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Los Alamos National Laboratory

2013

Annual Site Environmental Report

Los Alamos NATIONAL LABORATORY EST. 1943

Los Alamos National Laboratory Governing Policy for the Environment

- 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.

Spring owl surveys

Cooper's hawks in nest

Front cover: Rock cliff in Mortandad Canyon.
Cover design and photo by Phillip Noll, ENV-ES.

LA-UR-14-27564
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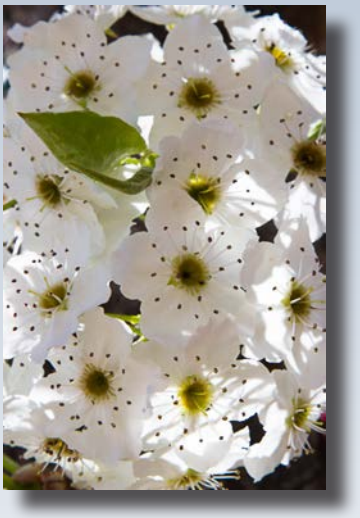

Spring blossoms in White Rock

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Los Alamos National Laboratory 2013 Annual Site Environmental Report

Environment, Safety, and Health Directorate
505-667-4218

Environmental Protection Division
505-667-2211

Environmental Stewardship Services Group
505-665-8855

Environmental Compliance Programs Group
505-667-0666

Operations Integration Office
505-667-0808

Waste Management Division
505-667-2211

Environmental Programs Directorate
505-606-2337

Corrective Actions Program
505-665-3388

Los Alamos National Laboratory environmental reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) environmental organizations, as required by U.S. Department of Energy Order 231.1B Environment, Safety, and Health Reporting, and Order 458.1, Radiation Protection of the Public and the Environment.

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

Chapter 1 provides an overview of the Laboratory site and the Laboratory's major environmental programs as well as 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 2013. 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 the Laboratory. 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 and figures will be available on the Laboratory's environmental website: http://www.lanl.gov/community-environment/environmental-stewardship/environmental-report.php.

Inquiries or comments regarding these annual reports may be directed to

U.S. Department of Energy
Office of Environmental Operations
3747 West Jemez Road
Los Alamos, NM 87544
Telephone: 505-667-5491

or

Los Alamos National Laboratory
Environmental Protection Division
P.O. Box 1663, MS K499
Los Alamos, NM 87545
Telephone: 505-667-2211

To obtain copies of the report, contact

Environmental Stewardship Communications
Los Alamos National Laboratory
P.O. Box 1663, MS K491
Los Alamos, NM 87545
Telephone: 505-667-0216
E-mail: lorriel@lanl.gov

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LOS ALAMOS NATIONAL LABORATORY 2013 ANNUAL SITE ENVIRONMENTAL REPORT

This year's report incorporates some changes to the format and content based on recommendations in the U.S Department of Energy's Guidance for Preparation of the 2013 Department of Energy Annual Site Environmental Reports. Each chapter contains a summary of the primary objectives and findings of the environmental monitoring discussed in the chapter. This report will be posted on the Laboratory's environmental website: http://www.lanl.gov/community-environment/environmental-stewardship/environmental-report.php.

REPORT ORGANIZATION

This year, vapor monitoring is presented in Chapter 9, Environmental Restoration, because of limited vadose-zone monitoring in 2013.

Abstract/Preface
Sam Loftin

Executive Summary
Sam Loftin

1.0 Introduction
Jean Dewart
Deborah Hall
Sam Loftin
Nita Patel
Jennifer Payne
Sonja Salzman
Marjorie Wright

2.0 Compliance Summary
Marc Bailey
Bob Beers
Michelle Coriz
David Fuehne
Robert Gallegos
Tim Goering
Leslie Hansen
Chuck Hathcock
Ken Hargis
David Keller
Terrill Lemke
Jacob Meadows
Michael McNaughton
Andy Montoya
Nita Patel
Dan Pava
Jennifer Payne
Ben Poff
Michael Saladen
Sonja Salzman
Steve Veenis
Luciana Vigil-Holterman
Walt Wetham
Holly Wheeler
Monica Witt
Marjorie Wright
Timothy Zimmerly

3.0 Dose and Risk Assessment
William Eisele
Jessica Gillis
Michael McNaughton
Jeffrey Whicker

4.0 Air Surveillance
Jean Dewart
David Fuehne
Jessica Gillis
Michael McNaughton

5.0 Groundwater Monitoring
David Rogers

6.0 Watershed Monitoring
Daria Cuthbertson
Stanislaw Marczak
Wendy Swanson
Amanda White

7.0 Soil Monitoring
Philip Fresquez

8.0 Foodstuffs and Biota Monitoring
Philip Fresquez
Chuck Hathcock
David Keller

9.0 Environmental Restoration
Richard J. Mirenda
Daniel Romero

10.0 Analytical Laboratory Quality Assurance
Nita Patel

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 solve national security challenges through scientific excellence. Meeting this 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;
- highlights significant programs and efforts; and
- describes property clearance activities in accordance with U.S Department of Energy (DOE) Order 458.1.

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 (the Long-Term Strategy). The intent of the Long-Term Strategy for Los Alamos National Laboratory is fourfold:

- To define our strategies to support environmental stewardship and restoration
- To implement actions to achieve our goals for environmental stewardship
- To involve every Laboratory employee in taking actions to protect and restore the environment
- To communicate transparently

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 DOE 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 2013, the Laboratory collected samples from air, water, soil, sediment, foodstuffs, and associated biota at approximately 1081 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 2013, with operations resulting in minimal impact to the public and the environment. The potential radiological and chemical doses to the public and biota doses from Laboratory operations were far below all regulatory limits and guidance.

To Read About **Turn to Page**

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Environmental Setting *1-2*
Laboratory Activities and Facilities *1-7*
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We at Los Alamos National 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

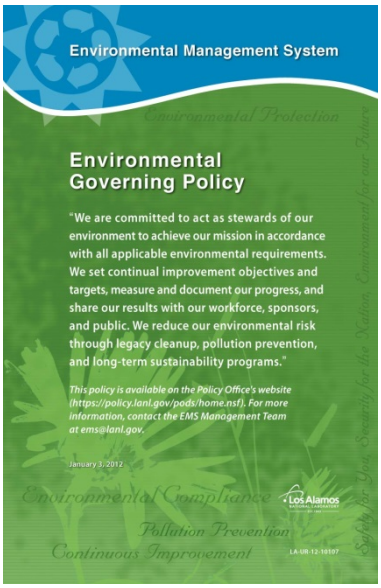
1. Background

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 (LANL or the Laboratory) in 1981. Through May 2006, the Laboratory was managed by the Regents of the University of California through the Los Alamos 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. The definition of the Laboratory's vision is "to deliver science and technology to protect our nation and promote world stability." The current mission is "to deliver science and technology to protect our nation and promote world stability."

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;
- highlight significant programs and efforts, including environmental performance indicators and/or performance measures programs; and
- summarize property clearance activities.

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 fingerlike 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. Santa Clara Pueblo is north of the Laboratory but does not share a border.

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 fingerlike 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.

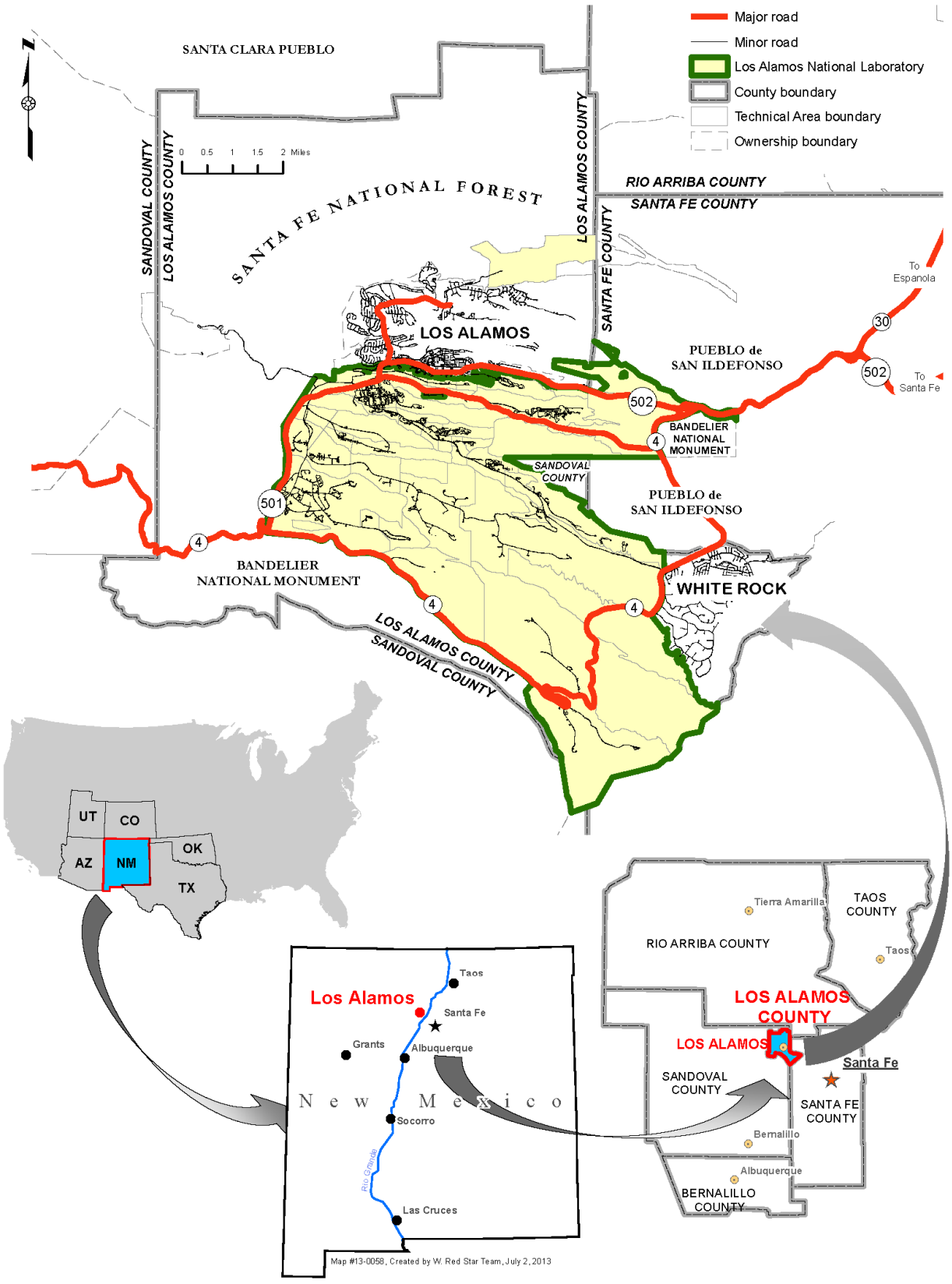


Figure 1-1 Regional location of the Laboratory

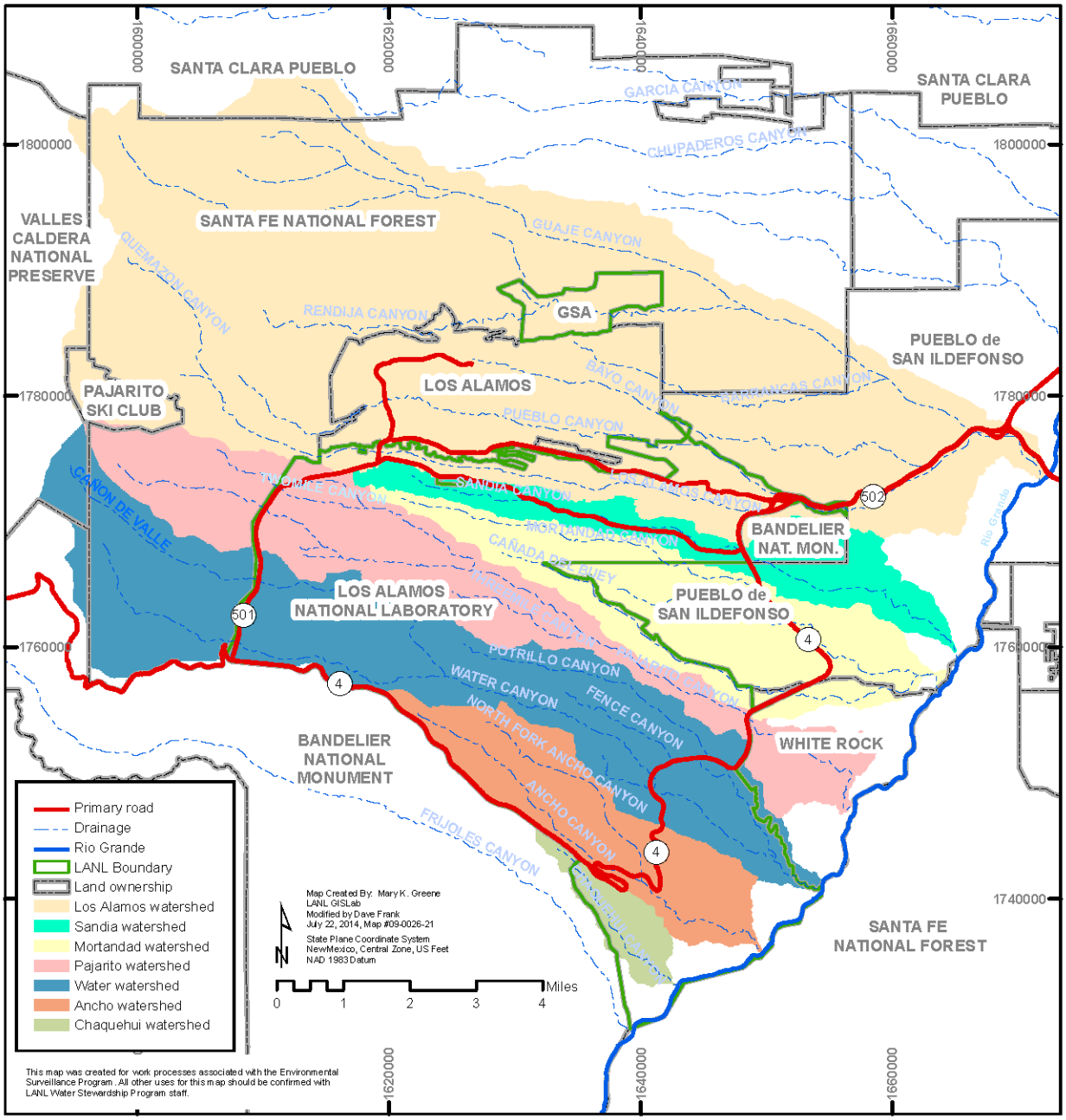


Figure 1-2 Primary watersheds at the Laboratory

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 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 each occupy 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.

The extreme drought conditions prevalent throughout New Mexico and Los Alamos in the past 10 yr have resulted in the mortality of many trees. Between 2002 and 2005, more than 90% of the mature piñon trees in the Los Alamos area died from a combination of drought stress and bark beetle infestation (Breshears et al. 2005). Lower elevation ponderosa pine and mixed-conifer stands were also affected. More recently, large numbers of mature ponderosa pine are apparently dying of prolonged drought stress.

The Laboratory and region are still recovering from the Las Conchas fire that burned 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, the Laboratory operates a program to reduce wildfire fuels and manage forest health throughout forested areas on Laboratory 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. The major roads within the facility continue to be thinned along the road easements to the fenceline to provide firebreaks and improve vehicle visibility to wildlife crossing the roads.

4. Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 90% 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). Eight areas (17 individual properties in total) located at the Laboratory 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).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. The bill was reintroduced as Senate Bill S. 507 in March 2013 and House Bill H.R. 1208 in April 2013.

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 organized 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 Laboratory 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/National Nuclear Security Administration 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 Laboratory operations (Table 1-1). Operations in the Key Facilities represent the majority of environmental impacts associated with Laboratory operations.

The facilities identified as key are those that house activities critical to meeting work assignments given to the Laboratory. 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
- are the facilities most subject to change as a result of programmatic decisions.

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

Note: Data from 2008 SWEIS.

In the SWEIS, the remaining Laboratory facilities were identified as "Non-Key Facilities" because these facilities do not meet the above criteria. The Non-Key Facilities can be found in 30 of the Laboratory's 49 TAs and occupy approximately 14,224 acres of the Laboratory's 26,480 acres. The Non-Key Facilities also currently employ about 74% of the total Laboratory 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.

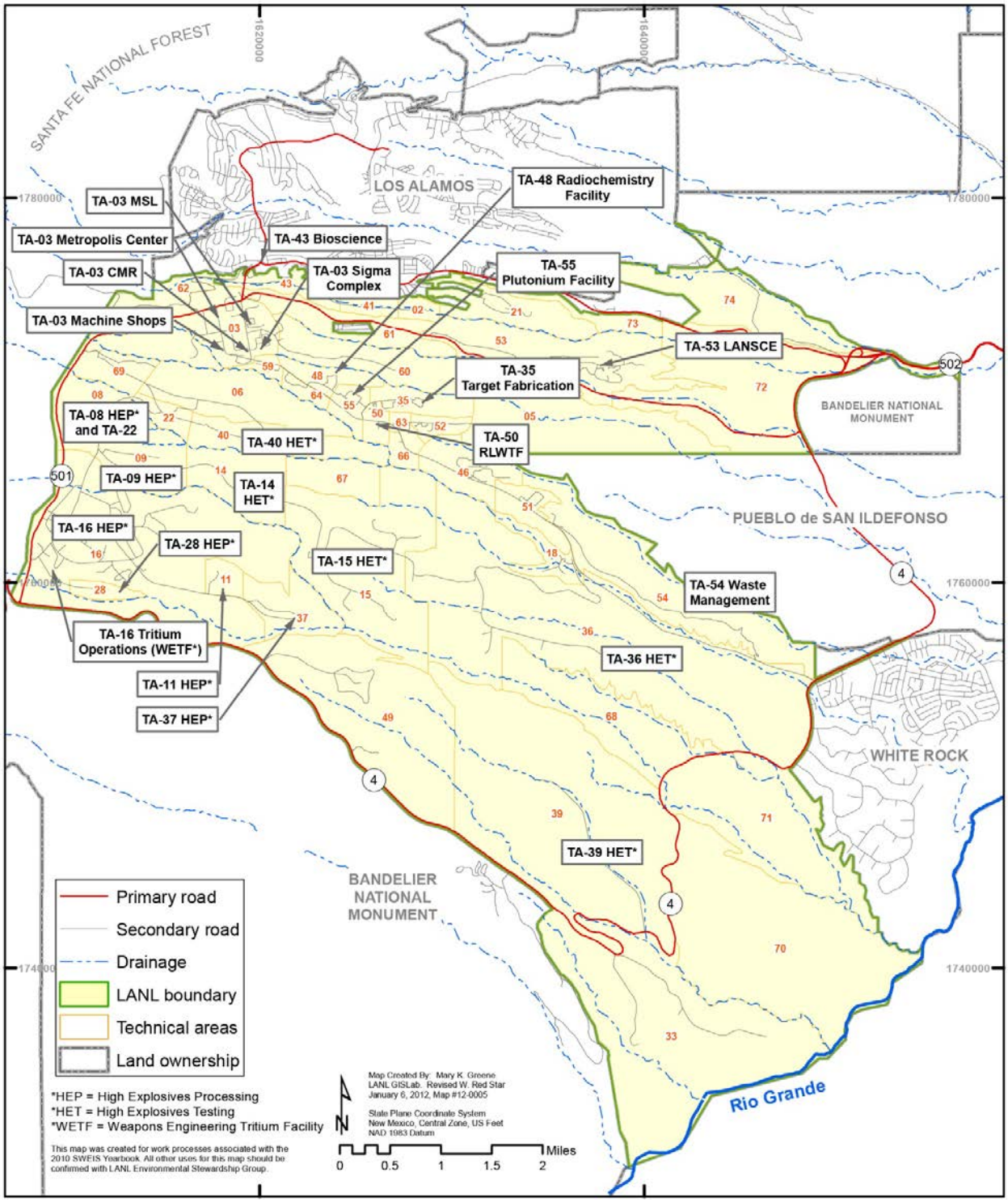


Figure 1-3 TAs and key facilities of the Laboratory in relation to surrounding landholdings

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. Organizational charts and descriptions are available at http://www.lanl.gov/resources/organizations.php. The major environmental programs and management system are described below.

1. Environmental Management System

Integrated with 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. DOE Order 436.1, Departmental Sustainability, requires that all DOE sites have an EMS "…certified to or conforming to the International Organization for Standardization's (ISO) 14001:2004…" (DOE 2011b). The Laboratory maintains third-party certification to ISO 14001:2004, Environmental Management Systems, to ensure a system-based, institution-wide focus on environmental performance, protection, and stewardship. Senior management commitment to the Laboratory's environmental footprint is formally communicated to the Laboratory workforce and to the Laboratory's neighbors, stakeholders, and regulators in the environmental policy (see Section A.1).

The Laboratory 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. In 2013, the Laboratory hosted two surveillance audits for maintenance of certification and successfully retained its certified status.

a. Environmental Management System and Work Management

The Laboratory EMS provides methods for assessing environmental impacts from mission activities, identifying and managing necessary controls, prioritizing improvements, and measuring results. The Laboratory has identified 22 core environmental aspects that potentially impact work performed on-site (Table 1-2).

Laboratory organizations are responsible for evaluating their work against these aspects for potential environmental impacts. An activity with one or more of these environmental impacts may be required to perform specific environmental controls to manage that risk appropriately.

Table 1-2
Core Environmental Aspects

Environmental Aspects	Description	Examples
Air emissions	Activities that release or have the potential to release material into the air	Operations that have point-source air emissions from stacks, vents, ducts, or pipes; use of greenhouse gas (GHG) contributors such as refrigerants and fluorinated gases; asphalt and concrete plant operation; vehicle operation; heater and boiler operation; use of paint and spray booths; electrical generator operation; use of aerosol cans; use of compressed gases; open-burning/detonation activities; combustion sources; air compressor operation; wood chipper/shredder operation

Table 1-2 (continued)

Environmental Aspects	Description	Examples
Interaction with surface water and storm water	Activities that release or have the potential to release material into a waterway or onto the ground near a waterway	Discharges from potable and nonpotable water supplies; discharges from permitted outfalls; spills, unintended discharges, and accidental releases to the environment; discharges of steam condensate; water line and hydrant treatment and flushing; storage of equipment or parking of vehicles off-road
Discharge to wastewater systems	Activities that release or have the potential to release material to or from a wastewater treatment system (sanitary, chemical, or radiological). This does not include isolated septic systems.	Use of Laboratory sinks plumbed to sanitary or radiological drains
Interaction with drinking water supplies/systems or groundwater	Activities that release or have the potential to release material into a drinking water supply system or into the groundwater. This includes planned or unplanned releases onto the ground or into surface water that have the potential to migrate to a drinking water supply. Impacts can be positive or negative.	Activities that use potable water, for example, using potable water in kitchens and bathrooms; using potable water in laboratory settings, in hoods, and as a source for machinery and process water; cooling tower water supply use; and landscape watering.
Work within or near floodplains and wetlands	Activities that release or have the potential to release material onto or into a floodplain, wetland, or area of overland flow	Monitoring well operations; utility and grounds operations.
Interaction with wildlife and/or habitat	Activities that impact or have the potential to impact wildlife or wildlife habitat. This includes direct impacts caused by workers and their work activities or indirect impacts that affect behavioral changes.	Landscape development; removal of weeds, brush, trees, or invasive species; trail work; road easement maintenance; establishment or modification of paths, walkways, and clearings.
Biological hazards	Activities that generate, use, or dispose of biological agents. This excludes human viral, bacterial, or blood-borne pathogens.	Handling of some wastes, animal waste.
Interaction with soil resources	Activities that release or have the potential to release material onto or into the ground. This includes planned or unplanned deposition of air-borne particulates and releases of solids or liquids onto or into the ground.	Operations that have point-source air emissions from stacks, vents, ducts, or pipes; above- or below-ground transmission line operation (water, sewer, gas, or wastewater); groundwater well construction and abandonment; use of electrical equipment such as transformers; physical removal of dead wood for fire suppression and control; activities that have the potential to disturb wildlife during nesting season
Spark or flame producing activities	Activities that cause or have the potential to start a fire or wildfire	Off-road vehicle operation
Cultural/historical resource disturbance	Activities that impact or have the potential to impact cultural or historical resources. Resources include historical buildings, buildings of special significance, archaeological sites, historic homesteads, and trails.	Maintenance or expansion of existing, established areas (trails, walkways, clearings, roads, and easements); ground-disturbing activities on belowgrade or surface areas; firing site activities (vibrations)
Visual resources	Activities that impact or have the potential to impact visual landscapes	Construction, management, and maintenance of utility corridors and power transmission systems through nonurban areas; design, construction, management, and maintenance of buildings, towers, stacks, domes, signs, etc.
Hazardous or radioactive material waste packaging and transportation	Activities that handle, package, or transport hazardous waste or radioactive material	Chemical transportation
Radioactive waste generation and management	Activities that generate or manage (handle, store, or dispose of) radioactive waste	Laboratory and research and development (R&D) procedures using or generating radioactive material
Hazardous or mixed-waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) hazardous or mixed waste	Laboratory and R&D procedures using or generating hazardous or mixed (chemical and radiological) materials

Table 1-2 (continued)

Environmental Aspects	Description	Examples
Solid or sanitary waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) nonhazardous and nonradioactive waste intended for disposal at a municipal or industrial waste landfill	Laboratory, machining, and process operations (producing nonhazardous or nonradioactive waste); activities that improve reduction of material waste products (e.g., conversion of paper documentation to electronic and expansion of recycling and reuse)
Interaction with contaminated sites	Activities that have the potential to increase or spread contamination because they are conducted within the boundary of or in close proximity to contaminated areas. Contaminated areas include solid waste management units or areas of concern, radiological sites or nuclear facilities, or high-explosive sites.	Construction activities
Chemical (industrial and laboratory) use and storage	Activities resulting in the purchase, use, management, or storage of chemicals	Application of pesticides and fertilizers; research laboratory operation
Radioactive material use and storage	Activities that handle or store radioactive material	Radioactive source management, use, and storage
Surplus properties and material management	Activities that manage (handle or store) surplus supplies, real estate, or other property	Managing (leasing, renting, selling, or purchasing) inactive real estate; decontamination and decommissioning facilities
Resource use and conservation	Activities or practices that impact resource use and affect conservation; may increase or reduce demand or wastes; may drive increases in efficiency of resource use (labor, natural material, energy, etc.), use of alternative material, or reuse/recycling opportunities	Applying sustainable design principles, for example, principles for cool roofs, natural lighting, insulated glass, or recycled or low-impact building materials; procuring alternative energy or fuel sources for the Laboratory; reuse and repurpose of materials, equipment, and supplies
Storage of hazardous or radioactive materials and wastes in tanks	Activities that handle or store nonhazardous and nonradioactive material and waste. This excludes sanitary waste storage (such as septic systems).	Installing or removing above- or below-ground tanks
Engineered nanomaterials	Activities that create nanoparticles. This excludes natural or incidentally formed nanoparticles. Biomolecules (proteins, nucleic acids, carbohydrates, etc.) should be addressed under biological safety.	Nanotechnology R&D that generates potentially hazardous or radioactive nanoparticle byproducts requiring environmental controls

Line managers provide environmental leadership and ensure that work is performed in accord with the Laboratory environmental policy, regulatory and contractual requirements. Managers and workers identify and manage environmental initiatives, communicate environmental information, allocate resources, assess performance, and are held accountable for environmental performance. LANL uses integrated safety management (ISM) 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. Integrated work management and integrated safeguards and security management both provide a framework for implementation of the five elements of an ISO-based EMS system:

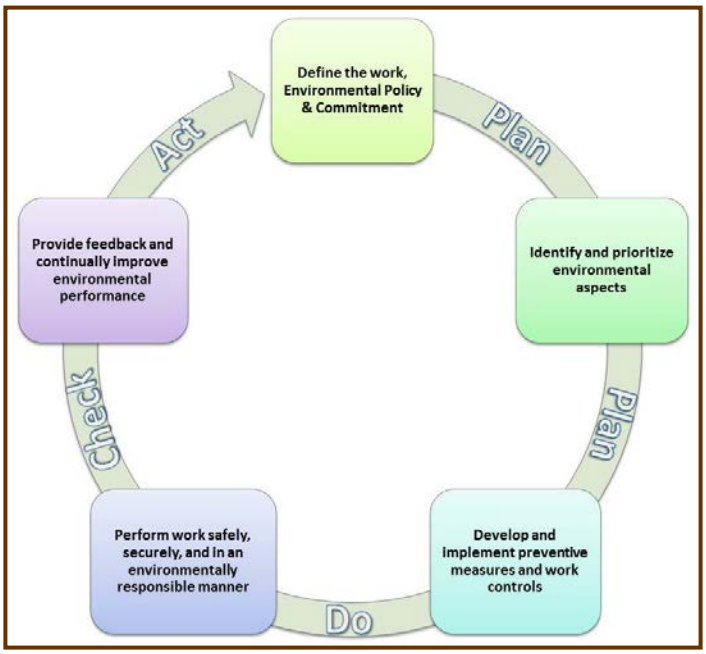
1. Policy and commitment
2. Planning
3. Implementation and operation
4. Checking and corrective action
5. Management review

b. Annual Environmental Objectives, Targets and Action Planning

In addition to identifying and controlling individual work activities to mitigate for significant environmental risks, the Laboratory's Environmental Senior Management Steering Committee identified 3 high-level objectives containing more than 20 different targets to support and help to focus institutional environmental stewardship efforts during 2013.

i. Clean the Past

- Monitor to detect changes to water and soil, take appropriate actions, and apply "defense in depth" strategy according to the requirements of the Compliance Order on Consent (Consent Order) with the New Mexico Environment Department (NMED)
- Protect surface water runoff through implementation of the Individual Storm Water Permit with the U.S. Environmental Protection Agency (EPA)
- Ship waste to the Waste Isolation Pilot Plant
- Reduce volume of waste in the site treatment plan
- Reduce footprint and reduce excess materials/equipment/liabilities



ii. Control the Present

- Monitor for compliance
- Integrate environment with safety tools for common work control
- Reduce spills and leaks
- Support sustainable acquisition
- Expand chemical re-use program
- Prevent pollution with focus on problematic pollutants from all environmental media
- Fund no-exposure projects to reduce multi-sector general permit compliance liabilities
- Improve access to government vehicles and fuel efficiency

iii. Create a Sustainable Future

- Site sustainability plan implementation:
  - ❖ Reduce energy intensity
  - ❖ Reduce water use
  - ❖ Reduce GHG with 10-yr GHG reduction plan
  - ❖ Implement high-performance sustainable buildings (HPSBs)
  - ❖ Design an environmental as low as reasonably achievable (ALARA) strategy for the Laboratory
  - ❖ Data center management
  - ❖ Regional and local planning
  - ❖ Develop new environmental/sustainable technologies

- 50 Year Environment Stewardship Plan implementation:
  - ❖ Use of integrated site planning, the decision support tool, and the public communication tool
  - ❖ Implement the "Integrating Strategies"
- "Green" existing facilities through expansion of the Green Team concept beyond HPSBs

Using these institutional objectives and targets, along with the evaluation of the environmental risks for their own work activities, multidisciplinary teams from each Laboratory directorate developed an environmental action plan. In 2013, the Laboratory developed and managed 355 actions in 17 of these action plans.

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.

The Laboratory disposes of wastes on-site and off-site and is permitted to discharge liquid effluents from the RLWTF and the Sanitary Wastewater Systems Plant into Mortandad and Sandia Canyons, respectively (National Pollutant Discharge Elimination System [NPDES] Permit No. NM0028355). There were no discharges from the RLWTF into Mortandad Canyon during calendar year 2013.

Some LLW is retrievably stored 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 generated wastes, including the majority of LLW, are sent for disposal off-site. See Chapter 2, Section B.3, Radiation Protection, for details.

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 the Consent Order. Certificates of Completion are granted to indicate corrective actions are 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 the Laboratory under the Consent Order is implemented by the Corrective Actions Program. This work also includes investigations and remediations in canyons, as well as sediment, groundwater, storm water, and vapor monitoring.

Program accomplishments for calendar year 2013 are presented in Chapter 9, Environmental Restoration.

5. Compliance and Surveillance Programs

The Laboratory'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 1-3). 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 1-3
Approximate Numbers of Environmental Samples, Locations, and Analytes Collected in 2013

Sample Type or Media	No. of Locations	Frequency of Sampling*	No. of Analytes or Measurements
Ambient air	41	Biweekly	2,248
Stack monitoring	29	Weekly	24,770
Vegetation	107	Annually	2,198
Sediment	47	Annually	10,992
Animal	18	Annually	3,472
Groundwater	181	Quarterly/semiannually/ annually	50,126
NPDES outfalls	8	Weekly	1,079
Surface water base flow	9	Quarterly/semiannually/ annually	1,962
Surface water storm runoff	131	Following rains	38,841
Neutron radiation	47	Quarterly	188
Gamma radiation	96	Quarterly	384
Environmental restoration soil/rock investigation sampling	349	Annually	17,351
Subsurface vapor monitoring	18	Monthly/quarterly/annually	10,912
Totals	**1,081**		**164,523**

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 the Laboratory 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 NMED and the Laboratory use in making remediation and other environmental management decisions.

The Laboratory is regulated under 27 separate environmental regulatory permits issued by NMED and the EPA. 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.

a. Flood Damage and Mitigations

On September 13, 2013, the Pajarito Plateau was subjected to what has been classified as a greater than 1000-yr rainfall event. Anywhere from 2.49 to 3.52 in. of rain fell at different locations around the Laboratory within a 24-h period. All of the local canyons flooded, and some experienced substantial channel and bank erosion and widespread sediment deposition. There was also significant damage to infrastructure, including roads, gaging stations, and other sampling equipment. Details of the rain event and flooding can be found in Chapters 4 and 6, respectively.

b. Fire Mitigation

Approximately 426 acres received wildfire mitigation treatments in 2013. Tree thinning and mastication were used to create defensible space and to improve forest health. Treatments focused on upper Mortandad Canyon, the entrance to TA-54 (Sandia Canyon), and along NM 4 southeast of the back gate (Water Canyon).

The Laboratory recently initiated a website with an orthophoto map that documents wildfire mitigation activities by year and location. The website is accessible at the following address: http://www.lanl.gov/community-environment/environmental-stewardship/protection/wildland-fire.php.

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 are likely to bring significant changes to the mission and operations of the Laboratory. Regardless, 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 define our strategies to support environmental stewardship and restoration
- To implement actions to achieve our goals for environmental stewardship
- To involve every Laboratory employee in taking actions to protect and restore the environment

- To communicate transparently

The Long-Term Strategy considers the nature of environmental stewardship after cleanup activities focused on the environmental legacy of the Manhattan Project and Cold War have been completed. 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 that the Laboratory will strive to achieve through integration of the Laboratory's environmental and operational programs (Figure 1-4). This annual environmental report serves as the primary reporting document for the Long-Term Strategy, and all the chapters of the 2013 environmental report address issues associated with these grand challenges.

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 process for setting environmental policy, planning and implementation, management review, and continual improvement. To manage these processes, the Laboratory uses the EMS (see Section D.1).

The first element of an EMS is to define the institution's senior management commitment to environmental stewardship. This is expressed in the Laboratory's environmental policy and communicated to all workers and the public (see Section A.1).

c. Overarching Strategies

The Long-Term Strategy provides for effective environmental stewardship at the Laboratory. Key strategies described in the Long-Term Strategy include the following:

- *"Defenses-in-Depth":* This strategy addresses the potential for movement of sediments containing chemicals and radionuclides released during historic Laboratory operations. It 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:* The Laboratory evaluates all new and modified operations that involve radioactive materials and ensures that impacts to human health are ALARA. This concept is also applied to environmental stewardship and sustainability.
- *Off-Site Disposal:* The Laboratory discontinues on-site disposal of wastes whenever possible.
- *Pollution Prevention:* A Laboratory strategy is to prevent pollution whenever and wherever possible by eliminating or reducing wastes and emissions. 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 stewardship actions and results that address the public's 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 Laboratory decision makers to compare alternatives and to keep environmental impacts ALARA. Specifically, the decision support application

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

During 2013, the Laboratory completed an environmental sampling plan (LANL 2014) under the Long-Term Strategy to help strengthen and optimize its environmental surveillance program.

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

A. INTRODUCTION

Many operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. 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 materials and wastes; (2) protecting ecological, archaeological, historical, 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 the Laboratory for the National Nuclear Security Administration (NNSA) and is a co-permittee with DOE and/or NNSA on most EPA- or NMED-administered permits. This chapter provides a summary of Laboratory compliance and status with respect to DOE environmental requirements and state and federal environmental regulations and permits.

B. COMPLIANCE STATUS

The EPA and NMED regulate Laboratory operations under various environmental statutes (e.g., Clean Air Act, Clean Water Act [CWA], Resource Conservation and Recovery Act [RCRA]) through operating permits, construction approvals, and the Compliance Order on Consent (the Consent Order). These permits are issued by the regulatory agencies to allow Laboratory operations to be conducted while ensuring that the public and air, land, soils, water, and biota are protected. The Laboratory's compliance performance is an assessment of our protection of the environment. Table 2-1 presents the environmental permits or approvals the Laboratory operated under in 2013 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2013. The following sections summarize the Laboratory's regulatory compliance performance during 2013.

Table 2-1
Environmental Permits or Approvals under which the Laboratory Operated during 2013

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA Permit	Hazardous Waste Facility Permit, hazardous waste storage units: Technical Area 03 (TA-03), TA-50, TA-54, TA-55, and TA-63	Renewed November 2010	December 2020	NMED
	40 Code of Federal Regulations (CFR) 265 standards, interim status hazardous waste storage and treatment facilities: TA-14, TA-16, TA-36, TA-39, and TA-54. Permit applications and closure plans have been submitted to NMED.	Post-1980 hazardous waste units, post-1991 mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
Consent Order	Investigations, corrective actions, and monitoring related to solid waste management units (SWMUs) and areas of concern (AOCs); revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised October 29, 2012	September 20, 2015	NMED
CWA/National Pollutant Discharge Elimination System (NPDES)	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012; administratively continued pending issuance of a new permit, expected in 2014.	EPA
	Multi-Sector General Permit (MSGP) for the discharge of storm water from industrial activities[a]	September 29, 2008	September 29, 2013; administratively extended by EPA pending resolution of public comments	EPA
	NPDES individual permit for storm water discharges from SWMUs and AOCs	November 1, 2010	October 31, 2015; application for renewal submitted to EPA in 2014	EPA
	Construction general permits for the discharge of storm water from construction activities[a]	February 16, 2012	February 16, 2017	EPA
CWA Sections 404/401	U.S. Army Corps of Engineers (USACE) nationwide permits (NWPs) (5) (i) Water Canyon Storm Drain Reconstruction – NWP 43 (ii) Sandia Canyon Grade-Control Structure – NWP 38 (iii) TA-72 Firing Site Storm Water Control – NWP 38 (iv) Mortandad Canyon Wetland Berm – NWP 38 (v) Cañon de Valle/Water Canyon Gage Repairs – NWP 18	(i) October 15, 2012 (ii) March 25, 2013 (iii) March 27, 2013 (iv) May 15, 2013 (v) September 9, 2013	(i) October 15, 2014 (ii–v) March 18, 2017	USACE/ NMED

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Groundwater Discharge Permit, TA-46 Sanitary Wastewater Systems (SWWS) Plant, DP-857	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998 Renewal application submitted July 2, 2010 Supplemental information submitted December 20, 2012	January 7, 2003[b]	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid Waste Treatment Facility (RLWTF), DP-1132	Discharge to groundwater	Application submitted August 20, 1996 Application resubmitted February 16, 2012 Supplemental information submitted August 10, 2012 Draft permit issued September 13, 2013	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, DP-1793	Discharge to groundwater	Application submitted December 20, 2011 Supplemental Information submitted March 13, 2012	Approval pending	NMED
Air Quality Operating Permit (20.2.70 New Mexico Administrative Code [NMAC])	LANL air emissions (P100) Renewal 1, Modification 3	August 7, 2009 (initial) April 26, 2013 (current) Renewal application submitted to NMED July 9, 2013[c]; Application ruled complete August 29, 2013; Copy of application forwarded to EPA September 3, 2013	August 7, 2014 (Permit renewal application submitted July 10, 2013)	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-kilowatt (kW) generator at TA-33 (2195-F) Permit revision 4	October 10, 2002 (initial) December 12, 2013 (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)	October 22, 2003	None	NMED

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Construction Permits (20.2.72 NMAC) (cont.)	Chemistry and Metallurgy Research Replacement (CMRR) facility, Radiological Laboratory/Utility/Office Building (RLUOB) (2195-N) Permit revision 2	September 16, 2005 (initial) September 25, 2012 (current)	None	NMED
Air Quality (National Emission Standards for Hazardous Air Pollutants [NESHAP] for beryllium)	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED

[a] National permit; no facility-specific terms and conditions.
[b] Permit was administratively continued through 2013.
[c] Permit coverage is extended until the new permit is issued.

Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2013

Date	Purpose	Performing Entity
8/20/13	Groundwater Discharge Plan DP-1793: R-42 and R-28 pumping tests	NMED
8/20/13	Groundwater Discharge Permit DP-857: Sanitary Effluent Reclamation Facility (SERF), NPDES outfalls	NMED
3/12/13	Compliance evaluation inspection of SERF discharge	NMED
5/13/13–5/20/13	RCRA compliance evaluation inspection	NMED
9/24/13	Title V Operating Permit compliance inspection	NMED
3/4/13–3/8/13	Environmental Management System (EMS) International Organization for Standardization (ISO) 14001 surveillance audit	Third-party certifier

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 report fulfills DOE Order 231.1B requirements to publish an annual site environmental report. The intent of this report is 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. Environmental Restoration and Waste Management

a. Comprehensive Environmental Response, Compensation, and Liability Act

i. Land Transfer

No land tracts were conveyed or transferred in calendar year (CY) 2013. DOE and LANS have implemented DOE Order 458.1, Radiation Protection of the Public and the Environment (DOE 2011b), and tracts are sampled in accordance with this order prior to their release.

ii. 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 2013 to work towards completing a natural resource damage assessment (NRDA) for the Laboratory. 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 the Laboratory. The final objective of the NRDA process is to restore, rehabilitate, or replace services provided by injured natural resources.

The Trustee Council released a draft damage assessment plan for public review and comment in November 2013. Publication of the final damage assessment plan is expected in 2014.

b. Resource Conservation and Recovery Act

i. Introduction

Hazardous wastes are generated primarily from research and development (R&D) activities, processing and recovery operations, decontamination and decommissioning (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 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 Laboratory's Hazardous Waste Facility Permit was initially granted in 1989 for storage and treatment operations and was renewed in 2010.

ii. RCRA Permitting Activities

The Laboratory's Hazardous Waste Facility Permit was issued by NMED on November 30, 2010, and became effective December 30, 2010. The permit now regulates 23 container storage units, 1 storage tank system, and 1 stabilization unit and includes operating requirements for the units and system, as well as reporting and notification requirements to NMED's Hazardous Waste Bureau (NMED-HWB) and the public.

In January 2013, NMED-HWB submitted changes to the permit to incorporate the Transuranic Waste Facility. NMED-HWB initiated a Class 3 permit modification request and began the public comment period for these changes. The Laboratory commented on the proposed changes to the permit in March 2013, and after review of the comments received, NMED-HWB approved the modification in December 2013. A Class 2 permit modification request for TA-54 West, building 38, was submitted in June 2013, and the Laboratory commented in August 2013. A Class 3 permit modification request to add an open-burning unit at TA-16 was submitted in September 2013, and two public meetings were held in June and October 2013 to discuss the proposed modification. The Laboratory submitted five Class 1 permit modification packages to the Laboratory's Hazardous Waste Facility Permit. The modifications revised figures from permitted units, identified two new AOCs, addressed changes within the contingency plan, updated the Part A Application, and changed text associated with these modifications. Public notices were sent via mail to the NMED-maintained Laboratory facility mailing list.

DOE and LANS (the permittees) received a disapproval letter on the closure plans for the open-burning/open-detonation unit at TA-14-23 and the open-detonation unit at TA-39-57 in March 2013 and responded to comments enclosed in the letter in June 2013. In November 2013, the NMED-HWB issued a public notice for the TA-16-399 burn tray closure plan, and the permittees commented on this plan in December 2013.

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 2013. Two expedited notifications for demolition were also submitted to NMED-HWB in 2013.

Reporting requirements associated with the permit included the submittal in November 2013 of a summary of instances of noncompliance and releases during fiscal year (FY) 2013 and a waste minimization report for FY13 at the Laboratory. Annual training on accessing and using the electronic public reading room was conducted in October 2013, and a community relations plan was also revised annually as required and published on the Laboratory environmental web page after comments were solicited and incorporated from the public.

iii. RCRA Compliance Inspections and Notices of Violation

From May 13, 2013, to May 20, 2013, NMED conducted a hazardous waste compliance inspection at the Laboratory. NMED noted 24 potential violations at the close of the inspection. A notice of violation and resolution has not been issued for the 2013 inspection.

iv. 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 the Laboratory and stored for more than 1 yr. In FY13, the Laboratory shipped approximately 1140 m^3 of STP-covered mixed low-level waste (MLLW) and approximately 823 m^3 of covered mixed transuranic (MTRU) waste for treatment and disposal.

v. Compliance Order on Consent

The Consent Order is an enforcement document that prescribes the requirements for RCRA 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 releases of nonradioactive contaminants from SWMUs and AOCs subject to RCRA and HSWA. The Consent Order does not apply to radionuclides, which are regulated by DOE under the Atomic Energy Act. The Consent Order also 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 2013 is presented in Chapter 9 of this report.

In 2013, the Laboratory submitted 11 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 2-1 shows each aggregate area, as defined by the Consent Order, and indicates the status of Laboratory investigation activities in these aggregate areas as (1) complete, (2) in progress, or (3) pending. For those aggregate areas presented as complete in Figure 2-1, 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 2013, scheduled investigation activities are complete at 8 aggregate areas, in progress at 19 aggregate areas, and pending at 2 aggregate areas.

vi. Solid Waste Disposal

The Laboratory sends sanitary solid waste (trash) and construction and demolition (C&D) debris to the Los Alamos County Eco Station on East Jemez Road for transfer to municipal landfills. 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 2013 included 1217 metric tons of trash and 73 metric tons of C&D debris. Through the Laboratory's recycling efforts in 2013, 1599 metric tons of non-C&D material was recycled and did not go to a landfill.

vii. Reported RCRA Noncompliances

In November 2013, an annual noncompliance report required by Section 1.9.14 of the Laboratory's 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, 2012, through September 30, 2013, there were no releases of hazardous waste or hazardous waste constituents from, or at, a permitted unit. The report detailed 193 instances of noncompliance that were recorded during FY13. The majority of the occurrences of noncompliance were associated with physical permit conditions such as aisle spacing, secondary containment requirements, and container labeling issues. Other noncompliance occurrences were for documentation and record-keeping requirements such as missing information on inspection record forms or delayed email notification. 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.

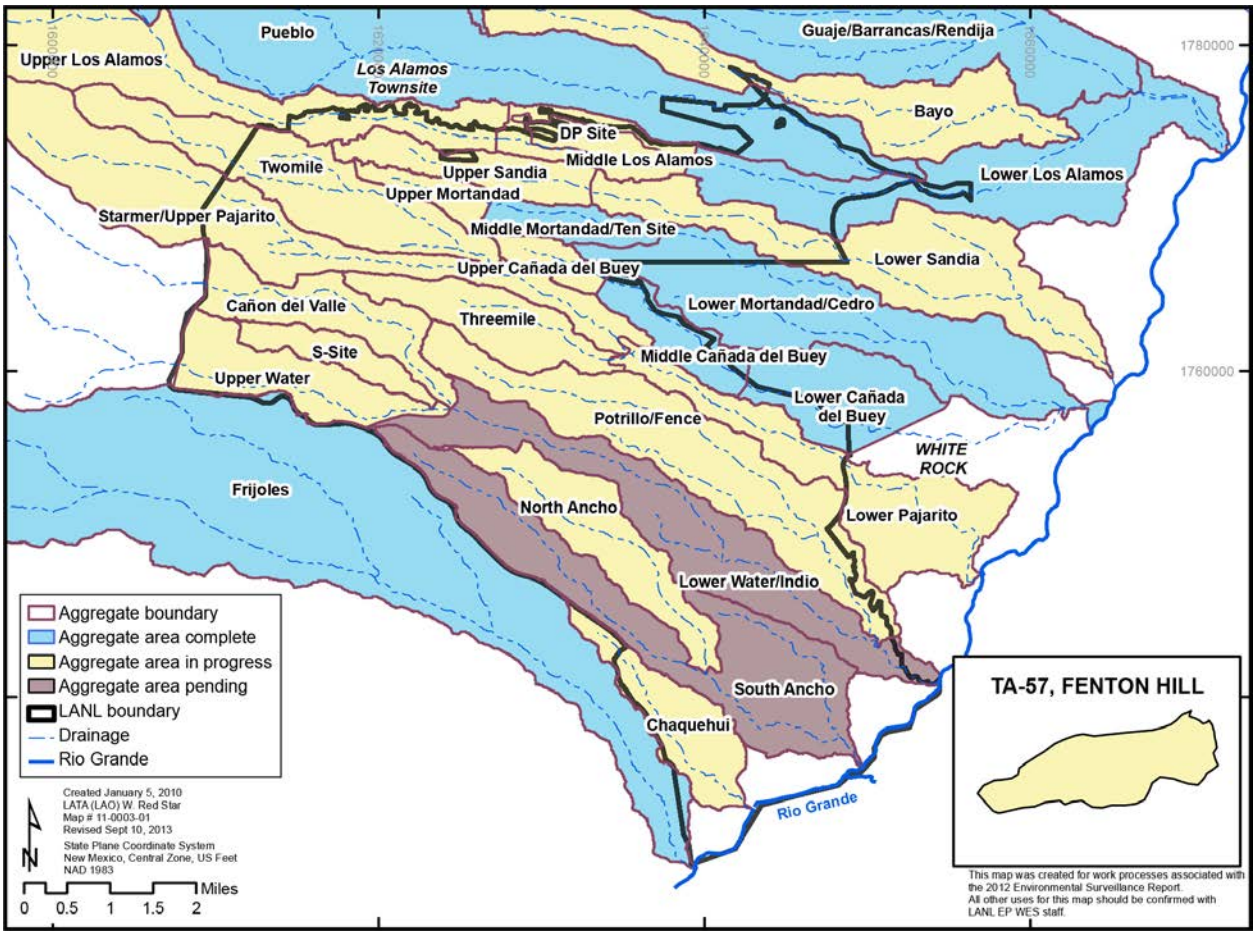

Figure 2-1 **Aggregate areas as defined for the Consent Order and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending.**

c. National Environmental Policy Act

Under the National Environmental Policy Act (NEPA) (42 U.S. Code 4331 et seq.), federal agencies such as DOE/NNSA must consider the environmental impacts of proposed activities, operations, and 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 maintaining compliance with NEPA, pursuant to DOE Order 451.1B. Proposed projects and actions at the Laboratory 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 2009). 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.

DOE/NNSA is required to prepare an SA to determine whether a supplemental or new SWEIS should be prepared pursuant to regulations issued by the President's Council on Environmental Quality, and the DOE NEPA Implementing Regulations at 10 CFR 1021.314. Work on an SA to the current SWEIS was begun in 2012, and a draft was submitted to the DOE/NNSA for review during 2013. While not yet completed, this SA will be used to determine if the current SWEIS would still be used to bound proposed Laboratory operations and activities over the next 5 to 10 yr.

The Laboratory 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. There were no LANL environmental assessments prepared in CY13. The Laboratory did prepare seven NEPA reviews proposing the use of DOE categorical exclusions or the SWEIS for LANL projects and activities. These NEPA reviews, each signed by the Los Alamos NEPA Compliance Officer during CY13 included the following: Storm Water Control Measures at Individual Permit Site, TAs-36 and -68 (DOE 2013a); Transfer of Contact-Handled Mixed Transuranic (TRU) Waste to Idaho National Laboratory (INL) for Processing and Shipment to Waste Isolation Pilot Plant (WIPP) (DOE 2013b); Biosafety Level 2 (BSL-2) Laboratory in Building 3-216 (DOE 2013c); Domestic Source Recovery FY 2014 (DOE 2013d); Foreign Location Source Recovery FY 2014 (DOE 2013e); TA-33 Storm Water Control Measure (DOE 2013f); and R-42 and R-28 Well Pump Test in Mortandad Canyon (DOE 2013g). The NNSA Reading Room provides further information regarding approved Laboratory NEPA documents at http://nnsa.energy.gov/aboutus/ouroperations/generalcounsel/nepaoverview/nepa.

d. 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 polychlorinated biphenyls (PCBs) and the import/export of small quantities of chemical substances used in R&D. The TSCA PCB regulations govern substances containing equal to or 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 2013, the Laboratory shipped 24 containers of PCB waste (≥50 ppm) off-site for disposal or recycling. The quantity of disposed or recycled PCB waste was 4571 lb (2073 kg), which consisted mainly of fluorescent light ballasts. The Laboratory manages all TSCA regulated wastes in accordance with 40 CFR 761 for manifesting, record-keeping, and disposal requirements. PCB wastes are sent to EPA-permitted treatment or disposal facilities. Light ballasts are shipped off-site for recycling or destruction. A PCB annual records/document log is generated each year in compliance with 40 CFR 761.180, and the Laboratory maintains the document on file for inspection by EPA Region 6. The Laboratory stopped disposing of PCB waste (≥50 ppm) on-site in 2006. During 2013, EPA did not perform a PCB site inspection. Seven TSCA reviews were conducted in 2013 on imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office.

e. 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, and equipment inspection as well as application, storage, and disposal of pesticides. Herbicide and pesticide usage was reported to the EPA in accordance with the NPDES Pesticide General Permit.

The New Mexico Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2013.

Table 2-3 shows the amounts of pesticides and herbicides the Laboratory used in 2013.

Table 2-3
Herbicides and Pesticides
Used at the Laboratory in 2013

Herbicide	Amount (gal.)
Ranger	5.6
Velossa	170.25
Insecticide	**Amount (lb)**
Maxforce Granules	0.2
Maxforce Granular Insect Bait	0.008
Summit B.T.I. Briquets	0.06
Water Treatment Chemical	**Amount**
Garratt-Callahan Formula 316	256.8 oz
Houghton Chemical Purobrom Tablets	5135 lb
Sump Buddies	39 oz

3. Radiation Protection

a. DOE Order 458.1, Radiation Protection of the Public and the Environment

During 2013, the Laboratory continued to implement DOE Order 458.1, which replaced Order 5400.5, Radiation Protection of the Public and the Environment (DOE 2011b), in 2011. DOE Order 458.1 establishes 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 millirem (mrem), requirements for clearance of real and personal property (see Chapter 3, Dose and Risk Assessment), 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 2013. Public and biota dose assessments, ALARA assessments, and the clearance of real and personal property are presented in Chapter 3, Dose and Risk Assessment.

b. DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of radioactive wastes: low-level waste (LLW), MLLW, transuranic (TRU) waste, and MTRU waste. (Note: LLW and TRU waste definitions are provided in the glossary.) MLLW is LLW that also contains a hazardous waste (RCRA-regulated) component, and MTRU waste is TRU waste with a hazardous waste component. Only LLW is selectively disposed of at the Laboratory or off-site; 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 2001, 1999). The hazardous waste component of MLLW and MTRU wastes is also regulated under RCRA and the Laboratory's Hazardous Waste Facility Permit which provides permit conditions for the management and storage of these wastes, but does not allow for disposal of hazardous waste on-site.

i. Institutional Requirements

All Laboratory operations that generate, store, treat, or dispose of radioactive waste must have a radioactive waste management basis (RWMB) approved by DOE's Los Alamos Field Office. The Los Alamos Field Office approved the most recent RWMB on November 7, 2013, 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 ensures that generated wastes (1) will meet the acceptance requirements for a disposal facility, (2) will meet Laboratory 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 Laboratory radioactive waste management practices are consistent with the requirements in DOE Order/Manual 435.1.

ii. Low-Level Waste

The Laboratory disposes of LLW off-site at the Nevada National Security Site and at a commercial site located near Clive, Utah, and on-site at TA-54, Area G. Other disposal facilities for LLW are available with an approved DOE 435.1 Exemption. 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 Area G CA accounts for all sources of radioactive material that are planned to remain on-site at the Laboratory 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-Los Alamos Site Office)
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-Los Alamos Site Office)

During 2013, the Laboratory disposed of 4331 m^3 of LLW (Figure 2-2). This amount includes waste generated during routine operations and during campaigns, such as environmental restoration cleanups. During 2013, LLW generation was similar to the previous year because of remediation and decommissioning projects at TA-54. In 2013, no LLW was buried at TA-54, Area G. Approximately 1 m^3 of LLW was placed in TA-54, Area G shafts. During 2013, the Laboratory treated and disposed of 2101 m^3 of MLLW in approved facilities. Reclassification of legacy MTRU to MLLW accounted for most of the increase in MLLW in 2013. The Laboratory maintained compliance with all aspects of its RWMB during 2013.

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

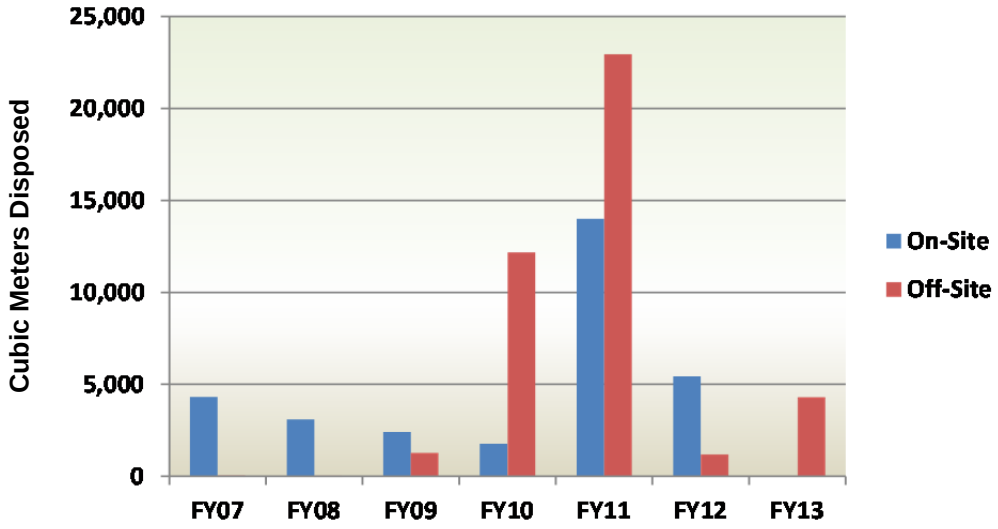

Figure 2-2 Laboratory LLW disposition

iii. Transuranic Waste

The Laboratory's 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 2-3 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 FY13, 1142 m^3 of TRU waste (including MTRU waste) was shipped to WIPP, and 360 m^3 of TRU waste that was reclassified to MLLW waste was shipped off-site to commercial treatment and disposal facilities. 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 the Laboratory. 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 m^3 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.

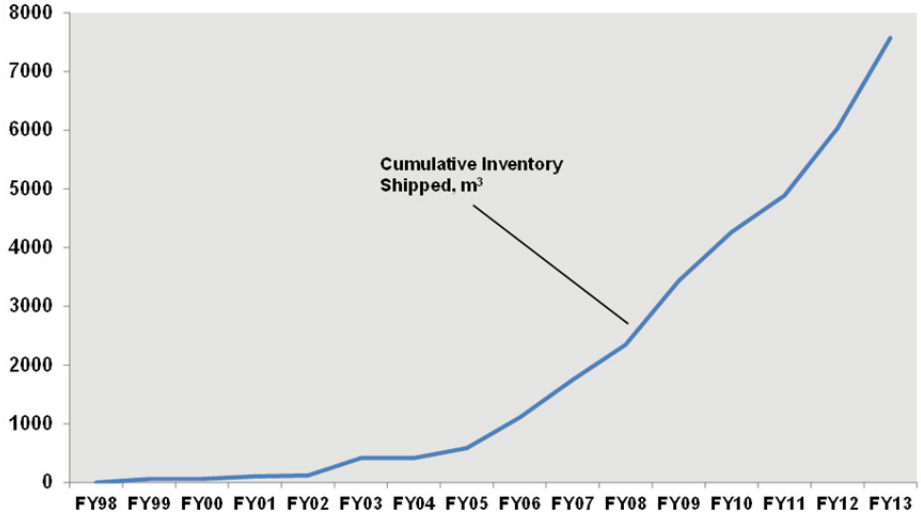

Figure 2-3 TRU waste shipping profile

Through the end of FY13, a total of 2746 m^3 of the 3706 m^3 of noncemented aboveground TRU stored at Area G as of October 1, 2011, had been removed. Also through the end of FY13, a total of 447 of the 473 containers of newly generated TRU waste received during FY12 and 403 of the 540 containers of newly generated TRU waste received during FY13 had been removed. A schedule with pacing milestones for disposition of the belowground TRU waste requiring retrieval at Area G was submitted to NMED on December 10, 2012. With suspension of operations at WIPP in February 2014, however, the schedule for removal of the belowground TRU waste requiring retrieval is uncertain.

4. Air Quality and Protection

a. Clean Air Act

On April 26, 2013, a revision to the Title V Operating Permit was issued to the Laboratory. The revision incorporated language to identify the specific Laboratory sources subject to the requirements of 40 CFR 63, Subpart ZZZZ (National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines), and added language reflecting previously approved compliance date extensions for these requirements for Laboratory source TA-33-G-1 (diesel generator). This modification also removed four retired boilers from the list of regulated sources.

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 2013, the Laboratory had no operating permit deviations.

No excess emissions occurred from any of the Laboratory-permitted sources, and the Laboratory met all required reporting deadlines during 2013.

The 2013 EPA Greenhouse Gas Emission Report was submitted on March 24, 2014. The report provided emissions of carbon dioxide (CO_2), methane, and nitrous oxide for CY13. The amount of these gases emitted during 2013 was approximately 53,687 metric tons of CO_2 equivalents from the combustion of fossil fuels. DOE has set aggressive goals to reduce greenhouse gas (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, the Laboratory is regulated as a major source of pollutants, based on the potential to emit nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOCs). In 2013, the TA-03 power plant and boilers located across the Laboratory emitted NOx, CO, and particulate matter (PM). However, the Laboratory's highest levels of emissions in 2013 were still significantly lower than the permit limits; for example, NOx emissions were approximately 19% of the permit limit, CO emissions were 14%, and PM emissions were 4%. R&D activities were responsible for most of the VOC and hazardous air pollutant (HAP) emissions. Table 2-5 summarizes these data.

Laboratory 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, the Laboratory submits an annual emissions inventory report and semiannual emissions reports, respectively, to NMED. Figure 2-4 depicts a 5-yr history of criteria pollutant emissions. Emissions from 2009 through 2013 are very similar and remain relatively constant.

Table 2-5
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2013

Emission Unit	Pollutants (tons)					
	NOx	SOx[a]	PM	CO	VOCs	HAPs
Asphalt plant	0.02	0.001	0.01	0.53	0.001	0.001
TA-03 power plant (3 boilers)	12.4	0.14	1.6	8.5	1.2	0.4
TA-03 power plant (combustion turbine)	2.4	0.16	0.32	0.5	0.10	0.07
Regulated boilers	3.1	0.02	0.33	1.82	0.24	0.06
R&D chemical use	n/a[b]	n/a	n/a	n/a	9.6	3.5
Degreaser	n/a	n/a	n/a	n/a	0.008	0.008
Data disintegrator	n/a	n/a	0.007	n/a	n/a	n/a
Stationary standby generators[c]	2.7	0.12	0.14	0.61	0.14	0.001
Miscellaneous small boilers[c]	24.0	0.15	1.92	19.4	1.39	0.46
TA-33 generators (4 units)	2.7	0.11	0.09	0.85	0.08	<0.001
TOTAL	**47.3**	**0.7**	**4.4**	**32.2**	**12.8**	**4.5**

[a] SOx = 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 2-4.

b. New Mexico Air Quality Control Act

i. Permits

The Laboratory 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 April 2013, NMED issued a modification to the Title V Operating Permit to clarify which sources are subject to new requirements under 40 CFR 63, Subpart ZZZZ. This modification also removed four retired boilers from the list of regulated sources. In July 2013, the Laboratory submitted an application for renewal for the Title V Operating Permit to NMED. In December 2013, NMED issued a modification to New Source Review (NSR) Permit 2195F, which removed an existing stationary generator from the permit and replaced it with an existing portable generator to be used to meet research activity needs. The Laboratory submitted eight exemption notifications to NMED during 2013. The exemptions were for boilers, heaters, standby generators, a cooling tower, and relocation of existing permitted portable generators. During 2013, the Laboratory operated under the air permits listed in Table 2-1.

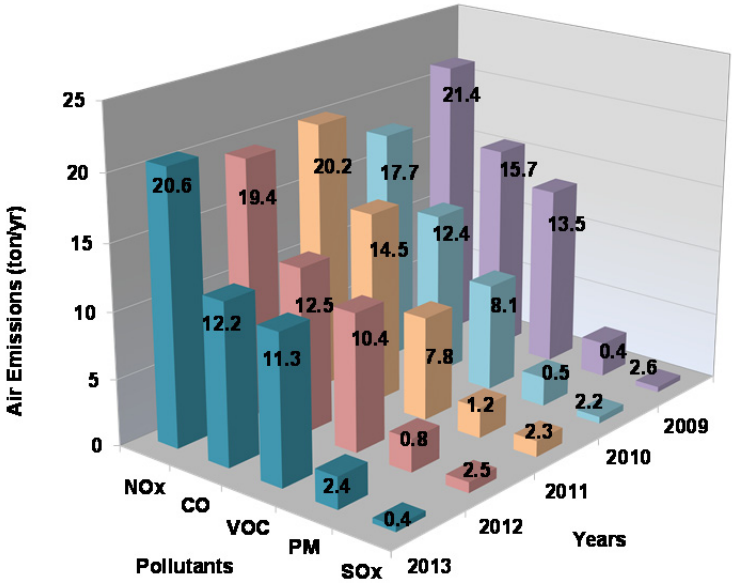

Figure 2-4 **Laboratory criteria pollutant emissions from 2009 through 2013 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.**

ii. Open Burning

The Laboratory 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. The Laboratory did not perform any open burning during 2013.

iii. Asbestos

The NESHAP for asbestos requires that the Laboratory 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.

The Laboratory continued to perform renovation and demolition projects in accordance with the requirements of the asbestos NESHAP. In 2013, 35 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. No new issues were identified.

c. 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 of all work that involves refrigerants as well as 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 Laboratory's 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 2013, the Laboratory removed approximately 1320 lb of Class I ODS and 796 lb of Class II ODS from the active inventory.

ii. Radionuclides

Emissions of airborne radionuclides are regulated under Subpart H of 40 CFR 61, which sets a dose limit of 10 millirem per year (mrem/yr) to any member of the public. The 2013 air-pathway dose to the maximally exposed individual (MEI) was 0.21 mrem (see Chapter 3, Section B.3.b.i). Other MEI cases are regulated by DOE Order 458.1 (DOE 2011b), which sets a dose limit of 100 mrem/yr (see also Chapter 3, Section B.3.b). For all these cases, the annual doses are less than 0.21 mrem and are far below the40 CFR 61 limit of 10 mrem/yr and the DOE limit of 100 mrem/yr.

5. Water Quality and Protection

a. 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 permits described below establish specific chemical, physical, and biological criteria and management practices that the Laboratory must meet before effluent is discharged.

i. NPDES Industrial Outfall Program

LANS and DOE/NNSA are co-permittees under the NPDES permit covering Laboratory industrial outfalls. 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. The Laboratory has been eliminating outfalls over the years and, as of 2013, there are a total of 11 outfalls on the NPDES permit (Table 2-6). To facilitate full compliance with the requirements in the current permit, the Laboratory is planning 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.

Table 2-6
Volume of Effluent Discharge from NPDES-Permitted Outfalls in 2013

Outfall No.	Building No.	Description	Watershed (Canyon)	2013 Discharge (gal.)
03A048	53-963/978	LANSCE[a] cooling tower	Los Alamos	19,356,140
051	50-1	TA-50 RLWTF	Mortandad	0
03A022	3-2238	Sigma cooling tower	Mortandad	10,000
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	498,610
03A181	55-6	Plutonium facility cooling tower	Mortandad	2,201,689
13S	46-347	Sanitary wastewater treatment plant	Sandia	see outfall 001[b]
001	3-22	Power plant (includes treated effluent from outfall 13S)	Sandia	77,728,500
03A027	3-2327	Strategic Computing Complex (SCC) cooling tower	Sandia	11,973,740
03A113	53-293/952	LANSCE cooling tower	Sandia	718,325
03A199	3-1837	Laboratory Data Communications Center	Sandia	10,620,200
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2013 Total:	123,107,200

[a] LANSCE = Los Alamos Neutron Science Center.

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

Outfalls listed on the current permit that did not discharge in CY13 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.

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 2013, none of the 54 samples collected from the SWWS plant's outfall exceeded effluent limits; however, 3 of the 1036 samples collected from industrial outfalls exceeded effluent limits.

The following is a summary of the corrective actions the Laboratory took during 2013 to address the NPDES outfall permit exceedances.

- *Outfall 001, February 1, 2013, total PCBs = 0.00105 µg/L:* SERF became inactive because of a failed hydrochloric acid pipe valve union connection. SERF stopped processing water on January 30, 2013, at approximately 10:40 p.m., resulting in treated sanitary effluent being discharged to outfall 001 without further treatment at SERF.

  Corrective action:

  1. It is believed coupling cracked because of an excessive gap between the sealing surface and the valve end O-ring. Upon repair, pipe fitters removed that gap, allowing the coupling to

seal with normal tightening and with no abnormal pressure or strain on the coupling. SERF remained in operation and did not experience any issues with the repaired coupling through CY13.

- *Outfall 03A048, June 27, 2013, total residual chlorine (TRC) = 1.41 mg/L:* The chlorine neutralizer pump failed at cooling tower 53-963.

  Corrective actions:

  1. The failed neutralizer pump was replaced.
  2. The facility will finalize the written procedure that outlines steps to perform routine checks of the blowdown portion of the system to ensure the chlorine analyzer responds accurately, the backup neutralizer pump activates, and the paging system is engaged when the alarm is activated.
  3. The chlorine monitoring system that activates a backup neutralizer pump does not appear to be working at tower 53-963 because the backup pump did not turn on. The backup system will be tested at regular intervals to ensure it is functioning properly.
  4. Daily checks of the cooling tower systems have been increased from once per day to twice per day. There were no further TRC compliance issues through the remainder of CY13.

- *Outfall 03A181, December 4, 2013, TRC = 0.23 mg/L:* The float valve on the cooling tower make-up water line stuck in the open position, causing chlorinated potable water to overflow to the outfall discharge pipe.

  Corrective action:

  1. The float valve was repaired, and a schedule for manual inspection of the float valve system was implemented. The facility will determine the optimum engineering control for the system. There were no more TRC compliance issues through the remainder of CY13.

ii. 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 2013, the SWWS plant generated approximately 35.9 dry tons (71,797 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.

iii. 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.

The Laboratory 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. Compliance with the NPDES CGP is demonstrated through 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 were required to have SWPPPs revised and NOIs submitted by May 16, 2012. Some of the new permit requirements include inspections of sites within 24 h of a 0.25-in. or greater precipitation event. Other new requirements include weekly inspections for sites that discharge into sensitive waters and that any routine maintenance found necessary be performed by the end of the next business day after the inspection.

During 2013, the Laboratory implemented and maintained 32 construction-site SWPPPs and SWPPP addendums and performed 664 storm water inspections at construction sites. Of the 664 site inspections performed, 566 inspections were compliant, for an overall compliance rate of 85.2%. The majority of noncompliant items were because of the subcontractors not meeting the corrective action timeframes established in the Construction General Permit. Items included meeting site stabilization time requirements and implementing routine maintenance on best management practices (BMPs). Corrective action items identified in 2013 have been addressed. Many are addressed immediately after the inspection report is issued.

iv. NPDES Industrial Storm Water Program

The NPDES MSGP Program regulates storm water discharges from identified industrial activities and their associated facilities. The 2008 MSGP authorizes eligible discharges to waters of the United States in accordance with conditions set forth in the permit and minimizes the discharge of potential pollutants. The types of industrial activities conducted at the Laboratory 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.

The Laboratory submitted its NOI to discharge under the 2008 MSGP in December 2008 and received coverage in January 2009. The Laboratory's permit tracking number under the 2008 MSGP is NMR05GB21. Nationwide authorization to discharge under this permit for all covered industrial facilities expired at midnight on September 29, 2013. However, EPA administratively continued the existing permit. EPA published the 2013 Draft National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges from Industrial Activities, also referred to as the MSGP, by Federal Register (FR) notice on September 27, 2013 (78 FR 59672).

The 2008 MSGP requires the implementation of control measures, development of SWPPPs, and monitoring of storm water discharges from permitted sites. The Laboratory implemented and maintained 11 SWPPPs covering 13 facilities in CY13.

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 CY13 MSGP monitoring are as follows. At TA-3-38, the average concentration of zinc associated with the four most recent quarterly benchmark monitoring samples at monitored

outfall 3-MFS-1 exceeded the benchmark value. Although the average concentration of zinc in these four samples did not exceed the Laboratory-specific storm water background, one individual result exceeded background. Therefore, benchmark monitoring for zinc will continue at this outfall. The yard has been swept to minimize the amount of zinc that could potentially discharge to the outfall.

At TA-54 Area G, the average concentration of chemical oxygen demand (COD) associated with the four most recent monitoring samples exceeded the benchmark value at monitored outfalls 54-G-1, 54-G-2, and 54-G-4. Facility personnel believe the COD exceedances at monitored outfalls 54-G-1 and 54-G-2 are from storm water contact with natural vegetation. Relative to outfall 54-G-4, the trench drain was cleaned out, and only one sample of the four used for the average was collected after the clean out. The concentration of COD in that sample was significantly lower than the previous two samples.

Based on the average concentration of the four most recent samples at monitored outfalls 54-G-1 and 54-G-2, magnesium exceeded the benchmark value. However, because magnesium was present at a concentration solely attributable to natural storm water background at both of these outfalls, the Laboratory was not required to perform corrective action or additional benchmark monitoring for this constituent. Per Part 6.2.1.2 of the 2008 MSGP, "if the average concentration of a pollutant exceeds a benchmark value, and you determine that exceedance of the benchmark is attributable solely to the presence of that pollutant in the natural background, you are not required to perform corrective action or additional benchmark monitoring." Gross alpha exceeded the State of New Mexico water quality criterion at 54-G-2 and 60-RG-8. This does not take into consideration adjusted gross alpha, which excludes source, special nuclear, and by-product material as defined by the Atomic Energy Act. Per "Preliminary Comments Regarding Use of Statistical Methods to Evaluate Background Surface Water Quality and Identify Laboratory Impacts" (LANL 2007a), virtually all of the background concentrations of adjusted gross alpha in storm water exceed the NMED water quality criterion for livestock watering. The referenced document also demonstrates that the variability in gross alpha in storm water samples is primarily because of variability in suspended load. The concentration of gross alpha at this outfall does not exceed the background for gross alpha in storm water.

At the Material Recycling Facility (MRF) located within TA-60, the average concentration from the four most recent monitoring samples exceeded benchmark for total suspended solids (TSS) and COD. As follow-up for the TSS and COD exceedances, the MRF pond was drained, sediment was removed, fossil filter pouches were replaced, and angular rock was added in front of the pond to help prevent the migration of sediment into the pond. Aluminum exceeded the State of New Mexico water quality criteria at outfall 60-RG-10. However, it was present at a concentration solely attributable to natural storm water background at this outfall. Per Part 6.2.4.2 of the 2008 MSGP, "this monitoring requirement does not apply after one year if the pollutant for which the waterbody is impaired is not detected above natural background levels in your stormwater discharge and you document, as required in Part 5.4 (Additional Documentation Requirements), that this pollutant is not expected to be present above natural background levels in your discharge." Therefore, the Laboratory will no longer monitor for gross alpha at outfalls 54-G-2 and 60-RG-8 or aluminum at outfall 60-RG-10. A background study was provided as part of the 2010 MSGP annual report submitted to EPA on November 4, 2010 (LANL 2010).

The Laboratory has completed all 5 yr of the required storm water analytical monitoring in accordance with the 2008 MSGP and continues to fulfill all requirements under the administratively continued permit. 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).

v. 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, with an expiration date of March 31, 2014. The IP authorizes discharges of storm water from certain SWMUs and AOCs (sites) at the Laboratory. The EPA has approved a permit renewal application extension request and the existing permit conditions will be in effect until a new permit is issued.

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 erosion driven by storm events 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 subwatersheds 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 a TAL is 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 2013, the Laboratory completed the following tasks:

- Published the 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 1474 control measure inspections on all 250 SMAs
- Completed 1935 sampling equipment inspections
- Conducted BMP maintenance at 110 SMAs
- Completed installation of additional controls at 37 SMAs
- Collected baseline confirmation monitoring samples at 55 SMAs
- Collected corrective action enhanced control confirmation samples at 26 SMAs
- Completed baseline monitoring at 7 SMAs with no TAL exceedances and no further monitoring required
- Initiated corrective action based on TAL exceedances at 48 SMAs
- Completed installation of enhanced control measures at 10 SMAs
- Completed corrective action at 10 sites
- Began recovery activities from the September 13, 2013, flood event. Recovery activities are ongoing.

- Submitted a request for extension to submit the permit renewal application deadline from September 30, 2013, to March 29, 2014.
- Submitted alternative compliance requests for 5 sites
- Submitted force majeure requests for extension of completion of corrective action at 6 High Priority Sites
- Held one public and two technical meetings
- Completed website updates and public notifications

vi. Aboveground Storage Tank Compliance Program

The Laboratory's Aboveground Storage Tank (AST) Compliance Program is responsible for ensuring compliance with the requirements established by EPA (CWA, 40 CFR 112) and NMED's Petroleum Storage Tank Bureau (PSTB) regulations (20.5 NMAC). During 2013, 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 CWA (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 2013, the Laboratory conducted approximately 33 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 (16 ASTs) that are operational pursuant to 20.5 NMAC. Three tank systems were placed into permanent closure status pursuant to 20.5 NMAC.

In 2013, two New Mexico Environmental Improvement Board (NMEIB) changes to the New Mexico Petroleum Storage Tank regulations impacted ASTs at the Laboratory. Effective July 1, 2013, existing emergency generator tanks were required to be upgraded to meet new tank standards or be closed, and concrete secondary containment structures were required to be lined or sealed. Two ASTs were upgraded to new tank standards, three systems were closed, and one AST concrete secondary containment structure sealant application was completed to meet the July 1, 2013, milestone.

vii. Dredge and Fill Permit Program

Section 404 of the CWA requires the Laboratory to obtain permits from USACE to perform work within perennial, intermittent, or ephemeral watercourses. Section 401 of the CWA requires states to certify that Section 404 permits issued by USACE 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. During 2013, Section 404/401 permits were issued for four construction projects at the Laboratory:

- Construction of grade-control structure in Sandia Canyon (NWP No. 38, Cleanup of Hazardous and Toxic Waste).
- Stream gage repairs in Cañon de Valle and Water Canyon (NWP No. 18, Minimal Discharges).
- Wetland berm construction in Mortandad Canyon (NWP No. 38, Cleanup of Hazardous and Toxic Waste).

- TA-72 Firing Site storm water controls (NWP No. 38, Cleanup of Hazardous and Toxic Waste).

The following Section 404/401 permit was issued in 2012 and is still open because of an annual monitoring requirement established in the permit authorization.

- Water Canyon storm drain reconstruction project (NWP No. 43, Stormwater Management Facilities)

NMED and USACE did not inspect any sites permitted under the Section 404/401 regulations during 2013.

b. 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 2010). 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 2013, 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 Laboratory contaminants.

c. Groundwater

i. 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 2013, the Laboratory had one discharge permit and three discharge plans pending NMED approval (see Table 2-1).

ii. 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 2013, 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, and supplemental information on December 20, 2012. 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 2013. NMED conducted a site inspection of the SERF and NPDES Outfalls 001 and 03A027 on August 20, 2013.

iii. 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, and supplemental information on August 10, 2012. On September 13, 2013, NMED issued a draft discharge permit for public review and comment. The 90-day public comment period ended on December 12, 2013. Issuance of a final discharge permit was pending at the end of 2013.

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 nitrogen), fluoride, total dissolved solids, and perchlorate. The Laboratory reports the analytical results to NMED quarterly. During 2013, none of the quarterly groundwater samples exceeded NMWQCC groundwater standards. No effluent samples were collected in 2013 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 did not conduct an inspection of the TA-50 RLWTF in 2013.

iv. 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 the Laboratory 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. The discharge plan application was amended on January 17, 2012. Issuance of a final discharge permit was pending at the end of 2013. NMED did not conduct an inspection of the Laboratory's septic tank/leachfield systems in 2013.

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

On December 20, 2011, 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 plan will capture activities beyond the R-28 pumping test to include, but not be limited to, pumping tests, aquifer tests, and well rehabilitation and tracer studies. 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 2013. NMED conducted an inspection of the R-42 and R-28 pumping tests in Mortandad Canyon on August 20, 2013.

vi. Groundwater Monitoring Activities

The Laboratory performed significant groundwater compliance work in 2013 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 2013. Maps of all monitoring well locations can be found in Chapter 5.

6. Other Environmental Statutes

a. Endangered Species Act

The Endangered Species Act requires federal agencies to protect populations and habitats of federally listed threatened or endangered species. The Laboratory implements these requirements through the biological resources management plan (LANL 2007b) and the habitat management plan (LANL 2011).

