg), benzo(k)fluoranthene (<2.1 mg/kg), and chrysene (<3.8 mg/kg), were far below the RSLs.

D. FACILITY MONITORING

1. Monitoring Network for Area G at TA-54

The Laboratory has conducted facility-specific soil monitoring at Area G since 1980 (Environmental Surveillance Group 1981, Mayfield and Hansen 1983). Area G is a 63-acre radioactive waste processing area located on the east end of Mesita del Buey at TA-54 (Lopez 2002) (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, Sohlt 1990). Tritium, plutonium, americium, uranium, and a variety of fission and activation products are the main radionuclides in waste materials at Area G (DOE 1979).

Thirteen surface soil samples were collected in May 2012 at designated locations around the perimeter of Area G, and one surface soil sample (site T3) was collected at the LANL/Pueblo de San Ildefonso boundary line approximately 800 ft northeast, downwind, and downgradient of Area G in Cañada del Buey (Figure 7-3). (Note: We report on the analyses of vegetation collected around the Area G facility in Chapter 8, Section B.4.a.)

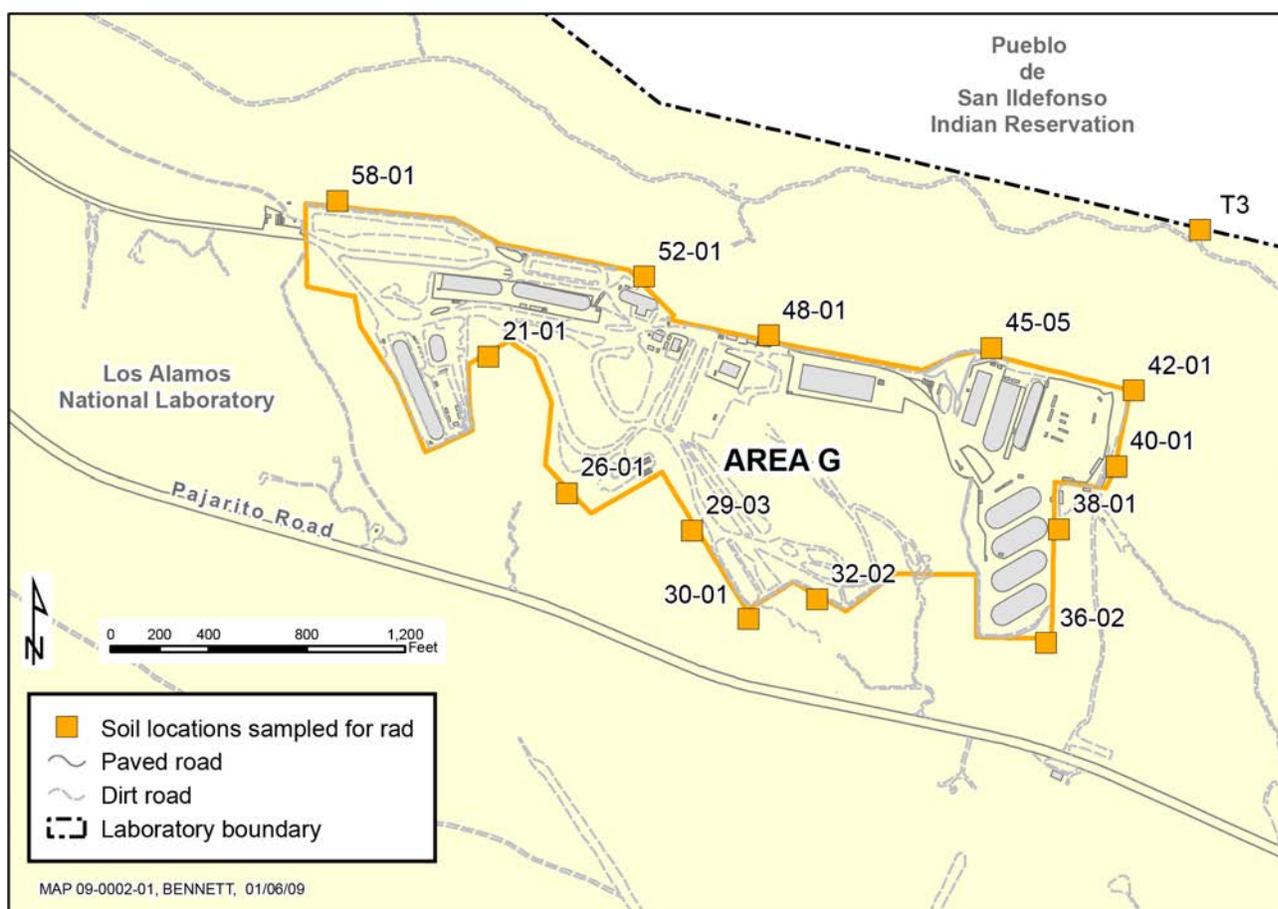


Figure 7-3 Locations of soil samples collected around Area G in 2012

All samples were analyzed by ALS Laboratory Group 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 at Area G were not analyzed because previous sampling showed no levels of concern. Results from previous sampling periods for most metals (478 out of 483 measurements) were similar to RSRLs (Fresquez 2007), and the few detected above RSRLs were far below the ISLs with no evident trends.

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 2012 (Table S7-6). These data are similar to past years.

Specifically, tritium was detected above the RSRL (0.77 picocuries per milliliter [pCi/mL]) in the same three locations as in years past. These areas are located in the southern portion of Area G where the tritium shafts are buried; site 29-03 had 388 pCi/mL, site 30-01 had 90 pCi/mL, and site 32-02 had 2.8 pCi/mL. Although these data are within the range of concentrations detected in past years and are generally not increasing over time, they are variable from year to year (Figure 7-4).

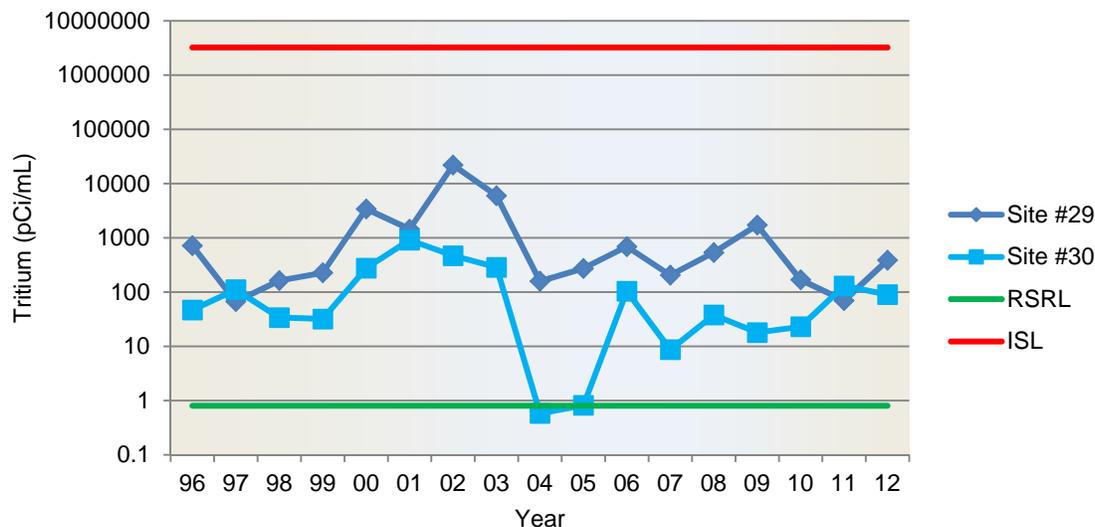


Figure 7-4 Tritium concentrations in surface soil samples collected from the southern portions of Area G at TA-54 from 1996 through 2012 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

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 $3.1E06$ 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 fenceline outward (approximately 33, 165, 330, 490, and 660 ft), showed that the concentrations of tritium decreased greatly with distance; by 330 ft away, the concentrations of tritium were not different from the RSRL (Fresquez et al. 2003).

Many 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 S7-6). The highest concentrations of americium-241 (0.52 pCi/g dry at site 38-01), plutonium-238 (2.4 pCi/g dry at site 45-05), and plutonium-239/240 (2.6 pCi/g dry at site 38-01) were detected in soil samples mostly 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 of most radionuclides at most sites are generally not increasing over time (Figures 7-5, 7-6, and 7-7). An exception may be concentrations of plutonium-239/240 in soil collected from the eastern side of Area G (site 38), which tends to contain higher concentrations as a whole in later years (2006–2012) versus earlier years (1996–2005).

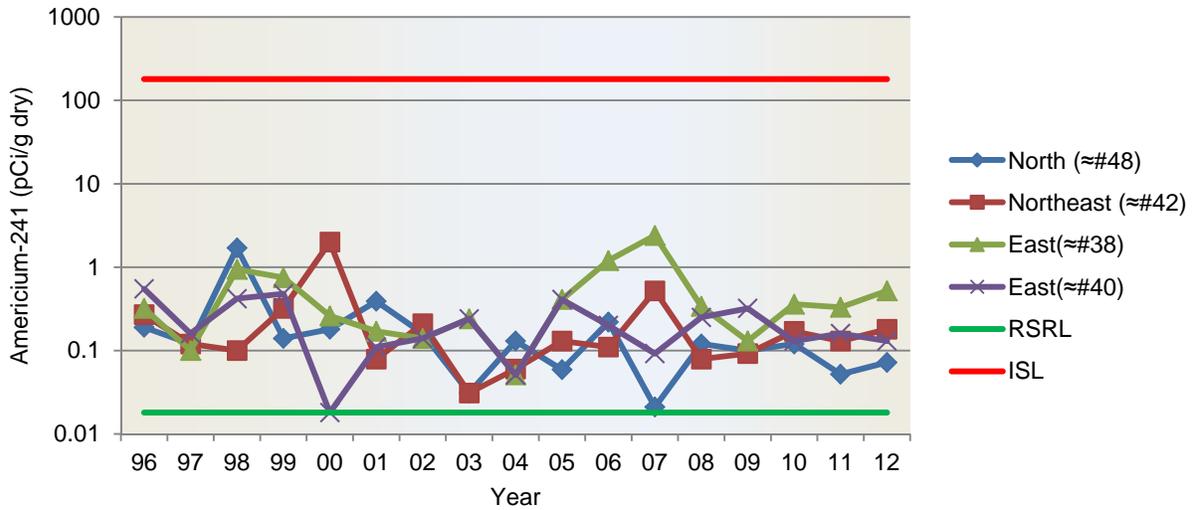


Figure 7-5 Americium-241 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2012 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

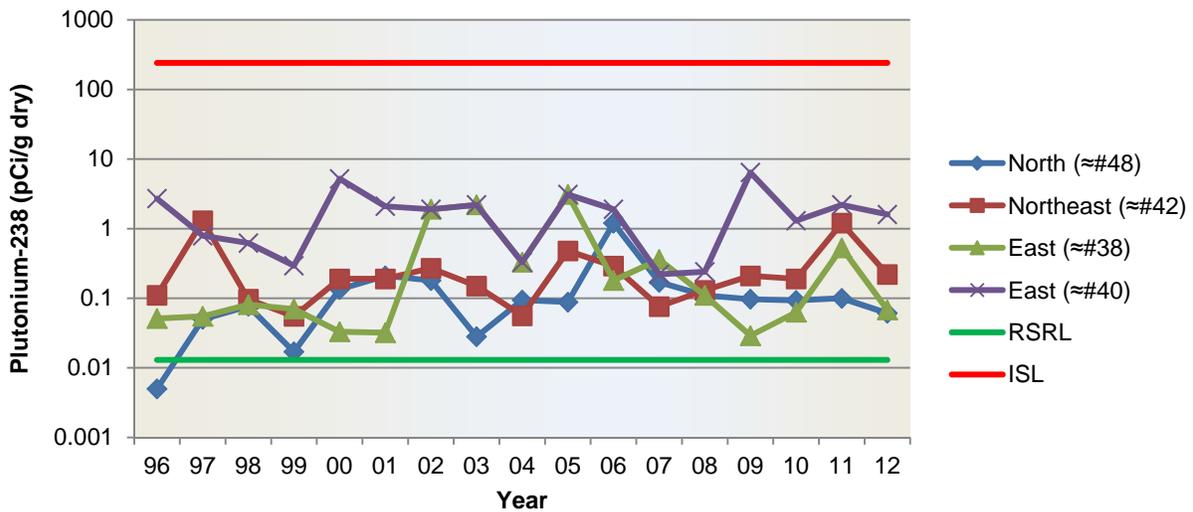


Figure 7-6 Plutonium-238 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2012 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

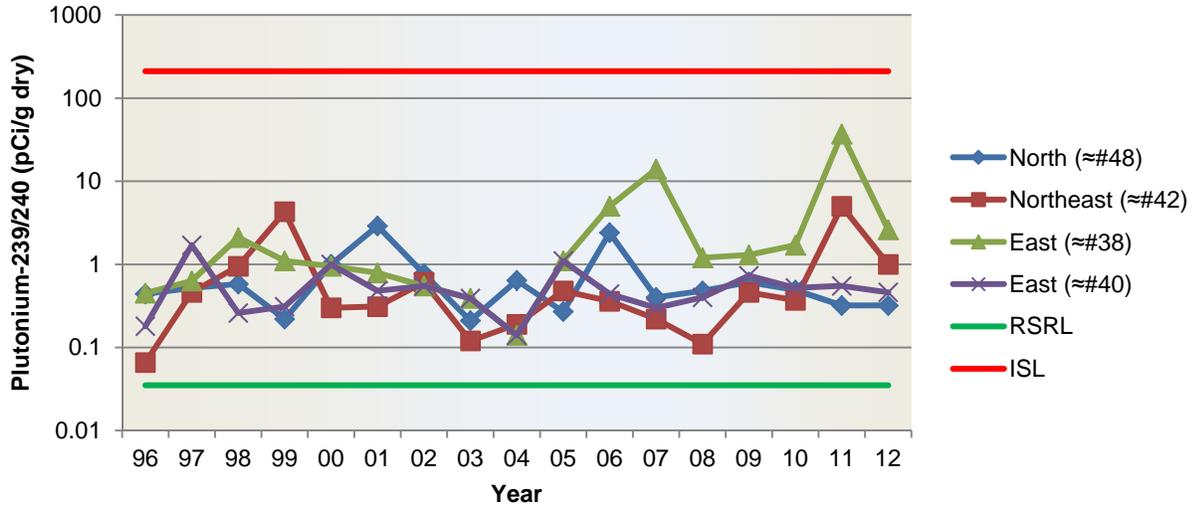


Figure 7-7 Plutonium-239/240 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2012 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

b. Results at the Pueblo de San Ildefonso Boundary

Plutonium-238 and plutonium-239/240 were detected at concentrations just above the RSRLs in 2012 in a soil sample collected at the LANL/Pueblo de San Ildefonso boundary northeast, downwind, and downgradient of Area G in Cañada del Buey (Site T3) (Table S7-6). However, the levels of these radionuclides, including americium-241, are far below the RSLs and have generally remained stable over the 6-yr period of study (Figures 7-8, 7-9, and 7-10).

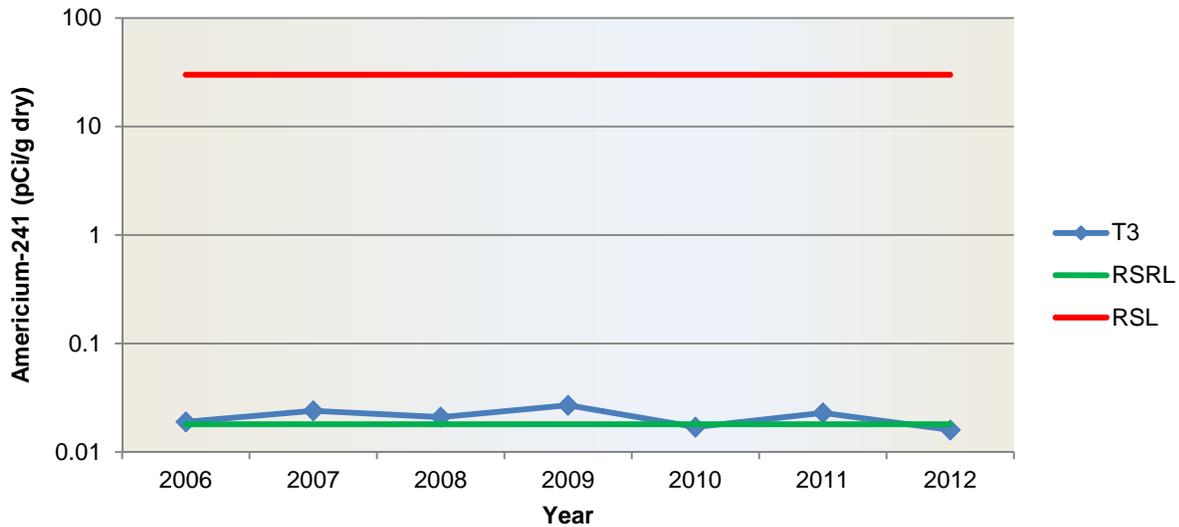


Figure 7-8 Americium-241 (detected and nondetected) concentrations in surface soil collected from the LANL/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 through 2012 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

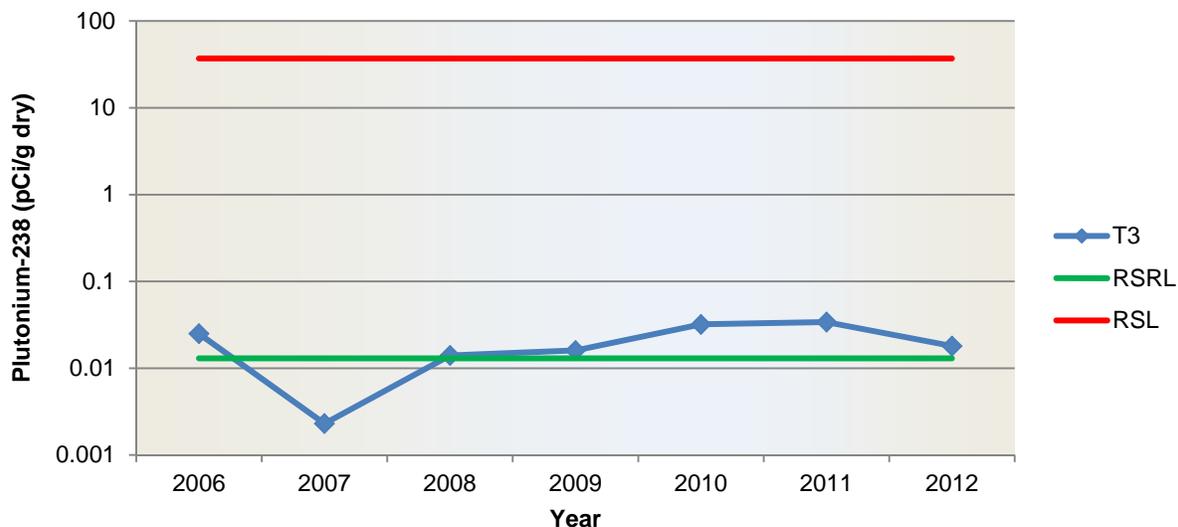


Figure 7-9 Plutonium-238 (detected and nondetected) concentrations in surface soil collected from the LANL/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 through 2012 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

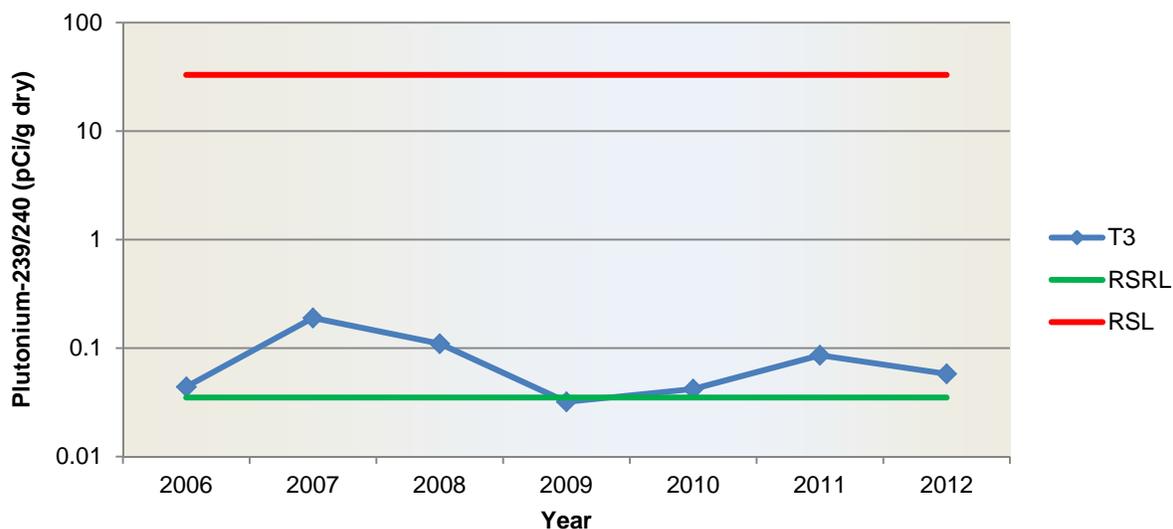


Figure 7-10 Plutonium-239/240 (detected and nondetected) concentrations in surface soil collected from the LANL/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 through 2012 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

3. Monitoring Network for DARHT at TA-15

The Laboratory has conducted facility-specific soil and sediment monitoring on an annual basis at the DARHT facility since 1996 (Nyhan et al. 2001). Approximately 20 acres in size, DARHT is located at R-Site (TA-15) on 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 nonnuclear mockup 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, four in FY10, three in FY11, and six in FY12) (DOE 2012, Carnes 2013). Potential contaminants of concern include radionuclides, beryllium (and other heavy metals), and organic chemicals like PCBs, SVOCs, and HE.

Soil samples were collected in late April 2012 on the north, east, south, and west sides (Figure 7-11) of the DARHT perimeter along the outside fenceline. An additional soil sample was collected about 75 ft north of the firing point. (The firing point has since been paved, and this was the closest soil site.) Sediment samples were collected on the north, east, south, and southwest sides. All soil and sediment samples were analyzed by ALS Laboratory Group for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, TAL elements, and HE. The firing point sample was also analyzed for dioxins and furans by Cape Fear Analytical. Although not analyzed for in 2012, 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.)

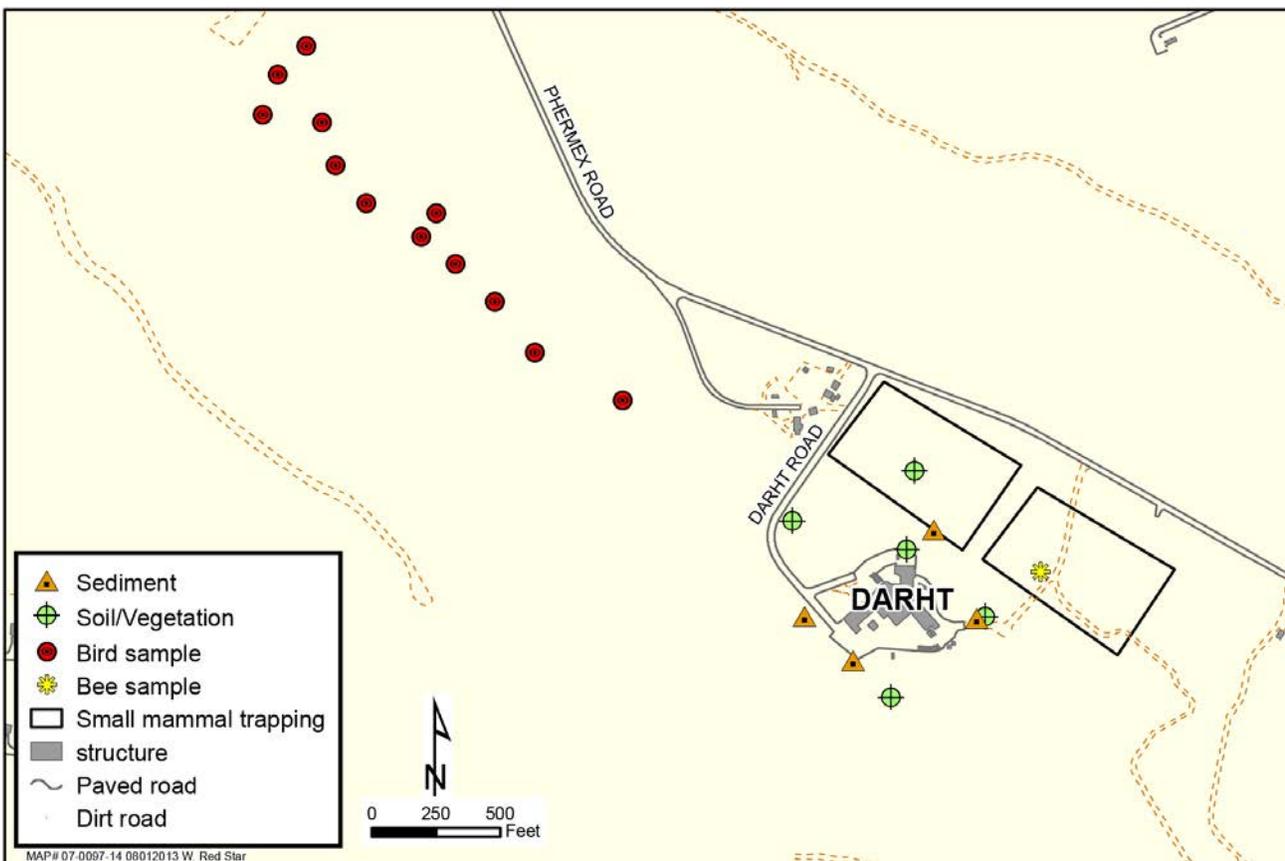


Figure 7-11 Soil, sediment, and biota sample locations at DARHT in 2012

We compared the radionuclide and TAL element results in soil and sediment from the DARHT sampling with 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 fenced perimeter boundary (>300 ft from the facility). This may have affected the postoperational concentrations of some radionuclides, particularly cesium-137 (fallout), relative to the BSRLs because the preoperation samples were collected in mostly disturbed soil, and the postoperation 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 postoperation start-up samples, for example, substantially decreased the detection limit of silver from 2 to 0.2 mg/kg.

4. Radionuclide and Chemical Analytical Results for DARHT

Most radionuclides in soil and sediment collected from within and around the perimeter of the DARHT facility were either not detected or detected below both the BSRLs and the RSRLs (Table S7-7). Those few radionuclides that were above the statistical reference levels, however, were far below the ISLs and do not pose an unacceptable dose to any site workers.

The only radionuclides in soil and sediments around the DARHT site that have consistently measured higher than the BSRLs over the years are the uranium isotopes, primarily uranium-238 in the soil sample collected nearest the firing point. Uranium-238 concentrations in the soil samples collected nearest the firing point peaked in 2008 (55 pCi/g dry). Probably because operations have changed to include the use of closed containment vessels (and subsequent cleanup of debris around the site), the concentrations of uranium-238 within the facility have decreased dramatically to baseline levels (Figure 7-12). Concentrations of uranium-238 in soil samples collected around the perimeter of the DARHT facility have generally remained close to the baseline levels. This year, however, one perimeter soil sample out of the four collected measured higher than normal for uranium-238; the north perimeter soil sample measured 39 pCi/g, which accounts for the spike in 2012. Because open-air detonations occurred from 2000 through 2006, it is not unexpected to find small particles of depleted uranium in the soil around the site on occasion.

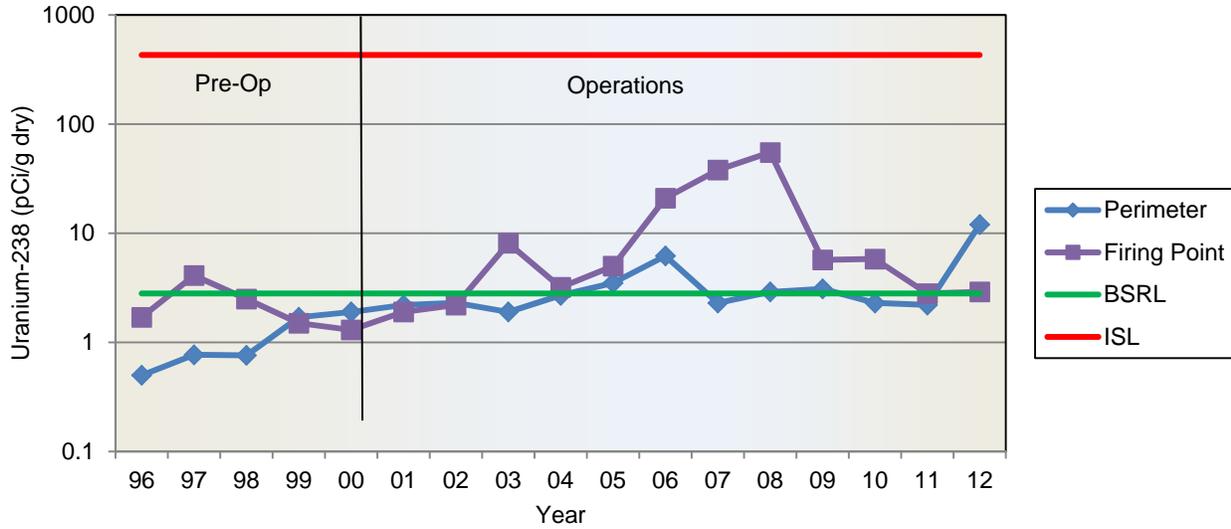


Figure 7-12 Uranium-238 concentrations in surface soil collected within (near the firing point) and around the DARHT perimeter (north-, west-, south-, and east-side average) at TA-15 from 1996–1999 (preoperations) to 2000–2012 (operations) compared with the BSRL and the ISL. Note the logarithmic scale 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 BSRLs and the RSRLs (Table S7-8). Beryllium, listed as a chemical of concern before 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 13-yr operations period have remained stable over time (Figure 7-13).

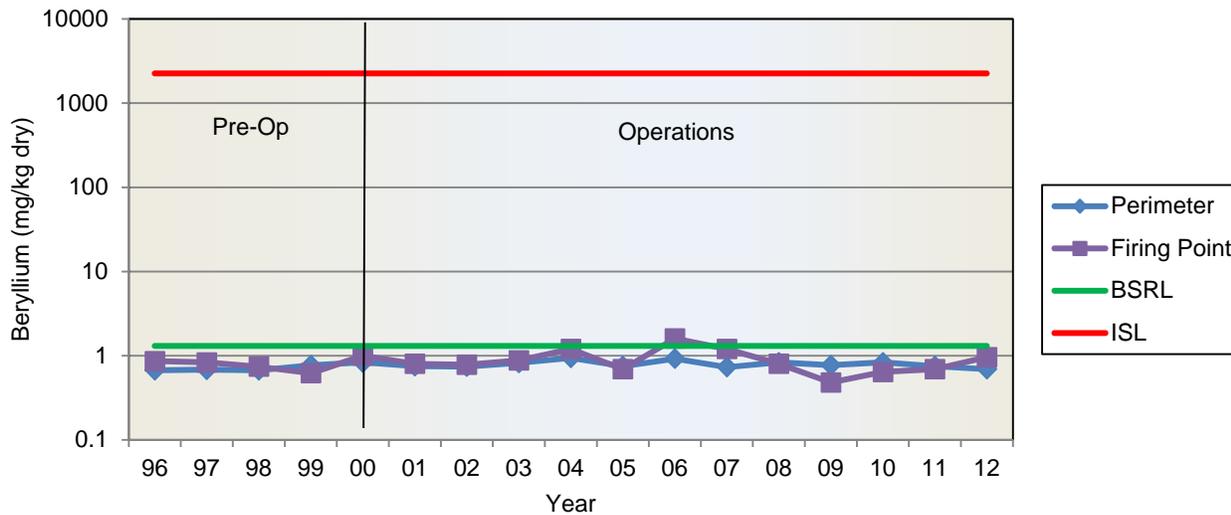


Figure 7-13 Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north-, west-, south-, and east-side average) at TA-15 from 1996–1999 (preoperations) to 2000–2012 (operations) compared with the BSRL and the ISL. Note the logarithmic scale on the vertical axis.

None of the 20 HE chemicals analyzed for were 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 S7-9). Also, most dioxins and furans were not detected above the MDLs in the soil sample nearest the firing point (Table S7-10). (Note: Trace amounts of 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin were found. Trace amounts of 1,2,3,4,6,7,8-heptachlorodibenzodioxin were detected last year.)

E. SPECIAL MONITORING STUDIES

No special soil monitoring studies were conducted in 2012.

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 (SOPs):

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program (SOP-5132)
- Sampling Soil and Vegetation at Facility Sites (SOP-5139)

These procedures, which are available on the LANL public website (<http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php>), 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 carefully documented procedures, listed above, which govern all aspects of the sample collection program.

The sampling 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 SFB 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 is assessed. A quality assessment document is created, attached to the data packet, and provided to the project leader.

Field data completeness for SFB in 2012 was 100%.

3. Analytical Laboratory Quality Assessment

We had no analytical laboratory data quality issues related to the SFB sampling program during 2012. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 10. Analytical data completeness for all SFB sampling programs was 100% in 2012.

G. REFERENCES

- Abeebe and Nyhan 1987: Abeebe, W.V., and J.W. Nyhan, "Emanation and Dispersal of Tritiated Water from Disposal Shafts," *Nuclear and Chemical Waste Management*, 7, 217–226 (1987).
- Budd et al. 2004: Budd, R.L., G.J. Gonzales, P.R. Fresquez, and E.A. Lopez, "The Uptake and Distribution of Buried Radionuclides by Pocket Gophers (*Thomomys bottae*)," *Journal of Environmental Science and Health Part A—Toxic/Hazardous Substances and Environmental Engineering*, 39(3), 611–625 (2004).

- Carnes 2013: Carnes, J., personal communication, January 24, 2013.
- Childs and Conrad 1999: Childs, M., and R. Conrad, "Area G Perimeter Surface-Soil Sampling," Los Alamos National Laboratory document LA-13646-PR (1999).
- Corely et al. 1981: Corely, J.P., D.H. Denham, R.E. Jaquish, D.E. Michels, A.R. Olsen, and D.A. Waite, "A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations," Department of Energy report DOE/EP-0023 (1981).
- DOE 1979: "Final Environmental Impact Statement: Los Alamos Scientific Laboratory Site," Los Alamos, New Mexico, U.S. Department of Energy report DOE/EIS-0018 (1979).
- DOE 1991: "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," U.S. Department of Energy report DOE/EH-0173T (January 1991).
- DOE 1995: "Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement," U.S. Department of Energy report DOE/EIS-0228 (August 1995).
- DOE 1996: "Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," U.S. Department of Energy report DOE/EIS-0228 (January 1996).
- DOE 1999a: "Radioactive Waste Management," U.S. Department of Energy Order 435.1 (July 1999).
- DOE 1999b: "Radioactive Waste Management Manual," U.S. Department of Energy Manual DOE M 435.1-1 (July 1999).
- DOE 1999c: "The Long-Term Control of Property: Overview of Requirements in Orders DOE 5400.1 and DOE 5400.5," U.S. Department of Energy report EH-412-0014/1099 (October 1999).
- DOE 2011a: "Departmental Sustainability," U.S. Department of Energy Order 436.1 (May 2, 2011).
- DOE 2011b: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 458.1 (February 11, 2011).
- DOE 2012: "Dual Axis Radiographic Hydrodynamic Test Facility (DARHT) Mitigation Action Plan Annual Report Fiscal Year 2011," in *Fiscal Year 2012 Site-Wide Environmental Impact Statement Mitigation Action Plan Annual Report, December 2012*, Los Alamos National Laboratory document LA-UR-12-26410 (2012).
- Environmental Surveillance Group 1981: "Environmental Surveillance at Los Alamos during 1980," Los Alamos Scientific Laboratory document LA-8810-ENV (1981).
- Fresquez 2007: Fresquez, P.R., "Soil Monitoring," in *Environmental Surveillance at Los Alamos during 2006*, Los Alamos National Laboratory document LA-14341-ENV (2007), pp. 233–249.
- Fresquez 2008: Fresquez, P.R., "Soil Monitoring," in *Environmental Surveillance at Los Alamos during 2007*, Los Alamos National Laboratory document LA-14369-ENV (2008), pp. 251–266.
- Fresquez 2010: Fresquez, P.R., "Soil Monitoring," in *Environmental Surveillance at Los Alamos during 2009*, Los Alamos National Laboratory document LA-14427-ENV (2010), pp. 255–276.
- Fresquez et al. 1996: Fresquez, P.R., M.A. Mullen, J.K. Ferenbaugh, and R. Perona, "Radionuclides and Radioactivity in Soils within and around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons," Los Alamos National Laboratory document LA-13149-MS (1996).

- Fresquez et al. 2001: Fresquez, P.R., J.W. Nyhan, H.T. Haagenstad, and R. Velasquez, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, and Vegetation around the DARHT Facility," in *Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)*, Los Alamos National Laboratory document LA-13808-MS (2001), pp. 13–40.
- Fresquez et al. 2003: Fresquez, P.R., L. Vasquez-Tator, and E.A. Lopez, "Tritium Concentrations in Vegetation as a Function of Distance from a Low-Level Waste Site at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-14091-MS (2003).
- Gallagher and Efurd 2002a: Gallaher, B.M., and D.E. Efurd, "Plutonium and Uranium from Los Alamos National Laboratory in Sediments of the Northern Rio Grande Valley," Los Alamos National Laboratory document LA-13974 (2002).
- Gallagher and Efurd 2002b: Gallaher, B.M., and D.E. Efurd, "Measurements of Actinides in Soil, Sediments, Water and Vegetation in Northern New Mexico," Los Alamos National Laboratory document LA-UR-02-6501 (2002).
- Keith 1991: Keith, L.H., *Environmental Sampling and Analysis: A Practical Guide*, CRC Press, Boca Raton, FL (1991).
- Kitto et al. 1997: Kitto, A.M., M. Pirbazari, B.N. Badriyha, V. Ravindran, R. Tyner, and C.E. Synolakis, "Emissions of Volatile and Semi-Volatile Organic Compounds and Particulate Matter from Hot Asphalts," *Environmental Technology*, 18(2), 121–138 (1997).
- Hansen et al. 1980: Hansen, W.R., D.L. Mayfield, and L.J. Walker, "Interim Environmental Surveillance Plan for LASL Radioactive Waste Areas," Los Alamos Scientific Laboratory document LA-UR-80-3110 (1980).
- Lopez 2002: Lopez, E., "MDA G and L Environmental Monitoring Plan for FY 2002," Los Alamos National Laboratory document LA-UR-02-6128 (2002).
- LANL 2009: "Radionuclide Screening Action Levels (SALs) from RESRAD, Version 6.5," Los Alamos National Laboratory document LA-UR-09-8111 (2009).
- Mayfield and Hansen 1983: Mayfield, D., and W.R. Hansen, "Surface Reconnaissance through 1980 for Radioactivity at Radioactive Waste Disposal Area G at the Los Alamos National Laboratory" Los Alamos National Laboratory document LA-9556-MS (1983).
- NMED 2009: "Technical Background Document for Development of Soil Screening Levels, Rev. 5.0," New Mexico Environment Department report (2009).
- Nyhan et al. 2001: Nyhan, J.W., P.R. Fresquez, K.D. Bennett, J.R. Biggs, T.K. Haarmann, D.C. Keller, and H.T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory document LA-13808-MS (2001).
- Purtymun 1973: Purtymun, W.D., "Underground Movement of Tritium from Solid Waste Storage Shafts," Los Alamos Scientific Laboratory document LA-5286-MS (1973).
- Purtymun et al. 1980: Purtymun, W.D., R.J. Peters, and A.K. Stoker, "Radioactivity in Soils and Sediments in and Adjacent to the Los Alamos Area, 1974-77," Los Alamos National Laboratory document LA-8234-MS (1980).
- Purtymun et al. 1987: Purtymun, W.D., R.J. Peters, T.E. Buhl, M.N. Maes, and F.H. Brown, "Background Concentrations of Radionuclide in Soils and River Sediments in Northern New Mexico, 1974-1986," Los Alamos National Laboratory document LA-11134-MS (1987).

- Soholt 1990: Soholt, L.F., "Environmental Surveillance of Low-Level Radioactive Waste Management Areas at Los Alamos during 1987," Los Alamos National Laboratory document LA-UR-90-3283 (1990).
- Vold 1997: Vold, E., "Evaluation of Atmospheric Release Sources for Gaseous Phase Contaminants Emanating from the Disposal Facility at Area G," Los Alamos National Laboratory document LA-UR-97-155 (1997).
- Yu et al. 1995: Yu, C., A.J. Zielen, J.J. Cheng, Y.C. Yuan, L.G. Jones, D.J. LePoire, Y.Y. Wang, C.O. Loureiro, E. Gnanapragasam, E. Faillace, A. Wallo III, W.A. Williams, and H. Peterson, "Manual for Implementing Residual Radioactive Material Guidelines using RESRAD, Version 5.60, Argonne National Laboratory report ANL/EAD/LD-2 (1995).

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A wide variety of wild and domestic crops and food products are grown and/or harvested at many locations surrounding Los Alamos National Laboratory (LANL or the Laboratory). The purpose of the foodstuff and biota monitoring programs is to determine whether Laboratory operations are affecting human health, via the food chain, and the environment. The objectives of the programs are to assess populations, composition, and diversity of biota species potentially impacted by LANL operations; to measure radionuclide and chemical concentrations and trends (that have a history of use at LANL) in foodstuffs and biota from on-site (LANL property) and perimeter locations and compare those concentrations with regional (background) areas; and to estimate radiation dose to humans, plants, and animals. The Laboratory's work in foodstuffs and biota sampling supports the Environmental Grand Challenge to *protect human and environmental health by managing and restoring lands*.

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 LANL. Also, many food products from domestic livestock (e.g., milk, eggs, and meat) and apiaries (honey) are available, and fishing in waters downstream of the Laboratory (e.g., the Rio Grande) and hunting (e.g., rabbits, turkey, deer, and elk) on neighboring properties around LANL are a common occurrence.

The purpose of the foodstuff monitoring program is to determine whether Laboratory operations are affecting human health via the food chain. U.S. Department of Energy (DOE) Orders 436.1 (DOE 2011a) and 458.1 (DOE 2011b) define the framework and requirements for this monitoring program. We accomplish this effort through the following tasks.

- 1) Measuring the concentrations of radionuclides and other chemicals that have a history of use at LANL in foodstuffs on Laboratory land, and if available, perimeter areas (neighboring communities and potentially impacted regions), and comparing those concentrations with regional (background) areas (areas >9 mi from LANL)
- 2) Assessing radionuclide and other chemical concentrations in foodstuffs over time (e.g., are concentrations increasing or decreasing?)
- 3) Estimating LANL-derived dose, if any, from the consumption of the foodstuffs. (See Chapter 3 for dose estimates to individuals from the ingestion of foodstuffs.)

We conduct sampling of native vegetation, foodstuffs, and biota on a 3-yr rotating schedule. The collection of agriculture-related samples (produce crops, goat milk, chicken eggs, and honey) from neighboring communities surrounding the Laboratory was accomplished in 2010 (Fresquez et al. 2011), and collection of Rio Grande-related samples (fish, crayfish, and benthic macroinvertebrates) upstream and downstream of the Laboratory was completed in 2011 (Fresquez 2012). This year, we present the results of soil (Chapter 7) and native vegetation (this chapter, Section B) collected from on-site, perimeter, and regional locations.

Other foodstuffs, like wild edible plants, livestock, and small and large game animals, are analyzed as they become available and when an adequate number of samples can be submitted to the laboratory. This year, we present the results for a common wild plant herb used to make a beverage tea (Navajo Tea), collected from perimeter locations surrounding the Laboratory.

2. Foodstuffs Comparison Levels

Concentrations of detected radionuclides and chemicals in foodstuffs potentially impacted by LANL operations are first compared with background-based screening levels. Regional statistical reference levels (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 in foodstuffs collected from regional locations more than 9 mi away from the influence of the Laboratory (DOE 1991). The concentrations of radionuclides and chemicals in foodstuffs collected from regional background areas are the result of worldwide fallout, other non-LANL sources, and natural processes (e.g., elements in soil to plants to animals). (Note: In some cases where there are numerous detections above RSRLs [$>25\%$] and there is an adequate number of samples collected from both potentially impacted and nonimpacted areas, a statistical test at the 0.05 probability level may be used to aid in comparisons and interpretation.)

If any radionuclide/chemical concentration in a foodstuff exceeds the RSRL(s), we then compare the concentration with dose- or risk-based screening levels (SLs). For radionuclides, the SL is 1 millirem per year (mrem/yr), which is based on 4% of the 25-mrem/yr DOE single-pathway constraint (DOE 1999, 2011b; LANL 2003), so that concerns may be identified in advance of the regulatory standard. 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 U.S. Environmental Protection Agency (EPA) guidelines, is 0.30 milligrams per kilogram (mg/kg) wet weight (parts per million [ppm]) (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 polychlorinated biphenyls (PCBs) in fish, we use EPA guidelines for SLs; in this case, we would compare total PCBs with the EPA risk-based consumption limits for human health (EPA 2007).

If radionuclide, mercury, or PCB concentrations exceed an SL, they are then 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, 2011b). For mercury and PCBs, the concentrations are compared with the Food and Drug Administration (FDA) action limits of 1 mg/kg (fish) and 3 mg/kg (red meat and poultry), respectively (FDA 2000). Table 8-1 presents a summary of the RSRLs, SLs, and the regulatory 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 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)	
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	RSRLs

3. Wild Edible Foods (Navajo Tea)

Navajo Tea (*Thelesperma spp.*; other common names include Greenthread, Cota, and Hopi Tea), a common wild plant used to make a beverage tea, was collected around the vicinity of LANL: the Los Alamos townsite to the north, White Rock/Pajarito Acres to the southeast, and the Pueblo de San Ildefonso to the east. The plant was also collected from regional background areas away from the influence of the Laboratory. Navajo Tea has been collected occasionally since 1996.

Based on a commercial formulation (10 g/L), approximately 20 g of (unwashed) air-dried tea stems were added directly to 2 L of tap water, brought to a boil, cooled, filtered, and poured into a plastic container and submitted as a liquid for the analysis of tritium, cesium-137, strontium-90, plutonium isotopes, americium-241, and uranium isotopes.

All of the radionuclides in Navajo Tea from perimeter areas were either not detected (most results) or below RSRLs (see supplemental Table S8-1). A nondetected value is one that is less than the minimum detectable activity or one in which the result is lower than 3 times the counting uncertainty and is not significantly different ($\alpha = 0.01$, or 99% confidence level) from 0 (Keith 1991, Corely et al. 1981), and RSRLs were based on the last five sampling events (1996–2012 data; $n = 5$).