The Laboratory contains potential habitat for two federally endangered species (Southwestern willow flycatcher, *Empidonax traillii extimus* and the Jemez Mountains salamander, *Plethodon neomexicanus);* one

federally threatened species (Mexican spotted owl, *Strix occidentalis lucida*); one species proposed federally as endangered (New Mexico meadow jumping mouse, *Zapus hudsonius luteus*); and one species proposed federally as threatened (yellow-billed cuckoo, *Coccyzus americanus occidentalis)*. 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 the Laboratory (Table 2-7).

Table 2-7
Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at the Laboratory

Scientific Name	Common Name	Protected Status[a]	Potential to Occur[b]
Empidonax traillii extimus	Southwestern Willow Flycatcher	E	Moderate
Mustela nigripes	Black-footed Ferret	E	Low
Strix occidentalis lucida	Mexican Spotted Owl	T	High
Coccyzus americanus occidentalis	Yellow-Billed Cuckoo (western population)	PT, NMS	High
Zapus hudsonius luteus	New Mexico Meadow Jumping Mouse	PE, NME	Moderate
Haliaeetus leucocepahlus	Bald Eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed Hummingbird	NMT	Low
Gila pandora	Rio Grande Chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains Salamander	E, NME	High
Falco peregrinus anatum	American Peregrine Falcon	NMT, FSOC	High
Falco peregrinus tundrius	Arctic Peregrine Falcon	NMT, FSOC	Moderate
Accipiter gentiles	Northern Goshawk	NMS, FSOC	High
Lanius ludovicianus	Loggerhead Shrike	NMS	High
Vireo vicinior	Gray Vireo	NMT	Moderate
Myotis ciliolabrum melanorhinus	Western Small-footed Myotis Bat	NMS	High
Myotis volans interior	Long-legged Bat	NMS	High
Euderma maculatum	Spotted Bat	NMT	High
Corynorhinus townsendii pallescens	Townsend's Pale Big-eared Bat	NMS, FSOC	High
Nyctinomops macrotis	Big Free-tailed Bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red Fox	NMS	Moderate
Ochotona princeps nigrescens	Goat Peak Pika	NMS, FSOC	Low
Cynomys gunnisoni	Gunnison's Prairie Dog	C, NMS	Low
Lilium philadelphicum var. andinum	Wood Lily	NME	High
Cypripedium calceolus var. pubescens	Greater Yellow Lady's Slipper	NME	Moderate
Speyeria Nokomis nitocris	New Mexico Silverspot Butterfly	FSOC	Moderate

[a] E = Federal Endangered; T = Federal Threatened; C = Federal Candidate Species; PE = Proposed Endangered; PT = Proposed Threatened; 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 at the Laboratory. Moderate = Habitat exists, though the species has not been recorded recently. High = Habitat exists, and the species occurs at the Laboratory.

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 2013, the Laboratory reviewed 572 excavation permits, 251 project profiles in the permits requirements identification process, and 10 storm water profiles for potential impacts to threatened or endangered species. The Laboratory conducted surveys for the Mexican spotted owl, Southwestern willow flycatcher, and Jemez Mountains salamander. Mexican

spotted owl surveys by the Laboratory biologists had positive results. Southwestern 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.

b. 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, Laboratory 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 2013, Laboratory biologists continued annual surveys in all major habitat types in each season (Hathcock and Keller 2012) and began additional monitoring at two firing sites and an open-burn site (Hathcock and Fair 2013). In addition, biologists completed a fourth year of bird netting to monitor the bird populations during fall migration in Pajarito Canyon (Mahowald et al. 2014). Bird captures were highest in 2010, were significantly lower in 2011, but seemed to have recovered in 2012. In 2013, bird captures decreased again to levels nearly equal with 2011. Fall migration monitoring sites at similar elevations and habitat also showed declines. Bird populations naturally fluctuate due to various environmental factors. According to Palmer Drought Severity Indices, May to August 2013 was the driest on record in the last 120 years in this area. This drought severity would account for a large reduction in food sources (plants and insects), which would explain why there was such a decrease in birds captured in 2013.

c. National Historic Preservation Act

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. The Laboratory 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 FY13 (October 2012 through September 2013), the Laboratory conducted 24 projects that required some field verification of previous cultural surveys. No new archaeological sites were identified in FY13. No archaeological sites were determined eligible for the National Register of Historic Places. As part of Section 106, the Laboratory conducts public outreach and provides site tours of historic and cultural sites for stakeholders, DOE/NNSA, and representatives of other federal agencies. NHPA information is provided on an FY basis to correspond to information provided to the Secretary of the Interior for a Report to Congress on Federal Archaeological Activities.

The Laboratory continued the Land Conveyance and Transfer Project (C&T). No land tracts were conveyed or transferred in CY13 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 2013 where the artifacts from the excavation of 39 C&T archaeological sites, along with collections from other earlier projects conducted at the Laboratory, are housed.

In support of its 2013 D&D program, square footage reduction, and operations consolidation, the Laboratory conducted archival documentation for four space-reuse/consolidation projects and continued work on another project as required under the provisions of the NHPA. Buildings included in these projects are located at TA-03, TA-16, TA-36, and TA-40. This work included field visits to historic properties (including interior and exterior inspections), digital and archival photography, and architectural documentation (using standard Laboratory 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 Laboratory 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 2013, consultations with the Pueblo de San Ildefonso were completed, and the culturally affiliated human remains discovered at TA-54 during 2011 were repatriated.

7. DOE Order 436.1, Departmental Sustainability

a. Introduction

The Laboratory's 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 (see Chapter 1, Section D.1 for more details). Institutional programs are in place for each of these environmental areas. In response to DOE Order 436.1 (DOE 2011c), the Laboratory also creates and manages an annual, FY-based site sustainability plan (SSP) to focus on energy and long-term sustainability milestones.

The Laboratory identified three high-level objectives to support its goal of establishing excellence in environmental stewardship during FY13. In addition to objectives focused on (1) cleaning the past and (2) controlling the present, a third objective was established to direct efforts to create a sustainable future.

More information about the Laboratory's EMS can be found in Chapter 1, Section D.1 and at http://www.lanl.gov/community-environment/environmental-stewardship/protection/environmental-management-system.php.

b. Pollution Prevention Program

The Pollution Prevention (P2) Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs 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 FY13 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, LLW, MLLW, and TRU/MTRU waste. The Laboratory also tracks its recycling percentage and weight of sanitary trash generated per person. In FY13, the Laboratory generated less routine hazardous and MLLW waste than in FY12 but more routine waste of all other types. In FY13, the amount of routine sanitary waste generated per person decreased from FY12 levels, and the recycling percentage of solid waste increased. The differences in routine waste generation and recycling percentage are shown in Table 2-8.

Table 2-8
Comparison of FY12 and FY13 Routine Waste Generation and Recycling Percentages

LANL P2 Performance Index	FY12 Generation	FY13 Generation
Routine hazardous waste	12.3 metric tons	6.7 metric tons
Routine LLW	726.8 m^3	1708.9 m^3
Routine MLLW	5.9 m^3	2.0 m^3
Routine sanitary waste	145 kg/person	125 kg/person
Routine TRU/MTRU waste	88.9 m^3	94.9 m^3
Recycling	81% of solid waste	89% of solid waste

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 the Laboratory 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.

c. 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 GHG reduction strategies and provide for implementation of an SSP. Site sustainability seeks to reduce consumption of natural resources so that the Laboratory 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 meet 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, 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 FY13 SSP (LANL 2013), and Table 2-9 shows the Laboratory's performance status toward meeting the sustainability goals.

Table 2-9
Sustainability Performance Status

DOE/NNSA Goal	Performance Status through FY13	Planned Actions and Contribution
28% Scopes 1 and 2 GHG reduction by FY20 from an FY08 baseline	The Laboratory has achieved an 18.8% reduction in Scopes 1 and 2 GHG emissions compared with the FY08 baseline.	The Laboratory will purchase Renewable Energy Certificates (RECs) and continue to pursue lower carbon electricity resources, as economically practical, and energy reduction projects to reduce GHG emissions and as part of an overall strategy to reach the 28% reduction goal.
13% Scope 3 GHG reduction by FY20 from an FY08 baseline	The top 3 contributors to the Laboratory's Scope 3 GHG emissions are travel, commuting, and losses associated with transmission and distribution lines. The Laboratory did not take any credit for Park and Ride, vanpool, or carpool activities. This metric is updated annually each November. The Laboratory achieved a 27.3% reduction in Scope 3 GHG emissions because of decreased air and ground travel and employee commuting.	The Laboratory recognizes that the most practical way to reduce Scope 3 GHG emissions is by reducing commuting. The Laboratory is exploring options for reducing commuting, e.g., changing work schedules to a 4 × 10 work week and larger-scale telecommuting.
30% energy intensity (British thermal units per gross square foot) reduction by FY15 from an FY03 baseline	In FY13, the Laboratory calculated and tracked a rolling 12-mo energy intensity based on an FY03 baseline. A year-end net energy intensity reduction of 12.2% was reported.	In FY14, the Laboratory plans to strategically invest $2M to reduce energy consumption in facilities. This investment is estimated to yield an energy reduction percentage of approximately 3%. With the same level of annual investment through FY15, the Laboratory anticipates achieving a cumulative energy intensity reduction of 15% to 17% compared with the FY03 baseline.
Energy Independence and Security Act of 2007 (EISA) Section 432 energy and water evaluations	The Laboratory completed the EISA "covered facilities" energy and water assessments identified in the 4-yr assessment schedule for FY13.	The Laboratory will continue to evaluate "covered facilities" on a 4-yr cycle to identify energy and water conservation measures and prioritize and implement energy and water conservation projects.

Table 2-9 (continued)

DOE/NNSA Goal	Performance Status through FY13	Planned Actions and Contribution
Individual buildings metering for 90% of electricity (by October 1, 2012) and for 90% of steam, natural gas, and chilled water (by October 1, 2015)	The Laboratory used the same evaluation methodology and justification determination designed for electric meters for thermal metering.	The Laboratory is complete with all electric and thermal meter installations required to meet the "as economically practicable" definition.
Cool roofs, unless uneconomical, for roof replacements unless project already has Critical Decision 2 (CD-2) approval. New roofs must have thermal resistance of at least R-30.	All new roofs meet cool roof requirements per engineering standards. In FY13, there was 61,476 square feet of cool roofing installed.	The Laboratory plans the replacement of approximately 35,000 square feet of roof for 2014. 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.
15% of existing buildings greater than 5000 gross square feet are compliant with the guiding principles (GPs) of HPSB by FY15.	The Laboratory has an average 65% GP implementation rate within the selected 31 HPSBs. In FY13, the Laboratory completed the GPs in 4 facilities.	The Laboratory plans to continue implementing the GPs within selected HPSBs, focusing on HVAC and building automation systems recommissioning. The Laboratory is investing approximately $1.3M in HPSBs in FY14 as part of the overall funding to reduce energy use in facilities. The risk of nonattainment is high because the Laboratory will target high return on investment energy reduction as the main HPSB focus in order to make progress in energy intensity reduction.
All new construction, major renovations, and alterations of buildings greater than 5000 gross square feet must comply with the GPs.	The 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 square feet of major new projects currently in the planning stages are being formulated to be certified as Leadership in Energy & Environmental Design (LEED) Gold projects. The Laboratory will continue to implement and manage efforts to address the requirement for achieving LEED Gold status and the 35% improvement over the American Society of Heating, Refrigerating and Air Conditioning Engineers requirement for new projects using cost-effective capital outlay strategies to achieve long-range operational benefits.
10% annual increase in fleet alternative fuel consumption by FY15 relative to an FY05 baseline	In FY13, Alternative Fuel consumption was 42,657 gal., which is a 380% increase compared with the FY05 baseline.	The Laboratory will continue to purchase and increase utilization of alternative fuel for vehicles using E-85 and B-5 in FY14. The Laboratory plans to increase the percentage of biodiesel within the blend over time based on operational performance and availability.
2% annual reduction in fleet petroleum consumption by FY20 relative to an FY05 baseline	The Laboratory has reduced fleet petroleum by 12.7% compared with the FY05 baseline.	The Laboratory purchased 2 Chevy Volts for its fleet. The Laboratory will continue to right-size the fleet and expand alternative fuel use to reduce petroleum consumption.
100% of light-duty vehicle (LDV) purchases must consist of alternative fuel vehicles (AFVs) by FY15 and thereafter (75% FY00–FY15). (For metropolitan statistical areas.)	The Laboratory's total fleet consists of 1570 vehicles. A total of 793 or 51% are considered LDVs. Of the 793 LDVs, 497 or 63% are AFVs; however, Los Alamos is not located in a metropolitan statistical area.	The Laboratory will continue to replace vehicles with AFVs as economically practicable.

Table 2-9 (continued)

DOE/NNSA Goal	Performance Status through FY13	Planned Actions and Contribution
Reduce fleet inventory of non-mission-critical vehicles by 35% by FY13 relative to an FY05 baseline	The Laboratory reviewed and recategorized its vehicles into two categories: mission support and mission essential. As part of this year's annual General Services Administration reorder process, vehicles not meeting NNSA's utilization standards averaged over the last 24 mo will not be reordered. The Laboratory continues to turn in vehicles that are no longer needed to meet the Laboratory's programmatic mission or vehicles that have continually been underutilized.	The Laboratory will continue to support the agency's reduction goal of 35% by ensuring the Laboratory's fleet is mission-appropriate and remains cost effective.
26% potable water intensity (gallons per gross square foot) reduction by FY20 from an FY07 baseline	In FY13, the Laboratory's water use reduction was dependent on SERF operations and industrial water reuse at the SCC. SERF supplied 100% of SCC water demand from June to September 2013. The Laboratory's **total** water use in FY13 was approximately 387 million gallons. Water intensity has increased by approximately 22% compared with the FY07 baseline largely because of cooling towers supporting increased supercomputing. However, water use has reduced by 12% compared with FY12.	SERF operations will avoid consumption of an additional 35 to 40 million gallons of water in FY14. The Laboratory's sustainability efforts focus on a cost-effective life-cycle approach emphasizing energy efficiency to reduce the Laboratory's regional impact on water use associated with energy generation. In addition, the Laboratory will focus on small, targeted water conservation measures that will dovetail with site infrastructure upgrades.
20% water consumption (gal.) reduction of industrial, landscaping, and agricultural (ILA) water by FY20 from an FY10 baseline	Currently, all of the Laboratory's water use is potable water and is therefore considered part of the 26% water intensity reduction goal reporting.	The Laboratory will not report on the ILA goal but will focus efforts in total potable water intensity reduction as described above.
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, by FY15	In FY13, the Laboratory diverted 56% of solid, nonhazardous waste.	The Laboratory will continue to identify and implement opportunities for improvement in nonhazardous solid waste recycling/diversion in FY14–FY15.
Divert at least 50% of construction and demolition materials and debris by FY15	In FY13, the Laboratory recycled or diverted 98% of construction and demolition waste.	The Laboratory will continue diverting construction and demolition waste.
Procurements meet requirements by including necessary provisions and clauses (sustainable procurements/bio-based procurements)	In FY13, the Laboratory received a Gold "GreenBuy" Award for procuring products in FY12 with sustainable attributes. The Laboratory met the DOE's leadership goals for 9 product types in 6 product categories.	In FY14, the Laboratory will strive to increase its procurement of environmentally preferable products while simultaneously increasing its visibility of those procurements and the associated reporting capability.
All data centers are metered to measure a monthly power utilization effectiveness (PUE) of 100% by FY15.	The Laboratory has reliable PUE metrics for all 3 major data centers. The Laboratory evaluated over 130 distributed server rooms and data centers to determine the extent of metering required. The Laboratory developed and proposed a "data center" definition to better focus efforts on opportunities for energy savings.	The Laboratory will develop a detailed server room and data center plan to meet the sustainability goals for PUE and metering. This plan will focus on (1) virtualization, (2) consolidation, and (3) management of server rooms and data centers. Metering will be part of the third section and will be planned for installation in enduring data centers only.
Maximum annual weighted average PUE of 1.4 by FY15.	The PUE at the SCC is currently averaging 1.32, and the PUE at the Laboratory Data Communications Center is averaging 1.58. The Central Computing Facility estimated PUE is 1.5. The FY13 annual weighted average PUE for all three major data centers is 1.41.	The Laboratory is planning to upgrade the SCC with Trinity beginning in 2016. The planned PUE for Trinity will be approximately 1.2. With the Trinity upgrade, the Laboratory will meet the PUE goal of 1.4.

Table 2-9 (continued)

DOE/NNSA Goal	Performance Status through FY13	Planned Actions and Contribution
Electronic Stewardship - 100% of eligible personal computers and laptops with power management actively implemented and in use by FY12	In FY13, the Laboratory completed the implementation of the System Center Configuration Manager (SCCM) with power management of Windows desktops and laptops.	In FY13, the Laboratory completed the implementation of the SCCM with power management of Windows desktops and laptops.
20% of annual electricity consumption from renewable sources by FY20 and thereafter	The Laboratory exceeded the 7.5% renewable energy goal in FY13. The Laboratory used approximately 437,290 megawatt hours of electricity in FY13, including on-site renewable generation. The purchased amount in addition to on-site renewable energy is approximately 9.7% of the annual electricity consumption.	The Laboratory will continue to purchase RECs and utilize the on-site renewable sources, such as the Abiquiu dam low-flow turbine, to meet this goal. In addition, the Laboratory is exploring the feasibility of working with DOE to contract with the Western Area Power Association for 1 megawatt of locally generated renewable power.

8. 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 and 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 2013.

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 2013.

c. Material Safety Data Sheet/Chemical Inventory Reporting

Title III, Sections 311 and 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 17 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2013.

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. Laboratory operations exceeded the threshold for use of lead in 2013, and therefore the Laboratory 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 2-10 summarizes the reported releases in 2013.

Table 2-10
Summary of 2013
Reported Releases under EPCRA Section 313

Reported Release	Lead (lb)
Air emissions	3.72
Water discharges	0.29
On-site land disposal	2001.5
Off-site waste transfers	14,619

9. Floodplain and Wetland Management

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. The Laboratory reviewed 42 project profiles for potential impacts to watercourses, floodplains, or wetlands. One floodplain/wetland assessment was prepared in 2013 for proposed work at the TA-41/Los Alamos Canyon ice rink expansion. No violations of the DOE floodplain/wetland environmental review requirements were recorded in 2013.

C. OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

1. DOE Order 232.2, Occurrence Reporting and Processing of Operations Information

DOE Order 232.2, Occurrence Reporting and Processing of Operations Information, requires that occurrences resulting from activities performed by facility personnel and by subcontractors in support of facility operation must be reported by facility personnel in accordance with the provisions of this order. For reportable occurrences, facility personnel must categorize the occurrences, notify other DOE elements as required, and prepare and submit occurrence reports.

The objectives of DOE Order 232.2 are (1) to ensure that DOE and NNSA are informed about events that could adversely affect the health and safety of the public or the workers, the environment, DOE missions, or the credibility of the department; (2) to promote organizational learning consistent with DOE's integrated safety management system goal of enhancing mission safety; and (3) to share effective practices to support continuous improvement and adaptation to change.

All reportable environmental occurrences at the Laboratory for 2013 are listed in Table 2-11. The order defines 10 groups of occurrences; environmental occurrences are group 5. Environmental occurrences are divided into two subgroups; subgroup A, releases, and subgroup B, ecological and cultural resources. There are four significance categories within subgroup A and two significance categories within subgroup B. All but one of the 24 environmental occurrences at the Laboratory in 2013 were subgroup A, significance category 2; one occurrence was subgroup A, significance category 3; and one occurrence was categorized as both significance categories 2 and 3.

Group 5, subgroup A, significance category 2: Any release (on-site or off-site) of a pollutant from a DOE facility that is above levels or limits specified by outside agencies in a permit, license, or equivalent authorization, when reporting is required in a format other than routine periodic reports.

Group 5, Subgroup A, significance category 3: Any release (on-site or off-site) that exceeds 100 gal. of oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil. For operations involving oil field crude or condensate, any discharge that must be reported to outside agencies in a format other than routine periodic reports is reportable under this criterion.

Table 2-11
2013 Laboratory Environmental Occurrences

Criterion	Report Title	Action(s)
5A(2) 4	NPDES Outfall Permit Effluent Limit for Total Residual Chlorine Exceeded at Outfall 03A048	1. Facility personnel shut off the blowdown pump and valve for the cooling towers and conducted an investigation, revealing a mechanical failure of the primary pump. The primary pump was replaced, and the system was returned to service the same day. Manual sampling frequency for both towers has been increased from once per day to twice per day while the backup pump's failure to initiate is investigated. 2. LANL environmental personnel verbally notified NMED and EPA.

Table 2-11 (continued)

Criterion	Report Title	Action(s)
5A(2) 4; 10(2d) 4	Management Concern: LANSCE Power Outage Results in Potable Water Release and Impacts Emergency Response	1. Personnel will develop and post instructions on manual opening of the TA-53 site main gate (for emergency access).
5A(2) 4	Water Distribution Leak Results in a Significant Amount of Potable Water Released to the Environment	1. The Utilities and Institutional Facilities (UI) Division crew isolated the leak, and the water line repair was scheduled. 2. LANL ENV-RCRA personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Discharge Exceeds Surface Water Limits	1. LANL ENV-RCRA personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports. 2. Water discharge information has been included in EMS training and coordinated/accepted by Central Training for inclusion. 3. LANL ENV-RCRA personnel to revise Section 01 3545, Water Discharge Requirements, to reflect that it is applicable to all LANL workers and not only subcontractors.
5A(2) 4	Water Release to the Environment Due to Float Valve Failure on a Temporary Cooling Tower	1. The Maintenance and Site Services pipefitter immediately isolated the water to the cooling tower. The TA-3-1698 operations management issued a work ticket for Trane personnel to replace the float valve. 2. The repairs to the fill assembly components have been completed.
5A(2) 4	Fire Suppression Water Discharged to the Environment Resultant of Frozen Ruptured Line	1. Los Alamos Fire Department personnel isolated the pressure-indicating valve to the fire suppression system that stopped the water flow. 2. The fire protection pipefitters repaired the line, and a fire watch was established until the system was tested and recharged. 3. On January 14, 2013, environmental personnel verbally notified NMED and EPA of the water release. On January 18, 2013, they submitted the 7-day written release report to NMED and EPA.
5A(2) 4	Water Distribution Leak Results in a Potable Water Release into the Environment	1. The UI Division crew isolated and repaired the water line. 2. LANL ENV-RCRA verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	NPDES Permit Exceedance at Outfall 001	1. LANL environmental personnel notified NMED and EPA.
5A(2) 4	Potable Water Leak on East Jemez Road	1. The UI Division crew isolated and repaired the water line. 2. LANL ENV-RCRA personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Unpermitted Discharge at SERF	1. A lock-out tag was placed on the discharge valve, and the lid on the discharge pipe was tack-welded. 2. Follow-on sampling was requested. 3. Personnel were notified to discontinue discharges.
5A(2) 4	Sewer Manhole Overflows Resulting in a Sanitary Waste Release into the Environment	1. The UI Division crew responded and manually ran the pumps to mitigate the issue. 2. Notification was made to LANL ENV-RCRA personnel. 3. LANL ENV-RCRA personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Water Tank Overflow Results in a Potable Water Release	1. The UI Division crew notified Los Alamos County to shut down fill pumps. 2. LANL Environmental Compliance Programs (ENV-CP) personnel reported the release to NMED. 3. A temporary connection to the level transmitter was put into place to allow normal operation of Tank 247.
5A(2) 4	Water Leak Results in a Potable Water Release in the Environment	1. The UI Division crew isolated the leak. 2. LANL ENV-CP personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Discharge Line Disconnects from Sampling Valve Resulting in Monitoring Well Water Release	1. LANL ENV-CP personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports. 2. The line connection was repaired, connections to the lines were secured with hose clamps, and the well was put back into service at a lower pumping rate.

Table 2-11 (continued)

Criterion	Report Title	Action(s)
5A(2) 4	Underground Water Line Fails Resulting in a Potable Water Release	1. The UI Division crew isolated the leak and scheduled repairs. 2. LANL ENV-CP personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Potable Water Release	1. The UI Division crew isolated the leak and scheduled repairs. 2. LANL ENV-CP personnel verbally notified NMED and the EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Potable Water Release	1. The UI Division crew isolated and repaired the leak. 2. LANL ENV-CP personnel verbally notified NMED and EPA of the release and will follow up with 7-day and 15-day written reports.
5A(2) 4	Potable Water Release	1. The UI Division crew isolated the water line. 2. LANL ENV-CP personnel made verbal notifications to NMED and will follow-up with 7-day and 15-day written reports.
5A(2) 4	Unplanned Facility Power Outage Results in a Potable Water Release to the Environment	1. The Science and Technology Operations manager isolated the emergency cooling water system valve that stopped the water flow. 2. LANL ENV-CP personnel verbally notified NMED and EPA of the water release and will follow up with the written report. 3. On August 20, 2013, NMED conducted a site visit of Outfall 022 and recommended that Laboratory personnel install rocks to ensure all potential flow will be diverted into the defined flow path.
5A(2) 4; 5A(3) 4	Release of Diesel Fuel in Excess of 100 Gallons Requiring a Special Report to the State of New Mexico	1. LANL Emergency Operations, Emergency Management was notified and took control of the scene at 1000. 2. Storm drains and runoffs were checked for diesel stains/smell, and none were detected. 3. A pump truck was requested to empty the sumps and arrived at 1100. 4. An emergency excavation permit was requested, received, and hand excavation was initiated at 1200. At approximately 1430, excavation was stopped because removal of more soil might undermine the AST footer. An engineering review will be performed before further excavation. The excavated soil was bagged. 5. The event was critiqued on the morning of January 23, 2013. At that time, the facility operations director (FOD) was informed that the conservative estimate of the amount of diesel fuel released was approximately 340 gallons. The FOD added 5A(3). 6. The fuel oil supply and return lines at AST 55-560 and within the transition sump were valved off by TA-55 RLUOB Operations, isolating the underground sections of the supply and return lines. 7. Locate and repair leaks within the fuel piping system for AST 55-560. Evaluate piping system for any other leaks and verify system integrity. System repair work to be performed by an NMED-PSTB certified tank installer. 8. Clean sump liquid detectors and ensure they are working properly. System repair work to be performed by an NMED-PSTB certified tank installer. 9. Add visual inspection of the 55-560 monitoring systems to RLUOB surveillance rounds. 10. The TA-55 FOD has made the decision to keep the RLUOB fuel oil tank dry (no fuel oil) to eliminate the risk of another discharge to the environment. If there is a short term operational need for fuel oil, then compensatory measures will be put into place to monitor the tank. 11. Have a structural engineer ensure integrity of the structure and provide guidance for the continued removal of contaminated soil from the vicinity of structures associated with 55-560. Engineering Services Division Design Engineering will provide direction to accomplish removal of contaminated underlying soils as necessary. 12. Complete removal of soils contaminated with diesel fuel to cleanup criteria established by NMED-PSTB.

Table 2-11 (continued)

Criterion	Report Title	Action(s)
5A(2) 4	Coolant Release that Required a Non-Routing Spill Report to the New Mexico Environment Department	1. Facility staff stopped the release and valved off the fractured hose immediately. 2. Spill kits were deployed to minimize the impacted area. 3. Facility staff also used sorb-all and began removing free product. 4. Emergency Operations and a hazardous materials (HAZMAT) response team responded and cleaned inside the structure. 5. The residual antifreeze outside the structure was treated with microblaze.
5A(2) 4	NPDES Permit Limit Exceedance for Chlorine Detected at Outfall during Weekly Compliance Sampling	1. The TA-55 operations personnel isolated the makeup water. 2. The TA-55 maintenance personnel replaced the float ball and returned the cooling tower system to service. 3. LANL ENV-CP personnel verbally notified EPA Region 6 and NMED-Surface Water Quality Bureau of the NPDES permit limit exceedance for total residual chlorine at Outfall 03A181. They will follow up with the 5-day written report.
5A(2) 4	Management Concern: Environmental Release Due to Rain Event Reveals Potentially Inadequate Work Controls	1. The roofers identified the event and promptly notified management. 2. LANL Deployed Services Environmental Safety and Health personnel evaluated the situation and notified the Emergency Management and Response Division. 3. The HAZMAT team responded and initiated several actions to mitigate the environmental release, including building a berm and an upstream dam and applying absorbent material and collecting surface water and solids. 4. The roofing work was paused pending a review of the work package and hazard controls.
5A(3) 4	LANL Subcontractor Truck Containing Non-Radiological/Non-Hazardous Waste Rollover on I-25	1. The DOE headquarters hotline was notified.

D. UNPLANNED RELEASES

1. Air Releases

No unplanned air releases occurred at the Laboratory during 2013.

2. Water Releases

No unplanned releases of radioactive liquids occurred on Laboratory land in 2013. There were 22 unplanned releases of nonradioactive liquids in 2013 that were reported to NMED pursuant to 20.6.2.1203 NMAC (Table 2-12). In addition, an unpermitted sanitary sewer seepage pit and two reports for groundwater detections in excess of New Mexico Groundwater Quality Standards were reported pursuant to 20.6.2.1203 NMAC. The two groundwater reports included three detections above the New Mexico Groundwater Quality Standards: a chromium detection at R-43, a manganese detection at alluvial well FLC-16-25280, and an iron detection at Martin Spring.

Table 2-12
2013 Unplanned Nonradioactive Releases

Material Released	Instances	Approximate Total Release (gal.)
Potable water	14	727,880
Diesel fuel	1	419
Hydraulic fluid	1	20
Groundwater	1	100
Antifreeze	1	50
SERF pipe discharge	1	Unknown
Sanitary wastewater	1	500
Fire-suppression water	1	6500
Roofguard	1	5

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 2013, the Laboratory was in the process of administratively closing all past release reports for the reportable releases with NMED's DOE Oversight Bureau. The Laboratory anticipates that these release reports will be closed out after final inspections.

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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 (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?" These assessments show that during 2013 all doses to the public and biota were far below all regulatory limits and guidance and that the public and biota are well protected.

A. INTRODUCTION

In this chapter, we assess dose and risk to ensure the public and biota 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 Los Alamos National Laboratory (LANL or the Laboratory) operations are much smaller than the regulatory limits and the naturally occurring background levels. 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. Values for dose are 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 Laboratory 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 (Section B.2, 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). Annual doses from community drinking water supplies are limited by the Clean Water Act to 4 mrem (EPA 2004).

The dose from natural background and medical/dental procedures is about 800 mrem per year (mrem/yr) (Section B.4). The potential doses from Laboratory operations are much less than 1 mrem/yr and are often too small to measure (Section B.3). Generally, doses less than 0.1 mrem/yr are too small to measure.

2. Exposure Pathways

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

a. Direct Radiation Pathway

The Laboratory 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 the

Laboratory. 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 measurable above-background doses from direct radiation are near Technical Area 53 (TA-53) and TA-54 (Section B.3).

b. Airborne Radioactivity (Inhalation Pathway)

At distances of more than 1 km from Laboratory 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 4) (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).

The air-pathway dose is described in the annual Rad-NESHAP report (Fuehne 2014) and in Section B.3.

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.

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/yr to the public dose.

Measurements of radioactivity in water are reported in Chapters 5 and 6. Drinking water contains no measurable radionuclides from current or historical Laboratory operations. For further information regarding Los Alamos County drinking water quality, refer to the Los Alamos Department of Public Utilities "Drinking Water Quality Report 2013" (Los Alamos County 2014). 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).

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. At all publicly accessible locations, the Laboratory-generated doses from soil, if any, are indistinguishable from background (Chapter 7).

e. Food (Ingestion Pathway)

We report measurements of the radioactive content of food and native vegetation in Chapter 8. No contamination from the Laboratory was detected in food.

f. Release of Items and Land Transfer

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 the Laboratory'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 the Laboratory 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, LANL 2009, DOE 2000) that demonstrate the dose is ALARA and does not exceed 15 mrem/yr (DOE 2000).

During 2013, no items with measurable contamination were released and no land was transferred, so the dose from this pathway was less than 0.1 mrem/yr.

3. Dose Calculations and Results

The objective of this section is to calculate doses to the public from Laboratory operations. Therefore, we do not include contributions from naturally occurring radioactive material, from global fallout, from consumer products, or from medical sources; these other sources are discussed in Section B.4.

We calculate doses from the Laboratory to the following members of the public:

a. The total population within 80 km of the Laboratory
b. The maximally exposed individual (MEI)

For the MEI, we consider three cases:

i. The Rad-NESHAP MEI, as required by the Clean Air Act (EPA 1986)
ii. The on-site MEI, as required by DOE Order 458.1 (DOE 2011)
iii. The off-site MEI, also required by DOE Order 458.1 (DOE 2011)

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 the Laboratory. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88. The doses from the other pathways are either negligible or nonexistent. (Section B.2).

The 2013 collective population dose to persons living within 80 km of the Laboratory is 0.14 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 65% of the dose, and short-lived activation products, such as carbon-11 from LANSCE, contributed about 30% of the dose. Collective population doses for the past 10 yr are shown in Figure 3-1.

b. Dose to the MEI

The MEI is a hypothetical member of the public who receives the greatest dose from Laboratory operations. In Sections i through iii below, we consider the Rad-NESHAP MEI, the on-site MEI, and the off-site MEI.

i. Rad-NESHAP MEI

The Rad-NESHAP dose calculations are described in detail in the annual Rad-NESHAP report (Fuehne 2014). For 2013, the AIRNET station south of 2101 Trinity Drive (#324) was determined to be the Rad-NESHAP MEI location, with a total dose of 0.21 mrem (Fuehne 2014). 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. This material is resuspended by high winds and can be detected within a few hundred meters of the source. The total emission is much less than 0.1 micro-curies of activity. At the adjacent AIRNET station 600 m downwind, the dose is only 2% of the 0.21 mrem measured at station #324, indicating that the resuspended dust settles within a short distance. Beyond 600 m, the dose is too small to measure.

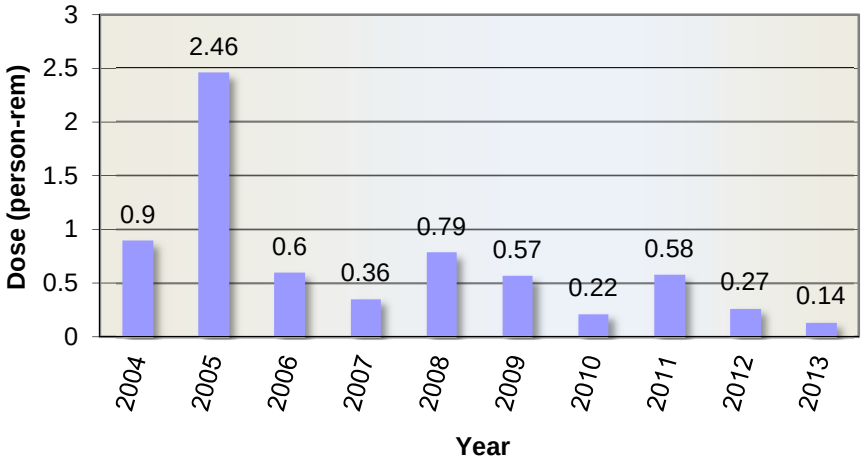

Figure 3-1 Annual collective dose (person-rem) to the population within 80 km of the Laboratory over the past 10 yr.

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

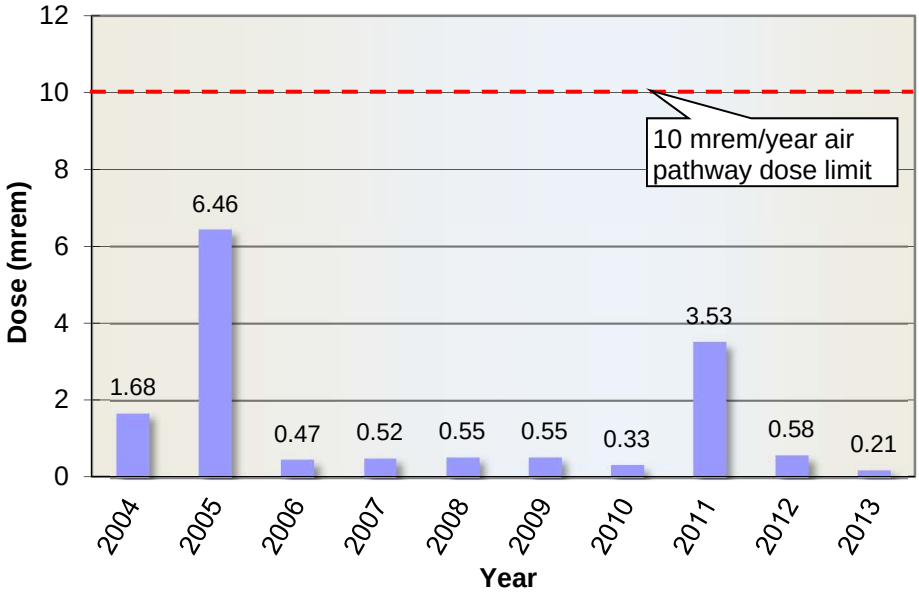

Figure 3-2 Annual Rad-NESHAP MEI dose over the past 10 yr.

ii. On-Site MEI

The on-site locations where a member of the public could receive a measurable dose are on or near the publicly accessible roads and hiking trails, which are described in McNaughton et al. (2013). The only location with a measurable Laboratory-generated dose is at East Jemez Road near TA-53. As reported in Chapter 4, Section C.3.a, at this location in 2013 the neutron dose was 0.2 mrem, and the gamma dose was 0.4 mrem, for a total of 0.6 mrem. The dose from stack emissions was less than 0.1 mrem. These are the doses that would be received by a hypothetical individual at this location 24 h per day and 365 days per year. However, members of the public, such as bus drivers or cyclists, spend less than 1% of their time at this location, so the on-site MEI dose is less than 1% of 0.6 mrem, which is much less than the off-site MEI dose described in the next section.

iii. Off-Site MEI

For the off-site MEI, we begin with the location with the highest direct-radiation dose and compare it with the Rad-NESHAP 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.3.b. After subtracting background, the measured neutron dose at the Laboratory boundary near TA-54 was 2.9 mrem. After applying the standard factor of 1/16 for occasional occupancy (NCRP 1976), the individual neutron dose was 2.9/16 = 0.18 mrem. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the Laboratory stacks as 0.01 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 (0.37 mrem) 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 2013 was measured as 0.20 mrem, which is almost the same as the 0.21-mrem Rad-NESHAP MEI dose.

iv. MEI Summary

The 2013 MEI dose of 0.21 mrem is far below the 10-mrem Rad-NESHAP limit (EPA 1986) and the 100-mrem DOE limit (DOE 1993, DOE 1999, DOE 2011).

4. Dose from Naturally Occurring Radiation

Near Los Alamos, 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 equipment 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.

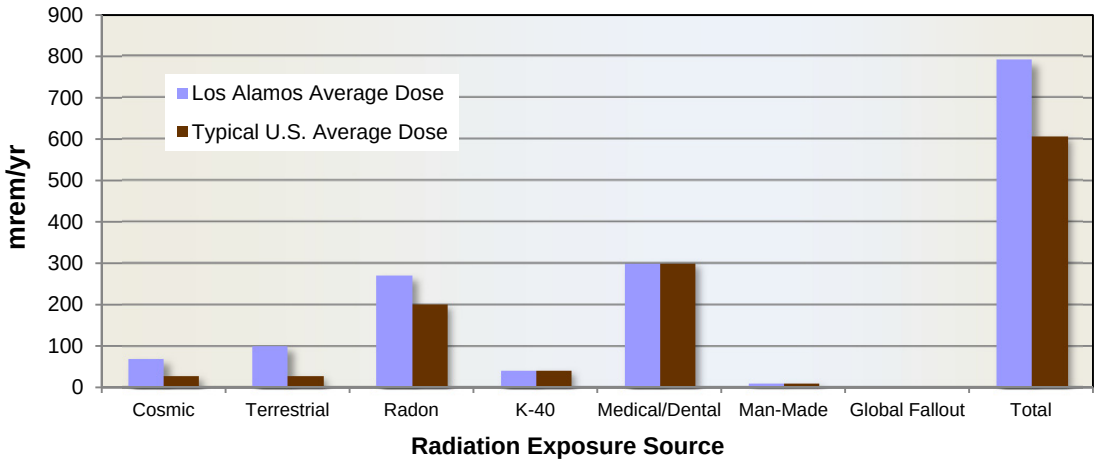

Figure 3-3 Average Los Alamos County radiation background dose compared with average U.S. radiation background dose. Los Alamos County background doses for potassium-40 (K-40), man-made radiation, and global fallout are assumed to be the same as the U.S. average.

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 mrem to 150 mrem (DOE 2012).

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 mrem 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 Laboratory 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 Laboratory-attributable MEI dose is less than 0.1% of the average U.S. background radiation dose from all sources.

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 Laboratory operations are much smaller (Table 3-1) and are far below all regulations and standards. The doses from Laboratory operations described in this chapter do not cause observable human health effects.

Table 3-1
LANL Radiological Doses for Calendar Year 2013

Pathway	Dose to MEI (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	0.21	0.2%	0.14	n/a[a]	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	0.21	0.2%	0.14	~343,000	~268,000[b]

[a] n/a = Not applicable.

[b] 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 the Laboratory are specified in the Quality Assurance Project Plan for the Biota Dose Assessment (listed on the Laboratory's public website at http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php and available at eprr.lanl.gov), and McNaughton (2005) describes in detail the application of these methods to specific locations at the Laboratory.

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 the following:

- 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 1-3 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 guides (BCGs) are the limiting concentrations in soil, sediment, or water that would not cause the dose limits to be exceeded. Exceedance of BCGs leads the user to the more-detailed tiers of analysis using the graded approach of the DOE standard (DOE 2002).

The air, breathed by both humans and biota, meets the EPA standards (Chapter 4) and is not harmful to biota (DOE 2002). Water data (Chapters 5 and 6) are 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 1-3 and described in Chapters 5 through 8, we collected water, soil, and biota samples from many locations. 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 17 picocuries per liter (pCi/L), which is above the EPA drinking water standard for humans, and is approximately 6% 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.

Surface water data are reported in Chapter 6. The highest concentrations of radioactive material were because of natural uranium and thorium, together with their decay products, and were similar to concentrations reported in previous years (McNaughton and Brock 2013). The concentrations during the unusual rainfall of September 2013 were not higher than those during some of the July and August storms and remained below biota-dose screening levels. No data were reported above the biota-dose screening levels, and therefore the surface water data do not require further evaluation.

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).

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 RESRAD-BIOTA. These data confirm the conclusions based on the underlying media (groundwater, 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 8 demonstrate that biota doses at the Laboratory are well below the DOE limits.

D. NONRADIOLOGICAL RISK

1. Overview

This section assesses the potential human health risk from nonradiological materials released from the Laboratory during 2013 and, in some cases, during the previous 70 yr of operations at the Laboratory. The Clean Air Act regulates nonradiological air pollutants, as discussed in Chapter 2, Section B.4. 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, 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 Laboratory monitoring are summarized below.

i. Air

The data reported in Chapter 2, Section B.4, show that the air emissions were well below all applicable standards.

ii. Groundwater

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

Regarding drinking water supplies, the Laboratory 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 Laboratory 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 Laboratory impact was found in this drinking water supply.

In nondrinking groundwater within Laboratory boundaries, we have 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 well 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 Laboratory origin were detected off-site. We conclude there is no current risk to the public from surface water and sediment exposure because of Laboratory operational releases.

iv. Soil

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

v. Foodstuffs (Ingestion)

We report measurements of food and native vegetation in Chapter 8. No contamination from the Laboratory has been detected in food.

vi. Biota Sampling

Metals and polychlorinated biphenyls (PCBs) were measured in indicator species to assess potential impacts of Laboratory operations. Specifically, vegetation, mice, and bees were sampled near the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility (Chapter 8, Section B), and the concentrations were below the screening levels. Also, no significant concentrations of dioxins or furan chemicals were found in field mice near DARHT.

Additionally, overstory vegetation was sampled and analyzed for metals, and concentrations were less than the baseline reference levels. PCBs in mice around the Los Alamos Canyon Weir were at their lowest since surveys began (Figure 8-13) and show that engineering controls are working.

3. Conclusion

The environmental data collected in 2013 show that there is no measurable harm to the public or biota from materials released from Laboratory operations.

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The purpose of Los Alamos National Laboratory's air quality surveillance program is to ensure protection of environmental and public health for the air pathway. Air quality is monitored using four interrelated programs: (1) ambient air monitoring at receptor locations, (2) stack sampling at the sources, (3) gamma and neutron radiation monitoring near the sources and near the receptors, and (4) meteorological monitoring. The specific objectives are to measure airborne radionuclides and chemicals in order to calculate the doses to humans, plants, and animals. Measured and calculated results are compared with U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) standards. In this report, we present the results of the 2013 measurements and conclude that the results were far below the DOE and EPA limits.

A. AMBIENT AIR SAMPLING

1. Introduction

The radiological air-sampling network, AIRNET (LANL 2013a) at Los Alamos National Laboratory (LANL or the Laboratory) measures concentrations of airborne radionuclides, such as plutonium, americium, uranium, and tritium. Regional airborne radioactivity from global fallout and naturally occurring radioactive materials is summarized in Table 4-1. The typical standard deviation of 1 picocurie per cubic meter (pCi/m^3) for tritium and 1 attocurie per cubic meter (aCi/m^3) for particulates results from uncertainties in the analytical processes and variation in local geology and meteorology. Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days increase soil entrainment, and meteorological conditions cause seasonal fluctuations. Generally, these background concentrations are similar year to year, and there is no discernible trend.

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

Analyte	Units	EPA Concentration Limit[b]	Annual Averages				
			2009	2010	2011	2012	2013
Tritium	pCi/m^3	1500	0 ± 1	0 ± 1	1 ± 1	0 ± 1	0 ± 1
Am-241	aCi/m^3	1900	-1[c] ± 1	0 ± 1	1 ± 1	0 ± 1	0 ± 1
Pu-238	aCi/m^3	2100	0 ± 1	1 ± 1	2 ± 1	2 ± 1	0 ± 1
Pu-239	aCi/m^3	2000	1 ± 1	0 ± 1	0 ± 1	1 ± 1	1 ± 1
U-234	aCi/m^3	7700	17 ± 1	16 ± 1	16 ± 1	18 ± 1	20 ± 1
U-235	aCi/m^3	7100	1 ± 1	1 ± 1	1 ± 1	1 ± 1	1 ± 1
U-238	aCi/m^3	8300	16 ± 1	15 ± 1	16 ± 1	17 ± 1	20 ± 1

[a] Regional air-sampling stations operated by the Laboratory.

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

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

Ambient air concentrations greater than background are compared with the EPA 10-mrem limit (EPA 1989) and the U.S. Department of Energy (DOE) 100-mrem limit (DOE 2011).

2. Air-Monitoring Network

During 2013, the Laboratory operated 41 environmental air stations to sample radionuclides by collecting particulate matter. Thirty-five of these stations also collected water vapor for tritium analysis, and one solar-powered station monitors tritium only. AIRNET sampling locations (Figures 4-1 through 4-3) 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 (LANL 2013a) 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; filters are changed out every 2 wk. Field sampling completeness is assessed for each 2-wk collection period. The run time for AIRNET stations averaged 98.4% for the year.

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 98.9% for filters and 99.6% for silica gel.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-5 summarize measured 2013 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.

b. Investigation of Elevated Air Concentration Measurements

Two air concentration thresholds have been established to determine when further action is warranted (LANL 2013a). 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 Laboratory operations personnel to assess potential sources and possibly implement mitigation plans.

During the year, investigation levels for plutonium-239 were exceeded three times. In all of these cases, the concentrations were well below the EPA standards. It was concluded that these were statistical outliers and no further action was needed.

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

During 2013, all annual mean concentrations were similar to recent years and well below EPA and DOE guidelines (Table 4-2). The highest off-site annual tritium concentration at any station was 0.1% of the EPA public dose limit.

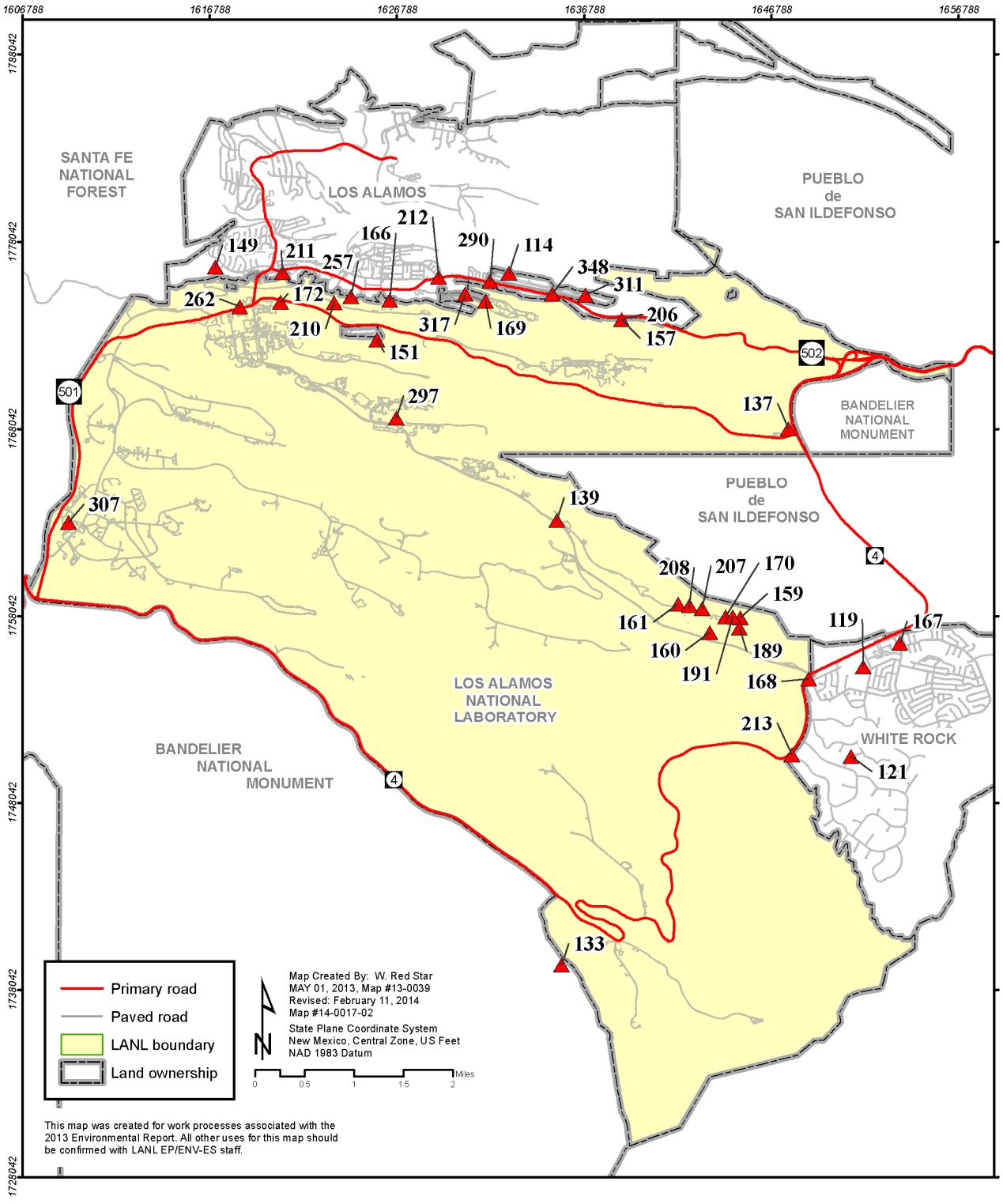

Figure 4-1 AIRNET station locations at and near the Laboratory.

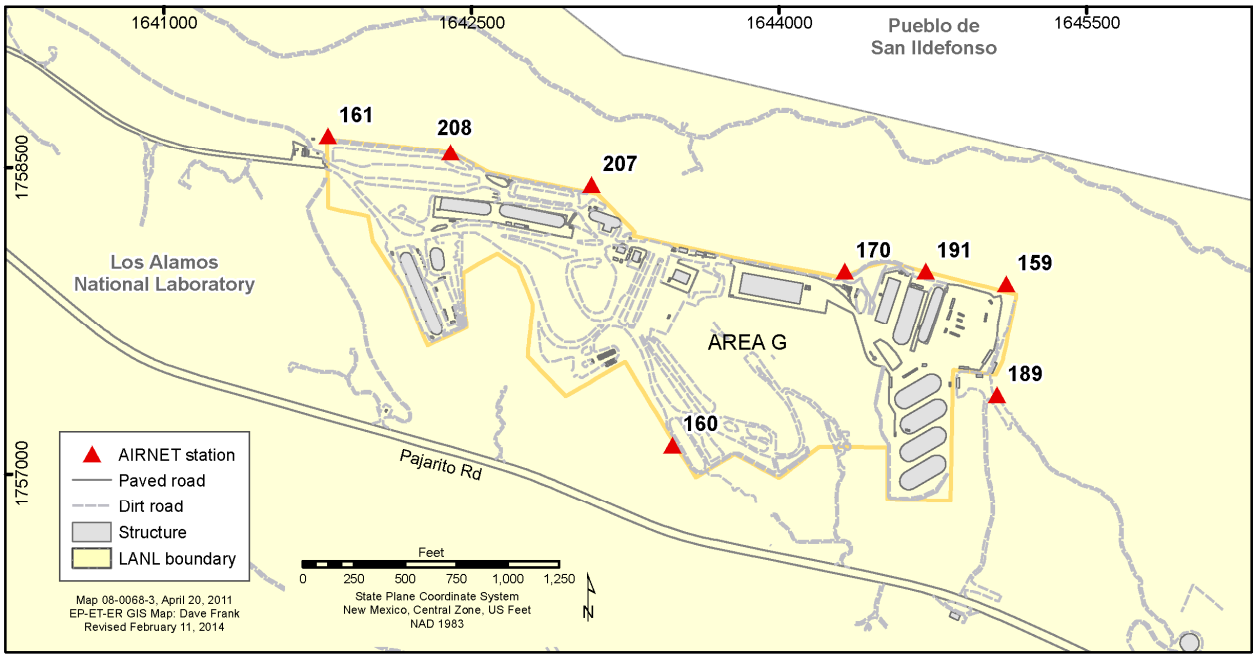

Figure 4-2 AIRNET station locations at the Laboratory's TA-54, Area G

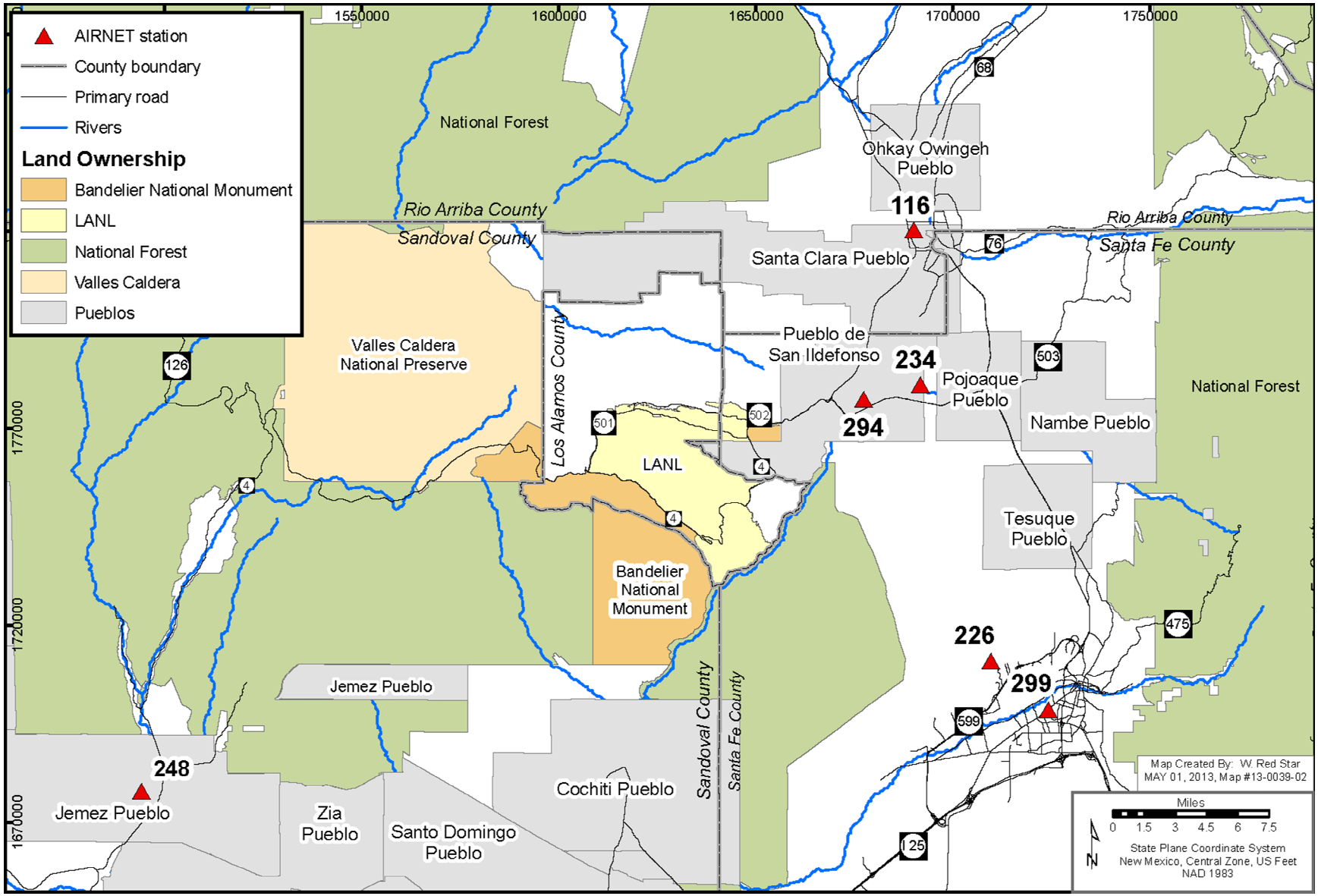

Figure 4-3 Regional and pueblo AIRNET station locations

Table 4-2
Airborne Tritium as Tritiated Water Concentrations for 2013—Group Summaries

Station Grouping[a]	Number of Biweekly Samples	Mean ± 3s[b] Uncertainty (pCi/m^3)	Maximum Annual Station Concentration (pCi/m^3)
Regional	99	1 ±1	1
Pueblo	48	1 ±1	1
Perimeter	522	1 ±2	2

[a] EPA 40 CFR 61, Appendix E, public concentration limit is 1500 pCi/m^3.

[b] 3s = Three standard deviations.

Table 4-3
Airborne Americium-241 Concentrations for 2013—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	1
Pueblo[a]	8	0 ±2	1
Perimeter[a]	92	0 ±2	1
Waste site[b]	32	0 ±3	1
On-site[b]	8	0 ±2	0
D&D[a]	8	1 ±2	1

[a] EPA 40 CFR 61, Appendix E, public concentration limit is 1900 aCi/m^3.

[b] Worker concentration limit is 19,000 aCi/m^3.

Table 4-4
Airborne Plutonium-238 and Plutonium-239/240 Concentrations for 2013—Group Summaries

		Group Mean ± 3s (aCi/m^3)		Maximum Annual Station Concentration (aCi/m^3)	
Station Grouping	Number of Samples	Pu-238	Pu-239/240	Pu-238	Pu-239/240
Regional[a]	16	0 ±2	1 ±2	1	2
Pueblo[a]	8	0 ±2	1 ±2	1	1
Perimeter[a]	92	0 ±2	1 ±2	4	14
Waste site[b]	32	1 ±2	12 ±3	2	72
On-site[b]	8	0 ±2	2 ±2	1	3
D&D[a]	8	1 ±2	6 ±3	1	9

[a] EPA 40 CFR 61, Appendix E, public concentration limit is 2100 aCi/m^3 for Pu-238 and 2000 aCi/m^3 for Pu-239/240.

[b] Worker concentration limit is 21,000 aCi/m^3 for Pu-238 and 20,000 aCi/m^3 for Pu-239/240.

Table 4-5
Airborne Uranium-234, -235, and -238 Concentrations for 2013—Group Summaries

Station Grouping	Number of Samples	Group Mean ± 3s (aCi/m^3)		
		U-234	U-235	U-238
Regional[a]	16	20 ±3	1 ±1	20 ±3
Pueblo[a]	8	22 ±6	1 ±1	20 ±5
Perimeter[a]	92	9 ±1	1 ±1	9 ±1
Waste site[b]	32	16 ±3	1 ±1	17 ±2
On-site[b]	8	9 ±2	0 ±1	8 ±2
D&D[a]	8	8 ±2	1 ±1	9 ±2

[a] EPA 40 CFR 61, Appendix E, public concentration limit is 7700 aCi/m^3 for U-234, 7100 aCi/m^3 for U-235, and 8300 aCi/m^3 for U-238.

[b] Worker concentration limit is 77,000 aCi/m^3 for U-234; 71,000 aCi/m^3 for U-235; and 83,000 aCi/m^3 for U-238.

d. Americium-241

Americium from global fallout occurs worldwide, in low concentrations. Table 4-3 summarizes 2013 sampling data, which were similar to recent years. The highest annual off-site and on-site averages for any station were 0.1% of the public limits. Concentrations show no distinctive trends.

e. Plutonium

Plutonium from global fallout occurs worldwide, in low concentrations. Table 4-4 summarizes the plutonium-238 and plutonium-239/240 data for 2013, which were similar to recent years. Outside of controlled areas, the highest averages were 0.2% of the limits for plutonium-238 and 0.7% of the limits for plutonium-239. Concentrations show no distinctive trends.

f. Uranium

Uranium-234, -235, and -238 are found in nature, and the highest airborne concentrations are typically at dusty locations. Natural uranium has constant and known relative isotopic abundances: uranium-238 activity is generally equal to uranium-234 (Walker et al. 1989). Only natural uranium was detected in 2013. Outside of controlled areas, the uranium concentrations (Table 4-5) were similar to previous years and below 0.5% of the EPA guidelines.

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 the minimum detectable activity. None was detected during 2013.

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 2013.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Operational facilities using radioactive materials may be vented to the environment through a stack or other release point. The Laboratory's stack monitoring team evaluates the operations to determine potential impacts to the public and the environment. Emissions are estimated using engineering calculations and radionuclide materials usage information, and every stack that may potentially result in a public dose as much as 0.1 mrem in a year is sampled 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, LANL 2013b). During 2013, we identified 28 stacks meeting this criterion.

2. Sampling Methodology

In 2013, we continuously sampled 28 stacks for the emission of radioactive material to the ambient air. The Laboratory 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, the Laboratory 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 and volatile compounds 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 the Laboratory'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 amounts of HTO and HT.

We measure GMAP emissions from LANSCE activities using real-time monitoring data (LANL 2013c). 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 the Laboratory'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 ship them to an off-site analytical laboratory. Before shipping, we screen each sample filter to determine if there are any unusually high levels of gross-alpha or

-beta radioactivity. The laboratory analyzes for alpha and beta radioactivity. 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 to 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.

c. Vaporous Activation Product Emissions

We remove and replace the charcoal canisters weekly 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 and transport them to the Laboratory's Health Physics Analysis Laboratory. The Health Physics Analysis Laboratory 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.

4. Analytical Results

Measurements of Laboratory stack emissions during 2013 totaled approximately 220 curies (Ci) (compared with 217 Ci in 2012). Of this total, tritium emissions contributed approximately 73 Ci (compared with 98 Ci in 2012), and air activation products from LANSCE stacks contributed nearly 148 Ci (compared with nearly 119 Ci in 2012). LANSCE diffuse emissions of air activation products contributed another 12 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 0.01 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 Laboratory 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 the Laboratory. During 2013, the LANSCE facility nonpoint source emissions of activated air comprised approximately 12 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 2013

Building No.	H-3[a]	Am-241	Pu[b]	U[c]	Th[d]	P/VAP[e]	GMAP	Sr-90[f]
TA-03-029		9.5E-07	3.7E-06	4.2E-06	2.7E-07	1.1E-04		4.0E-08
TA-03-102								
TA-16-205/450	5.2E+01							
TA-48-001				6.3E-09		8.0E-03		1.7E-08
TA-50-001			2.6E-08	4.9E-08				2.2E-07
TA-50-037					2.0E-09			9.7E-09
TA-50-069			3.8E-10	1.9E-09				9.9E-10
TA-53-003	1.3E+01					7.3E-05	3.8E+01	
TA-53-007	4.0E+00					1.5E-03	1.1E+02	
TA-54-231				9.7E-09				2.2E-09
TA-54-375			1.7E-09	1.3E-08				
TA-54-412				2.1E-09				4.3E-09
TA-55-004	2.0E+00		2.8E-10	9.7E-08	5.3E-09			
TA-55-400								
Total[g]	7.1E+01	9.5E-07	3.7E-06	4.4E-06	2.7E-07	1.1E-02	1.6E+02[h]	3.0E-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 2013

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	2.0E-05
TA-48-0001	Br-77	2.9E-03
TA-48-0001	Br-82	6.6E-05
TA-48-0001	Ge-68	4.9E-03
TA-48-0001	Ga-68	4.9E-03
TA-48-0001	Hg-197	0
TA-48-0001	Hg-197m	0
TA-48-0001	Mn-54	0
TA-48-0001	Se-75	1.4E-04
TA-53-0003	Ar-41	1.5E+00
TA-53-0003	As-73	0
TA-53-0003	Be-7	2.2E-05
TA-53-0003	Br-76	0
TA-53-0003	Br-77	0
TA-53-0003	Br-82	5.0E-05
TA-53-0003	C-11	3.6E+01
TA-53-0003	Na-24	0
TA-53-0003	Os-191	0
TA-53-0007	Ar-41	1.0E+01
TA-53-0007	As-73	0
TA-53-0007	Be-7	6.7E-07
TA-53-0007	Br-76	2.4E-04
TA-53-0007	Br-77	7.0E-06
TA-53-0007	Br-82	1.8E-03
TA-53-0007	C-10	1.5E-01
TA-53-0007	C-11	5.4E+01
TA-53-0007	Hg-197m	4.6E-04
TA-53-0007	Hg-197	1.7E-04
TA-53-0007	N-13	1.9E+01
TA-53-0007	N-16	4.1E-01
TA-53-0007	Na-24	0
TA-53-0007	O-14	1.5E-01
TA-53-0007	O-15	2.6E+01
TA-53-0007	Os-191	1.0E-06
TA-53-0007	Se-75	8.7E-07

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
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.

5. Long-Term Trends

Emissions of plutonium and uranium isotopes stayed relatively steady over recent years, in the microcurie range. Tritium emissions remained low as in recent years, reflecting minimal operations taking place at the main tritium facility during the year. In 2013, emissions of GMAP were similar to those measured in 2012. 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 beam operations to the 1L Target and the Lujan Neutron Scattering Center.

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

1. Introduction

The objective of the Direct Penetrating Radiation Monitoring Network (DPRNET, LANL 2013c) and the Neighborhood Environmental Watch Network (NEWNET, LANL 2013d) 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 2013 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 Laboratory operations was less than 1 mrem/yr.

In northern New Mexico, naturally occurring radiation varies from approximately 100 mrem/yr to 200 mrem/yr, so it is difficult to measure the much smaller radiation dose from the Laboratory. 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 the Laboratory 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 2013, DPRNET showed that dose rates near Area G decreased significantly (see Figures 4-4 and 4-5). These decreases are a result of waste being shipped off-site to WIPP.

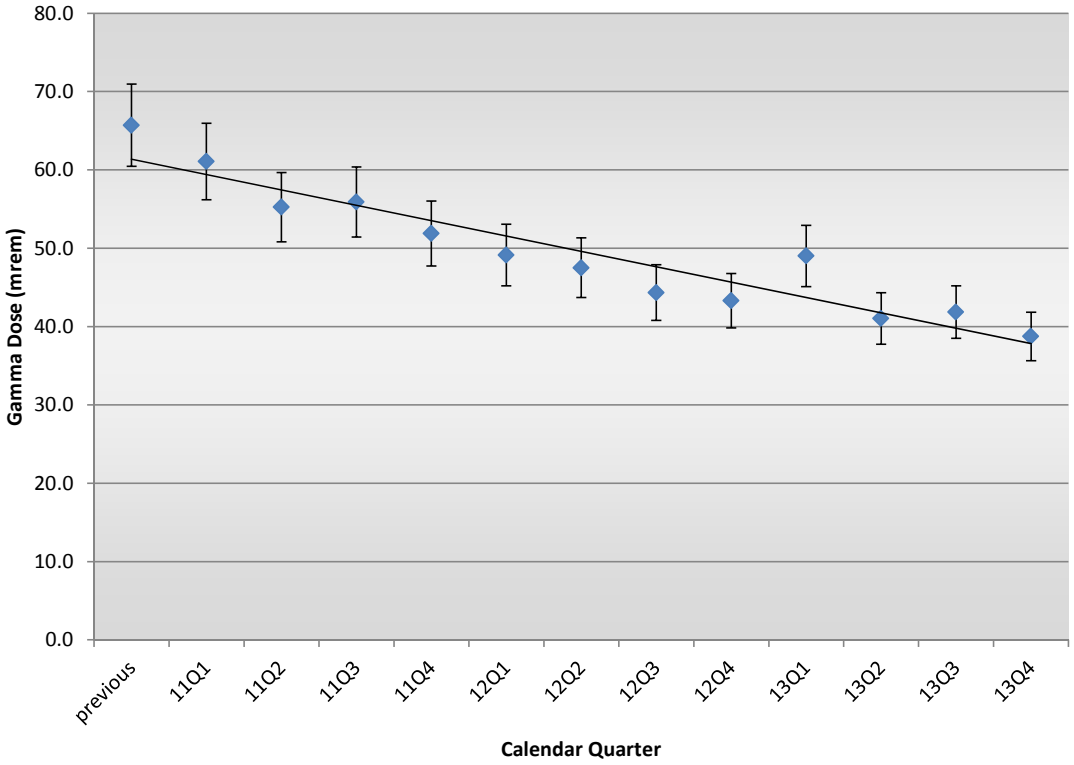

Figure 4-4 **Average quarterly gamma doses around the perimeter of Area G for the past 12 calendar quarters. The first point, at 66 ± 4 mrem, is the average of the previous 36 calendar quarters, during which the quarterly doses were approximately constant. Natural background at Area G is about 30 mrem to 35 mrem per quarter.**

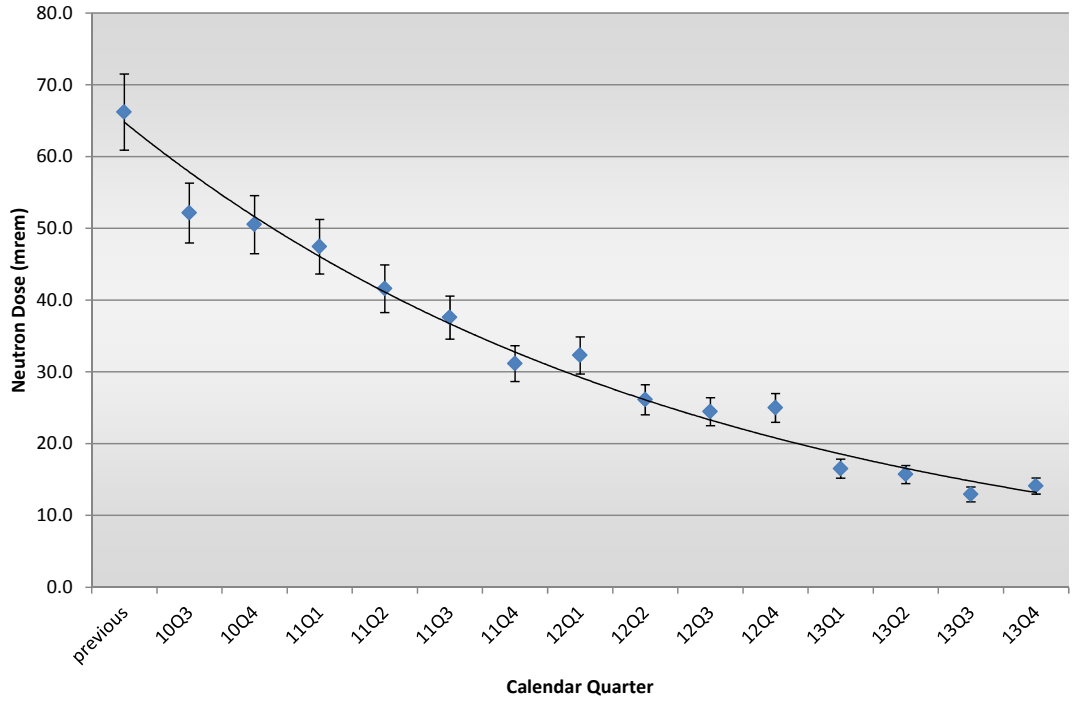

Figure 4-5 **Average quarterly neutron doses (mrem) around the perimeter of Area G for the past 14 calendar quarters. The first point, at 63 mrem, is the average of the preceding 14 calendar quarters. Natural background contributes less than 1 mrem to each point.**

a. Dosimeter Locations

We placed 96 TLD stations around the Laboratory 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 4-6); at TA-53, LANSCE (8 stations); at Santa Clara Pueblo (5 stations); and inside the Pueblo de San Ildefonso sacred area (2 stations).

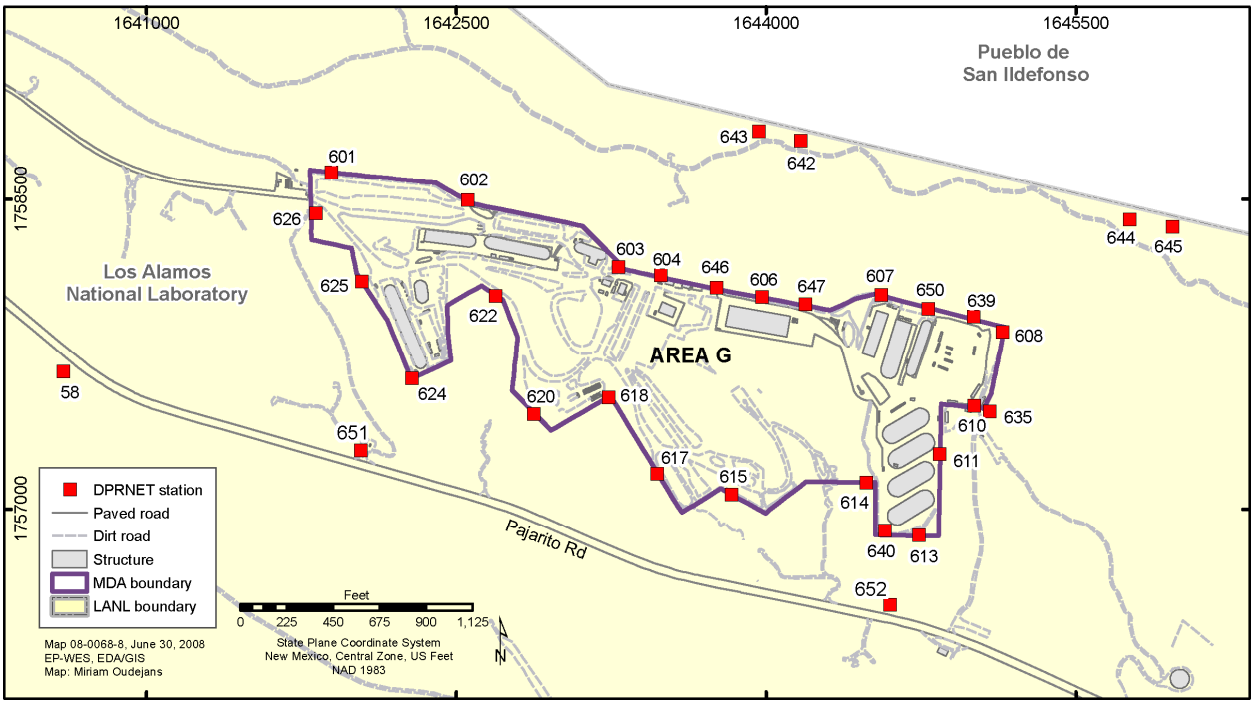

Figure 4-6 TLD locations at TA-54, Area G, as part of DPRNET

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 101 in Santa Fe and at station 57 near the offices of the AIRNET team. The average neutron background at these 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 Laboratory 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 320 mrem/yr, 190 mrem/yr above the background of 130 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 2013, the gamma dose at Jemez Road from the tanks was 0.2% of 190 mrem/yr, which is 0.4 mrem/yr. This is the dose that would be received by a person who is at this location 24 h/day, 365 days/yr. There are no public facilities near this location, so the occupancy factor is likely to be less than 1%, and the dose to a member of the public is likely to be less than 0.01 mrem/yr.

Four of the TLDs at TA-53 measured neutron doses of 4 ± 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 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 TA-53 (McNaughton 2013). During 2013, the neutron dose at TA-53 was 2 mrem/yr above the background of 2 mrem/yr, so the neutron dose at Jemez Road was 10% of 2 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. As stated previously, the occupancy factor is likely to be less than 1%, and the dose to a member of the public is likely to be less than 0.01 mrem.

b. TA-54

Figure 4-6 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. TLD 645 is in Cañada del Buey.

After subtracting background, the annual neutron dose measured by TLD 645 was 2.9 mrem. This is the dose that would be received by a person who is at the location of the TLD 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 645 is calculated to be 2.9/16 = 0.2 mrem/yr, which is less than previous years.

4. NEWNET

During 2013, 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 4-4 and 4-5. 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, and no further action is required to address radiological exposure to the public from Laboratory operations.

D. NONRADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

The nonradioactive ambient air-monitoring network monitors particulate matter smaller than 10 micrometers (μm) in diameter (PM-10) and particulate matter smaller than 2.5 μm (PM-2.5).

2. Air-Monitoring Network and Equipment

Ambient particulate matter monitoring continued at the old White Rock Fire Station on Rover Boulevard and at the Los Alamos Medical Center. At each location there are two monitors, one for PM-10 and one for PM-2.5 particles. These data measure the dust loading in the atmosphere.

3. Ambient Air Concentrations

During 2013, the particulate matter concentrations remained well below the EPA standards: 150 micrograms per cubic meter (μg/m^3) for PM-10 and 35 μg/m^3 for PM-2.5. In Los Alamos County, typical concentrations (95% of the time) were less than 40 μg/m^3 for PM-10 and less than 10 μg/m^3 for PM-2.5. The highest concentrations occurred during the spring from windblown dust and during the summer from wildfires in Arizona or New Mexico. During 2013, the maximum 24-h concentrations were 104 μg/m^3 for PM-10 and 26 μg/m^3 for PM-2.5.

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 (Dewart and Boggs 2014) 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 4-7). Four of the stations are located on mesa tops (TA-06, TA-49, TA-53, and TA-54), and two are in canyons (TA-41 in Los Alamos Canyon and TA-5 MDCN in Mortandad Canyon). 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.

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 TA-5 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 hertz (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.

Calibration frequency varies by instrument, following manufacturer's recommendations and operational considerations. We calibrate all wind instruments every 6 mo. All other sensors are calibrated annually, with the exception of solar radiation sensors, which are calibrated every5 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. The Technical Project Plan for Meteorological Monitoring provides details of the quality assurance program (LANL 2013e). An electronic copy of the plan is available online at eprr.lanl.gov.

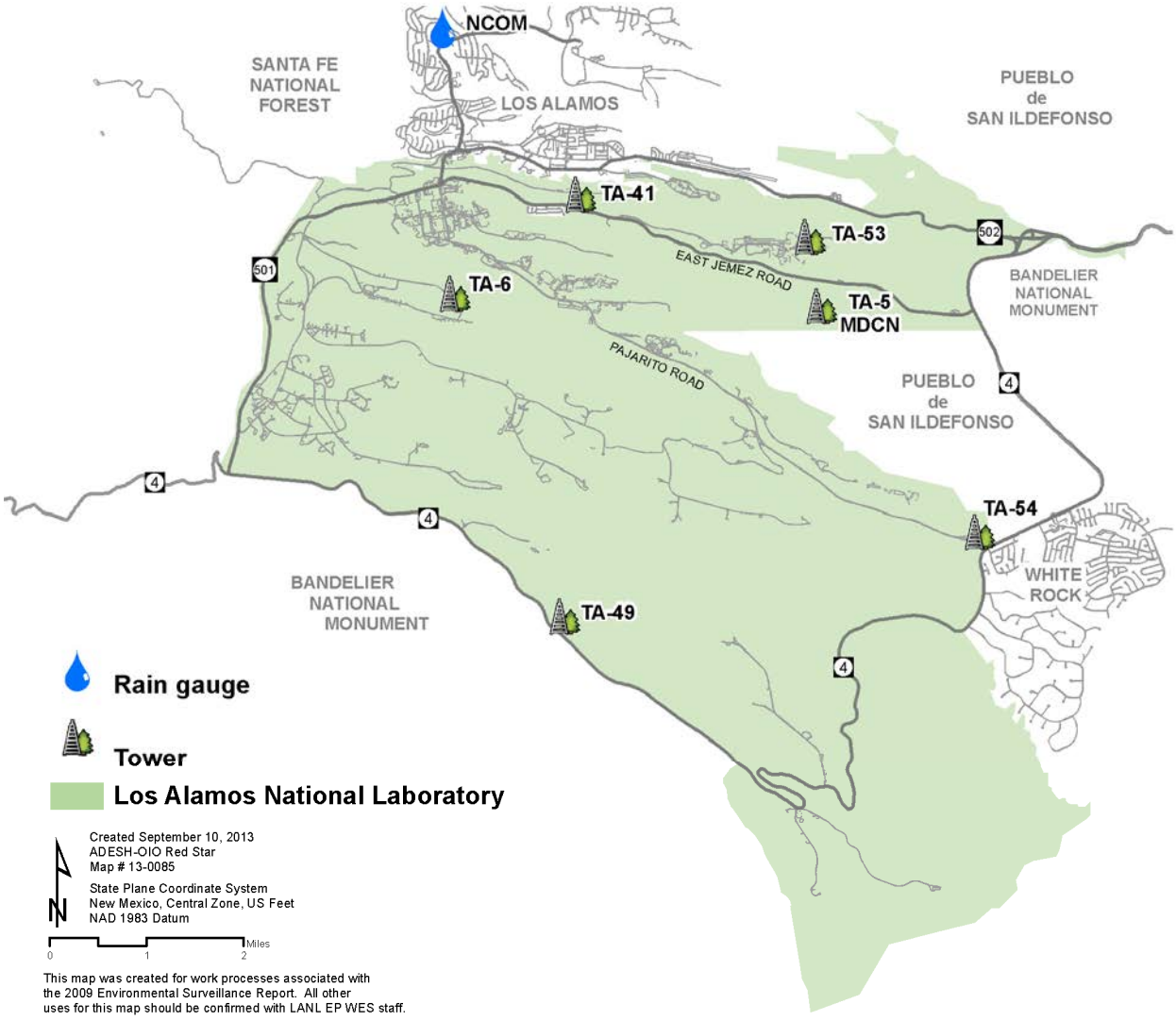

Figure 4-7 Locations of meteorological monitoring towers and rain gages

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; in 2021, 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 most recently on June 27, 2013. During the summer 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 57.5 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 34% 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. 2013 in Perspective

Table 4-9 presents a tabular perspective of Los Alamos weather during 2013, including snowfall and wind data. Figures 4-8 and 4-9 present graphical summaries of Los Alamos temperature and precipitation for 2013. Figure 4-8 presents the daily high and low temperature at TA-06 in comparison with the 1981–2010 normal values and the extreme recorded values from 1924 to the present. Temperatures during 2013 were about average with a cold winter followed by a warm spring and summer, and ending with a cool autumn. Figure 4-9 presents the cumulative daily rainfall for 2013, in comparison with the 1981–2010 average. Precipitation for the year was 8% above normal; but month to month averages were far from normal.

Table 4-9
Monthly and Annual Climatological Data for 2013 at Los Alamos

Month	Temperatures (°F)[a]								Precipitation (in.)[a]				12-m wind (miles per hour)[a]				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure[b]	Highest	Date	Lowest	Date	Total	Departure[b]	Total	Departure[b]	Average Speed	Departure[c]	Speed	From	Date
January	35.5	15.4	25.5	-3.9	53	24	-4	15	0.52	-0.43	1.0	-11.4	5.1	0.1	46	W	30
February	41.3	20.2	30.7	-2.2	52	17	-10	23	0.45	-0.41	5.0	-5.9	6.2	0.4	42	W	9
March	55.5	29.7	42.6	3.2	71	15	12	24	0.15	-1.05	0.5	-9.9	7.5	1.0	46	W	18
April	61.7	34.9	48.3	1.5	78	29	17	19	0.60	-0.46	3.0	-0.3	8.6	1.0	55	SW	16
May	70.4	43.1	56.8	0.8	83	23	22	3	0.11	-1.28	0.0	-0.3	8.3	0.9	45	WNW	1
June	84.9	55.8	70.4	5.4	95	27	45	1	0.76	-0.75	0	0	8.2	1.1	44	NE	7
July	80.4	56.2	68.3	0.1	89	9	49	18	3.71	0.89	0	0	6.2	0.6	46	NNE	5
August	79.8	55.6	67.7	1.9	87	31	49	9	1.80	-1.81	0	0	5.9	0.2	35	WSW	1
September	71.4	49.7	60.5	0.7	86	1	31	28	8.72	6.71	0	0	6.3	0.5	53	W	22
October	58.6	36.0	47.3	-1.9	73	1	27	19	1.44	-0.10	2.0	-0.2	6.6	0.6	47	WSW	10
November	46.3	27.7	37.0	-0.9	59	10	14	25	2.03	1.05	8.5	3.6	5.2	-0.1	45	WSW	16
December	38.5	20.1	29.3	-0.1	51	3	3	10	0.15	-0.76	4.2	-8.0	5.1	0.2	49	SW	8
Year	60.5	37.1	48.8	0.4	95	Jun 27	-10	Feb 23	20.44	1.47	25.1	-32.4	6.6	0.6	55	SW	Apr 16

[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.

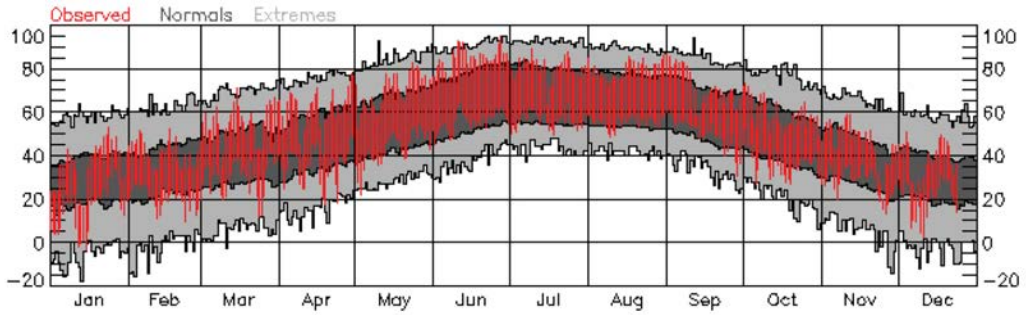

Figure 4-8 Los Alamos 2013 temperatures in degrees Fahrenheit

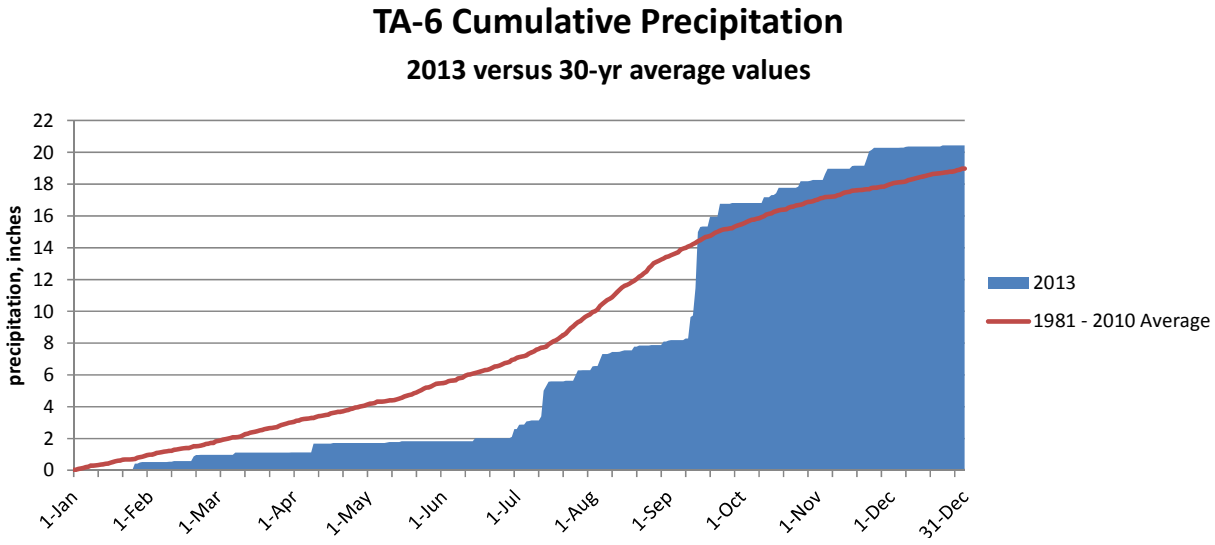

Figure 4-9 Weather summary for Los Alamos for 2013 at the TA-06 meteorology station

The year 2013 started out with a very dry winter and spring. Total rainfall through the end of June was 2.59 in. (37% of normal), making 2013 the second driest first half of the year on record. The driest first half of the year occurred in 2011, when Los Alamos only received 0.86 in. of precipitation from January through June. The summer monsoon arrived in July; however, the total July and August precipitation of 5.51 in. was only 86% of normal. Then, the wettest September on record arrived on the 10th in Los Alamos, with a total of 8.72 in. of precipitation. This was the third wettest month on record for Los Alamos, trailing only August 1952 at 11.18 in. and August 1923 with 9.08 in. September 2013 was also the wettest September in White Rock, with a total of 7.68 in. of precipitation. Los Alamos precipitation measured 2.03 in. in November, which was twice the normal value of 0.98 in. Above-average snowfall during November contributed to the total precipitation; snowfall totaled 8.5 in. in comparison with the 30-yr average of 4.9 in. December snowfall was well below 50% of normal. Overall for 2013, 25 in. of snowfall was measured, in comparison with the 30-yr average value of 57.5 in.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-10 shows the historical record of temperatures in Los Alamos from 1925 through 2013. The annual average temperature is not the average temperature per se, but the midpoint between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-10. 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 15 yr 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 2013 was the seventh highest on record, at 68.8°F. Five of the hottest summers on record have occurred since 2002. The highest summertime average temperature on record was 71.1°F, recorded during 2011.

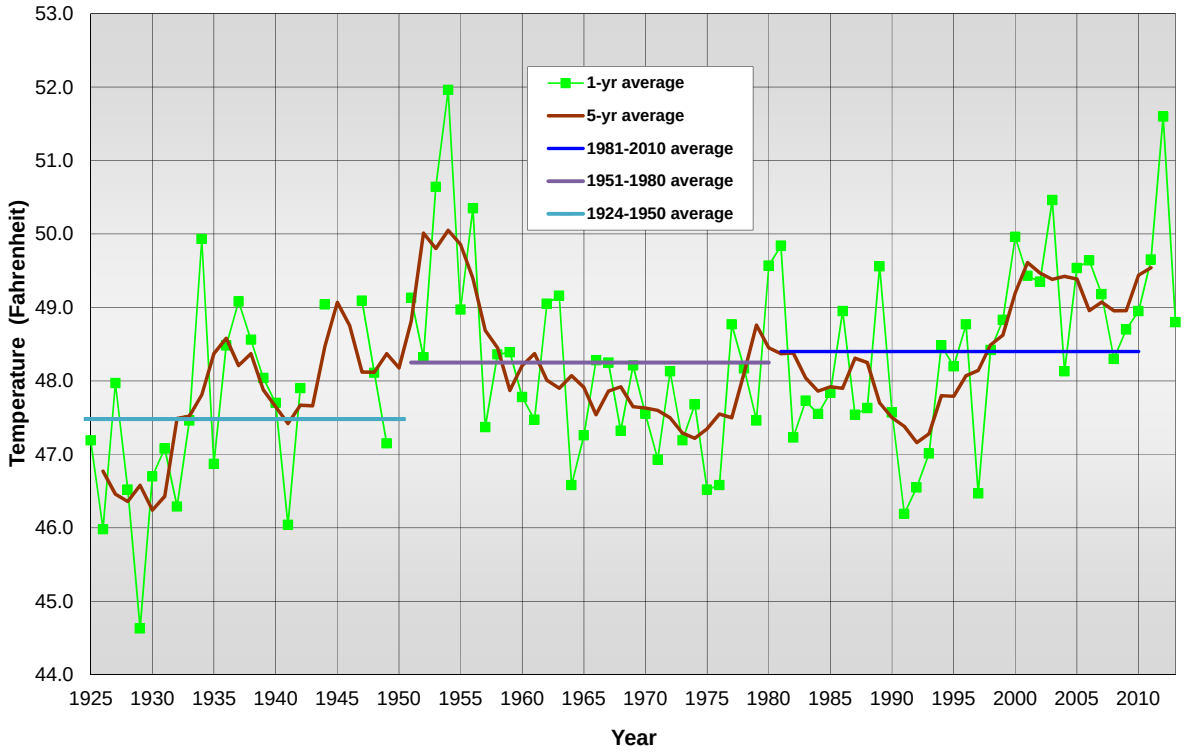

Figure 4-10 Temperature history for Los Alamos

Figure 4-11 shows the historical record of the annually summed total precipitation. The most recent drought has essentially spanned the years 1998 through 2013, with near-average precipitation years occurring from 2004 to 2010 and again in 2013. As with the historical temperature profile, the 5-yr running mean and the 30-yr normal values are also shown.

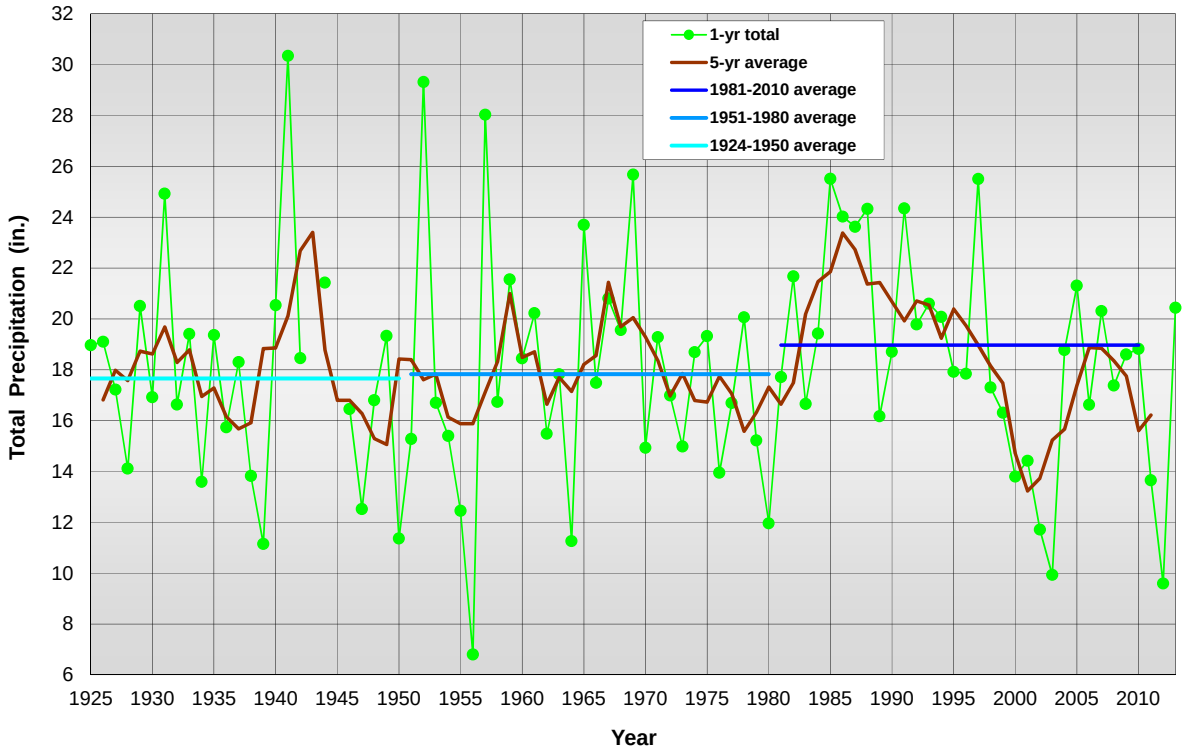

Figure 4-11 Total precipitation history for Los Alamos

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-12. The graphic has not been updated for 2013 because of the lack of a full year of TA-54 and TA-53 level 1 wind data (Dewart et. al. 2014). 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. 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 and 2012, higher-than-average wind speeds were recorded in 2013 (Table 4-9). Winds during April, May, and June were the highest, with average wind speeds in June being 15% above normal.

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

6. September 2013 Rainfall Event

An upper-level low-pressure system "parked" over the Great Basin from September 10 through the 15, with a high-pressure system centered to the east of New Mexico and Colorado. This combination of a stationary low pressure to our west and high pressure to our east produced a deep layer of southerly winds, bringing subtropical moisture from Mexico into New Mexico. A total of 7 in. of rain fell at the TA-06 station during these 5 days; this is considered to be a once-in-1000-yr storm (NOAA 2011) for Los Alamos. Rainfall totals for each Laboratory rain gage are presented in Table 4-10.

Table 4-10
Rainfall at LANL Stations during September 2013 Rainfall Event

Station	10-Sep (in.)	11-Sep (in.)	12-Sep (in.)	13-Sep (in.)	14-Sep (in.)	15-Sep (in.)	Total (in.)
TA-06	1.35	0.1	1.72	3.52	0.33	0.03	7.05
TA-49	1.4	0.08	1.18	2.9	1.77	0.08	7.41
TA-53	1.21	0.05	1.14	2.58	0.45	0.04	5.47
TA-54	1.37	0.02	1.79	2.49	0.9	0.13	6.7

September 13 was the wettest calendar day in Los Alamos records; the TA-06 station recorded 3.52 in. of rain. The previous record was 3.48 in., measured on October 5, 1911. For the 24-h period from noon on September 12 through noon on September 13, Los Alamos received 5.08 in.

The Laboratory operates two sets of rain gages, in addition to the LANL network. One set of rain gauges is located within and adjacent to the Laboratory boundary, to assist in determining when stormwater is flowing in LANL canyons. The second set of rain gauges, known as the Precipitation Emergency Notification System (PENS) is located in the mountains west of the Laboratory boundary, between 8200 ft and 9800 ft. The PENS was installed following the 2011 Las Conchas fire and provides automated notifications when heavy precipitation in the mountains could produce localized flooding in Laboratory canyons. Data from all three rain gauge networks for September 10 through 15 are presented in Figure 4-13. Rainfall totals in the mountains were over two times higher than at the Laboratory, reaching 18 in. at one station.

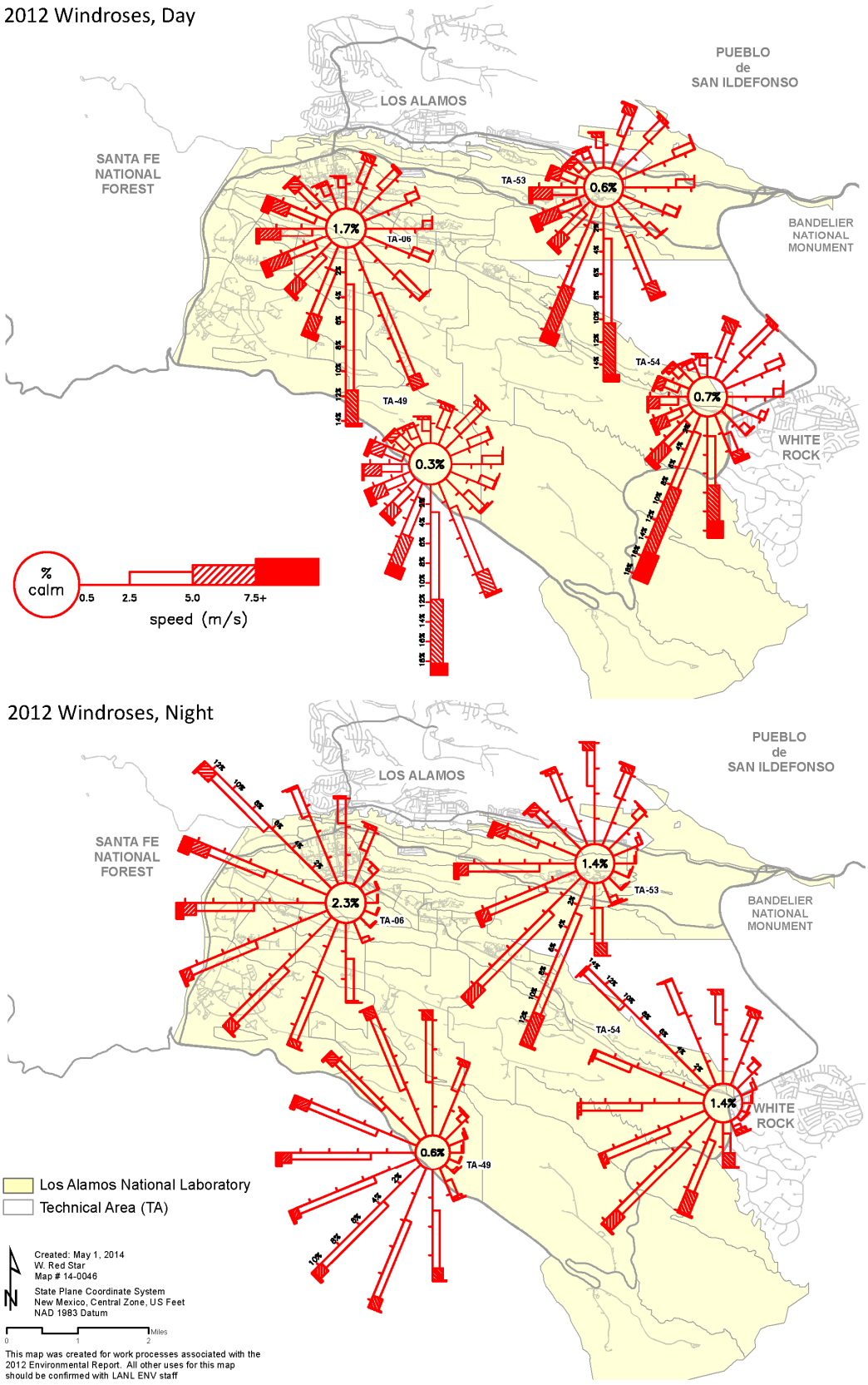

Figure 4-12 Daytime and nighttime wind roses for 2012 (complete data for 2013 not available).

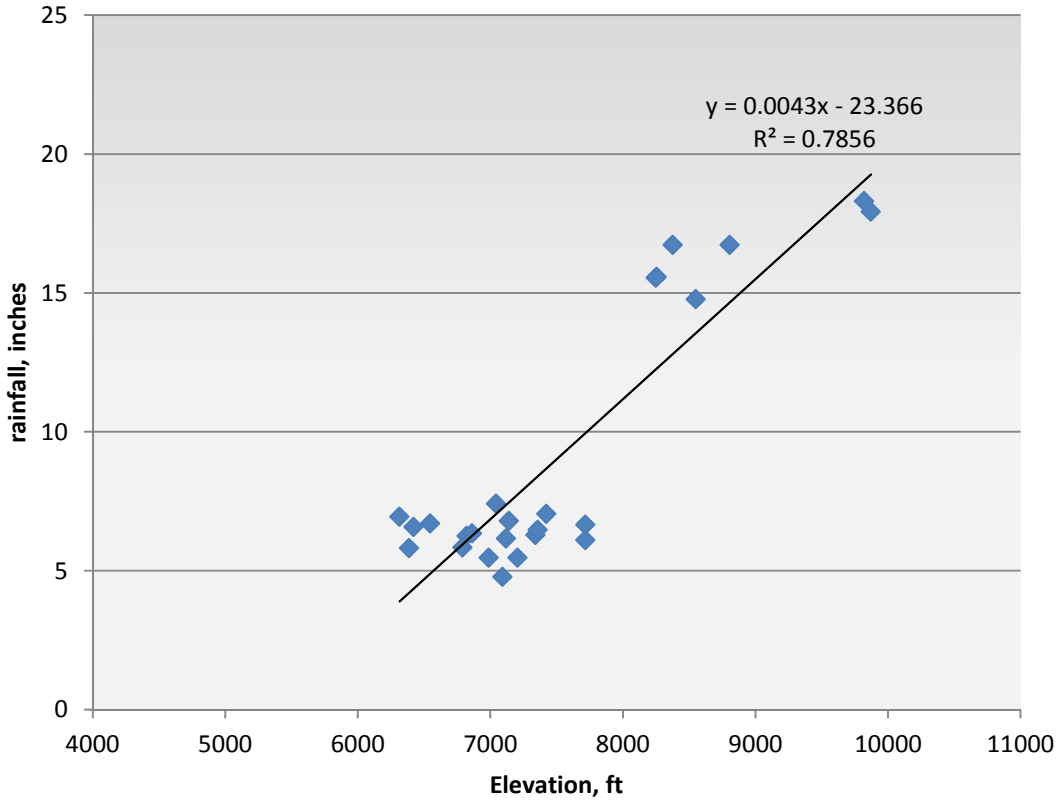

Figure 4-13 September 10 through 15 precipitation levels by elevation

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Los Alamos National Laboratory (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 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.

Laboratory operations have affected the quality of deep groundwater in the intermediate-perched zones and the regional aquifer primarily through past liquid effluent discharge. During the 1990s, the Laboratory significantly reduced both the number of industrial outfalls and their discharge volume and improved effluent quality through treatment process improvements, leading to an improvement in the shallow perched alluvial groundwater quality.

The regional aquifer is the source of drinking water for Los Alamos County and the Laboratory. Los Alamos County owns and operates the water-supply system. All drinking water meets federal and state drinking water standards.

Hexavalent chromium from discharges that ended in 1972 is found in Sandia Canyon and Mortandad Canyon regional aquifer monitoring wells at concentrations above the 50-micrograms per liter (µg/L) NM groundwater standard. Perchlorate at concentrations above the 4-µg/L NM Consent Order screening level is found in regional aquifer monitoring wells in Mortandad Canyon and Pueblo Canyon.

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and the surrounding area. Because of the Laboratory's semiarid, mountainside setting, significant groundwater is found only at depths greater than several hundred feet in the regional aquifer. The Los Alamos County public water supply comes from wells that draw water from the regional aquifer, found beneath the Laboratory, with the water table at depths ranging from 600 to 1200 ft. Groundwater protection efforts at the Laboratory focus on the regional aquifer and also include small bodies of shallow perched groundwater found within canyon alluvium and at intermediate depths above the regional aquifer.

U.S. Department of Energy (DOE) Order 458.1, Radiation Protection of the Public and the Environment, requires that operators of DOE facilities discharging or releasing liquids containing radionuclides from DOE activities must conduct radiological activities to ensure that radionuclides from DOE activities contained in liquid effluents do not cause private or public drinking water systems to exceed the drinking water maximum contamination limits in 40 Code of Federal Regulations (CFR) Part 141, National Primary Drinking Water Regulations. Operators must also ensure that baseline conditions of the ground water quantity and quality are documented.

Most of the groundwater monitoring conducted during 2013 was carried out according to the Interim Facility-Wide Groundwater Monitoring Plans (IFGMPs) (LANL 2012a, 2013a) approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (the Consent Order). The Laboratory's 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.

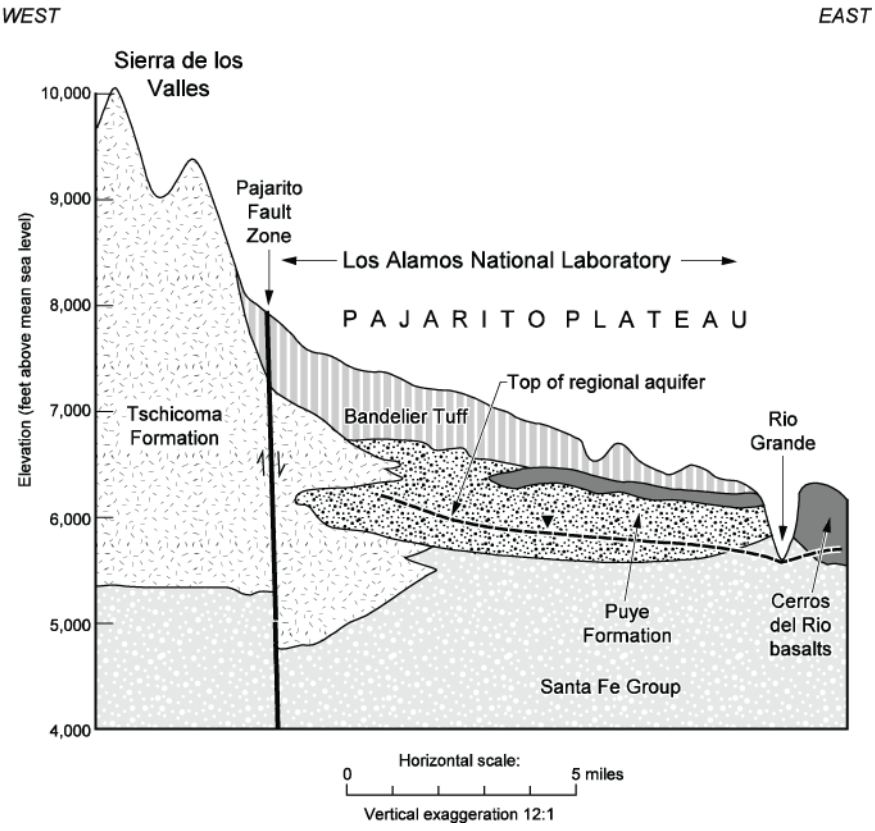


Figure 5-1 Generalized geologic cross-section of the Pajarito Plateau

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.

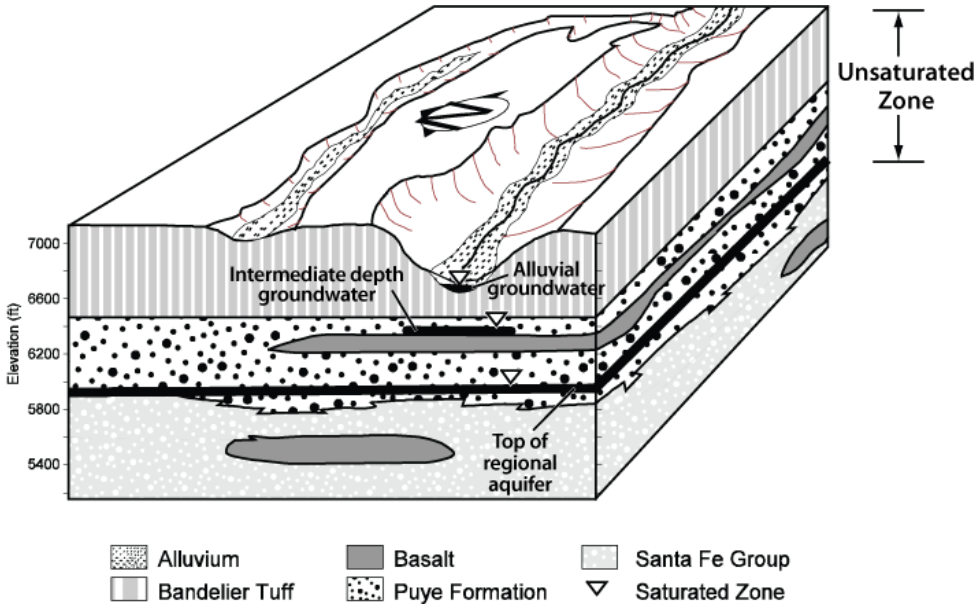


Figure 5-2 **Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence**

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.

Streams have filled some parts of canyon bottoms with alluvium up to a thickness of 100 ft. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. Stream runoff may be supplemented or maintained by Laboratory discharges. 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.

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 zones have limited area but may extend to neighboring 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.

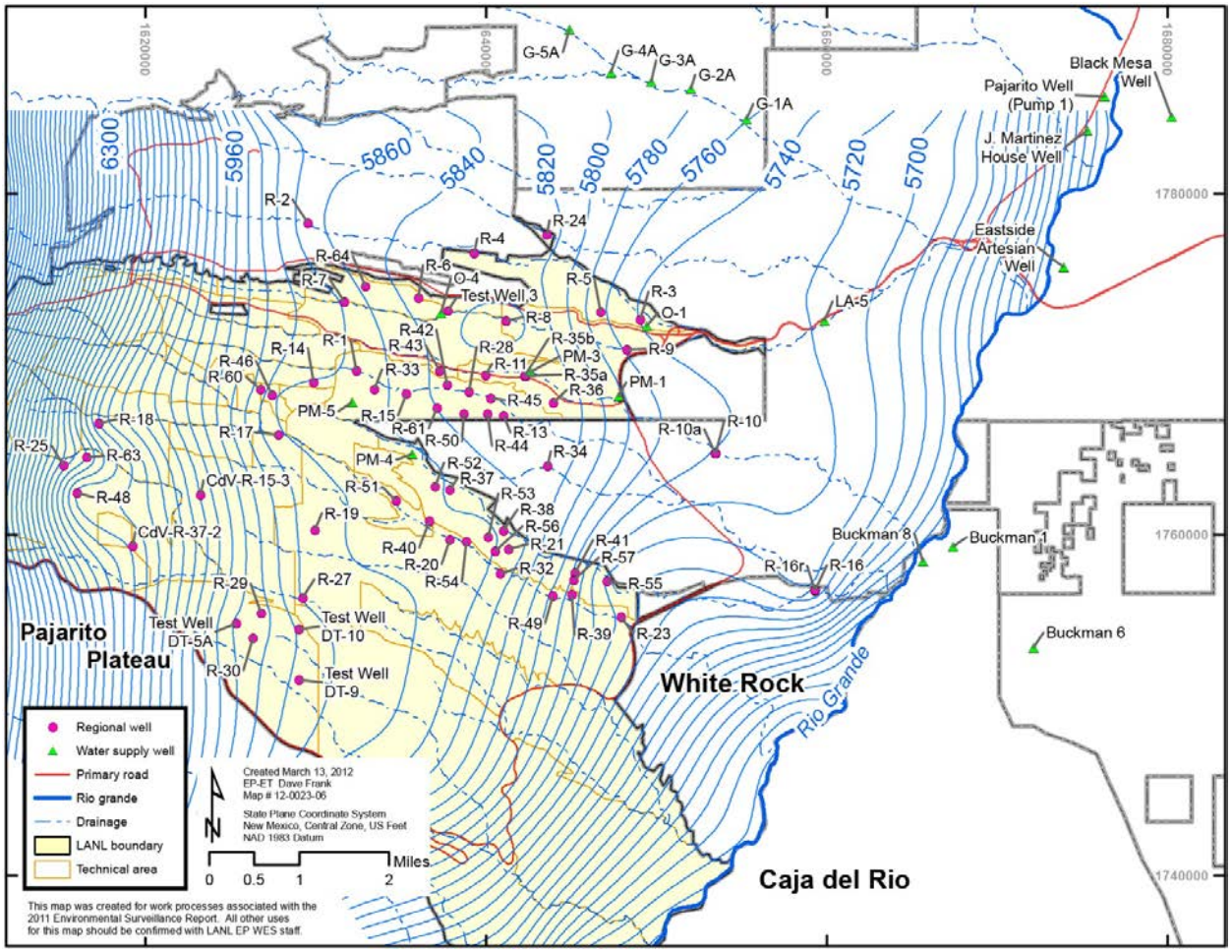


Figure 5-3 **Contour map of average water table elevations for the regional aquifer (based on a map in a Laboratory report [LANL 2012b]). This map represents a generalization of the data; other interpretations are possible.**

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.

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. Beneath some canyons this percolation is a source of contaminants that are mobile in water and 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 Laboratory Groundwater Monitoring Data

Sample Type	Constituent	Standard	Screening Level	Reference	Notes
Water supply wells	Radionuclides	EPA[a] MCLs[b]	DOE 4-mrem/yr[c] DCSs[d]	40 CFR 141–143, DOE Order 458.1	The 4-mrem/yr DCSs apply to water provided by DOE-owned drinking water systems. EPA MCLs apply to public 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[e], http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	EPA MCLs apply to public drinking water systems.
Non-water-supply groundwater samples	Radionuclides	NM groundwater standards	4-mrem/yr DCSs, EPA MCLs	20.6.2 NMAC, DOE Order 458.1, 40 CFR 141–143	NM groundwater standards apply to all groundwater. The 4-mrem/yr DCSs and EPA MCLs are for comparison because they apply only to public 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/risk/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 public drinking water systems.
Effluent samples	Radionuclides	DOE 100-mrem/yr DCSs	None	DOE Order 458.1	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] DCS = Derived concentration technical standard.

[e] 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 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 458.1, Radiation Protection of the Public and the Environment, establishes dose limits for radiation protection and provides DCSs 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 DCSs for the 100-mrem/yr public dose limit apply as effluent release guidelines. For ingested water, DCSs are calculated for DOE's 4-mrem/yr drinking water dose limit.

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 with a total dissolved solids (TDS) concentration of 10,000 milligrams per liter (mg/L) or less. 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 comparison. These screening levels are updated several times each year; the November 2013 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. 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 (µg/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 Laboratory uses the Consent Order groundwater cleanup levels as screening levels for groundwater monitoring data. Documents submitted to NMED by the Laboratory use these values for evaluation of groundwater results.

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 DCSs 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 DCSs and with EPA MCLs. When used in this chapter for assessing water samples from sources other than water supply wells, these DCSs 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 2013 at concentrations up to 0.73 µg/L. This concentration is now about twice that found in other water supply wells; it is 18% 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.

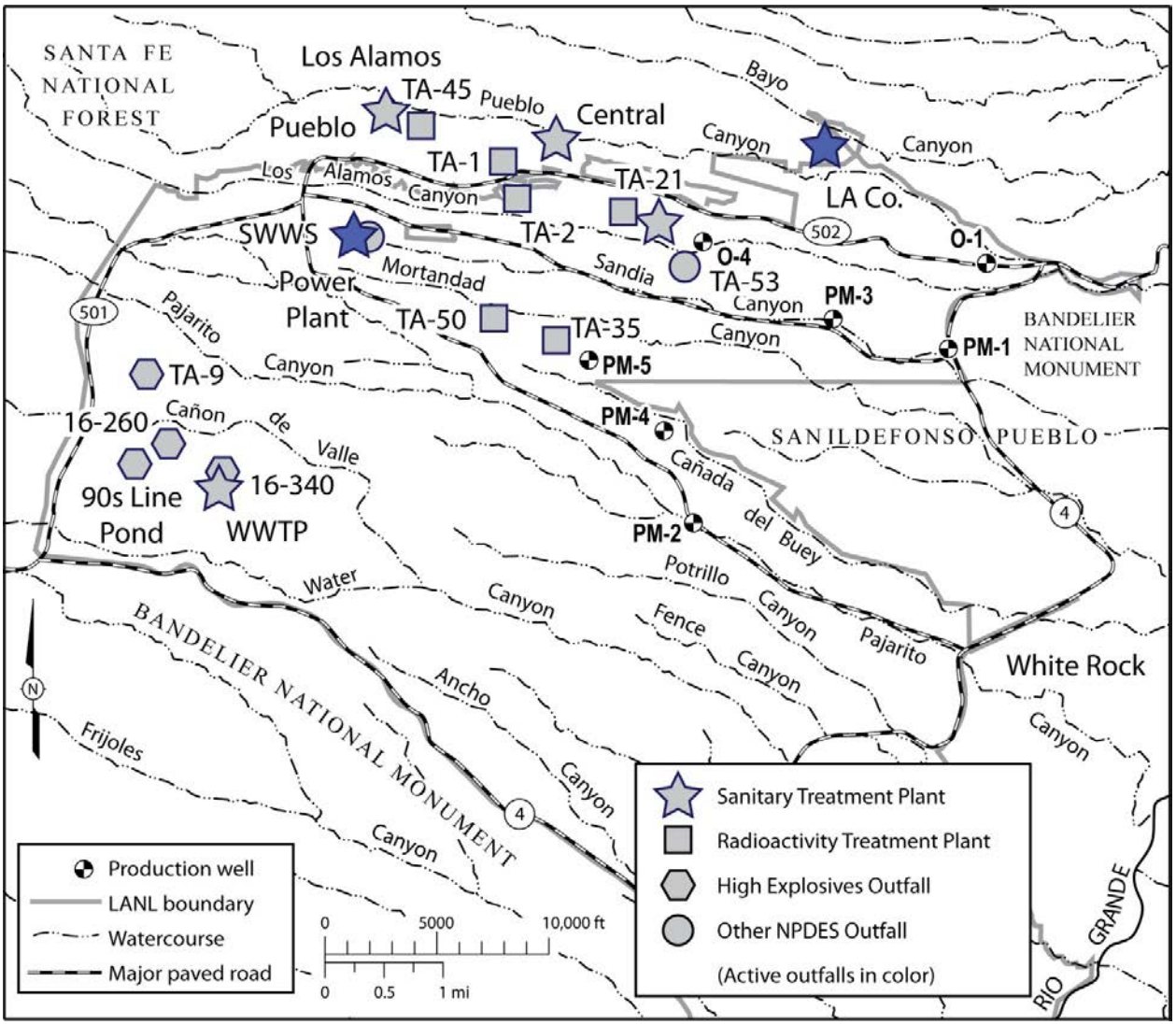
Since the 1940s, liquid effluent discharge by the Laboratory has affected the shallow perched alluvial groundwater that lies beneath the floor of a few canyons (Table 5-2). Liquid effluent discharge is also the primary means by which Laboratory operations have affected intermediate-perched zones and 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 2013

Chemical	Location	Result	Trends
Strontium-90	DP and Los Alamos Canyons	Up to 17 picocuries per liter (pCi/L), above 8-pCi/L EPA MCL screening level	Fairly steady for decades
Perchlorate	Mortandad Canyon	Up to 16.5 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 12,200 µg/L, above 1000-µg/L NM groundwater standard	Fairly steady for decades in several wells
RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	Cañon de Valle	Up to 15.1 µg/L, above 6.1-µg/L EPA tap water screening level	Above screening level in one well; present at similar levels for years in several wells
Tetrachloroethene	Cañon de Valle	15.6 µg/L, above 5-µg/L EPA MCL screening level	Present at similar levels for years in one well

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.



NPDES = National Pollutant Discharge Elimination System.

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

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.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls and the volume of water discharged. 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 Sandia Canyon and Mortandad Canyon, hexavalent chromium is

found at concentrations above the 50-µg/L NM groundwater standard. At a few wells, perchlorate concentrations were above the 4-µg/L Consent Order screening level (Table 5-4).

Table 5-3
Intermediate Groundwater Contaminants above Screening Levels in 2013

Chemical	Location	Result	Trends
Perchlorate	DP and Los Alamos Canyons	Up to 7.0 µg/L, above 4-µg/L Consent Order screening level	Generally steady in three wells for 8 yr, rising in LAOI-3.2 for 4 yr
Perchlorate	Lower Los Alamos Canyon	Up to 5.7 µg/L, above 4-µg/L Consent Order screening level	Steady in Vine Tree Spring for 3 yr
Chromium	Sandia Canyon	Up to 435 µg/L, above 50-µg/L NM groundwater standard	Decreasing for 5 yr from 658 µg/L in SCI-2
Chromium	Mortandad Canyon	Up to 81 µg/L, above 50-µg/L NM groundwater standard	Increasing for 7 yr in MCOI-6
Perchlorate	Mortandad Canyon	Up to 84 µg/L, above 4-µg/L Consent Order screening level	Between 60 µg/L and 100 µg/L for 5 yr in two wells
Dioxane[1,4-]	Mortandad Canyon	Up to 9.6 µg/L, above 6.7-µg/L EPA tap water screening level	Present in two wells; steady in MCOI-5 and declining in MCOI-6 for 7 yr
Dioxane[1,4-]	Upper Pajarito Canyon	Up to 38.5 µg/L, above 6.7-µg/L EPA tap water screening level	Highly variable concentrations in isolated perched zone for 8 yr
Boron	Tributary of Cañon de Valle	Up to 1100 µg/L, above 750-µg/L NM groundwater standard (for irrigation)	Above standard for more than 7 yr in Martin Spring, decreased to 647 µg/L in September 2013
RDX	Cañon de Valle	Up to 164 µg/L, above 6.1-µg/L EPA tap water screening level	Present for years in several wells and springs

Table 5-4
Regional Aquifer Groundwater Contaminants above Screening Levels in 2013

Chemical	Location	Result	Trends
Perchlorate	Pueblo Canyon	Up to 4.8 µg/L, above 4-µg/L Consent Order screening level	Steady for 6 yr in R-4
Chromium	Sandia Canyon	Up to 148 µg/L, above 50-µg/L NM groundwater standard	Steady near 148 µg/L at R-62, increasing for 5 yr in R-43 S1, now at 70 µg/L
Chromium	Mortandad Canyon	Up to 1070 µg/L, above 50-µg/L NM groundwater standard	Steady for 9 yr in R-28 and R-42, increasing for 3 yr in R-50 S1
Perchlorate	Mortandad Canyon	Up to 8.4 µg/L, above 4-µg/L Consent Order screening level	Slight increase over several years in R-15, fairly steady 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 (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 not detected in 2013 samples. In 2012 it was detected in only one of two sampling events, at a concentration just above the 0.3-µg/L method detection limit (MDL).

In 2013, the HE compound RDX continued to be detected in the regional aquifer at Pajarito Canyon monitoring well R-18. Concentrations in R-18 have risen steadily since 2007. The RDX concentration was at 30% 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, Los Alamos National Security, LLC (LANS, LANL'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 2013 was carried out according to two IFGMPs (LANL 2012a, 2013a). 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.

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 establish a baseline for comparison. 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 2013, the Laboratory sampled 173 groundwater wells, well screens, and springs in 319 separate sampling events. Many springs and alluvial wells were dry because of drought conditions and ongoing reductions in liquid effluent.

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 2013.

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.

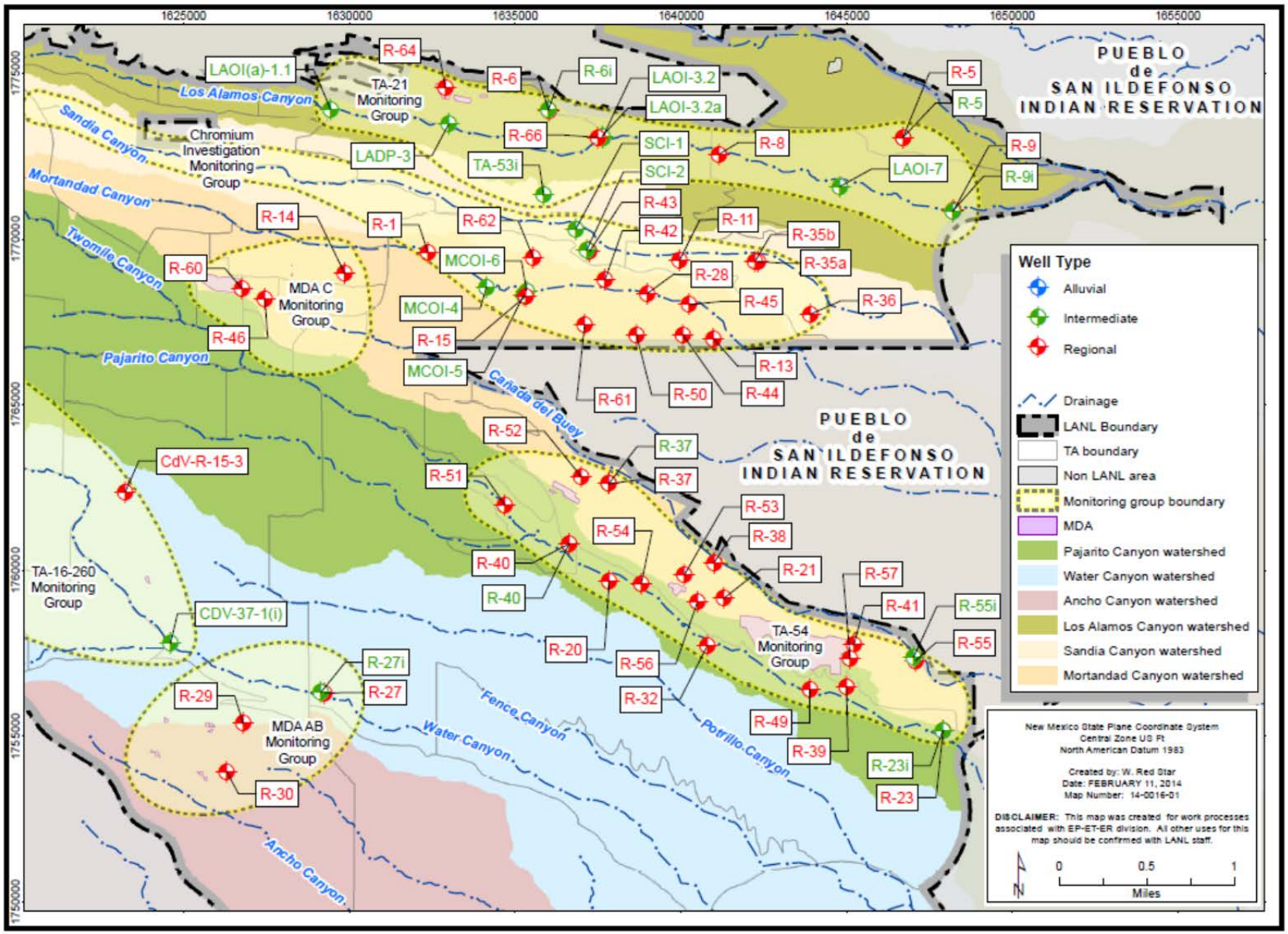


Figure 5-5a Groundwater monitoring wells assigned to area-specific monitoring groups

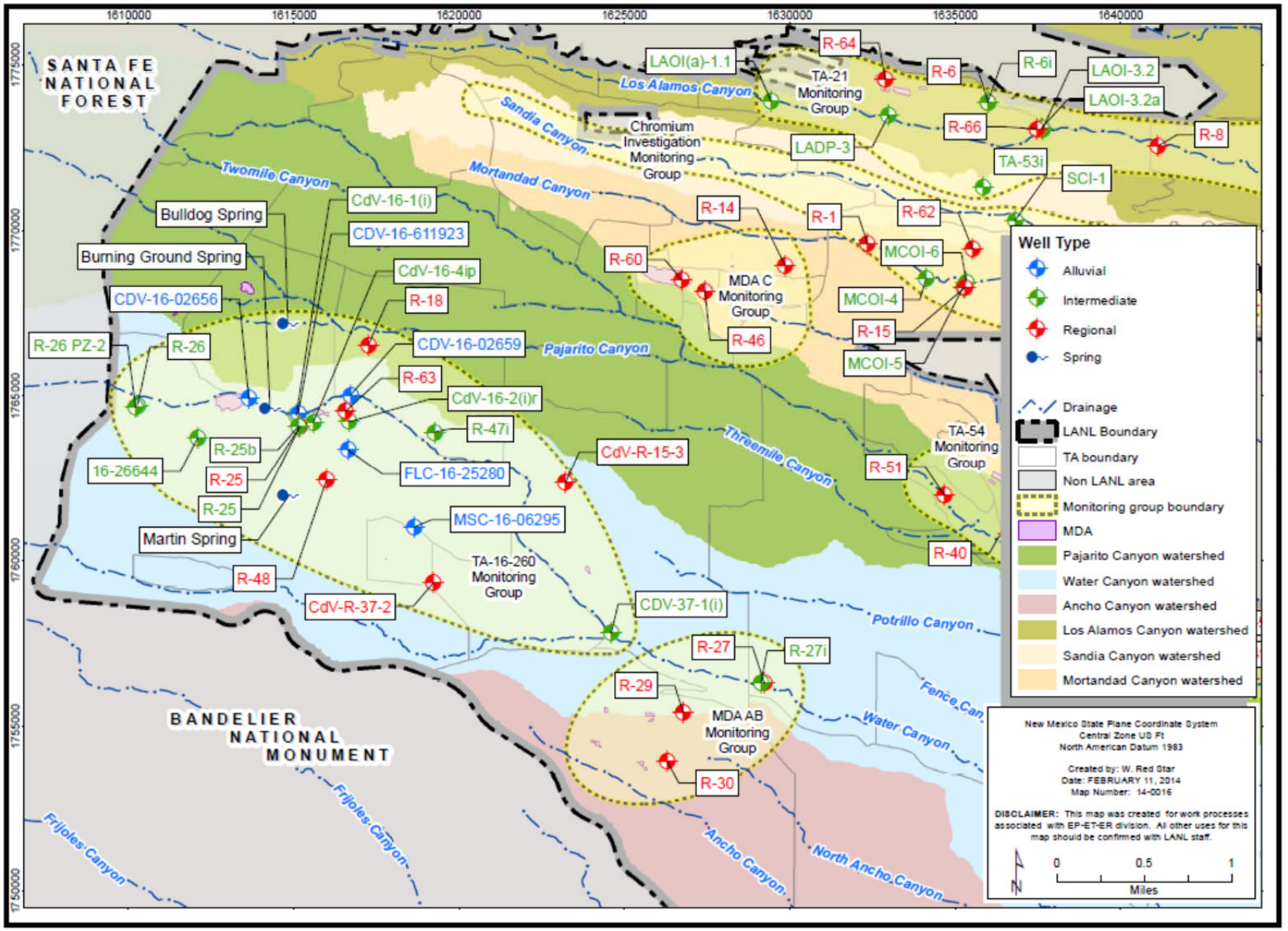


Figure 5-5b Groundwater monitoring wells and springs assigned to area-specific monitoring groups

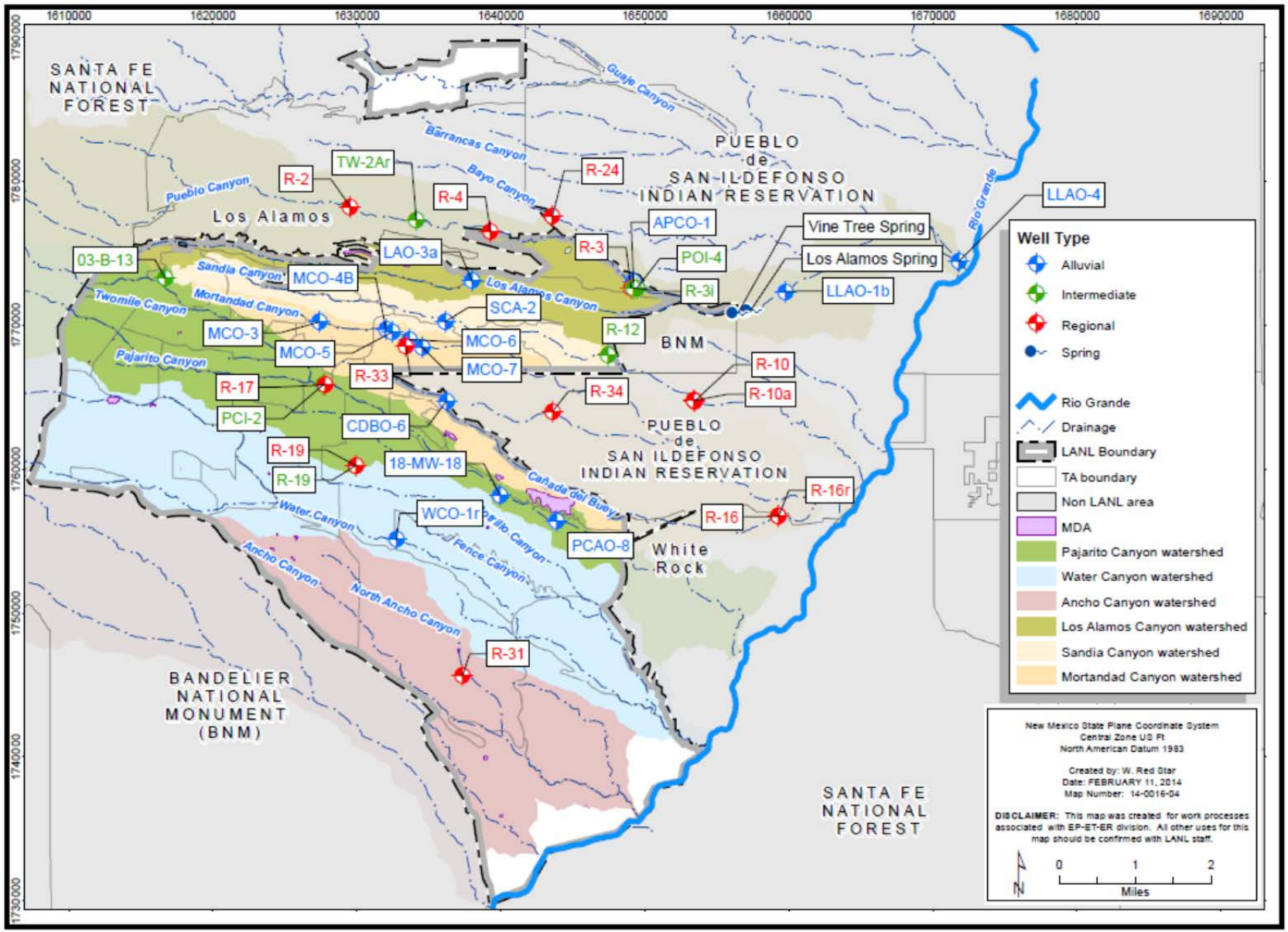


Figure 5-6 **Groundwater monitoring wells and springs assigned to general surveillance monitoring**

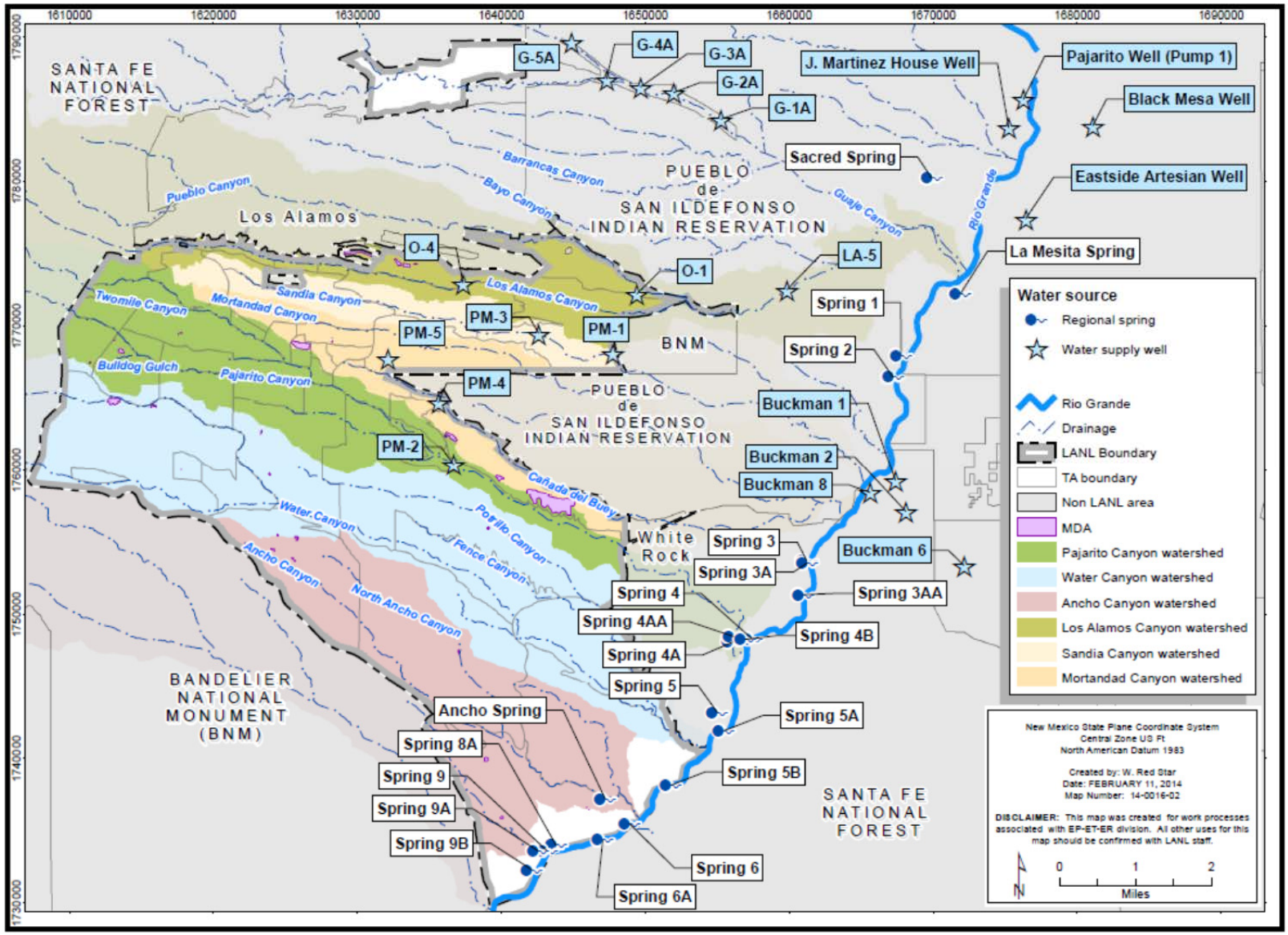


Figure 5-7 **Water supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon**

The Laboratory 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 calendar year 2013 for the Sigma Mesa Well (LANL 2014a)

No new monitoring wells were drilled in 2013.

From September 10 to 17, 2013, New Mexico and Colorado received historic amounts of rainfall. The resultant flooding around the Laboratory did extensive damage to environmental monitoring equipment and access roads (LANL 2013b). Seventeen wells had minor damage, usually requiring that the well pad be cleared of sediment and debris. Four alluvial wells will require replacement. Two wells were initially identified as destroyed: APCO-1 in Pueblo Canyon and MCO-3 in Mortandad Canyon. Alluvial well MSC-16-06295, in a tributary of Cañon de Valle, was identified as having minor damage, but was later found to have been destroyed. The stream bank at SCA-2 in Sandia Canyon was found to have been severely eroded, making site conditions unsafe.

F. GROUNDWATER SAMPLING RESULTS BY CONSTITUENT

The groundwater quality monitoring data for 2013 are available at http://www.intellusnmdata.com.

The analytical laboratory reports results relative to several defined measurement levels. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a set of samples in a given matrix containing the analyte (40 CFR Appendix B to Part 136).

A second level, the practical quantitation limit (PQL) does not have a standard definition. The PQL is intended to be a concentration above the MDL that can be consistently measured, with a quantification within 30% of the true sample concentration. The PQL is approximately (but not always) three times the MDL or is the lowest point on the analytical laboratory's calibration curve. Measured concentrations between the MDL and PQL are reported as estimated (marked with a J flag).

Analytical results for nondetects are reported at the PQL. This convention means that estimated results in a sample are reported with a lower result than a nondetect result for the same analyte in another sample.

The MDL and PQL do not apply to radiological measurements. For radiological measurements, the minimum detectable activity is analogous to the MDL, though it is calculated for each measurement from radioactive counting statistics. A second value for radiological measurements is the one-standard-deviation total propagated uncertainty. The total propagated uncertainty combines uncertainties resulting from radioactive counting statistics and other measurement errors that are part of the analytical process. To be detected, a radiological measurement must be greater than the minimum detectable activity and three times the one-standard-deviation total propagated uncertainty.

1. Organic Chemicals in Groundwater

In 2013, 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-µg/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. For the first time in years, no wells had bis(2-ethylhexyl)phthalate detections in 2013.

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 2013 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 DCSs applicable to drinking water. The 2013 samples from water supply wells used by the City of Santa Fe had uranium and gross-alpha results near or above screening levels, as described in a later section.

No 2013 radioactivity results for intermediate groundwater or regional aquifer wells within or immediately adjacent to the Laboratory were above screening levels.

The gross-alpha activity in La Mesita Spring, located east of the Rio Grande on Pueblo de San Ildefonso, was above the 15-pCi/L EPA MCL screening level. The elevated gross-alpha value reflects the presence of natural uranium. The 15-pCi/L gross-alpha EPA MCL excludes the gross-alpha contribution from uranium; this gross-alpha result was not corrected for uranium.

Results for strontium-90 from alluvial groundwater in Los Alamos Canyon were below the 4-mrem/yr DOE DCS and above the EPA MCL screening level (Table 5-5). Strontium-90 contributed most of the dose in alluvial groundwater for samples taken in 2013; other radioactive analytes contributed little.

Table 5-5

Radioactivity Results above Screening Levels in Alluvial Groundwater for 2013

Chemical	Location	Result	Trends
Gross alpha	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	15.9 pCi/L, above EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; this value was not corrected for this)	Naturally occurring, because of uranium
Strontium-90	One well in Los Alamos Canyon	17 pCi/L; above EPA MCL screening level of 8 pCi/L; below 40-pCi/L, 4-mrem/yr DOE DCS screening level	Fairly stable for 10 yr because of retention on alluvium

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 Laboratory releases. For this reason, such results are not discussed in detail in this report.

In some Laboratory 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, the Laboratory 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 microbial metabolism, creating reducing conditions by consuming dissolved oxygen and changing chemical behavior of several redox-sensitive constituents found in groundwater and adjacent aquifer material. With reducing conditions (beginning with the absence of dissolved oxygen), the solubility of metals such as manganese and iron increases, leading to dissolution from the surface of minerals that make up the aquifer's rock framework or possibly from well fittings. Wells drilled since 2007 have been drilled without the use of drilling fluids, other than water, in the saturated zone. There have been minor exceptions of 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 2013, samples from CdV-R-37-2 S2 (screen 2) and R-61 S2 had unusually high iron or manganese concentrations. Samples were collected in 2013 from R-55i and R-54 S1 only for VOCs and tritium (the 830-ft screen) because of high iron and manganese observed in earlier samples. The performance of these wells was evaluated to determine what actions might improve their water sample quality. R-61 was redeveloped during 2012 (LANL 2013c). The 2013 samples from R-40 Si continued to show unusually high iron or manganese concentrations.

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 also occurs in spring samples because sampling may incorporate surrounding soil material.

G. 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 Laboratory 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 2013 perchlorate concentrations (with a maximum of 0.73 µg/L) were up to 18% of the 4-µg/L Consent Order screening level, or 5% of the EPA's interim health advisory of 15 µg/L (Figure 5-8). This perchlorate concentration is about twice that found in other supply wells. Tritium was detected in only one of three sampling events at O-1 in 2013, at an activity of 3.2 pCi/L, which was far below the 20,000-pCi/L EPA MCL. The past 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 2013.

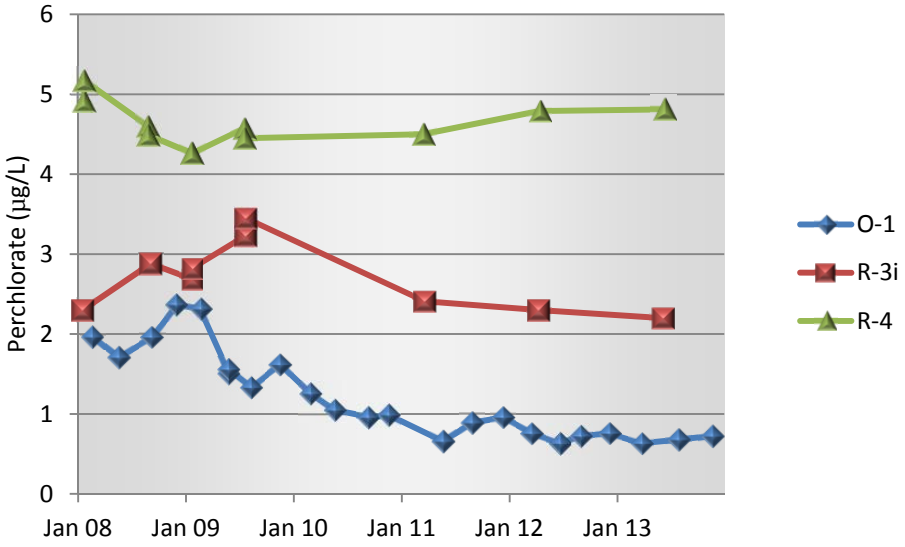


Figure 5-8 **Perchlorate at general surveillance and water supply (well O-1) monitoring locations in Pueblo Canyon intermediate and regional aquifer groundwater. The Consent Order screening level is 4 µg/L.**

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

Chemical	Location	Result	Trends
Tritium	Water supply well O-1	3.2 pCi/L, below EPA MCL of 20,000 pCi/L; only one detect of three samples	Results have declined from 58 pCi/L since 2004.
Perchlorate	Water supply well O-1	0.63 µg/L to 0.73 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 samples at concentrations above the 10-µg/L EPA MCL since the well field was developed in the early 1950s. In 2013, no samples were analyzed for metals.

b. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near the Rio Grande. Except for LA-5, which was part of the former Los Alamos well field, these wells are located north of the Laboratory along the Rio Grande; some are east of the river. As a result, the wells do not lie along groundwater flow paths emanating from the Laboratory. Other Pueblo de San Ildefonso wells and springs are covered in later sections. No Pueblo de San Ildefonso supply wells were sampled in 2013 because of scheduling and maintenance issues.

Past 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. 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 wells also have elevated natural concentrations of boron, fluoride, and arsenic.

c. City of Santa Fe

In 2013, the Laboratory sampled three wells in the City of Santa Fe's Buckman well field (Table 5-7). As in past samples, these wells contain natural uranium near or above the 30-µg/L NM groundwater standard. 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 2012c).

Table 5-7
Groundwater Quality in Buckman Well Field Supply Wells

Chemical	Location	Result	Trends
Uranium	Buckman Wells No. 1 and No. 8	16.4 µg/L to 18.1 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	Buckman Wells No. 1, No. 6, and No. 8	8.9 pCi/L to 18 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, 6, and No. 8	5.7 µg/L to 11.7 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 Laboratory activities (Table 5-8). 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 5-8
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	Minor 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 5-9). 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 5-9
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 55% 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 at 85% of EPA drinking water screening level	No monitoring locations	No monitoring locations
TA-21 monitoring group	Past effluent discharges	No monitoring locations	Fluoride at 71% of NM groundwater standard, perchlorate above Consent Order screening level, tritium up to 11% 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, the adsorption beds at MDA U, the former Omega West reactor cooling tower (SWMU 02-005), DP West, and waste lines and sumps. Other potential sources include DP East and leakage from an underground diesel fuel line. 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. The perchlorate concentration in samples from one regional aquifer monitoring well in Pueblo Canyon was above the Consent Order screening level, and tritium, nitrate, and fluoride concentrations in some wells were elevated but 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 5-10).

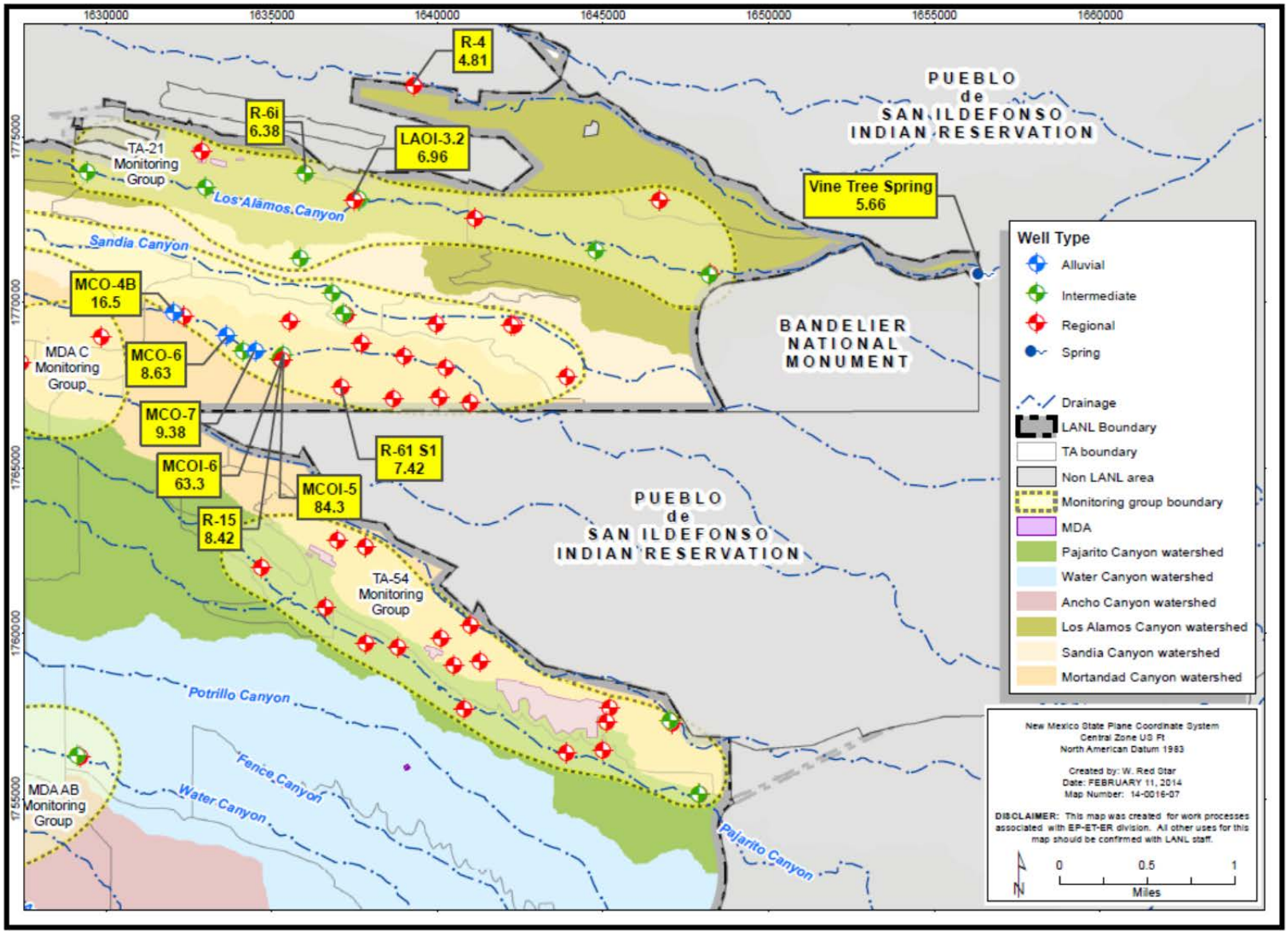


Figure 5-9 **Wells and springs with 2013 perchlorate concentrations above the 4-µg/L Consent Order screening level. The maximum concentration for the year is shown in µg/L.**

Table 5-10
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	2.2 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 5-10). The 2013 uranium concentration in a sample from Pueblo Canyon intermediate well R-3i was 8.3 µg/L, above levels in nearby wells but below the 30-µg/L standard. The higher uranium concentrations may result from dissolution of uranium from surrounding bedrock by sanitary effluent (Teerlink 2007).

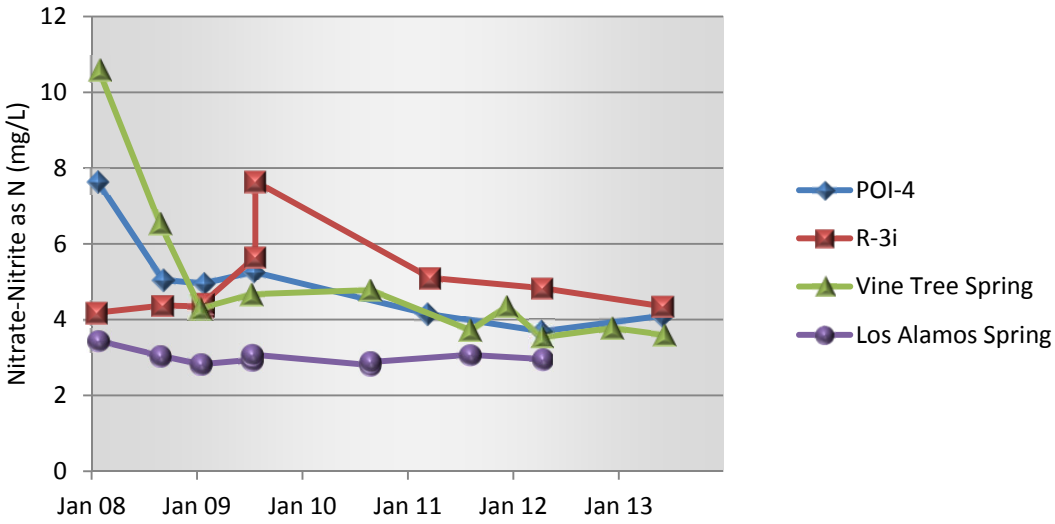


Figure 5-10 **Nitrate (as N) at general surveillance monitoring locations in Pueblo Canyon and lower Los Alamos Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L.**

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 (Table 5-11, Figures 5-11 through 5-13). Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 2280 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 showed fluoride concentrations higher than those in nearby wells, but the results were below the NM groundwater standard.

The 2013 perchlorate concentrations in R-6i, LAOI-3.2, and LAOI-3.2a ranged up to 7.0 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, the Laboratory measured and detected 1,4-dioxane for the first time in intermediate well R-6i. The compound was detected in nearly every sampling event through 2011.

Table 5-11
Groundwater Quality in TA-21 Monitoring Group

Chemical	Location	Result	Trends
Tritium	Intermediate wells R-6i, LAOI-3.2, and LAOI-3.2a	1280 pCi/L to 2280 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Highest activities in R-6i
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and R-9i S2	2.3 µg/L to 7.0 µg/L, above Consent Order screening level of 4 µg/L	Highest concentrations in LAOI-3.2, lowest concentrations but steady for 5 yr in R-9i S2
Fluoride	Intermediate well R-5 S2	1.1 mg/L, below NM groundwater standard of 1.6 mg/L	Concentrations fairly steady since 2004

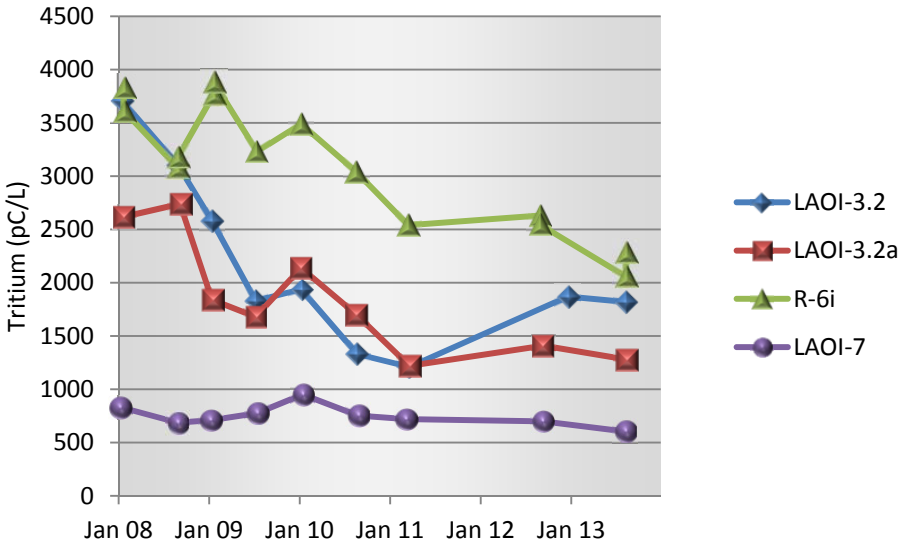


Figure 5-11 **Tritium in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL (which does not apply to these samples) is 20,000 pCi/L.**

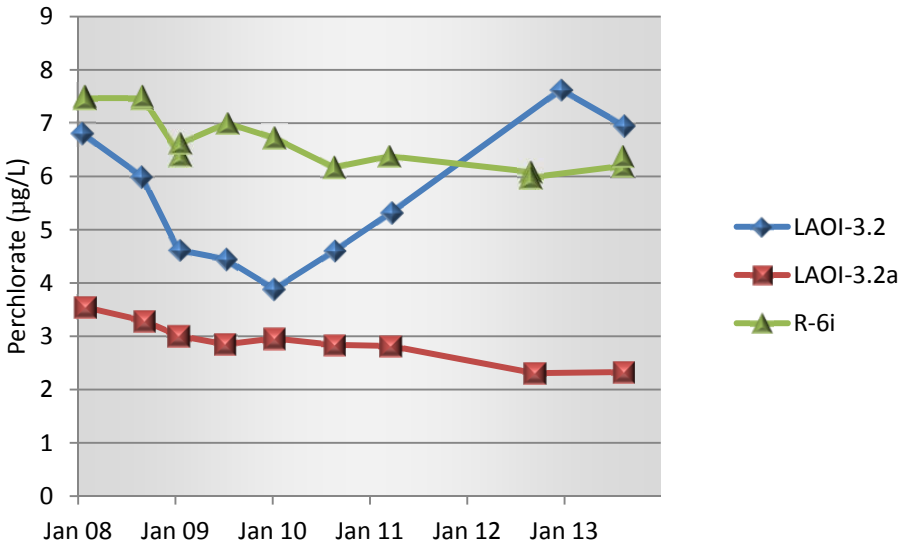


Figure 5-12 **Perchlorate in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

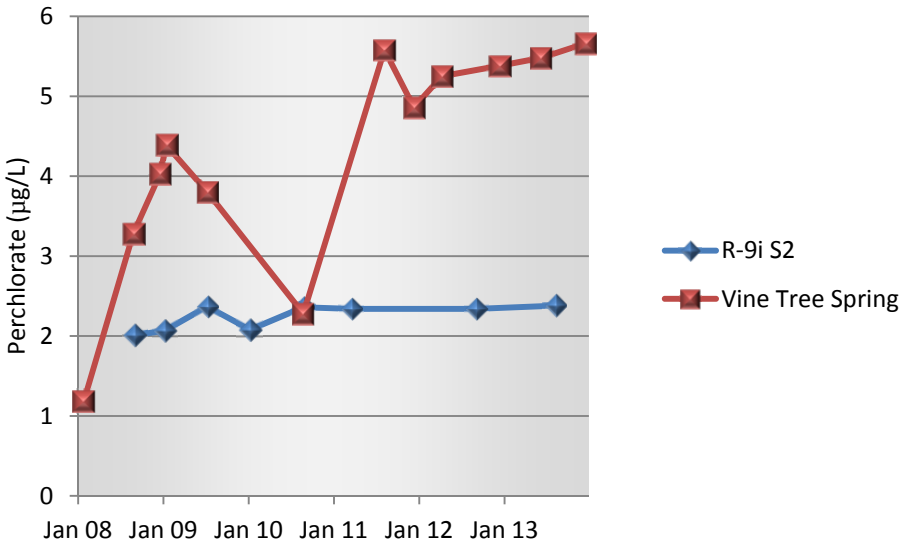


Figure 5-13 **Perchlorate in the TA-21 monitoring group at R-9i and at general surveillance monitoring location Vine Tree Spring (combined with Basalt Spring) in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

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 5-12). 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.