B. BIOTA MONITORING

1. Introduction

DOE Orders 436.1 (DOE 2011a) and 458.1 (DOE 2011b) define requirements for the monitoring of biota (plants and animals not normally ingested by humans) for the protection of ecosystems. Presently, in addition to native vegetation, we also monitor benthic macroinvertebrates, small mammals, amphibians, reptiles, birds, and bees within and around LANL on a systematic basis or for special studies. The number and types of organisms may indicate environmental changes and stress. Also, 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 objectives of the biota program are to

- 1) assess populations, composition, and diversity of biota species potentially impacted by LANL operations;
- 2) measure radionuclide and chemical concentrations (that have a history of use at LANL) in biota from on-site (LANL property) and perimeter locations and compare those concentrations with regional (background) areas;
- 3) evaluate trends in radionuclide and chemical concentrations over time (i.e., are concentrations increasing or decreasing?); and
- 4) estimate radiation dose to plants and animals. (Chapter 3 presents the results of the 2012 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 background-based SLs (e.g., RSRLs). If the levels of chemicals or radionuclides at potentially affected areas are higher than the background levels (RSRLs), then we compare the concentrations with the dose- or risk-based SLs, if available, and then with the regulatory standards, if any. More information about comparison levels is summarized below and presented in Table 8-2:

- Regional Statistical Reference Levels: RSRLs are the upper-level background concentrations (mean plus 3 standard deviations = 99% confidence level) for radionuclides and chemicals calculated from biota data collected from regional locations more than 9 mi away from the influence of the Laboratory (DOE 1991). The concentrations of radionuclides and chemicals in biota collected from

regional background locations are the result of worldwide fallout, other non-LANL sources, and natural processes (e.g., elements in soil to plants to animals).

- **Screening Levels:** SLs are set below DOE dose standards so that concerns may be identified in advance. If a constituent exceeds an SL, then the reason for the higher level is investigated. For radionuclides in biota, SLs were set at 10% of the regulatory standard by the dose assessment team at the Laboratory to identify radionuclides 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 level [BSRL]), then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2012). ESLs are derived from the literature and reflect the (highest) concentration of a substance in the soil that is 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).
- **Regulatory 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 DOE dose standard 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/day	0.1 rad/day	RSRLs
	DARHT ^a	Terrestrial plants	1 rad/day	0.1 rad/day	RSRLs/BSRLs ^b
	On-site and perimeter	Terrestrial animals	0.1 rad/day	0.01 rad/day	RSRLs
	DARHT	Terrestrial animals	0.1 rad/day	0.01 rad/day	BSRLs
Chemicals	On-site and perimeter	Biota	na ^c	ESLs ^d	RSRLs
	DARHT	Biota	na	ESLs	RSRLs/BSRLs

^a DARHT = Dual-Axis Radiographic Hydrodynamic Test (facility).

^b BSRLs and a discussion of these levels can be found in Section B.4.b.i.

^c na = Not available.

^d ESLs are based on the concentration in the soil.

3. Institutional Vegetation Monitoring

a. Monitoring Network

Native vegetation, either from understory (grasses and forbs) or overstory (tree) resources, is collected on a triennial basis at the same time and at the same locations (17 on-site, 11 perimeter, and 6 regional locations) as the soil sampling program described in Chapter 7, Section C.1 (Figure 7-1). The last vegetation sampling effort, conducted in 2009, focused on overstory plants (Fresquez et al. 2007a). This year, we collected samples from understory grasses and forbs. In general, samples of grasses and forbs are collected and placed into the appropriate containers and submitted to ALS (formerly Paragon) Laboratory Group for the analysis of the same radionuclides and TAL elements (mostly metals) as the soil samples.

i. Radionuclides

Most radionuclide concentrations in native understory vegetation collected from perimeter and on-site areas were either not detected (most results) or below RSRLs (Table S8-2). A few radionuclides, mostly plutonium-239/240, were higher than the RSRLs but were far below the SLs. The understory vegetation samples with plutonium-239/240 above RSRLs were collected at the same sites at Technical Area 73 (TA-73)/State Road (SR) 502 where soil samples contained this radionuclide (Chapter 7). These data agree with past results, and no increasing trends are evident (Gonzales et al. 2000, Fresquez and Gonzales 2004).

ii. *TAL Elements*

As with the radionuclides, the majority of TAL elements in understory vegetation from both perimeter and on-site locations were below the RSRLs. The few elements that were above the RSRLs at some perimeter and on-site locations were far below levels considered toxic to plants, based on values from Gough et al. (1979) (Table S8-3).

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 7-3). Radionuclides analyzed by the ALS Laboratory Group 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 picocuries per milliliter (pCi/mL) basis, results for the other radionuclides are reported on a picocuries per gram (pCi/g) ash weight basis, and results for the TAL elements are reported on a milligrams per kilogram (mg/kg) dry weight basis.

ii. *Vegetation at Area G*

With the exception of tritium, plutonium-238, and plutonium-239/240, radionuclides in tree samples collected around the perimeter of Area G were mostly not detected or below the RSRLs (based on 1998–2009 data; n = 15) (Table S8-4).

Tritium was detected above the RSRL in 100% of the tree samples collected around the perimeter of Area G with the highest amounts (1410 to 34,000 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. Although there is large variation in tritium concentrations from year to year, the concentrations are not increasing over time (Figure 8-1). A tritium migration study conducted in 2003 reported that most (86%) of the tree samples collected around the perimeter of Area G had tritium concentrations higher than the RSRL, but the measurement of tritium in trees in an outward direction from the Area G fenceline showed that the concentrations decreased rapidly with distance (Fresquez et al. 2003). At the site of the highest source (southern portion of Area G), for example, the concentrations of tritium decreased from 6700 to 0.47 pCi/mL at a distance of 476 ft from the perimeter fenceline.

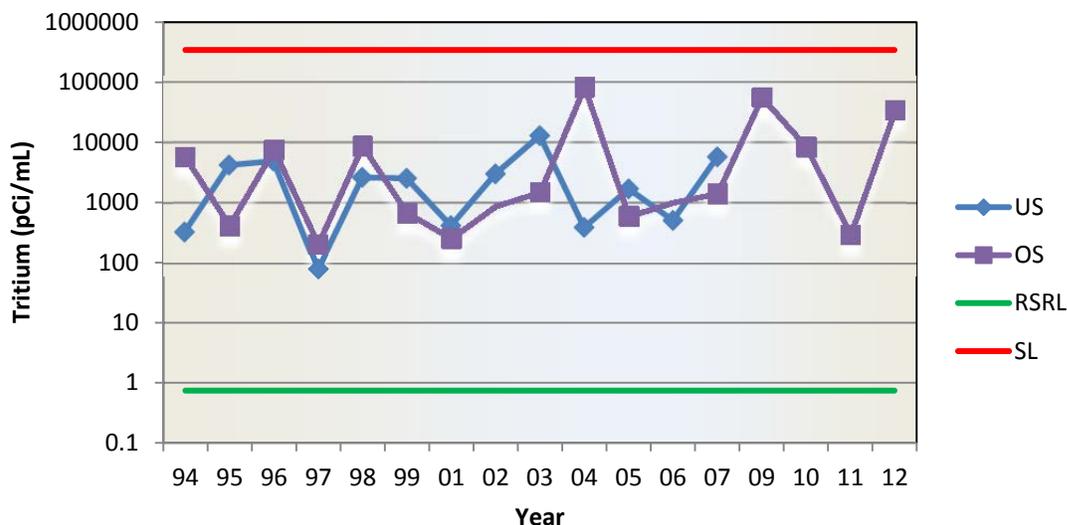


Figure 8-1 Tritium in understory (US) and overstory (OS) vegetation collected from the south side of Area G at TA-54 (site 29-03 or 30-01, whichever is highest) from 1994 through 2012 compared with the RSRL and the SL. Note the logarithmic scale on the vertical axis.

Another radionuclide that was detected above the RSRL in trees around Area G was plutonium-239/240 in five samples. These samples were collected on the north and northwestern sides of Area G (around sites 48-01, 52-01, and 58-01). The plutonium-239/240 concentrations in trees growing around the perimeter of Area G are far below the SL.

All radionuclides, with the exception of tritium, measured in samples from trees located downwind and northeast of Area G at the LANL/Pueblo de San Ildefonso boundary were either not detected or below RSRLs. The levels of tritium in tree samples collected at the LANL/Pueblo de San Ildefonso boundary are far below the SL for tritium (Table S8-4).

b. Dual-Axis Radiographic Hydrodynamic Test 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 and continuing to the present (three in fiscal year [FY] 2007, two in FY08, none in FY09, four in FY10, three in FY11, and six in FY12 [Carnes 2013]). Another factor that may influence the amount of potential chemicals around the DARHT site is that the firing point was covered 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 7-11, 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.

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 sides of the DARHT perimeter and analyzed for radionuclides, TAL elements, and dioxin/furans. Bee samples were collected from 1 hive located on the northeast side of the DARHT perimeter and analyzed for radionuclides and TAL elements. Birds were collected using 12 mist capture net traps spaced about 200 ft to 1600 ft outward from the west side of the DARHT facility (nets were spaced about 150 ft apart).

Vegetation, field mice, and bee samples were submitted to ALS Laboratory Group, 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. Field mice were submitted to Cape Fear Analytical and analyzed for dioxins/furans; results for dioxins/furans are reported on a picograms per gram (pg/g) (parts per trillion) wet weight basis.

Results of most of the biota chemical analysis were compared with BSRLs per the MAP (DOE 1996). BSRLs are the upper-limit baseline data established over a 4-yr period (1996–1999) before the start-up of DARHT operations in 2000 (Nyhan et al. 2001). The BSRLs, at the 3-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. 2007b). In cases where there are no BSRLs, the biota chemical analysis results were compared with RSRLs.

ii. Vegetation at DARHT

All radionuclide concentrations, including uranium-238, in overstory vegetation collected from around the perimeter of the DARHT facility were either not detected (most results) or detected below the BSRLs (or RSRLs when BSRL data were not available) (Table S8-5). In the past, uranium-238 was usually the only radionuclide 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 on all sides of the DARHT perimeter. This general decrease in uranium-238 concentrations with respect to the BSRL was probably because of the change in contaminant mitigation procedures from open-air and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation, starting in 2007 (Figure 8-2). (Note: The uranium-238 concentration in overstory vegetation collected from the north side of the perimeter of DARHT does not reflect the higher-than-normal concentration in soil from that location detected in 2012, as reported in Chapter 7.)

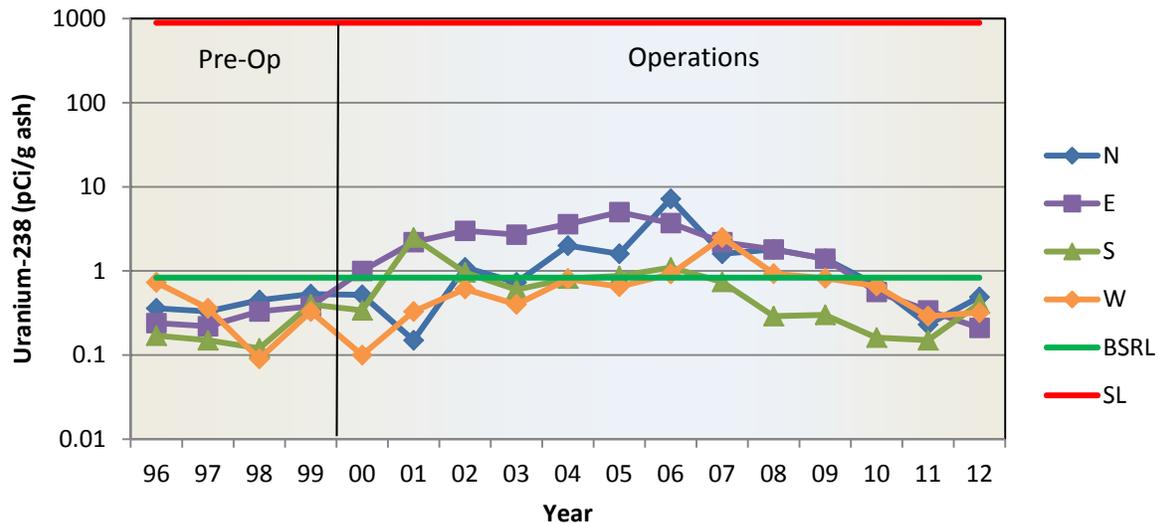


Figure 8-2 Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) sides of the DARHT facility at TA-15 from 1996–1999 (preoperations) through 2000–2012 (during operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.

The TAL element results in overstory vegetation collected from around the DARHT facility are summarized in Table S8-6. All of the metals were either not detected or similar to the BSRLs (or the RSRLs).

iii. Small Mammals at DARHT

All radionuclides in a composite field mouse sample ($n = 7$) collected from the north and northeast sides of the DARHT facility were either not detected (most results) or not different from the BSRLs (Table S8-7).

The amounts of uranium-238 in small mammals, 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-air and/or foam-mitigated detonations during the 2000–2006 period to closed vessel containment, starting in 2007 (Figure 8-3). (Note: The uranium-238 concentration in small mammals collected from the north side of the perimeter of DARHT does not reflect the higher-than-normal concentration in soil from that location detected in 2012, as reported in Chapter 7.)

Most TAL elements, with the exception of barium and lead, in a composite field mouse sample collected from the northeastern perimeter of the DARHT facility were either not detected or not different from RSRLs (based on 2007–2009 data; $n = 9$) (Fresquez 2011) (Table S8-8). The amounts of barium and lead detected in the mouse sample were higher than the RSRL. However, the amounts of these elements in soil from the north-side perimeter of DARHT (barium at 115 mg/kg, and lead at 10 mg/kg) were far below the ESLs (<1800 mg/kg and 120 mg/kg, respectively) for the deer mouse (LANL 2012).

Most dioxin or furan chemicals in a field mouse sample were not detected above the method detection limit (MDL); only an estimated trace amount (above the MDL but below the detection limit) of 1,2,3,4,6,7,8-heptachlorodibenzodioxin was listed, but the level was below the RSRL (based on 2011 data; $n = 8$) (Fresquez 2011) (Table S8-9). Trace amounts of 1,2,3,4,6,7,8-heptachlorodibenzodioxin were also detected in soil near the firing point above the MDL (Table S7-10).

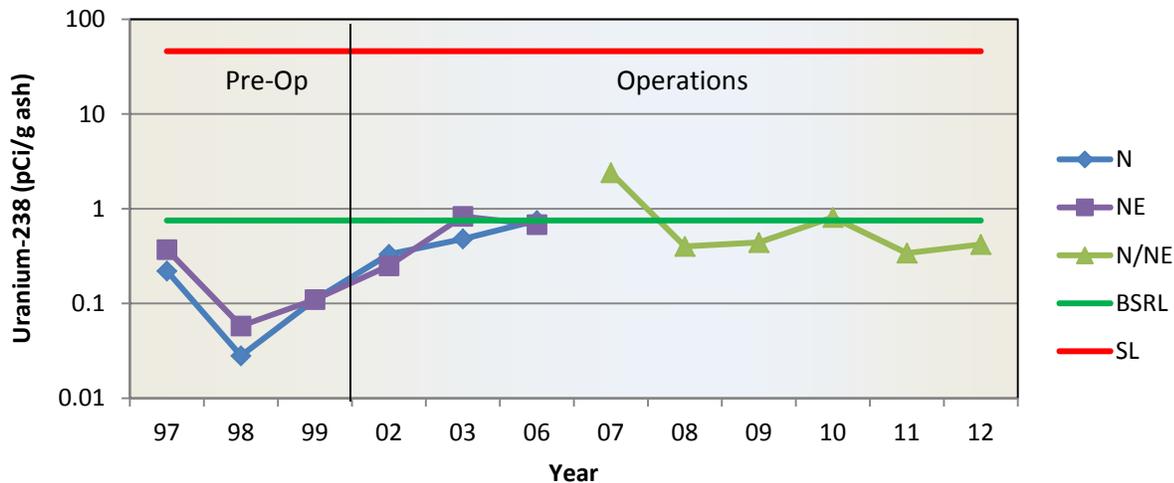


Figure 8-3 Uranium-238 concentrations in (whole-body) mice (n >5) collected from the north (N) and northeast (NE) sides of the DARHT facility at TA-15 from 1997–1999 (preoperations) and 2002–2012 (during operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.

iv. Bees at DARHT

All radionuclide concentrations in a honey bee sample collected from a hive located on the northeastern perimeter of the DARHT facility were either not detected (most results) or below the BSRLs (Table S8-10).

A comparison of uranium-238 in bee samples over the preoperational and operational periods at DARHT reveals the same general trend observed with the other biotic samples: there is an increase in activity to around 2006 and then a sharp decrease concurrent with the change in detonation mitigation practices from open-air/foam (2000–2006) to closed vessel containment, starting in 2007 (Figure 8-4).

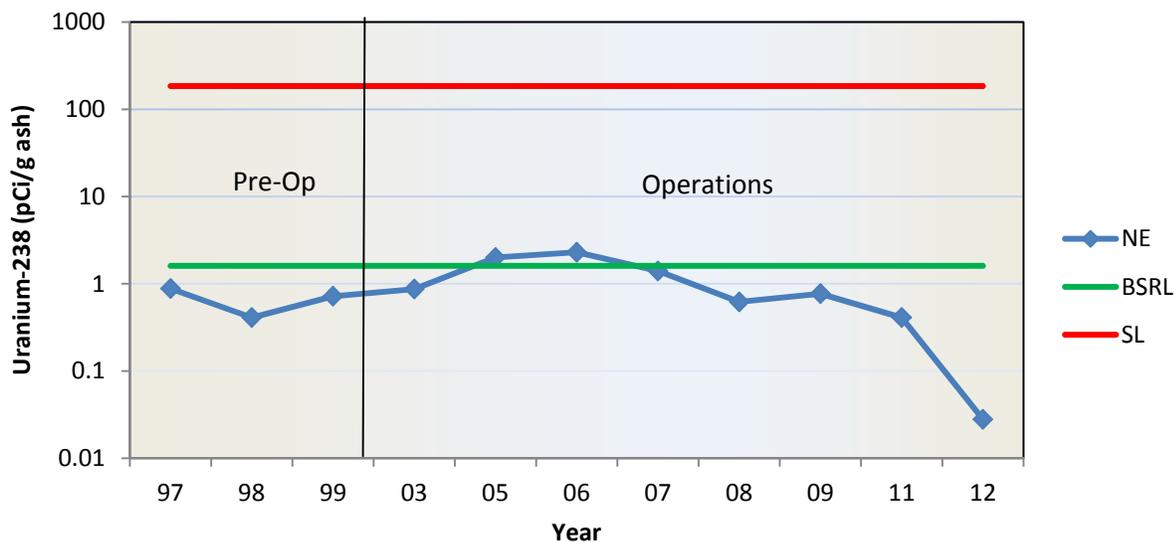


Figure 8-4 Uranium-238 concentrations in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (preoperations) and 2003–2012 (during operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.

Only a few of the TAL elements (manganese, lead, and mercury) in a composite bee sample collected from a hive northeast of the DARHT facility were higher than the RSRLs (based on 2010–2013 data; n = 4) (Table S8-11). All of these TAL elements, however, were within the same order of magnitude as the RSRLs.

A small number of bee background samples were used to calculate the RSRLs, which may have resulted in a low value for some bee RSRLs.

v. Birds at DARHT

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2012 compared with average results from 1997 through 1999 (preoperational phase) are presented in Table S8-12. 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, construction, etc.).

The number of bird species and the diversity and evenness (distribution) of birds collected in 2012 are slightly higher than those collected before the start-up of operations at DARHT (Figures 8-5 and 8-6). However, the number of birds in 2012 was the lowest since counts began—this was a result of one fewer netting sessions (9 out of 10 days) because of DARHT access restrictions. The types of birds collected at DARHT have changed since the late 1990s/early 2000s. The site has gradually changed from a ponderosa pine– (*Pinus ponderosa*–) dominated plant community to a more piñon/juniper (*Pinus edulis*/*Juniperus monosperma*) habitat because of wildland fire and bark beetle activity that has killed almost all of the ponderosa pines in the project area.



Virginia's Warbler (*Vermivora virginiae*)

The birds that were the most common during the preoperation period/early years of operation included the Chipping Sparrow (*Spizella passerina*), Virginia's Warbler (*Vermivora virginiae*), Western Tanager (*Piranga ludoviciana*), and the Western Bluebird (*Sialia mexicana*). This year, the most common birds included the Bushtit (*Psaltriparus minimus*), Virginia's Warbler, and the Rock Wren (*Salpinctes obsoletus*). Also, the Downy Woodpecker (*Picoides pubescens*) and the Western Kingbird (*Tyrannus verticalis*) were captured for the first time in 2012.

The Virginia's Warbler is listed in the top 100 birds at risk in North America in the Birder's Conservation Handbook (Wells 2007) and is a common inhabitant of the ecosystem near the DARHT facility.

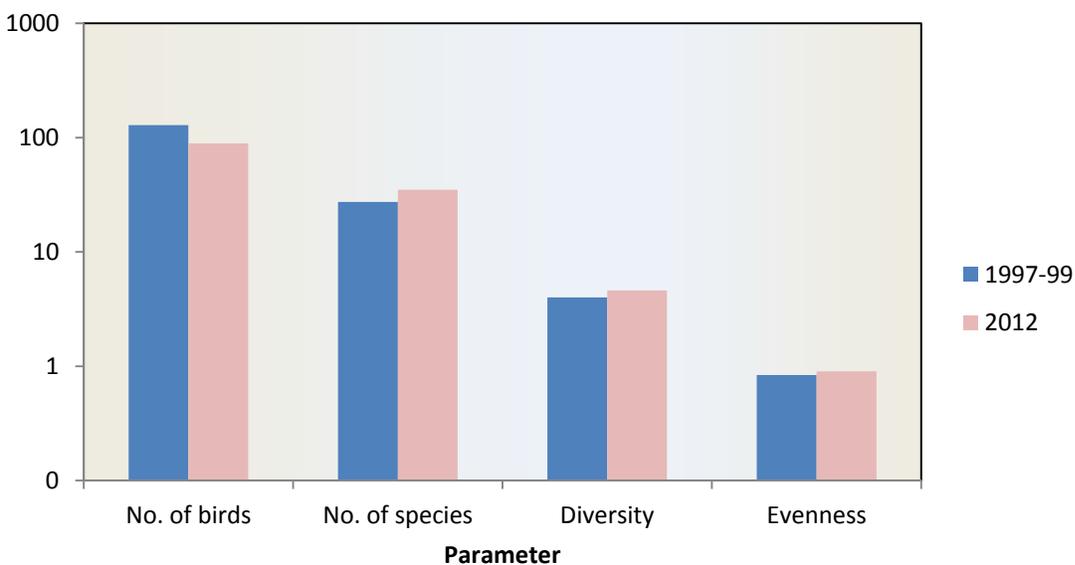


Figure 8-5 Populations, number of species, diversity, and evenness of birds occurring before (1997–1999) and during (2012) operations at DARHT. Note the logarithmic scale on the vertical axis.