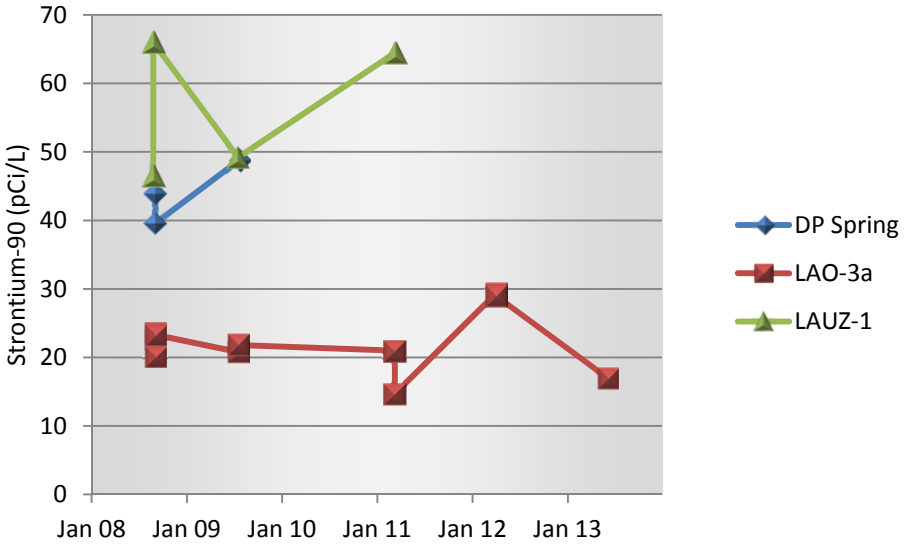


Figure 5-14 **Strontium-90 at current and previous general surveillance monitoring locations in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results. For comparison purposes, the EPA MCL (which does not apply to these samples) is 8 pCi/L.**

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

Chemical	Location	Result	Trends
Strontium-90	Alluvial well LAO-3a	17 pCi/L; above 8-pCi/L EPA MCL screening level; below 40-pCi/L, 4-mrem/yr DOE DCS screening level	Decreased since cessation of discharges in 1986, remains elevated because of retention on alluvium
Gross beta	Alluvial well LAO-3a	42 pCi/L, below 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. Los Alamos Spring was dry and could not be sampled. 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 subsequent samples have been collected. The 2013 nitrate (as N) result in Vine Tree Spring was 3.6 mg/L, below the NM groundwater standard of 10 mg/L. Past nitrate (as N) results from Basalt Spring were above the standard. The perchlorate concentrations since late 2008 at Vine Tree Spring and Basalt Spring have been near or above the Consent Order screening level of 4 µg/L (Table 5-13, Figure 5-13).

Table 5-13
Groundwater Quality in Lower Los Alamos Canyon

Chemical	Location	Result	Trends
Perchlorate	Vine Tree Spring (intermediate)	5.7 µg/L, above Consent Order screening level of 4 µg/L	Combined with results from nearby Basalt Spring, increasing since 2006

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 discharges 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 suspended 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). NPDES Outfall 051 remains an active outfall; discharges have not been eliminated but suspended temporarily.

Sandia Canyon has a small drainage area that heads at TA-03. The canyon receives sanitary effluent from TA-46 and releases from cooling tower discharges from computing facilities and the TA-03 cogeneration power and steam plants (Table 5-14). 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 5-14
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, dry in 2013	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 61% of NM groundwater standards
Chromium Investigation monitoring group (Mortandad Canyon)	Past effluent discharges	No monitoring locations	Tritium at 17% of EPA MCL screening level; perchlorate above Consent Order screening level; chromium above and nitrate up to 82% of NM groundwater standards; 1,4-dioxane above EPA regional screening level for tap water	Chromium above and nitrate at 57% of NM groundwater standards, perchlorate above Consent Order screening level
Mortandad and Ten Site Canyons	Past effluent discharges	Fluoride at 67% and TDS at 65% 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 one from the RLWTF at TA-50 (Table 5-14). 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 2013 chromium concentrations exceeded the NM groundwater standard in five regional aquifer wells: R-28, R-42, R-62, R-50 S1 and R-43 S1 (Figure 5-15). Two intermediate wells also had chromium concentrations above the standard: SCI-2 and MCOI-6. The primary source of chromium resulted from discharges of chromated water from the TA-03 power plant cooling tower that occurred from 1956 to 1972. Perchlorate exceeds the Consent Order screening level of 4 µg/L in wells R-15 and R-61. The primary source of perchlorate resulted from effluent discharged from the TA-50 RLWTF that occurred from 1963 until removal of perchlorate from RLWTF effluent in March 2002. Other constituents detected at elevated concentrations or activities in wells in the monitoring group include nitrate 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 TA-46 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.

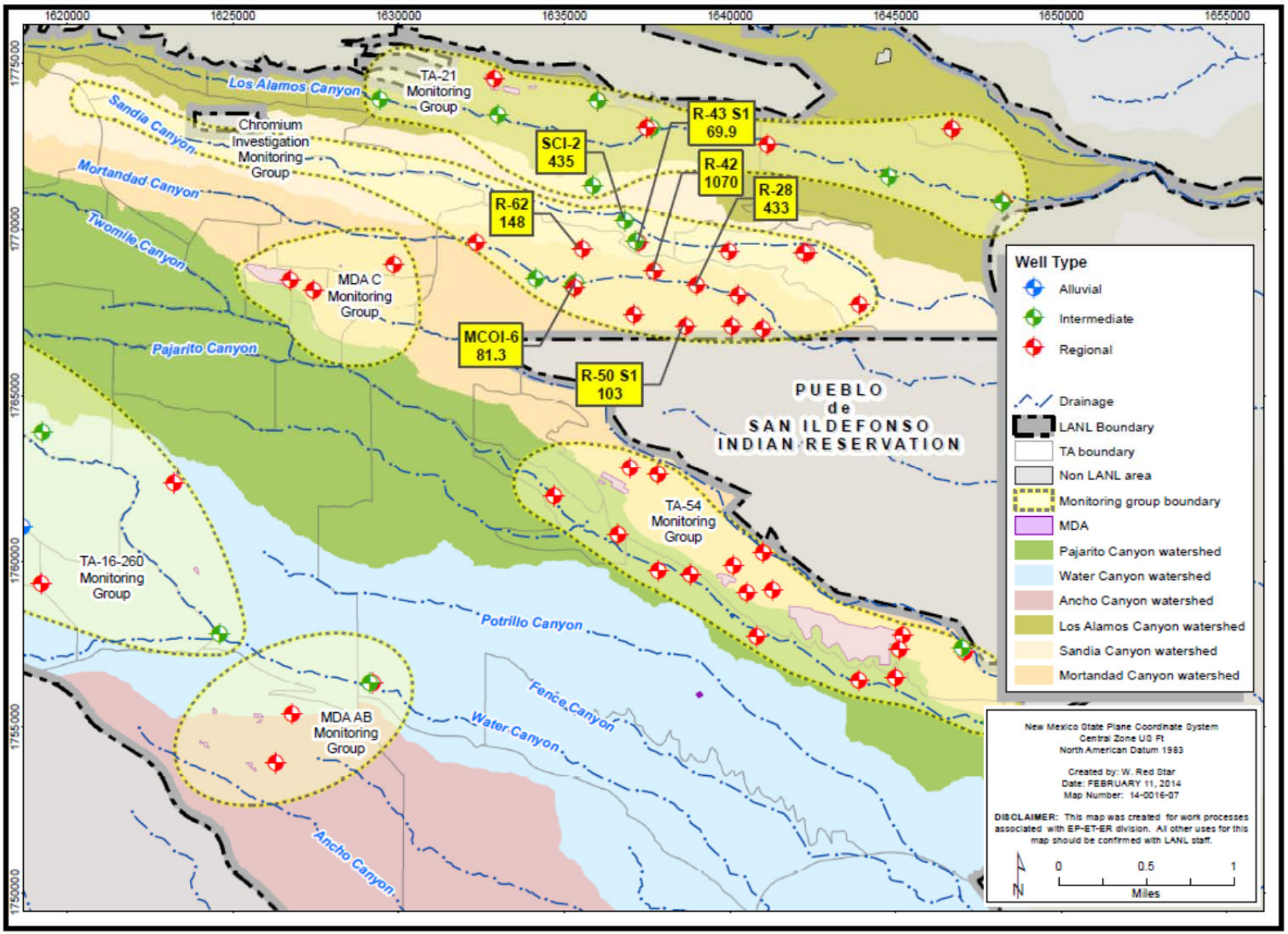


Figure 5-15 **Wells with 2013 dissolved or hexavalent chromium concentrations above the 50-µg/L NM groundwater standard. The maximum concentration for the year is shown in µg/L.**

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 2013. SCA-2, an alluvial well, was not sampled because of lack of water. The September 2013 flooding eroded the bank next to this well, making it unsafe to sample.

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 elevated filtered chromium concentrations that ranged from 26.4 µg/L in Sandia Canyon well R-11 to 1070 µg/L in Mortandad Canyon well R-42 (Table 5-15, Figures 5-15 through 5-18). The NM groundwater standard is 50 µg/L. Chromium concentrations have also increased steadily in R-45 S1; the November 2013 concentration of 27.7 µg/L has reached 55% of the standard.

During 2013, the Laboratory began tests for remediation of chromium-contaminated groundwater (LANL 2014b). Tests were conducted at three monitoring wells, R-28, R-42, and SCI-2. As a result, these wells were not always available for collection of monitoring samples.

Table 5-15

Groundwater Quality in the Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)

Chemical	Location	Result	Trends
Chromium	Seven regional aquifer wells in Sandia and Mortandad Canyons	26.4 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; steady for 2 yr at R-62
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 5 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 5.8 µg/L to 8.4 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	2100 pCi/L to 3390 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 422 µg/L in SCI-2 and 72.5 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-1, SCI-2, MCOI-5, and MCOI-6	2.1 mg/L to 8.2 mg/L, below NM groundwater standard of 10 mg/L	Stable in three 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	56 µg/L to 84 µg/L, above Consent Order screening level of 4 µg/L	Results in MCOI-6 decreased substantially, less change in MCOI-5
Dioxane[1,4-]	Mortandad Canyon intermediate wells MCOI-5 and MCOI-6	5.1 µg/L to 9.6 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

Regional aquifer wells R-43 S1 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon had 2013 nitrate (as N) concentrations up to 61% of the 10-mg/L NM groundwater standard (Figures 5-19 and 5-20). 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.

The perchlorate concentration in R-15 was above the Consent Order screening level of 4 µg/L (Figures 5-9 and 5-21). Samples taken from R-61 S1 (screen 1) were also above the screening level.

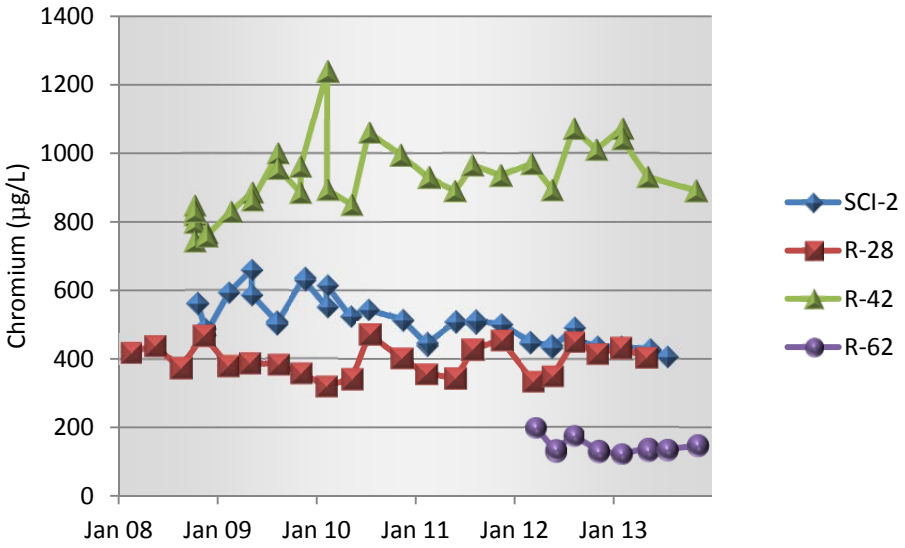


Figure 5-16 **Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.**

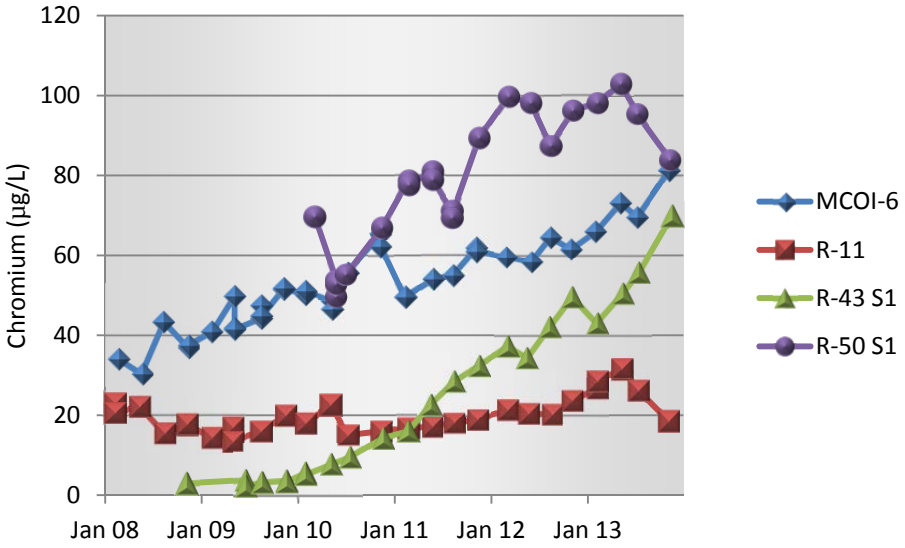


Figure 5-17 **Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.**

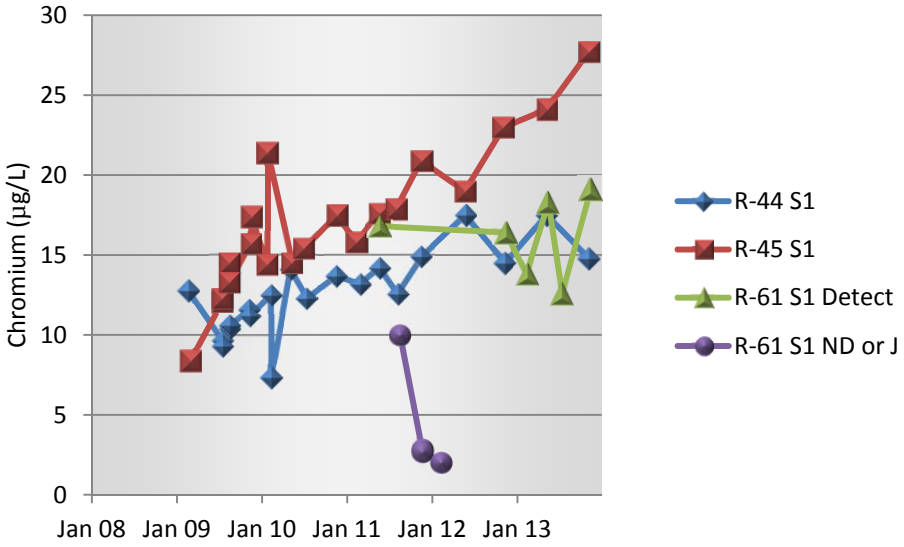


Figure 5-18 **Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L. For R-16 S1, detected values are shown separately from estimated (J) or nondetected (ND) results.**

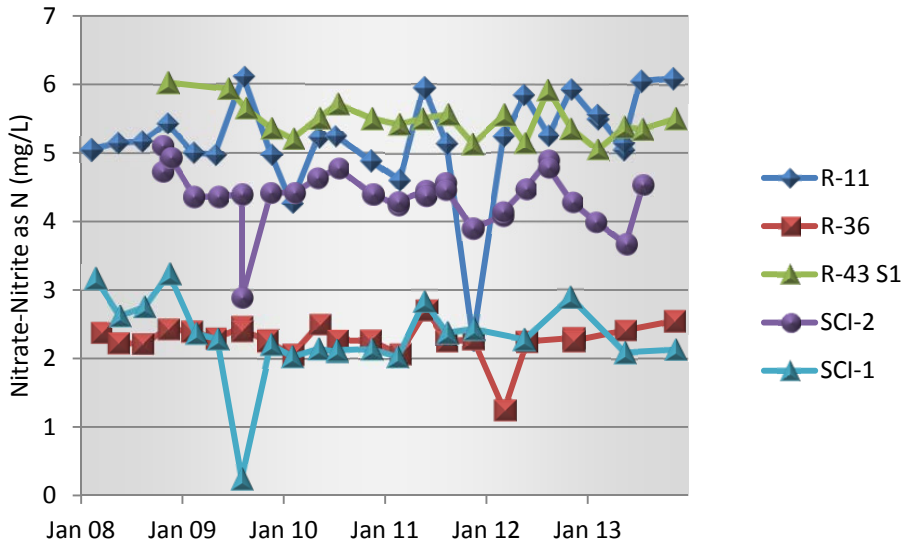


Figure 5-19 **Nitrate (as N) in the Chromium Investigation monitoring group in Sandia Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Many of the results in 2008 are estimated because of analytical quality issues.**

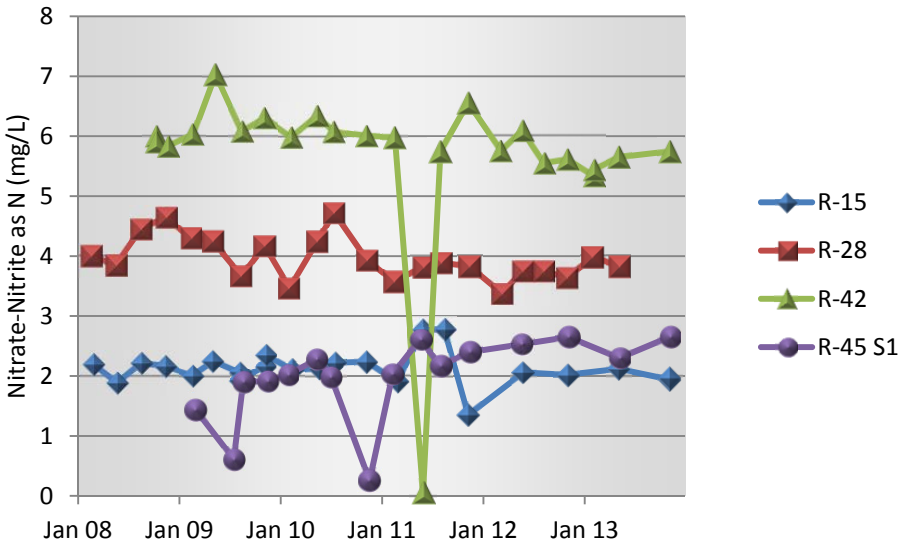


Figure 5-20 **Nitrate (as N) in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Some of the 2009 results are estimated because of analytical quality issues.**

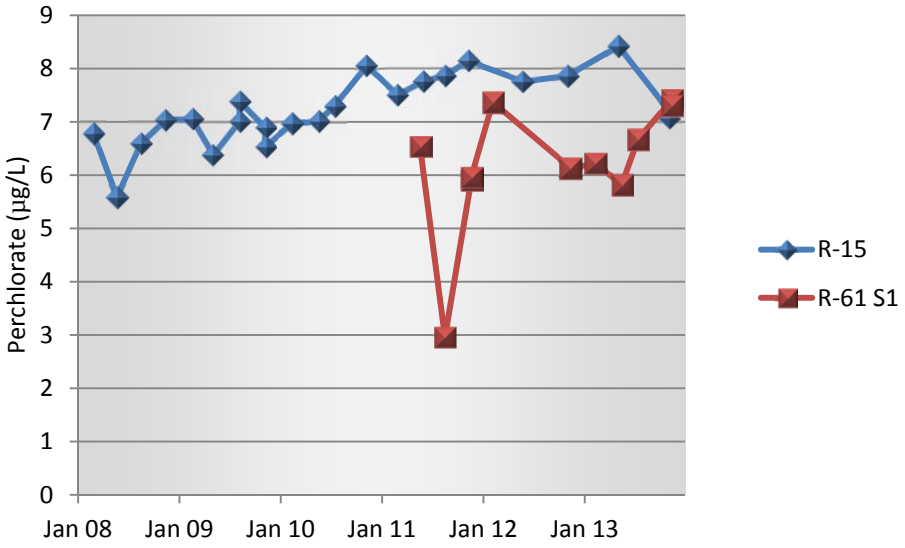


Figure 5-21 **Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer wells R-15 and R-61 S1 (1125-ft screen). The Consent Order screening level is 4 µg/L.**

SCI-2, an intermediate groundwater monitoring well in Sandia Canyon, had filtered chromium concentrations up to 435 µg/L during 2013 (Table 5-15, Figures 5-15 and 5-16). In Mortandad Canyon, MCOI-6 had filtered chromium concentrations up to 81.3 µg/L (Figures 5-15 and 5-17). The nitrate (as N) concentration in SCI-2 was up to 4.5 mg/L (Figure 5-19) and in MCOI-5 and MCOI-6 was up to 8.2 mg/L (Figure 5-22), below the 10-mg/L NM groundwater standard.

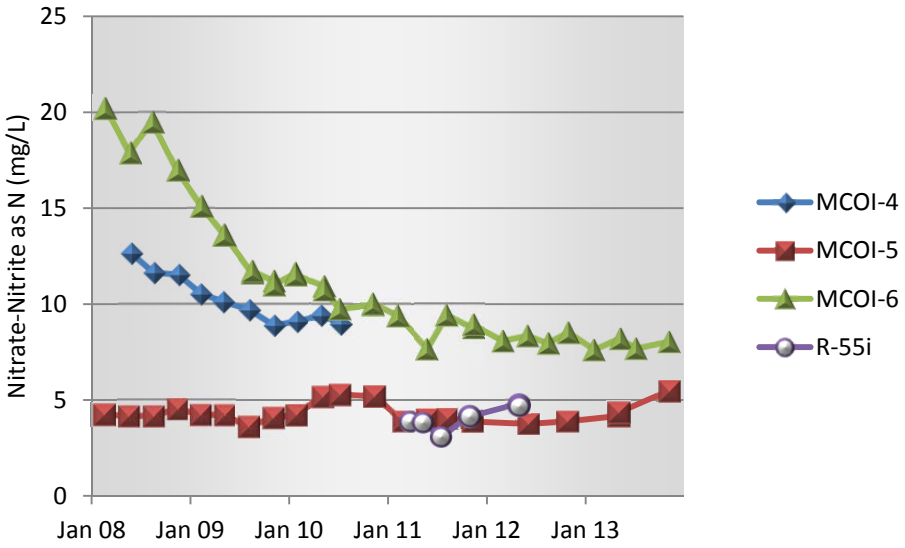


Figure 5-22 **Nitrate (as N) in the Chromium Investigation monitoring group and in the TA-54 monitoring group (R-55i) in Mortandad Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L. Many of the results are estimated because of analytical laboratory quality issues.**

The chemical 1,4-dioxane has been detected since 2006 in MCOI-4, MCOI-5, and MCOI-6 (Figures 5-23 and 5-24). The 1,4-dioxane EPA regional screening level for tap water is 6.7 µg/L. MCOI-4, which has had the highest concentrations, has not been sampled since 2010 because of lack of water. Perchlorate in these wells is above the 4-µg/L Consent Order screening level (Figures 5-9 and 5-25).

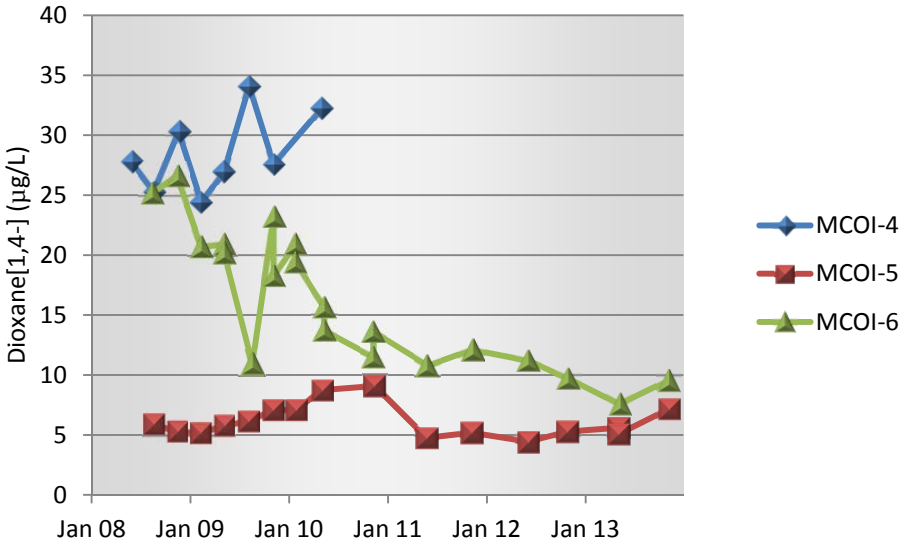


Figure 5-23 **Concentrations of 1,4-dioxane in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. The EPA regional screening level for tap water is 6.7 µg/L. About half the results are near the MDL and hence are estimated.**

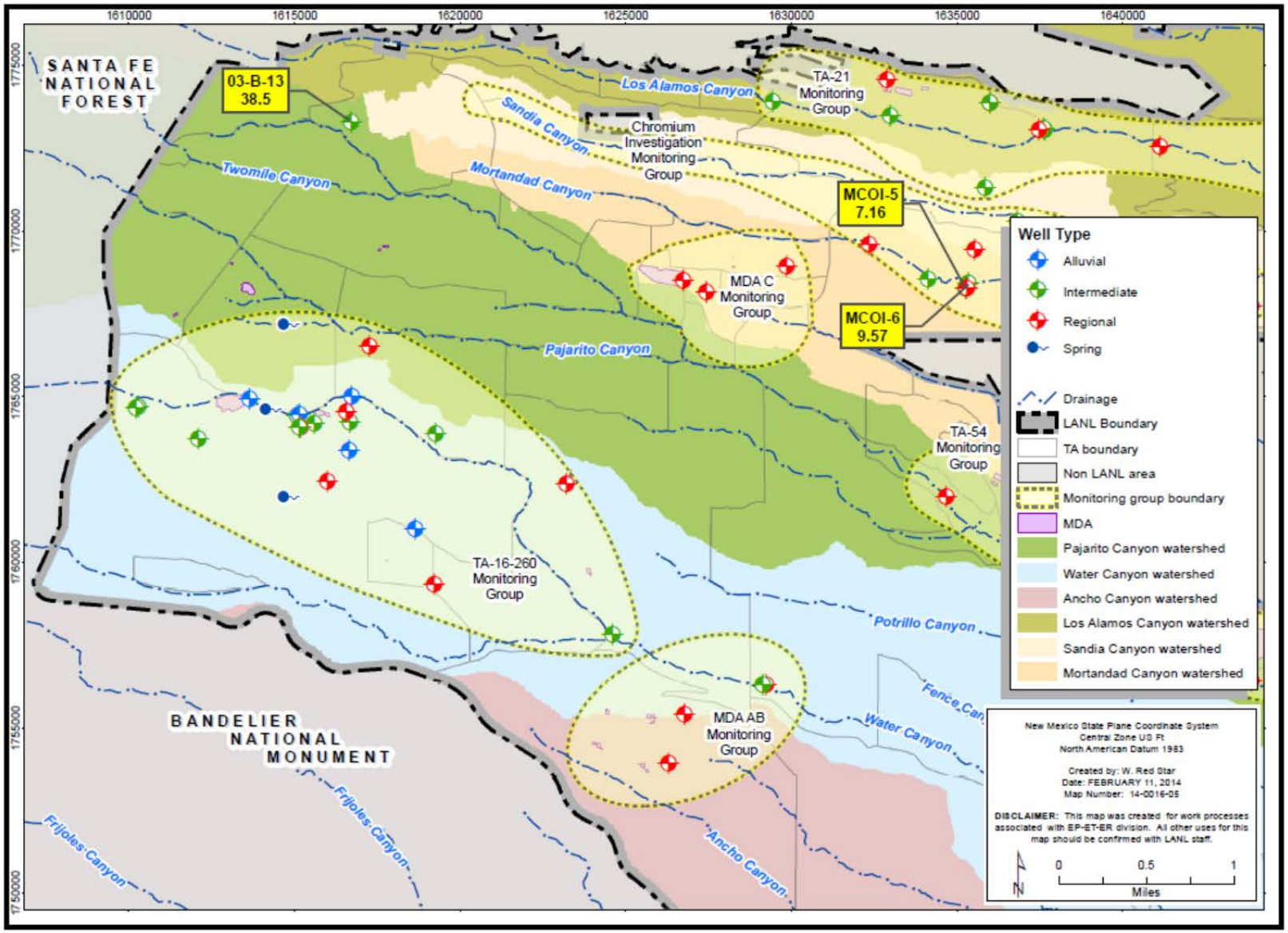


Figure 5-24 **Wells with 2013 1,4-dioxane concentrations above the 6.7-µg/L EPA tap water screening level. The maximum concentration for the year is shown in µg/L.**

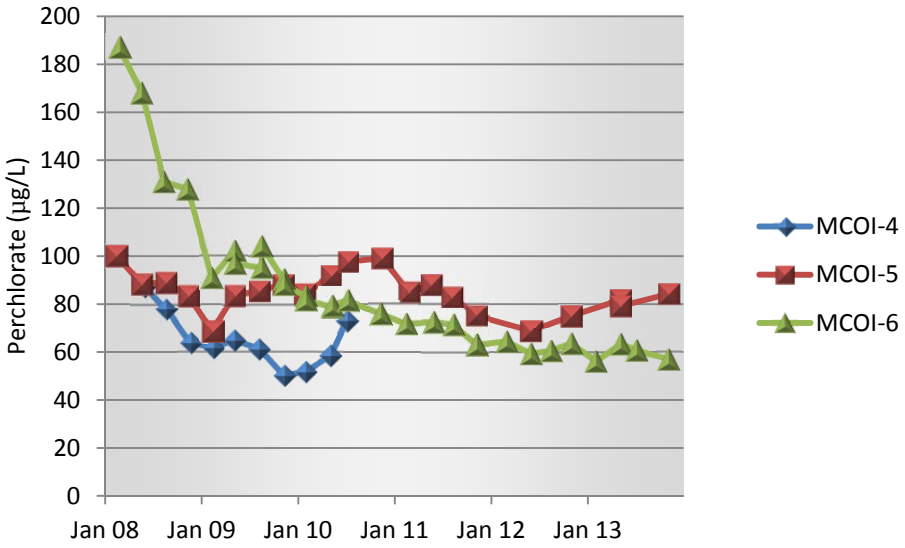


Figure 5-25 **Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

Intermediate wells MCOI-5 and MCOI-6 had tritium activities that ranged from 11% to 17% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-26). Tritium activities in these wells and MCOI-4 have decreased significantly since 2007.

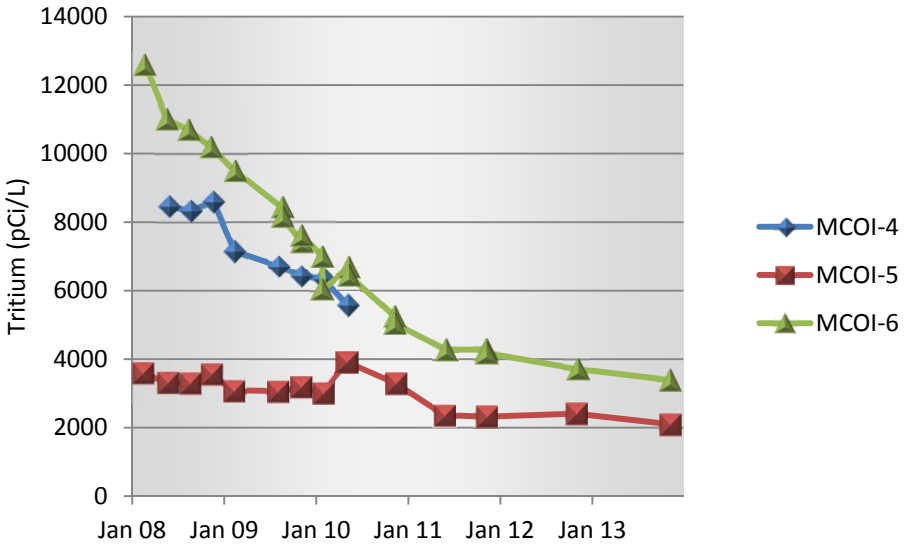


Figure 5-26 **Tritium in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 20,000 pCi/L.**

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 2013.

No alluvial wells in Mortandad Canyon were sampled during 2013 for radionuclides. 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 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 DCS screening levels (applicable to effluent discharges).

Under the groundwater discharge plan application for the TA-50 RLWTF and NPDES outfall, the Laboratory has collected additional quarterly samples since 1999 for nitrate, fluoride, perchlorate, and TDS from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCO-3, MCO-4B, MCO-6, and MCO-7 (Table 5-16). Because of drought conditions during 2013, there was little runoff, and alluvial wells in Mortandad Canyon were often dry. MCO-3 was destroyed by flooding in September 2013.

Table 5-16
Groundwater Quality in Mortandad Canyon Alluvial Groundwater

Chemical	Location	Result	Trends
Fluoride	Alluvial well MCO-7	1.08 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 well MCO-7	9.4 µg/L, above Consent Order screening level of 4 µg/L	Results substantially decreasing since 2002 effluent treatment upgrades
TDS	Alluvial well MCO-4B	649 mg/L, below NM groundwater standard of 1000 mg/L	Has been about 300 mg/L since 2005

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 5-27). 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. Of alluvial wells in this canyon, only MCO-3 was sampled for chloride in 2013. The TDS result of 649 mg/L at MCO-4B in November 2013 was above a previous high (except for an outlier) of 493 mg/L in June 2003.

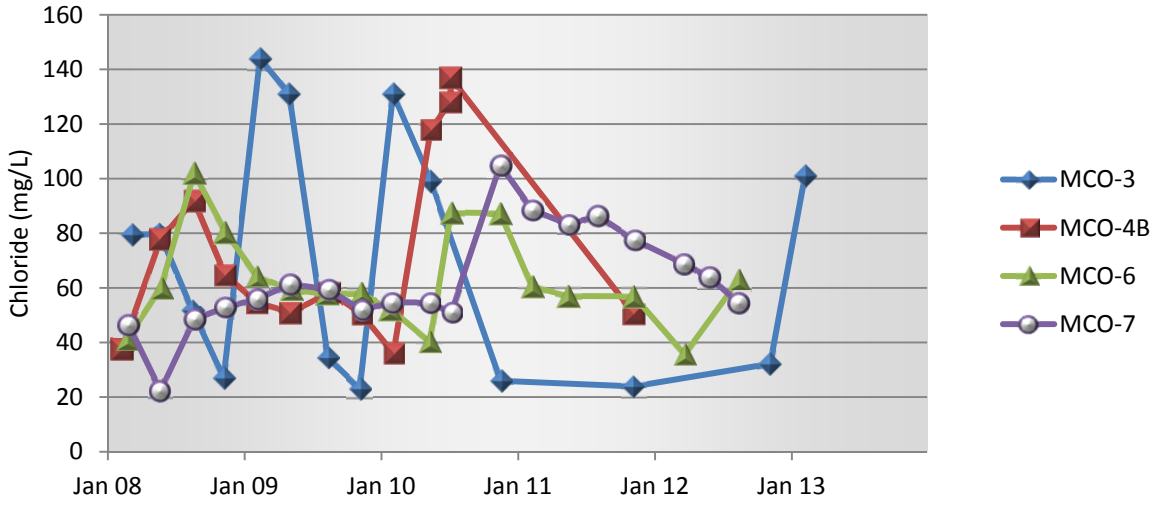


Figure 5-27 **Chloride at general surveillance and groundwater discharge plan monitoring locations in Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.**

The chloride concentrations at MCO-3 and downstream alluvial groundwater wells have risen since 2003 and since 2006 are higher than most previous values. The RLWTF effluent discharge and total chloride mass discharge decreased after 1990 and were temporarily suspended since 2010. 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 2013 nitrate (as N) concentrations in these wells were below the NM groundwater standard of 10 mg/L; the maximum was 2.96 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 2013 groundwater fluoride concentration downstream of the former RLWTF outfall was 1.08 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 5-28). The 2013 concentrations at three 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.

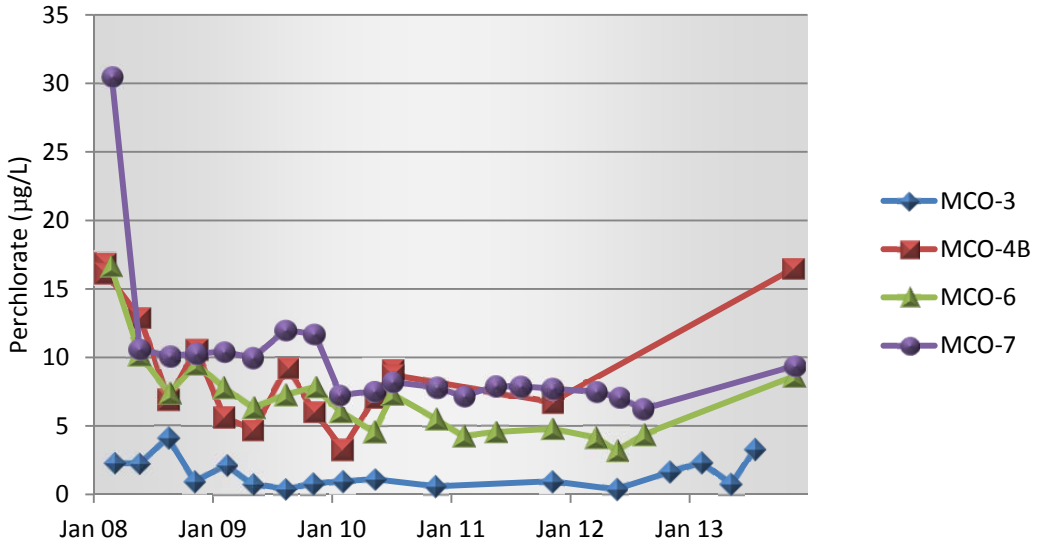


Figure 5-28 **Perchlorate at general surveillance and groundwater discharge plan monitoring locations in Mortandad Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.**

d. Cañada del Buey General Surveillance Monitoring

Alluvial well CDBO-6 in Cañada del Buey was dry and not sampled in 2013.

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 5-17). Some firing sites border portions of tributaries Twomile and Threemile Canyons. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at TA-18. Waste management areas at TA-54, used for disposal of organic chemicals and low-level radioactive waste, occupy the mesa north of the lower part of the canyon. A small contaminated 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 5-18 and 5-19).

Table 5-17
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	Antimony at 88% of EPA MCL screening levels
TA-54 monitoring group (Mortandad and Pajarito Canyons)	Noneffluent sources	No monitoring locations	1,4-dioxane at 59% of EPA regional screening level for tap water; trichloroethene at 16% of EPA MCL screening level	None
Pajarito, Twomile, and Threemile Canyons	Noneffluent sources, liquid sources major in the past but minor currently	None	1,1-dichloroethene at 41% of; 1,1,1-trichloroethane at 88% of; and iron above NM groundwater standards; 1,4-dioxane above EPA regional screening level for tap water	None

Table 5-18
Groundwater Quality in the MDA C and TA-54 Monitoring Groups

Chemical	Location	Result	Trends
Total antimony	MDA C regional aquifer well R-46	3.7 µg/L to 5.3 µg/L, below EPA MCL screening level of 6 µg/L	Results in this range since first samples in 2009
Dioxane[1,4-]	TA-54 intermediate well R-37 S1	One sample nondetect and one at 3.95 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 3-µg/L MDL and estimated

Table 5-19
Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
Iron	Intermediate well 03-B-13	3470 µg/L, above 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	2.0 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	52.9 µg/L, below NM groundwater standard of 60 µg/L	Detected in every sample since 2006, seasonally variable
Dioxane[1,4-]	Intermediate well 03-B-13	38.5 µg/L, above EPA regional screening level for tap water of 6.7 µg/L	Detected since 2006, seasonally variable

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 2011a). The primary vapor-phase contaminants beneath MDA C are trichloroethene 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.

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 2011b, 2011c, 2011c).

a. MDA C Monitoring Group

The total and filtered antimony concentrations at regional aquifer well R-46 ranged from 3.7 µg/L to 5.3 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 chemical bis(2-ethylhexyl)phthalate was not detected in samples from regional aquifer well R-46 for the first time since well construction. The concentration of this compound was 96 µg/L in samples taken after well construction in 2009, and concentrations have declined with time. The EPA MCL screening level is 6 µg/L. The presence of bis(2-ethylhexyl)phthalate was 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 has not been detected since that date. Concentrations reached 3.04 µg/L in December 2009. Sample concentrations then declined through early 2012. The EPA MCL for trichloroethene (which does not apply to these samples) is 5 µg/L.

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 µg/L and 0.81 µg/L. Trichloroethene was not detected in samples at this screen during 2012 or 2009 but was detected in one of two samples in 2013 at 0.8 µg/L.

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 2013 samples from R-37 S1, the 929-ft intermediate upper screen of R-37, located near the upper part of Cañada del Buey (Figure 5-29). The detected concentration was 59% of the EPA regional screening level for tap water. This 3.5-µg/L result was estimated because it was near the 3-µg/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.

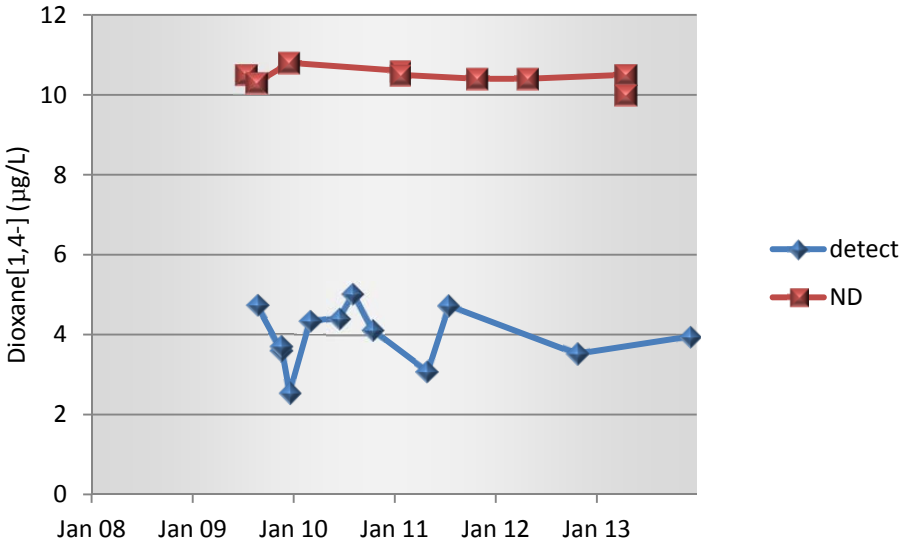


Figure 5-29 **Concentrations of 1.4-dioxane in Mortandad Canyon intermediate groundwater at 929 ft in R-37; the EPA tap water screening level is 6.7 µg/L. All detected results are estimated; by convention, nondetects (ND) are reported at the PQL. Presenting results for both detects and nondetects shows all the sample data and their relationship through time.**

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. Samples from 03-B-13 in past years had chloride (Figure 5-30) 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 chlorinated solvents (Table 5-19). 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.

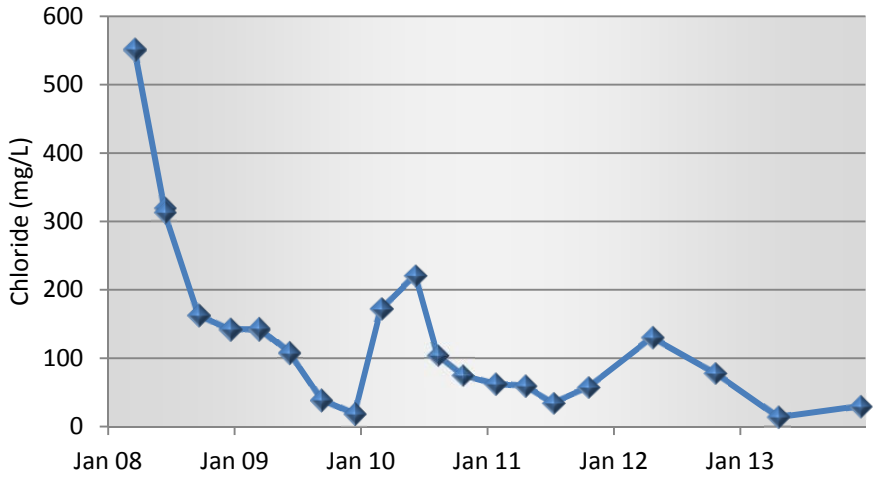


Figure 5-30 Chloride in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 250 mg/L.

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. Under more reducing conditions (that is, with less oxygen), iron and manganese are more soluble; these changes lead to observed seasonal changes in turbidity and concentrations of dissolved iron and manganese.

Figures 5-31 through 5-33 show 1,1-dichloroethene; 1,1,1-trichloroethane; and 1,4-dioxane histories for 03-B-13 (see also Figure 5-24). For some solvents, retention on solid surfaces is lower in water with overall higher dissolved 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.

Several other alluvial and intermediate groundwater and regional aquifer wells in Pajarito Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above applicable standards in these wells during 2013.

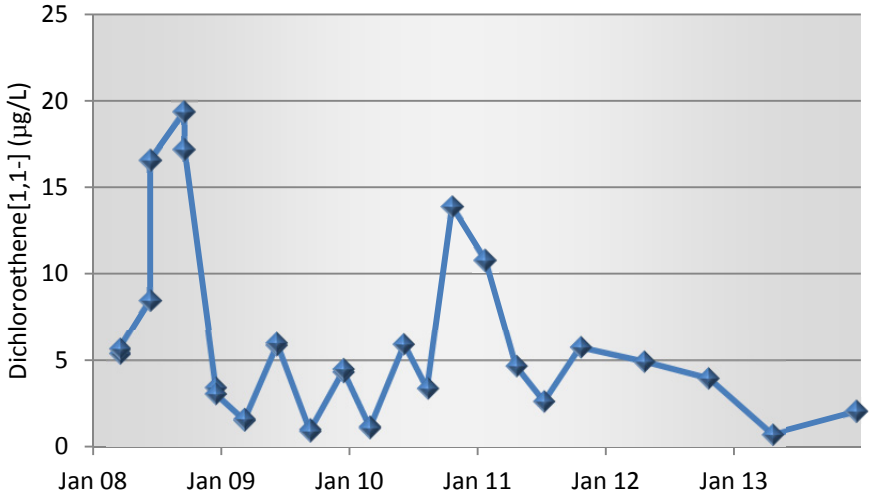


Figure 5-31 Concentrations of 1,1-dichloroethene in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 5 µg/L.

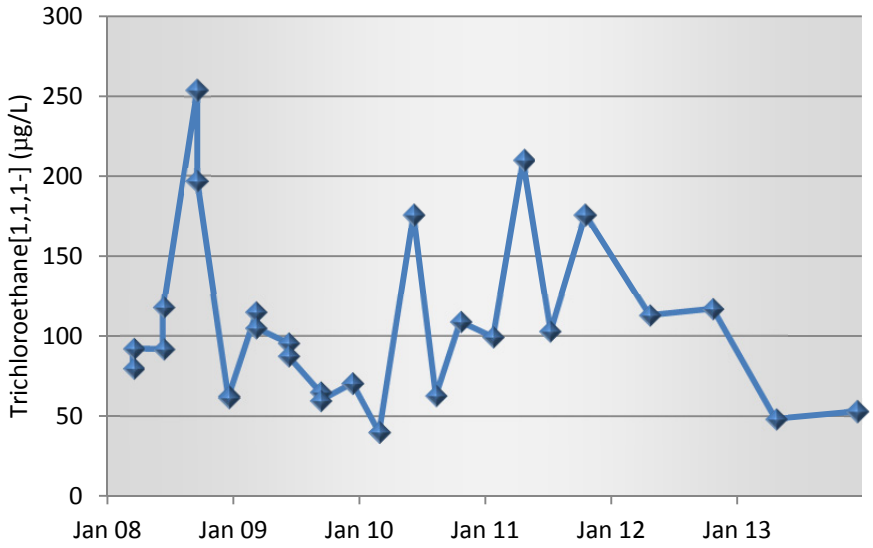


Figure 5-32 **Concentrations of 1,1,1-trichloroethane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 60 µg/L.**

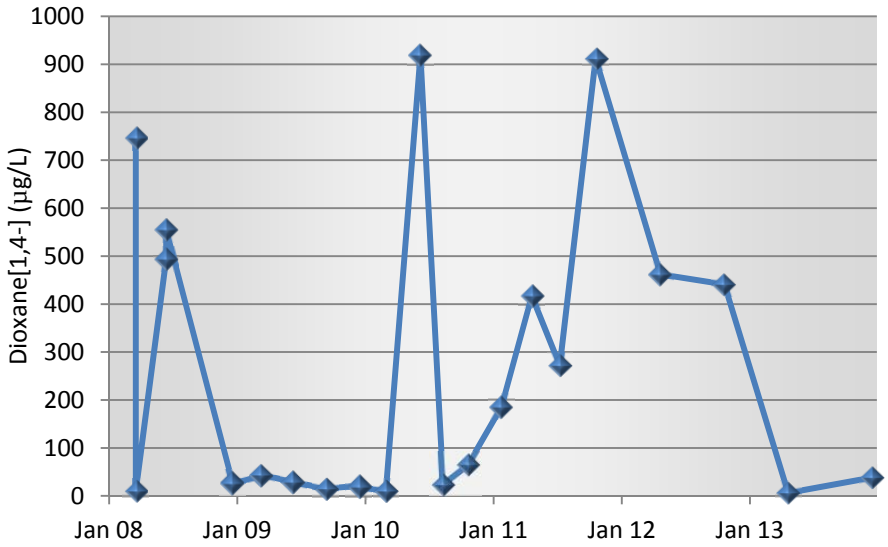


Figure 5-33 **Concentrations of 1,4-dioxane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. For comparison purposes, the EPA regional screening level for tap water is 6.7 µg/L.**

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 the Laboratory 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 5-20). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall at the High Explosives Wastewater Treatment Facility. This outfall has evaporated all treated effluent since June 2007 but is permitted to discharge, as needed.

Table 5-20
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, RDX above EPA regional screening level for tap water, trichloroethene at 59% of and tetrachloroethene above EPA MCL screening level	Boron above NM groundwater standard, tetrachloroethene at 51% and trichloroethene at 43% of EPA MCL screening levels, RDX above EPA regional screening level for tap water	RDX at 30% 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 weapon 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 discharged HE-bearing water from an HE-machining facility to Cañon de Valle from 1951 through 1996.

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 5-34), 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 30% of the 6.1-µg/L EPA regional screening level for tap water (Table 5-21). RDX has been detected at this well at increasing concentrations in every sample since August 2006. Tetrachloroethene was also detected for the first time in September 2013 in this regional aquifer well, at concentrations below the 5-µg/L EPA MCL screening level. However, the results are just above the 0.30-µg/L MDL, and tetrachloroethene was not detected in the R-18 samples collected in March 2013 or March 2014.

Regional well R-63 was first sampled in 2011. The 2013 RDX concentrations ranged from 1.21 µg/L to 1.44 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 2013 RDX concentrations of 0.31 µg/L to 0.90 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.

Samples from intermediate Bulldog Spring in upper Pajarito Canyon contained RDX, HMX, and other HE compounds similar to prior years. The RDX result from Bulldog Spring was up to 75% of the EPA regional screening level for tap water.

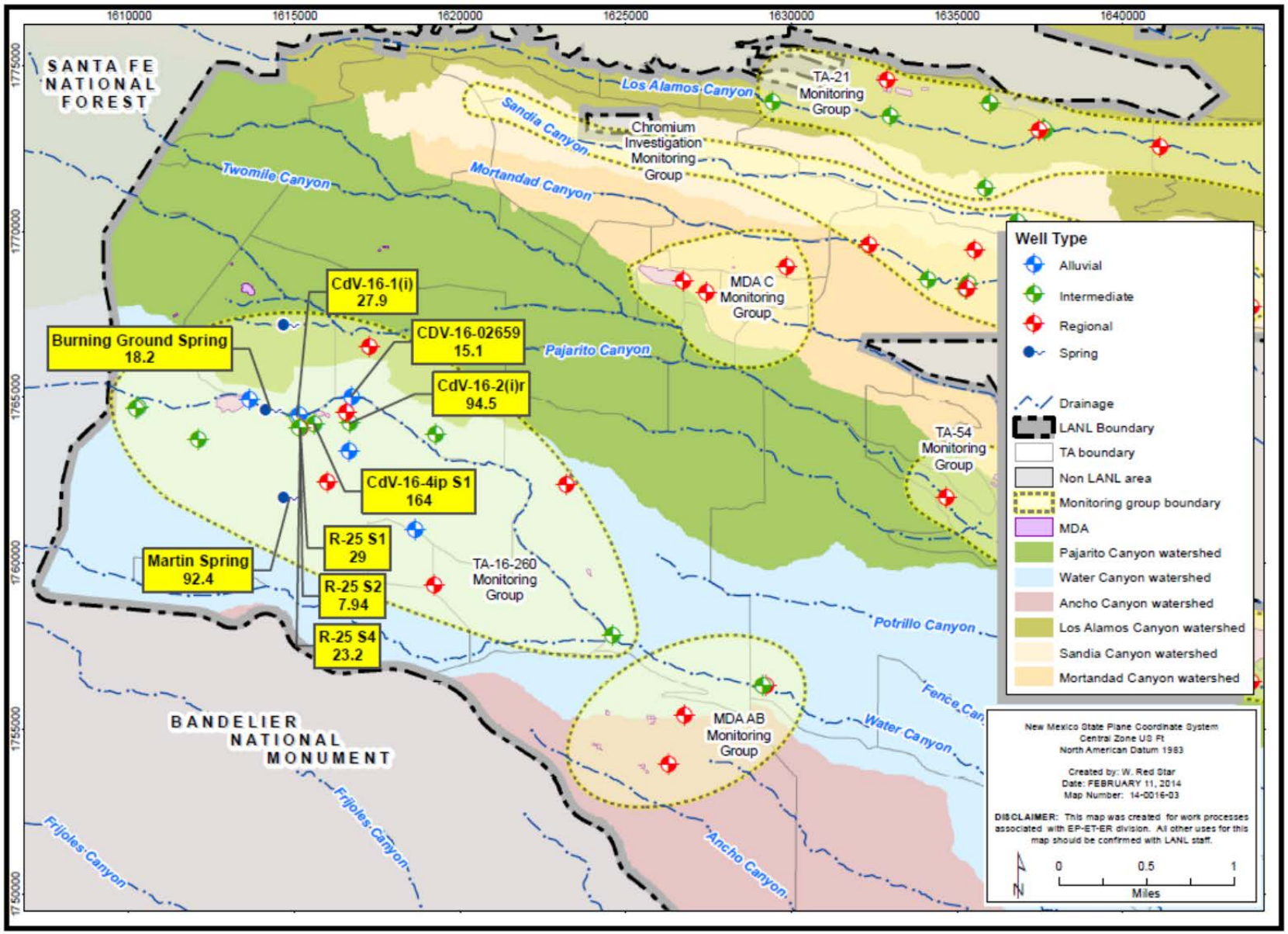


Figure 5-34 Wells and springs with 2013 RDX concentrations above the 6.1-µg/L EPA tap water screening level. Maximum concentration for the year is shown in µg/L.

Table 5-21
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 1.8 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
Tetrachloroethene	Regional aquifer well R-18	Up to 0.35 µg/L, below EPA MCL screening level of 5 µg/L	First detection in 9 yr of sampling. Results are just above the 0.30-µg/L MDL.
Boron	Intermediate Martin Spring	1100 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Approximate 60% decrease since 2003
RDX	Eight intermediate wells or well screens	Up to 164 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Highest at CDV-16-4ip S1, present at these levels for several years
RDX	Intermediate Bulldog, Martin, and Burning Ground Springs	Up to 92 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	Nine intermediate wells or well screens	Up to 2.56 µg/L, below EPA MCL screening level of 5 µg/L	Present at these levels for several years
Tetrachloroethene	Intermediate Burning Ground Spring	Up to 1.79 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 1.91 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, one in Fishladder Canyon	677 µg/L to 12,200 µg/L, above NM groundwater standard of 1000 µg/L	Present at these levels for several years of sampling
RDX	One alluvial well in Cañon de Valle, one in Fishladder Canyon	Up to 15 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Present at these levels for several years of sampling
Tetrachloroethene	One alluvial well in Fishladder Canyon	15.6 µg/L, above EPA MCL screening level of 5 µg/L	Decreased from 200 µg/L in 2009
Trichloroethene	One alluvial well in Fishladder Canyon	2.97 µg/L, below EPA MCL screening level of 5 µg/L	Decreased from 23 µg/L in 2008

Samples from eight intermediate-perched zone wells or well screens contained RDX at concentrations near or above the 6.1-µg/L EPA regional screening level for tap water (Figures 5-34 through 5-37). 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 5-35 and 5-36). 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 5-21).

Boron was found in samples from intermediate groundwater at Martin Spring at concentrations above the NM groundwater standard for irrigation use (Figure 5-38); however, this spring is not used for irrigation. Boron is also present at elevated levels in downstream alluvial wells.

Barium exceeded the NM groundwater standard in several alluvial wells in Cañon de Valle (Figures 5-39 and 5-40). 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 5-34 and 5-41).

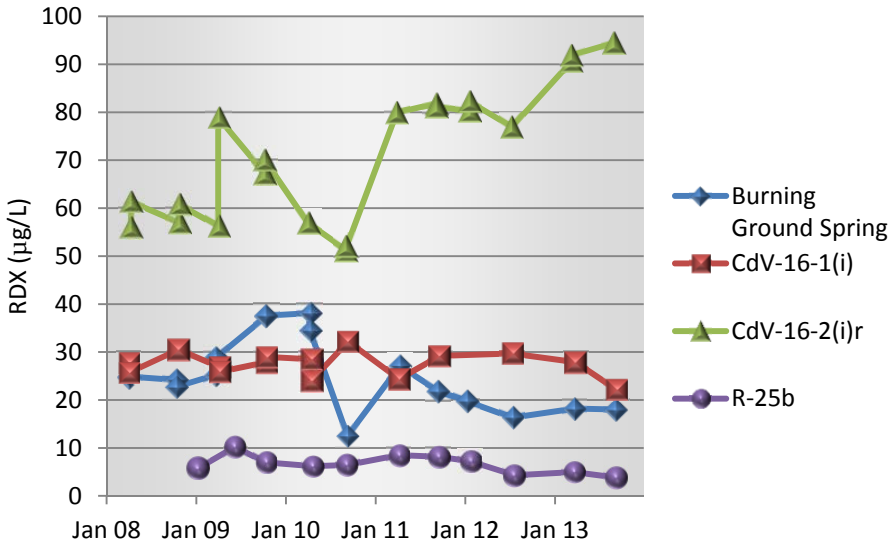


Figure 5-35 **RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA tap water screening level is 6.1 µg/L.**

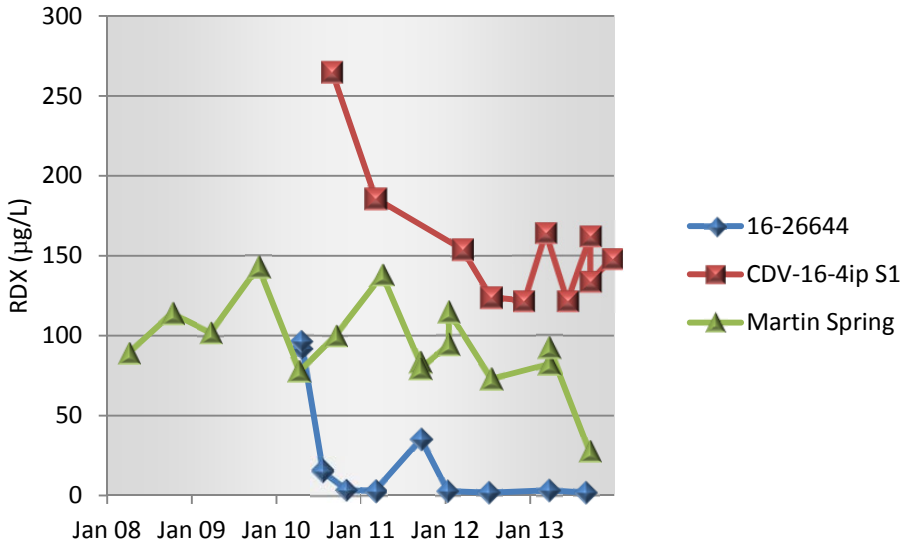


Figure 5-36 **RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA tap water screening level is 6.1 µg/L.**

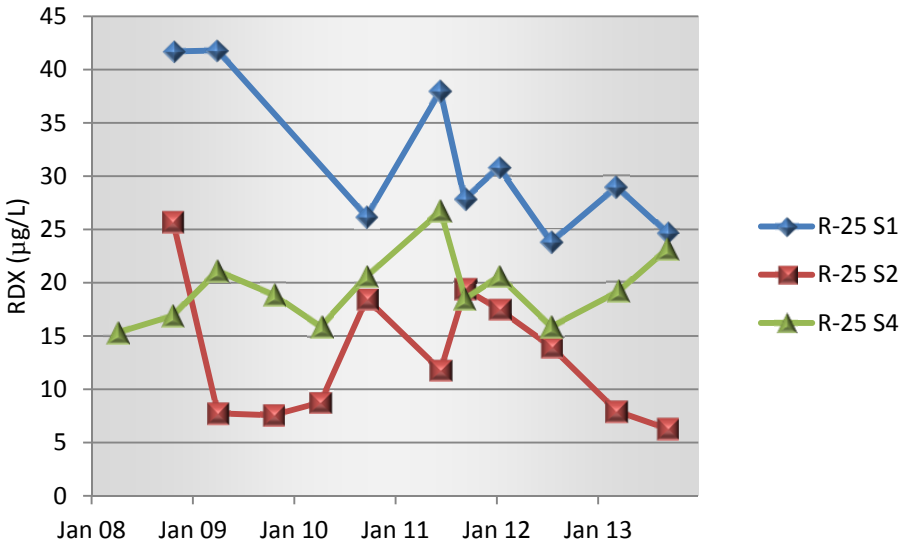


Figure 5-37 **RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA regional screening level for tap water is 6.1 µg/L.**

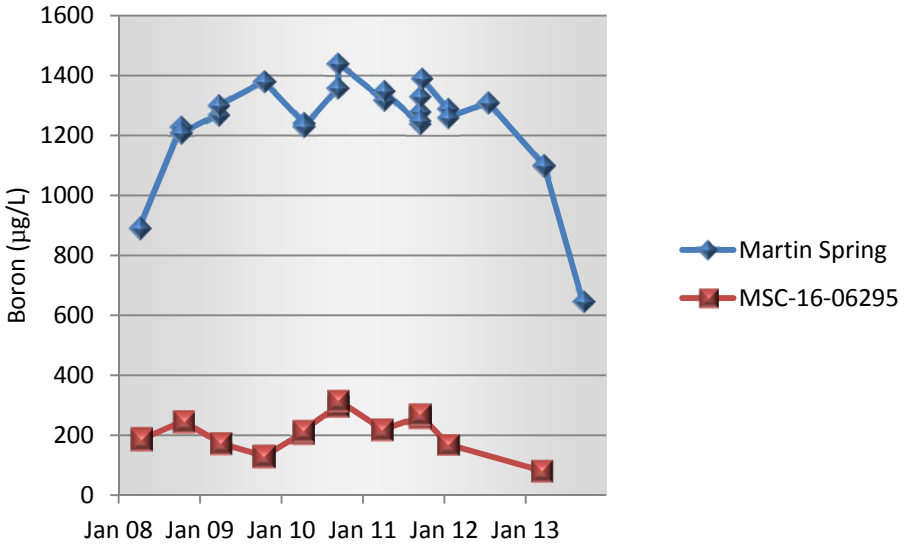


Figure 5-38 **Boron at intermediate groundwater Martin Spring and an alluvial groundwater well in the TA-16 260 monitoring group in Martin Spring Canyon (a Cañon de Valle tributary). The NM groundwater standard for irrigation use is 750 µg/L.**

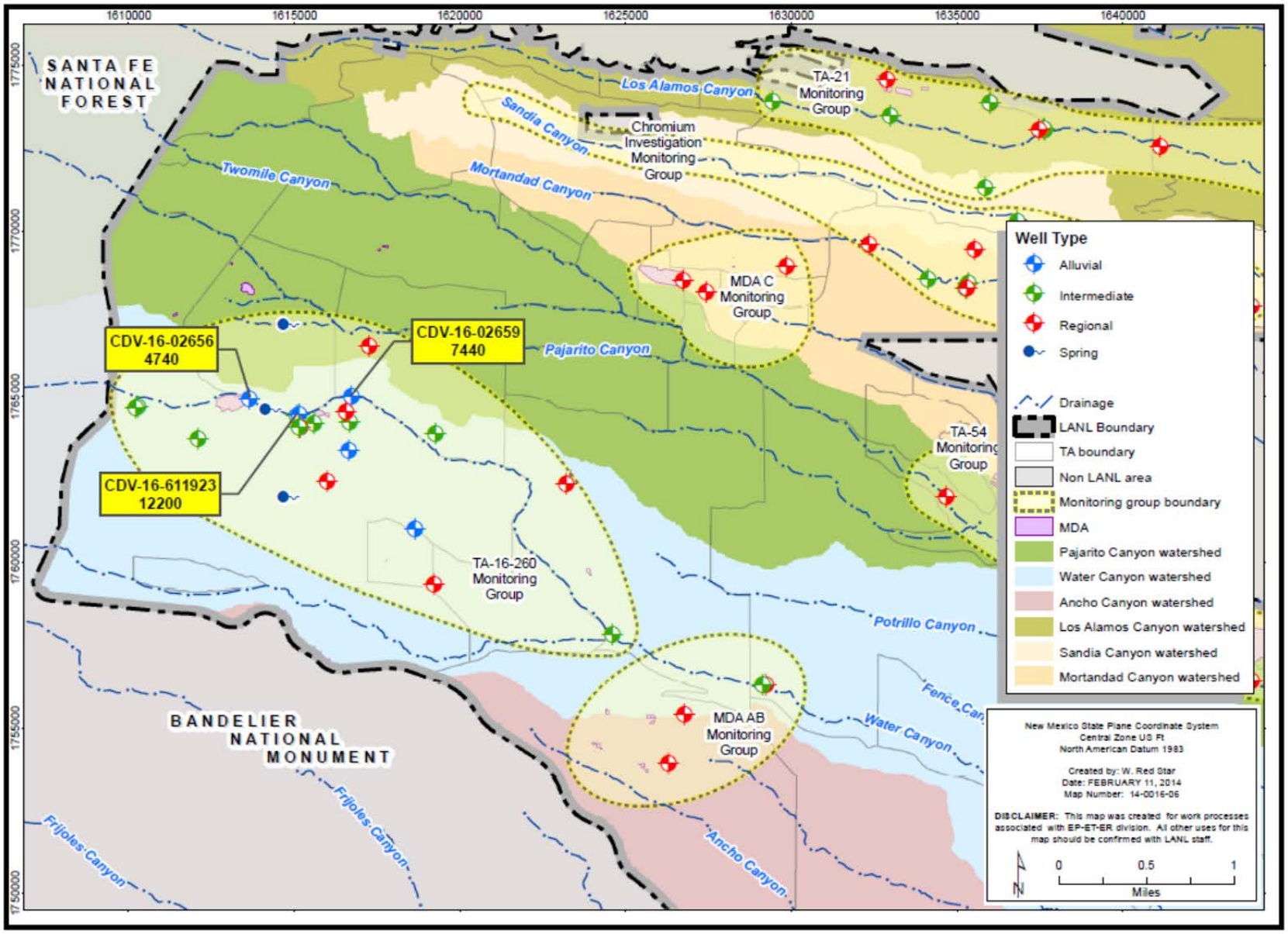


Figure 5-39 Wells with 2013 barium concentrations above the 1000-µg/L NM groundwater standard. The maximum concentration for the year is shown in µg/L.

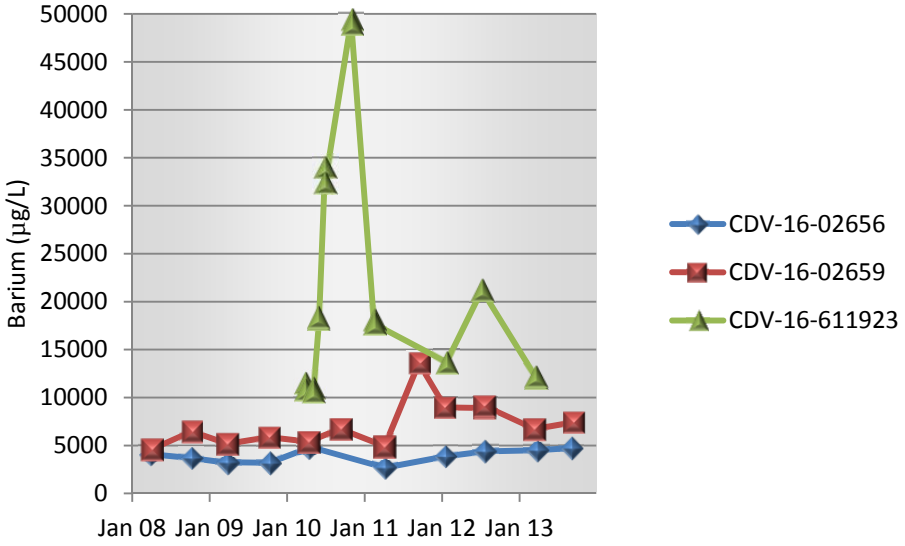


Figure 5-40 **Barium in the TA-16 260 monitoring group in Cañon de Valle alluvial groundwater. The NM groundwater standard is 1000 µg/L.**

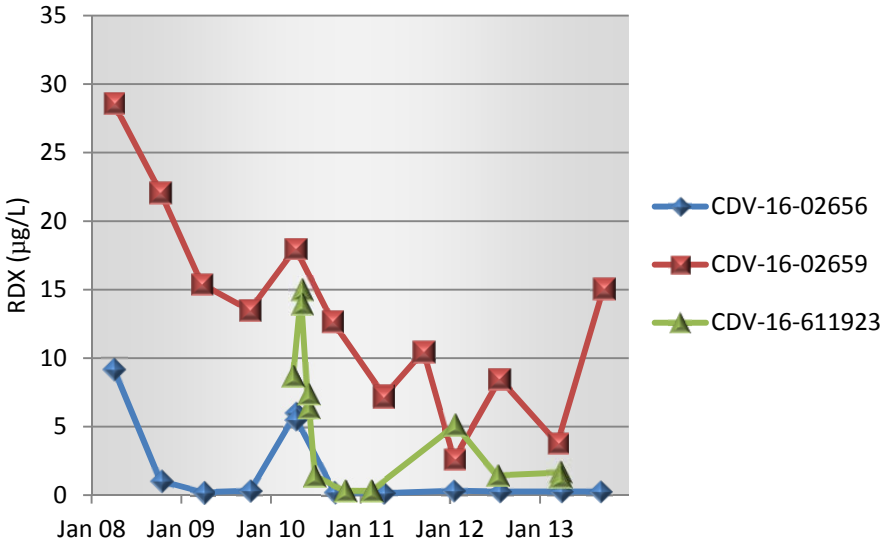


Figure 5-41 **RDX in the TA-16 260 monitoring group in Cañon de Valle alluvial groundwater. The EPA tap water screening level is 6.1 µg/L.**

Barium in the 2013 sample from alluvial well FLC-16-25280 in Fish Ladder Canyon (Figure 5-42) was 677 µg/L or 68% of the 1000-µg/L NM groundwater standard.

The 2013 sample from this well also contained tetrachloroethene (15.6 µg/L) and trichloroethene (2.97 µg/L) (Figure 5-43). Both compounds have EPA MCL screening levels of 5 µg/L; the tetrachloroethene concentration was above the screening level. The well has been sampled since 2006, with prior tetrachloroethene results up to 200 µg/L in 2009. Tetrachloroethene concentrations of about 40 µg/L have also been found in past samples from nearby Fish Ladder Spring. Past trichloroethene concentrations measured at FLC-16-25280 were up to 12 µg/L. Both compounds are found in other groundwater samples in this part of the Laboratory.

The 2013 RDX concentration of 4.76 µg/L in FLC-16-25280 was below the 6.1-µg/L EPA regional screening level for tap water (Figure 5-44). RDX concentrations in the well have been near or above the screening level since the first samples were collected in 2008.

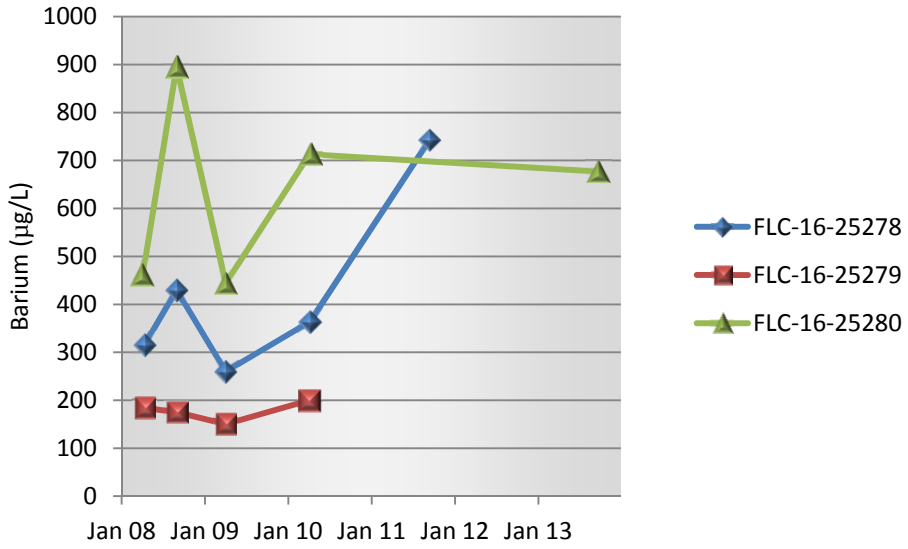


Figure 5-42 **Barium in the TA-16 260 monitoring group in Fishladder Canyon alluvial groundwater. The NM groundwater standard is 1000 µg/L.**

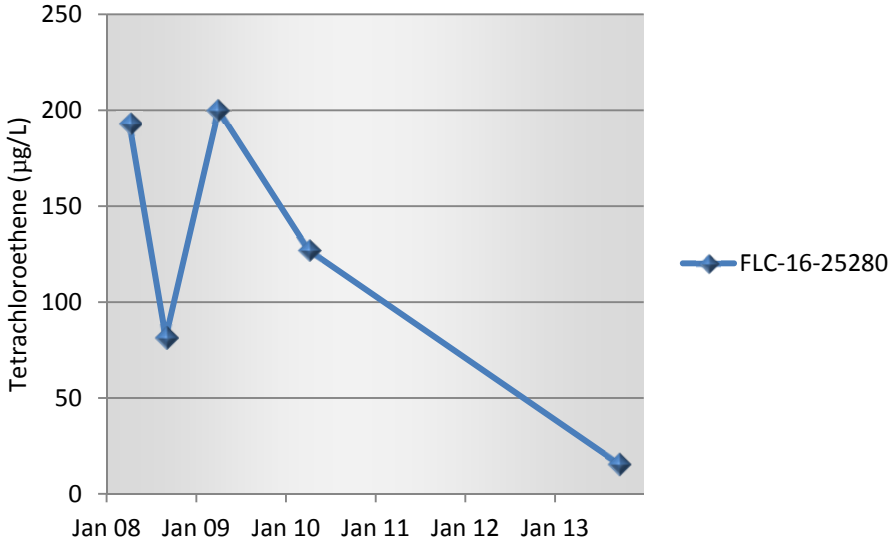


Figure 5-43 **Tetrachloroethene in the TA-16 260 monitoring group in Fishladder Canyon alluvial groundwater. The EPA MCL screening level is 5 µg/L.**

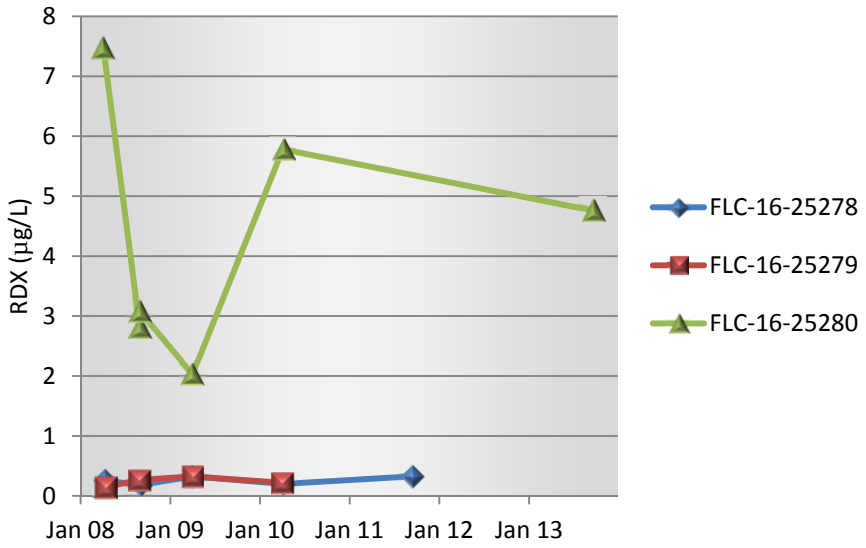


Figure 5-44 **RDX in the TA-16 260 monitoring group in Fishladder Canyon groundwater. The EPA tap water screening level is 6.1 µg/L.**

b. Water Canyon General Surveillance Monitoring

Water Canyon has only one general surveillance monitoring location, alluvial well WCO-1r. This well was dry in 2013.

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 involved 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).

In 2013, no contaminants were found in MDA AB wells at concentrations near or above standards (Table 5-22).

Two screens of regional aquifer well R-31 in Ancho Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above standards in these screens during 2013.

Table 5-22
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 5-23). 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). Only a few springs were sampled during 2013 and analytical suites were limited.

Table 5-23
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 5-24). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs. The gross-alpha activity in the spring was above the 15-pCi/L EPA MCL screening level, reflecting the presence of uranium. The 15-pCi/L gross-alpha EPA MCL excludes the gross-alpha contribution from uranium; this gross-alpha result was not corrected for uranium.

Table 5-24
Groundwater Quality in White Rock Canyon Springs

Chemical	Location	Result	Trends
Uranium	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	12.1 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	15.9 pCi/L, above EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; this value was not corrected for this)	Naturally occurring, because of uranium
Arsenic	Regional aquifer Sacred Spring (Pueblo de San Ildefonso)	4.1 µg/L, below EPA MCL screening level of 10 µg/L; NM groundwater standard is 100 µg/L	Naturally occurring

Two White Rock Canyon springs, La Mesita Spring and Sacred Spring, were sampled for perchlorate in 2013. The results were consistent with prior data. The highest perchlorate concentration of 0.888 µg/L occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso land. This spring also shows elevated concentrations for nitrate (2.67 mg/L, below the 10-mg/L NM groundwater standard) and uranium (12.1 µg/L, below the 30-µg/L NM groundwater standard); it is not located near any apparent sources of contamination.

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Los Alamos National Laboratory (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. That is, human health and ecological risk assessments have been performed as part of each of the Canyons Investigation Reports (IRs) conducted under the Compliance Order on Consent. The human health risk assessments in those reports have concluded that concentrations of contaminants present in canyon 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 Laboratory 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 2013 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.

A. INTRODUCTION

Los Alamos National Laboratory (LANL or 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 the Laboratory 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 the Laboratory 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 July 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/Pueblo, Sandia, and Mortandad Canyon watersheds (LANL 2008a, 2008b, 2011d, 2012a, 2013a, 2014).

Sediment and surface water monitoring and assessments at the Laboratory in 2013 occurred under several tasks. Extensive sediment monitoring in 2013 occurred following the annual summer monsoon season, and was based on the 2012 sediment 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 2013b). Control and monitoring of storm water discharges associated with permitted solid waste management units (SWMUs) and areas of concern (AOCs) occurred under the National Pollutant Discharge Elimination System (NPDES) Individual Permit for Storm Water (IP) (Permit No. NM0030759) with the U.S. Environmental Protection Agency (EPA). Sampling of storm water at gage stations occurred as part of the Laboratory's Environmental Surveillance Program. These data are presented in this chapter.

The Laboratory also operates under the NPDES Storm Water General Permit for Construction Activities (construction general permit [CGP]), which is used to control storm water discharges from projects that impact 1 acre or greater that are cleared, graded, or excavated. However, this permit does not require sampling. The Laboratory's NPDES Multi-Sector General Permit (MSGP) is used to monitor industrial activities and requires quarterly sampling of outfalls; however, discharges under this permit are not precipitation-based storm water, thus are not included in this chapter. The 2013 Interim Facility-Wide Groundwater Monitoring Plan (LANL 2012c) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels for an extensive list of constituents. These data are not from precipitation-based storm water, thus are not presented in this chapter; data are presented in Chapter 5 of this report. In addition, 2013 sampling of storm water occurred in watersheds along the western boundary of the Laboratory and in urban, developed landscapes in the Los Alamos townsite and on Laboratory 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 2013c).