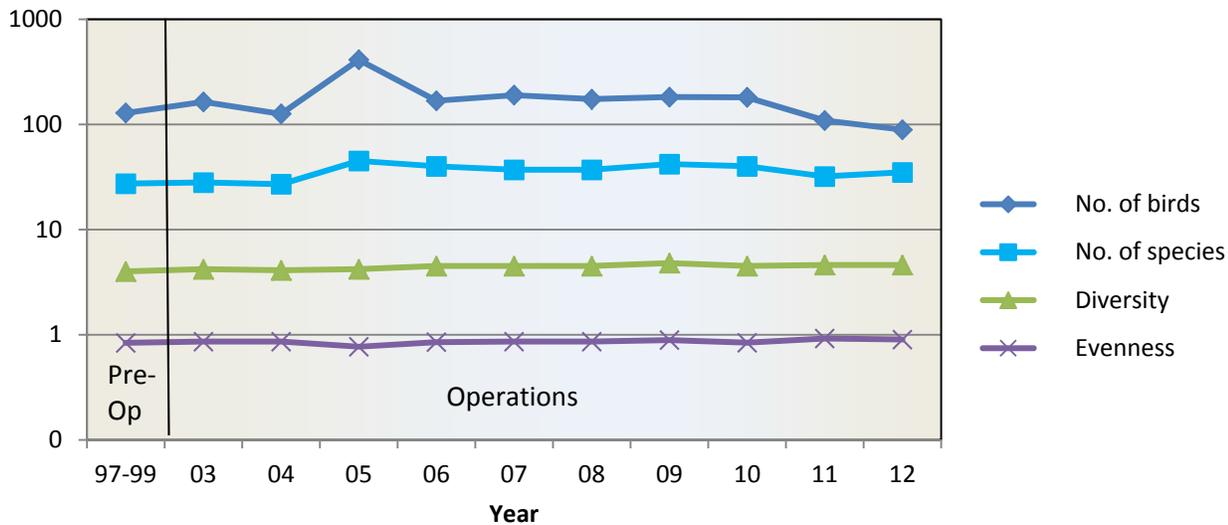


Figure 8-6 Populations, number of species, diversity, and evenness of birds occurring before (1997–1999) and during (2003–2012) operations at DARHT. Note the logarithmic scale on the vertical axis.

C. SPECIAL MONITORING STUDIES

The following special studies were conducted in 2012 in support of MAPs, the Biological Resources Management Plan (BRMP), and the Environmental Surveillance Program.

1. Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Basins: 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 7500 acres on LANL property. Because the Cerro Grande Fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increased sediment (and potential contaminant) transport from LANL to off-site locations. As a preventive measure, the U.S. Army Corps of Engineers constructed two large erosion control structures to control storm water 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 NM 4 and NM 502 and (2) a large cement flood-retention structure located downstream of the confluence of Twomile and Pajarito Canyons.

As part of the Special Environmental Analysis actions taken in response to the Cerro Grande Fire at LANL (DOE 2000), 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 water or silt 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 retention basin of the Los Alamos Canyon Weir (LACW) and upgradient of 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 (0.089 to 1.5 acres).

ALS Laboratory Group analyzed the field mouse (whole-body) samples for radionuclides and TAL elements. PCBs (congeners, homologs, and totals) in whole-body field mice were analyzed by Cape Fear Analytical. The following two sections report the 2012 results of this monitoring.

a. Los Alamos Canyon Weir

The LACW structure was installed in 2001 and has been partially excavated of sediments on several occasions since. The following biota samples were collected in mid June 2012.

The concentrations of radionuclides and TAL elements in a composite understory vegetation sample that was collected within the LACW retention basin can be found in Tables S8-13 and S8-14, respectively. All radionuclides in understory vegetation growing within the LACW retention basin were either not detected or similar to RSRLs (based on 1999–2012 data; n = 22). The values for strontium-90, plutonium-238, plutonium-239/240, and americium-241 are orders of magnitude lower than last year but vary widely from year to year (Figure 8-7). Similarly, all TAL elements in understory vegetation were below the RSRLs (based on 2012 data; n = 6).

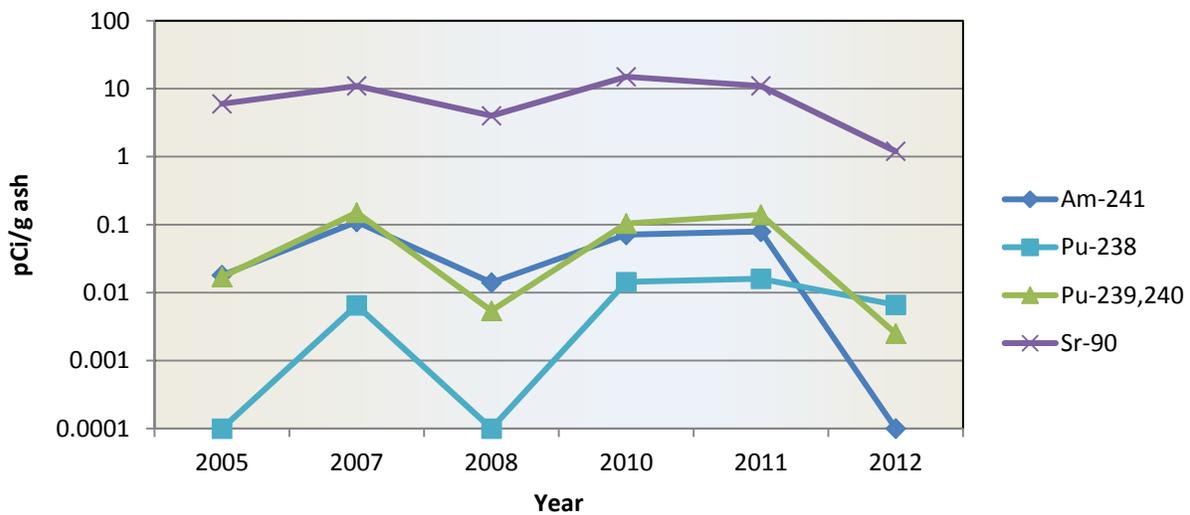


Figure 8-7 Americium-241, plutonium-238, plutonium-239/240, and strontium-90 concentrations in understory vegetation collected on the upgradient side (retention basin) of the LACW from 2005 through 2012. Note the logarithmic scale on the vertical axis.

The variability of these radionuclides in vegetation collected from the LACW from year to year may occur because plant material may be removed during the excavation of the sediment or may be buried with sediment during high-runoff events prior to sampling. In these cases, vegetation samples are collected near the sides of the basin or further upgradient of normal sampling locations. Plant samples may also contain sediment on the leaves and stems because of high-runoff events; this fact may alter radionuclide contents to significantly higher than normal.

The concentrations of all radionuclides in a composite field mouse sample (n = 5) collected from within the LACW retention basin were either not detected or not different from RSRLs (based on 2002–2009 data; n = 7) (Fresquez et al. 2011) (Table S8-15); these data correlate well with the vegetation data and are similar to past years (Figure 8-8).

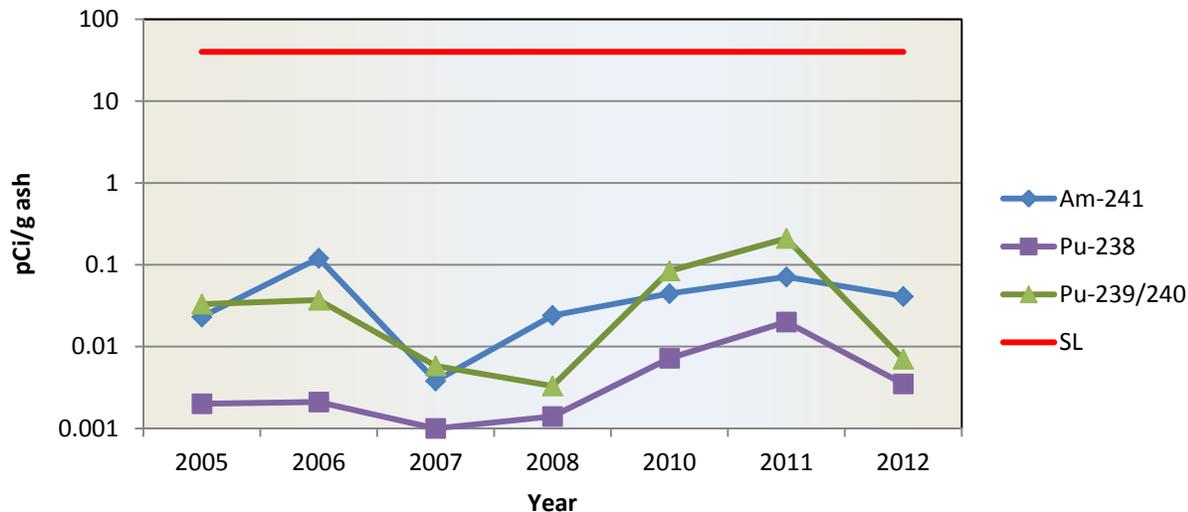


Figure 8-8 Americium-241, plutonium-238, and plutonium-239/240 in composite whole-body field mouse samples ($n > 5$) collected on the upgradient side (retention basin) of the LACW from 2005 through 2012, compared with the SL. Note the logarithmic scale on the vertical axis.

Results of the TAL elements in whole-body field mice can be found in Table S8-16. Most TAL elements in field mice ($n = 3$) collected on the upgradient side of the LACW were lower than or not different from the RSRLs. The few exceptions, based on one or more samples being an order of magnitude higher than the RSRL, are aluminum, barium, manganese, lead, and thallium. The tissue values for these elements are higher than in past years, but based on the soil concentrations of these elements within the LACW retention basin (Chapter 6), no ESLs are exceeded for the field mouse (LANL 2012).

Concentrations of total PCBs in whole-body field mice ($n = 3$) collected from the retention-basin side of the LACW were slightly higher than the RSRL (Table S8-17). Although the PCB levels in field mice collected from the retention basin are just above the RSRL, the concentrations were far below the average whole-body amount ($2.3E06$ pg/g) that has been observed at PCB-contaminated sites that results in field mice population effects by decreasing reproductive capability and changing liver, spleen, and adrenal function (Batty et al. 1990). Thus, the current levels are not expected to significantly impact the field mice population. No PCB Aroclors were detected in LACW sediment above the detection levels (White 2013).

The current levels of total PCBs in field mice collected around the LACW are at their lowest since surveys began in 2007. Concentrations decreased from 2008 to the present (Figure 8-9) and suggest that LANL engineering controls (sediment traps, willow plantings, and sediment removal) upgradient of the LACW appear to be reducing the levels of PCBs available to field mice at the weir. In other words, engineering controls employed by the Laboratory to decrease or remove sediment loads (and contaminants) appear to be working successfully. Moreover, the level of PCBs in field mice decreases downgradient from the LACW towards the Rio Grande. In a past study, Fresquez et al. (2010) reported that the mean total PCB amounts in field mice collected approximately 4.5 mi downgradient of the LACW were about 90% lower than those detected in field mice collected from within the LACW retention basin. Therefore, based on this relationship and using the mean total PCB amount in field mice collected from the LACW in 2012 (3932 pg/g wet), the estimated concentration of total PCBs in field mice 4.5 mi downgradient of the LACW would be about 393 pg/g wet; this amount is on the same order of magnitude as the RSRL (885 pg/g wet).

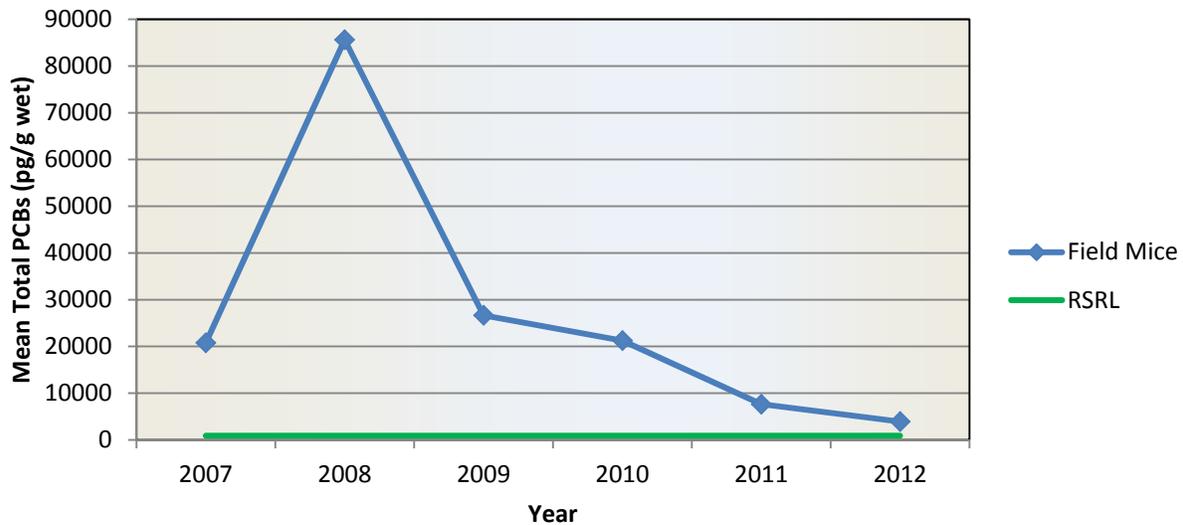


Figure 8-9 Mean total PCB concentrations in whole-body field mice collected on the upgradient side (retention basin) of the LACW from 2007 through 2012 compared with the RSRL (885 pg/g wet)

A comparison of the mean PCB homolog distribution of field mice collected around the LACW shows that the pattern is mostly within the Aroclor-1260 profile formulation (Figure 8-10). Aroclor-1260 has been the most consistently detected PCB formulation in sediment collected upgradient of the LACW (Fresquez et al. 2007c, 2008; Reneau and Koch 2008).

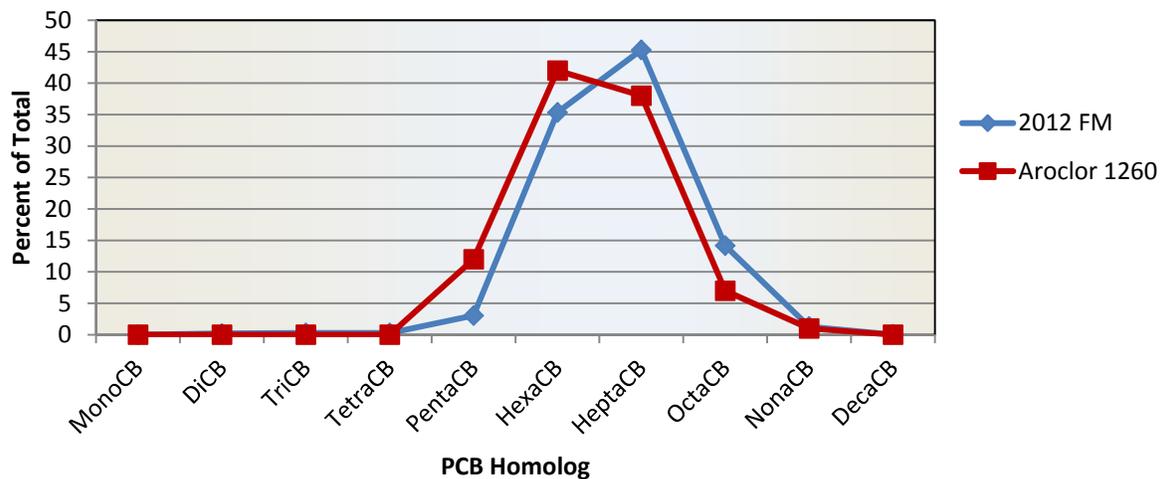


Figure 8-10. The mean total PCB homolog distribution for whole-body field mice samples collected on the upgradient side of the LACW in 2012 compared with Aroclor-1260

b. Pajarito Canyon Flood Retention Structure

Concentrations of radionuclides and TAL elements in native understory vegetation (grasses and forbs) and radionuclides, TAL elements, and PCBs in field mouse samples collected from within the silt/sediment retention basin (upgradient side) of the PCFRS in late June 2012 are presented in Tables S8-18 through S8-22.

All of the radionuclides (Table S8-18) and TAL elements (Table S8-19) in a composite native understory vegetation sample collected from the upgradient side of the PCFRS were either not detected or were below the RSRLs. These data are similar to past years.

All of the radionuclides in a composite field mouse sample (n = 5 subsamples) collected from the upgradient side of the PCFRS were either not detected or not different from RSRLs (Fresquez et al. 2011) (Table S8-20). Similarly, most of the TAL elements were below or not different from the RSRLs (Table S8-21).

Compared with last year (2011), smaller amounts of total PCBs were detected in field mice (n = 3) from the upgradient side of the PCFRS; the mean total in 2012 was similar to the RSRL (Fresquez et al. 2011) (Table S8-22). For the past 3 yr, the levels have been quite variable, but like those seen at the LACW, the general trend is declining amounts of total PCBs (Figure 8-11).

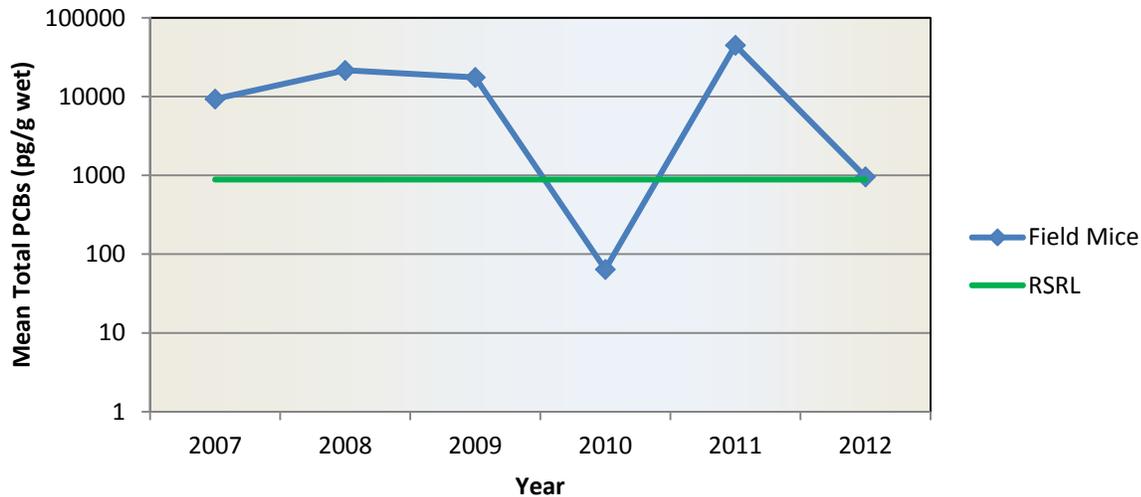


Figure 8-11 Mean total PCB concentrations in whole-body field mouse samples collected on the upgradient side (retention basin) of the PCFRS from 2007 through 2012 compared with the RSRL. Note the logarithmic scale on the vertical axis.

The mean PCB homolog distribution of field mice collected from the PCFRS mostly overlaps the distribution pattern of Aroclor-1260 (Figure 8-12). Trace amounts of Aroclor-1254 and Aroclor-1260 have been detected in sediment collected upgradient (Fresquez et al. 2007c, 2008, 2009; Reneau and Koch 2008) and downgradient of the PCFRS in past years (LANL 2008).

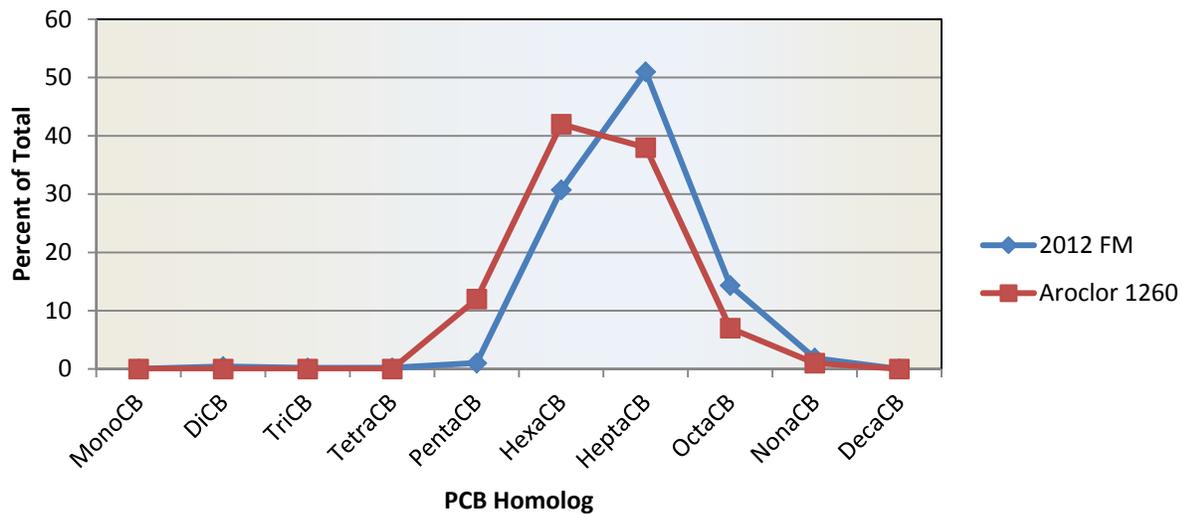


Figure 8-12 Mean PCB homolog distribution of whole-body field mouse samples collected on the upgradient side of the PCFRS in 2012 compared with Aroclor-1260

2. Chemical Concentrations in Field Mice/Voles Collected from an Open-Burn Site at Technical Area 16 at Los Alamos National Laboratory: Revision 1

The purpose of this revision was to increase the database for small mammal collections at the TA-16 burning grounds. In addition to inorganic element and dioxin/furan concentrations in field mice/voles collected in 2011, the population parameters of field mice around the TA-16 burning ground site were estimated, and samples were analyzed for PCBs, high explosives (HE), and perchlorate. As such, field mice and voles were collected around an open-burn (HE waste) site, TA-16-388 (flash pad), at TA-16 in March 2011 for the analysis of 23 TAL elements (mostly metals) and 17 dioxin/furan chemicals. In July 2012, small mammal community and population parameters were estimated across the site, and samples were analyzed for PCBs, HE, and perchlorate. All TAL elements in whole-body field mouse samples ($n = 3$) were either similar to RSRLs or below ESLs. Dioxins and furans ($n = 6$) and HE ($n = 2$) were not detected in any of the whole-body field mouse/vole samples. Perchlorate concentrations ($n = 2$) were below the RSRL. One out of the two small mammal samples contained PCB Aroclor-1260 above nonurban RSRLs; the amount, however, was similar to the urban RSRL. There was no adverse effect of burning ground operations on local small mammal populations. For a more detailed description of this study, see Fresquez et al. (2013).

3. Bioassessment of the Rio Grande Upstream and Downstream of Los Alamos National Laboratory, New Mexico, USA

This study summarizes two benthic macroinvertebrate sampling events in the Rio Grande conducted in 2009 (Fresquez et al. 2010) and in 2011 (Fresquez 2012). Benthic macroinvertebrates (aquatic insects) were collected from the Rio Grande upstream and downstream of its confluence with Los Alamos Canyon, a major drainage that crosses LANL lands in northern New Mexico. Los Alamos Canyon contains legacy contaminants, including radionuclides and PCBs, and occasionally discharges storm water and snowmelt flows to the Rio Grande. The Rio Grande is the major waterway that flows southward across the state. In 2009, rock baskets were placed in waters 61 to 76 cm deep within each reach (five per reach), and after approximately 6 wk of colonization, the rock baskets were retrieved. All samples were sorted completely, and organisms were identified to the lowest possible taxonomic level. Both reaches in 2009 were dominated by the collector-filtering, net-spinning caddisfly, *Hydropsyche occidentalis*. In 2011, benthic macroinvertebrates were collected using D kick nets from shallow riffle locations (15- to 31-cm depth) from each reach (six per reach). These samples were collected after wildland fire-related flooding events (post-Las Conchas Fire) moved sediment and ash through the two study areas. The reach downstream of Los Alamos Canyon experienced higher flows and a greater number of flooding events than the upstream reach. Each kick net sample consisted of ten 1-m (kick) samples. The 10 subsamples were composited and organisms were picked from randomly selected cells in a sorting pan until 500 organisms were identified to the lowest possible taxonomic level. Both reaches in 2011 were dominated by the collector-gathering mayfly, *Baetis tricaudatus*. A bioassessment of the downstream reach compared with the upstream (reference) reach was conducted by scoring 10 metrics related to the structure and function of the benthic macroinvertebrate community. While the downstream reach in 2009 ranked at the highest level (nonimpaired), in 2011 it ranked at a level lower (slightly impaired). The somewhat lower bioassessment score of the downstream reach in 2011 may be a result of flooding impacts following the Las Conchas Fire. Overall, based on the similarity of benthic macroinvertebrate metrics between reaches and the composition of benthic macroinvertebrates favoring pollution-intolerant taxa, LANL influences, if any, via the Los Alamos Canyon system to the Rio Grande are not significantly impacting water quality of the Rio Grande. For more information on this study, see Fresquez and Jacobi (2012).

4. Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2010-12

During 2012, LANL biologists completed the third year of monitoring songbirds during the fall at the Laboratory. Songbirds were captured at a mist-netting station located in a large wetland/riparian complex in TA-36 on the north side of Pajarito Road in Los Alamos County. Captured birds were identified, measured, and banded with a U.S. Fish and Wildlife Service (USFWS) migratory bird band. Banding operations took place between August 7 and October 10, 2012, with the completion of a total of 10 mist-netting sessions. This project was conducted as part of implementation of the BRMP and in compliance with Executive Order 13186 and the 2006 Memorandum of Understanding between the USFWS and the DOE/National Nuclear Security Administration. A total of 443 birds, representing 49 species, were banded in 2012. Broad-tailed, Black-chinned, Calliope, and Rufous Hummingbirds were also captured in August and September but

are not analyzed as part of this project. Between 2010 and 2012, the overall number of birds captured has been variable, but in 2012 the number of captures improved substantially compared with 2011. The warblers were the species with the greatest decline in 2011, and their numbers in 2012 remained lower than 2010. The variability in bird populations is likely driven by regional climatic factors. See Hathcock et al. (2013) for a more detailed discussion of this study.

5. Winter and Breeding Bird Surveys at Los Alamos National Laboratory: Progress Report for 2010 to 2012

Biologists on the Resources Management Team at LANL initiated a multiyear monitoring program for migratory birds in FY11 to implement the BRMP and to comply with federal laws, executive orders, and regulations related to migratory birds. The objective of this ongoing study is to monitor patterns and trends of bird abundance and richness over time at the Laboratory. LANL biologists completed a second year of surveys in the winter of 2011 and the summer of 2012. Four habitat types were surveyed for this project: (1) mixed conifer forest, (2) ponderosa pine forest, (3) piñon-juniper woodland, and (4) riparian/wetland. Transects were 2.0 to 2.5 km in length and contained 9 survey points spaced approximately 250 m apart. Winter surveys took place in each of the 4 habitat types in December, January, and February. The summer breeding bird surveys were conducted in each of the 4 habitat types in May, June, and July. Over 3700 birds representing 95 species were recorded during the FY12 surveys with 40 species detected during the winter bird surveys and 76 species detected during the summer breeding bird surveys. Of the 95 species detected during this project, 92 are protected under the Migratory Bird Treaty Act. Additionally, 6 of the species detected are on the Birds of Conservation Concern list for Bird Conservation Region 16, the Southern Rockies/Colorado Plateau region (USFWS 2008). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Four species detected during this study are on the top 100 list. For more detailed information about this study, see Hathcock and Keller (2012).

6. Preliminary Results of Chytrid Fungus Testing of Amphibians at Los Alamos National Laboratory: Revision 1

As part of a cooperative study with the New Mexico Department of Game and Fish (NMDGF), various amphibian species at LANL—the canyon tree frog (*Hyla arenicolor*), western chorus frog (*Pseudacris triseriata*), Woodhouse's toad (*Anaxyrus woodhousii*), and Jemez Mountains salamander (*Plethodon neomexicanus*)—were tested for chytridiomycosis fungus (*Batrachochytrium dendrobatidis*) (Bd) infection. The Bd infection is linked to amphibian declines worldwide—more than 40% of all amphibian species are currently in decline (Cheng et al. 2011). The Bd infection has a flagellated infective life stage called the zoospore that embeds itself into the keratinized skin of amphibians, causing hyperkeratosis, loss of skin function, osmoregulatory failure, and death (Voyles et al. 2009). Infection of Bd has been documented throughout New Mexico, and a preliminary investigation into whether Bd exists on LANL property was initiated in 2007 as part of the BRMP. Amphibians opportunistically encountered in the field were swabbed for Bd between 2007 and 2011. Samples were transferred to the NMDGF, who submitted them to Pisces Molecular, LLC, for analysis. A total of eight samples have been submitted from amphibians found in the following watersheds in or adjacent to LANL: Los Alamos Canyon, Pajarito Canyon, Twomile Canyon, Pueblo Canyon, and Chaquehui Canyon. All eight samples were negative for Bd. Continued and expanded sampling is warranted because the Jemez Mountains salamander has been documented on LANL property and is under consideration for listing as endangered under the Endangered Species Act. A Jemez Mountains salamander was documented with Bd on the Valles Caldera National Preserve west of LANL (Cummer et al. 2005).

In September 2012, two neotenic adult tiger salamanders (*Ambystoma tigrinum*) and one terrestrial adult tiger salamander were captured from Milagro Pond at the Fenton Hill satellite facility (TA-57) and swabbed for Bd infection. The three samples were transferred to the NMDGF, who submitted them to Pisces Molecular, LLC, for analysis. All three samples were negative for Bd. For more information, contact Chuck Hathcock, ENV-ES (505-665-3366, hathcock@lanl.gov).

7. A Long-Term Study of Cavity-Nesting Birds at Los Alamos National Laboratory

A long-term study of survival and reproduction in cavity-nesting birds was initiated in 1997 using an Avian Nest Box Network to monitor for effects of exposure to legacy releases from LANL operations. Using data collected over 17 yr of banding and recaptures in Western Bluebirds (*Sialia mexicana*), we investigated the potential effects of both chemicals and radionuclides and environmental variability on cavity-nesting bird populations. The first objective of the study was to investigate chemical residues in unhatched eggs to estimate exposure to heavy metals, organochlorines, and radionuclides. Second, reproductive success and productivity were examined across all locations and years. Third, local survival and reproductive success of individual birds breeding in the different locations and in respect to annual environmental variation over the years were measured. Findings included the following:



Western Bluebird
(*Sialia mexicana*)

1. All radioisotopes in eggs were below the detection limits, and radioisotopes did not vary among species or locations. Metal analyses consisted of chromium, manganese, nickel, copper, zinc, arsenic, selenium, silver, cadmium, antimony, barium, lead, and mercury. All samples were below detection levels for cadmium, lead, and antimony. Metals, in general, did not vary much among eggs.
2. While there was considerable annual and location variation in all of the reproductive parameters (clutch size, hatch date, hatching success, and fledging success), none of these parameters were linked to areas of concern at LANL. However, this study has documented that environmental factors, such as drought (Fair and Whitaker 2008) and the resulting habitat changes have impacted the bluebirds on the Pajarito Plateau.
3. For the bluebird populations, there is a much higher return rate for male hatch-year birds versus female bluebirds. Survival probability did not differ between the sexes or among the locations.

Because of annual environmental variation and resulting impacts on wildlife, this study highlights the importance of long-term studies in ecotoxicological investigations. While there were no measured effects of exposure to chemicals or radionuclides that were shown to be biologically meaningful for population-level impacts, this study was designed to help discern focus areas for additional environmental investigations.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

The soil, foodstuffs, and biota monitoring program uses the same quality assurance protocols described in Chapter 7 (quality assurance program development, field sampling quality assurance, and analytical laboratory quality assessment), some of the same standard operating procedures (SOPs) used by analytical laboratories, and also the following SOPs:

- Produce Sampling (SOP-5134)
- Fish Sampling (SOP-5135)
- Game Animal Sampling (SOP-5136)
- Collection of Crawfish in the Rio Grande (SOP-5249)
- Collection of Macroinvertebrates in the Rio Grande (SOP-5247)
- Processing Biota Samples for Analysis (SOP-5137)

These procedures, which are available on the LANL public website (<http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php>), 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.

E. REFERENCES

- Batty et al. 1990: Batty, J., R.A. Leavitt, N. Biondao, and D. Polin, "An Ecotoxicological Study of a Population of the White-Footed Mouse (*Peromyscus leucopus*) Inhabiting a Polychlorinated Biphenyls-Contaminated Area," *Archives of Environmental Contamination and Toxicology*, 19:283-290 (1990).
- Bennett et al. 2001: Bennett, K., J. Biggs, P.R. Fresquez, and H.T. Haagenstad, "DARHT Facility Small Mammal Baseline Report for Radionuclides (1997–1999)," in *Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)*, Los Alamos National Laboratory document LA-13808-MS, pp. 41–50 (2001).
- Carnes 2013: Carnes, J., personal communication, January 24, 2013.
- Cheng et al. 2011: Cheng, T.L., S. Rovito, D. Wake, and V. Vredenburg, "Coincident Mass Extirpation of Neotropical Amphibians with the Emergence of the Infectious Fungal Pathogen *Batrachochytrium dendrobatidis*," in *Proceedings of the National Academy of Sciences*, 108(23), 9502–9507 (2011).
- Corely et al. 1981: Corely, J.P., D.H. Denham, R.E. Jaquish, D.E. Michels, A.R. Olsen, and D.A. Waite, "A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations," U.S. Department of Energy report DOE/EP-0023 (1981).
- Cummer et al. 2005: Cummer M., D.E. Green, and E.M. O'Neill, "Aquatic Chytrid Pathogen Detected in a Terrestrial Plethodontid Salamander," *Herpetological Review*, 36, 248–249 (2005).
- DOE 1991: "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," U.S. Department of Energy report DOE/EH-0173T (January 1991).
- DOE 1996: "Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," U.S. Department of Energy document DOE/EIS-0228 (1996).
- DOE 1999: "The Long-Term Control of Property: Overview of Requirements in Orders DOE 5400.1 and DOE 5400.5," U.S. Department of Energy document EH-412-0014/1099 (October 1999).
- DOE 2000: "Special Environmental Analysis for the Department of Energy, National Nuclear Security Administration, Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory," U.S. Department of Energy Los Alamos Area Office report DOE/SEA-03 (2000).
- DOE 2002: "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," U.S. Department of Energy Standard DOE-STD-1153-2002 (July 2002).
- DOE 2011a: "Departmental Sustainability," U.S. Department of Energy Order 436.1 (May 2, 2011).
- DOE 2011b: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 458.1 (February 11, 2011).
- EPA 2001: "Water Quality Criterion for the Protection of Human Health: Methylmercury, Office of Science and Technology," U.S. Environmental Protection Agency report EPA-823-R-01-001 (2001).
- EPA 2007: "Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition, Risk-Based Consumption Limit Tables," U.S. Environmental Protection Agency, available at http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/risk/volume2_index.cfm (2007).
- Fair and Whitaker 2008: Fair, J.M., and S.J. Whitaker, "Avian Cell-Mediated Immune Response to Drought," *Wilson Journal of Ornithology*, 120:813-819.
- FDA 2000: "Action Levels for Poisonous or Deleterious Substance in Human Food and Animal Feed," Food and Drug Administration document, Washington, DC (2000).

- Fresquez 2011: Fresquez, P.R., "The Concentrations of Radionuclides, Heavy Metals, and Polychlorinated Biphenyls in Field Mice Collected from Regional Background Areas: Revision 1," Los Alamos National Laboratory document LA-UR-11-11687 (2011).
- Fresquez 2012: Fresquez, P.R., "Foodstuffs and Biota Monitoring," in *Environmental Surveillance at Los Alamos during 2011*, Los Alamos National Laboratory document LA-14461-ENV, pp. 8-1-8-44 (2012).
- Fresquez and Gonzales 2004: Fresquez, P.R., and G.J. Gonzales, "Radionuclide Concentrations in Vegetation at the Los Alamos National Laboratory in 2002/2003," Los Alamos National Laboratory document LA-14160-PR (2004).
- Fresquez and Jacobi 2012: Fresquez, P.R., and G.Z. Jacobi, "Bioassessment of the Rio Grande Upstream and Downstream of Los Alamos National Laboratory, New Mexico, USA," *Journal of Environmental Protection*, 3:1596-1605 (2012).
- Fresquez et al. 2001: Fresquez, P.R., J.W. Nyhan, H.T. Haagenstad, and R. Velasquez, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, and Vegetation around the DARHT Facility," in *Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)*, Los Alamos National Laboratory document LA-13808-MS, pp. 13-40 (2001).
- Fresquez et al. 2003: Fresquez, P.R., L. Vasquez-Tator, and E.A. Lopez, "Tritium Concentrations in Vegetation as a Function of Distance from a Low-Level Waste Site at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-14091-MS (2003).
- Fresquez et al. 2007a: Fresquez, P.R., J.K. Ferenbaugh, and L. Naranjo, "Moisture Conversion Ratios for the Foodstuffs and (Nonfoodstuffs) Biota Environmental Surveillance Programs at Los Alamos National Laboratory (Revision 3)," Los Alamos National Laboratory document LA-UR-07-0280 (2007).
- Fresquez et al. 2007b: Fresquez, P.R., D.C. Keller, and C.D. Hathcock, "Bird Surveys at DARHT before and during Operations: Comparison of Species Abundance and Composition and Trace Elements," Los Alamos National Laboratory document LA-14355 (2007).
- Fresquez et al. 2007c: Fresquez, P.R., C. Hathcock, and D. Keller, "Foodstuffs and Biota Monitoring," in *Environmental Surveillance at Los Alamos during 2006*, Los Alamos National Laboratory document LA-14341-ENV, pp. 253-266 (2007).
- Fresquez et al. 2008: Fresquez, P.R., C. Hathcock, and D. Keller, "Foodstuffs and Biota Monitoring," in *Environmental Surveillance at Los Alamos during 2007*, Los Alamos National Laboratory document LA-14369-ENV, pp. 269-289 (2008).
- Fresquez et al. 2009: Fresquez, P.R., C. Hathcock, D. Keller, and G. Gonzales, "Foodstuffs and Biota Monitoring," in *Environmental Surveillance at Los Alamos during 2008*, Los Alamos National Laboratory document LA-14407-ENV, pp. 265-296 (2009).
- Fresquez et al. 2010: Fresquez, P.R., C. Hathcock, and D. Keller, "Foodstuffs and Biota Monitoring," in *Environmental Surveillance at Los Alamos during 2009*, Los Alamos National Laboratory document LA-14427-ENV, pp. 279-304 (2010).
- Fresquez et al. 2011: Fresquez, P.R., C. Hathcock, and D. Keller, "Foodstuffs and Biota Monitoring," in *Environmental Surveillance at Los Alamos during 2010*, Los Alamos National Laboratory document LA-14445-ENV, pp. 8-1-8-26 (2011).
- Fresquez et al. 2013: Fresquez, P.R., L. Hansen, and C. Hathcock, "Chemical Concentrations in Field Mice/Voles Collected from an Open-Burn Site at Technical Area 16 at Los Alamos National Laboratory: Revision 1," Los Alamos National Laboratory document LA-UR-13-20040 (2013).

- Gonzales et al. 2000: Gonzales, G.J., P.R. Fresquez, M.A. Mullen, and L. Naranjo, Jr., "Radionuclide Concentrations in Vegetation at the Los Alamos National Laboratory in 1998," Los Alamos National Laboratory document LA-13704-PR (2000).
- Gough et al. 1979: Gough, L.P., H.T. Shacklette, and A.A. Case, "Element Concentrations Toxic to Plants, Animals, and Man," Geological Survey Bulletin 1466, U.S. Government Printing Office, Washington, DC (1979).
- Haarmann 2001: Haarmann, T.K., "Baseline Concentrations of Radionuclides and Heavy Metals in Honey Bee Samples Collected near DARHT," in *Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)*, Los Alamos National Laboratory document LA-13808-MS (2001).
- Hathcock and Keller 2012: Hathcock, C., and D. Keller, "Winter and Breeding Bird Surveys at Los Alamos National Laboratory: Progress Report for 2010 to 2012," Los Alamos National Laboratory report LA-UR-12-25120 (2012).
- Hathcock et al. 2013: Hathcock, C., H. Mahowald, and D. Keller, "Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2010-12," Los Alamos National Laboratory document LA-UR-13-20413 (2013).
- Keith 1991: Keith, L.H., *Environmental Sampling and Analysis: A Practical Guide*, CRC Press, Inc., Boca Raton, FL (1991).
- LANL 2003: "Quality Assurance Project Plan for the Environmental Dose Assessment," Los Alamos National Laboratory document RRES-MAW-DOSE (December 22, 2003).
- LANL 2008: "Pajarito Canyon Investigation Report," Los Alamos National Laboratory document LA-UR-08-5852 (2008).
- LANL 2012: ECORISK Database, Version 3.1, Los Alamos National Laboratory document LA-UR-12-24548 (2012).
- McNaughton 2006: McNaughton, M., "Calculating Dose to Non-Human Biota," Los Alamos National Laboratory Meteorology and Air Quality Group procedure ENV-MAQ-514, R1 (2006).
- Nyhan et al. 2001: Nyhan, J.W., P.R. Fresquez, T. Haarmann, K. Bennett, T. Haagenstad, K. Keller, and H. Hinojosa, "Baseline Concentrations of Radionuclides and Trace Elements," in *Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)*, Los Alamos National Laboratory document LA-13808-MS (2001).
- Reneau and Koch 2008: Reneau, S.L., and R.J. Koch, "Watershed Monitoring," in *Environmental Surveillance at Los Alamos during 2007*, Los Alamos National Laboratory document LA-14369-ENV, pp. 201–248 (2008).
- USFWS 2008: U.S. Fish and Wildlife Service, Birds of Conservation Concern 2008. U.S. Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp. [Online version available at <<http://www.fws.gov/migratorybirds/>>]
- Voyles et al. 2009: Voyles, J., S. Young, L. Berger, C. Campbell, W. Voyles, A. Dinudom, D. Cook, R. Webb, R. Alford, L. Skerratt, and R. Speare. 2009. "Pathogenesis of Chytridiomycosis, a Cause of Catastrophic Amphibian Declines," *Science*, 326, 582–585, (2009).
- Wells 2007: Wells, J.V., *Birder's Conservation Handbook: 100 North American Birds at Risk*, Princeton University Press, Princeton, New Jersey. (2007).
- White 2013: White, A., Los Alamos National Laboratory, personal communication (March 5, 2013).

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Los Alamos National Laboratory (LANL or the Laboratory) samples and remediates sites to ensure that chemicals and radionuclides in the environment associated with past operations do not pose a potential unacceptable risk or dose to human health or the environment. The Environmental Programs (EP) Directorate directs site investigations with the objectives of (1) determining the nature and extent of the chemicals and radionuclides released into the environment from past operations and (2) identifying and implementing remediation or other corrective measures (as necessary) to remove or mitigate the presence and/or migration of the chemicals and radionuclides. The Laboratory's work in sampling and corrective action supports the following Environmental Grand Challenges—*remove or stabilize pollutants from the Manhattan Project and Cold War eras* and *protect human and environmental health by managing and restoring lands*.

A. INTRODUCTION

LANL is sampling and remediating sites to ensure that chemicals and radionuclides in the environment associated with past operations do not pose a potential unacceptable risk or dose to human health or the environment. The EP Directorate is directing the site investigations with the objectives of (1) determining the nature and extent of the chemicals and radionuclides released into the environment from past operations and (2) identifying and implementing remediation or other corrective measures (as necessary) to remove or mitigate the presence and/or migration of the chemicals and radionuclides.

The general approach for characterizing and remediating sites is the corrective action process. An investigation involves the collection of samples and the evaluation of data and information for a site. 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. Using the environmental data obtained for a site, human health and ecological risk assessments are conducted. A corrective action is taken, when necessary, to rectify conditions potentially adverse to human health and the environment. Corrective actions are complete at a site when LANL has demonstrated and documented, to the regulatory authority's satisfaction, that the site poses no unacceptable risk or dose to humans and ecological resources, such as plants and animals. Long-term stewardship activities, including surveillance and monitoring, might be implemented where material remains in place to ensure that there are no changes in potential risk/dose and concentrations.

In January 2012, the New Mexico Environment Department (NMED) and the U.S. Department of Energy (DOE)/National Nuclear Security Administration (NNSA) announced a framework agreement between the two agencies to address prioritization of environmental work at the Laboratory. This nonbinding agreement, in principle, calls for the Laboratory to accelerate the shipment of transuranic (TRU) wastes from Technical Area 54 (TA-54) to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. The DOE/NNSA agreed to ship 3706 m³ of TRU waste from TA-54 to WIPP by June 30, 2014. To achieve the accelerated waste shipments within existing and anticipated budgets, NMED agreed that some work that would have been performed under the Compliance Order on Consent (the Consent Order) during this timeframe be delayed so that funding originally assigned to the Consent Order work could be transferred to the TRU waste disposition activities. As a result, fewer activities than originally scheduled under the Consent Order were performed in 2012.

1. Programs

The Corrective Actions Program investigates consolidated units, SWMUs, and AOCs intermixed with active Laboratory operations as well as sites located within the Los Alamos townsite (property currently owned by private citizens, businesses, or Los Alamos County) and property administered by the U.S. Forest Service, the National Park Service, and DOE. The Corrective Actions Program also includes the Consolidated Unit 16-021(c)-99 (260 Outfall) corrective measures implementation (CMI), the Material Disposal Area (MDA) C corrective measures evaluation (CME), TA-21 and TA-54 closure projects, canyons investigations, the groundwater monitoring program (implemented through the annual Interim Facility-Wide Groundwater Monitoring Plan [IFGMP]), vapor monitoring, storm water and surface water monitoring, and the implementation of best management practices to minimize erosion.

The TA-21 Closure Project involves all of the sites associated with TA-21 and includes MDAs A, B, T, U, and V; various process waste lines; a radioactive waste treatment system; and the DP Site Aggregate Area sumps, outfalls, leach fields, historic container storage areas, and other former facilities.

The TA-54 Closure Project 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 developed and/or revised one investigation work plan (along with the associated historical investigation report), one monitoring plan, one CME report, one supplemental remedy completion report, two progress reports, five investigation reports, and four miscellaneous reports, which were submitted to NMED during 2012. A work plan proposes investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, and/or canyons. Samples of designated environmental media are collected from approved locations and depths and analyzed for some or all of the following analytical suites/analytes: target analyte list (TAL) 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 submitted in a report that presents and assesses the sampling results and recommends additional sampling, remediation, monitoring, or no further action, as appropriate.

Table 9-1 summarizes the plans submitted and/or approved in 2012. The table also provides general information and details regarding the activities to be conducted under these plans when implemented. Table 9-2 presents the reports submitted and/or approved in 2012 as well as the status of the reports/sites through 2012. NMED granted Certificates of Completion for 19 SWMUs and AOCs in 2012 (Table 9-3). The certificates for 17 sites were for corrective actions complete without controls, meaning no additional corrective actions or conditions are necessary. The certificates for 2 sites were for corrective actions complete with controls, which requires future site use to be restricted to industrial activities. Figure 9-1 shows the sites where environmental characterization was reported in 2012. In addition to the work plans and reports presented in the tables, numerous other documents related to groundwater, surface water, storm water, and well installations were written and submitted to NMED. These include periodic monitoring reports, drilling work plans, and well completion reports as well as the annual update to the IFGMP (LANL 2012a).

B. CORRECTIVE ACTIONS PROGRAM

In 2012, a work plan was developed for one aggregate area (Table 9-1). In addition, reports were written or revised in 2012 for three aggregate areas (including the investigation of TA-14 in Cañon de Valle Aggregate Area, which was conducted in 2011 but reported in 2012); two canyon systems; one MDA; and one former TA (Table 9-2). Reports and plans were also submitted in 2012 describing/proposing monitoring, inspection, and survey activities, and presenting a CME (Table 9-2). Table 9-4 presents a summary of the site, aggregate area, and canyon investigations conducted and/or reported in 2012. In addition, an update is presented for the continuing activities associated with the 260 Outfall CMI, and the CME for MDA C is summarized. A summary of the 2012 vapor monitoring at MDA C is also presented.