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 2013, there was no snowmelt runoff that crossed the eastern boundary of the Laboratory. Total storm water runoff for 2013 at downstream gages in the canyons leaving the Laboratory is estimated at 1400 acre-feet (ac-ft), most of this occurring in Los Alamos, Pueblo, Pajarito, Water, Ancho, and Chaquehui Canyons. Runoff in Sandia, Mortandad, and Potrillo Canyons and Cañada del Buey is not minimal compared with previous years, but is minimal compared with the other canyons in 2013. Indeed, 2013 was the first time in almost 40 yr that water from Mortandad Canyon flowed off of the Laboratory. Figure 6-2 shows the estimated storm water runoff volume at the Laboratory for June through October from 2010 to 2013 and seasonal precipitation from 1995 to 2013, indicating that the total storm water runoff of the 5-mo period in 2013 (1400 ac-ft) was 30 times greater than in 2012 (47 ac-ft). Over 90% of the 2013 runoff occurred during the September 12 to 13 storm event. Approximately 20 ac-ft of the 2013 total storm water runoff volume is attributed to effluent from the Los Alamos County Waste Water Treatment Facility (WWTF) that reached gage station E060.1 during storm events in August and September. Figure 6-3 shows the 1995 to 2012 mean monthly total precipitation (snow water equivalent and monsoonal precipitation) across the Pajarito Plateau throughout each year and the 2013 mean monthly precipitation. Every month in 2013 was drier than normal, with the exception of July, September, and November. In August, the total monthly precipitation was only 43% of the historic mean. Figure 6-4 shows the 1995 to 2012 monthly mean of the daily maximum and minimum temperatures across the Pajarito Plateau throughout each year and the monthly mean of the daily maximum and minimum temperatures during 2013. The 2013 temperatures were above normal in March and June, below normal in January and February, and normal the rest of the year.

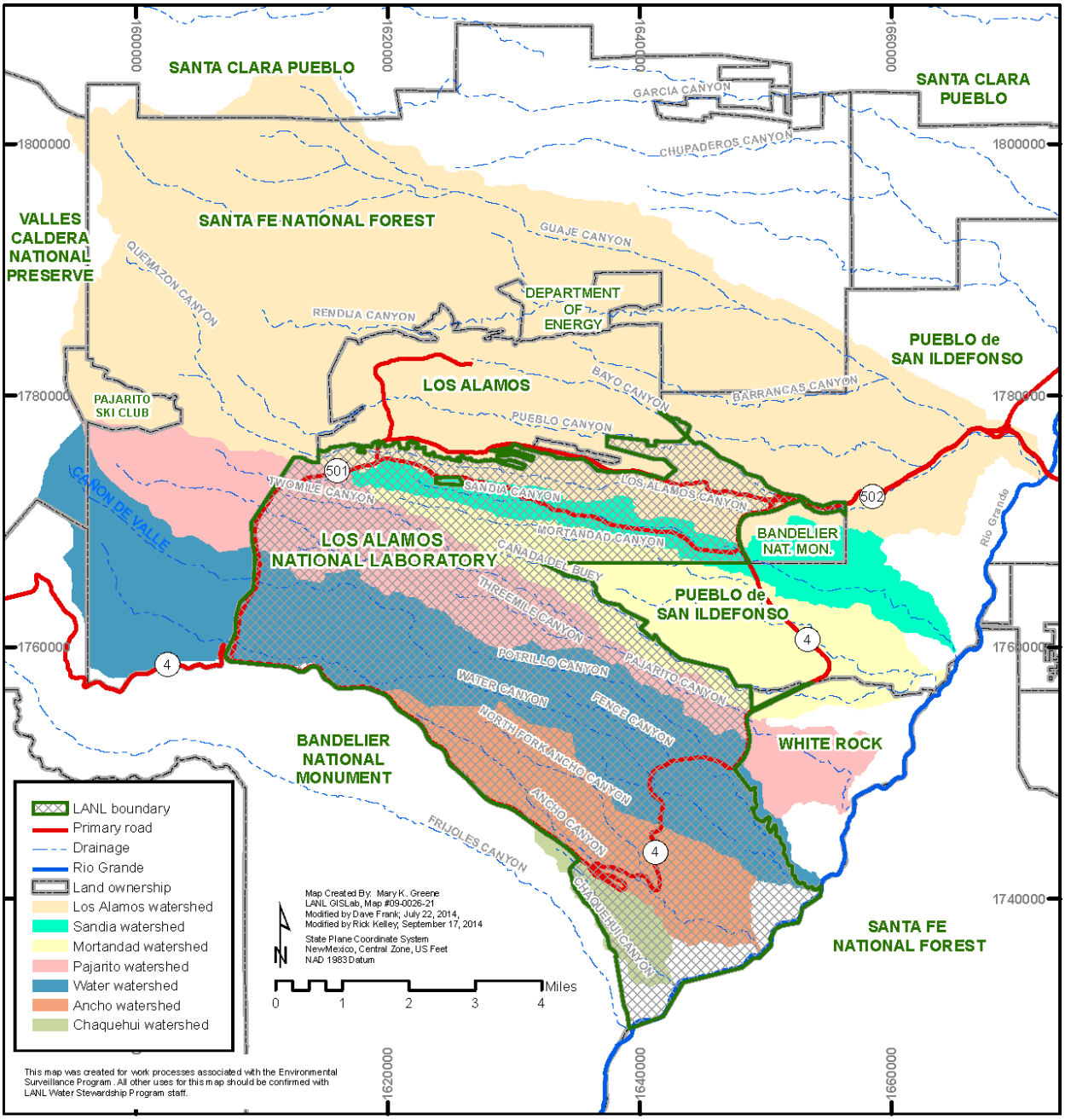


Figure 6-1 Primary watersheds at the Laboratory

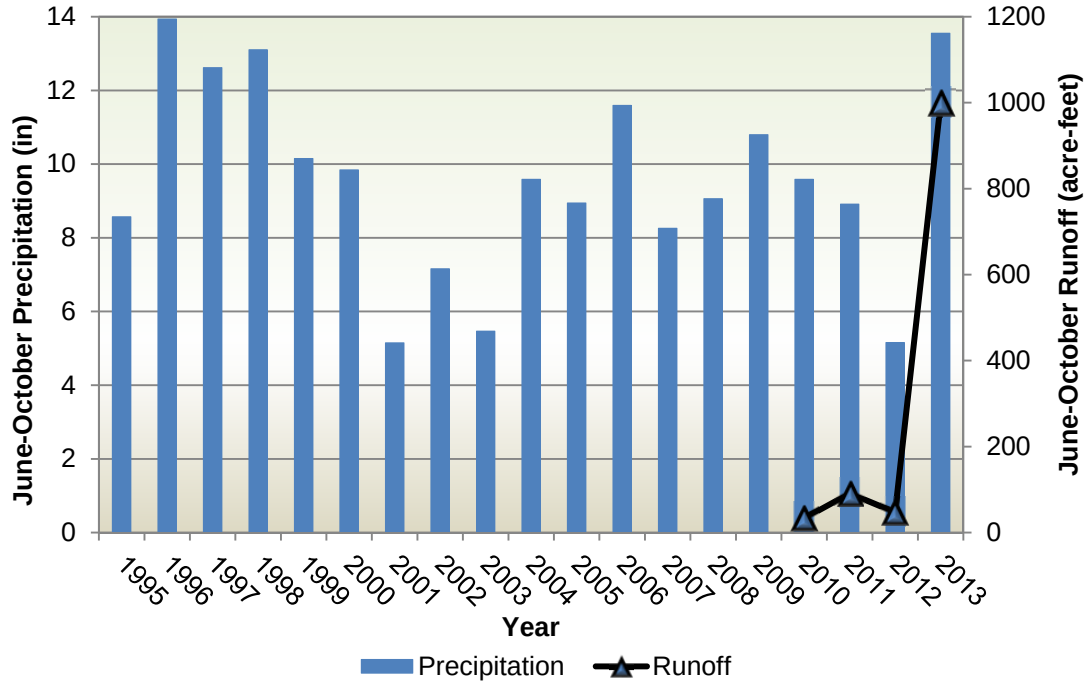


Figure 6-2 **Estimated storm water runoff volume in Laboratory canyons from 2010 to 2013 and total June through October precipitation from 1995 to 2013 averaged across the Laboratory's meteorological tower network (Technical Area 06 [TA-06], TA-49, TA-53, TA-54, and northern community)**

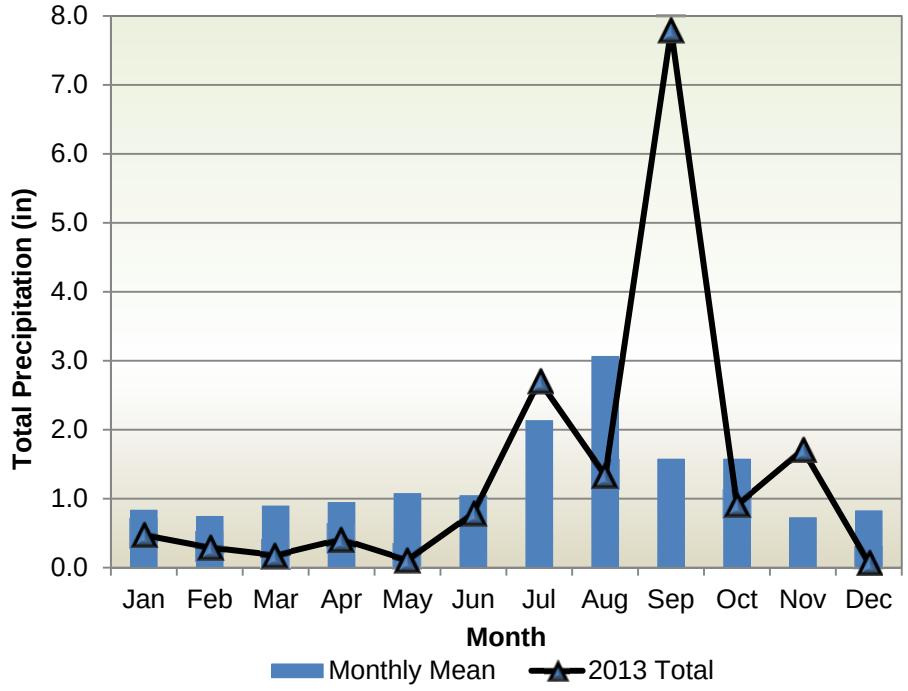


Figure 6-3 **Mean of the monthly total precipitation from the Laboratory's meteorological tower network (TA-06, TA-49, TA-53, TA-54, and northern community) over the period of record 1995 to 2012 and the mean of the monthly total precipitation during 2013**

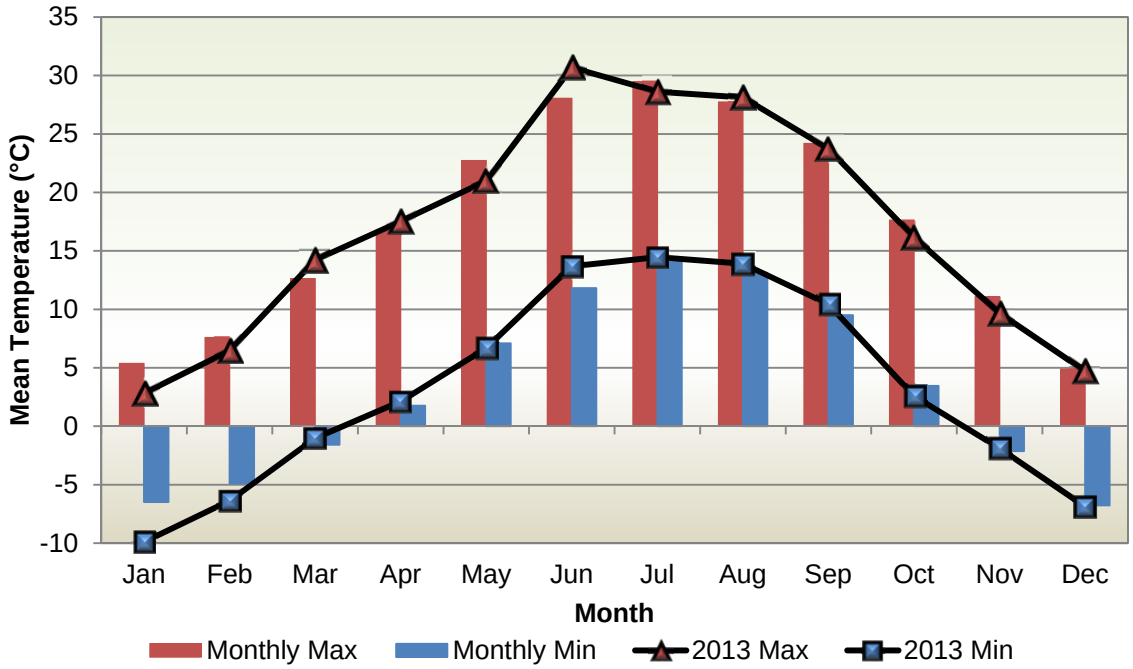


Figure 6-4 Monthly mean of the daily maximum and minimum temperatures averaged from the Laboratory's meteorological tower network (TA-06, TA-49, TA-53, and TA-54) over the period of record 1995 to 2012 and the monthly mean of the daily maximum and minimum temperatures during 2013

Between September 10 and 17, 2013, New Mexico and Colorado received a historically large amount of precipitation (see Chapter 4 for details). Los Alamos County, New Mexico, received between 200% and 600% of the normal precipitation for this time period, and the Laboratory received approximately 450% percent of its average precipitation for September, causing an exceptionally large volume of runoff compared with historical levels (Figures 6-2 and 6-3). The Laboratory was inundated with rain and runoff, including the extremely large, greater-than-1000-yr return period event that occurred between September 12 and 13. With saturated antecedent soil conditions from the September 10 storm, when the September 12 to 13 storm occurred, the flooding damaged the Laboratory's environmental monitoring and control infrastructure and included damage to access roads, groundwater monitoring wells, gage stations, watershed controls, and control measures installed under the NPDES IP. The damage to or impairment of flood- and sediment-control structures includes the following: a large amount of erosion occurred in the Pueblo Canyon Wetlands, the Mortandad Canyon sediment traps filled and overflowed, the upper Los Alamos Canyon detention basins associated with SWMU 01-001(f) filled and overflowed, the Los Alamos Canyon low-head weir filled and overflowed, the Pueblo Canyon grade-control structure aggraded and/or degraded in places, and the Pajarito Canyon retention structure retained a large amount of sediment.

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, 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 promote the establishment of additional riparian or wetland vegetation that will also dampen flood peaks and slow floods resulting in sediment deposition (LANL 2008a and 2008b). In DP Canyon, a grade-control structure was installed to stabilize and potentially bury the channel and adjacent floodplains where Laboratory-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 in May 1999 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 in upper Los Alamos Canyon below SWMU 01-001(f) to capture polychlorinated biphenyl (PCB) contaminated sediment in runoff into the canyon (from this point forward, these detention basins will be referred to as the upper Los Alamos Canyon detention basins). In Mortandad Canyon, three sediment traps were constructed 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 addition to Laboratory-installed controls, the existing wetlands in lower Pajarito Canyon and upper Sandia Canyon reduce peak discharge and trap suspended sediment.

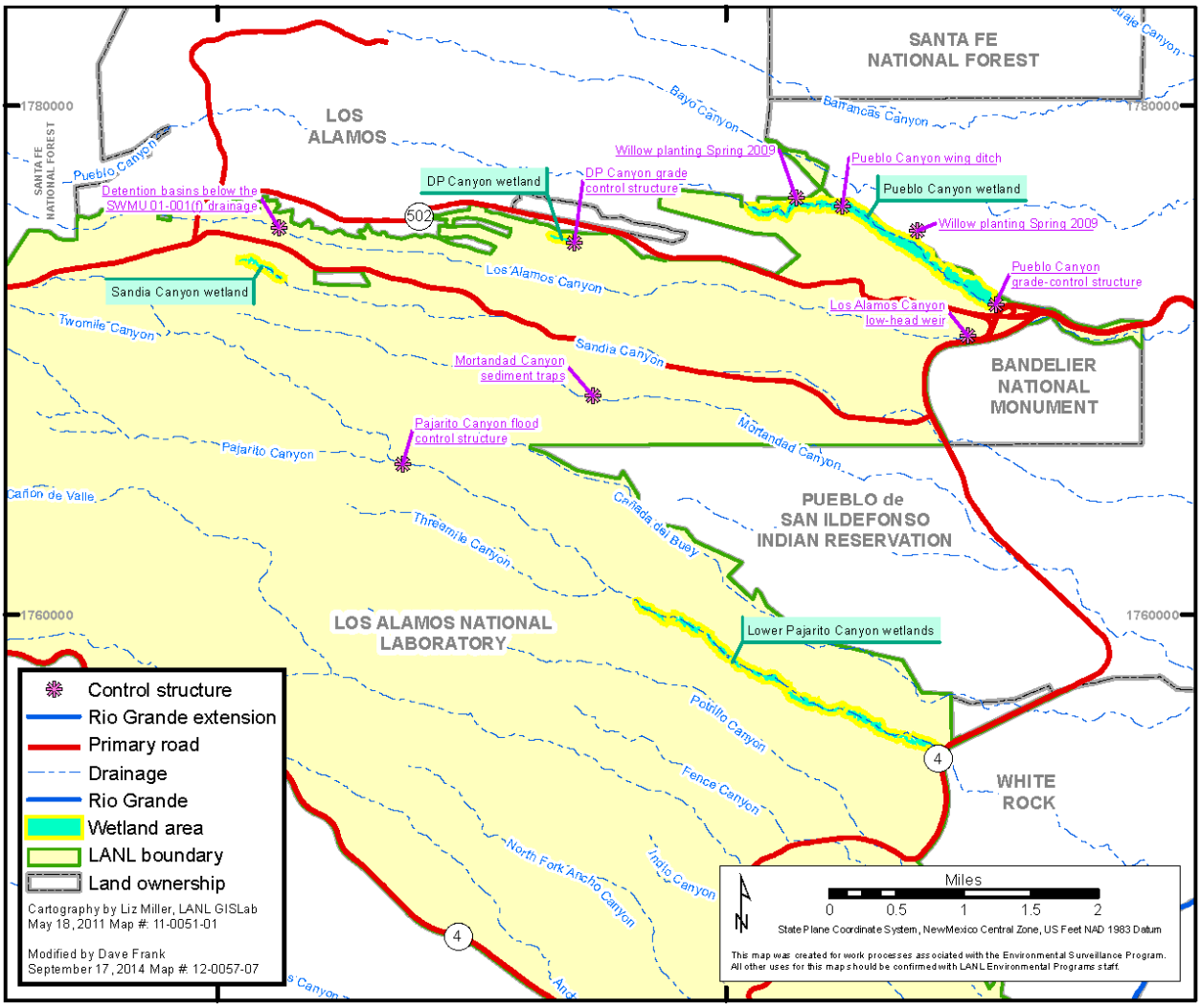


Figure 6-5 Sediment-control structures installed by the Laboratory

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 the Laboratory. 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 (coldwater or marginal warmwater) 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) exposure limit for riparian or terrestrial animals.
Surface water, nonradionuclides, radionuclides, and radioactivity		Background	LANL (2012d, 2013c)	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 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. Streamflow may also extend beyond the Laboratory boundary (i.e., onto Pueblo de San Ildefonso land).

Under the NMWQCC standards, all surface waters within Laboratory boundaries are assigned specified designated uses, including coldwater aquatic life, marginal warmwater aquatic life, limited aquatic life, livestock watering, wildlife habitat, primary contact, and secondary contact. Perennial surface waters within Laboratory 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 the Laboratory to Los Alamos County and portions of streams off of Laboratory property are designated as intermittent under 20.6.4.98 NMAC.

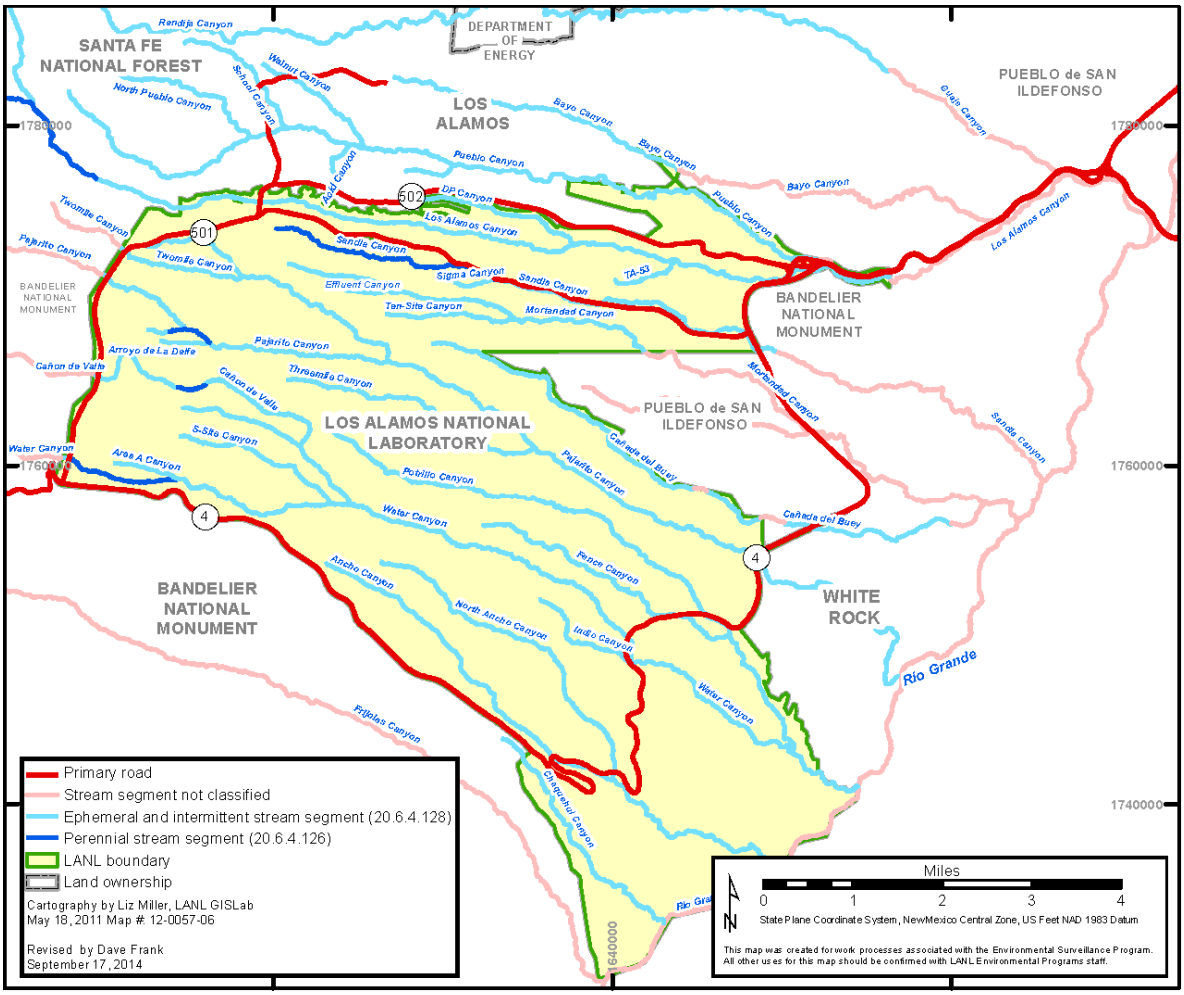


Figure 6-6 Major drainages within Laboratory land showing designated stream segments

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

Stream Segment	Designated Uses	Description of Associated Users
20.6.4.126 NMAC – "Perennial portions of Cañon deValle 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."	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
Designated perennial segments on Laboratory property, including parts of Cañon de Valle, Pajarito, Water, and Sandia Canyons	Coldwater aquatic life (i.e., chronic aquatic life standard)	Fish, aquatic invertebrates, etc.
20.6.4.128 NMAC – "Ephemeral and intermittent portions of watercourses within lands managed by U.S. department of energy (DOE) within Los Alamos national laboratory, 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.)"	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
Ephemeral and intermittent segments on Laboratory property		
20.6.4.98 NMAC – "All intermittent surface waters of the state that are not included in a classified water of the state in 20.6.4.101 through 20.6.4.899 NMAC."	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Marginal warmwater aquatic life	Limited ability for stream to sustain a natural aquatic life population on a continuous annual basis
Intermittent segments not on Laboratory property, i.e., Acid and Pueblo Canyons	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

Samples of storm water from Site Monitoring Areas (SMAs) associated with SWMUs and AOCs regulated under the IP (Permit No. NM0030759) are compared with target action levels (TALs) contained in the IP. Analytical results from storm water samples collected from gage stations under the Laboratory's 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" (LANL 2012d) and "Background Metals Concentrations and Radioactivity in Storm Water on the Pajarito Plateau, Northern New Mexico" (LANL 2013c). 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 $CaCO_3$/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 2013).

2. Radionuclides in Surface Water

DOE Order 458.1 (DOE 2011) prescribes total dose limits associated with exposure to radionuclides in environmental media. Because of the limited extent of streamflow, 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.

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 2013c). NMWQCC standards and Pajarito Plateau background values (BVs) 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 of 1954, and the gross-alpha radioactivity data discussed in this chapter were not adjusted to remove these sources of radioactivity.

3. Sediment

There are no regulatory compliance 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 2012d). 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 the Laboratory'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 the Laboratory'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 Laboratory lands and are also sampled along some short tributary drainages. Canyon-bottom channel and floodplain sediment is sampled to evaluate the accumulation of Laboratory-derived substances (DOE 1991), to evaluate trends over time, and to monitor effects on the canyon systems from disturbances such as construction and flooding subsequent to the Las Conchas fire. The Laboratory 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 streamflow and storm water samples collected using automated samplers.

Figure 6-7 shows surface water locations sampled in 2013 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, Sandia, and Mortandad Canyon watersheds. These locations are mostly at stream gages but also include grab samples at sediment detention basins in upper Los Alamos Canyon. Figure 6-8 shows locations of IP SMAs where storm water runoff samples were collected in 2013.

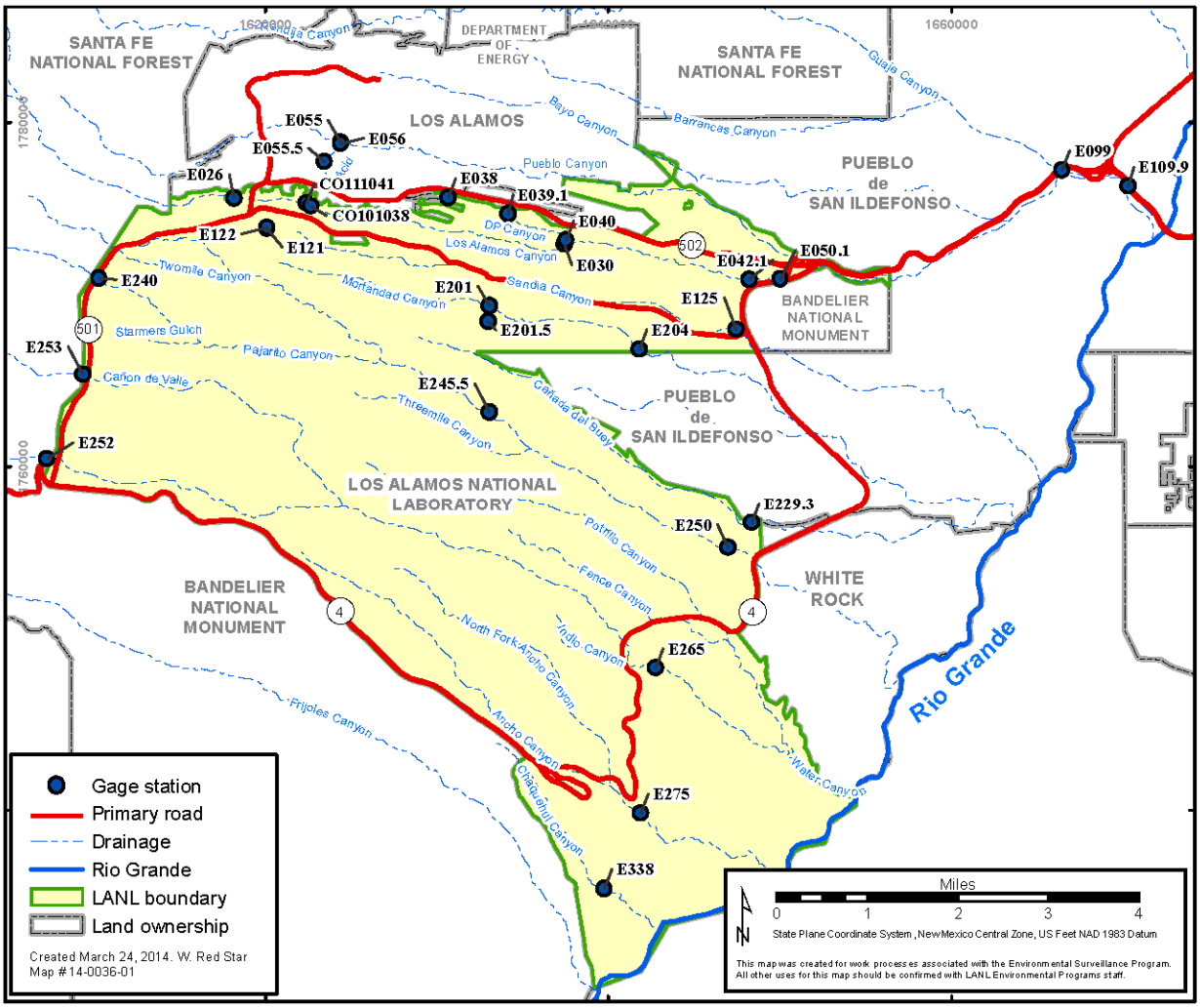
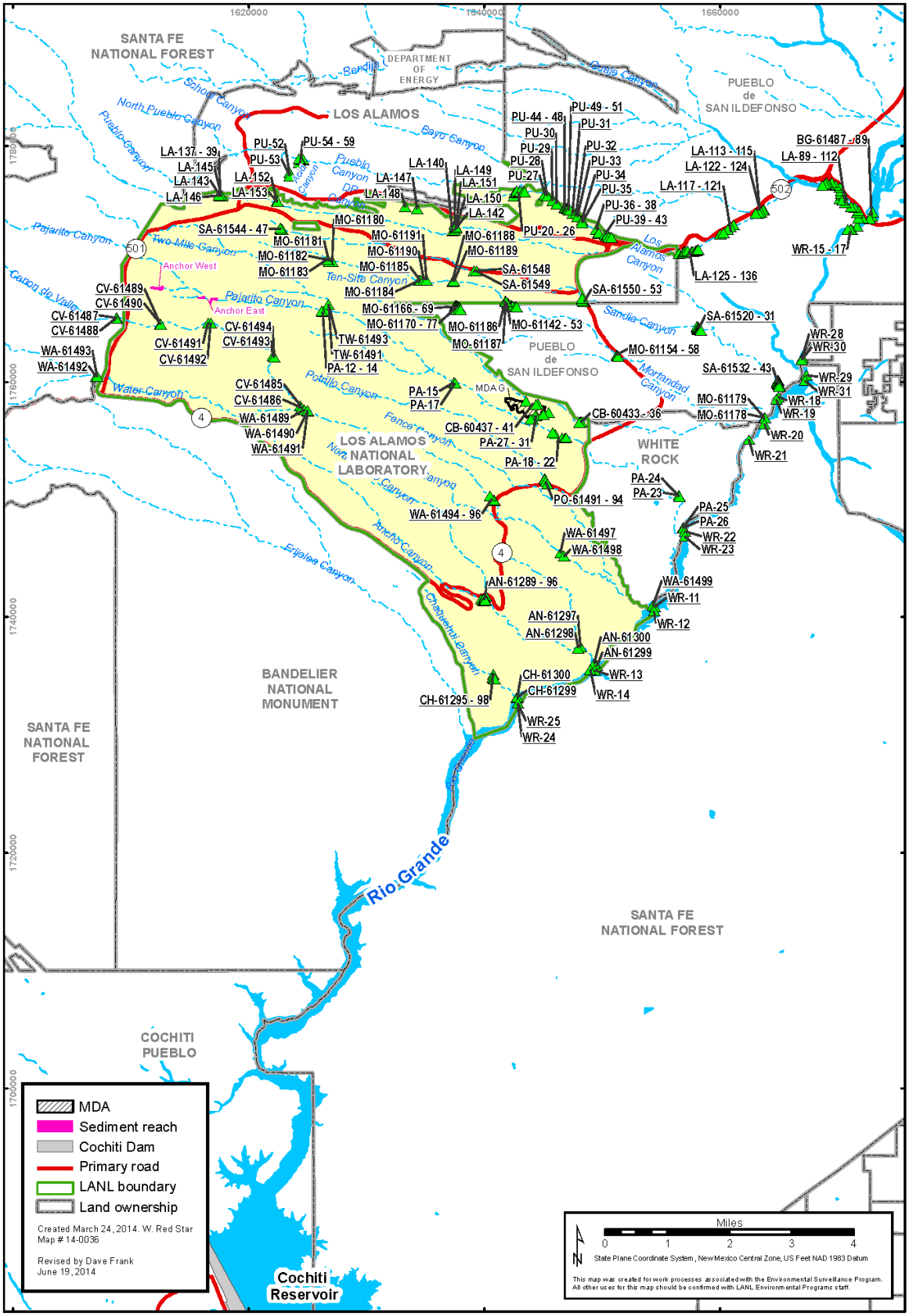


Figure 6-7 Surface water locations sampled in 2013 as part of the Environmental Surveillance Program and the Los Alamos and Pueblo Canyons monitoring plan (locations CO111041 and CO101038 are run-on into and runoff from the sediment detention basins in upper Los Alamos Canyon, respectively)

Figure 6-8 Surface water locations sampled in 2013 at IP SMAs

Figure 6-9 shows sediment locations sampled in 2013 as part of the Environmental Surveillance Program. The Laboratory collected sediment samples from stream channels and adjacent flood plains with new (i.e., 2013) sediment deposits on the Pajarito Plateau to a depth of 0 to 55 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.



MDA = Material disposal area.

Figure 6-9 Sediment locations sampled in 2013 as part of the Environmental Surveillance Program

The procedures for surface water sampling depend on the type of streamflow 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 2013 was the tenth 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 2-h 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, the Laboratory 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 the Laboratory's storm water processing facility. These samples are then shipped to commercial analytical laboratories without compositing or splitting.

E. SAMPLING RESULTS BY CONSTITUENTS

Laboratory releases to Pajarito Plateau watersheds were initiated in the first years of Laboratory 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. Effluent discharges at the Laboratory have been permitted since 1978. The Laboratory currently manages four NPDES permits to control point-source discharges to storm water. The Laboratory's NPDES Industrial Point Source Outfall Permit Program has reduced outfalls from 141 in 1993 to 11 permitted outfalls in 2013, 2 of which do not discharge. The Laboratory's outfall reduction efforts are still underway. Storm water runoff from a subset of SWMUs and AOCs is managed under the IP. Storm water runoff from construction sites is managed under the CGP and industrial discharges are managed under the MSGP. In addition, large watershed-scale and small drainage-scale approaches to control sediment are being implemented to reduce sediment transport.

During 2013, storm water runoff overtopped stream banks in every watershed on Laboratory property during the September 13 flood, therefore sediment samples were collected in every watershed. Tables 6-3 and 6-4 present summaries of results for radionuclides and inorganic/organic chemicals, respectively, in Pajarito Plateau sediment samples from 2013 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 2013 as compared with the standards/screening levels discussed in Table 6-1. Only analytes above the standards/screening levels are presented in Tables 6-3 through 6-6 and 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 Laboratory activities and global atmospheric fallout. Uranium-234 and uranium-238 are included in the discussion as associated with Laboratory activities and regional background. Additionally, barium and the explosive compound RDX are discussed in Water Canyon in association with Laboratory 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 (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. Sediment data presented in this report are used to verify the conceptual model that the scale of storm-water-related contaminant transport observed in Laboratory 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 2013 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 collected in 2013

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (pCi/g[a])	Average (pCi/g)	Maximum (pCi/g)	Sediment Background (pCi/g)	Number Greater than Sediment Background	Residential SAL (pCi/g)	Number Greater than Residential SAL	Industrial SAL (pCi/g)	Number Greater than Industrial SAL	Construction Worker SAL (pCi/g)	Number Greater than Construction Worker SAL	Recreational SAL (pCi/g)	Number Greater than Recreational SAL	Terrestrial BCG for Sediment (pCi/g)	Number Greater than Terrestrial BCG for Sediment
Los Alamos Canyon	Upper Los Alamos	Am-241	21	8	0.0301	0.336	0.715	0.04	6	49	0	85	0	590	0	890	0	4000	0
		Cs-137	11	9	0.177	0.72	1.65	0.9	2	6.7	0	18	0	23	0	210	0	2000	0
		Pu-238	13	2	0.0355	0.0382	0.0408	0.006	2	50	0	79	0	780	0	850	0	—[b]	—
		Pu-239/240	13	9	0.0489	0.337	0.705	0.068	7	48	0	72	0	720	0	770	0	6000	0
		Sr-90	11	6	0.127	0.53	1.26	1.04	1	9	0	980	0	2100	0	3200	0	300	0
	DP	Am-241	12	10	0.26	0.6	1.4	0.04	10	49	0	85	0	590	0	890	0	4000	0
		Cs-137	6	5	2.17	2.82	3.49	0.9	5	6.7	0	18	0	23	0	210	0	2000	0
		Pu-238	6	4	0.0351	0.062	0.116	0.006	4	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	6	6	0.152	0.331	0.542	0.068	6	48	0	72	0	720	0	770	0	6000	0
		Sr-90	6	6	0.24	0.61	1.07	1.04	1	9	0	980	0	2100	0	3200	0	300	0
	Acid	Am-241	4	4	0.152	0.33	0.47	0.04	4	49	0	85	0	590	0	890	0	4000	0
		Pu-238	4	2	0.025	0.028	0.0316	0.006	2	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	4	4	1.6	5.5	9.03	0.068	4	48	0	72	0	720	0	770	0	6000	0
	Pueblo	Am-241	55	25	0.0253	0.077	0.231	0.04	18	49	0	85	0	590	0	890	0	4000	0
		Pu-239/240	30	30	0.144	1.30	4.27	0.068	30	48	0	72	0	720	0	770	0	6000	0
		Tritium	27	5	0.0194589	0.38847	1.33109	0.093	3	510	0	3.7E04	0	1.2E05	0	4.3E05	0	2.0E05	0
		U-238	27	27	0.424	0.9	2.3	2.29	1	92	0	250	0	450	0	1700	0	2000	0
	Lower Los Alamos	Am-241	108	32	0.0142	0.063	0.185	0.04	19	49	0	85	0	590	0	890	0	4000	0
		Pu-238	57	1	0.0314	0.0314	0.0314	0.006	1	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	57	51	0.0326	0.56	2.34	0.068	48	48	0	72	0	720	0	770	0	6000	0

Table 6-3 (continued)

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (pCi/g[a])	Average (pCi/g)	Maximum (pCi/g)	Sediment Background (pCi/g)	Number Greater than Sediment Background	Residential SAL (pCi/g)	Number Greater than Residential SAL	Industrial SAL (pCi/g)	Number Greater than Industrial SAL	Construction Worker SAL (pCi/g)	Number Greater than Construction Worker SAL	Recreational SAL (pCi/g)	Number Greater than Recreational SAL	Terrestrial BCG for Sediment (pCi/g)	Number Greater than Terrestrial BCG for Sediment
Mortandad Canyon	Upper Mortandad	Am-241	15	13	0.237	2.8	14.4	0.04	13	49	0	85	0	590	0	890	0	4000	0
		Cs-137	1	1	1.97	1.97	1.97	0.9	1	6.7	0	18	0	23	0	210	0	2000	0
		Pu-238	14	12	0.0741	1.17	4.74	0.006	12	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	14	12	0.111	2.5	11.2	0.068	12	48	0	72	0	720	0	770	0	6000	0
	Lower Mortandad	Am-241	20	18	0.128	1.45	3.61	0.04	18	49	0	85	0	590	0	890	0	4000	0
		Cs-137	20	18	0.495	3.64	7.82	0.9	17	6.7	2	18	0	23	0	210	0	2000	0
		Pu-238	20	18	0.0452	0.57	1.52	0.006	18	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	20	19	0.0361	1.22	2.92	0.068	18	48	0	72	0	720	0	770	0	6000	0
	Cañada del Buey	Am-241	10	4	0.0278	0.077	0.139	0.04	3	49	0	85	0	590	0	890	0	4000	0
		Pu-238	10	4	0.0311	0.41	1.01	0.006	4	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	10	5	0.0466	0.122	0.188	0.068	3	48	0	72	0	720	0	770	0	6000	0
Pajarito Canyon	Upper Pajarito	Am-241	18	6	0.0245	0.05	0.13	0.04	3	49	0	85	0	590	0	890	0	4000	0
		Pu-238	18	4	0.0174	0.0222	0.0297	0.006	4	50	0	79	0	780	0	850	0	—	—
		Pu-239/240	18	7	0.0336	0.080	0.262	0.068	1	48	0	72	0	720	0	770	0	6000	0
Ancho Canyon	Ancho North	U-238	5	5	0.465	1.26	2.71	2.29	1	92	0	250	0	450	0	1700	0	2000	0

[a] pCi/g = Picocuries per gram.

[b] — = Standard does not exist for analyte.

Table 6-4

Summary of Results for Inorganic and Organic Chemicals in Pajarito Plateau Sediment Samples collected in 2013

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (mg/kg[a])	Average (mg/kg)	Maximum (mg/kg)	Residential SSL (mg/kg)	Number Greater than Residential SSL	Industrial SSL (mg/kg)	Number Greater than Industrial SSL	Construction Worker SSL (mg/kg)	Number greater than Construction Worker SSL	Sediment Background (mg/kg)	Number Greater than Sediment Background
Los Alamos Canyon	Upper Los Alamos	Barium	11	11	27.6	68	128	15600	0	4350	0	223000	0	127	1
		Lead	11	11	6.03	13.2	19.9	400	0	800	0	800	0	19.7	1
		Manganese	11	11	237	406	648	1860	0	440	3	26700	0	543	3
		PCB-126	9	3	0.0000115	0.000299	0.000593	0.000341	1	0.0117	0	0.00127	0	—[b]	—
	DP	Iron	6	6	6910	9550	15800	54800	0	217000	0	795000	0	13800	1
		Lead	6	6	7.72	15	34	400	0	800	0	800	0	19.7	1
		Zinc	6	6	40.9	57.7	88.3	23500	0	92900	0	341000	0	60.2	2
	Acid	Lead	4	4	9.91	19.0	28.4	400	0	800	0	800	0	19.7	2
		Zinc	4	4	34.4	49.3	77.1	23500	0	92900	0	341000	0	60.2	1
	Pueblo	Copper	32	32	1.21	3	15	3130	0	12400	0	45400	0	11.2	2
		Iron	32	32	3260	7142	19100	54800	0	217000	0	795000	0	13800	2
		Lead	32	32	3.53	8	24	400	0	800	0	800	0	19.7	3
		Manganese	32	32	96.8	253	547	1860	0	440	4	26700	0	543	1
		Zinc	32	32	16.5	38.1	92.5	23500	0	92900	0	341000	0	60.2	3
	Lower Los Alamos	Barium	53	53	9.98	38	133	15600	0	4350	0	223000	0	127	1
		Calcium	53	53	502	1455	4510	—	—	—	—	—	—	4420	1
		Chromium	53	53	1.59	4.7	11.1	117000	0	465000	0	1700000	0	10.5	1
		Cobalt	53	53	0.952	2.32	9.03	23	0	34.8	0	300	0	4.73	1
		Copper	53	53	0.846	4	12	3130	0	12400	0	45400	0	11.2	1
		Iron	53	53	4280	8996	32700	54800	0	217000	0	795000	0	13800	2
		Manganese	53	53	101	264	810	1860	0	440	3	26700	0	543	3
		Nickel	53	53	0.855	4.3	14.9	1560	0	6190	0	22500	0	9.38	2
		Vanadium	53	53	4.93	13.1	33.1	391	0	1550	0	5680	0	19.7	3
		Zinc	53	53	13.6	36	156	23500	0	92900	0	341000	0	60.2	1

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (mg/kg[a])	Average (mg/kg)	Maximum (mg/kg)	Residential SSL (mg/kg)	Number Greater than Residential SSL	Industrial SSL (mg/kg)	Number Greater than Industrial SSL	Construction Worker SSL (mg/kg)	Number greater than Construction Worker SSL	Sediment Background (mg/kg)	Number Greater than Sediment Background
Sandia Canyon	Upper Sandia	Chromium	11	11	2.53	22.2	44.7	117000	0	465000	0	1700000	0	10.5	9
		Copper	11	11	1.06	5.5	12.3	3130	0	12400	0	45400	0	11.2	2
		Lead	11	11	4.85	16.3	39.8	400	0	800	0	800	0	19.7	3
		Manganese	11	11	115	350	641	1860	0	440	1	26700	0	543	1
		Silver	11	11	0.119	0.71	1.43	391	0	1550	0	5680	0	1	3
		Zinc	11	11	19.1	47.1	70.4	23500	0	92900	0	341000	0	60.2	4
	Lower Sandia	Calcium	27	27	297	2232	4940	—	—	—	—	—	—	4420	4
		Chromium	27	27	1.59	7.1	14.6	117000	0	465000	0	1700000	0	10.5	3
		Cobalt	27	27	0.7	3.3	6.28	23	0	34.8	0	300	0	4.73	4
		Iron	27	27	3480	10573	23900	54800	0	217000	0	795000	0	13800	4
		Magnesium	27	27	228	1748	3910	—	—	—	—	—	—	2370	12
		Manganese	27	27	141	310	669	1860	0	440	2	26700	0	543	2
		Nickel	27	27	0.709	7.6	22.6	1560	0	6190	0	22500	0	9.38	13
		Vanadium	27	27	3.24	17.9	39.1	391	0	1550	0	5680	0	19.7	14
		Zinc	27	27	13.3	37.0	110	23500	0	92900	0	341000	0	60.2	2
Mortandad Canyon	Upper Mortandad	Copper	13	13	0.771	5	14	3130	0	12400	0	45400	0	11.2	2
		Manganese	13	13	88.7	285	484	1860	0	440	1	26700	0	543	0
		Selenium	13	1	0.374	0.374	0.374	391	0	1550	0	5680	0	0.3	1
		Zinc	13	13	14.3	40.0	68.2	23500	0	92900	0	341000	0	60.2	1
	Lower Mortandad	Antimony	18	6	0.344	0.600	0.898	31.3	0	124	0	454	0	0.83	1
		Calcium	18	18	560	3173	5460	—	—	—	—	—	—	4420	4
		Cobalt	16	16	0.516	1.99	6.23	23	0	34.8	0	300	0	4.73	1
		Manganese	18	18	187	380	462	1860	0	440	5	26700	0	543	0
		Vanadium	16	16	1.76	7.9	27.9	391	0	1550	0	5680	0	19.7	1

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (mg/kg[a])	Average (mg/kg)	Maximum (mg/kg)	Residential SSL (mg/kg)	Number Greater than Residential SSL	Industrial SSL (mg/kg)	Number Greater than Industrial SSL	Construction Worker SSL (mg/kg)	Number greater than Construction Worker SSL	Sediment Background (mg/kg)	Number Greater than Sediment Background
Mortandad Canyon (continued)	Cañada del Buey	Antimony	10	4	0.467	0.615	0.956	31.3	0	124	0	454	0	0.83	1
		Iron	10	10	1910	7561	15300	54800	0	217000	0	795000	0	13800	1
		Manganese	10	10	119	266	527	1860	0	440	1	26700	0	543	0
		Vanadium	10	10	2.48	12.0	28.7	391	0	1550	0	5680	0	19.7	2
Pajarito Canyon	Upper Pajarito	Barium	18	18	21.3	73	218	15600	0	4350	0	223000	0	127	4
		Cadmium	18	10	0.125	0.358	0.764	70.3	0	277	0	897	0	0.4	4
		Calcium	18	18	412	2017	5290	—	—	—	—	—	—	4420	1
		Cobalt	18	18	1.18	3.14	6.36	23	0	34.8	0	300	0	4.73	3
		Copper	18	18	1.71	7.0	16.6	3130	0	12400	0	45400	0	11.2	5
		Lead	18	18	3.4	11.3	24.3	400	0	800	0	800	0	19.7	3
		Manganese	18	18	156	393	1430	1860	0	440	5	26700	0	543	3
		Nickel	18	18	1.12	4.9	15.5	1560	0	6190	0	22500	0	9.38	3
		Silver	18	14	0.0897	1.93	6.81	391	0	1550	0	5680	0	1	8
		Vanadium	18	18	4.22	11.9	21.1	391	0	1550	0	5680	0	19.7	1
		Zinc	18	18	16.1	43.7	70.9	23500	0	92900	0	341000	0	60.2	3
	Twomile	Lead	3	3	9.85	15.9	19.8	400	0	800	0	800	0	19.7	1
		Manganese	3	3	378	478	588	1860	0	440	2	26700	0	543	1
		Nickel	3	3	5.76	7.5	10.5	1560	0	6190	0	22500	0	9.38	1
	Lower Pajarito	Barium	5	5	28.7	75	141	15600	0	4350	0	223000	0	127	2
		Calcium	5	5	1590	4090	7820	—	—	—	—	—	—	4420	2
		Cobalt	5	5	2.35	3.93	6.06	23	0	34.8	0	300	0	4.73	2
		Copper	5	5	2.66	6.2	11.3	3130	0	12400	0	45400	0	11.2	1
		Iron	5	5	7330	10180	14100	54800	0	217000	0	795000	0	13800	2
		Lead	5	5	3.88	10.4	22.6	400	0	800	0	800	0	19.7	1

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (mg/kg[a])	Average (mg/kg)	Maximum (mg/kg)	Residential SSL (mg/kg)	Number Greater than Residential SSL	Industrial SSL (mg/kg)	Number Greater than Industrial SSL	Construction Worker SSL (mg/kg)	Number greater than Construction Worker SSL	Sediment Background (mg/kg)	Number Greater than Sediment Background
Pajarito Canyon (continued)	Lower Pajarito (continued)	Magnesium	5	5	901	1670	2640	—	—	—	—	—	—	2370	2
		Manganese	5	5	147	281	460	1860	0	440	2	26700	0	543	0
		Nickel	5	5	6	8	11.1	1560	0	6190	0	22500	0	9.38	2
		Vanadium	5	5	10.7	16.8	24.6	391	0	1550	0	5680	0	19.7	2
Water Canyon	Main Channel	Barium	16	16	31.8	193	722	15600	0	4350	0	223000	0	127	5
		Calcium	16	16	284	2902	12300	—	—	—	—	—	—	4420	3
		Cobalt	16	16	1.31	2.91	5.79	23	0	34.8	0	300	0	4.73	1
		Copper	16	16	0.919	4.7	12.8	3130	0	12400	0	45400	0	11.2	1
		Manganese	16	16	114	342	571	1860	0	440	4	26700	0	543	2
		Silver	16	9	0.132	0.55	1.22	391	0	1550	0	5680	0	1	2
		Vanadium	16	16	3.95	13.8	25.6	391	0	1550	0	5680	0	19.7	1
	Cañon de Valle	Barium	12	12	25.2	340	1020	15600	0	4350	0	223000	0	127	10
		Copper	12	12	1.87	9.7	32.5	3130	0	12400	0	45400	0	11.2	4
		Iron	12	12	7600	9893	16100	54800	0	217000	0	795000	0	13800	1
		Manganese	12	12	232	323	505	1860	0	440	2	26700	0	543	0
		Nickel	12	12	0.863	13.6	83.2	1560	0	6190	0	22500	0	9.38	3
		Silver	12	11	0.136	4.3	36.3	391	0	1550	0	5680	0	1	4
	Potrillo	Chromium	5	5	3.98	9	19	117000	0	465000	0	1700000	0	10.5	1
		Cobalt	5	5	2.41	4.0	5.3	23	0	34.8	0	300	0	4.73	1
		Iron	5	5	10900	15780	31100	54800	0	217000	0	795000	0	13800	1
		Manganese	5	5	375	438	553	1860	0	440	1	26700	0	543	1
		Vanadium	5	5	15.6	26.4	63.1	391	0	1550	0	5680	0	19.7	1
		Zinc	5	5	41.8	61	124	23500	0	92900	0	341000	0	60.2	1

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (mg/kg[a])	Average (mg/kg)	Maximum (mg/kg)	Residential SSL (mg/kg)	Number Greater than Residential SSL	Industrial SSL (mg/kg)	Number Greater than Industrial SSL	Construction Worker SSL (mg/kg)	Number greater than Construction Worker SSL	Sediment Background (mg/kg)	Number Greater than Sediment Background
Ancho Canyon	**North Ancho**	Copper	5	5	1.07	6.5	16.2	3130	0	12400	0	45400	0	11.2	1
		Iron	5	5	3770	8068	14800	54800	0	217000	0	795000	0	13800	1
		Mercury	5	5	0.00565	0.064	0.215	23.5	0	92.9	0	341	0	0.1	1
		Zinc	5	5	16	33	63.1	23500	0	92900	0	341000	0	60.2	1

[a] mg/kg = Milligrams per kilogram.

[b] — = Standard does not exist for analyte.

Table 6-5
Summary of Results for Radionuclides in Pajarito Plateau Storm Water Samples Collected at Gage Stations collected in 2013

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Analyses	Number of Detects	Minimum (pCi/L[a])	Average (pCi/L)	Maximum (pCi/L)	Bandelier Tuff Background Value (pCi/L)	Number Greater than Bandelier Tuff BV	Urban Area Background Value (pCi/L)	Number Greater than Urban Area BV	Terrestrial BCG for Water (pCi/L)	Number Greater than Terrestrial BCG for Water	Livestock Watering Standard (pCi/L)	Number Greater than Livestock Watering Standard
Los Alamos Canyon	Upper Los Alamos	LA Ponds Runoff at CO101038	Gross alpha	2	2	13.7	25.8	37.9	1490	0	32.5	1	—[b]	—	15	1
		LA Ponds Run-on at CO111041	Gross alpha	1	1	41.3	41.3	41.3	1490	0	32.5	1	—	—	15	1
		Los Alamos above low-head weir at E042.1	Sr-90	3	3	7.87	10	14	—	—	—	—	50000	0	—	—
		Los Alamos below low-head weir at E050.1	Gross alpha	4	4	26.1	156	479	1490	0	32.5	3	—	—	15	4
			Ra-226 and Ra-228	4	4	2.83	5.29	8.32	52.7	0	—	—	—	—	30	0
			Ra-228	4	4	1.16	2.91	4.45	—	—	—	—	7000	0	—	—
			Sr-90	4	4	3.49	5.6	10.4	—	—	—	—	50000	0	—	—
	DP	DP above Los Alamos at E040	Sr-90	2	2	9.71	11.8	13.8	—	—	—	—	50000	0	—	—
	Lower Los Alamos	Guaje at SR-502 at E099	Sr-90	4	3	3.36	17.5	31.9	—	—	—	—	50000	0	—	—
			U-234	6	5	0.778	147	574	—	—	—	—	400000	0	—	—
			U-238	6	5	0.438	155	583	—	—	—	—	400000	0	—	—
		Los Alamos above Rio Grande at E109.9	Gross alpha	6	6	3.24	4267	8730	1490	4	32.5	5	—	—	15	5
			Pu-239/240	14	9	3.25	113	312	—	—	—	—	200000	0	—	—
			Ra-226	5	5	18.2	233	672	—	—	—	—	8000	0	—	—
			Ra-226 and Ra-228	5	5	35.8	406	885	52.7	4	—	—	—	—	30	5
			Ra-228	5	5	17.6	173	613	—	—	—	—	7000	0	—	—
			U-234	9	9	19.9	610	1240	—	—	—	—	400000	0	—	—
			U-238	9	9	19.3	592	1240	—	—	—	—	400000	0	—	—
Mortandad Canyon	Upper Mortandad	Mortandad above Ten Site at E201	Sr-90	2	2	13.5	19	24.5	—	—	—	—	50000	0	—	—

[a] pCi/L = Picocuries per liter.
[b] — = Standard does not exist for analyte.

Table 6-6
Summary of Results for Inorganic and Organic Chemicals in Pajarito Plateau Storm Water Samples Collected at Gage Stations collected in 2013

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Analyses	Number of Detects	Minimum (µg/L[a])	Average (µg/L)	Maximum (µg/L)	Bandelier Tuff BV (µg/L)	Number Greater than Bandelier Tuff BV	Urban Area BV (µg/L)	Number Greater than Urban Area BV	Irrigation Standard (µg/L)	Number Greater than Irrigation Standard	Livestock Watering Standard (µg/L)	Number Greater than Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number Greater than Wildlife Habitat Standard	Acute Aquatic Life Standard[b] (µg/L)	Number Greater than Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)	Number Greater than Chronic Aquatic Life Standard	Human Health-Organism Only Aquatic Life Standard (µg/L)	Number Greater than Human Health-Organism Only Aquatic Life Standard
Los Alamos Canyon	Upper Los Alamos	Los Alamos below Ice Rink at E026	Cyanide	1	1	0.00729	0.00729	0.00729	—[c]	—	—	—	—	—	—	—	0.0052	1	0.022	0	—	—	0.14	0
			Mercury	1	1	0.798	0.798	0.798	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Dioxins[d]	1	1	2.39E-06	2.39E-06	2.39E-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	1
			Total PCB	1	1	0.034	0.034	0.034	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
		LA Ponds Runoff at CO101038	Aluminum	4	4	78.4	259	440	2241	0	245	2	5000	0	—	—	—	—	670 to 7530	0	—	—	—	—
			Boron	4	3	22.6	34.4	56.3	—	—	47.3	1	750	0	5000	0	—	—	—	—	—	—	—	—
			Vanadium	4	4	1.6	3.9	7.16	5.77	1	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Total PCB	4	4	0.0116	0.266	0.545	0.0117	3	0.098	3	—	—	—	—	0.014	3	2	0	—	—	0.00064	4
		LA Ponds Run-on at CO111041	Aluminum	9	9	34.9	255	753	2241	0	245	3	5000	0	—	—	—	—	404 to 1370	1	—	—	—	—
			Copper	9	9	3.37	4.85	7.63	3.43	8	32.3	0	200	0	500	0	—	—	3.09 to 7.15	5	—	—	—	—
			Nickel	9	9	1.1	1.8	3.69	3.53	1	7.57	0	—	—	—	—	—	—	125 to 266	0	—	—	4600	0
			Zinc	9	9	13.8	33.1	94.6	109	0	1120	0	2000	0	25000	0	—	—	38.7 to 87	1	—	—	26000	0
			Total PCB	9	9	4.09	12.4	21.8	0.0117	9	0.098	9	—	—	—	—	0.014	9	2	9	—	—	0.00064	9
		Los Alamos above DP at E030	Aluminum	2	2	444	519	594	2241	0	245	2	5000	0	—	—	—	—	1660 to 2380	0	—	—	—	—
			Arsenic	2	1	2.61	2.61	2.61	—	—	2.55	1	100	0	200	0	—	—	340	0	—	—	9	0
			Mercury	2	2	1.59	1.70	1.81	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
			Selenium	2	2	4	5	6.69	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Dioxins	1	1	1.04E-05	1.04E-05	1.04E-05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	1
			Total PCB	2	2	0.847	0.96	1.08	0.0117	2	0.098	2	—	—	—	—	0.014	2	2	0	—	—	0.00064	2
		Los Alamos above low-head weir at E042.1	Aluminum	3	3	645	759	911	2241	0	245	3	5000	0	—	—	—	—	619 to 1570	2	—	—	—	—
			Copper	3	3	2.74	3.62	5.16	3.43	1	32.3	0	200	0	500	0	—	—	4.15 to 7.87	0	—	—	—	—
			Total PCB	5	5	0.0704	0.177	0.477	0.0117	5	0.098	4	—	—	—	—	0.014	5	2	0	—	—	0.00064	5
		Los Alamos below low-head weir at E050.1	Aluminum	4	4	577	799	952	2241	0	245	4	5000	0	—	—	—	—	1100 to 1900	0	—	—	—	—
			Arsenic	4	2	1.86	2.25	2.64	—	—	2.55	1	100	0	200	0	—	—	340	0	—	—	9	0
			Copper	4	4	2.54	3.46	4.16	3.43	3	32.3	0	200	0	500	0	—	—	6.15 to 8.96	0	—	—	—	—
			Total PCB	12	12	0.0928	0.202	0.437	0.0117	12	0.098	11	—	—	—	—	0.014	12	2	0	—	—	0.00064	12
	DP	DP above TA-21 at E038	Aluminum	5	5	276	1079	2030	2241	0	245	5	5000	0	—	—	—	—	411 to 1100	4	—	—	—	—
			Cadmium	4	1	0.405	0.405	0.405	—	—	0.36	1	10	0	50	0	—	—	0.466 to 0.814	0	—	—	—	—
			Copper	4	4	3.23	4.61	8.01	3.43	2	32.3	0	200	0	500	0	—	—	3.32 to 6.15	2	—	—	—	—
			Lead	4	4	0.569	1.55	3.65	—	—	3.3	1	5000	0	100	0	—	—	12.5 to 25.9	0	—	—	—	—
			Nickel	4	4	1.16	1.92	3.96	3.53	1	7.57	0	—	—	—	—	—	—	134 to 232	0	—	—	4600	0
			Zinc	4	4	10.5	24.3	55.2	109	0	1120	0	2000	0	25000	0	—	—	41.5 to 75.2	0	—	—	26000	0
			Total PCB	4	4	0.0229	0.0527	0.0784	0.0117	4	0.098	0	—	—	—	—	0.014	4	2	0	—	—	0.00064	4

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Analyses	Number of Detects	Minimum (µg/L[a])	Average (µg/L)	Maximum (µg/L)	Bandelier Tuff BV (µg/L)	Number Greater than Bandelier Tuff BV	Urban Area BV (µg/L)	Number Greater than Urban Area BV	Irrigation Standard (µg/L)	Number Greater than Irrigation Standard	Livestock Watering Standard (µg/L)	Number Greater than Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number Greater than Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)	Number Greater than Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)	Number Greater than Chronic Aquatic Life Standard	Human Health-Organism Only Aquatic Life Standard (µg/L)	Number Greater than Human Health-Organism Only Aquatic Life Standard
Los Alamos Canyon	DP (continued)	DP below grade control structure at E039.1	Aluminum	5	5	465	1219	1650	2241	0	245	5	5000	0	—	—	—	—	543 to 1040	4	—	—	—	—
			Copper	5	5	3.43	5.1	7.6	3.43	4	32.3	0	200	0	500	0	—	—	3.79 to 5.92	3	—	—	—	—
			Total PCB	5	5	0.0121	0.0224	0.0435	0.0117	5	0.098	0	—	—	—	—	0.014	2	2	0	—	—	0.00064	5
		DP above Los Alamos at E040	Aluminum	3	3	568	1139	1850	2241	0	245	3	5000	0	—	—	—	—	546 to 1310	2	—	—	—	—
			Copper	3	3	3	4	5.01	3.43	1	32.3	0	200	0	500	0	—	—	3.8 to 6.94	0	—	—	—	—
			Lead	3	3	0.624	1.69	3.43	—	—	3.3	1	5000	0	100	0	—	—	14.6 to 29.9	0	—	—	—	—
			Dioxins	1	1	1.09E-07	1.09E-07	1.09E-07	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	1
			Total PCB	3	3	0.0211	0.0390	0.0685	0.0117	3	0.098	0	—	—	—	—	0.014	3	2	0	—	—	0.00064	3
	Acid	Pueblo above Acid at E055	Aluminum	2	2	567	934	1300	2241	0	245	2	5000	0	—	—	—	—	—	—	246 to 258	2	—	—
			Copper	2	2	3.71	4.54	5.36	3.43	2	32.3	0	200	0	500	0	—	—	—	—	3.06 to 3.16	2	—	—
			Lead	2	2	0.842	1.48	2.12	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.627 to 0.652	2	—	—
			Total PCB	2	2	0.0382	0.0586	0.0789	0.0117	2	0.098	0	—	—	—	—	0.014	2	—	—	0.014	2	0.00064	2
		South Fork of Acid at E055.5	Aluminum	2	2	918	1329	1740	2241	0	245	2	5000	0	—	—	—	—	—	—	107 to 151	2	—	—
			Copper	2	2	2.45	3.14	3.82	3.43	1	32.3	0	200	0	500	0	—	—	—	—	1.82 to 2.26	2	—	—
			Lead	2	2	1.1	1.5	1.91	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.315 to 0.421	2	—	—
			Total PCB	2	2	0.0413	0.0519	0.0624	0.0117	2	0.098	0	—	—	—	—	0.014	2	—	—	0.014	2	0.00064	2
		Acid above Pueblo at E056	Aluminum	4	4	817	1194	1470	2241	0	245	4	5000	0	—	—	—	—	—	—	100 to 289	4	—	—
			Copper	4	4	3	5	7.47	3.43	3	32.3	0	200	0	500	0	—	—	—	—	1.75 to 3.39	4	—	—
			Lead	4	4	1.37	2.05	3.43	—	—	3.3	1	5000	0	100	0	—	—	—	—	0.299 to 0.716	4	—	—
			Total PCB	3	3	0.0146	0.035	0.062	0.0117	3	0.098	0	—	—	—	—	0.014	3	—	—	0.014	3	0.00064	3
	Lower Los Alamos	Guaje at SR-502 at E099	Arsenic	2	2	4.12	5.9	7.6	—	—	2.55	2	100	0	200	0	—	—	340	0	—	—	9	0
			Cobalt	2	2	2.84	5.95	9.06	7.53	1	9.2	0	50	0	1000	0	—	—	—	—	—	—	—	—
			Manganese	2	2	349	2740	5130	—	—	—	—	—	—	—	—	—	—	3000 to 4370	1	—	—	—	—
			Mercury	4	2	1.3	2.7	4.18	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
			Nickel	2	2	2.48	4.18	5.87	3.53	1	7.57	0	—	—	—	—	—	—	472 to 1230	0	—	—	4600	0
			Vanadium	2	2	5.94	5.98	6.01	5.77	2	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Total PCB	1	1	0.0165	0.0165	0.0165	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
		Los Alamos above Rio Grande at E109.9	Aluminum	6	6	49.9	662	965	2241	0	245	5	5000	0	—	—	—	—	1980 to 10100	0	—	—	—	—
			Arsenic	6	5	2.12	3.58	6.93	—	—	2.55	3	100	0	200	0	—	—	340	0	—	—	9	0
			Cobalt	6	5	1.69	5.60	9.06	7.53	2	9.2	0	50	0	1000	0	—	—	—	—	—	—	—	—
			Copper	6	6	1.3	3.4	7.25	3.43	2	32.3	0	200	0	500	0	—	—	9.24 to 32.9	0	—	—	—	—
			Cyanide	3	2	0.0384	0.0401	0.0417	—	—	—	—	—	—	—	—	0.0052	2	0.022	2	—	—	0.14	0

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Analyses	Number of Detects	Minimum (µg/L[a])	Average (µg/L)	Maximum (µg/L)	Bandelier Tuff BV (µg/L)	Number Greater than Bandelier Tuff BV	Urban Area BV (µg/L)	Number Greater than Urban Area BV	Irrigation Standard (µg/L)	Number Greater than Irrigation Standard	Livestock Watering Standard (µg/L)	Number Greater than Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number Greater than Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)	Number Greater than Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)	Number Greater than Chronic Aquatic Life Standard	Human Health-Organism Only Aquatic Life Standard (µg/L)	Number Greater than Human Health-Organism Only Aquatic Life Standard
Los Alamos Canyon (continued)	Lower Los Alamos (continued)	Los Alamos above Rio Grande at E109.9 (continued)	Mercury	7	6	0.716	3.15	4.85	—	—	—	—	—	—	10	0	0.77	5	—	—	—	—	—	—
			Nickel	6	6	1.99	6	18	3.53	3	7.57	1	—	—	—	—	—	—	335 to 1050	0	—	—	4600	0
			Selenium	7	1	8.21	8.21	8.21	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Vanadium	6	6	1.36	3.67	8.57	5.77	1	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Dioxins	3	3	4.34E-08	3.33E-06	9.86E-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	2
			Total PCB	10	10	0.0127	0.154	0.899	0.0117	10	0.098	3	—	—	—	—	0.014	9	2	0	—	—	0.00064	10
Sandia Canyon	Main Channel	Sandia right fork at Power Plant at E121	Aluminum	3	3	276	549	731	2241	0	245	3	5000	0	—	—	—	—	—	—	82.1 to 221	3	—	—
			Copper	3	3	2.65	4.48	6.48	3.43	2	32.3	0	200	0	500	0	—	—	—	—	1.55 to 2.87	3	—	—
			Lead	3	3	0.571	0.638	0.714	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.253 to 0.575	2	—	—
			Mercury	3	3	0.085	0.51	1.17	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Zinc	3	3	19.4	25.7	35.8	109	0	1120	0	2000	0	25000	0	—	—	—	—	18.7 to 36.1	1	26000	0
			Total PCB	3	3	0.093	0.151	0.217	0.0117	3	0.098	2	—	—	—	—	0.014	3	—	—	0.014	3	0.00064	3
		Sandia left fork at Asphalt Plant at E122	Aluminum	1	1	795	795	795	2241	0	245	1	5000	0	—	—	—	—	—	—	410	1	—	—
			Total PCB	1	1	0.406	0.406	0.406	0.0117	1	0.098	1	—	—	—	—	0.014	1	—	—	0.014	1	0.00064	1
		Sandia above SR-4 at E125	Aluminum	1	1	859	859	859	2241	0	245	1	5000	0	—	—	—	—	401	1	—	—	—	—
			Selenium	1	1	5.46	5.46	5.46	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	1	1	0.00416	0.00416	0.00416	0.0117	0	0.098	0	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
Mortandad Canyon	Upper Mortandad	Mortandad above Ten Site at E201	Aluminum	2	2	998	1184	1370	2241	0	245	2	5000	0	—	—	—	—	873 to 1380	1	—	—	—	—
			Copper	2	2	4.47	5.95	7.43	3.43	2	32.3	0	200	0	500	0	—	—	5.25 to 7.2	1	—	—	—	—
			Mercury	2	2	0.565	0.6775	0.79	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Total PCB	2	2	0.0319	0.0466	0.0613	0.0117	2	0.098	0	—	—	—	—	0.014	2	2	0	—	—	0.00064	2
	Ten Site	Ten Site above Mortandad at E201.5	Aluminum	1	1	1050	1050	1050	2241	0	245	1	5000	0	—	—	—	—	935	1	—	—	—	—
			Copper	1	1	4.92	4.92	4.92	3.43	1	32.3	0	200	0	500	0	—	—	5.51	0	—	—	—	—
			Mercury	1	1	2.66	2.66	2.66	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Selenium	1	1	8.85	8.85	8.85	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	1	1	0.28	0.28	0.28	0.0117	1	0.098	1	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
	Lower Mortandad	Mortandad at LANL Boundary at E204	Aluminum	1	1	409	409	409	2241	0	245	1	5000	0	—	—	—	—	2984	0	—	—	—	—
			Boron	1	1	52.8	52.8	52.8	—	—	47.3	1	750	0	5000	0	—	—	—	—	—	—	—	—
			Copper	1	1	3.46	3.46	3.46	3.43	1	32.3	0	200	0	500	0	—	—	12.23	0	—	—	—	—
			Mercury	1	1	1.52	1.52	1.52	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Selenium	1	1	9.23	9.23	9.23	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	1	1	0.196	0.196	0.196	0.0117	1	0.098	1	—	—	—	—	0.014	1	2	0	—	—	0.00064	1

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Analyses	Number of Detects	Minimum (µg/L[a])	Average (µg/L)	Maximum (µg/L)	Bandelier Tuff BV (µg/L)	Number Greater than Bandelier Tuff BV	Urban Area BV (µg/L)	Number Greater than Urban Area BV	Irrigation Standard (µg/L)	Number Greater than Irrigation Standard	Livestock Watering Standard (µg/L)	Number Greater than Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number Greater than Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)	Number Greater than Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)	Number Greater than Chronic Aquatic Life Standard	Human Health-Organism Only Aquatic Life Standard (µg/L)	Number Greater than Human Health-Organism Only Aquatic Life Standard
Mortandad Canyon (continued)	Cañada del Buey	Cañada del Buey above SR-4 at E229.3	Aluminum	2	2	998	1029	1060	2241	0	245	2	5000	0	—	—	—	—	422 to 728	2	—	—	—	—
			Vanadium	2	2	4.63	5.415	6.2	5.77	1	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
Pajarito Canyon	Main Channel	Pajarito below SR-501 at E240	Aluminum	2	2	1000	1280	1560	2241	0	245	2	5000	0	—	—	—	—	564 to 1250	1	—	—	—	—
			Copper	2	2	2.44	3.275	4.11	3.43	1	32.3	0	200	0	500	0	—	—	3.89 to 6.72	1	—	—	—	—
		Pajarito above Threemile at E245.5	Aluminum	2	2	1130	1420	1710	2241	0	245	2	5000	0	—	—	—	—	890 to 893	2	—	—	—	—
			Cyanide	2	2	0.00313	0.00427	0.00541	—	—	—	—	—	—	—	—	0.0052	1	0.022	0	—	—	0.14	0
			Silver	2	1	0.559	0.559	0.559	—	—	—	—	—	—	—	—	—	—	0.593 to 0.595	0	—	—	—	—
			Total PCB	2	2	0.00559	0.012945	0.0203	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	2
		Pajarito above SR-4 at E250	Aluminum	1	1	954	954	954	2241	0	245	1	5000	0	—	—	—	—	942	1	—	—	—	—
			Total PCB	1	1	0.00404	0.00404	0.00404	0.0117	0	0.098	0	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
Water Canyon	Upper Water	Water above SR-501 at E252	Aluminum	2	2	298	879	1460	2241	0	245	2	5000	0	—	—	—	—	1170 to 4750	1	—	—	—	—
			Mercury	2	2	1.44	1.6	1.76	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
			Selenium	2	2	11.5	12.8	14.1	—	—	—	—	—	—	—	—	5	2	20	0	—	—	—	—
	Cañon de Valle	Cañon de Valle above SR-501 at E253	Aluminum	1	1	949	949	949	2241	0	245	1	5000	0	—	—	—	—	2099	0	—	—	—	—
			Copper	1	1	5.49	5.49	5.49	3.43	1	32.3	0	200	0	500	0	—	—	9.60	0	—	—	—	—
			Cyanide	1	1	0.0203	0.0203	0.0203	—	—	—	—	—	—	—	—	0.0052	1	0.022	0	—	—	0.14	0
			Mercury	1	1	0.895	0.895	0.895	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Nickel	1	1	4.55	4.55	4.55	3.53	1	7.57	0	—	—	—	—	—	—	346	0	—	—	4600	0
	Lower Water	Water below SR-4 at E265	Aluminum	1	1	1060	1060	1060	2241	0	245	1	5000	0	—	—	—	—	1997	0	—	—	—	—
			Copper	1	1	3.52	3.52	3.52	3.43	1	32.3	0	200	0	500	0	—	—	9.28	0	—	—	—	—
			Mercury	1	1	0.981	0.981	0.981	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Selenium	1	1	10.4	10.4	10.4	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Vanadium	1	1	7.29	7.29	7.29	5.77	1	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Total PCB	1	1	0.0217	0.0217	0.0217	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
Ancho Canyon	Main Channel	Ancho below SR-4 at E275	Aluminum	2	2	743	1101.5	1460	2241	0	245	2	5000	0	—	—	—	—	1060 to 1370	1	—	—	—	—
			Arsenic	2	2	1.85	3.1	4.35	—	—	2.55	1	100	0	200	0	—	—	340	0	—	—	9	0
			Cobalt	2	2	3.96	7.08	10.2	7.53	1	9.2	1	50	0	1000	0	—	—	—	—	—	—	—	—
			Mercury	2	2	0.36	0.7	1.04	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Nickel	2	2	2.04	3.59	5.14	3.53	1	7.57	0	—	—	—	—	—	—	227 to 266	0	—	—	4600	0
			Selenium	2	2	2.71	4.595	6.48	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Vanadium	2	2	4.3	5.28	6.26	5.77	1	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Total PCB	2	2	0.000846	0.010273	0.0197	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	2

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Analyses	Number of Detects	Minimum (µg/L[a])	Average (µg/L)	Maximum (µg/L)	Bandelier Tuff BV (µg/L)	Number Greater than Bandelier Tuff BV	Urban Area BV (µg/L)	Number Greater than Urban Area BV	Irrigation Standard (µg/L)	Number Greater than Irrigation Standard	Livestock Watering Standard (µg/L)	Number Greater than Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number Greater than Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)	Number Greater than Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)	Number Greater than Chronic Aquatic Life Standard	Human Health-Organism Only Aquatic Life Standard (µg/L)	Number Greater than Human Health-Organism Only Aquatic Life Standard
Chaquehui Canyon	Main Channel	Chaquehui at TA-33 at E338	Aluminum	1	1	1040	1040	1040	2241	0	245	1	5000	0	—	—	—	—	501	1	—	—	—	—
			Copper	1	1	4.13	4.13	4.13	3.43	1	32.3	0	200	0	500	0	—	—	3.59	1	—	—	—	—
			Total PCB	1	1	0.00935	0.00935	0.00935	0.0117	0	0.098	0	—	—	—	—	0.014	0	2	0	—	—	0.00064	1

[a] µg/L = Micrograms per liter.

[b] Acute and chronic aquatic 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). These standards are presented as a range if hardness-adjusted. In addition, acute and chronic aquatic life standards apply to different stream segments (see Table 6-2 and Figure 6-6), thus are purposefully not shown for particular streams.

[c] — = Standard does not exist for analyte.

[d] Dioxins are 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. From this point forward, NMWQCC standards will be referred to by their name, e.g., acute aquatic life standard, human health standard, etc.

Filtered storm water samples collected on the Pajarito Plateau in 2013 commonly contained aluminum concentrations above the aquatic life standards. However, most or all of this aluminum is likely naturally occurring (e.g., Reneau et al. 2010). For example, the ash- and sediment-laden samples from the upgradient boundary gage station in Cañon de Valle after the Cerro Grande fire had filtered aluminum concentrations of 19,900 µg/L and 13,200 µg/L in 2000 and 2001, respectively. Similarly, a sample from the upgradient boundary gage station in Pajarito Canyon had a filtered aluminum concentration of 11,500 µg/L in 2005. Aluminum is a natural component of soil and Bandelier Tuff and is not known to be derived from Laboratory operations in any significant quantity. The NMED Surface Water Quality Bureau has also noted that "the large number of exceedances" for aluminum on the Pajarito Plateau "may reflect natural sources associated with the geology of the region," and that aluminum also exceeds 658 µg/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 2013. For sampling conducted under the IP, the highest result for filtered aluminum was 3750 µg/L at 2M-SMA-3 in upper Twomile Canyon (tributary of Pajarito Canyon). The highest aluminum result determined at a gage station in 2013 in Pajarito Canyon was 2030 µg/L at DP above TA-21 (E038), which is located at the Laboratory's upper boundary. In 2013, 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 2013 had arsenic above the human health standard of 9 µg/L. Eight of 74 storm water samples had arsenic above the urban area BV of 2.55 µg/L: 1 was collected at Los Alamos above DP Canyon (E030) with an arsenic concentration 2.61 µg/L, 1 was collected at Los Alamos below the Low-Head Weir (E050.1) with an arsenic concentration of 2.64 µg/L, 2 were collected in Guaje Canyon (E099) with arsenic concentrations of 4.12 µg/L and 7.6 µg/L, and 3 were collected downstream of these gage stations. One was collected in Ancho Canyon above SR-4 with an arsenic concentration of 4.35 µg/L. The highest filtered arsenic result detected at a gage station in 2013 was 6.93 µg/L in Los Alamos above the Rio Grande (E109.9). For sampling under the IP, 1 of 66 samples exceeded the IP TAL at M-SMA-1.2 with an arsenic concentration of 10.6 µg/L. In 2013, 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 such as buildings and parking lots, and forest fires. In 2013, copper concentrations in filtered storm water were detected above the chronic aquatic life standard in Sandia Canyon (3 of 4 samples) and Acid Canyon (8 of 8 samples) and above the acute aquatic life standard in the run-on into the upper Los Alamos sediment detention basins, DP, Mortandad, upper Pajarito, and Chaquehui Canyons (20 of 70 samples). Most of these locations receive a large percentage of runoff from developed areas. Also, 39 of 74 storm water samples had copper concentrations greater than the Bandelier Tuff BV (3.43 µg/L), but none of the 74 samples had concentrations greater than the urban area BV (32.3 µg/L). Prior to 2013, every watershed across the Laboratory had recorded elevated copper concentrations in storm water, including all of the Laboratory's upgradient boundary stations, indicating that copper most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. In addition, since the IP began, every watershed has had a maximum TAL (MTAL) exceedance for copper concentrations in IP-related storm water samples. However, the highest copper concentrations at IP SMAs are higher than copper concentrations at gage stations, indicating either a Los Alamos County or a Laboratory contribution of copper to the canyons. For sampling under the IP, the highest result for filtered copper was 245 µg/L at A-SMA-3 in Ancho Canyon and is associated with Laboratory operations. The highest filtered copper result detected at a gage station in 2013 was 8.01 µg/L at DP above TA-21 (E038), a Laboratory upgradient boundary

station. In 2013, copper concentrations in sediment were not detected above the residential SSL of 3130 mg/kg.

Total cyanide concentrations in storm water samples collected in 2013 were detected above the wildlife habitat standard (5.2 µg/L) in 5 of 22 samples, all of which are in Las Conchas fire–affected watersheds, and above the acute aquatic life standard (22 µg/L) in 2 of 22 samples, both of which were collected at Los Alamos above the Rio Grande (E109.9). In 2013, cyanide was analyzed but not detected in Chaquehui Canyon sediment samples; in 2011, cyanide was detected above the regional BV for sediment (0.83 mg/kg) in 41 of 58 samples collected, but 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 have declined over the 3 yr since the Las Conchas fire, 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 total cyanide (weak acid dissociable) was 17.5 µg/L at CDV-SMA-1.7 in Cañon de Valle. The highest total cyanide result detected at a gage station in 2013 was 41.7 µg/L in Los Alamos Canyon above the Rio Grande (E109.9).