Table 9-1
Summary of Plans Submitted in 2012

Document	Date Submitted	Date Approved	TAs	Types of Sites to be Investigated or Description of Activities	Number of Sites to be Investigated	Number of Samples Proposed	Sites Where Cleanup Proposed
Investigation Work Plan for Technical Area 57 Aggregate Area (Fenton Hill)	4/27/12	7/11/12	TA-57	Waste storage drum and a leach field	2	42	Sites proposed for sampling only, not remediation
Historical Investigation Report for Technical Area 57 Aggregate Area (Fenton Hill) ^a	4/27/12	n/a ^b	TA-57	n/a	n/a	n/a	n/a
2012 Monitoring Plan for Los Alamos and Pueblo Canyons Sediment Transport Mitigation Project, Revision 2	9/28/12	1/23/13	n/a	Monitoring of geomorphic changes associated with the mitigation measures will be conducted using repeat cross-section surveys, channel thalweg surveys, and general area surveys. Storm water monitoring will be conducted throughout the watershed.	Geomorphic changes at 11 locations and storm water at 16 locations (including 13 gage stations)	Up to 94 storm water samples per event (unfiltered except for metals, which includes filtered)	n/a

^a The historical investigation report is a supporting document to the investigation work plan.

^b n/a = Not applicable.

Table 9-2
Reports Submitted in 2012

Document	Date Submitted	Date Approved	Status
Investigation Report for Cañon de Valle Aggregate Area, Technical Area 14	1/30/12	n/a ^a	To be revised
Investigation Report for DP Site Aggregate Area Delayed Sites [Consolidated Unit 21-004(b)-99 and Solid Waste Management Unit 21-011(b)] and DP East Building Footprints at Technical Area 21, Revision 1 ^b	3/21/12	n/a	To be revised Phase II work plan may be developed
Results of 2011 Sediment Monitoring in the Pajarito Canyon Watershed	3/28/12	6/29/12	Monitoring will continue
Investigation/Remediation Report for Material Disposal Area B, Solid Waste Management Unit 21-015, Revision 1 ^b	4/27/12	— ^c	Pending review by NMED Excavation of waste and remediation of trenches is complete.
Reconnaissance Survey Report for Post-Las Conchas Fire Flooding in Water Canyon and Cañon de Valle	7/30/12	10/11/12	2012 report due April 2013
Investigation Report for Lower Mortandad/Cedro Canyons Aggregate Area, Revision 1 ^b	8/22/12	9/10/12	No further investigation or remediation activities proposed Sites recommended for corrective action complete without controls
Semiannual Progress Report [for] Corrective Measures Evaluation (CME)/Corrective Measures Implementation (CMI) for Consolidated Unit 16-021(c)-99, October 2011 to March 2012	4/19/12	5/3/12	CME/CMI activities continue
Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99	9/28/12	10/24/12	CME/CMI activities continue
Phase II Investigation Report for Sandia Canyon	9/28/12	—	Pending review by NMED
Corrective Measures Evaluation Report for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50	9/28/12	—	Pending review by NMED
Evaluation of Contamination on Los Alamos County Property within Former Technical Area 32 (draft)	10/15/12	n/a	n/a
2012 Nest Box Monitoring Report for the Upper Pajarito Canyon Watershed	12/13/12	2/20/13	Further monitoring not necessary
Supplemental Remedy Completion Report for Upper Los Alamos Canyon Aggregate Area, Former Technical Area 32	12/20/12	1/25/13	Corrective action complete with controls for SWMUs 32-002(a) and 32-002(b1)

^a n/a = Not applicable.

^b This document is a revision to an investigation report previously described in the 2011 environmental report. Revision 1 did not involve additional sampling or remediation, so the original investigation results and conclusions remain unchanged.

^c — = Not yet approved.

Table 9-3
SWMUs and AOCs Granted Certificates of Completion in 2012

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
SWMU 00-011(c)		X	5/16/12
AOC C-00-020		X	5/16/12
SWMU 16-004(e)		X	7/2/12
SWMU 16-029(d)		X	7/2/12
SWMU 16-029(g2)		X	7/2/12
SWMU 16-017(p)-99		X	7/2/12
AOC C-16-049		X	7/2/12
AOC C-16-062		X	7/2/12
AOC C-16-063		X	7/2/12
SWMU 46-002		X	7/13/12
SWMU 46-004(m)		X	7/13/12
SWMU 46-004(p)		X	7/13/12
SWMU 46-006(b)		X	7/13/12
SWMU 46-006(g)		X	7/13/12
SWMU 52-001(d)		X	7/13/12
AOC C-46-001		X	7/13/12
AOC 32-003		X	12/20/12
SWMU 32-002(b1)	X		12/28/12
AOC 32-004	X		12/28/12

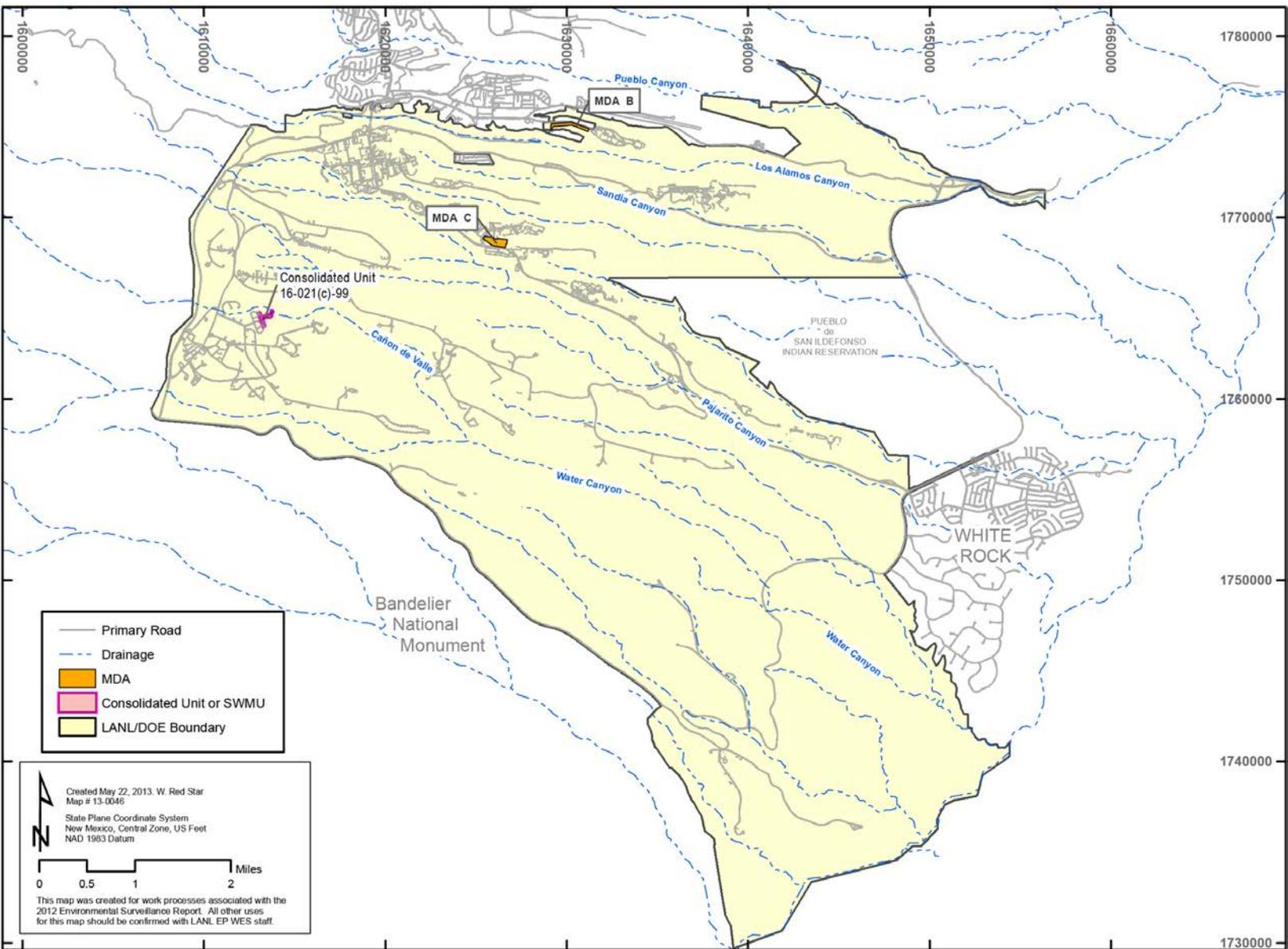


Figure 9-1 Locations of sites and canyons where characterization work was performed in 2012

**Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Reported in 2012 under the Corrective Actions Program**

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites Where Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Investigation Report for Cañon de Valle Aggregate Area, Technical Area 14 ^a	TA-14	27 sites addressed in this investigation report, of which 18 were sampled during the investigation	Approx. 260 samples	0	Extent defined at 5 sites, further sampling for extent not warranted at 2 sites; 1 site sampled to show contaminants are not migrating off-site; and extent not defined at 10 sites	Seven sites do not pose potential unacceptable human health and ecological risks/doses.	Seven sites were recommended for complete without controls [AOCs 14-001(a, b, c, d, e) and C-14-001, SWMU 14-003]. Ten sites require further sampling for extent; two of these sites were also recommended for remediation. Ten sites were recommended for deferred/delayed characterization and investigation.
Supplemental Remedy Completion Report for Upper Los Alamos Canyon Aggregate Area, Former Technical Area 32 ^a	Former TA-32	2	6	0	Extent defined at 2 sites	Two sites do not pose potential unacceptable human health (industrial) and ecological risks/doses.	Two sites were recommended and granted complete with controls [SWMUs 32-002(a) and 32-002(b1)]. Further evaluation of the SWMUs and AOCs within former TA-32 may be performed in the future with the objective of supporting a determination of corrective action complete without controls.
Investigation Report for Lower Mortandad/Cedro Canyons Aggregate Area, Revision 1 ^c	TA-05	4	Approx. 170 samples	At SWMU 05-006(c), approx. 2.1 yd ³ of soil, debris, and lead shielding excavated	Extent defined at 4 sites	Four sites do not pose potential human health and ecological risks/doses.	Four sites were recommended for complete without controls [SWMUs 05-003, 05-004, 05-005(b), and 05-006(c)]. Investigation is complete.
Nest Box Monitoring Report for the Upper Pajarito Canyon Watershed ^a	n/a ^b	3 reaches	9 insect samples	n/a	n/a	No difference in risk from chemicals of potential ecological concern (COPECs) between the Pajarito reaches and reference locations. Reproductive measures (eggshell thickness, clutch size, hatch date, hatching success, and fledgling success) not affected by contaminants.	Weight of evidence indicates COPECs in the Pajarito reaches do not pose a potential risk to population abundance or persistence and species diversity of avian ground invertevore feeding guild species. Further characterization of cavity-nesting birds and their food for metals and PCBs in the Pajarito watershed reaches is not warranted.

Table 9-4 (continued)

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites Where Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Results of 2011 Sediment Monitoring in the Pajarito Canyon Watershed ^a	n/a	14 reaches or areas	26 samples	n/a	n/a	n/a	Analytical results from sediment samples collected in the watershed and in baseline areas downstream from the Las Conchas burn area in 2011, combined with results from previous sediment samples, indicate that concentrations of most chemicals of potential concern (COPCs) released from Laboratory sites decrease downstream from the sources and also decrease over time. These data also indicate that many COPCs detected in the 2011 sediment samples have a primary source in the Las Conchas burn area and are associated with the transport of ash. Other COPCs detected in the 2011 sediment samples have a source in runoff from developed areas, consistent with results downstream from urban areas, such as the Los Alamos townsite.
Investigation Report for DP Site Aggregate Area Delayed Sites [Consolidated Unit 21-004(b)-99 and Solid Waste Management Unit 21-011(b)] and DP East Building Footprints at Technical Area 21, Revision 1 ^c	TA-21	8 (5 SWMUs/ AOCs and 3 building footprints)	Approx. 368 samples	Structures, waste lines, debris, and/or asphalt (approximately 30 yd ³) were removed. Some structures could not be fully excavated because of the depth below the ground surface or nearby active utilities.	Extent of contamination is not defined at any of the sites.	0	Additional sampling for extent may be required at all sites. Limited additional soil removal and associated confirmation sampling may also be warranted for areas with contamination above soil screening levels (SSLs)/screening action levels (SALs). A Phase II investigation work plan has been proposed to address the additional sampling and remediation required at the sites.

Table 9-4 (continued)

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites Where Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Phase II Investigation Report for Sandia Canyon	TA-03	1 reach (S-5EC), 5 stream gage stations, 1 spring, 41 wells	15 sediment samples, 88 surface water samples, 857 groundwater samples	0	Contaminants in sediment originally released from TA-03 extend for approximately 10 to 12 km (6 to 7 mi) downcanyon from the sources. Concentrations measured in supplemental reach S-5EC are generally much lower than the maximum concentrations measured during Phase I.	The conclusions of the ecological and human health risk assessments are not changed from those presented in the Phase I report based on the additional Phase II sediment and surface water sampling results.	Surface water/storm water will continue to be monitored. Groundwater will also continue to be monitored for potential changes in concentrations or distribution of contaminants within wells in the Chromium Investigation monitoring group.
Investigation/ Remediation Report for Material Disposal Area B, Solid Waste Management Unit 21-015, Revision 1	TA-21	1	187 confirmation samples, 7 borehole samples, 4 pore-gas samples, 3 geotechnical samples. In 2012, 10 confirmation samples of repackaging area were collected	All waste was removed, and contaminated soil/tuff from 0–10 ft below ground surface (bgs) was excavated. A total of 47,350 yd ³ of waste from the trenches at MDA B was shipped from the site.	Extent is defined by results from previous investigations, including the 1998 angled boreholes, direct-push technology sampling, confirmation sample data, soil-vapor data, and the results from the three post-remediation vertical boreholes drilled beneath the trenches at MDA B.	No inorganic or organic COPC concentrations from samples collected in the depth range of 0–10 ft bgs exceeded residential SSLs. Concentrations for all radionuclides, except plutonium-239/240 in one sample, were below the residential SALs from 0–10 ft bgs. The overall 95% upper confidence limit (9.85 picocuries per gram [pCi/g]) for plutonium-239/240 from 0–10 ft bgs was below the residential SAL. The pore-gas screening evaluation indicates that VOCs and tritium in subsurface pore gas below MDA B pose an extremely low risk of groundwater contamination.	The investigation/remediation work plan objectives have been met, and the nature and extent of residual contamination from historical waste disposal activities have been defined. Further sampling and/or remediation at MDA B are not necessary pending a risk/dose assessment for the site.

Table 9-4 (continued)

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites Where Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Reconnaissance Survey Report for Post-Las Conchas Fire Flooding in Water Cañon and Cañon de Valle	TA-16	14 reaches, 3 springs, 4 alluvial wells, 4 gage stations	Approx. 180 sediment samples, 84 storm water samples, 620 alluvial groundwater and spring samples	n/a	n/a	n/a	There is little evidence of perturbations to key contaminant concentrations in springs, alluvial wells, and surface water. The sole observed effect was an increase in barium concentrations in one alluvial well in samples collected in September 2011. Storm water samples showed increased concentrations in both filtered and unfiltered barium upgradient and downgradient of the Laboratory. The resultant deposits also show very low concentrations consistent with, or less than, prefire concentrations. There is no need for mitigation actions to reduce sediment transport in future floods.

^a The report was submitted in 2012, but the investigation was conducted and completed in 2011 or earlier.

^b n/a = Not applicable.

^c Revision 1 did not involve additional sampling or remediation, so the original investigation results and conclusions remain unchanged.

1. 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 high-explosives (HE) processing and machining since 1951. Wastewater from machining operations contained dissolved HE and may have contained entrained HE cuttings. Wastewater treatment consisted of routing the water to 13 settling sumps for recovery of any entrained HE cuttings. From 1951 to 1996, the water from these sumps 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 CMI plan (LANL 2007a) in 2009 and completed the plan's remediation and investigation actions in 2010 (LANL 2010a, 2010b). 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 for Consolidated Unit 16-021(c)-99 proceeded at a reduced pace during fiscal year 2012 compared with previous years, primarily because of the ongoing effects of the 2011 Las Conchas fire. The principal relevant activities for the surface CMI included (1) an evaluation of post-fire flooding effects in Cañon de Valle, which revealed moderate levels of geomorphic damage and minimal impacts to contaminant concentrations in alluvial wells and springs in the canyon, and (2) inspection of a monitoring well and bentonite pond cap downgradient of the 260 Outfall ponds, which indicated the injection grouting and bentonite pond cap in that area were working effectively.

The Cañon de Valle pilot PRB remains nonoperational because of post-Las Conchas fire flooding, which destroyed the capture wall for the PRB. A continued risk of flooding precludes reinstalling the PRB at this time. The current location of the PRB is not feasible for barrier reinstallation because of the deep scouring of the alluvial sediment in that area.

Sediment sampling of key reaches within Cañon de Valle and Water Canyon was completed during June/July of 2012. This sampling was designed to evaluate the effects of post-Las Conchas fire flooding on the alluvial systems in Cañon de Valle and Water Canyon. The results are summarized in the "Reconnaissance Survey Report for Post-Las Conchas Fire Flooding in Water Canyon and Cañon de Valle" (LANL 2012b) (Table 9-4). In summary, sediment reaches are variably disturbed, with the highest impacts occurring in the more western reaches. In most reaches, sediment packages with the highest contaminant levels were not disturbed by the post-fire flooding.

2. MDA C Investigations

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 7 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 to 107 are lined with 12-in.-thick concrete, while the rest of the pits and shafts are unlined. The pits and shafts are constructed in the Tshirege Member of the Bandelier Tuff. The regional aquifer is approximately 1320 ft bgs. 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

A variety of investigations have previously been performed at MDA C. These include investigations performed before 1990 when the corrective action requirements of the Resource Conservation and Recovery Act (RCRA) became effective, investigations performed as part of the MDA C RCRA facility investigation (RFI), and investigations performed under the Consent Order.

Field investigations conducted from 2004 to 2007 at MDA C under the Consent Order are reported in the MDA C investigation report (LANL 2006) and a supplemental data report (LANL 2007b). Under this investigation, a radiological survey was conducted and surface samples were collected at 6 locations and analyzed for radionuclides to supplement the surface sample data from the Phase I RFI. Geophysical and seismic surveys were performed to better define pit boundaries and to map the walls between Pits 1 to 4. Thirty-three boreholes were drilled, and 209 core samples were collected and analyzed for inorganic and organic chemicals and radionuclides to characterize the nature and extent of subsurface contamination. Core samples for geotechnical characterization were also collected from one of the boreholes. A total of 378 pore-gas samples were collected from the 33 boreholes and 2 existing boreholes in 2 sampling rounds and analyzed for VOCs and tritium to characterize subsurface vapor contamination. Three additional boreholes were drilled, and 40 pairs of core and pore-gas samples were collected to determine the relationship between VOC and tritium concentrations in core and pore gas. Four additional boreholes were drilled between Pits 2 and 3, and 25 core and 25 pore-gas samples were collected to characterize potential contamination beneath the pits. A risk-screening assessment was conducted that concluded surface and shallow subsurface contamination did not pose a potential unacceptable risk to human health and the environment based on current (i.e., industrial) site use.

Phase II investigations conducted in 2008 and 2009 at MDA C under the Consent Order are reported in the Phase II MDA C investigation report (LANL 2009). The specific objectives for the Phase II investigation were (1) to define the nature and extent of TAL metals at the surface at MDA C and (2) to characterize subsurface pore-gas concentrations of VOCs and tritium (LANL 2007c). Under this investigation, 59 surface and near-surface samples were collected at 30 locations to define the extent of TAL metals and conduct risk-screening assessments. Subsurface investigation activities included installing 5 new boreholes at locations without existing boreholes, extending 8 existing boreholes, installing 7 new deep boreholes next to existing shallow boreholes, and installing 1 new pilot-test borehole. Fourteen vapor-monitoring wells were constructed in the new boreholes and associated existing boreholes. A total of 104 core and 91 pore-gas samples were collected from these boreholes and vapor-monitoring wells to better define the vertical and lateral extent of contamination in tuff and pore gas.

Phase III investigations conducted in 2010 and 2011 at MDA C under the Consent Order are reported in the Phase III MDA C investigation report (LANL 2011). The Phase III investigation was conducted to define the vertical extent of VOCs in pore gas, evaluate concentrations of metals in the Tschicoma dacite, and determine whether contaminants had migrated to groundwater. Four new boreholes were advanced into the top of the Tschicoma dacite. Dacite samples were collected at 2 depths from each of the 2 boreholes located outside the MDA C boundary and analyzed for TAL metals. Because the lateral and vertical extent of inorganic chemicals, organic chemicals, and radionuclides in tuff had been defined previously, no samples were collected from the overlying tuff in any of the new boreholes. The 4 new boreholes were completed as vapor-monitoring wells. Six quarterly rounds of vapor sampling were performed in 2010 and 2011. The first 4 rounds were performed using the 14 existing Phase II vapor-monitoring wells, and the final 2 rounds were performed using the Phase II wells and the 4 new Phase III wells. To evaluate potential groundwater contamination, a new regional well, well R-60, was installed approximately 100 ft east of MDA C. Two quarterly rounds of groundwater samples were collected from well R-60 in January and April 2011.

The Phase III investigation report recommended quarterly monitoring from 46 sampling ports at 7 locations and annual monitoring from 108 ports at 10 locations (LANL 2011). In December 2011, the Laboratory was

directed to conduct semiannual vapor monitoring from 80 sampling ports at 18 locations, with all samples analyzed for VOCs and tritium. The results from the 3 monitoring events conducted after submittal of the Phase III investigation report are consistent with results of previous monitoring.

The regional monitoring-well network around MDA C is designed to provide reliable detection of potential contaminants from MDA C reaching the regional aquifer. Groundwater monitoring under the Consent Order is conducted in accordance with the IFGMP. The IFGMP is updated annually to revise monitoring suites, frequencies, and locations based on evaluation of previous monitoring results and installation of new wells. Data from groundwater monitoring wells in the vicinity of MDA C have previously been reported in the periodic monitoring reports for the Pajarito Canyon watershed (wells R-17, R-60, and PCI-2) and the Mortandad and Sandia Canyons watershed (wells R-14 and R-46). Data from wells R-14, R-46, and R-60 are now included in the MDA C monitoring group. Data from wells R-17 and PCI-2, which are not specific to MDA C, are part of the General Surveillance monitoring group. The MDA C monitoring group, which consists of regional wells R-14, R-46, and R-60, as well as nearby well R-17, is capable of producing reliable water-quality samples. Groundwater monitoring is discussed in Chapter 5.

c. Conclusions and Recommendations

Based on the results of the previous investigations, NMED directed the Laboratory to prepare a CME for MDA C, which was completed and submitted to NMED in 2012 (LANL 2012c). The purpose of the CME is to identify and evaluate potential remedial alternatives for MDA C. The CME focuses on realistic remedies, is tailored to this site, and is consistent with expected future land uses. Consent Order–specified evaluation criteria were used to select the recommended corrective measures alternative for the MDA C subsurface units based on evaluation of specific site conditions, including the contaminant inventory, the design of the disposal units, the environmental setting, and the nature and extent of contamination.