Filtered manganese concentrations were detected above the acute aquatic life standard in 1 of 74 storm water samples collected in 2013 in Guaje Canyon (E099). Also in 2013, manganese concentrations in sediment were not above the residential SSL of 1860 mg/kg, but 17 of 279 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 wildlife habitat standard of 5 µg/L in 58 of 74 storm water samples collected in 2013. Selenium concentrations in storm water at IP SMAs are less than selenium concentrations at gage stations affected by the Las Conchas fire. Total selenium exceeded the IP TAL of 5 µg/L in 3 of 66 samples collected in 2013: CDV-SMA-7 (5.33 µg/L), P-SMA-0.3 (10.7 µg/L), and A-SMA-3 (12.1 µg/L). The highest total selenium result detected at a gage station in 2013 was 690 µg/L in Los Alamos Canyon above the Rio Grande (E109.9), which includes runoff from Guaje Canyon. In 2013, 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 1 of 279 samples collected (0.374 mg/kg in Mortandad Canyon). 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 2013, filtered zinc concentrations in storm water were above the chronic aquatic life standard in 1 of 4 samples in Sandia Canyon (E121) and above the acute aquatic life standard in 1 of 69 samples (run-on into the upper Los Alamos sediment detention basins); however, none were above the Bandelier Tuff BV of 109 µg/L or the urban area BV (1120 µg/L). Since the IP began, every watershed has had MTAL exceedances (42 µg/L) of zinc concentrations in IP-related storm water samples. Prior to 2013, every watershed across the Laboratory, with the exception of Mortandad, has had elevated zinc concentrations in storm water, including all of the Laboratory's upgradient boundary stations, indicating that zinc most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. No 2013 zinc concentrations in sediment were above the residential SSL (23,500 mg/kg).

In 2013, storm water samples analyzed for gross-alpha radioactivity levels were collected in Los Alamos Canyon from the following: run-on into and runoff from the upper Los Alamos Canyon sediment detention basins, below the low-head weir (E050.1), and above the Rio Grande (E109.9). The gross-alpha activity levels below the low-head weir were significantly lower (26.1 pCi/L to 479 pCi/L) than above the Rio Grande (3.24 pCi/L to 8730 pCi/L), indicating that fire-affected Guaje Canyon continues to exert considerable influence over lower Los Alamos Canyon. Eleven of the 13 samples collected had activity levels above the livestock watering standard (15 pCi/L), and 10 of the 13 samples had activity

levels above the urban area BV (32.5 pCi/L); however, only 4 of the 13 samples had activity levels above the Bandelier Tuff BV (1490 pCi/L), all of which were collected at Los Alamos above the Rio Grande (E109.9), which receives water from Guaje Canyon. In previous years, many storm water samples had gross-alpha radioactivity levels above the livestock watering standard. Indeed, in 2011 and 2012 the highest activity levels of gross alpha in storm water, 6200 pCi/L to 1100 pCi/L, were measured in samples containing ash from the Las Conchas fire. The highest detected gross-alpha activity level at the gage stations in 2013 was 8730 pCi/L at Los Alamos above the Rio Grande (E109.9). For sampling under the IP in 2013, the highest detected gross-alpha activity level was 486 pCi/L at B-SMA-0.5 in Bayo Canyon. The analytical results from 2013 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 2013, storm water samples analyzed for radium-226 and radium-228 radioactivity levels were collected in Los Alamos Canyon below the low-head weir (E050.1) and Los Alamos above the Rio Grande (E109.9). The radium activity levels below the low-head weir were significantly lower (1.11 pCi/L to 8.32 pCi/L) than above the Rio Grande (17.6 pCi/L to 885 pCi/L), indicating that fire-affected Guaje Canyon continues to exert considerable influence over lower Los Alamos Canyon. The five samples collected at Los Alamos above the Rio Grande had radium-226 and radium-228 activity levels above the 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 livestock watering standard. Indeed, in 2011 and 2012 the highest activity levels of radium-226 and radium-228 in storm water, 122 pCi/L to 109 pCi/L, were measured in samples containing ash from the Las Conchas fire at Los Alamos Canyon above the Rio Grande. The highest detected radium-226 and radium-228 activity level at the gage stations in 2013 was 885 pCi/L. For sampling under the IP in 2013, the highest detected radium-226 and radium-228 activity level was 55.6 pCi/L at P-SMA-0.3 in Pueblo Canyon. The analytical results from 2013 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. Los Alamos National Laboratory–Related Constituents

Several constituents were measured in storm water runoff and resultant sediment deposits that relate to historical Laboratory 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 2013 storm water and sediment samples and the relationship of their concentrations to pre-existing concentrations and spatial distributions.

Supplemental figures denoted below and Figures 6-10 and 6-11 illustrate the relationships between 2013 constituent concentrations in storm water and sediment to those prior to 2013. In these figures, the x-axis is reversed because the Rio Grande is to the east of the Laboratory, thus water flows to the right through the Laboratory. 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-2013 results for each subwatershed are identified using a unique color, and results obtained in 2013 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. The highest concentration of filtered barium in storm water collected in 2013 is in Guaje Canyon (E099, 274 µg/L), indicating that barium occurs naturally in rocks and soils on and upgradient of the Pajarito Plateau. However, gage station Water Canyon above SR-4 (E265), which is below contaminant sources of barium in sediment in Water Canyon (LANL 2011c), also had high concentrations of barium in 2013 (267 µg/L) and historically (Supplemental Figures S6-1a and b). Pre-2013 barium concentrations in sediment were above the residential SSL of 15,600 mg/kg in Cañon de Valle; however, 2013 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-2013 storm water data, filtered lead concentrations were above the acute aquatic life standard (17 µg/L for a hardness of 30 mg $CaCO_3$/L) in Pueblo, DP, and upper Los Alamos Canyons (Supplemental Figures S6-2a through f). In 2013, two of four samples in Sandia Canyon (E121) and eight of eight samples in Acid Canyon (E055, E055.5, and E056) were above the chronic aquatic life standard, and there were no IP TAL (17 µg/L) exceedances for lead. For samples collected under the IP in 2013, the highest result for filtered lead was 14.2 µg/L at A-SMA-3 in Ancho Canyon. The highest filtered lead result at ESR gage stations in 2013 was 3.65 µg/L in DP Canyon above TA-21 (E038). Concentrations of lead in storm water collected during 2013 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-2013 lead concentrations in sediment that were above the regional BV (19.7 mg/kg) but below the residential SSL (400 mg/kg). No 2013 lead concentrations in sediment were above the residential SSL. Lead concentrations in sediment decreased to levels near background by the Laboratory boundary.

c. Mercury

In pre-2013 storm water data, total mercury concentrations were above the wildlife habitat standard (0.77 µg/L) in Cañon de Valle and Acid, Los Alamos, Pajarito, and Water Canyons (Los Alamos and Water Canyons are shown in Supplemental Figures S6-3a through d; the other canyons do not have a Laboratory source for mercury, concentrations are low, or there is minimal data and thus are not shown in the figures). For 2013, unfiltered mercury concentrations in storm water were above the wildlife habitat standard in Cañon de Valle and Ancho, Guaje, Los Alamos, Mortandad, Sandia, and Water Canyons, and IP samples exceeded the average TAL (0.77 µg/L) in Ancho, Los Alamos, Mortandad, Pajarito, Pueblo, Ten Site, and Water Canyons. Mercury concentrations are similar at gage stations and IP SMAs with the exception of the highest result for unfiltered mercury collected under the IP in 2013, which was 39.3 µg/L at P-SMA-0.3 in Pueblo Canyon. The highest unfiltered mercury result detected at the gage stations in 2013 was 4.85 µg/L in Los Alamos Canyon above the Rio Grande (E109.9). 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-2013 mercury concentration in sediment was above the residential SSL of 23.5 mg/kg in Threemile Canyon (LANL 2009b). No 2013 mercury concentrations in sediment were above the residential SSL.

d. Silver

In pre-2013 storm water data, filtered silver concentrations were above the acute aquatic life standard (0.4 µg/L for a hardness of 30 mg $CaCO_3$/L) in Cañon de Valle and Acid, Pajarito, and Water Canyons (Supplemental Figures S6-4a through f). In 2013, no storm water samples were above the acute aquatic life standard for filtered silver, and the highest detected concentration at the gage stations in 2013 was 0.559 µg/L in Pajarito Canyon above Threemile Canyon (E245.5). For samples collected under the IP in 2013, one exceeded the MTAL (0.4 µg/L) with 4.02 µg/L at STRM-SMA-1.5 in Starmer's Gulch, a subwatershed of Pajarito Canyon. No pre-2013 or 2013 sediment concentrations of silver were above the residential SSL of 391 mg/kg; however, one 2013 sediment sample collected in Cañon de Valle had a

fairly high silver concentration of 36.3 mg/kg. 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 100% of storm water samples collected in 2013, 79 of 84 samples had concentrations above the human health standard of 0.00064 µg/L, and 69 of 84 samples had concentrations above the chronic aquatic life standard of 0.014 µg/L (Figures 6-10a through j; Ancho and Chaquehui Canyons are presented in Supplemental Figures S6-5a through d because of the minimal congener data available for comparison). 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" (PCB background report) (LANL 2012d):

1) *Storm water runoff from nonurban, nonindustrial areas on the Pajarito Plateau.* Five of the 84 storm water samples collected at gage stations in 2013 fall into this category. In 3 samples, the total PCB concentrations were below the upper threshold limit (UTL) of 0.013 µg/L identified in the PCB background report (LANL 2012d), and in the other two samples, the total PCB concentrations were above the UTL (0.0165 µg/L in Guaje Canyon [E099] and 0.034 µg/L in Los Alamos Canyon below the Ice Rink [E026]). This indicates nonpoint sources of PCBs, including atmospheric deposition and Las Conchas fire impacts.
2) *Storm water runoff from Los Alamos County townsite without point sources of PCBs.* Four of the 84 storm water samples collected at gage stations in 2013 fall into this category. The total PCB concentrations (0.0229 µg/L to 0.0784 µg/L) for these samples collected in DP Canyon above TA-21 (E038) were below the UTL of 0.098 µg/L identified in the PCB background report (LANL 2012d), indicating an absence of point sources of PCBs.
3) *Storm water runoff from potential point and nonpoint sources of PCBs.* Seventy-five of the 84 storm water samples collected at gage stations in 2013 fall into this category. The total PCB concentrations in 37 of the 75 samples (49%) were above the UTL of 0.098 µg/L identified in the PCB background report (LANL 2012d), potentially indicating a presence of sources of PCBs. The other 38 samples (51%) 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 ranged from 4.09 µg/L to 21.8 µg/L, and the total PCB concentrations at the outlet of the lower retention basin ranged from 0.0116 µg/L to 0.545 µg/L. Concentrations of PCBs in runoff from burned areas are as high as 0.034 µg/L in upper Los Alamos Canyon (E026) and 0.0165 µg/L in Guaje Canyon (E099), indicating that PCBs are concentrated in fire-influenced sediment-laden runoff. Concentrations of PCB Aroclor mixtures do not directly correspond to PCB congener concentrations and thus are not presented.

f. RDX

No pre-2013 RDX concentrations exceeded the TAL for IP-related sampling; in 2013, one IP sample exceeded the average TAL (200 µg/L) at CDV-SMA-1.7 (908 µg/L). At the gage stations in 2013, there was one detection of RDX (1.11 µg/L) in Water Canyon below SR-4 (E265). In Cañon de Valle, pre-2013 RDX concentrations in sediment were above the residential SSL of 58.2 mg/kg and are associated with former high-explosives-machining facilities, including MDAs, burning grounds, and settling ponds (LANL 2011c). In 2013, no RDX concentrations in sediment were above the residential SSL, and there were only two detections (0.796 mg/kg and 0.154 mg/kg), both of which are in Cañon de Valle. The detections in storm water and sediment and the exceedance in IP-related storm water samples might indicate the movement of RDX-laden sediment in Cañon de Valle.

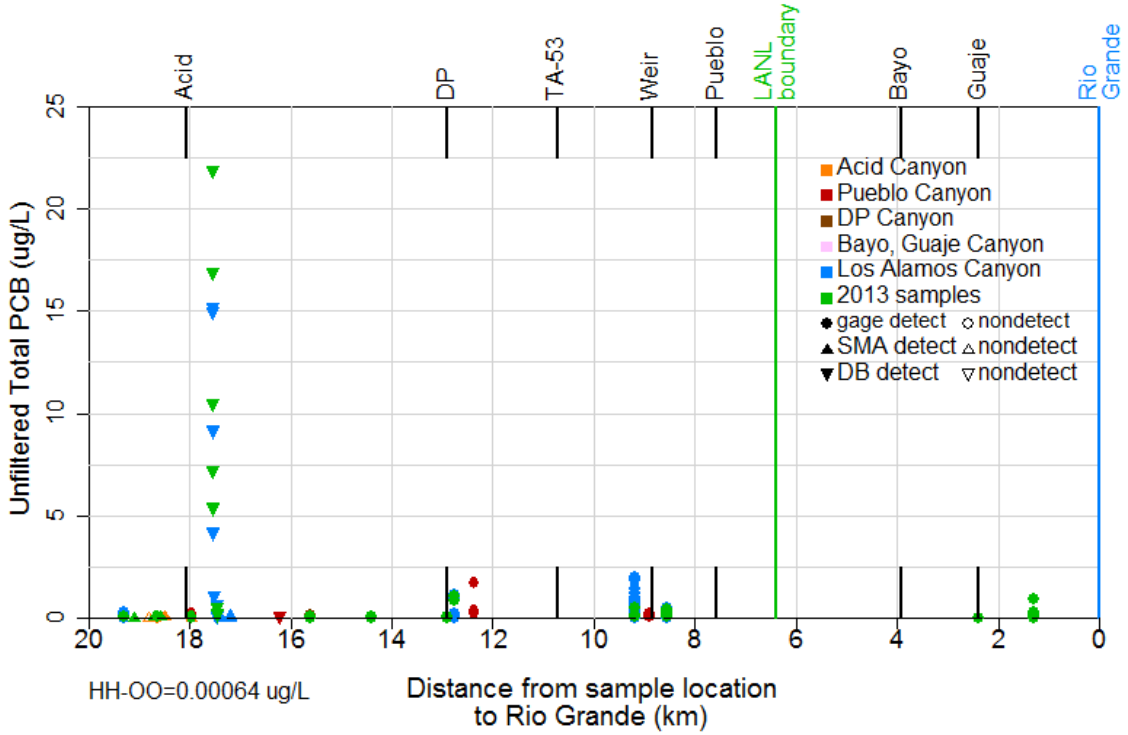


Figure 6-10a Los Alamos Canyon watershed unfiltered total PCB concentrations in storm water from SMA stations (2011–2013) and gages (2009–2013); upside down triangle is from upper Los Alamos detention basins (DB)

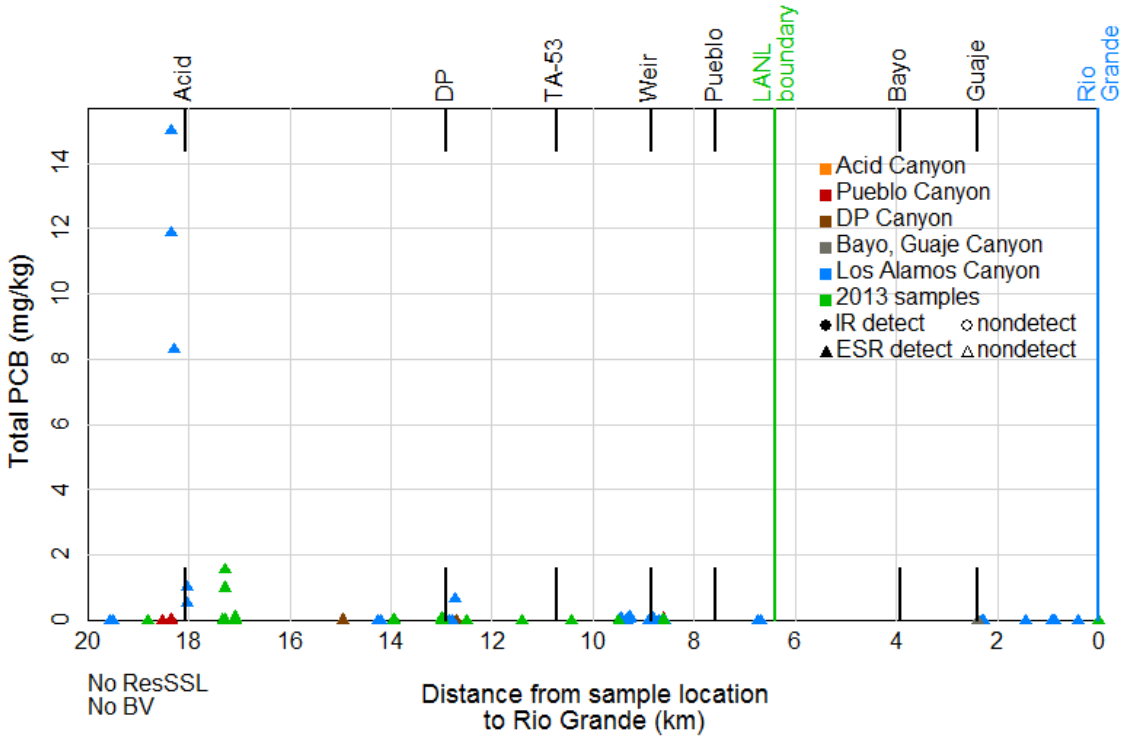


Figure 6-10b Los Alamos Canyon watershed total PCB concentrations in sediment from ESRs (2009–2013); congeners not analyzed in Los Alamos Canyon before 2011

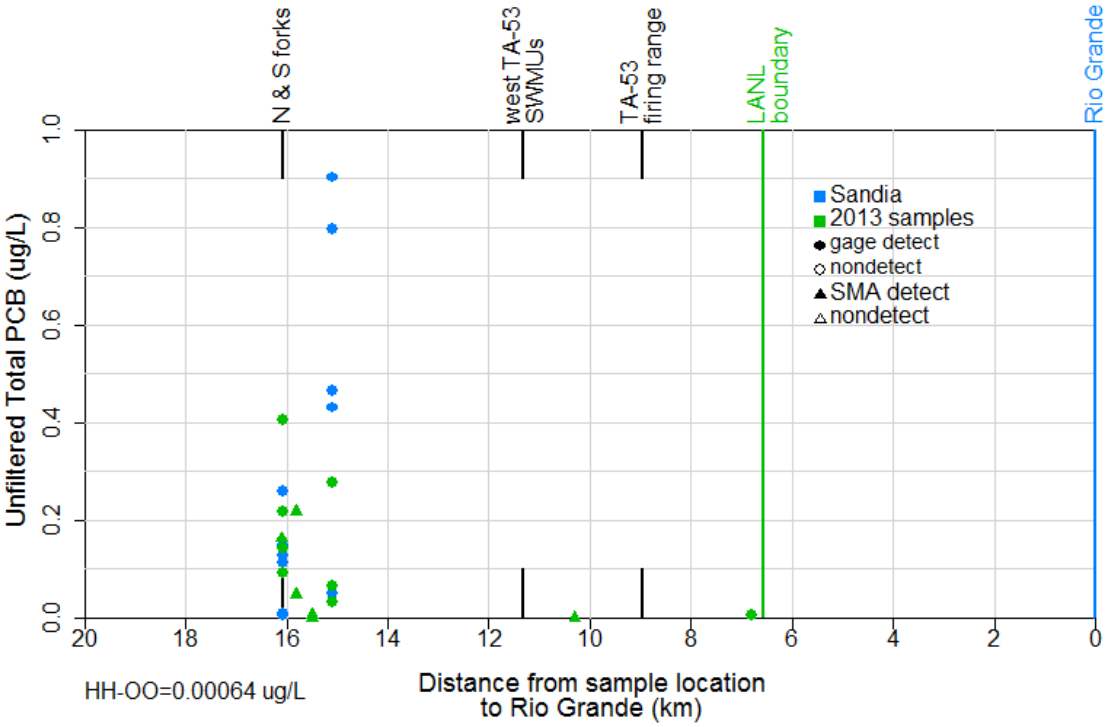


Figure 6-10c Sandia Canyon watershed unfiltered total PCB concentrations in storm water from gages (2012, 2013); no SMA samples analyzed

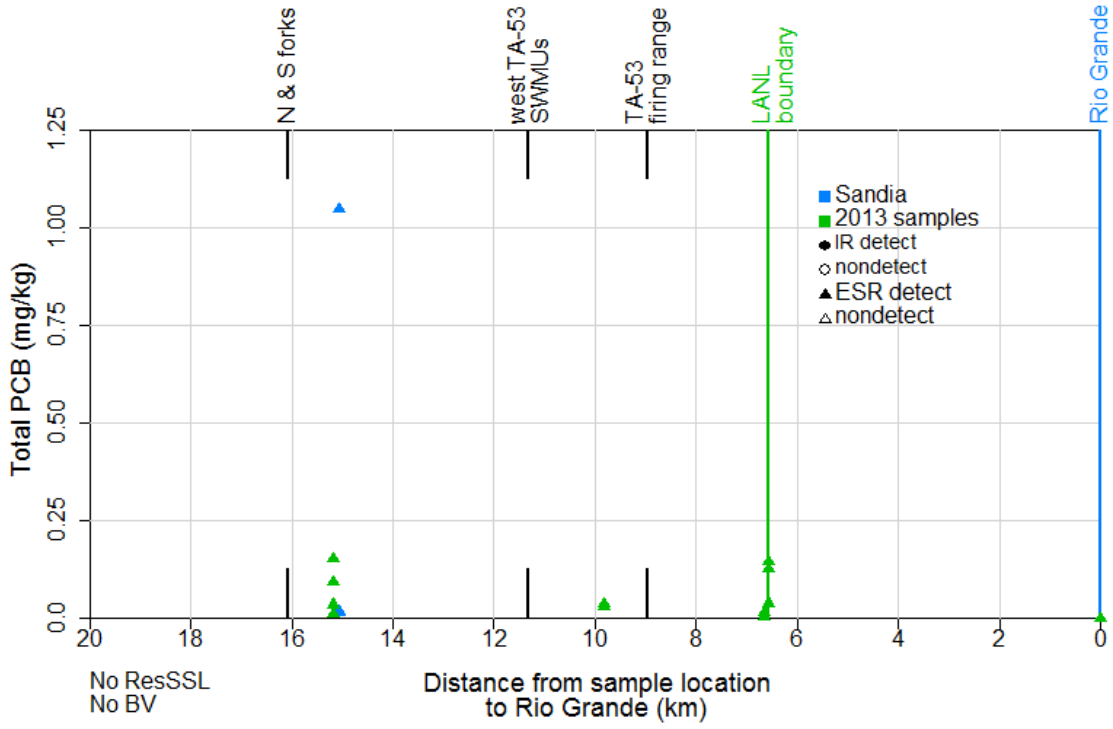


Figure 6-10d Sandia Canyon watershed total PCB concentrations in sediment from ESRs (2012, 2014); congeners not analyzed in Sandia Canyon before 2011

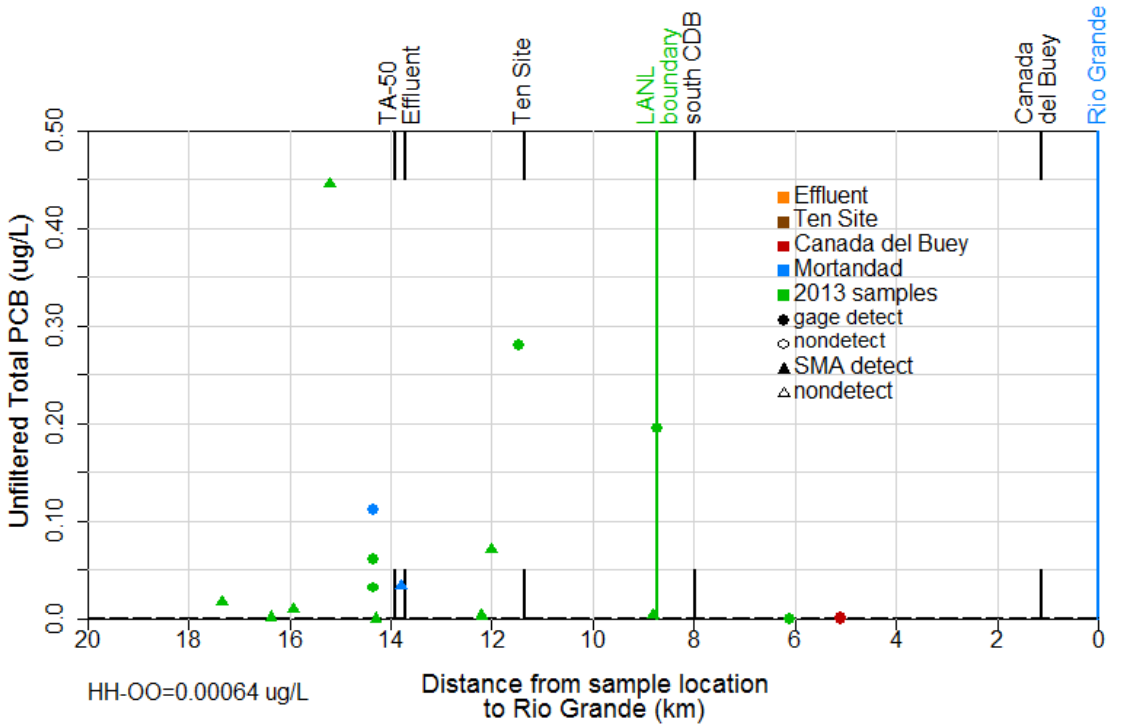


Figure 6-10e Mortandad Canyon watershed unfiltered total PCB concentrations in storm water from SMA stations (2012) and gages (2013)

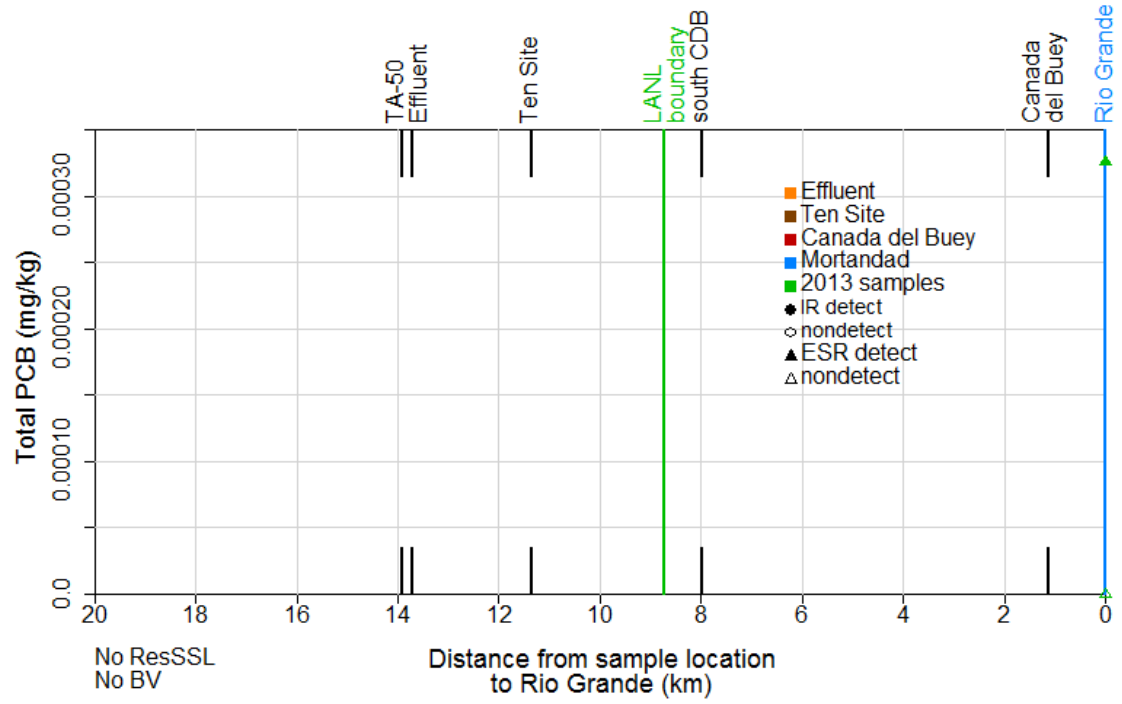


Figure 6-10f Mortandad Canyon watershed total PCB concentrations in sediment from ESRs (2012, 2013); congeners not analyzed in Mortandad Canyon before 2011

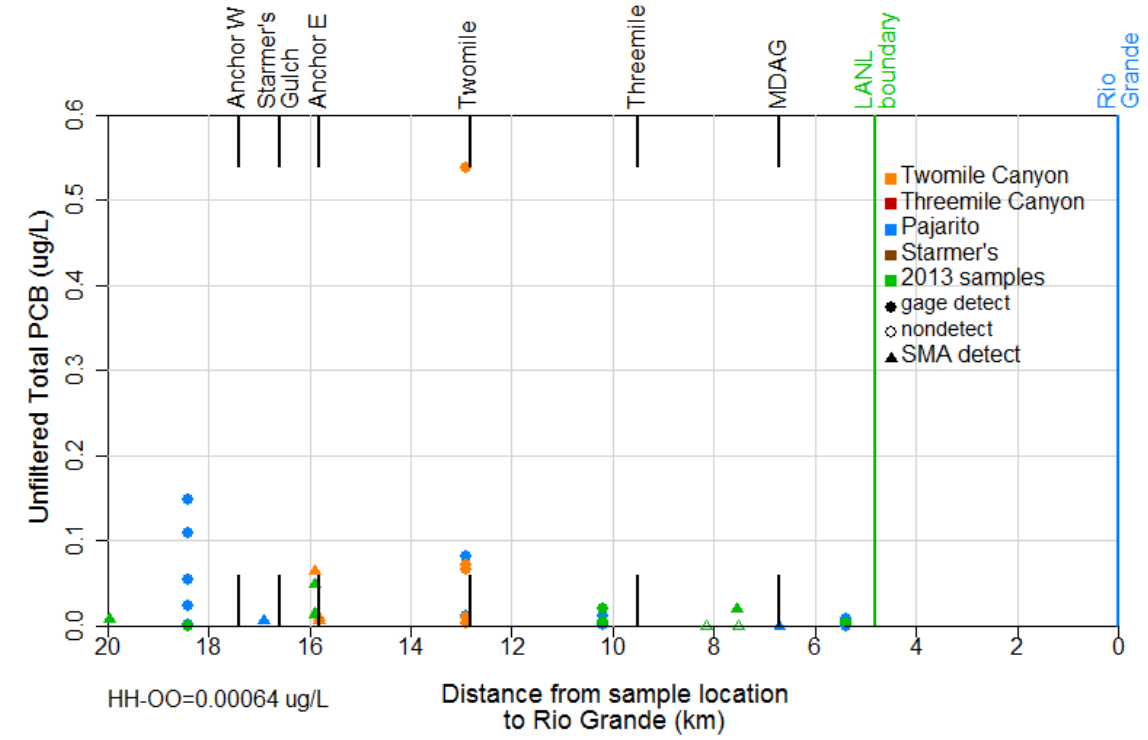


Figure 6-10g Pajarito Canyon watershed unfiltered total PCB concentrations in storm water from SMA stations (2011, 2013) and gages (2010–2013)

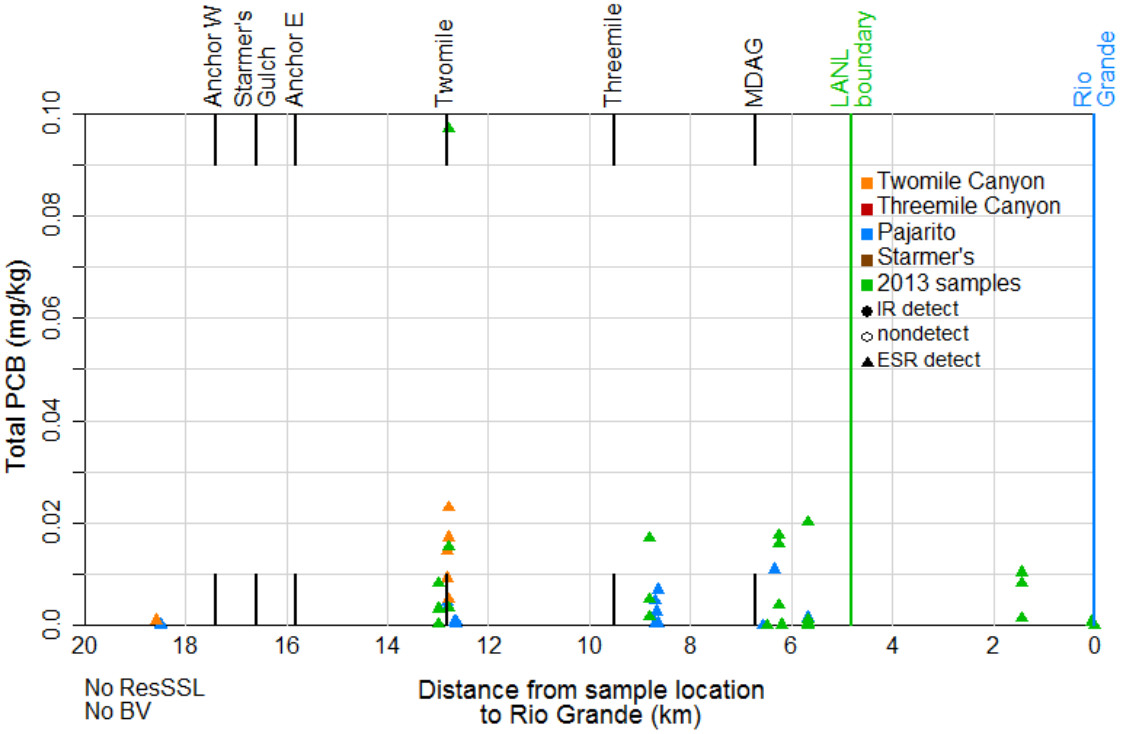


Figure 6-10h Pajarito Canyon watershed total PCB concentrations in sediment from ESRs (2011–2012, 2013); congeners not analyzed in Pajarito Canyon before 2011

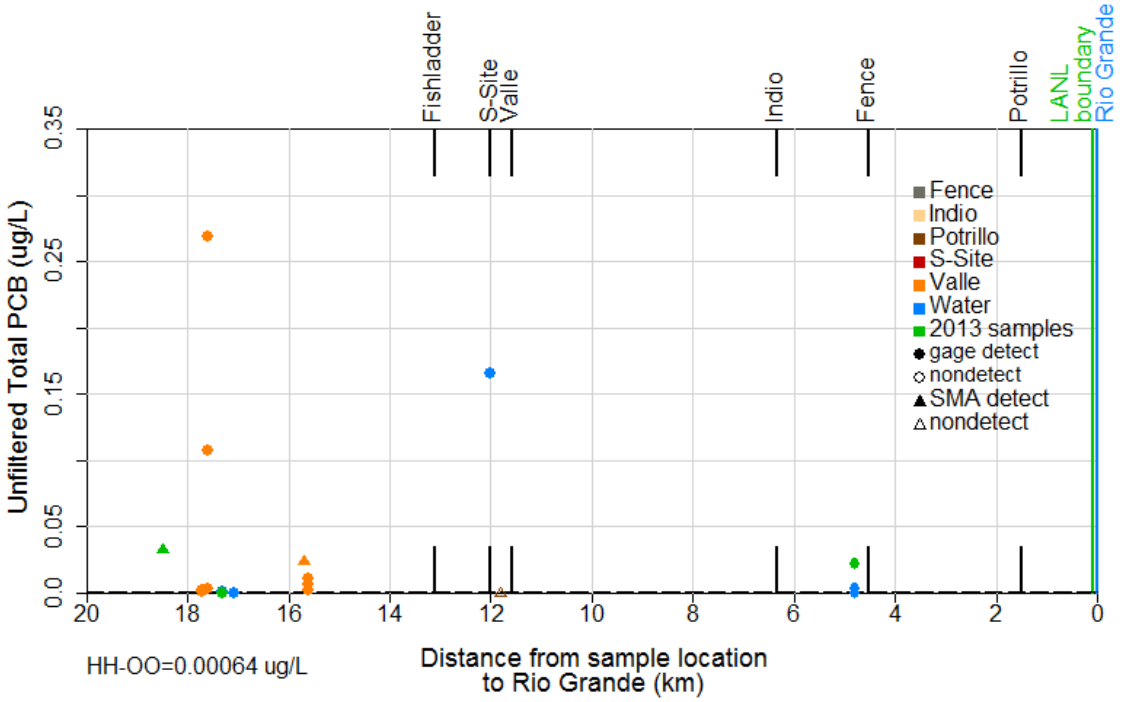


Figure 6-10i Water Canyon watershed unfiltered total PCB concentrations in storm water from SMA stations (2011) and gages (2010–2013)

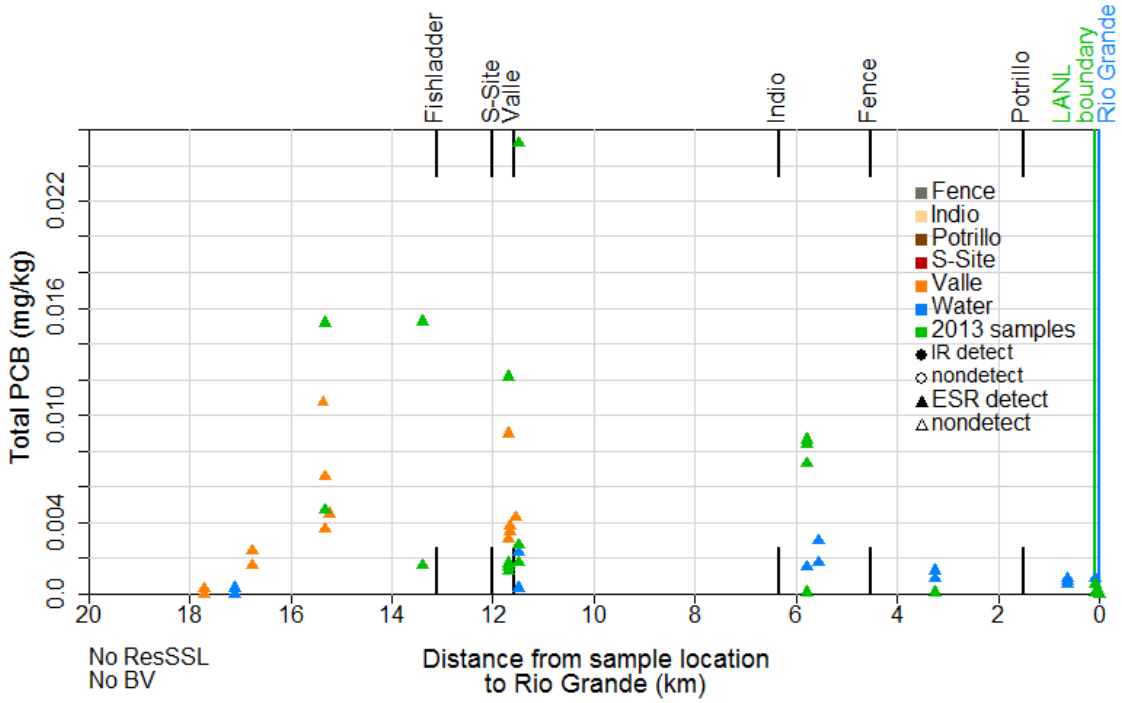


Figure 6-10j Water Canyon watershed total PCB concentrations in sediment from ESRs (2011–2013); congeners not analyzed in Water Canyon before 2011

g. Radionuclides

Storm water runoff from Las Conchas fire 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 on the Pajarito Plateau from 2004 to 2013 had plutonium-238 (Supplemental Figures S6-6a through h) or plutonium-239/240 (Figures 6-11a through h) radioactivity levels above the terrestrial DOE BCG for water of 200,000 pCi/L. In 2013, the highest activity level of plutonium-238 in storm water (48.9 pCi/L) was in Mortandad Canyon at the Laboratory boundary (E204), and the highest activity level of plutonium-239/240 in storm water (312 pCi/L) was in Los Alamos Canyon above the Rio Grande (E109.9). In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), elevated activity levels of plutonium-238 and plutonium-239/240 in storm water at the upgradient boundary stations in 2011 through 2013 are related to ongoing fire-influenced sediment-laden runoff from Las Conchas fire burn areas. Elevated activity levels of plutonium-238 and plutonium-239/240 in storm water at the lower boundary of Los Alamos Canyon are potentially associated with Guaje Canyon runoff, which contained sediment from Las Conchas fire burn areas; elevated activity levels of plutonium in Acid Canyon sediment; and erosion in the Pueblo Canyon wetland during the September 13 flood where elevated activity levels of plutonium exist (LANL 2004 and 2005a). In Mortandad Canyon, elevated activity levels of plutonium-238 and plutonium-239/240 in storm water in 2013 are potentially related to historical Laboratory sources at TA-50 and Effluent Canyon (LANL 2006) and erosion in the sediment traps during the September 13 flood.

In Los Alamos Canyon, only one pre-2013 sediment sample in Acid Canyon had plutonium-238 activity levels that were above the Laboratory residential SAL (37 pCi/g). Pre-2013 plutonium-238 activity levels in sediment decreased from the historical Laboratory sources in Acid Canyon, DP Canyon, and TA-53 (LANL 2005a) to near regional background (0.006 pCi/g) or nondetectable levels before reaching the confluence with the Rio Grande. Pre-2013 plutonium-239/240 activity levels in Los Alamos Canyon watershed were above the Laboratory 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-2013 activity levels of plutonium-238 and plutonium-239/240 in sediment were above the Laboratory residential SALs, although MDA G had activity levels above regional BVs. From the historical Laboratory source at MDA G (LANL 2009b), the pre-2013 plutonium-238 and plutonium-239/240 activity levels in sediment decreased to near regional BVs before the Laboratory boundary and were at nondetectable levels at the confluence with the Rio Grande. In Mortandad Canyon, pre-2013 activity levels of plutonium-238 and plutonium-239/240 in sediment were above the Laboratory residential SALs, particularly from the historical Laboratory sources at TA-50 and Effluent Canyon (LANL 2006), but decreased to below regional background levels or nondetectable levels at the confluence with the Rio Grande.

In 2013, sediment samples collected in Los Alamos, Pajarito, and Mortandad Canyons had plutonium-238 or plutonium-239/240 activity levels above the regional BVs but below the Laboratory residential SALs. Concentrations of plutonium isotopes are present above the BV in 2013 sediment deposits below the Laboratory boundary in Mortandad Canyon. In all of these canyons, the elevated levels may be associated with the historical Laboratory sources mentioned above. In Los Alamos and Pajarito Canyons, these samples contained sediment from Las Conchas fire burn areas. In Los Alamos and Mortandad Canyons, the elevated levels are potentially associated with erosion during the September 13 flood in Acid Canyon, the Pueblo wetlands, and the Mortandad Canyon sediment traps. The highest plutonium-238 and plutonium-239/240 activity levels in 2013 sediment samples (4.74 pCi/g and 11.2 pCi/g, respectively), were in the Mortandad Canyon sediment traps. Water Canyon sediment samples were not analyzed for plutonium-238 or plutonium-239/240 in 2013.

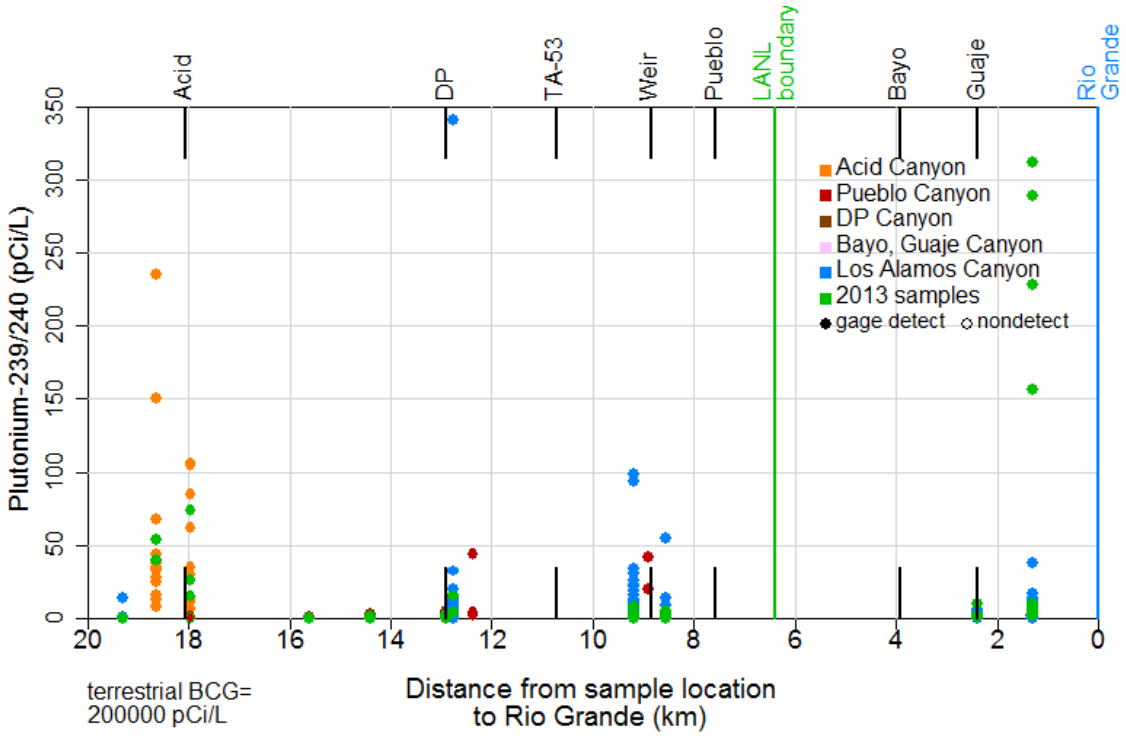


Figure 6-11a Los Alamos Canyon watershed plutonium-239/240 radioactivity levels in storm water from gages (2004–2013); no SMA samples analyzed

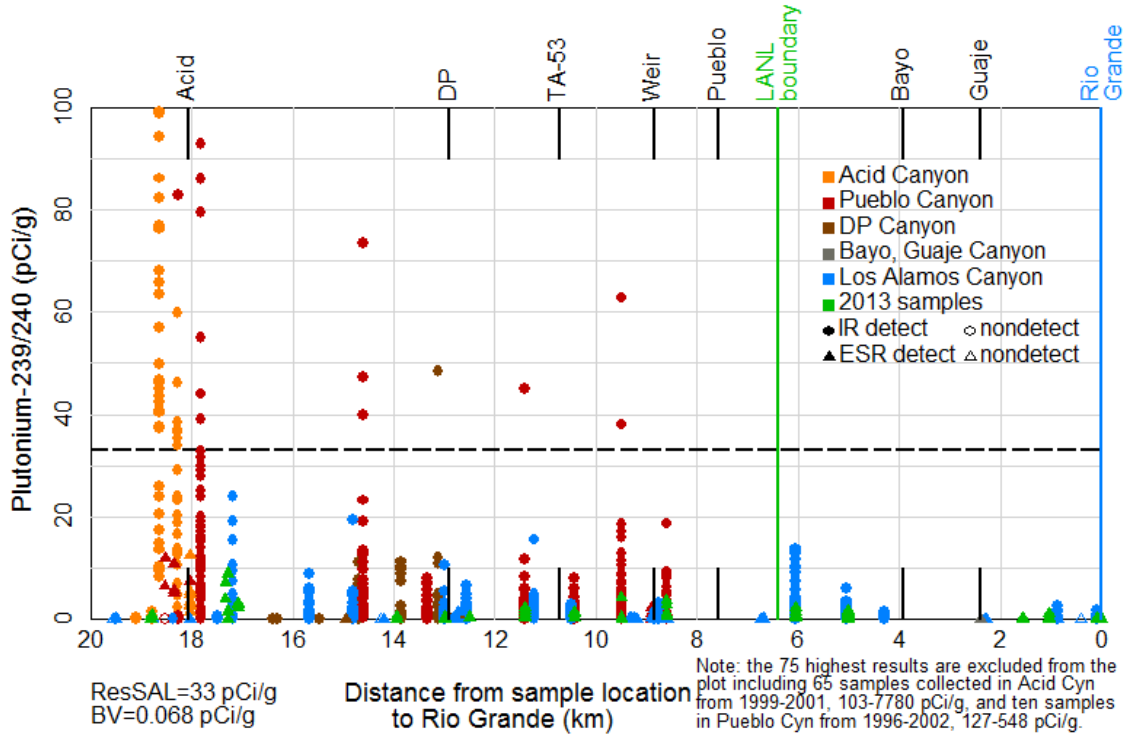


Figure 6-11b Los Alamos Canyon watershed plutonium-239/240 radioactivity levels in sediment from Canyons IRs (1994–2003) and ESRs (2003–2013)

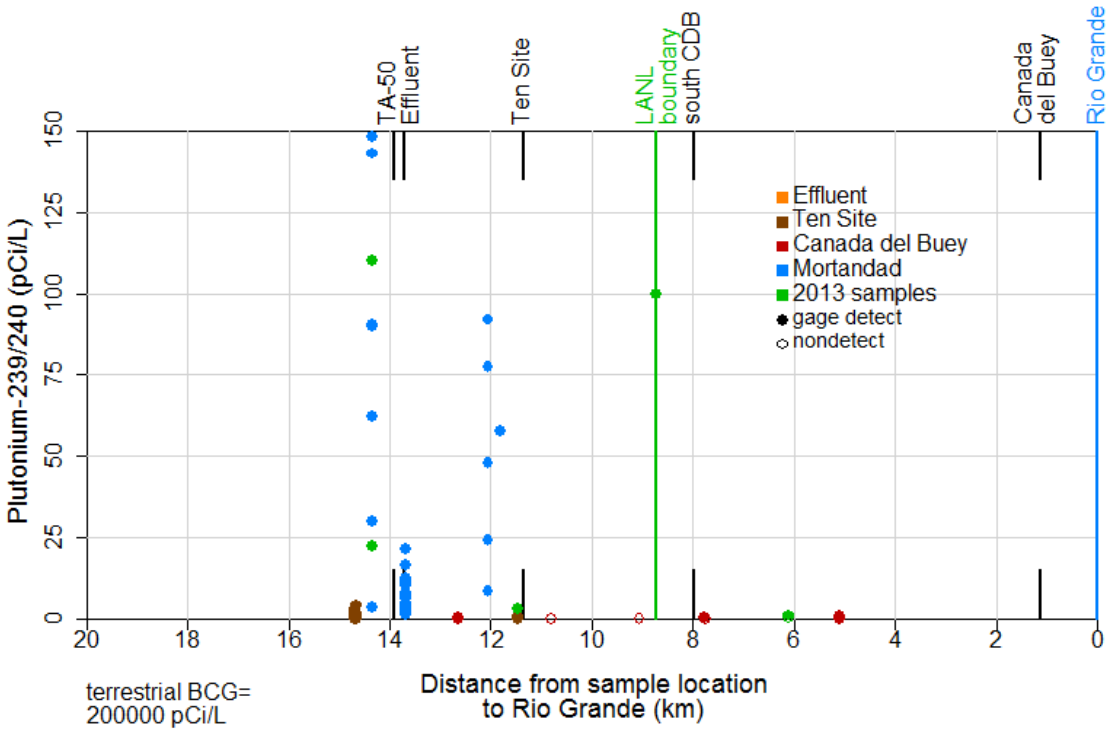


Figure 6-11c Mortandad Canyon watershed unfiltered plutonium-239/240 radioactivity levels in storm water from gages (2013); no SMA samples analyzed

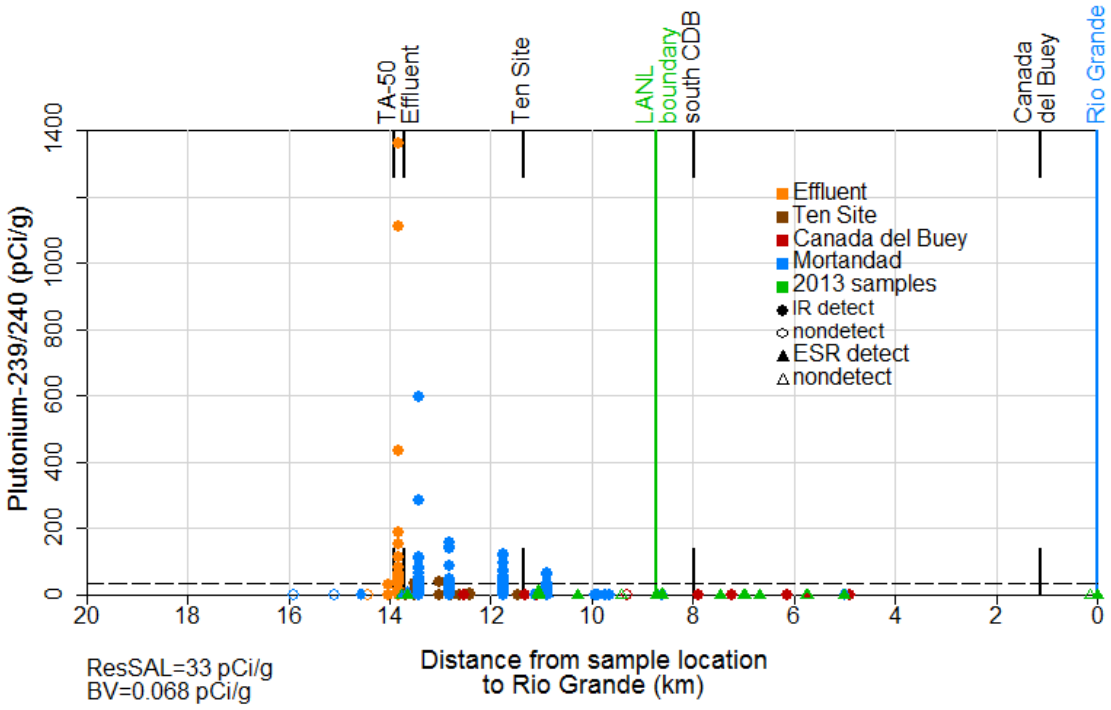


Figure 6-11d Mortandad Canyon watershed plutonium-239/240 radioactivity levels in sediment from canyons IRs (1998–2002, 2004–2005, 2008) and ESRs (2003–2013)

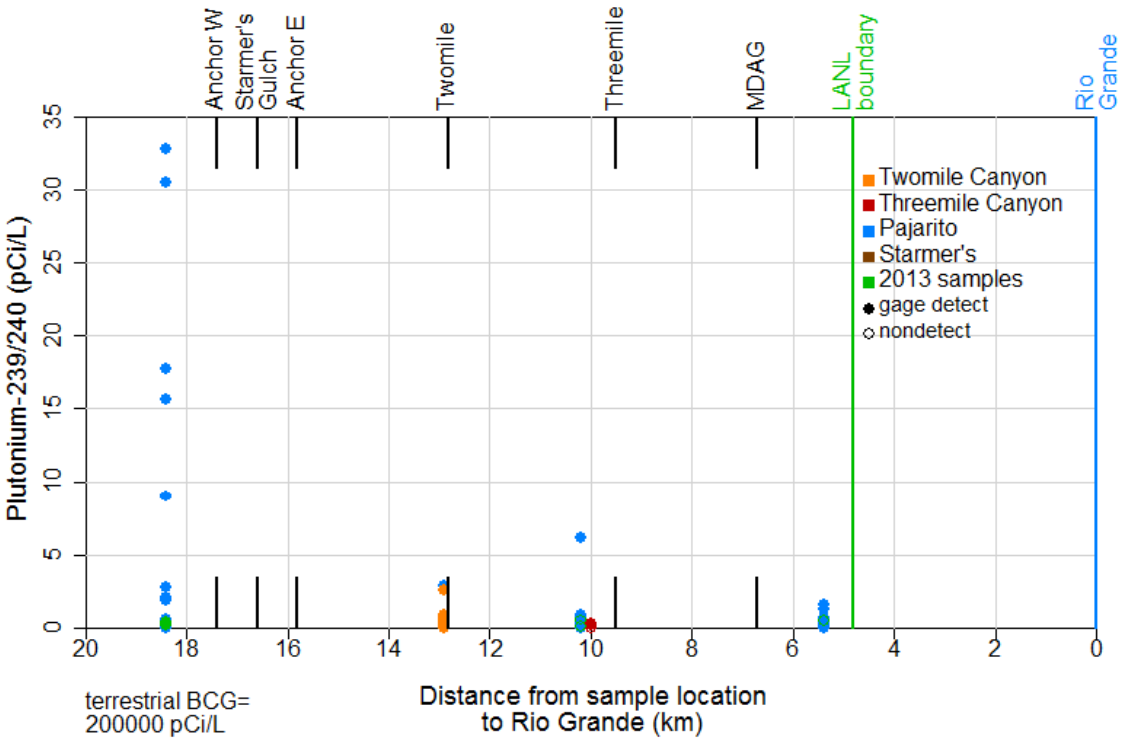


Figure 6-11e Pajarito Canyon watershed unfiltered plutonium-239/240 radioactivity levels in storm water from gages (2004–2013); no SMA samples analyzed

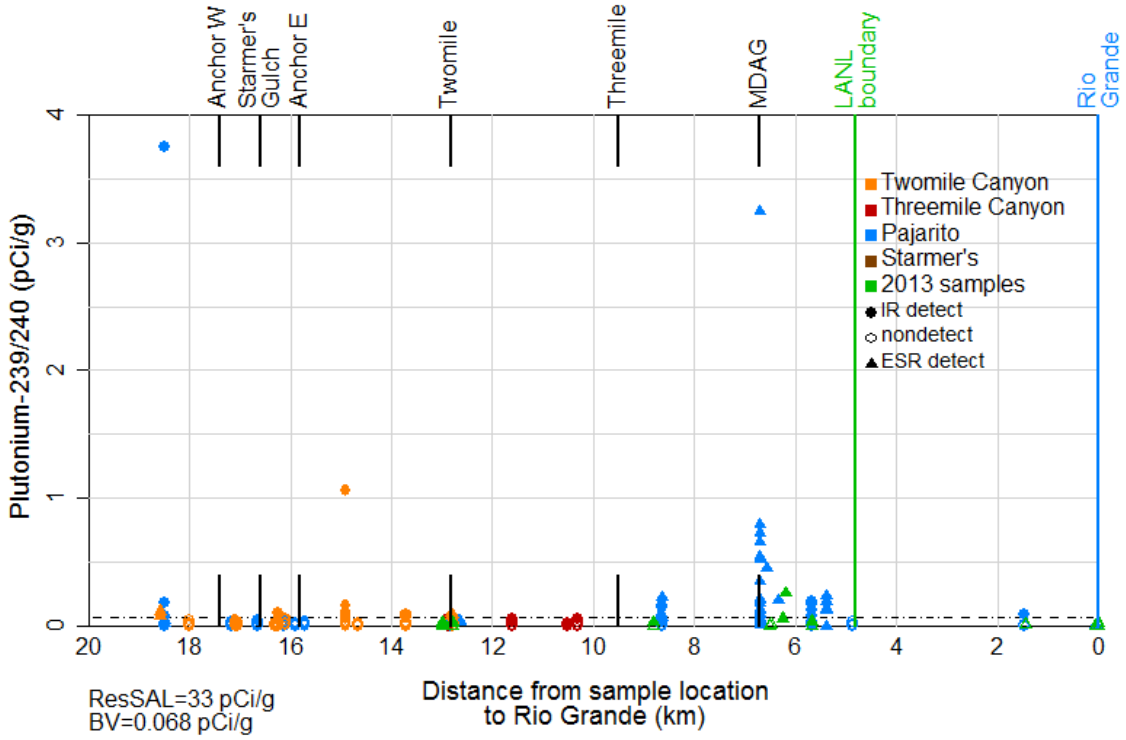


Figure 6-11f Pajarito Canyon watershed plutonium-239/240 radioactivity levels in sediment from canyons IRs (2000, 2004–2007) and ESRs (2003–2013)

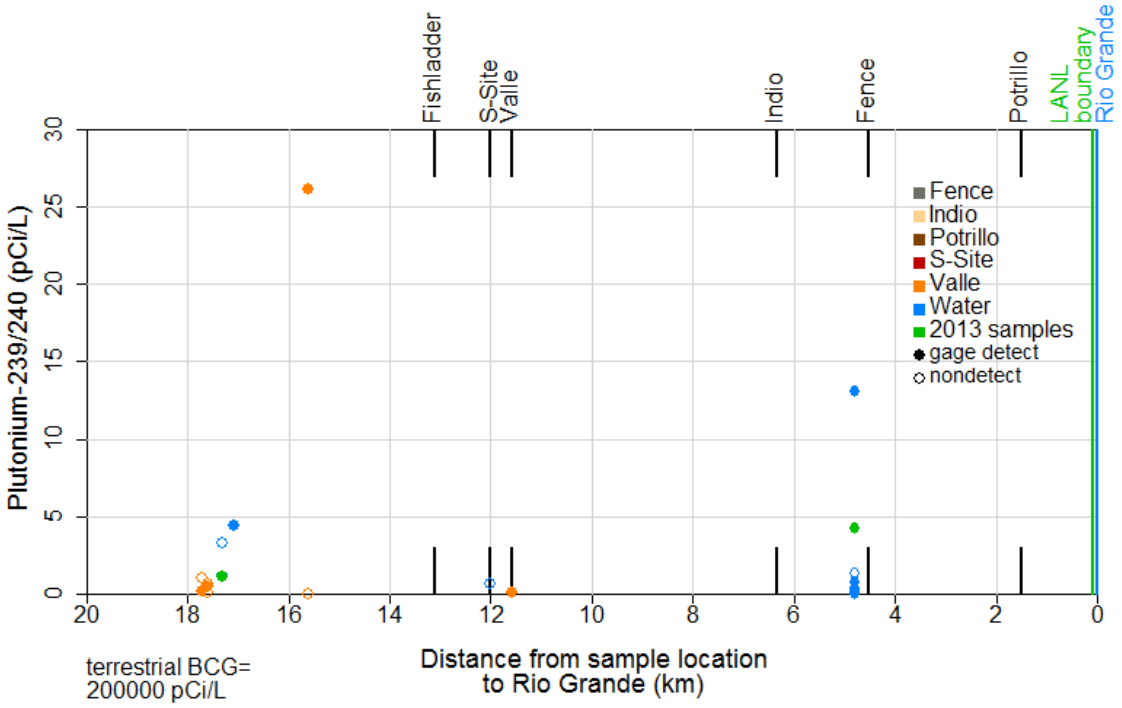


Figure 6-11g Water Canyon watershed unfiltered plutonium-239/240 radioactivity levels in storm water from gages (2004–2008, 2011–2013); no SMA samples analyzed

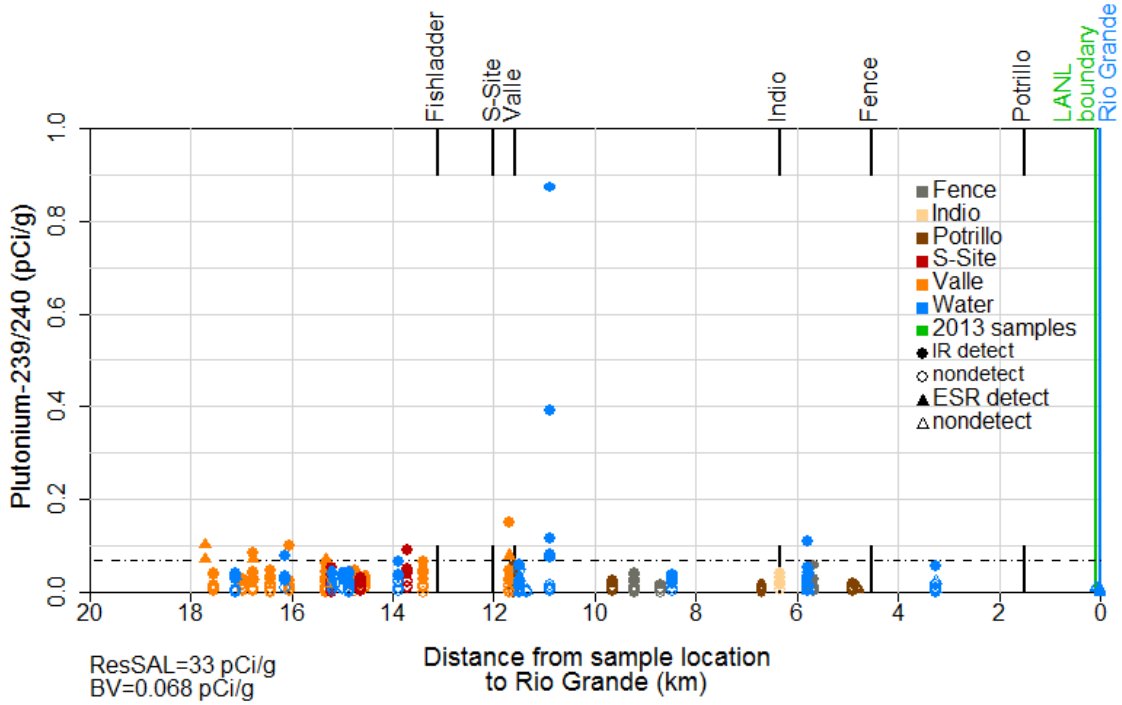


Figure 6-11h Water Canyon watershed plutonium-239/240 radioactivity levels in sediment from canyons IRs (2000, 2008–2011) and ESRs (2003–2009, 2011–2012)

i. Uranium-234 and Uranium-238

No storm water samples collected on the Pajarito Plateau from 2004 to 2013 had uranium-234 (Supplemental Figures S6-7a through f) or uranium-238 (Supplemental Figures S6-8a through f) radioactivity levels above the terrestrial DOE BCG for water of 400,000 pCi/L. In 2013, the highest activity level of uranium-234 and uranium-238 in storm water (1240 pCi/L) was in Los Alamos Canyon above the Rio Grande (E109.9). In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), elevated activity levels of uranium-234 and uranium-238 in storm water at the upgradient boundary stations in 2011 through 2013 are related to runoff from Las Conchas burn areas. Elevated activity levels of uranium-234 and uranium-238 in storm water at the lower boundary of Los Alamos Canyon are most likely associated with Guaje Canyon runoff, which contained sediment from Las Conchas fire burn areas.

In Los Alamos, Pajarito, and Water Canyons, no pre-2013 sediment samples had uranium-234 or uranium-238 activity levels above the Laboratory residential SALs of 170 pCi/g and 87 pCi/g, respectively. In fact, almost all sediment samples had uranium-234 and uranium-238 activity levels 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-2013 uranium-234 and uranium-238 sediment activity levels in Los Alamos, Pajarito, and Water Canyons originating from the historical Laboratory sources in Acid (LANL 2005a), Threemile (LANL 2009b), and Potrillo Canyons (LANL 2011c) were below BVs at the Laboratory boundary and the confluence with the Rio Grande. In sediment samples collected in Los Alamos, Pajarito, and Water Canyons in 2011 through 2013, post–Las Conchas fire, uranium-234 and uranium-238 activity levels were below the Laboratory residential SALs and below to near regional BVs. All post-fire uranium-234 and uranium-238 activity levels in sediment decreased to near background before the Laboratory boundary and the confluence with the Rio Grande. In 2013, the highest uranium-234 activity level in sediment (2.11 pCi/g) was in the Pueblo Canyon wetlands, although all uranium-234 activity levels were below BVs. Two sediment samples had uranium-238 activity levels above BVs: in Ancho Canyon at the Laboratory boundary (2.71 pCi/g) and in the Pueblo Canyon wetlands (2.30 pCi/g).

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

No storm water samples collected in Los Alamos or Mortandad Canyons from 2004 to 2013 had americium-241 (Supplemental Figures S6-9a and b), cesium-137 (Supplemental Figures S6-10a through d), or strontium-90 (Supplemental Figures S6-11a through d) radioactivity levels above the terrestrial DOE BCGs for water of 200,000 pCi/L;20,000 pCi/L; and 30,000 pCi/L, respectively.

In Los Alamos Canyon, elevated activity levels of americium-241, cesium-137, and strontium-90 in storm water samples collected in 2011 through 2013 are associated with runoff from Las Conchas fire burn areas. Indeed, elevated activity levels of americium-241, cesium-137, and strontium-90 in storm water samples at the upgradient Laboratory boundary of Los Alamos Canyon and throughout Los Alamos Canyon, particularly after the Guaje Canyon confluence, are associated with ash and sediment. In 2013, the highest activity levels of americium-241, cesium-137, and strontium-90 in storm water in Los Alamos Canyon are: 13.8 pCi/L in Los Alamos Canyon above the Rio Grande (E109.9); 251 pCi/L in Los Alamos Canyon above the Rio Grande (E109.9); and 31.9 pCi/L in Guaje Canyon, respectively. In Mortandad Canyon, elevated activity levels of cesium-137 and strontium-90 in storm water samples are associated with historical Laboratory sources at TA-50 and Effluent Canyon (LANL 2006). In 2013, the highest activity levels of cesium-137 and strontium-90 in storm water in Mortandad Canyon were 551 pCi/L in Mortandad Canyon at the Laboratory boundary (E204) and 24.5 pCi/L in Mortandad Canyon above Ten Site Canyon (E201), respectively.

In Los Alamos Canyon, pre-2013 sediment samples had americium-241, cesium-137, and strontium-90 activity levels above the Laboratory residential SALs (30 pCi/g, 5.6 pCi/g, and 5.7 pCi/g, respectively) in Acid, DP, and downstream Los Alamos Canyons because of historical Laboratory sources (LANL 2005a), yet decreased to near or below regional background levels (0.04 pCi/g, 0.9 pCi/g, and 1.04 pCi/g, respectively) at the Laboratory boundary and before the confluence with the Rio Grande. In

fire-affected sediment samples collected in Los Alamos Canyon in 2011 through 2013, americium-241, cesium-137, and strontium-90 activity levels were below the Laboratory 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 (E042.1) had a strontium-90 activity level above the Laboratory residential SAL and is associated with ash and sediment from burn areas. All other 2011 through 2013 sediment samples collected in Los Alamos Canyon had strontium-90 activity levels below background levels with the exception of two 2013 sediment samples that were slightly above BVs (1.07 pCi/g and 1.26 pCi/g), both near the confluence of Los Alamos and DP Canyons.

In Mortandad Canyon, pre-2013 sediment samples had cesium-137 and strontium-90 activity levels above the Laboratory residential SALs in Effluent Canyon and downstream Mortandad Canyon because of historical Laboratory sources (LANL 2006), yet decreased to near or below regional background levels at the Laboratory boundary and before the confluence with the Rio Grande. In 2013, sediment samples in Mortandad Canyon had americium-241 and strontium-90 activity levels above regional BVs but below the Laboratory residential SALs, and 2 of 21 sediment samples had cesium-137 activity levels (7.45 pCi/g and 7.82 pCi/g) above residential SALs but below recreational SALs, both of which were below the Laboratory boundary in Mortandad Canyon. These elevated levels may be associated with the historical Laboratory sources mentioned above and/or potentially associated with erosion during the September 13 flood in the Mortandad Canyon sediment traps.

The highest americium-241, cesium-137, and strontium-90 activity levels in 2013 sediment samples were in the Mortandad Canyon sediment traps (14.4 pCi/g), Mortandad Canyon below the Laboratory boundary (7.82 pCi/g), and Los Alamos Canyon above the DP Canyon confluence (1.26 pCi/g), respectively.

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 through 2013. 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 yr (Gallaher and Koch 2004, 2005). A similar return to pre-fire conditions is expected for the Las Conchas fire.

Storm water samples collected in 2013 downgradient of burned areas contained increased concentrations of 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 activity levels in radionuclides in storm water were observed, including: aluminum, arsenic, barium, cobalt, copper, cyanide, dioxins/furans, manganese, mercury, nickel, selenium, vanadium, 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 Laboratory-constructed and -maintained flood- and sediment-control features such as wetlands, detention basins, sediment traps, and weirs. In 2013, the Pueblo Canyon wetland reduced storm water discharge such that the gage station downstream of the wetland and grade-control structure measured only two storm events: one during the extremely large September 13 flood and one small event on September 21 during which the soil was still highly saturated. 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 also trapped upstream of the Pajarito Canyon flood-control structure, reducing sediment transport downstream. The upper Los Alamos Canyon detention basins below SWMU 01-001(f) are not associated with burn areas, but were quite effective at reducing the total PCB concentrations in storm water runoff from the contaminated hillslope.

With the extremity of the September 13 flood and the damage to Laboratory environmental monitoring infrastructure and flood- and sediment-control structures, the lack of movement of contaminated sediment is quite remarkable. This is in part because of the sheer volume of flood water and dilution; however, sediment samples taken in flood plain deposits do not show highly elevated levels of contaminants. PCBs and radionuclides were elevated in water samples collected in Los Alamos Canyon above the Rio Grande, potentially because of the influence of fire-affected Guaje Canyon and erosion during the flood in Acid Canyon and the Pueblo wetlands. Mortandad Canyon at the Laboratory boundary also had elevated levels of radionuclides in water, potentially because of erosion in the sediment traps during the flood. RDX in Water Canyon and silver in Cañon de Valle may have mobilized during the flood, but water and sediment concentrations did not increase significantly above past levels. In addition, during the flood plutonium-239/240 may have mobilized in Los Alamos Canyon. In Mortandad Canyon, several radionuclides, including cesium-137, americium-241, plutonium-238, and plutonium-239/240, were found in 2013 deposits above their respective BVs and higher than existing sediment deposits below the Laboratory boundary.

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 Laboratory 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 2013 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. Indeed, despite the considerable erosion and deposition throughout the Laboratory during the September 13 flood, concentrations of constituents in sediment deposits were not significantly different in magnitude in 2013 as compared to historical values.

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A soil monitoring program offers the most direct means of determining the concentrations, distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities. In 2013, we collected 13 surface soil samples from around the perimeter of Area G (the primary low-level radioactive solid waste burial and storage site); 1 sample downgradient and downwind of Area G at the Pueblo de San Ildefonso boundary; 9 samples from within and around the perimeter of the Dual Axis Radiographic Hydrodynamic Test facility (the primary explosive test facility); and samples from gardens located at Pueblo de Cochiti, Sile, and Peña Blanca downstream of Los Alamos National Laboratory (the Laboratory) and irrigated with Rio Grande water. Soil samples were analyzed for one or more of the following sets of analytes that have a history of use at the Laboratory: radionuclides, heavy metals, and/or organic chemicals. All radionuclides, heavy metals, and/or organic chemicals were below screening levels.

A. INTRODUCTION

A soil monitoring program offers the most direct means of determining the concentrations (or 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 data may provide information about several potential exposure pathways (e.g., soil ingestion, food ingestion, inhalation of air particulates and dust, and drinking water) that could deliver radioactive materials or chemicals to humans and biota.

The overall soil surveillance program implemented by Los Alamos National Laboratory (LANL or the Laboratory) consists of the following:

1) An institutional component that monitors surface soil within and around the perimeter of the Laboratory 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 perimeters of two active Laboratory sites:

   - The principal low-level 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 2012).

3) A special studies component that investigates cases where there may be a lack of data for 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 the Laboratory's soil surveillance program are to monitor for new operational releases of radionuclides or chemicals, to assess trends in activities and concentrations that resulted from historic operational releases, and to provide data for dose and risk assessments. The program

1) measures activities and concentrations of radionuclides and chemicals that have had a history of use at the Laboratory in soil at on-site and perimeter locations and compares the concentrations to regional background locations,

2) assesses trends in radionuclide activities and/or chemical concentrations in soil at the same locations over time (i.e., are activities/concentrations increasing or decreasing?), and

3) collects samples needed to estimate the committed effective dose equivalent from radionuclides to humans and biota and to determine the potential risk to humans and biota from metals or organic chemicals in soil (see Chapter 3 for the dose and risk assessments).

B. SOIL COMPARISON LEVELS

To evaluate the presence and potential effects of Laboratory-derived radionuclides and chemicals in surface soil, individual (detected) on-site and perimeter results are compared with regional statistical reference levels (RSRLs). A detected result for a radionuclide is one in which the result is higher than the minimum detectable activity (concentration) and/or higher than three times the total propagated uncertainty (Keith 1991, Corely et al. 1981). Similarly, a detected result for a chemical is one in which the result is higher than the method detection limit. RSRLs are the upper-level background concentrations (the mean plus three standard deviations) for radionuclides and chemicals in soil collected from regional locations more than 9 mi away from the Laboratory (DOE 1991). The concentrations of radionuclides and chemicals in soil collected from these regional background locations are the result of worldwide fallout, other non-Laboratory sources, and natural processes.

In cases where multiple samples (n > 3) are collected from a defined sample population/location (e.g., Los Alamos townsite, White Rock/Pajarito Acres, Pueblo de San Ildefonso, Pueblo de Cochiti, downstream farms, etc.), then mean concentrations are compared with mean background concentrations using a statistical test at the 0.05 probability level.

If individual or mean results exceed the appropriate statistical test, the Laboratory then compares the concentrations with human health– (risk-/dose-) based screening levels (SLs) and, if appropriate, with regulatory standards. More detailed descriptions of the RSRLs, the SLs, and the regulatory standard used to evaluate the sampling results are presented 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 regional background locations. These samples are collected from locations that surround the Laboratory in all major directions: near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast; on Rowe Mesa (near Pecos) to the southeast; in Youngsville to the northwest; and at Jemez Springs to the southwest. As required by DOE, all locations are at elevations similar to Laboratory elevations, are more than 9 mi away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (DOE 1991). RSRLs, which represent natural and fallout levels (or anthropogenic sources not from the Laboratory), are regularly recalculated as additional data become available over time 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 limit of 25 millirem per year (mrem/yr) (DOE 1999c, DOE 2011b). If a radionuclide exceeds the SL, we investigate the basis for the elevated activity, check laboratory records, and reanalyze the sample and/or resample the site to determine the cause for any higher-than-normal result. The Laboratory 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 2012) using the residual radioactivity (RESRAD) computer model (Yu et al. 1995).

  For chemicals (inorganic and organic), we compare concentrations with the New Mexico Environment Department (NMED) or U.S. Environmental Protection Agency (EPA) regional

residential or industrial SLs (ISLs) at a 10^{-5} risk level for carcinogens and a hazard quotient (HQ) of 1 for noncarcinogens (NMED 2012; EPA 2013). If a chemical exceeds the SL, we investigate the basis for the elevated levels, check laboratory records, and reanalyze the sample and/or resample the site to determine the cause for any higher-than-normal result. NMED is notified if the exceedance of SLs is confirmed.

To evaluate radionuclides and chemicals in soil, the analytical results from on-site areas are evaluated against ISLs, and analytical results from perimeter areas are compared with residential screening levels (RSLs). The RSLs assume that families live at the 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 activities available for a given year based on a residential scenario. (These data are presented in supplemental 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 used are presented in a report by Fresquez et al. (1996). This calculated dose is then compared with the 25-mrem/yr DOE single-pathway dose limit. There are no regulatory standards for organic or inorganic chemicals.

Table 7-1
Application of Standards, SLs, and Background 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. Only applicable to DARHT; other on-site areas use RSRLs. A discussion of these levels is provided in Section D.3.
[b] na = Not available.

C. INSTITUTIONAL MONITORING

1. Monitoring Network

Surface soil composite samples (5 discrete subsamples per site) are collected from 17 on-site, 11 perimeter, and 6 regional background locations once every 3 yr (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 (tritium, americium-241, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238), target analyte list (TAL) elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury), polychlorinated biphenyls (PCBs) (Aroclors), semivolatile organic compounds (SVOCs), and high explosives (HE), occurred in 2012, and results are reported in the 2012 Environmental Report (Fresquez 2013).

Although the institutional soil sampling program was changed to a 3-yr sampling cycle, the Pueblo de San Ildefonso requested that the Laboratory collect some soil (perimeter) samples on an annual basis for radionuclides and TAL metals on pueblo lands that are downwind of Area G, the Laboratory's principal low-level radioactive waste disposal and storage site. Area G is located in Technical Area 54 (TA-54) at the Laboratory's eastern boundary. The sample location and results of the analyses of a soil sample collected in 2013 at the Laboratory/Pueblo de San Ildefonso boundary downwind of Area G can be found in Section D.1 (site T3) and D.2.b, respectively.

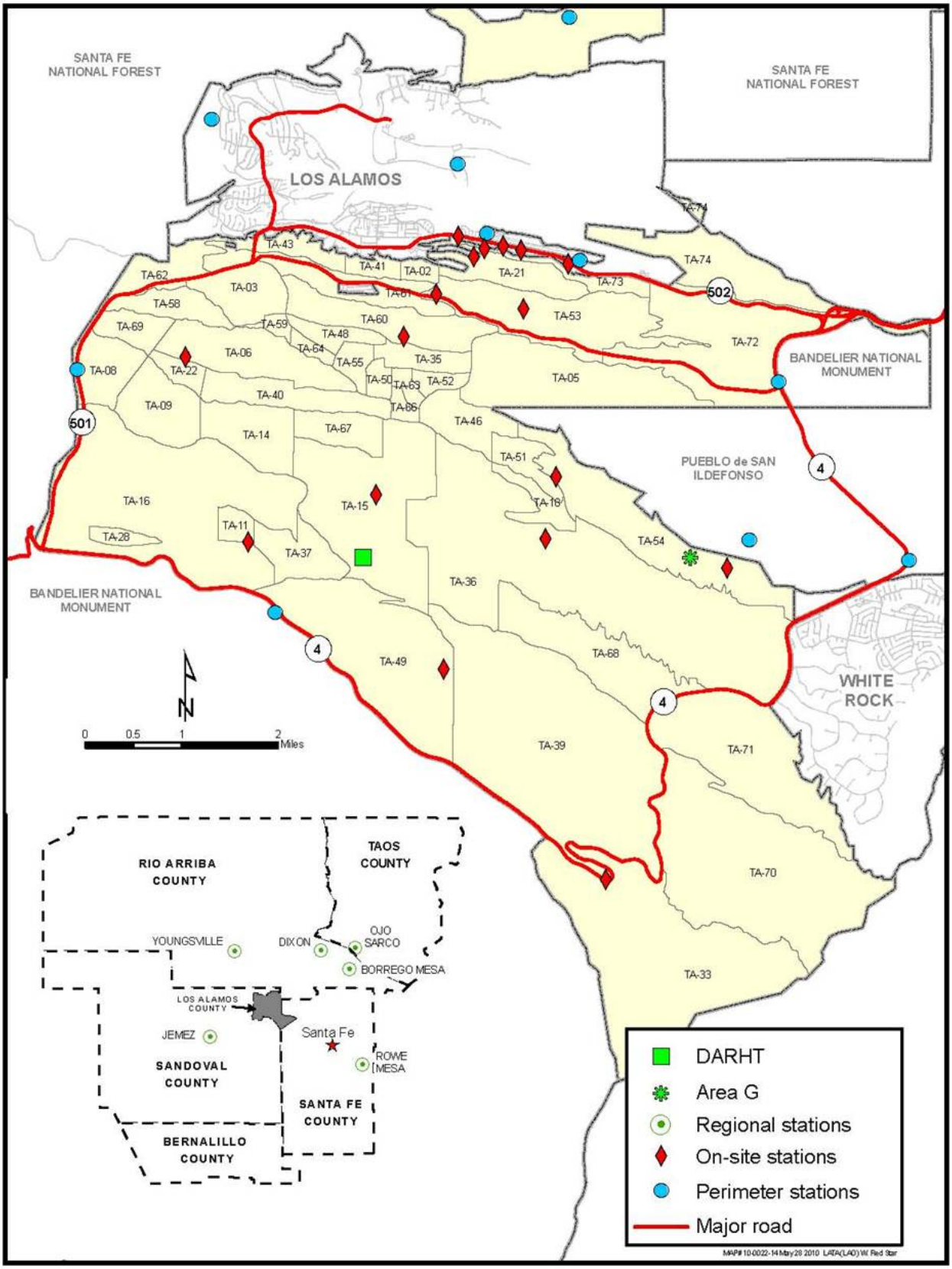

Figure 7-1 **On-site, perimeter, and regional soil sampling locations. The Otowi perimeter station is not shown but is about 5 mi east of the Laboratory near the confluence of Los Alamos Canyon and the Rio Grande.**

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). Established in 1957, Area G, approximately 63 acres in size, is the Laboratory's primary low-level radioactive solid waste burial and storage site located on the east end of Mesita del Buey at TA-54 (Hansen et al. 1980, Soholt 1990, Lopez 2002) (Figure 7-1). Tritium, plutonium, americium, and uranium are the main radionuclides in waste materials at Area G (DOE 1979).

Thirteen surface soil grab samples were collected in April 2013 at designated locations around the perimeter (outside) fenceline of Area G, and one surface soil sample (site T3) was collected at the Laboratory/Pueblo de San Ildefonso boundary line approximately 800 ft northeast, downwind, and downgradient of Area G in Cañada del Buey (Figure 7-2). (Note: We report on the analyses of overstory vegetation collected around the Area G facility in Chapter 8, Section B.4.a.)

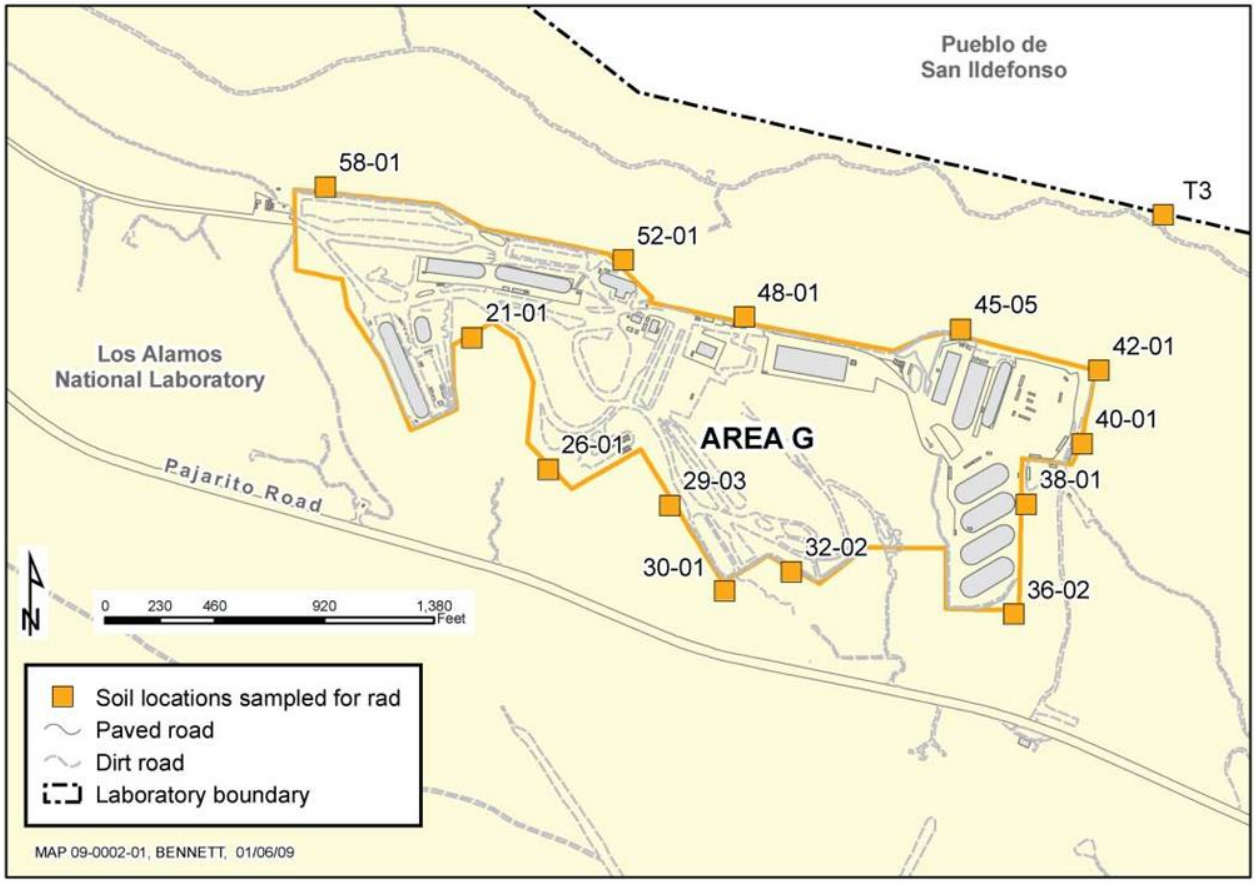

Figure 7-2 Locations of soil samples collected around Area G in 2013

All samples were analyzed by ALS Laboratory Group for tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238.

Previous sampling for TAL metals at Area G showed no levels of concern, so TAL metals analysis was not performed in 2013. Results from previous sampling periods for most metals (478 out of 483 measurements) were similar to RSRLs (Fresquez 2007), and the few detected concentrations above RSRLs were far below the ISLs (and RSLs) with no evident trends.

2. Radionuclide Results for Area G

a. Perimeter Results

Tritium, americium-241, plutonium-238, and plutonium-239/240 were detected at activities above the RSRLs (based on 2002–2012 data; n = 25) in many of the 13 soil samples collected around the perimeter fenceline of Area G in 2013 (Table S7-1).

Specifically, tritium was detected above the RSRL (0.77 picocuries per milliliter [pCi/mL]) in 5 of the 13 locations with the highest activities being in the same three locations as in years past. These areas are located in the southern portion of Area G near tritium buried in underground shafts; site 29-03 had 2612 pCi/mL, site 30-01 had 135 pCi/mL, and site 32-02 had 15 pCi/mL (Figure 7-2). Although these data are within the range of activities detected in past years and are not statistically increasing over time (Mann-Kendall nonparametric test for trend at the 0.05 probability level), they are variable from year to year (Figure 7-3).

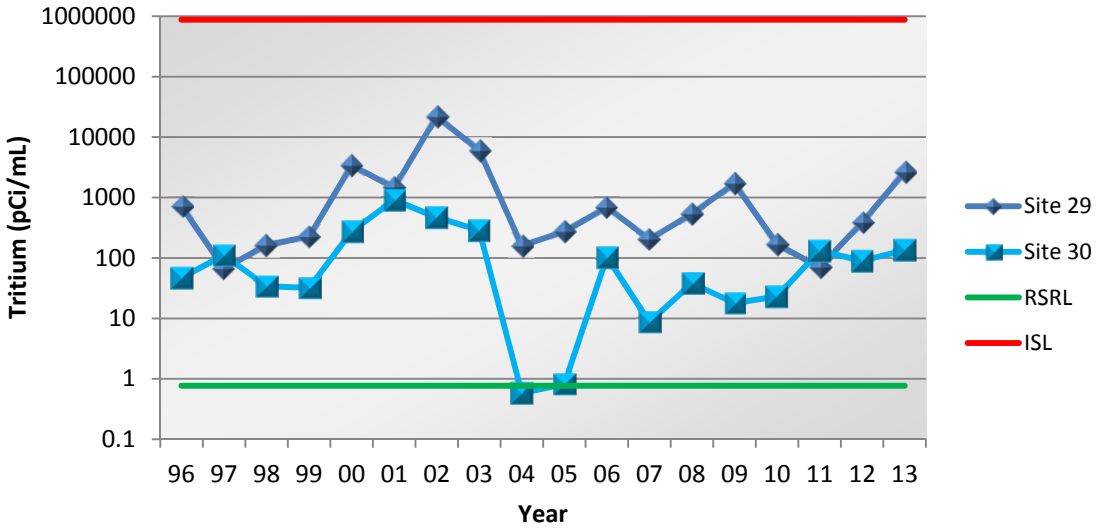

Figure 7-3 **Tritium activities in surface soil samples collected from the southern portions of Area G at TA-54 from 1996 to 2013 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.**

The degree of variability in tritium activities 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 activities of tritium in surface soil at Area G are far below the ISL of 880,000 pCi/mL (equivalent to 120,000 pCi/g at 12% moisture), and the migration of tritium from the Area G boundary at subsurface depths is not extensive. In 2003 (Fresquez et al. 2003) and in 2013 (supplemental Table S8-17), the measurement of tritium in trees at the southern portion of Area G, starting from the perimeter of Area G outward, showed that the tritium activity decreased greatly with distance; by 330 ft away, the activities of tritium were not different from the RSRL.

Many soil samples collected around the perimeter of Area G contain activities 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 S7-1). The highest activities of americium-241 (0.86 pCi/g dry at site 38-01), plutonium-238 (2.9 pCi/g dry at site 40-01 and 2.5 pCi/g dry at site 45-05), and plutonium-239/240 (5.4 pCi/g dry at site 38-01) were detected in soil samples primarily located on the perimeter of the eastern side of Area G near the Transuranic Waste Inspection Project domes. Although the activities of these radionuclides in soil are higher than the RSRLs, all levels are still far below ISLs, and the activities of most radionuclides at most sites are generally not statistically increasing over time (Figures 7-4, 7-5, and 7-6). An exception may be activities of plutonium-239/240 in soil collected from the eastern side of Area G (site 38), which contains statistically higher activities

(Mann-Whitney U Test = p <0.05) in later years (2005–2013; average = 7.7 pCi/g) than in earlier years (1996–2004; average = 0.79 pCi/g); the overall trend shows that plutonium-239/240 is increasing over time at this location (based on a Mann-Kendall nonparametric test for trend at the 0.05 probability level) (Figure 7-6). The increase in plutonium-239/240 in soil over the latter years on the eastern side is probably associated with shifting drainage patterns from within the Area G pads. The increase in water runoff on the eastern side may be responsible for the large variation in activity at that location over time. Activities of plutonium-239/240 in surface soil on the east side, however, decrease with distance from the perimeter fenceline. For example, a composite surface soil sample collected in 2012 on the eastern side of Area G, approximately 75 m (246 ft) away from the perimeter fenceline, measured 0.27 (±0.027) pCi/g of plutonium-239/240 (Fresquez 2013).

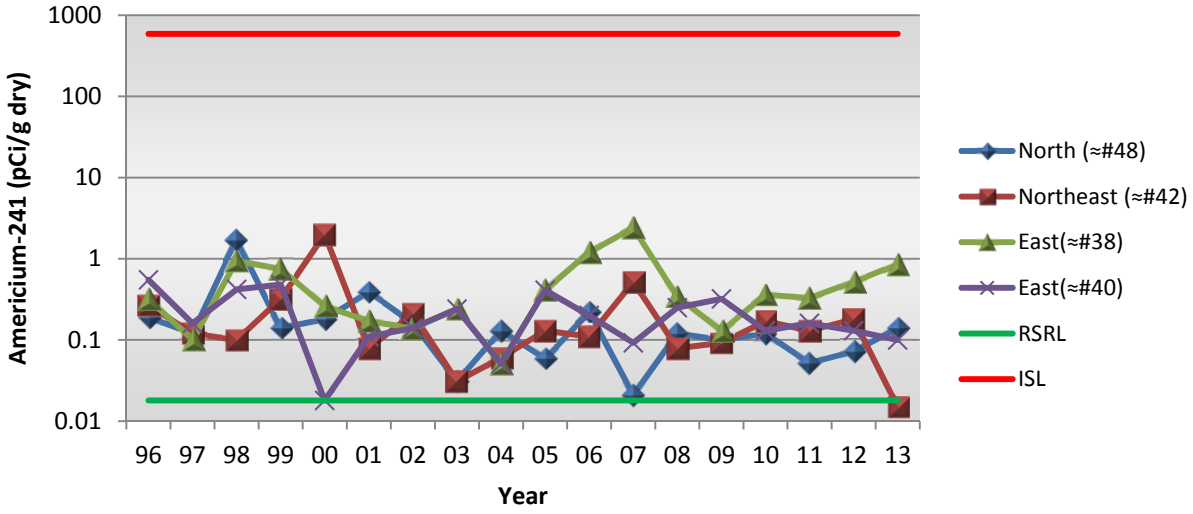

Figure 7-4 **Americium-241 activities in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 to 2013 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.**

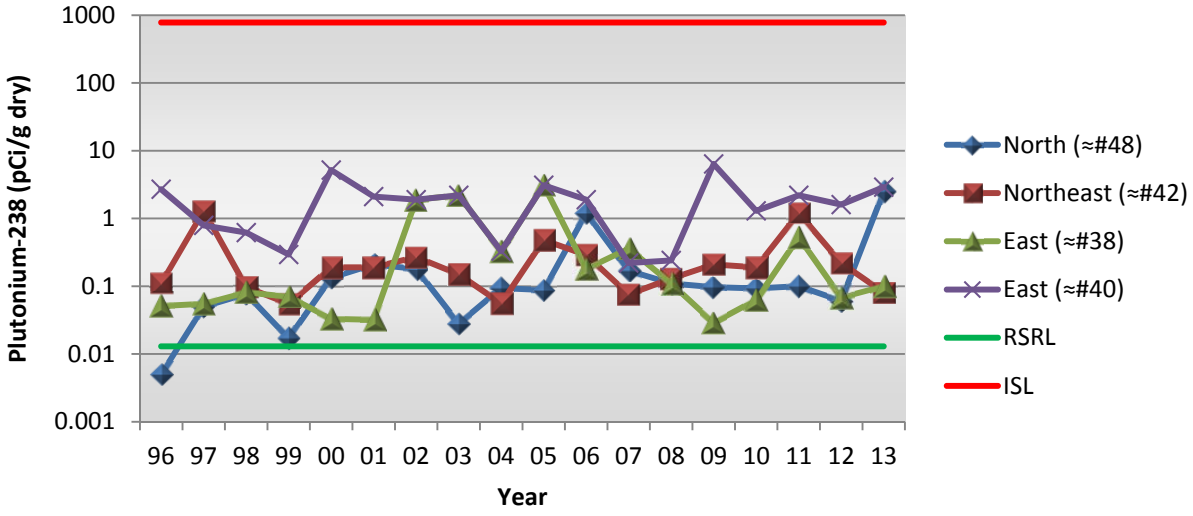

Figure 7-5 **Plutonium-238 activities in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 to 2013 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.**

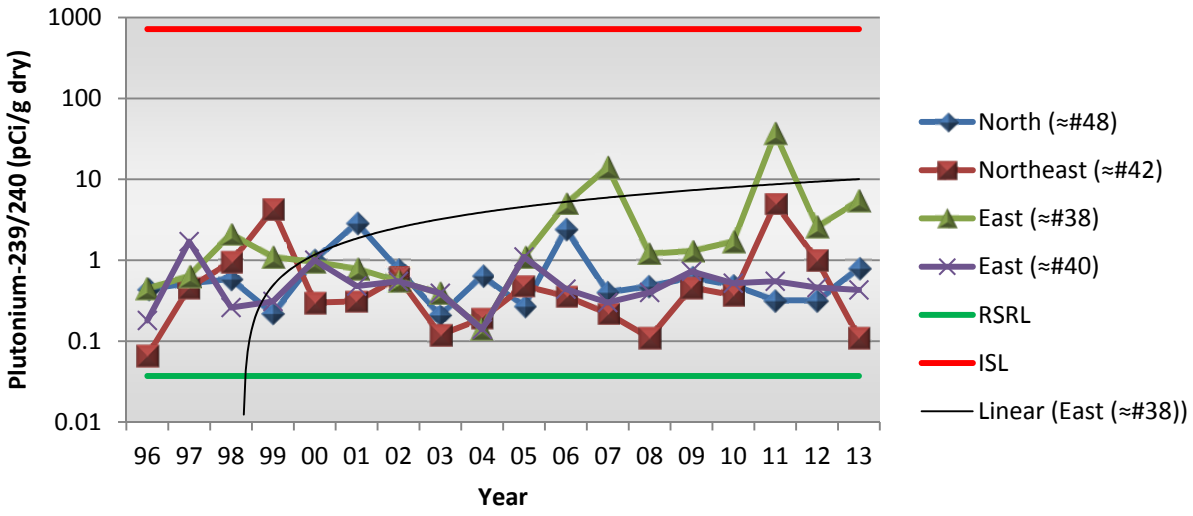

Figure 7-6 **Plutonium-239/240 activities in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 to 2013 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.**

b. Results at the Pueblo de San Ildefonso Boundary

All radionuclides in a soil sample collected at the Laboratory/Pueblo de San Ildefonso boundary northeast, downwind, and downgradient of Area G in Cañada del Buey (Site T3) were either not detected or were below the RSRLs (Table S7-1). A nondetected value is one in which the result is lower than three times the counting uncertainty (Keith 1991; Corely et al. 1981) or is less than the minimum detectable activity.

In the past, americium-241, plutonium-238, and plutonium-239/240 were detected at activities just above the RSRLs. However, the levels of these radionuclides are far below the RSLs and have generally remained stable over the 6-yr period of study (Figures 7-7, 7-8, and 7-9).

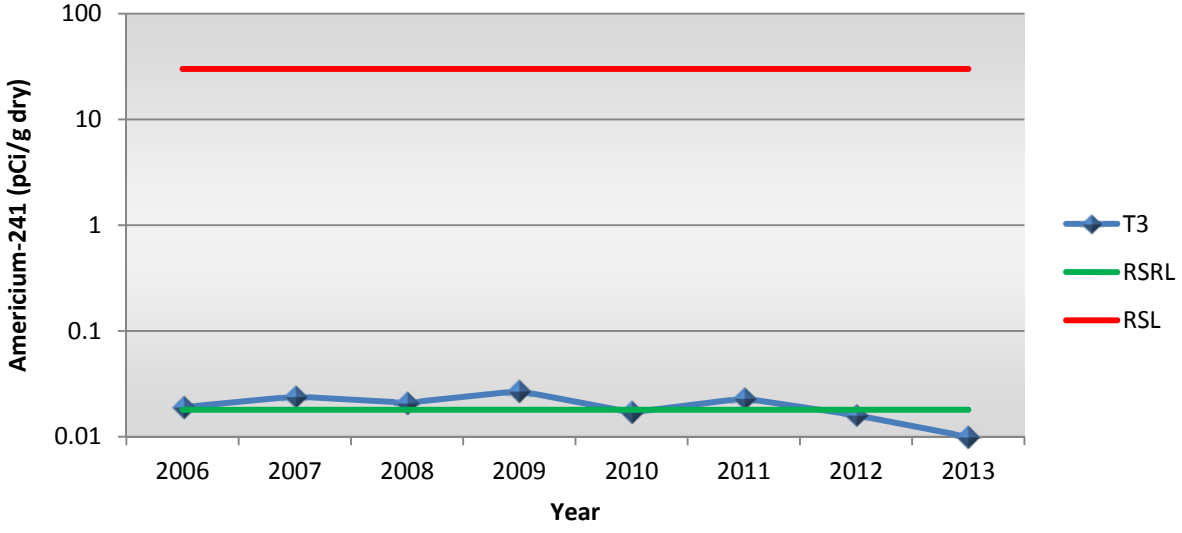

Figure 7-7 **Americium-241 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 to 2013 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.**

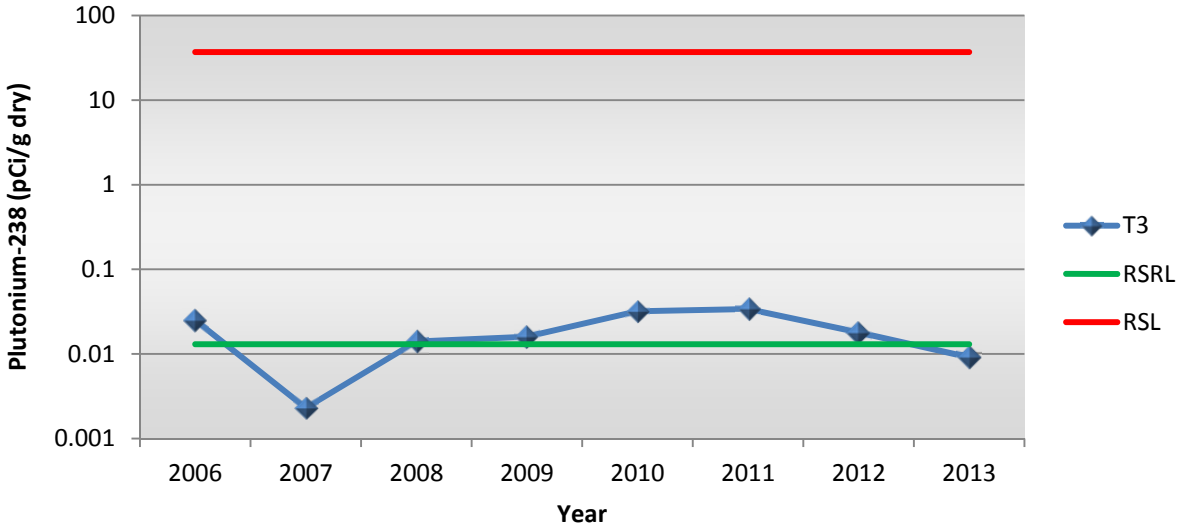

Figure 7-8 **Plutonium-238 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 to 2013 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.**

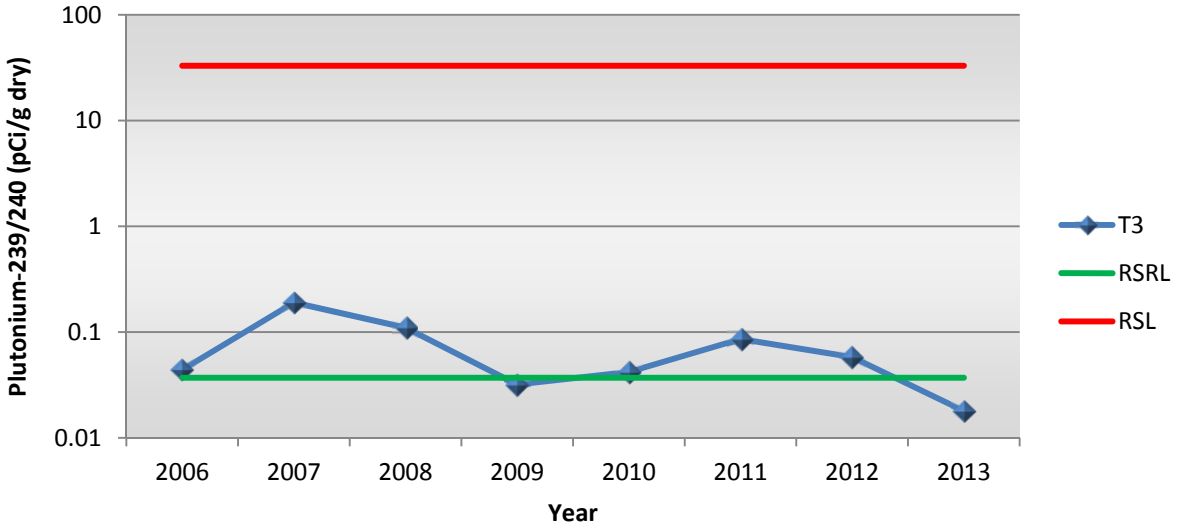

Figure 7-9 **Plutonium-239/240 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 to 2013 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.**

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, six in FY12, and five

in FY13). Contaminants of potential concern include radionuclides, beryllium (and other heavy metals), and organic chemicals such as PCBs, SVOCs, HE, and dioxins/furans.

Soil composite samples (five subsamples per site) were collected in late April 2013 on the north, east, south, and west sides (Figure 7-10) 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 grab 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 metals, and HE. The firing point sample was also analyzed for dioxins and furans by Cape Fear Analytical. Although not analyzed for in 2013, 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: The analyses of vegetation, small mammals, bees, and birds collected around the DARHT facility is reported in Chapter 8, Section B.4.b.)

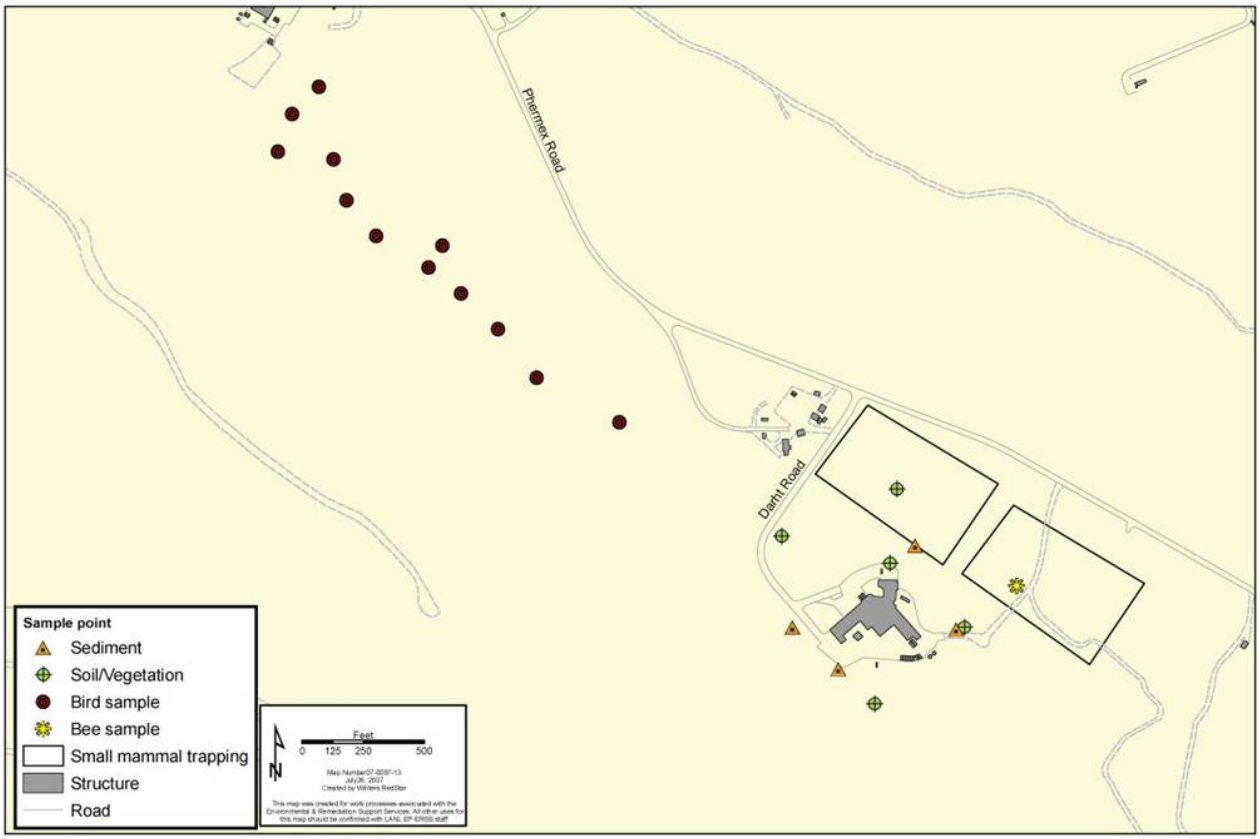

Figure 7-10 Soil, sediment, and biota sample locations at DARHT in 2013

The Laboratory compared the radionuclide and TAL metal results in soil and sediment from the DARHT sampling with both RSRLs and BSRLs. The BSRLs are the activities and concentrations of radionuclides and inorganic chemicals (the 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 activities, such as for cesium-137, may be biased low, and some baseline inorganic chemical concentrations, such as silver, may be biased high regardless of DARHT activities. Moreover, some TAL metals analyzed recently have no baseline levels at all. To accommodate parking spaces and storage areas constructed 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 activities 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 limits of silver from 2 mg/kg to 0.2 mg/kg.

4. Radionuclide and Chemical 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 S7-2). The 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 above the BSRLs over the years are the uranium isotopes, primarily uranium-238 in the soil sample collected nearest the firing point. Those activities peaked in 2008 at 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 uranium-238 activity within the facility has decreased dramatically to baseline levels (Figure 7-11).

In 2012, one perimeter soil sample 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 (Figure 7-11). 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. In 2013, the uranium-238 activities, including the amounts on the north side, are at BSRLs.

Most of the TAL elements, with the exception of sodium and selenium, in the soil and sediment samples collected within and around the DARHT facility were below both the BSRLs and the RSRLs (Table S7-3). There is no ISL for sodium, and the selenium concentration is far below the ISL of 5680 mg/kg.

Beryllium, listed as a chemical of potential 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 14-yr operations period have mostly remained below the BSRL over time (Figure 7-12).

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 S7-4). Also, most dioxin and furan congeners were not detected above the method detection limits in the soil sample nearest the firing point (Table S7-5). (Note: Trace amounts of 1,2,3,4,6,7,8-

heptachlorodibenzodioxin and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin were detected above the method detection limit but below the report detection limit. Similar amounts of these two congeners were detected in 2012.)

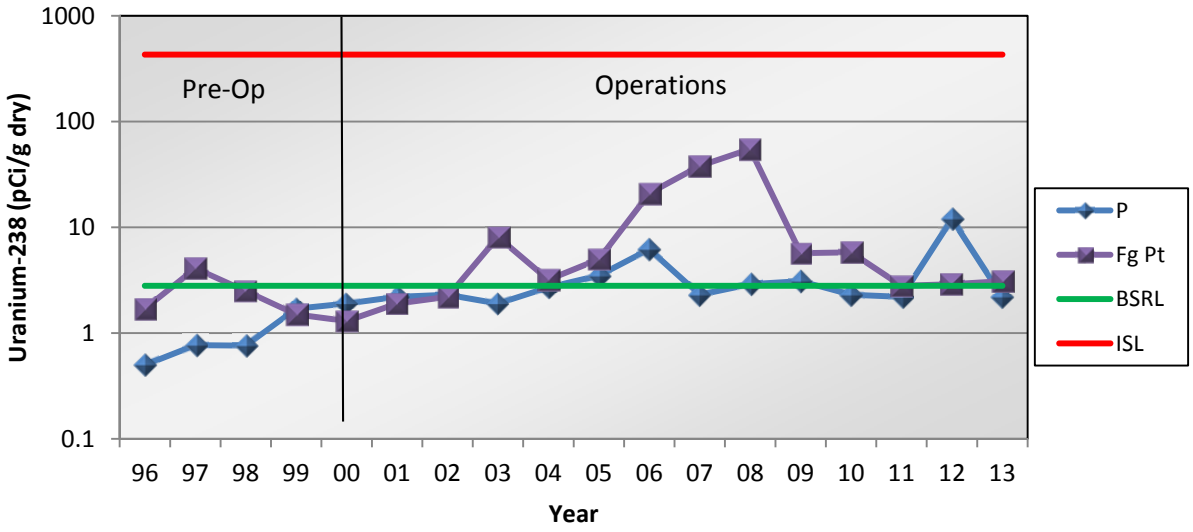

Figure 7-11 **Uranium-238 activities in surface soil collected within (near the firing point [Fg Pt]) and around the DARHT perimeter (P) (north-, west-, south-, and east-side average) at TA-15 from 1996 to 1999 (preoperations) and from 2000 to 2013 (operations) compared with the BSRL and the ISL. Note the logarithmic scale on the vertical axis.**

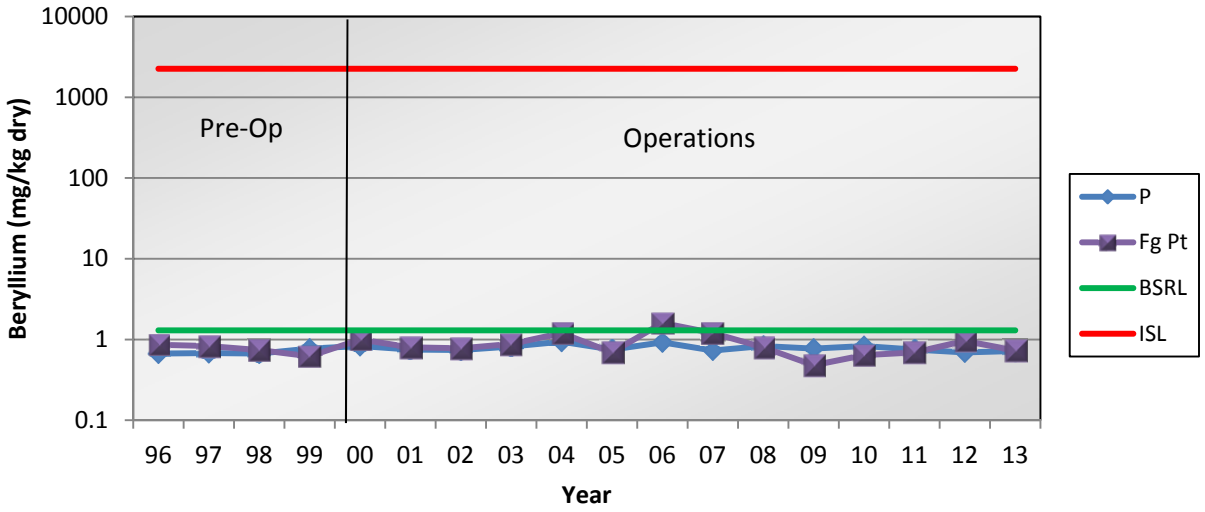

Figure 7-12 **Beryllium concentrations in soil collected within (near the firing point [Fg Pt]) and around the DARHT perimeter (P) (north-, west-, south-, and east-side average) at TA-15 from 1996 to 1999 (preoperations) and from 2000 to 2013 (operations) compared with the BSRL and the ISL. Note the logarithmic scale on the vertical axis.**

E. SPECIAL MONITORING STUDIES

1. Chemicals in Soil Collected from Gardens Downgradient of Cochiti Lake and Irrigated with Rio Grande Water

a. Monitoring Network

Soil samples from four garden sites in New Mexico below Cochiti Lake and irrigated with Rio Grande water were collected in September 2012. One sample was from the Pueblo de Cochiti, two samples were from Sile, and one sample was from Peña Blanca. (Note: These soil samples were collected in late 2012 after the growing season. Because the data were not received in time to be reported in the 2012 report, they are being reported here for completeness.) Soil samples were previously collected from garden sites downstream of Cochiti Lake in 2000 (Fresquez et al. 2001b) and in 2009 (Fresquez 2010).

At each study site, a composite soil sample (five sub samples per site) for radionuclide and TAL metal analyses and two grab samples for organic chemical analyses were collected with a disposable polystyrene scoop at the 0- to 6-in. depth. (Note: The fields were plowed to a depth of at least 1 ft in preparation for planting.) The composite soil sample, after mixing, was placed into a prelabeled 500-mL polyethylene bottle; the two soil grab samples, one for the analysis of SVOCs and HE and the other for the analysis of PCB congeners, were placed directly into prelabeled 500-mL amber-colored glass jars. All sample containers were secured with chain-of-custody tape, placed into Ziploc bags, cooled to 4°C, and submitted to the Laboratory's Sample Management Office. The composite samples were shipped under full chain-of-custody procedures to ALS for the analysis of radionuclides and TAL elements. Samples for SVOCs and HE analyses were shipped to ALS, and samples for PCB congener analysis were shipped to Cape Fear Analytical.

a. Radionuclide Results

With the exception of the plutonium isotopes, the mean activities of the other radionuclides in soil collected from garden sites downstream of Cochiti Lake and irrigated with Rio Grande water were not statistically higher than regional background using a Mann-Whitney nonparametric U test at the 0.05 probability level (Table S7-6). Activities of plutonium-238 and plutonium-239/240 were statistically higher than background but three orders of magnitude below the RSLs of 50 pCi/g and 48 pCi/g, respectively.

b. TAL Elements, HE, SVOCs, and PCB Results

There were no mean concentrations of heavy metals in the garden soil samples that were statistically higher than background using a Mann-Whitney nonparametric U test at the 0.05 probability level (Table S7-7). Other (nonmetal) elements that were statistically higher than background include barium, magnesium, sodium, and selenium. The type of crop, parent material (soil type), soil pH, tillage, irrigation source, and organic and inorganic fertilizers are all potential reasons why TAL elements may differ from one place to another within perimeter area gardens. With the exception of barium and selenium, there are no RSLs for these elements in soil, and the mean barium (185 mg/kg) and selenium (1.1 mg/kg) concentrations were far below the RSLs of 15,600 mg/kg and 400 mg/kg, respectively.

All HE (Table S7-8) and SVOCs (Table S7-9) were not detected above the method detection limits in the garden soil samples.

Total PCBs concentrations in garden soil were very low, ranging from 25 pg/g wet to 180 pg/g wet (average = 111 pg/g wet), and the mean concentration was statistically similar to background (1921 pg/g) using a Mann-Whitney nonparametric U test at the 0.05 probability level (Table S7-10).

Overall, the data from downstream farm soil irrigated with Rio Grande water are similar to past years (Fresquez et al. 2001b, Fresquez 2010).

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 Laboratory's *Quality Assurance Project Plan for the Soil, Foodstuffs, and Nonfoodstuffs Biota Monitoring Project* and in the following Laboratory 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, listed on the Laboratory's public website at http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php and available at eprr.lanl.gov, ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results are conducted in a consistent manner from year to year. 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 Laboratory's Sample Management Office, which ships the samples 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 sample collection in 2013 was 100%.

3. Analytical Laboratory Quality Assessment

We had no analytical laboratory data quality issues related to the SFB sampling program during 2013. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 10. Analytical data completeness for soil sampling programs was 100% in 2013.

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A wide variety of wild and domestic crops and food products are grown and/or harvested at many locations surrounding the Los Alamos National Laboratory (the Laboratory); our objective is to determine if past or current releases from Laboratory operations are impacting the human food chain. In 2013, we collected 47 vegetable samples, 6 fruit samples, 12 fruit branch samples, 2 honey samples, 4 chicken egg samples, 2 goat milk samples, and 16 wild edible plant samples from one or more of the following neighboring communities surrounding the Laboratory: Los Alamos, White Rock/ Pajarito Acres, Pueblo de San Ildefonso, and Pueblo de Cochiti. Samples from these areas were compared with similar samples collected from regional background locations away from the influence of the Laboratory.

We also monitor various types of wildlife and vegetation for exposure to released substances and/or changes in population attributes (abundance, diversity, and composition) as a result of Laboratory operations. Seven deer and two elk samples were collected as roadkill from Pueblo de San Ildefonso and Laboratory lands. Fourteen overstory vegetation samples were collected from the perimeter of Area G (waste and storage facility). Four overstory vegetation samples, three field-mouse samples, and one honey-bee sample were collected from the perimeter of the Dual Axis Radiographic Hydrodynamic Test (DARHT) (firing site) facility. Birds were identified, counted, and banded near the DARHT facility. One sample of understory vegetation and 10 samples of field mice were collected upgradient and downgradient of the Los Alamos Canyon sediment-control structure (weir). One sample of understory vegetation and seven field-mouse samples were collected upgradient of the Pajarito Canyon sediment-control structure. Bats and birds were identified and counted around other Laboratory sites.

Collected samples were analyzed for one or more of the following sets of analytes that have a history of use at the Laboratory: radionuclides, metals, and organic chemicals. All radionuclides, metals, and/or organic chemicals that were analyzed in samples collected from within and around the Laboratory were either not detected (most results), statistically similar to regional background, or below screening levels. Bird populations and diversity at DARHT were not impacted by operations, but the composition has changed over time with changes in overstory vegetation from drought, fire, and insect activity. Polychlorinated biphenyls in field mice collected upgradient and 4.5 mi downgradient of the Los Alamos Canyon weir have decreased over time to regional background concentrations.

A. FOODSTUFFS MONITORING

1. Introduction

A wide variety of wild and domestic crops, including vegetables, fruits, berries, nuts, and grains, are grown and/or harvested at many locations surrounding Los Alamos National Laboratory (LANL or the Laboratory). Also, many food products from domestic livestock (e.g., milk, eggs, and meat) and apiaries (honey) are available, and fishing in waters downstream of the Laboratory (e.g., the Rio Grande) and hunting (e.g., rabbits, turkey, deer, and elk) on neighboring properties around the Laboratory 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 requirements for this monitoring program. We accomplish this effort through the following tasks:

1) Measuring the concentrations of radionuclides (activities) and chemicals associated with Laboratory operations in foodstuffs from Laboratory, perimeter (neighboring communities and potentially impacted regions), and regional background areas

2) Assessing radionuclide and chemical concentrations in foodstuffs over time (e.g., are activities/concentrations increasing or decreasing?)

3) Providing data for the estimation of Laboratory-derived dose or risk, 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 foodstuffs and biota on a 3-yr rotating basis in the following order: the collection of agriculture-related samples (crops, goat milk, chicken eggs, and honey) from communities surrounding the Laboratory in year one; the collection of Rio Grande–related samples (fish, crayfish, and benthic macroinvertebrates) upstream and downstream of the Laboratory in year two; and the collection of native vegetation (and soil) from on-site, perimeter, and regional locations in year three. Rio Grande samples were collected in 2011 (Fresquez et al. 2012) and native vegetation (and soil) were collected in 2012 (Fresquez et al. 2013). This year (2013), we present the results of agriculture-related samples collected from the communities surrounding the Laboratory.

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 analytical laboratory. This year, we present the results of wild edible plants collected from neighboring communities and several elk and deer collected as roadkill from Laboratory lands.

2. Foodstuffs Comparison Levels

To evaluate the presence and potential effects of Laboratory-derived radionuclides and chemicals in foodstuffs, we compare individual (detected) on-site and perimeter results to regional statistical reference levels (RSRLs). A detected result for a radionuclide is one in which the result is higher than the minimum detectable activity (concentration) and/or higher than three times the total propagated uncertainty (Keith 1991, Corely et al. 1981). Similarly, a detected result for a chemical is one in which the result is higher than the method detection limit. RSRLs are the upper-level background concentrations (the mean plus three standard deviations) for radionuclides and chemicals in foodstuffs collected from locations more than 9 mi away from 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-Laboratory sources, and natural processes (e.g., elements in soil to plants to animals).

In cases where multiple samples ($n > 3$) are collected from a defined sample population/location (e.g., Los Alamos townsite, White Rock/Pajarito Acres, Pueblo de San Ildefonso, Pueblo de Cochiti, downstream farms, etc.), then mean concentrations are compared with mean background concentrations using a statistical test at the 0.05 probability level.

If individual or mean results exceed either statistical test, we then compare the concentrations with human health– (risk-/dose-) based screening levels (SLs) and, if appropriate, with regulatory standards.

For radionuclides, the SL (expressed in concentrations on a per gram basis) is based on 1 millirem per year (mrem/yr), which is 4% of the 25-mrem/yr DOE single-pathway constraint (DOE 1999, 2011b; LANL 2003). If a radionuclide activity exceeds an SL, the basis for that exceedance 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 the Laboratory. 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]. Concentrations of analytes are presented as ranges, 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 in lieu of SLs; in this case, we compare measured total PCBs with the EPA risk-based consumption limits for human health (EPA 2007).

If radionuclide, mercury, and PCB concentrations exceed an SL/guideline, they are 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 resulting from Laboratory operations, past and present, 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)	RSRLs
Selenium	Fish		1.5–94 ppm (wet)	RSRLs
Arsenic	Fish		0.002–0.13 ppm (wet)	RSRLs
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. Crop (Vegetable and Fruit) Monitoring

We collected 47 vegetable and 6 fruit samples from perimeter and regional background locations in the summer/fall of 2013 (Figure 8-1). Vegetable samples consisted of green chile, lettuce, cucumbers, peas, collard greens, radish, eggplant, chard, zucchini squash, beets, potatoes, corn, rhubarb, spinach, pumpkin, garlic, melon, and carrots; the fruit samples consisted of grapes and tomatoes.

Because of a late spring freeze in 2013, no tree fruit samples (e.g., apples, apricots, peaches, plums, etc.) were collected from perimeter and regional background locations, and, because fruit trees are the only crop growing within Laboratory boundaries, no samples were collected from on-site areas. Because of the lack of traditional fruit tree samples in 2013, branches and leaves from apple, apricot, plum or peach, and pear trees were collected as surrogates from the two communities closest to Laboratory lands (Los Alamos and White Rock).

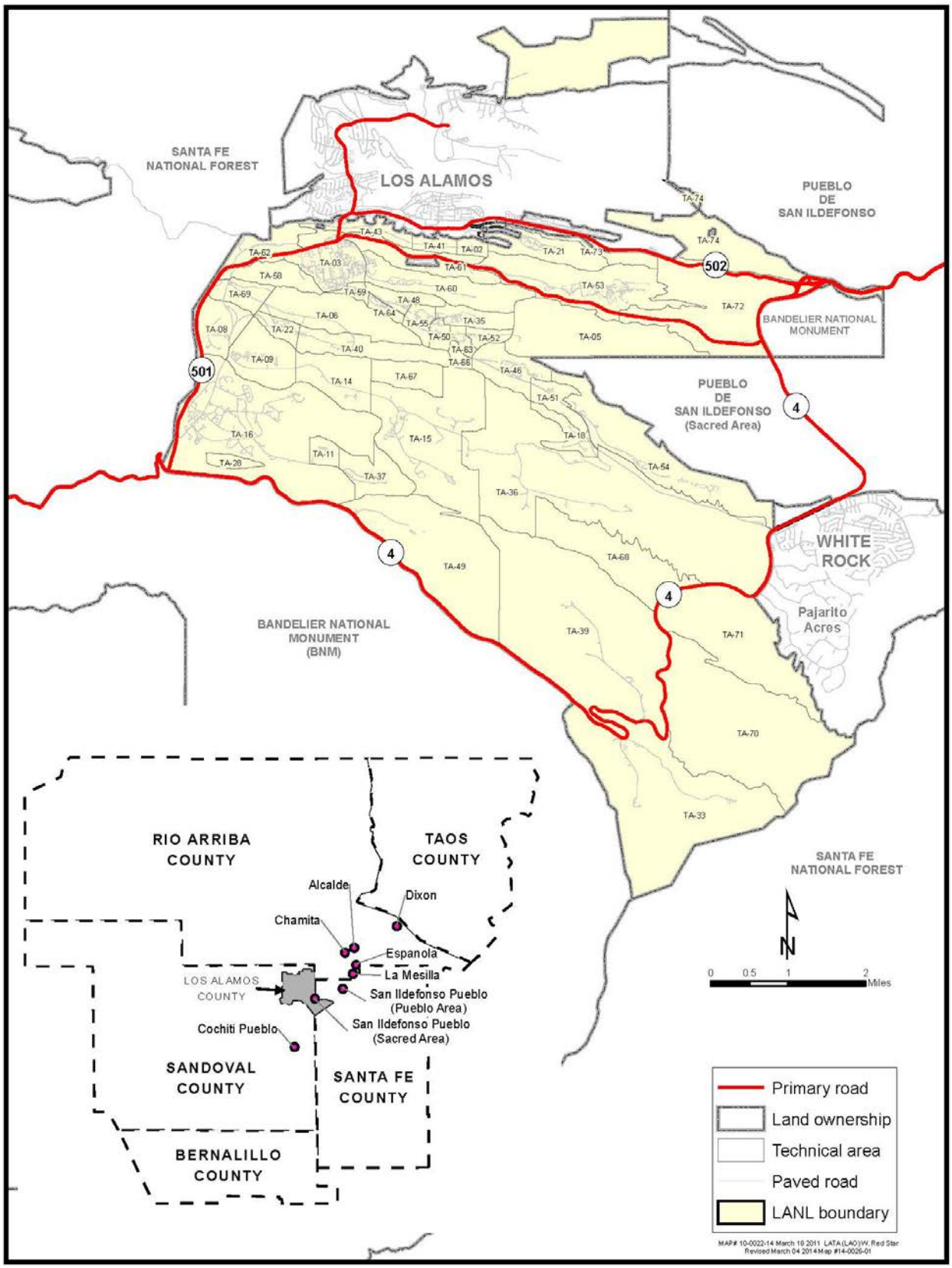

Figure 8-1 **Perimeter (Los Alamos, White Rock/Pajarito Acres, San Ildefonso sacred area), near perimeter (San Ildefonso Pueblo area and Cochiti Pueblo) and regional locations (see text for sample type and numbers for these sites)**

The locations with respect to the Laboratory boundary, type and number of samples collected, and potential transport pathway(s) were as follows:

- Perimeter: Los Alamos townsite; borders the Laboratory on the north side; 8 vegetable, 1 fruit, and 4 fruit branch/leaf samples; air pathway (foliar and air to soil to plant).
- Perimeter: White Rock/Pajarito Acres townsites; borders the Laboratory on the southeast side; 8 vegetable, 2 fruit, and 4 fruit branch/leaf samples; air pathway.
- Near perimeter: Pueblo de San Ildefonso (Pueblo Area); located along NM 502 northeast of the Laboratory; 9 vegetable samples and 1 fruit sample; air pathway.
- Near perimeter: Pueblo de Cochiti; located along the Rio Grande basin south and downstream of the Laboratory; 10 vegetable samples; Rio Grande water/irrigation pathway.
- Regional Background: Española/La Mesilla/Chamita/Dixon/Alcalde; located greater than 9 mi away and upstream of the Laboratory; 12 vegetable, 2 fruit, and 4 fruit branch/leaf samples; no pathway.

All samples, about 2 to 3 lb each, were collected at each of the garden sites (Figure 8-2). Each sample was rinsed thoroughly with tap water, submitted to the Laboratory's Sample Management Office (SMO) under chain-of-custody procedures, and shipped to the ALS Laboratory Group (formally Paragon Analytical) for the processing and analysis of tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Additionally, 5 crop samples from each location were analyzed for 23 TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury).

Results for tritium in vegetables, fruit, and fruit branches are reported on a picocuries per milliliter (pCi/mL) basis; results for the other radionuclides in vegetables and fruit are reported on a picocuries per gram (pCi/g) dry basis (converted from pCi/g ash to pCi/g dry by multiplying the ash/dry-weight ratio found in Fresquez et al. [2007]); results for the other radionuclides in fruit branches are reported in pCi/g ash; and the results for the TAL elements in all samples are reported on a mg/kg dry-weight basis.

Figure 8-2 Collecting produce samples irrigated with Rio Grande waters from Pueblo de Cochiti gardens in 2013

a. Radionuclide Results (Vegetable and Fruit Samples)

Radionuclide concentrations in produce collected from perimeter and regional (background) locations during the 2013 growing season are presented in supplemental Table S8-1.

There were no statistical differences in any of the radionuclides in produce from any of the perimeter areas as compared with regional background using a Mann-Whitney U test at the 0.05 probability level.

In 2010, we reported 2 tritium detections out of 19 produce samples collected from the White Rock/Pajarito Acres area that were above the RSRL. In 2013, there were no detections of tritium in any of the 10 produce samples collected from the White Rock/Pajarito Acres area, and the overall mean activity (combining detected and nondetected values) is similar to past years in both Los Alamos townsite and White Rock/Pajarito Acre samples (Figure 8-3). No statistically increasing trends are evident at either site (based on a Mann-Kendall nonparametric test for trend at the 0.05 probability level). These data are consistent with past results and results from samples collected downstream of the Laboratory and irrigated with Rio Grande water (Pueblo de Cochiti, Sile, and Pena Blanca).

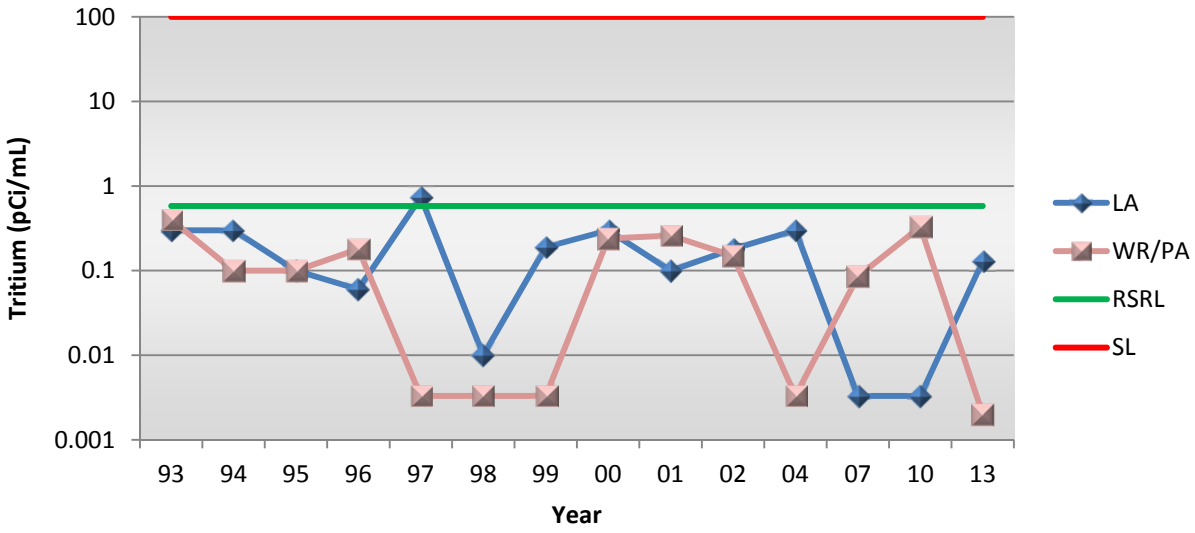

Figure 8-3 **Mean tritium activities in produce collected from the closest Laboratory neighbors, Los Alamos (LA) to the north and White Rock/Pajarito Acres (WR/PA) to the east, from 1993 to 2013 compared with the RSRL and the SL. Note the logarithmic scale on the vertical axis.**

b. TAL Results (Vegetable and Fruit Samples)

Five crop samples randomly picked from each site were analyzed for TAL elements (Table S8-2). With the exception of nickel in produce collected from the Pueblo de Cochiti, there were no statistically higher amounts of mean TAL elements in crops from the perimeter locations as compared with crops from regional background using a Mann-Whitney U test at the 0.05 probability level.

The type of crop, parent material (soil type), soil pH, tillage, irrigation source, and organic and inorganic fertilizer amendments are all potential reasons why TAL elements may differ from one place to another within perimeter area gardens.

c. Radionuclide Results (Fruit Branch and Leaf Samples)

Four different fruit branches plus leaves (apple, apricot, plum or peach, and pear) from the Los Alamos townsite and White Rock/Pajarito Acres were analyzed, in lieu of actual fruit samples, and compared with regional background samples. There were no statistically higher mean levels of radionuclides in fruit branches from perimeter areas as compared with regional background using a Mann-Whitney U test at the 0.05 probability level (Table S8-3).

d. TAL Results (Fruit Branch Samples)

Two fruit branch samples (apple), one from the Los Alamos townsite location and one from the White Rock/Pajarito Acre location, were analyzed for TAL elements and compared with apple branch samples from regional background locations. Most TAL elements in apple branch samples were similar to RSRLs (based on 1998–2013 data; n = 10) (Table S8-4), and the few TAL elements that were above the RSRL were within the same order of magnitude as regional background.

4. Wild Edible Plant Monitoring

a. Monitoring Network

We have been collecting numerous samples of wild tea and edible plants from surrounding areas since 1996 (Armstrong and Fresquez 1997) and 1997 (Fresquez 1998), respectively. Common purslane (*Portulaca oleracea*), common lambsquarters (*Chenopodium album*), amaranth (pigweed) (*Amaranthus* sp.) and prickly pear cactus (*Opuntia* sp.) were collected in late summer of 2013 in the vicinity of the Laboratory: the Los Alamos townsite to the north, White Rock/Pajarito Acres to the southeast, and the Pueblo de San Ildefonso to the east. (Note: Samples collected on Pueblo de San Ildefonso lands consisted of purslane and lambsquarters, which were collected on the east side of the Rio Grande [Pueblo de San Ildefonso Area], and amaranth and prickly pear, which were collected on the west side of the Rio Grande on Sacred Area Lands near lower Mortandad Canyon. Unfortunately, the lambsquarter plant sample was not analyzed for radionuclides by the analytical laboratory.) Two wild edible plant samples, lambsquarters (including the one from the Pueblo de San Ildefonso) and amaranth, were analyzed for TAL elements.

These wild, edible plants were also collected from regional background areas away from the influence of the Laboratory. Wild edible plants have been collected occasionally since 1997.

Samples were collected, processed, submitted, and analyzed for the same radionuclides and TAL elements as local produce described in Section 3.

b. Radionuclide Results

There were no radionuclides in wild, edible plant mean concentrations that were statistically different from the means of wild, edible plants collected from regional background locations using a Mann-Whitney U test at the 0.05 probability level (Table S8-5).

c. TAL Results

All TAL elements in lambsquarters and amaranth plants collected from perimeter areas around the Laboratory were below RSRLs (based on 1997–2013 data; n = 6) and consistent with past years (Table S8-6).

5. Goat Milk Monitoring

a. Monitoring Network

Milk from dairy cows and goats has been collected from 1994 to 1997 and from 1997 to the present, respectively. The (cow) dairy, which was located approximately 25 mi east of the Laboratory, closed in 1998, and no detections of radionuclides above regional background were ever made in these milk samples.

The collection of goat milk from the surrounding communities has continued—the milk is for private use and is not sold commercially. In 2013, we sampled unprocessed goat milk from a perimeter farm in the White Rock/Pajarito Acres area and from a regional background farm located in Santa Cruz, New Mexico.

The goat milk samples were collected by the farmers, placed into a labeled 1-L polyethylene bottle provided by the Laboratory, submitted under chain of custody to the SMO, and then shipped to ALS Laboratory Group for the analysis of tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. All results are reported on a picocurie per liter (pCi/L) basis.

b. Radionuclide Results

All radionuclides in goat milk from the regional background location and from the White Rock/Pajarito Acres area were not detected (Table S8-7). These data are the same as previous years.

6. Chicken Egg Monitoring

a. Monitoring Network

Chicken eggs from neighboring farms around the Laboratory have been collected since 1995. We collected two dozen (medium-sized) eggs each from farmers raising free-ranging chickens from the following perimeter areas: Los Alamos townsite (North Mesa), White Rock/Pajarito Acres, and Pueblo de San Ildefonso (Pueblo area). Chicken eggs from a regional background area, Española, were also collected. All samples were submitted to ALS Laboratory Group for the analysis of the liquid part of the egg for tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Results are reported in pCi/L.

b. Radionuclide Results

All radionuclides in chicken eggs from the three perimeter sites around the Laboratory and the regional background area were either not detected (most results) or below RSRLs (based on 1995–2013 data; n = 8) (Table S8-8). These data are similar to past years.

7. Honey Monitoring

a. Monitoring Network

Honey from neighboring farms around the Laboratory has been collected since 1979. In 2013, we collected honey from bee hives located in a perimeter site south and downstream of the Laboratory on Pueblo de Cochiti land and from a regional background site near Alcalde, New Mexico. The Pueblo de Cochiti honey sample was located within the community gardens irrigated with Rio Grande water. Approximately 1 qt of honey in glass jars was submitted under chain of custody to the SMO and shipped to the ALS Laboratory Group for the analysis of tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. All results are reported on a pCi/L basis.

b. Radionuclide Results

The complete data set of radionuclides in honey from the regional background location and from the perimeter location on Pueblo de Cochiti can be found in Table S8-9. No radionuclides of Laboratory origin were detected in honey from either regional background or from the Pueblo de Cochiti. These data are similar to past years.

8. Deer and Elk Monitoring

a. Monitoring Network

Since 1991, mule deer and rocky mountain elk have been routinely sampled from roadkill along highways within and around the Laboratory. To date, we have analyzed 35 deer and 46 elk samples collected from Laboratory, perimeter, and regional background sites. This reporting period, we report on the analysis of radionuclides, metals, and PCBs in six deer from the Laboratory and one deer from the Pueblo de San Ildefonso (Figure 8-4). In addition, two elk from Laboratory locations were analyzed.

b. Deer

Seven deer killed in vehicle collisions were collected from roadsides in 2012 and 2013. Three deer were collected along East Jemez Road, one deer was collected along Anchor Ranch Road, one deer was collected along La Mesita Road (off East Jemez Road), and one deer was collected along Pajarito Road. Each of these carcasses was collected within various technical areas (TAs) on Laboratory lands. In addition, one mule deer carcass was collected along NM 502 within the Pueblo de San Ildefonso near the Totavi gas station.

Based on a preliminary study that analyzed various tissues (brain, hair, heart, jawbone, kidneys, leg bone, liver, and muscle), it was concluded that muscle and leg bone were the two organs that would provide the most information (Fresquez et al. 1994). Therefore, at each site, one of the front shoulders of the animal was collected, and the muscle and bone samples were submitted for analysis. All samples were frozen and submitted under chain-of-custody procedures to the SMO; muscle samples were then submitted to ALS Laboratory Group for the analysis of radionuclides and TAL elements and to Cape Fear Analytical

Laboratory, Inc., for the analysis of PCB congeners. Bone tissues were submitted to ALS Laboratory Group for the analysis of radionuclides only.

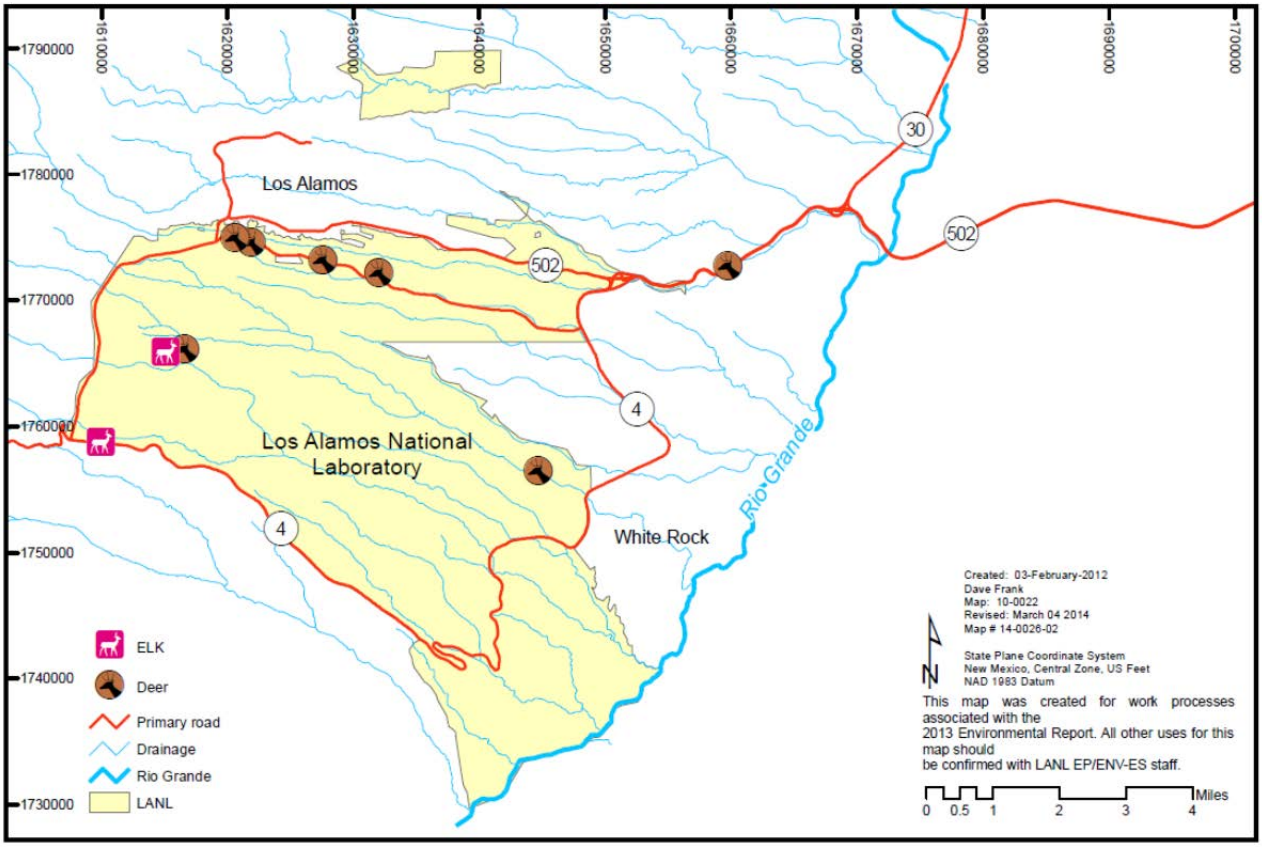

Figure 8-4 Locations of deer and elk collected as roadkill from within and around the perimeter of the Laboratory in 2013

i. Analysis

Radionuclide analyses included tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium results are reported on a per milliliter of water basis. Results of the other radionuclides were reported in pCi/g dry weight after being converted from pCi/g ash weight. Samples were analyzed for all 23 TAL elements listed earlier. These elements are reported on a mg/kg wet-weight basis. PCBs were analyzed as 209 possible chlorinated congeners and reported as homologs (groups of congeners) in picograms per gram (pg/g) (parts per trillion) wet.

ii. Radionuclide Results (Deer)

With the exception of tritium in samples from the muscle tissue of three deer, all other radionuclides in muscle and bone tissues of deer collected from Laboratory and perimeter sites were either not detected (most results) or below the RSRLs (based on 1991–2000 data; n = 5) (Table S8-10). Tritium in the samples from muscle tissues of deer from Anchor Ranch Road (TA-14), East Jemez Road (TA-53), and NM 502 (Pueblo de San Ildefonso) ranged in activity from 1.2 pCi/mL to 8.9 pCi/mL; the highest tritium activity was detected in the sample from muscle tissue of a deer collected from the Pueblo de San Ildefonso. All activities of tritium in muscle tissue of these animals, however, were far below the SL (<100 pCi/mL), and the amounts in muscle tissue in these three animals do not correlate very well with the amounts of tritium in the bone tissues of the same animals. Tritium in the bone tissues of these three animals was not detected above the minimum detectable activity, and the tritium activities in muscle and bone of the other animals tested were similar to each other. Nevertheless, tritium activities are still far below the SL and are not a concern.

i. TAL Results (Deer)

Results of TAL elements in muscle tissues of seven roadkilled deer collected in 2012 and 2013 can be found in Table S8-11. Most of the TAL elements in muscle tissue of deer collected on Laboratory or perimeter lands were generally similar to the RSRLs; however, because the RSRLs are based on only two background deer, similarity means that the results are on the same order of magnitude as the RSRLs. We will continue to collect background deer as they become available.

ii. Polychlorinated Biphenyl Results (Deer)

Total PCB homolog distributions in muscle tissues of six roadkilled deer collected alongside Laboratory lands and one roadkilled deer along Pueblo de San Ildefonso lands can be found in Table S8-12. The total PCB concentrations in the deer collected from Laboratory and perimeter lands are very low and are not above the RSRL (based on 2010 data; n = 2).

c. Elk

In 2012, two roadkilled elk on Laboratory property were collected: one on Anchor Ranch Road at TA-09 and one on NM 4 at TA-16.

Like the deer, the front shoulder was collected and the muscle and bone submitted for analysis for the same radionuclides, TAL elements, and PCB congeners.

ii. Radionuclide Results (Elk)

All of the radionuclides in muscle and bone tissues of two elk collected from Laboratory lands in 2012 were either not detected (most results) or below the RSRLs (based on 1991–2000 data; n = 9) (Table S8-13). These data agree with past results.

iii. TAL Element Results (Elk)

Results of TAL elements in muscle tissue from the two roadkilled elk collected along Anchor Ranch Road at TA-09 and NM 4 at TA-16 can be found in Table S8-14. TAL elements in these elk samples are similar to the RSRLs.

iv. Polychlorinated Biphenyl Results (Elk)

There were very few PCBs detected in the muscle tissues of two elk collected from Laboratory lands (<11 pg/g wet), and the total amounts were less than the RSRL (Table S8-15). These data are similar to past years.

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 typically 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 the Laboratory 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 monitoring program are to

1) assess populations, diversity, and composition of biota species potentially impacted by Laboratory operations as a general measure of ecosystem health;
2) measure concentrations of radionuclides and chemicals (that have a history of use at the Laboratory) in biota from on-site (Laboratory 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 potential radiation dose and chemical risk to plants and animals. (Chapter 3 presents the results of the 2013 biota dose and risk assessments at the Laboratory.)

2. Biota Comparison Levels

Like the foodstuffs data, radionuclides and chemical concentrations in individual biota samples from Laboratory or perimeter areas are compared with background-based levels (e.g., RSRLs). If there are more than three samples from a defined population/location, then a nonparametric test at the 0.05 probability levels versus regional background is used to determine statistical differences.

If the levels of chemicals or radionuclides at potentially affected areas are above the RSRLs or are statistically significant from background, we then compare the concentrations with the biota dose- or risk-based SLs and then with 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 activities/concentrations (mean plus three 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-Laboratory sources, and natural processes (e.g., elements in soil to plants to animals).
- Screening Levels: Radionuclide SLs are set below DOE biota dose standards. If a constituent exceeds an SL, then the reason for the exceedance is investigated. For radionuclides in biota, SLs (expressed in concentrations) 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's concentration in the soil at the place of collection is compared with ecological screening levels (ESLs) for that chemical (LANL 2012). ESLs are derived from the literature and reflect concentrations in the soil that are not expected to produce adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on the soil (i.e., they are the concentrations that are protective of ecological receptors under chronic exposure conditions).
- Regulatory Standards: Based on the activities 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 the 0.1-rad/day DOE dose standard for terrestrial animals (DOE 2002).

Table 8-2
Standards and Other SLs 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	Terrestrial biota	na[c]	ESLs[d]	RSRLs
	DARHT	Terrestrial 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 effort described in Chapter 7, Section C.1 (Figure 7-1). The last vegetation sampling effort, conducted in 2012, focused on understory plants and can be found in Fresquez et al. (2013).

4. Facility Monitoring

a. Area G at TA-54

i. Monitoring Network

Native overstory vegetation (branches and needles of mostly juniper trees) around the perimeter of Area G were collected at the same general locations as the soil samples described in Chapter 7, Section D.1 (Figure 7-2). However, because of a firebreak between the fenceline and the trees (>10 m from the fenceline), samples of overstory vegetation may have occurred at various distances away from the perimeter of Area G. 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 pCi/mL basis, results for the other radionuclides are reported on a pCi/g ash-weight basis, and results for the TAL elements are reported on a mg/kg dry-weight basis.

In 2013, we collected three extra overstory vegetation samples from each of two sites (29-03 and 30-01) near the south portion of Area G for tritium analysis; these samples were collected at increasing distances from the fenceline, and sampling was generally similar to what was done in a 2003 study (Fresquez et al. 2003).

ii. Radionuclides in Vegetation around the Perimeter of Area G

Tritium, plutonium-238, and plutonium-239/240 activities in many overstory samples collected around the perimeter of Area G were detected above the RSRLs (based on 1998–2009 data; n = 15) (Table S8-16). Americium-241 and the uranium isotopes were either not detected or below the RSRLs.

Tritium was detected above the RSRL in 100% of the tree samples collected around the perimeter of Area G with the highest amounts (385 pCi/mL to 262,000 pCi/mL) occurring in trees growing in the southern sections (sites 29-03 and 30-01) near the tritium disposal shafts. All levels of tritium, however, are below the SL, and the overall trend, based on the average on the south side, is not significantly increasing over time (based on a Mann-Kendall nonparametric trend test at the 0.05 probability level) (Figure 8-5).

Like the tritium migration study conducted in 2003 (Fresquez et al. 2003), samples from trees collected at various distances from the Area G perimeter on the south side in 2013 showed that the activities of tritium decreased rapidly with distance from the source (Table S8-17). For example, the highest tritium amount (262,000 pCi/mL) collected closest to the fenceline decreased approximately 99% to 12 pCi/mL at approximately 43 m (141 ft) from the fenceline.

Like the soil results, plutonium-239/240 was detected above the RSRL in many overstory tree samples (61%) around the perimeter of Area G, probably as a result of foliar deposition. The highest amount (1.5 pCi/g ash) was detected on the northwest side of Area G (site 58-01); however, these data do not correlate very well with the levels of plutonium-239/240 in soil collected in that area (i.e., <RSRL). The lack of correlation for plutonium-239/240 between soil and overstory vegetation in the northwest corner of Area G may be because the trees sampled are not located next to the fenceline where the soil samples were collected but are a distance away from the perimeter fenceline. Also, the majority of plutonium-239/240 contamination detected from a branch and needle sample may be a result of windblown dust, rather than root uptake, and because the branch and needle samples were not washed prior to analysis, the isotopes may be from other sources within Area G. Nevertheless, the amounts of plutonium-239/240 in trees growing around the perimeter of Area G, including those in the northwest corner, were far below the SL and are not a concern.

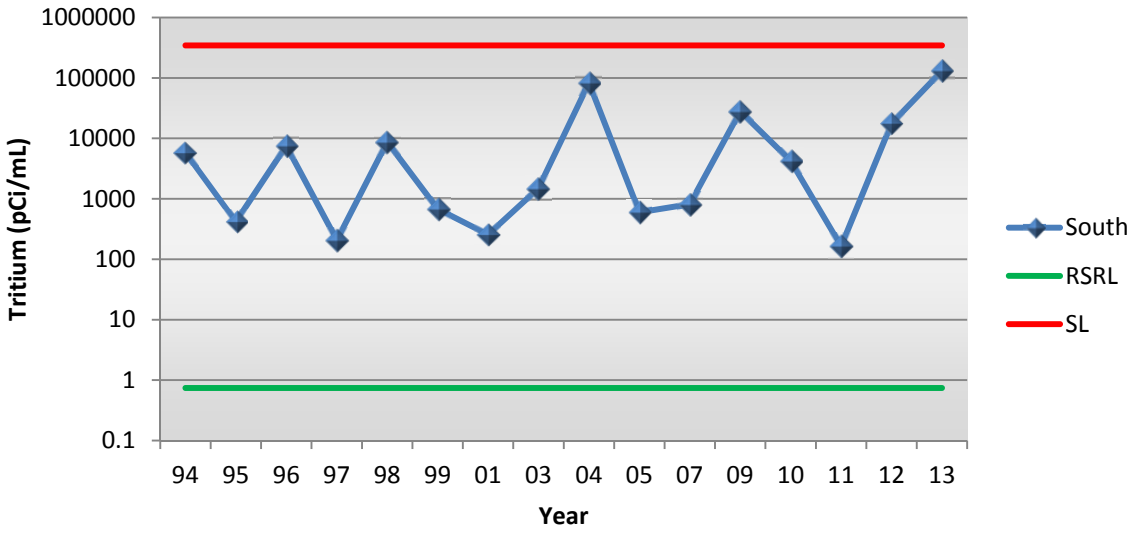

Figure 8-5 Mean activities of tritium in overstory vegetation collected from the south side of Area G at TA-54 (site 29-03 and 30-01) from 1994 through 2013 compared with the RSRL and the SL. Note the logarithmic scale on the vertical axis.

All radionuclides, with the exception of tritium, measured in samples from trees located downwind and northeast of Area G at the Laboratory/Pueblo de San Ildefonso boundary were either not detected or below the RSRLs. The levels of tritium (11 pCi/mL) in tree samples collected at the Laboratory/ Pueblo de San Ildefonso boundary were far below the SL for tritium (Table S8-16).

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 explosive firing site at the Laboratory—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 to 2006, detonations using foam mitigation from 2002 to 2006, and detonations within closed steel containment vessels, starting in 2007 and continuing to the present. Another factor that may influence the contaminants 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 7-10, for sample locations). Vegetation, field mice, and bee samples are collected for chemical analysis, whereas birds are mostly captured (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 one hive located on the northeast side of the DARHT perimeter and analyzed for radionuclides and TAL elements. Birds were collected using 12 mist net capture 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, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, 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 a mg/kg dry-weight basis, and results for the TAL elements in field mice and bees are reported on a 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 pg/g wet-weight basis.

Results of most of the biota chemical analysis were compared with the 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 activities, 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 (Table S8-18). In the past, uranium-238 was the only radionuclide 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 activities 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 8-6).

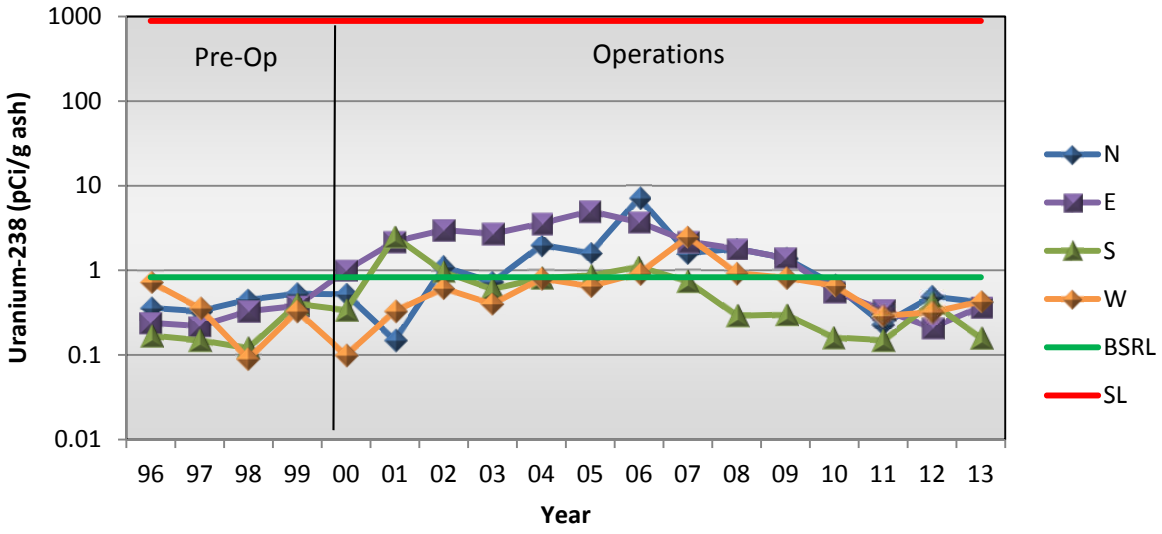

Figure 8-6 **Uranium-238 activities in overstory vegetation collected from the north (N), east (E), south (S), and west (W) sides of the DARHT facility at TA-15 from 1996 to 1999 (preoperations) and 2000 to 2013 (operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.**

The TAL element results in overstory vegetation collected from around the DARHT facility are summarized in Table S8-19. All of the metals were either not detected or were similar to the BSRLs (or the RSRLs).

iii. Small Mammals at DARHT

All radionuclides in a composite field-mouse sample (n = 5) collected from the north and northeast sides of the DARHT facility were either not detected (most results) or not different from the BSRLs (Table S8-20).

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 8-7).

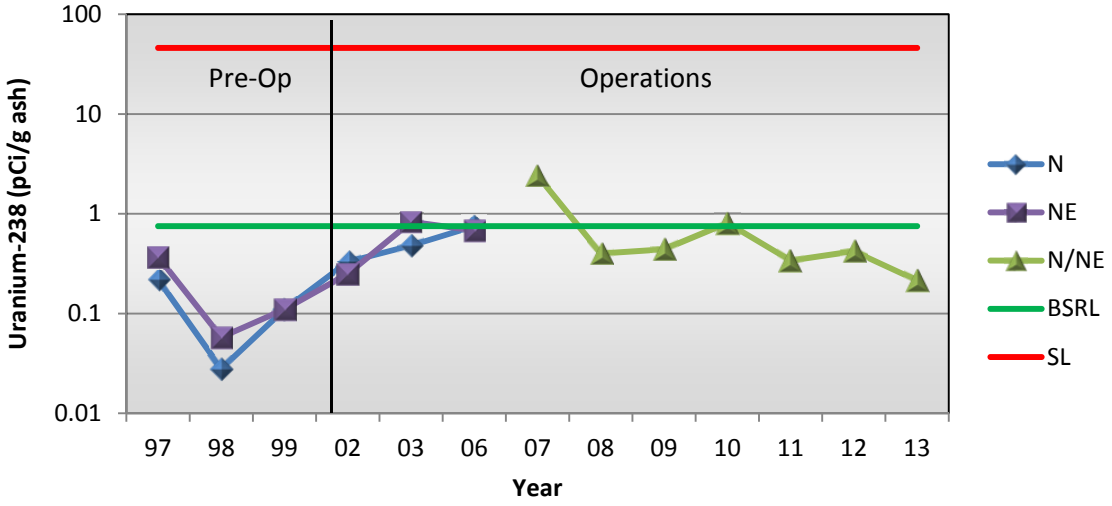

Figure 8-7 **Uranium-238 activities in (whole-body) mice (n >5) collected from the north (N) and northeast (NE) sides of the DARHT facility at TA-15 from 1997 to 1999 (preoperations) and 2002 to 2013 (operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.**

Most TAL elements, with the exception of lead, in a field-mouse sample collected from the northeastern perimeter of the DARHT facility were either not detected or not different from RSRLs (based on 2007–2013 data; n = 12) (Fresquez 2013) (Table S8-21). The amount of lead detected in the mouse sample was higher than the RSRL. However, the amount of lead in soil from the north-side perimeter of the DARHT facility (14 mg/kg) was far below the ESL (<120 mg/kg) for the deer mouse (LANL 2012).