Treatment technologies were identified and screened for applicability to the sources of contamination present at MDA C (LANL 2012c). Applicable technologies were then combined into corrective measures alternatives to address the remedial action objectives for MDA C. The corrective measures alternatives were screened against the threshold criteria per Section VII.D.4.a of the Consent Order. Alternatives that satisfy the threshold criteria were then evaluated and ranked against the Remedial Alternative Evaluation Criteria (i.e., balancing criteria) identified in Section VII.D.4.b of the Consent Order. The highest-ranking alternative was selected as the recommended corrective measures alternative.

As a result of this evaluation, the recommended corrective measures alternative includes constructing an evapotranspiration (ET) cover over the pits and shafts to provide a barrier against human and ecological exposure to waste and contaminated soil (LANL 2012c). The ET cover also restricts the infiltration of water by providing a soil medium to hold infiltrated water until it is removed by evaporation from the surface and by transpiration through vegetation. The alternative includes constructing and operating a soil-vapor extraction system to remove VOCs from the subsurface to prevent the downward migration of these VOCs to the groundwater (LANL 2012c). Performance monitoring and institutional controls will be included to ensure the remedial action objectives have been satisfied. Long-term monitoring at MDA C that couples vapor monitoring in the vadose zone near the disposal units with regional aquifer monitoring will provide a defense-in-depth approach to demonstrate the effectiveness of the final remedy.

3. MDA C Subsurface Vapor Monitoring

Subsurface vapor (pore-gas) monitoring was conducted during 2012 beneath and surrounding MDA C. Subsurface vapor-monitoring samples have been collected at the site since 2004, and vapor-monitoring data indicate VOCs and tritium are present in the subsurface (LANL 2012c). The data collected from vapor-monitoring wells are used to characterize the nature and extent of 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 groundwater and whether corrective actions may be required. The analytical data are available on the online Intellus New Mexico website (<http://www.intellusnmdata.com>).

Sample collection was conducted using stainless-steel sampling systems that are capable of isolating specific depth intervals 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 the U.S. Environmental Protection Agency (EPA) Method TO-15 for VOCs and EPA Method 906.0 for tritium.

Vapor monitoring at MDA C was conducted 2 times during 2012 at 80 sampling ports within 18 vapor-monitoring wells. Figure 9-2 presents the 18 monitoring wells sampled during 2012 at MDA C. The sampling locations and frequency were specified by NMED (2011). The first sampling event was conducted during March and April, and the second sampling event was conducted during October and November.

Because no regulatory criteria currently exist for vapor-phase contaminants in soil, LANL evaluated VOC pore-gas data for the potential to contaminate groundwater above applicable government standards. A Tier I screening analysis has been routinely used to evaluate the pore-water concentration that would be in equilibrium with the maximum pore-gas concentration of each VOC detected. The equilibrium relationship between pore-gas and water concentrations is explained in the CME report for MDA C (LANL 2012c). The Tier I screening ratio (SR) is the ratio of the measured VOC pore-gas concentration to the Tier I screening level, i.e., the pore-gas concentration corresponding to that VOC's groundwater standard. If the Tier I SR is above 1, the VOC could theoretically have the potential to impact groundwater. The Tier I screening yields conservative SRs because the maximum vapor concentrations are located in the unsaturated zone several hundred feet above the regional groundwater. In addition, the screening evaluation does not account for aquifer dilution.

In the MDA C CME report, a Tier II screening process was also developed and applied (LANL 2012c). To provide a more realistic estimate of the potential impact that the vapor plume may ultimately have on groundwater, the Tier II screening accounts for migration of VOCs through the unsaturated zone to the regional aquifer and subsequent dilution within the aquifer. These calculated groundwater concentrations are compared with the groundwater standards. The Tier II screening values vary with depth because they are a function of the depth to groundwater in the unsaturated zone.

A total of 28 VOCs and tritium were detected in pore gas at MDA C during the first 2012 sampling event; 16 VOCs and tritium were detected in pore gas during the second 2012 sampling event. Table 9-5 lists the VOCs for which the SRs were above 1 during 2012 using the Tier I screening analysis. The maximum Tier I SRs calculated for these VOCs are also listed. The screening evaluation of the 2012 data identified three VOCs with vapor concentrations above their respective Tier I screening values: 2-hexanone, methylene chloride, and trichloroethene (TCE).

TCE is the only VOC detected at concentrations above the Tier II screening values presented in the MDA C CME report (LANL 2012c). Figures 9-3 and 9-4 show the TCE vapor data for the first and second 2012 pore-gas sampling events, respectively, compared with the depth-dependent Tier II TCE screening values. The TCE screening values assume there is vapor diffusion through porous media in the unsaturated zone and dilution in the regional aquifer. Figure 9-3 shows that the Tier II screening levels were exceeded in samples collected at monitoring wells 50-24813, 50-603470, and 50-603471 during March and April 2012. Figure 9-4 shows that the Tier II screening levels were exceeded in samples collected at monitoring wells 50-24813 and 50-603471 during October and November 2012. The TCE vapor concentrations were above the Tier II screening values in a limited area at the eastern end of MDA C at a depth of 241 to 360 ft bgs and over 800 ft above the regional aquifer. The locations with the highest TCE concentrations were consistent with data from 2010 and 2011 presented in the CME report (LANL 2012c) and in the 2011 environmental report (LANL 2012d).

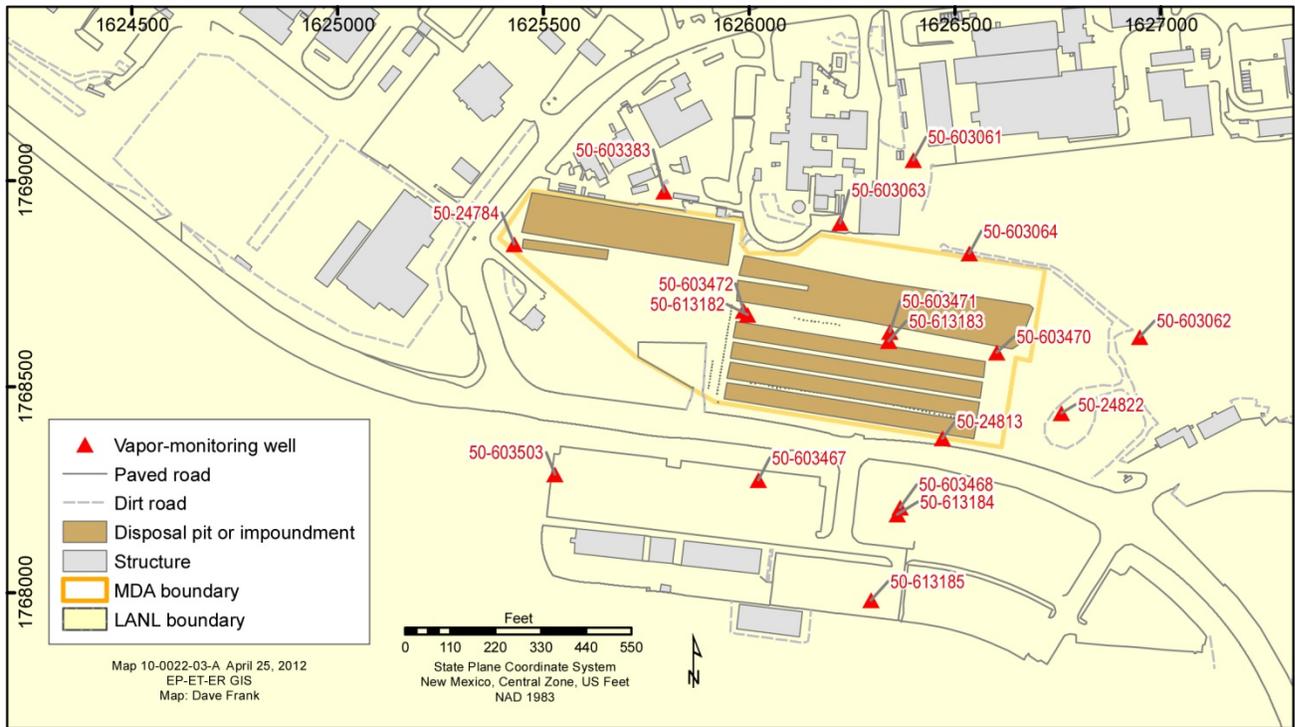


Figure 9-2 MDA C vapor-monitoring well locations

Table 9-5
 VOCs above Tier I Screening Values in 2012 Samples at MDA C

VOC	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard, Tier I Screening Value ($\mu\text{g}/\text{m}^3$) ^a	Maximum Pore-Gas Concentration ($\mu\text{g}/\text{m}^3$) ^a during First Sampling Event	Maximum Tier I Screening Ratio (unitless) for First Sampling Event	Maximum Pore-Gas Concentration ($\mu\text{g}/\text{m}^3$) during Second Sampling Event	Maximum Tier I Screening Ratio (unitless) for Second Sampling Event
Hexanone[2-]	180	737	4.1	409	3.1
Methylene Chloride	650	2430	3.7	1735	2.6
TCE ^b	2000	85,930	43.0	69,816	34.9

^a $\mu\text{g}/\text{m}^3$ = Micrograms per cubic meter.

^b TCE concentrations were also above the Tier II screening value developed for MDA C (LANL 2012c).

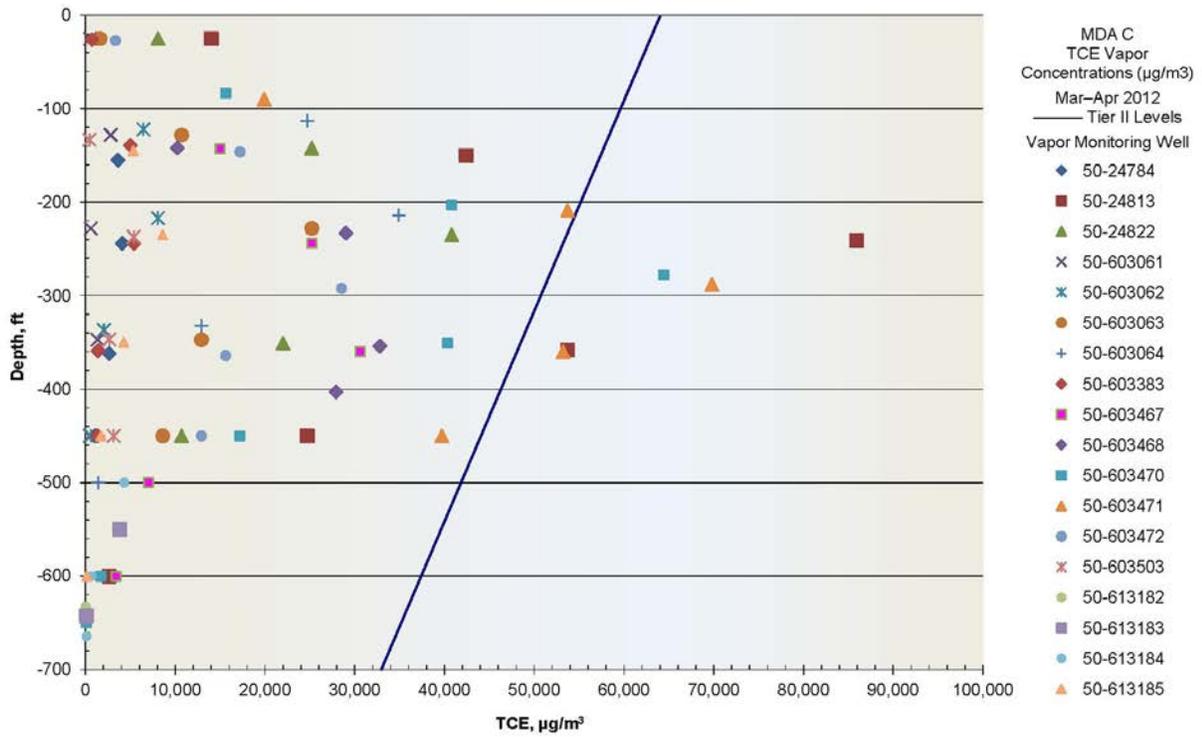


Figure 9-3 TCE vapor concentrations measured at MDA C during March and April 2012, compared with the depth-dependent Tier II screening levels

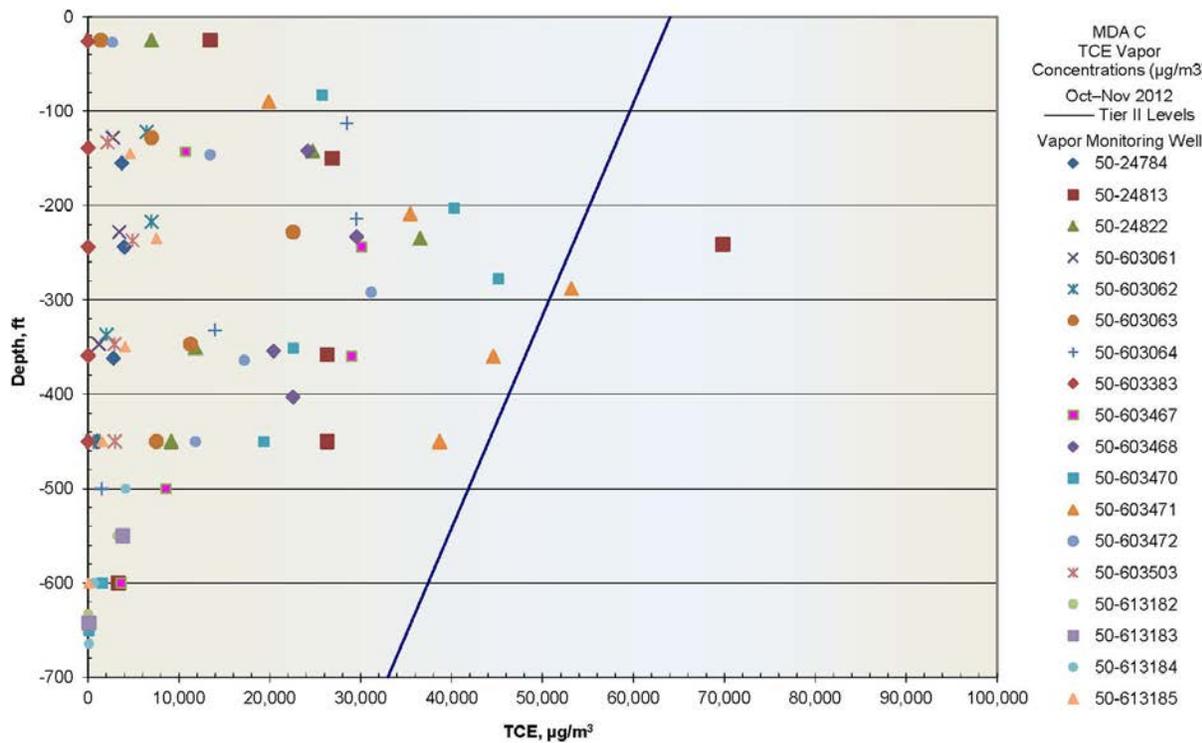


Figure 9-4 TCE vapor concentrations measured at MDA C during October and November 2012, compared with the depth-dependent Tier II screening levels

The vapor plume is associated with disposal trenches and shafts near the eastern end of MDA C that contain wastes with some solvent contamination. However, the characteristics of the vapor plume, particularly that the maximum concentrations occur below the disposal trenches and shafts, indicate the highest concentration portion of the plume is predominantly related to releases that occurred in the past rather than from ongoing releases. Further explanation is included in the MDA C CME report (LANL 2012c). Although the TCE plume is presently located over 800 ft above the regional aquifer, the CME report noted that there is some uncertainty associated with the future transport of vapor-phase contaminants through the fractured dacite rock layer beneath the plume. Therefore, the CME recommended that soil vapor extraction be used as a remedy to decrease subsurface vapor concentrations of VOCs, particularly TCE, because its vapor concentration exceeds the Tier II screening levels (LANL 2012c).

Tritium activity was detected in vapor samples collected at MDA C. At most locations, the tritium activity decreased with depth, and most values (>84%) are below the Tier I screening value of 20,000 picocuries per liter (pCi/L) (the groundwater standard). The CME report recommended a Tier II screening level for tritium (288,800 pCi/L), which was calculated as the product of the Tier I screening level (20,000 pCi/L) and an aquifer dilution factor of 14.44 (LANL 2012c). The Tier II screening level established for tritium does not account for transport in the unsaturated zone. Most tritium concentrations (>92%) are below the Tier II screening value. At most of the monitoring wells, the activities that exceed the Tier I and Tier II screening values occur at a single port. For example, the maximum activity reported during 2012 was 6,001,000 pCi/L in monitoring well 50-24822 at a depth of 235 ft, at the eastern end of MDA C (Figure 9-2), but tritium activities in ports above and below this depth were 3 or 4 orders of magnitude less. However, tritium activities exceeded either the Tier I or the Tier II screening value in samples collected at four or five ports at monitoring well 50-603383 along the northern boundary of MDA C for the two sampling events (Figure 9-2). These results were consistent with previous sampling data.

Vapor monitoring at MDA C will continue on a semiannual basis to support remedy selection.

C. TA-54 CLOSURE PROJECT

The Laboratory continues to monitor groundwater in and around TA-54. The Laboratory reports these monitoring results in the periodic monitoring reports. Groundwater monitoring is discussed in Chapter 5.

D. TA-21 CLOSURE PROJECT

TA-21 is located on DP Mesa on the northern boundary of the Laboratory and is immediately east-southeast of the Los Alamos townsite. In 1945, plutonium research and metal production activities were conducted at the newly built facilities at TA-21.

The Laboratory continues to monitor groundwater in and around TA-21. The Laboratory reports these monitoring results in the periodic monitoring reports. Groundwater monitoring is discussed in Chapter 5. For other sampling, evaluations, or investigations reported in 2012 at TA-21, see Table 9-4.

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 collected under common EPA chain-of-custody procedures using field notebooks and sample collection logs and then prepared and stored in certified precleaned 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.

F. REFERENCES

- LANL 2006: "Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50," Los Alamos National Laboratory document LA-UR-06-8096 (December 2006).
- LANL 2007a: "Corrective Measures Implementation Plan for Consolidated Unit 16-021(c)-99, Revision 1," Los Alamos National Laboratory document LA-UR-07-4715 (July 2007).
- LANL 2007b: "Submittal of Drilling and Sampling Results from Boreholes Between Pit 2 and Pit 3 at Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50" Los Alamos National Laboratory letter (EP2007-0231) to J.P. Bearzi (NMED-HWB) from C.A. Mangeng (LANL) and G.J. Rael (DOE-LASO) (April 2007).
- LANL 2007c: "Phase II Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50, Revision 1," Los Alamos National Laboratory document LA-UR-07-5083 (July 2007).
- LANL 2009: "Phase II Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50, Revision 1," Los Alamos National Laboratory document LA-UR-09-6266 (October 2009).
- LANL 2010a: "Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-10-0947 (March 2010).
- LANL 2010b: "Addendum to the Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-10-5576 (August 2010).
- LANL 2011: "Phase III Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50," Los Alamos National Laboratory document LA-UR-11-3429 (June 2011).
- LANL 2012a: "Interim Facility-Wide Groundwater Monitoring Plan for the 2013 Monitoring Year, October 2012–September 2013," Los Alamos National Laboratory document LA-UR-12-21331 (August 2012).
- LANL 2012b: "Reconnaissance Survey Report for Post–Las Conchas Fire Flooding in Water Canyon and Cañon de Valle," Los Alamos National Laboratory document LA-UR-12-23405 (July 2012).
- LANL 2012c: "Corrective Measures Evaluation Report for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50," Los Alamos National Laboratory document LA-UR-12-24944 (September 2012).

LANL 2012d: "Los Alamos National Laboratory Environmental Report 2011," Los Alamos National Laboratory report LA-14461-ENV (September 2012).

NMED 2011: "Approval, Phase III Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico (December 2011).

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A. INTRODUCTION

The 2012 environmental sampling incorporated a graded approach to quality assurance (QA) in accordance with U.S. Department of Energy (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 Los Alamos National Laboratory's (LANL's or the Laboratory's) environmental data across all media. Overall, our analytical laboratories' performance met 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. 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 U.S. Environmental Protection Agency (EPA) Contract Laboratory Program National Functional Guidelines for Data Review (EPA 2004, 2005, 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, New Mexico, 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 2012 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 public Intellus New Mexico website, <http://www.intellusnmdata.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. See the Intellus website for SOPs for 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, surrogate samples, tracers, and matrix spike 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 revalidation. 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 2012 validation corrective action reports are addressed and resolved appropriately by the analytical laboratory. AQA validated all of the 2012 data packages.

After data validation by AQA, approximately 99.7% of all results are of good quality and are usable; AQA assigned R qualifiers (rejected) to approximately 0.3% of the 2012 data. Overall, approximately 10% of the accepted results are qualified during data validation based on data quality issues such as surrogate, laboratory control sample, duplicate, tracer, and matrix spike recoveries that do not meet specifications; calibration of internal standards that are not met; or holding times that have expired. The analytical laboratory assigned J qualifiers to approximately 3% of the data, indicating that the results represent a detection, but the value is estimated. The analytical laboratory confirmed 21% of the analytes as detected. Even after validation, 66% of the data are qualified as not detected with no QC issues. Table 10-1 displays the overall quality of the 2012 samples.

Table 10-1
Overall Quality of 2012 Samples

Qualifiers Affecting Quality Control	Percent of 2012 Data
U, U_LAB: qualified as not detected by lab with no QC issues	66
J, J_LAB: qualified as detected between method detection limit and estimated quantitation limit	3
NQ: detected above the reporting limit with no QC issues	21
R: rejected in validation	0.3
UJ (estimated nondetect) or J because of QC issues discovered in validation	10

Table 10-2 shows the percentage of data qualified based on AQA's secondary data validation of laboratory QC samples. Less than 1% of all 2012 data were qualified as rejected (R).

Table 10-2
Auto-Validation Summary for 2012 Data

QC Sample Type	Number of Analytes Qualified as Estimated (J)	Percent 2012 Data
Blanks	48	0.03
Holding times	77	0.05
Initial calibration verifications or continuing calibration verifications	22	0.01
Internal standards or surrogates	15	0.00
Laboratory control samples	24	0.01
Laboratory duplicates	304	0.19

Table 10-2 (continued)

QC Sample Type	Number of Analytes Qualified as Rejected (R)	Percent 2012 Data
Initial calibration verifications or continuing calibration verifications	13	0.01
Internal standards or surrogates	186	0.12
Laboratory control samples	77	0.05
Laboratory duplicates	3	0.00
Spectra do not match	106	0.07
Professional judgment	58	0.04

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 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 2012, the majority of the analyses were performed by GEL Laboratories in Charleston, South Carolina; TestAmerica, Inc., St. Louis in Earth City, Missouri; ALS Laboratory Group (formally Paragon) in Fort Collins, Colorado; Southwest Research Institute in San Antonio, Texas; and American Radiation Services, Inc., in 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 for the required analytical methods.

LANL requires analytical laboratories to participate in independent national performance evaluation programs. These performance evaluation 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, Water Study, 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 were reported.

All of the laboratories provided detailed analytical laboratory performance evaluation studies, investigation reports, and corrective 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. U.S. 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 that eliminates audit redundancy by involving all DOE program line organizations and field elements, provides a pool of trained auditors sufficient to support consolidated audits, standardizes terms and conditions of existing and proposed contracts to allow acceptance of consolidated audit results, and interfaces 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.

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 met 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 audits have been approved and are available from the DOECAP website.

E. REFERENCES

EPA 2004: "National Functional Guidelines for Inorganic Data Review," U.S. EPA Contract Laboratory Program, OSWER 9240.1-45, EPA 540-R-04-004 (October 2004).

EPA 2005: "National Functional Guidelines for Chlorinated Dioxin/Furan Data Review," U.S. EPA Contract Laboratory Program, EPA-540-R-05-001 (September 2005).

EPA 2008: "National Functional Guidelines for Superfund Organic Methods Data Review," U.S. EPA Contract Laboratory Program, EPA-540-R-08-01 (June 2008).

NNSA 2006: "Model Data Validation Procedure," Revision 4.1, U.S. Department of Energy National Nuclear Security Administration Service Center (August 2006).

NNSA 2010: "Model Statement of Work for Analytical Laboratories," U.S. Department of Energy National Nuclear Security Administration Service Center (August 2010).

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 U.S. Environmental Protection Agency (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 U.S. 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 millirem per year (mrem/yr). For one specific activity or pathway, DOE guidance specifies a “dose constraint” of 25 mrem/yr (DOE 1999.) The public dose limits and the DOE occupational dose limits are

**Table A-1
DOE Dose Limits
for External and Internal Exposures**

Exposure Pathway	Dose Equivalent at Point of Maximum Probable Exposure
Exposure of Any Member of the Public	
All pathways	100 mrem/yr ^a
One specific pathway (dose constraint)	25 mrem/yr ^b
Air pathway only ^c	10 mrem/yr
Drinking water	4 mrem/yr
Occupational Exposure	
Stochastic Effects	5 rem/yr ^d (TEDE) ^e
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 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/yr.

^b Guidance (DOE 1999).

^c This level is from EPA’s regulations issued under the Clean Air Act (40 Code of Federal Regulations [CFR] 61, Subpart H) (EPA 1989a).

^d rem/yr = rem per year.

^e Refer to Glossary for definition (see “dose”).

based on recommendations from the 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 L/yr, would give a dose of 100 mrem/yr.

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/yr.

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 DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 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.

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 the National Pollutant Discharge Elimination System and the limits established for sanitary and industrial outfalls can be found at <http://www.lanl.gov/community-environment/environmental-stewardship/protection/compliance/individual-permit-stormwater/index.php>.

Table A-2
DOE's Derived Concentration Guides for Water^a

Nuclide	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L ^b)	DCGs for Drinking Water Systems ^c (pCi/L)
³ H	2,000,000	80,000
⁷ Be	1,000,000	40,000
⁸⁹ Sr	20,000	800
⁹⁰ Sr	1000	40
¹³⁷ Cs	3000	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 DCGs for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990). DCGs apply to concentrations in excess of those occurring naturally or that are because of worldwide fallout.

^b pCi/L = Picocuries per liter.

^c Drinking water DCGs are 4% of the DCGs for nondrinking water.

Table A-3
National (40 CFR 50) and
New Mexico (20.2.3 New Mexico Administrative Code) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm ^a	0.02	0.030	
	24 h	ppm	0.10	0.14	
	3 h	ppm			0.5
Hydrogen sulfide	1 h	ppm	0.010		
Total reduced sulfur	1/2 h	ppm	0.003		
Total suspended particulates	Annual	µg/m ^{3b}	60		
	30 days	µg/m ³	90		
	7 days	µg/m ³	110		
	24 h	µg/m ³	150		
PM-10 ^c	Annual	µg/m ³		50	50
	24 h	µg/m ³		150	150
PM-2.5 ^d	Annual	µg/m ³		15	15
	24 h	µg/m ³		65	65
Carbon monoxide	8 h	ppm	8.7	9	
	1 h	ppm	13.1	35	
Ozone	1 h	ppm		0.12	0.12
	8 h	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 h	ppm	0.10		
Lead and lead compounds	Calendar quarter	µg/m ³		1.5	1.5

^a ppm = Parts per million.

^b µg/m³ = Micrograms per cubic meter.

^c PM-10 = Particles ≤10 µm in diameter.

^d PM-2.5 = Particles ≤2.5 µm in diameter.

DRINKING WATER STANDARDS

For chemical constituents in drinking water, regulations and standards are issued by the 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 Water 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 stipulate that combined radium-226 and radium-228 may not exceed 5 pCi/L. Gross-alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi/L.

A screening level of 5 pCi/L 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/yr, 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/yr. 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.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.htm>. 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 (RSRLs), the concentrations are first compared with screening levels. The screening level for soils is the concentration that would produce (1) a dose of 15 mrem or greater to an individual, (2) a carcinogen risk of 10^{-5} , or (3) a hazard quotient greater than 1. Screening levels for radionuclides are found in a Laboratory document (LANL 2005); screening levels for nonradionuclides are found in an NMED document (NMED 2006). If radionuclide concentrations in soil exceed the screening levels, then a dose to a person is calculated using the residual radioactivity (RESRAD) computer model and all of the measured radionuclide concentrations available for a given year (these data are presented in Supplemental Table S7-1). This calculated dose is compared with 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 nonradionuclides (e.g., mercury and polychlorinated biphenyls [PCBs]) in foodstuffs. Federal screening levels exist for selected nonradionuclides; LANL has established screening levels for radionuclides. If contaminant concentrations in foodstuffs exceed RSRLs, the concentrations are compared with screening levels. LANL has established a screening level of 1 mrem/yr 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 with 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 RSRLs, the concentrations are compared with screening levels. For radionuclides in biota, screening levels were set at 10% of the standard by LANL to identify the potential contaminants of concern (McNaughton 2006). For chemicals, there are no screening levels 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 (LANL 2008).

Based on the concentrations of radionuclides in biota, LANL calculates a dose and compares 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).

REFERENCES

- DOE 1990: "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 5400.5 (February 8, 1990).
- DOE 1999: "The Long-Term Control of Property: Overview of Requirements in Orders DOE 5400.1 & 5400.5," U.S. Department of Energy Brief EH-412-0014/1099 (October 1999)
<http://www.hss.energy.gov/sesa/environment/guidance/aea/doc5415b.pdf>
- DOE 2002: "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," U.S. Department of Energy Standard DOE-STD-1153-2002 (July 2002).
- EPA 1989a: "40 CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," U.S. Environmental Protection Agency, Federal Register 54, 51 653-51 715 (December 15, 1989).
- EPA 1989b: "National Interim Primary Drinking Water Regulations," Code of Federal Regulations, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143, U.S. Environmental Protection Agency (1989).
- EPA 1993: "External Exposure to Radionuclides in Air, Water, and Soil," U.S. Environmental Protection Agency, Federal Guidance Report No. 12, EPA 402-R-93-081 (September 1993).
- EPA 1999: "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," U.S. Environmental Protection Agency, Federal Guidance Report No. 13, EPA 402-R-90-001 (September 1999).
- EPA 2001: "Water Quality Criterion for the Protection of Human Health: Methylmercury," U.S. Environmental Protection Agency, Office of Science and Technology, EPA-823-R-01-001 (2001).
- EPA 2007: "Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition, Risk Based Consumption Limit Tables," U.S. Environmental Protection Agency, available at <http://www.epa.gov/waterscience/fishadvice/volume2/v2ch4.pdf> (2007)
- FDA 2000: "Action Levels for Poisonous or Deleterious Substance in Human Food and Animal Feed," Food and Drug Administration, Washington, DC (2000).
- ICRP 1988: "Limits for Intakes of Radionuclides by Workers," International Commission on Radiological Protection Publication 30, Parts 1, 2, and 3, and their supplements, Annals of the ICRP 2(3/4) -8(4) (1979-1982), and Publication 30, Part 4, 19(4) (1988).
- LANL 2005: "Derivation and Use of Radionuclide Screening Actions Levels, Revision 1," Los Alamos National Laboratory document LA-UR-05-1849 (2005).
- LANL 2008: "ECORISK Database," version 2.3. Los Alamos National Laboratory report LA-UR-08-6673 (2008).
- McNaughton 2006: McNaughton, M., "Calculating Dose to Non-Human Biota," Los Alamos National Laboratory, Meteorology and Air Quality Group procedure ENV-MAQ-514, R1 (2006).

NCRP 1987: "Recommendations on Limits for Exposure to Ionizing Radiation," National Council on Radiation Protection and Measurements report No. 91 (June 1987).

NMED 2006: "Technical Background Document for Development of Soil Screening Levels, Rev. 4.0," New Mexico Environment Department report (2006).

NMEIB 1995: "New Mexico Drinking Water Regulations," New Mexico Environmental Improvement Board (as amended through January 1995).

NMWQCC 1995: "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," New Mexico Water Quality Control Commission, Section 3-101.K (as amended through January 23, 1995).

Throughout this report the U.S. 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, U.S. 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 International System of Units (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 U.S. 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 2000. 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 U.S. Customary Units**

Multiply U.S. Customary Unit	by	to Obtain SI (Metric) Unit
degrees Fahrenheit (°F)	5/9 - 32	degrees Celsius (°C)
inches (in.)	2.54	centimeters (cm)
cubic feet (ft ³)	0.028	cubic meters (m ³)
acres	0.4047	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)
picocuries (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	1000 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 or Abbreviation	Definition	Symbol or Abbreviation	Definition
aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu	British thermal unit	nCi	nanocurie
Ci	curie	nCi/dry g	nanocuries per dry gram
cm ³ /s	cubic centimeters per second	nCi/L	nanocuries per liter
cpm/L	counts per minute per liter	ng/m ³	nanograms per cubic meter
fCi/g	femtocuries per gram	pCi/dry g	picocuries per dry gram
ft	foot or feet	pCi/g	picocuries per gram
ft ³ /min	cubic feet per minute	pCi/L	picocuries per liter
ft ³ /s	cubic feet per second	pCi/m ³	picocuries per cubic meter
kg	kilogram	pCi/mL	picocuries per milliliter
kg/h	kilograms per hour	pg/g	picograms per gram
m ³ /s	cubic meters per second	pg/m ³	picograms per cubic meter
μCi/L	microcuries per liter	PM ₁₀ or PM-10	small particulate matter (less than 10 μm diameter)
μCi/mL	microcuries per milliliter	PM _{2.5} or PM-2.5	small particulate matter (less than 2.5 μm diameter)
μg/g	micrograms per gram	R	roentgen
μg/m ³	micrograms 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 ambient air monitoring network (AIRNET) station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

$$s = (\sum (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

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 (1s) for the station and group means.

REFERENCE

Gilbert 1975: Gilbert, R.O., “Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group,” Battelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

APPENDIX C – DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by Los Alamos National Laboratory (LANL) in Los Alamos County are shown in Figure 1-3 in Chapter 1. The main programs conducted at each of the areas are listed in this appendix.

Technical Area	Activities
TA-00 (Off-site Facilities)	This TA designation is assigned to structures leased by the U.S. Department of Energy (DOE) that are located outside LANL's boundaries in the Los Alamos townsite and White Rock.
TA-02 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-megawatt 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-03 (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 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-05 (Beta Site)	This TA is largely undeveloped. Located between East Jemez Road and the Pueblo de San Ildefonso, it contains physical support facilities, an electrical substation, and test wells.
TA-06 (Twomile 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-08 (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-09 (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.

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

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 the National Nuclear Security Administration'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 Los Alamos Neutron Science Center (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 yr.
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 mi (32 km) 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 at 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-03. 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-03. TA-59 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-03. 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. Because of 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-03 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 newest 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 NM 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 de San Ildefonso and is no longer part of LANL.

APPENDIX D – RELATED WEBSITES

For more information on environmental topics at Los Alamos National Laboratory (LANL), access the following websites:

Current environmental report and supplemental data tables	http://www.intellusnmdata.com/
Current and past environmental reports	http://www.lanl.gov/community-environment/environmental-stewardship/environmental-report.php
LANL website	http://www.lanl.gov/
U.S. Department of Energy/National Nuclear Security Administration Los Alamos Field Office website	http://www.doeal.gov/laso/default.aspx
U.S. Department of Energy website	http://www.energy.gov/
LANL's air quality pages	http://www.lanl.gov/community-environment/environmental-stewardship/protection/monitoring/air-quality.php
LANL's water quality pages	http://www.lanl.gov/community-environment/environmental-stewardship/protection/monitoring/water-quality.php
LANL's environmental stewardship pages	http://www.lanl.gov/community-environment/environmental-stewardship/index.php
LANL's environmental database	http://www.intellusnmdata.com/

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. A release that may warrant investigation or remediation and is not a SWMU.
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 Los Alamos National 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 signal 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 value of the constituent are unknown to the analyst.
CAA	Clean Air Act. The federal law that authorizes the 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 in this glossary). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	Any Los Alamos National 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 times 10 ¹⁰ nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DCG	Derived Concentration Guide. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for 1 yr 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	U.S. 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 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 $100 \times 0.12 = 12$ 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 Los Alamos National 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 1000 people each received a radiation dose of 1 rem, their population dose would be 1000 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 Los Alamos National 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 Los Alamos National Laboratory's environmental monitoring and surveillance programs.
environmental monitoring	The sampling of contaminants in liquid effluents and gaseous emissions from Los Alamos National 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	U.S. 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 ($1/2 \times 1/2$), after three half-lives, one-eighth remains ($1/2 \times 1/2 \times 1/2$), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding of 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. RCRA regulations set strict controls on the management of hazardous wastes.
hazardous waste constituent	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.
ionizing radiation	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.
isotopes	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.
long-lived isotope	A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than 3 yr).
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 2 days or less).
LANS	Los Alamos National Security, LLC. The limited liability corporation that took over management of Los Alamos National Laboratory in June 2006.
LASO	Los Alamos Site Office. The Los Alamos office of the DOE's NNSA. The name changed to the Los Alamos Field Office in January 2013.
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 <i>Atomic Energy Act of 1954</i> , 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. 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, the population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc., is determined and becomes the MEI.
mixed waste	Waste that contains a hazardous waste component regulated under Subtitle C of RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act.
mrem	Millirem. See definition of rem in this glossary. 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 DOE that is responsible for national security through the military application of nuclear energy.
nonhazardous waste	Chemical waste regulated under the Solid Waste Act, TSCA, and other regulations, including asbestos, PCBs, 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 CWA, 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 biphenyl. 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, standards 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.
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 in this glossary]).
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 micrograms per liter ($\mu\text{g/L}$) or nanograms per milliliter (ng/mL). Also used to express the weight/weight ratio as nanograms per gram (ng/g) or micrograms per kilogram ($\mu\text{g/kg}$).
ppm	Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as milligrams per liter (mg/L). Also used to express the weight/weight ratio as micrograms per gram ($\mu\text{g/g}$) or milligrams per kilogram (mg/kg).
QA	Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of QA 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. $1 \text{ rad} = 1000 \text{ millirad (mrad)}$
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. $\text{rem} = \text{rad} \times \text{quality factor}$ $1 \text{ rem} = 1000 \text{ millirem (mrem)}$
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 Los Alamos National Laboratory, 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 dosimeter made of a material (Los Alamos National 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 the 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.

APPENDIX F – ACRONYMS AND ABBREVIATIONS

2s	two sigma (two standard deviations)
3s	three sigma (three standard deviations)
aCi/m ³	attocuries per cubic meter
ACA	accelerated corrective action
ADESH	Associate Directorate for Environment, Safety, and Health
AIRNET	ambient air monitoring network
AFV	alternative fuel vehicle
ALARA	as low as reasonably achievable
AOC	area of concern
AQA	Analytical Quality Associates, Inc.
AR	Abiquiu Reservoir
ARRA	American Recovery and Reinvestment Act
ARSL	American Radiation Services, Inc.
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
AST	aboveground storage tank
BCG	biota concentration guide
Bd	<i>Batrachochytrium dendrobatidis</i> (amphibian infection)
BDD	Buckman Direct Diversion Project
BEIR	Biological Effects of Ionizing Radiation
bgs	below ground surface
BMI	benthic macroinvertebrate
BMP	best management practice
BOD	biological oxygen demand
BRMP	Biological Resources Management Plan
BSRL	baseline statistical reference level
C&T	(Land) Conveyance and Transfer (Project)
CA	composite analysis
CAA	Clean Air Act
CAP88	Clean Air Act Assessment Package-1988
CD	Critical Decision
CEM	Certified Energy Manager
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act

CFR	Code of Federal Regulations
cfs	cubic feet per second
CGP	Construction General Permit
CH ₄	methane
CME	corrective measures evaluation
CMI	corrective measures implementation
CMR	Chemistry and Metallurgy Research (facility)
CMRR	Chemistry and Metallurgy Research Replacement (facility)
CO	monoxide
CO ₂	carbon dioxide
COD	chemical oxygen demand
COE	U.S. Army Corps of Engineers
Consent Order	Compliance Order on Consent
COPC	chemical of potential concern
CR	Cochiti Reservoir
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DAC	derived air concentration
DARHT	Dual-Axis Radiographic Hydrodynamic Test (facility)
DB	detention basin
DCG	derived concentration guide
DL	detection limit
DMCC	DOE Meteorological Coordinating Council
DOE	U.S. Department of Energy
DOECAP	DOE Contract Analytical Program
DPA	Data Package Assessment
DRO	diesel-range organics
DPRNET	Direct Penetrating Radiation Monitoring Network
DU	depleted uranium
EDE	effective dose equivalent
EIS	Environmental Impact Statement
ELG	Effluent Limitation Guideline

EMS	Environmental Management System
EO	Executive Order
EP	Environmental Programs (Directorate)
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPRR	Electronic Public Reading Room
ES&H	environment, safety, and health
ESH&Q	Environment, Safety, Health, and Quality Directorate
ESL	ecological screening level
ESPC	Energy Savings Performance Contract
EStar	Environmental Sustainability (award)
EU	enriched uranium
fCi/m ³	femto-curies per cubic meter
FCRS	Flood Control Retention Structure
FDA	Food and Drug Administration
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FLUTE	Flexible Liner Underground Technologies, LLC
FOD	Facility Operations Director
FSOC	Federal Species of Concern
FY	fiscal year
GAC	granular activated carbon
GEL	General Environmental Laboratory
GHG	greenhouse gas
GMAP	gaseous mixed activation products
GP	Guiding Principle
GSA	General Services Administration
GSAF	Generator Set-Aside Fee
HAP	hazardous air pollutant
HE	high explosives
HEP	High Explosives Processing
HET	High Explosives Testing

HEWTF	High Explosives Wastewater Treatment Facility
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HPRR	Hardcopy Public Reading Room
HPSB	High Performance Sustainable Building
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiological Protection
ILA	industrial, landscaping, and agricultural
Interim Plan	Interim Facility-Wide Groundwater Monitoring Plan
IP	Individual Permit
ISL	industrial screening level
ISM	Integrated Safety Management
ISO	International Organization for Standardization
IT	information technology
JIT	just in time
kW	kilowatt
LAC	Los Alamos County
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 (DOE, changed to the Los Alamos Field Office in January 2013)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
LCS	laboratory control sample
LDCC	Laboratory Data Communications Center
LEED	Leadership in Energy and Environmental Design
LLW	low-level waste

MAP	mitigation action plan
MAPAR	Mitigation Action Plan Annual Report
MAPEP	Mixed-Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MCNP	Monte-Carlo N-Particle (program)
MDA	material disposal area
MDCN	Mortandad Canyon
MDL	method detection limit
MEI	maximally exposed individual
MLLW	mixed low-level waste
MOU	memorandum of understanding
MOV	management observation and verification
μR/h	microrentgen/hour
MRF	Material Recycling Facility
MS	matrix spike
MSGP	Multi-Sector General Permit
MSL	Materials Science Laboratory
MTRU	mixed transuranic
N ₂ O	nitrous oxide
NCOM	North Community
NCRP	National Council on Radiation Protection
ND	nondetect
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEWNET	Neighborhood Environmental Watch Network
NHPA	National Historic Preservation Act
NISC	Nonproliferation and International Security Center
NM	New Mexico
NMAC	New Mexico Administrative Code
NMDGF	New Mexico Department of Game and Fish
NME	New Mexico Endangered
NMED	New Mexico Environment Department

NMED-HWB	New Mexico Environment Department - Hazardous Waste Bureau
NMEIB	New Mexico Environmental Improvement Board
NMS	New Mexico Sensitive
NMT	New Mexico Threatened
NMWQCC	New Mexico Water Quality Control Commission
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NOV	Notice of Violation
NO _x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRDA	Natural Resource 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
OS	overstory
OSRP	Off-Site Source Recovery Project
P2	Pollution Prevention (Program)
PA	performance assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCFRS	Pajarito Canyon Flood Retention Structure
PE	performance evaluation
PJMT	Pajarito Mountain
PM	particulate matter
PM-10	particulate matter smaller than 10 micrometers in diameter
PM-2.5	particulate matter smaller than 2.5 micrometers in diameter
PMR	periodic monitoring report
ppm	parts per million

ppb	parts per billion
PQL	practical quantitation limit
PRB	permeable reactive barrier
PRS	potential release site
PSI	Pueblo de San Ildefonso
PSTB	Petroleum Storage Tank Bureau
PUE	power utilization effectiveness
PV	photovoltaic
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
R&D	research and development
rad/d	radian per day
Rad-NESHAP	National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other than Radon
RAMP	Roof Assessment Management Program
RAP	Radiological Assistance Program
RBG	regional background
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
REC	Renewable Energy Certificate
RESRAD	residual radioactivity (computer model)
RLUOB	Radiological Laboratory/Utility/Office Building
RLWTF	Radioactive Liquid Waste Treatment Facility
ROD	Record of Decision
RP-2	Health Physics Measurements Group (LANL)
RSL	residential screening level
RSRL	regional statistical reference level
RWMB	Radioactive Waste Management Basis
SA	Supplement Analysis
SAL	screening action level

SCC	Strategic Computing Complex
SCCM	System Center Configuration Manager (Microsoft)
SDPPP	Site Discharge Pollution Prevention Plan
SDWA	Safe Drinking Water Act
SERF	Sanitary Effluent Reclamation Facility
SFB	soil, foodstuffs, and biota
SI	International System of Units
SL	screening level
SMA	Site Monitoring Area
SMO	Sample Management Office
SODAR	sonic detection and ranging
SOP	standard operating procedure
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SSL	soil screening level
SSP	Site Sustainability Plan
SSPP	Strategic Sustainability Performance Plan
STP	Site Treatment Plan
SV	screening value
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWEIS	Site-Wide Environmental Impact Statement
SWPPP	Storm Water Pollution Prevention Plan
SWMU	solid waste management unit
SWSC	Sanitary Wastewater Systems Consolidation
SWWS	Sanitary Wastewater Systems (Plant)
TA	technical area
TAL	target action level (under the Individual Permit)
TAL	target analyte list
TCDD	tetrachlorodibenzodioxin
TCDF	tetrachlorodibenzofuran
TCA	1,1,1-trichloroethane
TCE	trichloroethylene

TDS	total dissolved solids
TEDE	total effective dose equivalent
TEQ	toxicity equivalent quotient
TLD	thermoluminescent dosimeter
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TRC	total residual chlorine
TRU	transuranic
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, or disposal facility
TSS	total suspended solids
UI	Utilities and Infrastructure Facilities
US	understory
U.S.	United States
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTL	upper threshold limit
VOC	volatile organic compound
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Project
WMO	World Meteorological Organization
WWTP	wastewater treatment plant
WY	water year
ZLD	zero liquid discharge
ZVI	zero-valent iron

APPENDIX G – ELEMENTAL AND CHEMICAL NOMENCLATURE

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 ₂ O
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	³ H
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



The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

Environment, Safety, and Health Directorate

Environmental Protection Division

Environmental Stewardship Services Group (Jeanne Fair, Jean Dewart, and Sonja Salzman, Coordinators)

Environmental Compliance Programs Group (Robert Beers, Coordinator)

Operations Integration Office

Waste Management Division (Luciana Vigil-Holterman, Coordinator)

Environmental Programs Directorate

Corrective Actions Program

Engineering and Technology Division

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