Most dioxin or furan congeners in a field-mouse sample were not detected above the method detection limit; only trace amounts (above the method detection limit but below the report detection limit) of 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin were reported, but the concentrations were below the RSRL (based on 2008–2011 data; n = 8) (Fresquez 2013) (Table S8-22). Trace amounts of 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin were also detected in soil near the firing point (Table S7-5).

iv. Bees at DARHT

All radionuclide activities 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 S8-23).

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 decrease concurrent with the change in detonation mitigation practices from open-air/foam (2000–2006) to closed vessel containment, starting in 2007 (Figure 8-8).

Only a few of the TAL elements (beryllium and lead) in a composite bee sample collected from a hive northeast of the DARHT facility were above the RSRLs (based on 2010–2012 data; n = 4) (Table S8-24). 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.

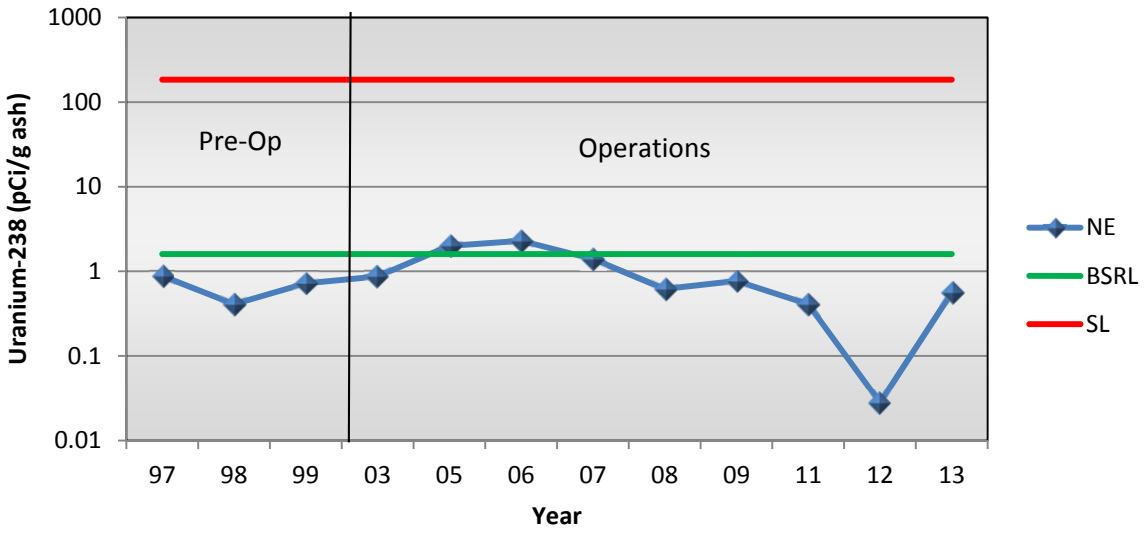

Figure 8-8 **Uranium-238 activities in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997 to 1999 (preoperations) and from 2003 to 2013 (operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.**

v. Birds at DARHT

Populations, diversity, and composition of birds collected just west of the DARHT facility during operations in 2013 compared with average results from 1997 through 1999 (preoperational phase) are presented in Table S8-25. The purpose of the bird monitoring project is to determine the general ecological stress levels in birds around the vicinity of DARHT that may be associated with facility operations (e.g., noise, disturbance, traffic, construction, etc.).

Virginia's Warbler (*Vermivora virginiae*)

The number of birds, taxa, diversity, and evenness (distribution) of birds collected in 2013 are similar to those collected before the start-up of operations at DARHT; thus, there are no impacts to bird attributes as a result of DARHT operations (Figures 8-9 and 8-10). However, the types of birds collected at DARHT have changed since the late 1990s/early 2000s, likely because the site has gradually changed from a ponderosa pine–(*Pinus ponderosa*–) dominated plant community to a more piñon/juniper (*Pinus edulis*/*Juniperus monosperma*) open grassland habitat; the change in habitat may be a result of drought, wildland fire, and bark beetle activity that has killed almost all of the ponderosa pines in the project area.

The top seven most common birds during the preoperational period included the Chipping Sparrow (*Spizella passerina*), Virginia's Warbler (*Vermivora virginiae*), Western Bluebird (*Sialia mexicana*), Broad-tailed Hummingbird (*Selasphorus platycercus*), Pygmy Nuthatch (*Sitta pygmaea*), Mountain Chickadee (*Poecile gambeli*), and Gray Flycatcher (*Empidonax wrightii*). In 2013, the top six birds included the Chipping Sparrow, Virginia's Warbler, Western Bluebird, Rock Wren (*Salpinctes obsoletus*), Black-headed Grosbeak (*Pheucticus melanocephalus*), and Blue-gray Gnatcatcher (*Polioptila caerulea*). Birds not collected during the preoperational period but present in 2013 include the American Robin (*Turdus migratorius*), Black-chinned Hummingbird (*Archilochus alexandri*), Blue-gray Gnatcatcher, Brown-headed Cowbird (*Molothrus ater*), Cordilleran Flycatcher (*Empidonax occidentalis*), MacGillivray's Warbler (*Oporornis tolmiei*), and Rock Wren.

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.

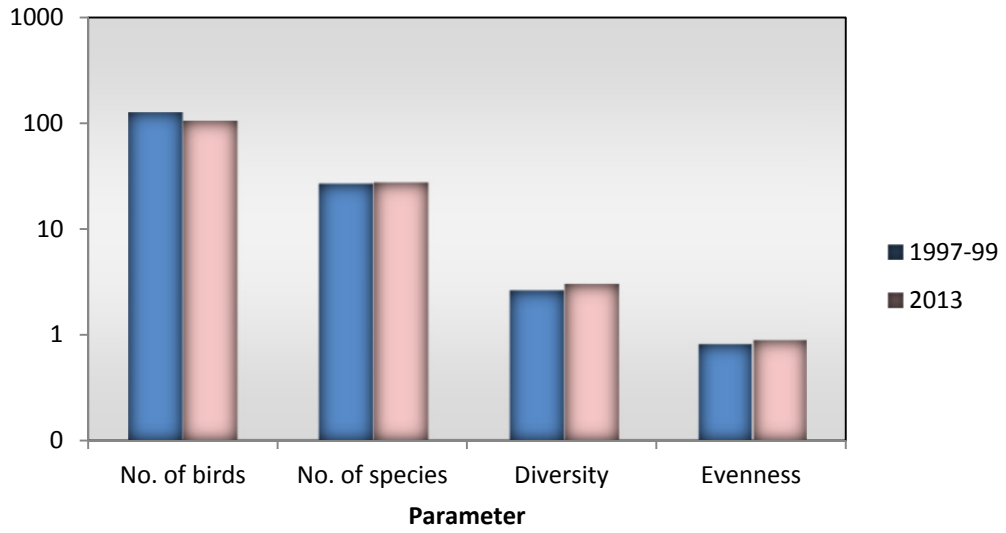

Figure 8-9 **Number of birds, number of species, diversity, and evenness of birds occurring before (1997–1999) and during (2013) operations at DARHT. Note the logarithmic scale on the vertical axis.**

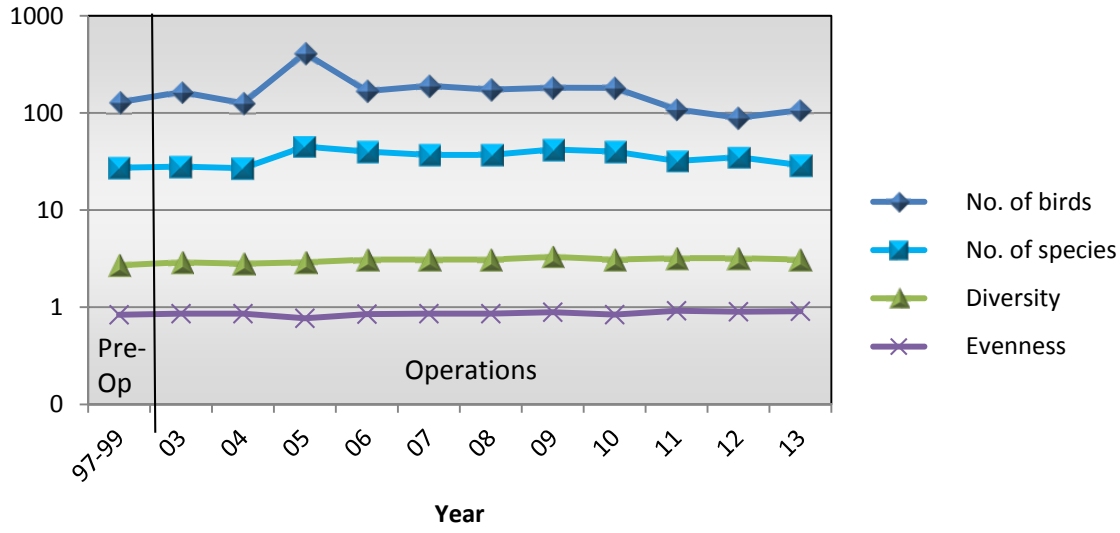

Figure 8-10 **Numbers of birds, number of species, diversity, and evenness of birds occurring before (1997–1999) and during (2003–2013) operations at DARHT. Note the logarithmic scale on the vertical axis.**

C. SPECIAL MONITORING STUDIES

The following special studies were conducted in 2013 in support of MAPs, the Biological Resources Management Plan (BRMP), and the Environmental Surveillance Program.

1. Radionuclide and Chemical Concentrations in Biota Collected from the Sediment Retention Basin behind the Los Alamos Canyon Weir and behind the Pajarito Canyon Flood-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 Laboratory property. Because the Cerro Grande fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increases in flooding and transport of sediment from the Laboratory to off-site locations.

As a preventive measure, the Laboratory constructed two structures to control storm water and sediment runoff. 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 the Laboratory (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 sediment retention upstream (upgradient) of flood-control structures, within sediment-retention basins, and within sediment traps to determine if contaminant concentrations in these areas adversely 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).

The 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 2013 results of this monitoring.

a. Los Alamos Canyon Weir

The LACW structure was installed in late 2000 and was excavated of accumulated sediments in 2009, 2011, and 2013. Excavated sediments in 2009 were placed on the west side of the basin and stabilized, whereas sediments in 2011 and 2013 were removed from the area.

Vegetation and small mammals were collected in mid June 2013 approximately 2 mo after excavation of the sediments.

The radionuclide activities and TAL element concentrations in a composite understory vegetation sample collected within the LACW retention basin can be found in Tables S8-26 and S8-27, respectively. All radionuclides, with the exception of plutonium-239/240, in the understory vegetation growing within the LACW retention basin were either not detected or below the RSRLs (based on 1999–2012 data; n = 22). The level of plutonium-239/240 in the understory vegetation was just above the RSRL and orders of magnitude below the SL. These data along with activities of the other actinides, plutonium-238 and americium-241, vary widely from year to year (Figure 8-11). The high variability of these radionuclides in vegetation collected from the LACW from year to year may be from changes in sampling locations as a result of plant material being removed during the excavation process, plants being buried with sediment during high-runoff events, and plants containing sediment of the leaves and stems as a result of high-runoff events. Sediment on plant material may alter radionuclide contents to significantly higher than normal levels. All TAL elements in understory vegetation were below the RSRLs (based on 2012 data; n = 6).

The activities of all radionuclides in a composite field-mouse sample (n = 6) collected from within the LACW retention basin were either not detected or similar to RSRLs (based on 2002–2013 data; n = 8) (Fresquez 2013) (Table S8-28); these data are similar to past years (Figure 8-12).

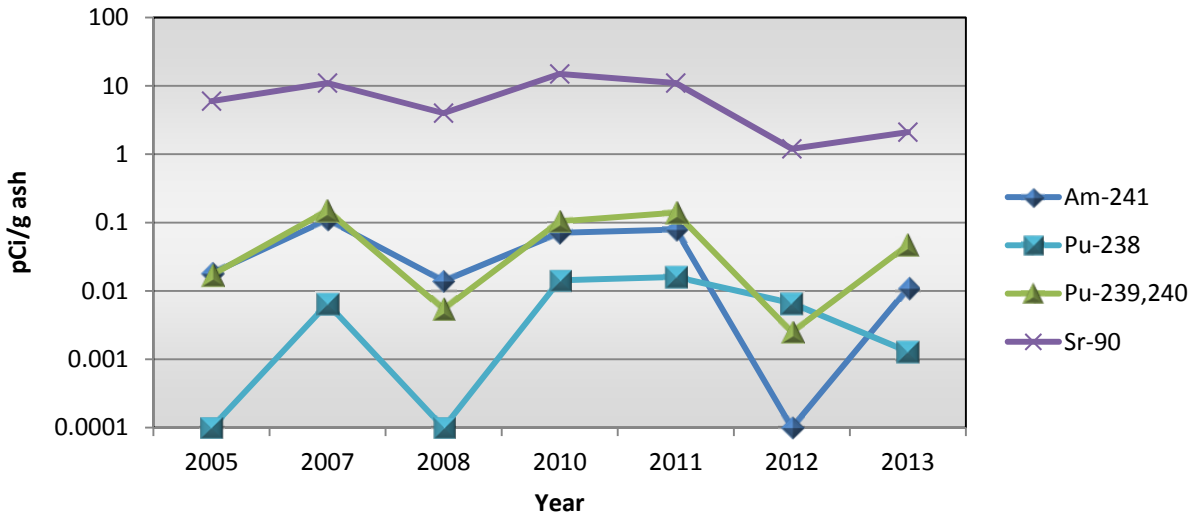

Figure 8-11 **Americium-241, plutonium-238, plutonium-239/240, and strontium-90 concentrations in understory vegetation collected on the upgradient side (retention basin) of the LACW from 2005 to 2013. Note the logarithmic scale on the vertical axis.**

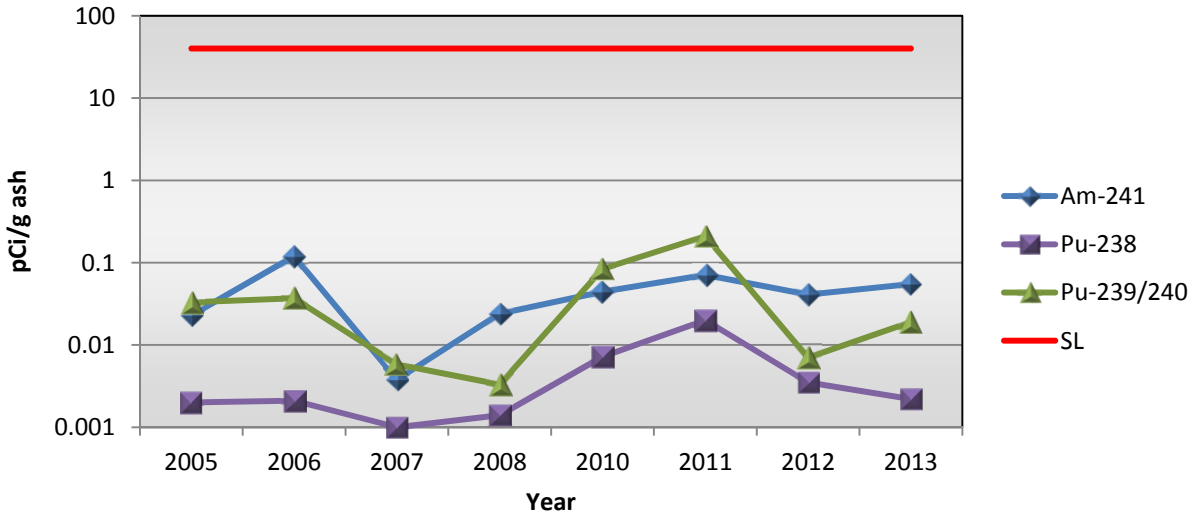

Figure 8-12 **Americium-241, plutonium-238, and plutonium-239/240 in composite whole-body field-mouse samples (n >5) collected on the upgradient side (retention basin) of the LACW from 2005 to 2013 compared with the SL. Note the logarithmic scale on the vertical axis.**

Results of TAL elements in whole-body field mice can be found in Table S8-29. With the exception of lead and nickel, all mean TAL element concentrations in field mice (n = 3) collected on the upgradient side of the LACW were not statistically different from regional background using a Mann-Whitney U (nonparametric) test at the 0.05 probability level.

Concentrations of total PCBs in whole-body field-mouse samples (n = 3) collected upgradient and 4.5 mi downgradient from the retention-basin side of the LACW were not statistically different from regional background using a Mann-Whitney U (nonparametric) test at the 0.05 probability level (Table S8-30) (Fresquez 2014).

The highest individual total PCB concentration (5530 pg/g wet) in field mice collected from the retention basin in 2013 was far below the average whole-body amount (2,500,000 pg/g wet) reported at PCB-contaminated sites that has resulted in field-mouse population effects by decreasing reproductive capability and changing liver, spleen, and adrenal function (Batty et al. 1990). Thus, the current PCB levels were not expected to significantly impact the field-mouse population. These data correlated well with the sediment data because no Aroclors were detected in LACW sediment above the detection levels in early 2013 (White 2013).

The current levels of total PCBs in field mice collected around the LACW were at their lowest since surveys began in 2007. Concentrations decreased from 2008 to the present (Figure 8-13) and indicated that Laboratory engineering controls (sediment traps, willow plantings, and sediment removal) upgradient of the LACW are reducing the levels of PCBs available to field mice at the weir. In addition, the impediment of at least one-half of the sediment load by the LACW itself (Gallaher 2006) may have been partly responsible for the even lower amounts of PCBs in field mice 4.5 mi downgradient of the LACW as compared with upgradient concentrations. Natural fluvial processes over time, including the adsorption of contaminants to sediment/organic materials, subsequent flooding and the redistribution and mixing of (noncontaminated) sediments from other sources, and distance from the source, may also have played a role in the lower PCB levels in the field mice 4.5 mi from the LACW (LANL 2004, 2008).

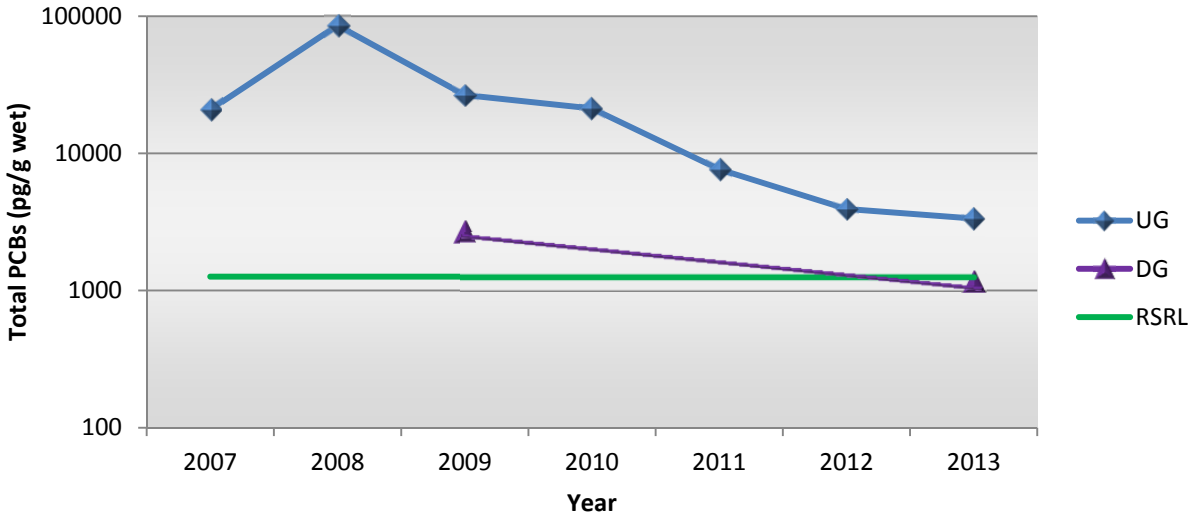

Figure 8-13 **Mean total PCB concentrations in whole-body field mice collected on the upgradient (UG) (retention basin) and 4.5 mi downgradient (DG) of the LACW from 2007 to 2013 compared with the RSRL (1262 pg/g wet)**

A comparison of the mean PCB homolog distribution of field mice collected around the LACW shows that the pattern was mostly within the Aroclor-1260 profile formulation (Figure 8-14). 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).

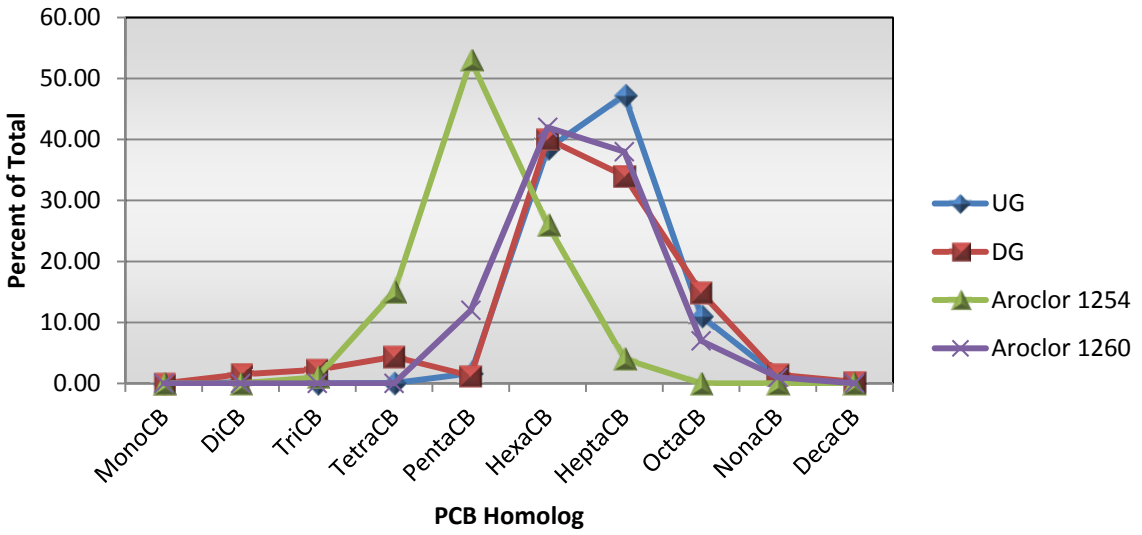

Figure 8-14 **The mean total PCB homolog distribution for whole-body field-mouse samples collected upgradient and 4.5 mi downgradient of the LACW in 2013 compared with Aroclor-1240 and Aroclor-1260**

b. Pajarito Canyon Flood Retention Structure

Radionuclide activities and TAL element concentrations in native understory vegetation (grasses and forbs) and radionuclides, TAL elements, and PCBs in field-mouse samples collected from within the sediment retention basin (upgradient side) of the PCFRS in early August 2013 are presented in Tables S8-31 through S8-35.

All of the radionuclides (Table S8-31) and TAL elements (Table S8-32) 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 combined) collected from the upgradient side of the PCFRS were either not detected or below the RSRLs (2002–2013; n = 8) (Table S8-33).

With the exception of chromium, mercury, selenium, thorium, and zinc, there were no TAL mean elements in field mice (n = 3) that were statistically higher than regional background using a Mann-Whitney U (nonparametric) test at the 0.05 probability level (Table S8-34).

The mean concentrations of total PCBs in whole-body field mice collected upgradient of the PCFRS were not statistically different from regional background using a Mann-Whitney U (nonparametric) test at the 0.05 probability level.

For the past 3 yr, the PCB levels have been quite variable, probably because of the varying amounts of sediment with storm events; however, the trend does not appear to be increasing over time (Figure 8-15).

The mean PCB homolog distribution of field mice collected from the PCFRS mostly overlaps the distribution pattern of Aroclor-1260 (Figure 8-16). 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).

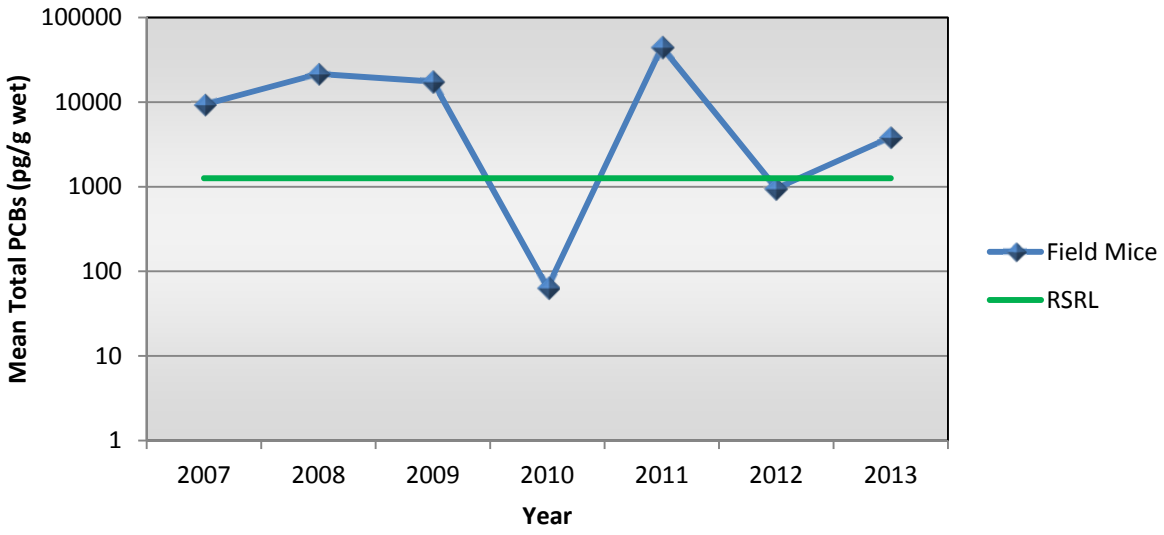

Figure 8-15 **Mean total PCB concentrations in whole-body field-mouse samples collected on the upgradient side (retention basin) of the PCFRS from 2007 to 2013 compared with the RSRL. Note the logarithmic scale on the vertical axis.**

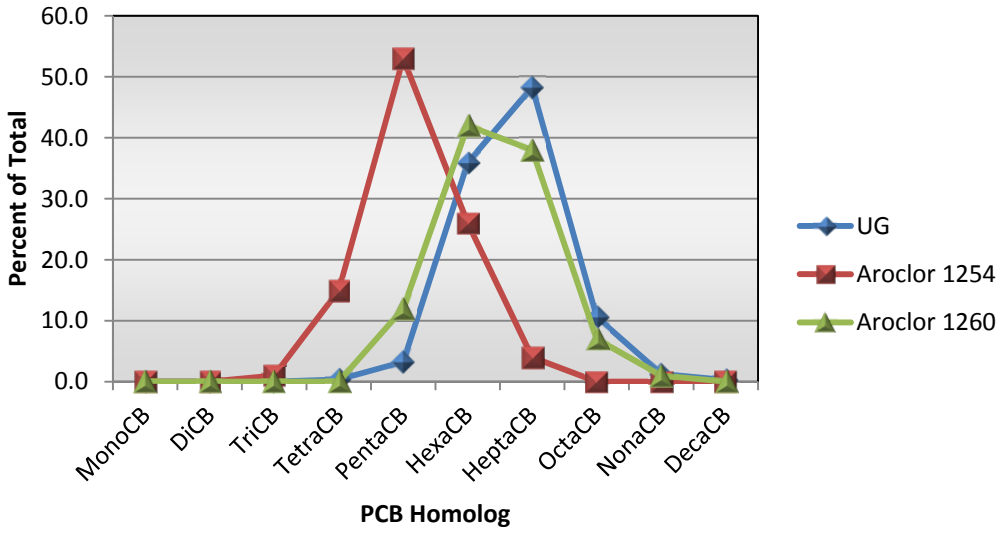

Figure 8-16 **Mean PCB homolog distribution of whole-body field-mouse samples collected on the upgradient (UG) side of the PCFRS in 2013 compared with Aroclor-1254 and Aroclor-1260**

2. Monitoring Sensitive Bat Species at Los Alamos National Laboratory

Bats play a critical role in ecosystems and are vulnerable to disturbance and disruption by human activities. In recent decades, bat populations in the United States and elsewhere have decreased tremendously. There are 47 different species of bat in the United States and 28 of these occur in New Mexico with 15 different species documented at the Laboratory and surrounding areas. *Euderma maculatum* (the spotted bat) is listed as "threatened" by the state of New Mexico and is known to occur at the Laboratory. Four other species of bats are listed as "sensitive" and also occur here.

In 1995, a 4-yr study was initiated at the Laboratory to assess the status of bat species of concern, elucidate distribution and relative abundance, and obtain information on roosting sites. There have been no definitive studies since then. Biologists in the Environmental Protection Division at the Laboratory initiated a multi-year monitoring program for bats in May 2013 to implement the BRMP. The objective of this ongoing study is to monitor bat species diversity and seasonal activity over time at the Laboratory

as a general measure of ecosystem health. Bat species diversity and seasonal activity were measured using an acoustic bat detector, the Pettersson D500X. This ultrasound recording unit is intended for long-term, unattended recording of bat and other high-frequency animal calls. During 2013, the detector was deployed at two locations around the Laboratory. Study sites were selected based on proximity to water where bats may be foraging. Recorded bat calls were analyzed using Sonobat, software that can help determine specific species of bat through their calls. A list of bat species at the two sites was developed and compared with lists from previous studies. Species diversity and seasonal activity, measured as the number of call sequences recorded each month, were compared between sites and among months. A total of 17,923 bat calls were recorded representing 15 species. Results indicated that there is a statistically significant relationship between bat diversity and month of the year. Future studies will be implemented based on these findings. See Schoenberg (2014) for more detailed information.

3. Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Grounds

Laboratory biologists in the Environmental Protection Division initiated a multi-year monitoring program for migratory birds in 2013 to monitor avifauna at two open-air detonation sites and one open-burn site at the Laboratory. The objective of this ongoing study is to monitor patterns and trends of bird abundance and diversity over time at these sites as a general measure of ecosystem health. Biologists completed the first year of this effort in 2013. Three surveys were completed at each of the study sites at TA-36 Minie Site, the TA-39 Point 6, and the TA-16 Burn Grounds between May and July 2013. A total of 590 birds representing 55 species was recorded. Of the 55 species detected at the three study sites, 54 are protected under the Migratory Bird Treaty Act. Results indicate that the avian abundance and diversity at the three study sites were comparable to or greater than that of the control sites, which indicates no adverse impacts. Continued monitoring will produce trends over time in avian abundance and diversity that can be compared with local, regional, and national data. See Hathcock and Fair (2013) for more detailed information.

4. Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2010–2013

During the fall of 2013, Laboratory biologists completed the fourth year of monitoring fall migration passerines (songbirds). Songbirds were captured at a mist-netting station located in a large wetland/riparian complex at 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 9, 2013, with the completion of nine mist-netting sessions. A scheduled session in September was cancelled because of a week-long storm event. This project was conducted as part of implementation of the BRMP and is in compliance with the 2013 Memorandum of Understanding between the USFWS and the DOE/National Nuclear Security Administration and Executive Order 13186.

In 2013, 166 birds, representing 41 species, were banded. Broad-tailed, Black-chinned Calliope and Rufous Hummingbirds were also captured in August and September but were not analyzed as part of this project. Between 2010 and 2013, the overall number of birds captured has been variable; in 2013 the number of captures decreased substantially compared with 2012. The warblers were the most affected species, and their numbers remained significantly down from 2010. The variability in bird populations was likely driven by regional climatic factors. See Mahowald et al. (2014) for more detailed information.

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 Benthic Macroinvertebrates in the Rio Grande (SOP-5247)
- Processing Biota Samples for Analysis (SOP-5137)

These procedures, listed on the Laboratory's public website at http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php and available at eprr.lanl.gov, ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results are conducted in a manner consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

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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. During each investigation, samples of the environmental medium of interest are collected, and the data are evaluated to determine if potential unacceptable risk and/or dose is present. A corrective action is taken, when necessary, to rectify conditions potentially adverse to human health and the environment.

The EP Directorate developed the annual monitoring plan for Los Alamos and Pueblo Canyons and wrote or revised reports for three canyon systems, one aggregate area, one area of concern, three solid waste management units, and one material disposal area (MDA). Sediment and storm water monitoring in the canyons generally indicates sediment transport is substantially reduced down the canyon, and concentrations of most chemicals of potential concern released from Laboratory sites decrease downstream from the sources. Biennial surveys of asphalt at one site and ordnance at three sites within the Guaje/Barrancas/Rendija Canyons Aggregate Area found asphalt and tar, which were removed and recycled at the Los Alamos County Eco Station, and several pieces of munitions debris, which were removed by Laboratory Emergency Response personnel. Sediment was excavated from the Los Alamos Canyon low-head weir to maximize the sediment-retention capacity. No potential unacceptable human health and ecological risks were present. A supplemental investigation report written for the Upper Sandia Canyon Aggregate Area concluded 31 sites require no further sampling, 10 sites require additional sampling, no potential unacceptable human health risks or doses exist under the industrial and construction worker scenarios at any of the sites, and no potential ecological risks exist for any of the sites. Subsurface vapor (pore-gas) monitoring was conducted beneath and surrounding MDA C, and vapor-monitoring data indicate volatile organic compounds (VOCs) and tritium are present in the subsurface. Of the 26 VOCs detected in 2013, only trichloroethene was detected above its depth-dependent Tier II screening levels at three wells in the spring and two of the three wells in the fall. Most tritium activities (>90%) are below the Tier II screening level, but activities were above the Tier II screening level in three monitoring wells. However, the tritium activities decrease with depth in all three monitoring wells. The VOC and tritium pore-gas results are consistent with previous sampling data.

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) investigates and, where necessary, remediates sites to ensure that chemicals and radionuclides in the environment associated with releases from past operations do not pose a potential unacceptable risk or dose to human health or the environment. The sites under investigation are designated as consolidated units, solid waste management units (SWMUs), or areas of concern (AOCs). Using the environmental data obtained for a site, human health and ecological risk assessments are conducted. Sites are remediated if the risk assessments indicate potential adverse impacts to human health and/or the environment. Corrective actions are complete at a site when the Laboratory has demonstrated and documented, to the regulatory authority's satisfaction, that the site poses no unacceptable risk or dose to human and ecological receptors. Long-term stewardship activities, including surveillance and monitoring, are implemented when necessary 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 aboveground 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 m^3 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 2013.

1. Programs

The Corrective Actions Program investigates sites or areas 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 scope also includes the Consolidated Unit 16-021(c)-99 (260 Outfall) corrective measures evaluation (CME) and corrective measures implementation (CMI), Material Disposal Area (MDA) C, 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 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 include 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 monitoring plan, two progress reports, three monitoring reports, one investigation/remediation report, one supplemental investigation report, and two survey/inspection reports, which were submitted to NMED during 2013 or early 2014. A work plan proposes investigation activities designed to characterize sites, aggregate areas, and/or canyons or canyon segments. 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 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 2013. 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 2013 as well as the status of the reports/sites through 2013. NMED granted Certificates of Completion for 15 SWMUs and AOCs in 2013 (Table 9-3). The certificates for 9 sites were for corrective actions complete without controls, meaning no additional corrective actions or conditions are necessary. The certificates for 6 sites were for corrective actions complete with controls, which require future site use to be restricted to nonresidential use and/or maintenance of storm water controls. 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 2013a).

Table 9-1
Summary of Plans Submitted in 2013

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
2013 Monitoring Plan for Los Alamos and Pueblo Canyons Sediment Transport Mitigation Project, Revision 1 (LANL 2013b)	6/21/2013	7/19/2013	n/a*	Monitoring of storm water and geomorphic changes associated with the mitigation measures conducted to minimize storm water contaminant transport	Monitoring of geomorphic changes (e.g., sediment deposition or erosion) using repeat cross-section, channel, and general area surveys. Storm water monitoring is conducted at a series of 13 gages.	The objective is to sample a minimum of 4 storm water runoff events each year. The specific number of samples is dependent on a number of factors, including the frequency of precipitation and runoff events.	n/a

* n/a = Not applicable.

Table 9-2
Reports Submitted in 2013

Document	Date Submitted	Date Approved	Status
Storm Water Performance Monitoring in the Los Alamos/Pueblo Canyons Watershed during 2012	12/4/2013	—[a]	Monitoring will continue
Results of 2012 Sediment Monitoring in the Pajarito Canyon Watershed	3/28/2013	5/8/2013	Monitoring will continue[b]
Results of 2012 Sediment Monitoring in the Water Canyon and Cañon de Valle Watersheds	4/26/2013	—	Monitoring will continue
Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99	4/26/2013	n/a[c]	CME/CMI activities continue
Investigation/Remediation Report for Material Disposal Area B, Solid Waste Management Unit 21-015, Revision 2[d]	6/27/2013	—	Pending review by NMED Excavation of waste and remediation of trenches is complete.
Supplemental Investigation Report for Upper Sandia Canyon Aggregate Area	8/27/2013	—	Pending review by NMED
Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99	11/26/2013	n/a	CME/CMI activities continue
2013 Biennial Asphalt Monitoring and Removal Report for Area of Concern C-00-041, Guaje/Barrancas/Rendija Canyons Aggregate Area	12/20/2013	—	Pending review by NMED
2013 Biennial Ordnance Survey Report, Solid Waste Management Units 00-011(a, d, and e), Guaje/Barrancas/Rendija Canyons Aggregate Area	1/3/2014	—	Pending review by NMED
2013 Excavation of the Los Alamos Canyon Low-Head Weir	1/6/2014	—	Pending review by NMED

[a] — = Not yet approved.
[b] Monitoring to be part of surveillance program.
[c] n/a = Not applicable.
[d] This document is a revision to an investigation report previously described in the 2011 annual site environmental report. Revision 2 incorporates changes requested by NMED and did not involve additional sampling or remediation; the original investigation results and conclusions thus remain unchanged.

Table 9-3
SWMUs and AOCs Granted Certificates of Completion in 2013

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
SWMU 32-002(a)	X		1/29/2013
SWMU 45-001		X	2/22/2013
SWMU 45-002		X	2/22/2013
SWMU 45-003		X	2/22/2013
SWMU 45-004		X	2/22/2013
AOC C-45-001		X	2/22/2013
SWMU 00-011(a)	X		5/7/2013
SWMU 00-011(d)	X		5/7/2013
SWMU 00-011(e)	X		5/7/2013
AOC 15-006(e)		X	5/30/2013
SWMU 53-001(b)		X	7/31/2013
AOC 53-013		X	7/31/2013
AOC 53-014		X	7/31/2013
AOC 35-014(e2)	X		9/27/2013
SWMU 35-016(i)	X		9/27/2013

B. CORRECTIVE ACTIONS PROGRAM

In 2013, the annual monitoring plan was written for a canyon system (Table 9-1). Reports were written or revised in 2013 for three canyon systems, one aggregate area, one AOC, three SWMUs, and one MDA (Table 9-2). Table 9-4 presents a summary of the site, aggregate area, and canyon investigations conducted and/or reported in 2013. Figure 9-1 shows the sites where environmental characterization was conducted in 2013. In addition, the supplemental investigation report for the Upper Sandia Canyon Aggregate Area and the results of the 2013 vapor monitoring activities at MDA C are summarized.

1. Upper Sandia Canyon Aggregate Area Supplemental Investigation

a. Site Description and History

The Upper Sandia Canyon Aggregate Area is located in TA-03, TA-60, and TA-61 and consists of 180 SWMUs and AOCs, 91 of which were investigated and/or remediated before the March 2005 effective date of the Consent Order and have been approved for no further action. The remaining 89 SWMUs or AOCs were addressed in the approved investigation work plan for Upper Sandia Canyon Aggregate Area (LANL 2008, NMED 2008). These sites were investigated and the results documented in the approved investigation report for Upper Sandia Canyon Aggregate Area (LANL 2010, NMED 2010). The approved investigation report concluded additional sampling to define the nature and extent of contamination was required for 41 SWMUs and AOCs.

TA-03 occupies a large area located near the western end of South Mesa between Los Alamos Canyon to the north and Mortandad Canyon to the south. Sandia and Mortandad Canyons originate within TA-03 and divide the eastern two-thirds of the area into fingerlike projections. The middle mesa where most of TA-03 is located is called Sigma Mesa. The core operational facilities for the Laboratory are located at TA-03, including the principal administration buildings, library, the Chemistry and Metallurgy Research Building, Beryllium Technology Facility, a gas-fired electrical generating plant, and a former sanitary wastewater treatment plant and supporting structures. Thirty-five sites (26 SWMUs and 9 AOCs) located in TA-03 are addressed in the supplemental investigation report.

TA-60, also known as Sigma Mesa Site, lies on Sigma Mesa, between Sandia and Mortandad Canyons. All buildings at TA-60 are located on the western end of the mesa and contain Laboratory support and maintenance operations and subcontractor-service facilities. The Nevada Test Site (NTS) Test Fabrication Facility; the NTS test tower (buildings 60-17 and 60-18); several small abandoned experimental areas, including a solar pond and a test drill hole; and storage sites for pesticides, topsoil, and recyclable asphalt are also located at TA-60. Five sites (four SWMUs and one AOC) located in TA-60 are addressed in the supplemental investigation report.

TA-61 is bounded on the north by Los Alamos Canyon and on the south by Sandia Canyon. TA-61 contains physical support and infrastructure facilities, including the Los Alamos County solid waste transfer station, sewer pump stations, general storage sheds, a blower house, a private batch concrete batch plant, and general warehouse storage for maintenance activities. A small parcel of private property, the Royal Crest Manufactured Home Community, is surrounded by TA-61. The inactive Los Alamos County landfill site occupies most of TA-61. The landfill was created in 1974 when large trenches and disposal areas were excavated from the north wall of Sandia Canyon and was operated until 2009. Two sites (one SWMU and one AOC) located in TA-61 are addressed in the supplemental investigation report.

Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Reported in 2013 under the Corrective Actions Program

Document/ Activity	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
Storm Water Performance Monitoring in the Los Alamos/ Pueblo Canyons Watershed during 2012 (LANL 2013c)[a]	n/a[b]	Monitoring is conducted at 13 gage stations located throughout the watershed.	30 sampling events (a sampling event is defined as the collection of one or more samples from a specific gaging station during a specific runoff event) resulting in 483 samples collected	n/a	n/a	n/a	Net sediment deposition occurred in most surveyed areas that experienced monsoonal flood events in 2012, which is consistent with the goal of the sediment transport mitigation work plans. The surveys document that the sediment transport mitigation sites are currently operating as desired and are not undergoing net erosion over the period of this monitoring program. Analytical data collected from storm water samples indicate that for the 9 analytes exceeding New Mexico water-quality standards, only total PCBs has a recognized source at certain Laboratory sites. Concentrations of PCBs measured in lower Los Alamos Canyon are similar to those measured in upper Los Alamos Canyon above Laboratory sites and are consistent with concentrations of PCBs from the Las Conchas fire burn area down Guaje Canyon. PCBs in the burn area have a global source in atmospheric fallout and have accumulated in the watershed over time. The weir in Los Alamos Canyon substantially reduced transport of these PCBs. The transport of radionuclides in storm water that have a Laboratory source was also substantially reduced by the settling of sediment above the weir.

Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Reported in 2013 under the Corrective Actions Program

Document/ Activity	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 2012 Sediment Monitoring in the Pajarito Canyon Watershed (LANL 2013d)[a]	n/a	8 reaches, drainages, or areas	18 samples	n/a	n/a	n/a	Analytical results from sediment samples collected in the Pajarito Canyon watershed and in baseline areas downstream from the Las Conchas fire burn area in 2012, combined with results from previous sediment investigations, indicate concentrations of most chemicals of potential concern (COPCs) decrease downstream from the sources and are also lower than previous samples collected in the reaches (LANL 2013d). This finding is consistent with the conceptual model. Dissipation of flood energy and deposition of entrained sediment in the areas between TA-18 and NM 4 contributed greatly to reducing the downstream transport of contaminants from farther west in the watershed. These data also indicate many COPCs detected in the 2012 sediment samples have a primary source in the Las Conchas fire burn area and are associated with the transport of ash.
Results of 2012 Sediment Monitoring in Water Canyon and Cañon de Valle Watershed (LANL 2013e)[a]	n/a	8 reaches and 6 gage stations	16 sediment samples, 31 storm water flow readings	n/a	n/a	n/a	Floods during the 2012 monsoon season resulted in some erosion of contaminated and noncontaminated sediment deposits next to the active stream channel. This condition resulted in downstream transport of sediment with typically low concentrations of COPCs. This pattern was also observed in the post-2011 monsoon season investigation (LANL 2011). Barium, high explosives, and PCB concentrations in fine-grained post–Las Conchas fire sediment deposits show decreasing concentrations downstream from Laboratory source areas and are well within the concentration distribution documented in the Water Canyon/Cañon de Valle investigation report (LANL 2011).

Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Reported in 2013 under the Corrective Actions Program

Document/ Activity	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
Semiannual Progress Reports for Corrective Measures Evaluation/ Corrective Measures Implementation for Consolidated Unit 16-021(c)-99 (LANL 2013f and 2013g)[c]	16	1	Best management practices inspected (8 separate significant rain events were recorded between March and September 2013); 45 groundwater samples (split over 2 periodic monitoring events) as part of TA-16-260 monitoring group	n/a	n/a	n/a	The Cañon de Valle pilot permeable reactive barrier (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. The bentonite cap in the former TA-16-260 Outfall pond was inspected following the September 12 to 13, 2013, storm event and was in good condition. Three wells (CdV-16-4ip, CdV-R-15-3, and CdV-R-37-2) were reconfigured into single-screen wells between June and August 2013. Four drilling work plans and an interim measures work plan for source removal at one well were approved. The storms on September 12 and 13, 2013, produced a total of 5.39 in. of precipitation at the TA-06 weather station. Precipitation was higher in the headwaters area than on Laboratory property. This flood caused geomorphic changes to Cañon de Valle and Water Canyon. Damage was reported at three wells: 16-25280, CdV-16-1(i), and MSC-16-06295 (LANL 2013g). Groundwater analytical data are presented and discussed in Chapter 5.
Phase II Investigation Sampling of Upper Los Alamos Canyon Aggregate Area	00, 01, former 32, 43, 61	16	663 soil/fill, tuff, sediment samples	n/a	7 sites extent defined/9 sites extent not defined	n/a	14 sites are scheduled to undergo remediation for one or more contaminants. Additional sampling is needed at 9 sites to better delineate the area and/or depth of soil requiring excavation.

Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Reported in 2013 under the Corrective Actions Program

Document/ Activity	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
2013 Biennial Asphalt Monitoring and Removal Report for Area of Concern C-00-041, Guaje, Barrancas, Rendija Canyons Aggregate Area (LANL 2013h)	00	1	One-half 55-gal. drum of asphalt and tar was removed	1	n/a	n/a	Exposed asphalt and tar fragments were found and removed during the site inspection. Asphalt or tar was removed only if it was visible at the surface and involved no excavation or significant soil disturbance. The asphalt and tar pieces ranged in size from less than an inch to up to 12 in. in length and width. A total of 660 lb of asphalt and tar was removed and transferred to and recycled at the Los Alamos County Eco Station.
2013 Biennial Ordnance Survey Report, Solid Waste Management Units 00-011(a, d, and e), Guaje/ Barrancas/ Rendija Canyons Aggregate Area (LANL 2013i)	00	3	No unexploded ordnance (UXO) or munitions and explosives were found. Several pieces of munitions debris were found at the three SWMUs.	3	n/a	n/a	Activities conducted in 2013 included visual inspections of the sites using lines of personnel trained to recognize UXO. The trained personnel conducted site walkovers to identify any suspect material. No UXO was found at the three sites. Several pieces of munitions debris were identified, removed, and photographed by Laboratory Emergency Response personnel. Approximately the same amount of munitions debris has been found each year the sites have been surveyed.

Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Reported in 2013 under the Corrective Actions Program

Document/ Activity	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
2013 Excavation of the Los Alamos Canyon Low-Head Weir (LANL 2013j)	n/a	3 sub-basins behind the Los Alamos Canyon low-head weir	6 Sediment samples collected to characterize the material to be excavated	3 sub-basins	n/a	Maximum concentrations were not greater than residential soil screening levels/screening action levels and were less than respective minimum ecological screening levels (ESLs), except for 7 metals and 1 organic chemical. Maximum concentrations of these analytes were less than or equivalent to the minimum lowest effect level ESLs.	An estimated 6000 yd^3 of sediment was removed from the three basins to maximize the sediment-retention capacity and provide room for more sediment from future events. No potential unacceptable human health and ecological risks were present.

[a] The report was submitted in 2013, but the investigation was conducted and completed in 2012.

[b] n/a = Not applicable.

[c] Both progress reports are summarized together.

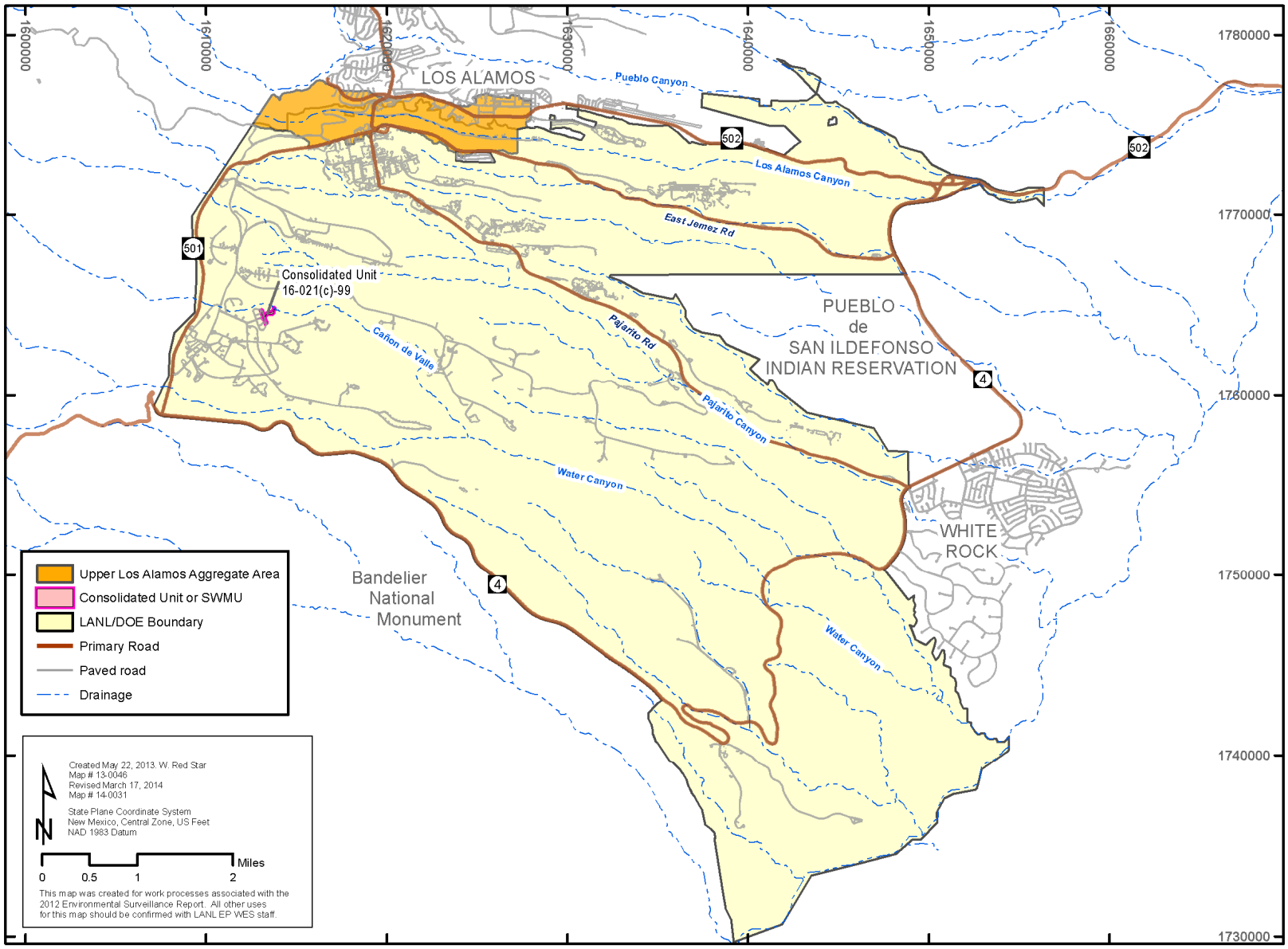

Figure 9-1 Locations of sites and canyons where characterization work was performed in 2013

b. Remediation and Sampling Activities

The 2009 investigation data for the 41 sites within the Upper Sandia Canyon Aggregate Area proposed for Phase II investigation and data from an additional site remediated in 2005–2006 were reevaluated using the revised data evaluation process based on U.S. Environmental Protection Agency (EPA) guidance and aimed at providing a greater emphasis on risk/dose reduction. Changes to the data evaluation process are as follows:

- Initially identify COPCs to focus efforts on the constituents of most concern
- Screen COPCs against soil screening levels and screening action levels during determination of extent to focus efforts on characterizing contamination potentially posing a risk/dose and requiring corrective action
- Perform screening level risk/dose evaluations on all sites, even if extent is not defined, to incorporate risk/dose reduction into recommendations for further actions

c. Conclusions and Recommendations

Based on the revised evaluation of the data, the nature and extent of contamination have been defined, and/or no further sampling for extent is warranted for 31 sites (LANL 2013k). The nature and extent of contamination have not been defined, and further sampling is warranted for 11 sites (LANL 2013k). One of the 11 sites is proposed for delayed characterization and investigation pending decontamination and decommissioning of certain buildings and structures within the aggregate area.

The human health risk-screening assessments found no potential unacceptable risks or doses at any of the sites under the industrial and construction worker scenarios. For the residential scenario, 13 sites had total excess cancer risks and 3 sites had hazard indices above the regulatory target levels. The remaining sites had no potential unacceptable risks or doses under the residential scenario. Complete exposure pathways to receptors are not present at one site where the potential contamination is deeper than 10 ft. Therefore, human health risk-screening assessments were not conducted for this site.

No potential ecological risks were found for any receptor following risk screenings and evaluations. Complete exposure pathways to receptors are not present at one site where the potential contamination is deeper than 5 ft. Therefore, an ecological risk-screening assessment was not conducted for this site.

Based on the results of the data evaluations presented in the supplemental investigation report (LANL 2013k), the following recommendations were made:

- Corrective action complete without controls is recommended for 20 sites for which nature and extent are defined and which pose no potential unacceptable human health risk under the residential scenario and no unacceptable ecological risk.
- One site has been found to have no complete exposure pathways to human and ecological receptors under the industrial, construction worker, and residential scenarios and is appropriate for corrective actions complete without controls.
- One site has been found to pose no potential unacceptable risks to human health under the industrial, construction worker, and residential scenarios and to have no pathway to ecological receptors.
- Corrective action complete with controls is recommended for 10 sites for which extent is defined and which pose no potential unacceptable human health risk under the industrial and construction worker scenarios and pose no unacceptable ecological risk.
- Additional sampling is recommended for 10 sites for which extent is not defined and which pose no potential unacceptable human health risk under one or more scenarios and pose no unacceptable ecological risk.

2. MDA C Subsurface Vapor Monitoring

Subsurface vapor (pore-gas) monitoring was conducted during 2013 beneath and in the area 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 2012a). 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 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 EPA Method TO-15 for VOCs and EPA Method 906.0 for tritium.

Subsurface vapor monitoring at MDA C was conducted twice during 2013 at 80 sampling ports within 18 vapor-monitoring wells. Figure 9-2 presents the 18 monitoring wells sampled during 2013 at MDA C. The sampling locations and frequency were specified by NMED (2011). The first sampling event was conducted during March and April 2013, and the second sampling event was conducted during November and December 2013.

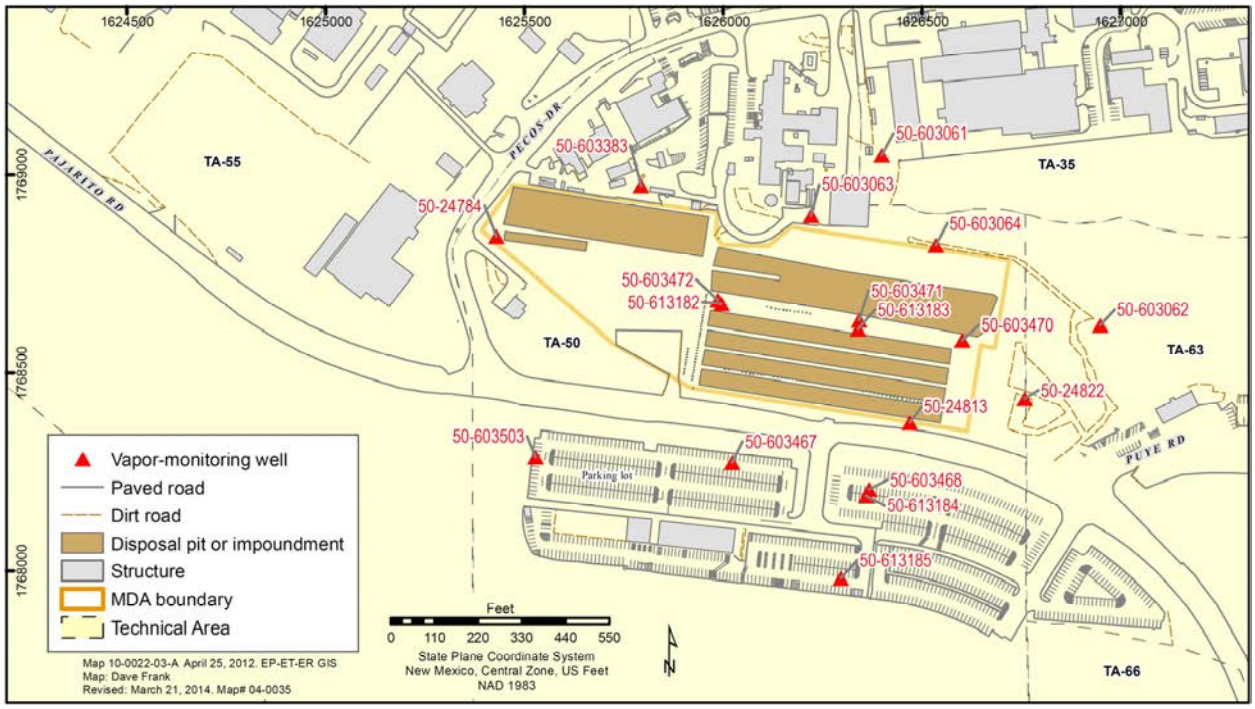

Figure 9-2 MDA C vapor-monitoring well locations

Because no regulatory criteria currently exist for vapor-phase contaminants in soil, the Laboratory evaluated VOC pore-gas data using a Tier I screening analysis (LANL 2012a). 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 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 attenuation.

A Tier II screening process was also developed and applied (LANL 2012a). The Tier II screening accounts for migration of VOCs through the unsaturated zone to the regional aquifer and subsequent attenuation within the aquifer. These calculated groundwater concentrations are compared with groundwater standards. The Tier II screening levels vary with depth because they are a function of the depth to groundwater in the unsaturated zone.

A total of 26 VOCs and tritium were detected in pore gas at MDA C during the first 2013 sampling event; 20 VOCs and tritium were detected in pore gas during the second 2013 sampling event. Table 9-5 lists the VOCs for which the SRs were above 1 during 2013 using the Tier I screening analysis. The maximum Tier I SRs calculated for these VOCs are also listed. The screening evaluation of the 2013 data identified three VOCs with vapor concentrations above their respective Tier I screening levels: 2-hexanone, methylene chloride, and trichloroethene (TCE).

Table 9-5
VOCs above Tier I Screening Levels in 2013 Samples at MDA C

VOC	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard, Tier I Screening Level ($\mu g/m^3$[a])	Maximum Pore-Gas Concentration during First Sampling Event ($\mu g/m^3$)	Maximum Tier I Screening Ratio for First Sampling Event (unitless)	Maximum Pore-Gas Concentration during Second Sampling Event ($\mu g/m^3$)	Maximum Tier I Screening Ratio for Second Sampling Event (unitless)
Hexanone[2-]	130	696	5.6	ND[b]	n/a[c]
Methylene Chloride	650	1805	2.8	1389	2.1
TCE[d]	2000	85,928	43.0	64,446	32.2

[a] $\mu g/m^3$ = Micrograms per cubic meter.
[b] ND = Not detected.
[c] n/a = Not applicable.
[d] TCE concentrations were also above the Tier II screening level developed for MDA C (LANL 2012a).

TCE is the only VOC detected at concentrations above the Tier II screening levels. Figures 9-3 and 9-4 show the TCE vapor data for the first and second 2013 pore-gas sampling events, respectively, compared with the depth-dependent Tier II TCE screening values. The TCE screening levels assume there is vapor diffusion through porous media in the unsaturated zone and dispersion 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 2013. Figure 9-4 shows that the Tier II screening levels were exceeded in samples collected at monitoring wells 50-24813 and 50-603471 during November and December 2013. The TCE vapor concentrations were above the Tier II screening levels 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 previous monitoring data (LANL 2012a, 2012b, 2013l).

The vapor plume is associated with disposal trenches and shafts near the eastern end of MDA C that contain wastes with some solvent contamination. 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 (LANL 2012a).

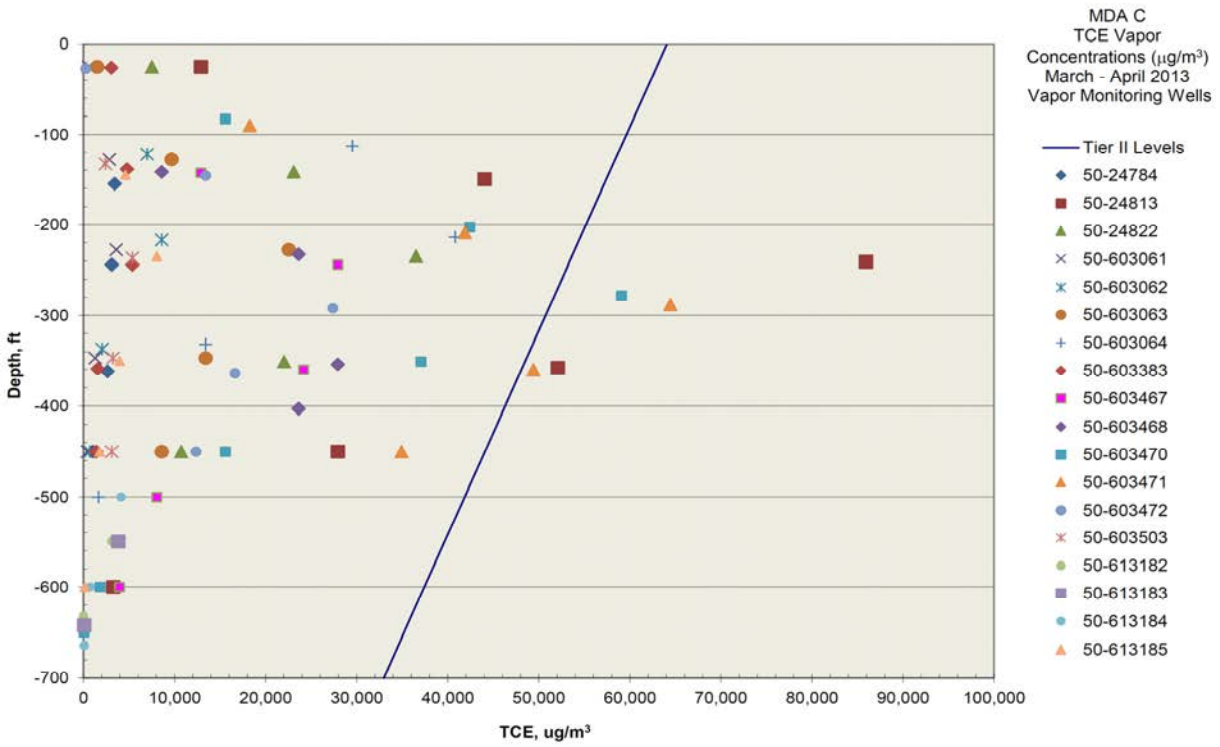

Figure 9-3 **TCE vapor concentrations measured at MDA C during March and April 2013 compared with the depth-dependent Tier II screening levels**

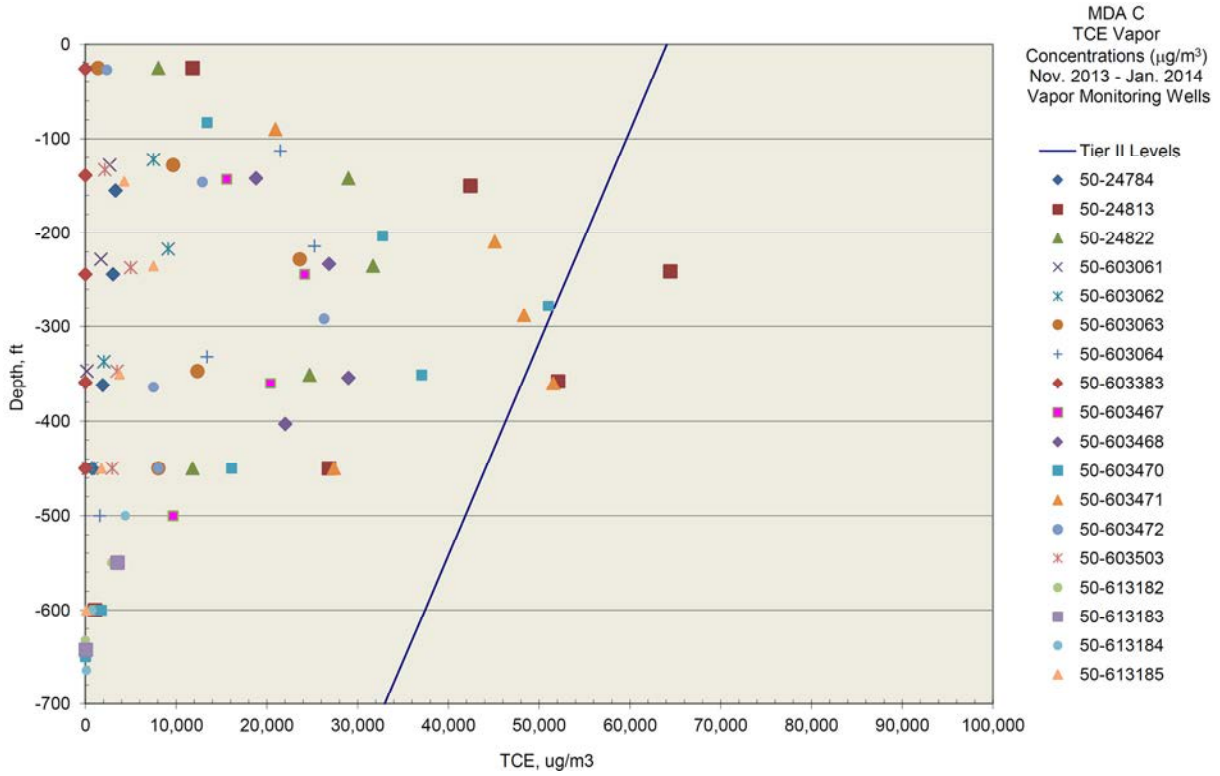

Figure 9-4 **TCE vapor concentrations measured at MDA C during November and December 2013 compared with the depth-dependent Tier II screening levels**

Tritium activity was detected in vapor samples collected at MDA C. At most locations, the tritium activity decreased with depth, and most activities (>80%) were below the Tier I screening value of 20,000 picocuries per liter (pCi/L) (the EPA maximum contaminant level for drinking water). 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 2012a). To be conservative, the Tier II screening level established for tritium does not account for transport and decay in the unsaturated zone. Most tritium activities (>90%) were below the Tier II screening level. Figures 9-5 and 9-6 present the 2013 tritium data for the first and second sampling events, respectively, compared with the Tier II screening level. The graphs show that tritium activities exceeded the Tier II screening level at monitoring wells 50-603470, 50-603383, and 50-603472 for both sampling events. However, the tritium activities decreased substantially with depth in all three monitoring wells. For example, the maximum tritium activity reported during 2013 was 3,232,570 pCi/L in monitoring well 50-603470 at a depth of 83 ft, at the eastern end of MDA C (Figure 9-2), but tritium activities in the ports below this depth were orders of magnitude less (Figures 9-5 and 9-6). These results are consistent with previous sampling data.

Vapor monitoring at MDA C will continue on a semiannual basis to support remedy selection.

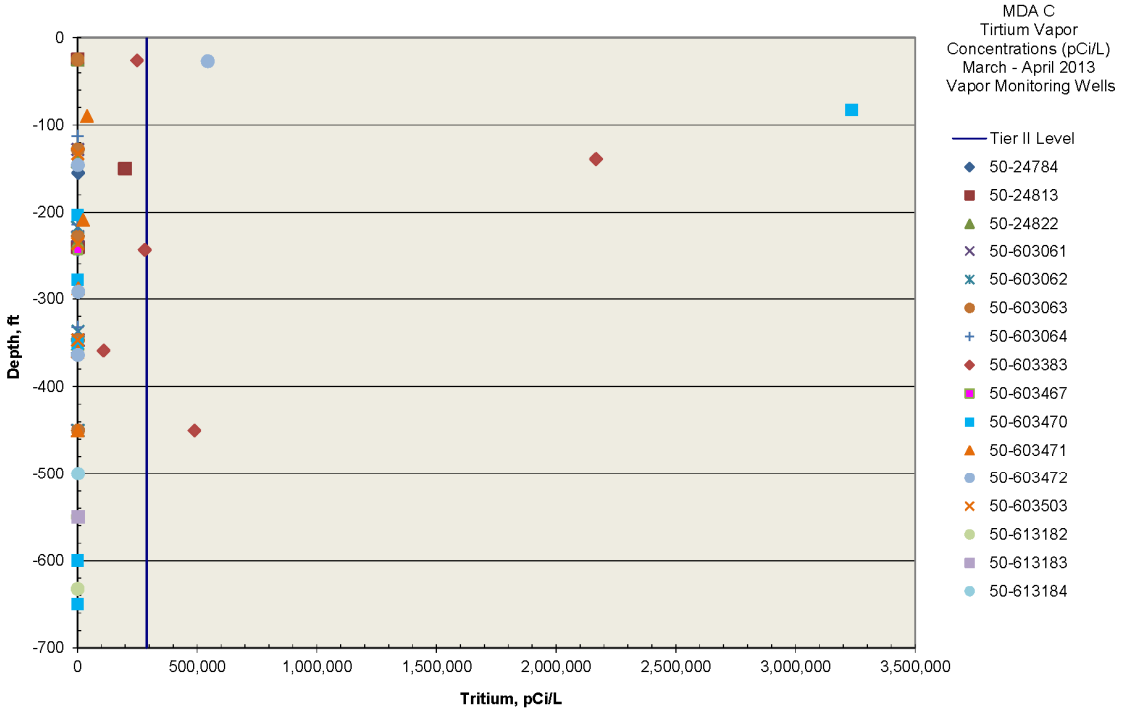

Figure 9-5 **Tritium activities measured at MDA C during March and April 2013 compared with the Tier II screening level**

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

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.

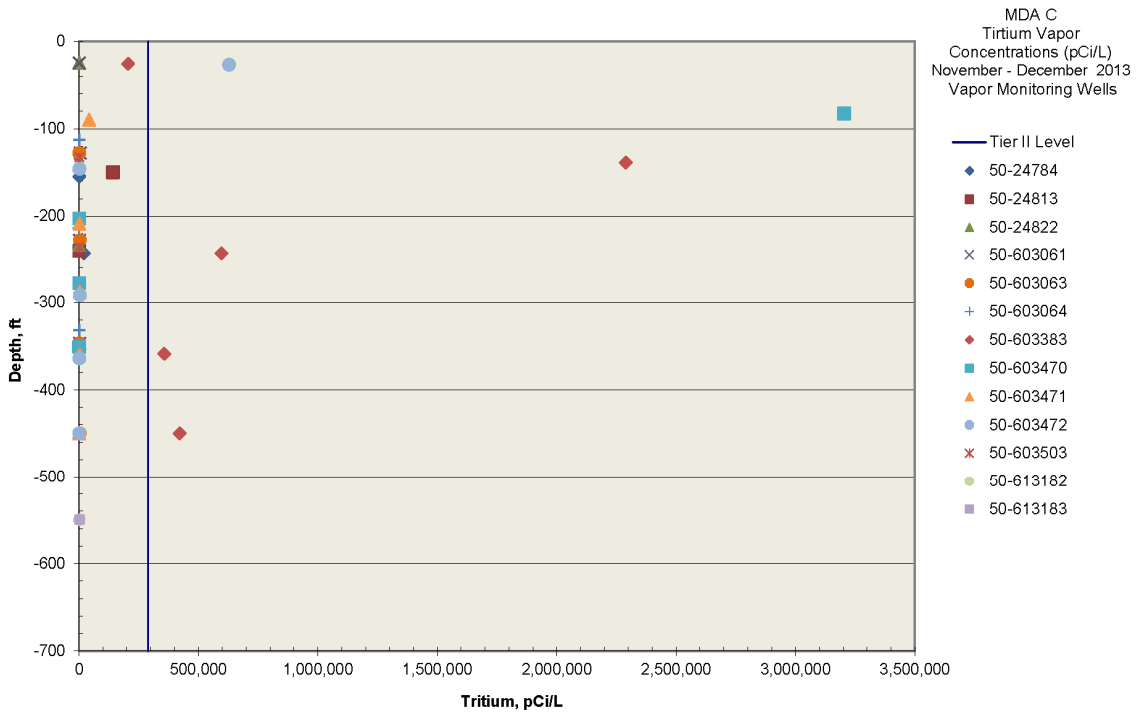

Figure 9-6 **Tritium activities measured at MDA C during November and December 2013 compared with the Tier II screening level**

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 Laboratory's 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

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LANL 2013k: "Supplemental Investigation Report for Upper Sandia Canyon Aggregate Area," Los Alamos National Laboratory document LA-UR-13-26024 (August 2013).

LANL 2013l: "Los Alamos National Laboratory Environmental Report 2012," Los Alamos National Laboratory report LA-UR-13-27065 (September 2013).

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NMED 2010: "Notice of Approval, Investigation Report, Upper Sandia Canyon Aggregate Area," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico (November 2010).

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A. INTRODUCTION

The 2013 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) 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 Environmental Information Management (EIM) auto-validation following the guidelines of the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program National Functional Guidelines for Data Review (EPA 2004, 2005, 2008), EPA methodologies, and LANL SOPs. This process includes review of completeness established within the electronic data deliverable checkers in the EIM database. This process also includes automated quality control (QC) checks assessed by the criteria determined in auto validation; the database applies data qualifiers to the data according to LANL validation SOPs.

Field QA procedures and the quality plan documents were followed during 2013 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.intellusnm.com/, which contains all the air, surface water, sediment, soil, 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 with 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 2013). LANL requires all laboratories to produce legally defensible data packages, which include the following types of 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 an auto-validation review by the EIM auto-validation module (LANL 2012). Additional problems beyond auto validation may be identified during data review by the subject matter end user. A focused validation is conducted by a chemist as a detailed investigation of a particular data record having concerns. The analytical laboratory may be contacted, and attempts to resolve or clarify the related issues are established in corrective action reports submitted to LANL. All validation corrective action reports for 2013 were addressed and resolved appropriately by the analytical laboratory. The EIM auto-validation module validated all of the 2013 data packages.

After auto validation, approximately 99% of all results are of good quality and are usable; auto validation assigned R qualifiers (rejected) to approximately 1.02% of the 2013 data. Overall, approximately 1.4% 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 The analytical laboratory assigned J qualifiers to approximately 2.6% of the data, indicating that the results represent detection, but the value is estimated. The analytical laboratory confirmed 21% of the analytes as detected. Even after validation, 74% of the data are qualified as not detected with no QC issues. Table 10-1 displays the overall quality of the 2013 samples.

Table 10-1
Overall Quality of 2013 Samples

Qualifiers Affecting Quality Control	Percent of 2013 Data
U, U_LAB = Qualified as not detected by lab with no QC issues	74
J, J_LAB = Qualified as detected between method detection limit and estimated quantitation limit	2.6
NQ = Detected above the reporting limit with no QC issues	21
R = Rejected in validation	1.02
UJ (estimated nondetect) or J because of QC issues discovered in validation	1.4

Table 10-2 shows the percentage of data qualified as estimated detects (J) based on the auto validation of laboratory QC samples. Table 10-3 shows approximately 1% of all 2013 data were qualified as rejected (R).

Table 10-2
Auto-Validation Summary for Estimated Detects (J) of 2013 Data

QC Sample Type	Number of Analytes Qualified as Estimated (J)	Percent 2013 Data
Internal standards or surrogates	21	0.009
Laboratory control samples	258	0.184
Laboratory duplicates	581	0.245

Table 10-3
Auto-Validation Summary for Rejected 2013 Data

QC Sample Type	Number of Analytes Qualified as Rejected (R)	Percent 2013 Data
Initial calibration verifications or continuing calibration verifications	25	0.01
Internal standards or surrogates	80	0.034
Laboratory control samples and duplicates	24	0.01
Spectra do not match	319	0.134
Professional judgment	1989	0.84

C. QUALIFICATION AND PERFORMANCE ASSESSMENT OF ANALYTICAL LABORATORIES

LANL is responsible for acquiring analytical services that support environmental activities. The LANL 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 2013, 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 studies, 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. It 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).

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GENERAL FORMATION OF A STANDARD

Standards are created to protect a target group from 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 children. Contaminants of concern are addressed by a governing body, such as the U.S. Environmental Protection Agency (EPA). Pathways of exposure include air, water, soil, biota, and foodstuffs that can be ingested, absorbed, or inhaled. Time of exposure is important 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 436.1, Departmental Sustainability; 458.1, Radiation Protection of the Public and the Environment; and 231.1B, 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.

In 2011, DOE issued Order 458.1, which describes the radiation protection standards for the public (DOE 2011). 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 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.)

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 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.

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
One specific pathway (dose constraint)	25 mrem/yr[a]
Air pathway only[b]	10 mrem/yr
Drinking water	4 mrem/yr

[a] Guidance (DOE 1999).

[b] This level is from EPA's regulations issued under the Clean Air Act (40 Code of Federal Regulations [CFR] 61, Subpart H) (EPA 1989a).

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 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.

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://water.epa.gov/polwaste/npdes/.

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.nmcpr.state.nm.us/nmac/parts/title20/20.007.0010.pdf.

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.

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.

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. In addition, DOE Order 458.1 requires that persons consuming water from DOE-operated public water supplies do not receive a dose 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 standards, which references the state's radiation protection regulations. 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. 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; the Laboratory has established screening levels for radionuclides. If contaminant concentrations in foodstuffs exceed RSRLs, the concentrations are compared with screening levels. The Laboratory 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 the Laboratory 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, the Laboratory 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).

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NMEIB 1995: "New Mexico Drinking Water Regulations," New Mexico Environmental Improvement Board (as amended through January 1995).

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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.

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)

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).

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

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

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
$\mu g/m^3$	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:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1*s*) for the station and group means.

REFERENCE

Gilbert 1975: 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.

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.

For more information on environmental topics at Los Alamos National Laboratory (the Laboratory), access the following websites:

Current and past environmental reports and supplemental data tables	http://www.lanl.gov/community-environment/environmental-stewardship/environmental-report.php
The Laboratory's website	http://www.lanl.gov/
U.S. Department of Energy/National Nuclear Security Administration Los Alamos Field Office website	http://nnsa.energy.gov/fieldoffices/losalamos
U.S. Department of Energy website	http://www.energy.gov/
The Laboratory's air quality pages	http://www.lanl.gov/community-environment/environmental-stewardship/protection/monitoring/air-quality.php
The Laboratory's water quality pages	http://www.lanl.gov/community-environment/environmental-stewardship/protection/monitoring/water-quality.php
The Laboratory's environmental stewardship pages	http://www.lanl.gov/community-environment/environmental-stewardship/index.php
The Laboratory'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 1010 nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DCG	Derived Concentration 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 × 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 *Atomic Energy Act of 1954*, as amended], or naturally occurring radioactive material.
MCL	Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system. 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 (µg/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 (µg/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 (µg/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 rad = 1000 millirad (mrad)
radionuclide	An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.
RCRA	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
release	Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.
rem	Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation. rem = rad × quality factor 1 rem = 1000 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.

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	*Batrachochytrium dendrobatidis* (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	microroentgen/hour
MRF	Material Recycling Facility
MS	matrix spike
MSGP	Multi-Sector General Permit
MSL	Materials Science Laboratory
MTRU	mixed transuranic
N_20	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
NOx	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

Actinium	Ac	Erbium	Er
Aluminum	Al	Europium	Eu
Americium	Am	Fermium	Fm
Argon	Ar	Fluorine	F
Antimony	Sb	Francium	Fr
Arsenic	As	Gadolinium	Gd
Astatine	At	Gallium	Ga
Barium	Ba	Germanium	Ge
Berkelium	Bk	Gold	Au
Beryllium	Be	Hafnium	Hf
Bicarbonate	HCO_3	Helium	He
Bismuth	Bi	Holmium	Ho
Boron	B	Hydrogen	H
Bromine	Br	Hydrogen oxide	H_2O
Cadmium	Cd	Indium	In
Calcium	Ca	Iodine	I
Californium	Cf	Iridium	Ir
Carbon	C	Iron	Fe
Cerium	Ce	Krypton	Kr
Cesium	Cs	Lanthanum	La
Chlorine	Cl	Lawrencium	Lr (Lw)
Chromium	Cr	Lead	Pb
Cobalt	Co	Lithium	Li
Copper	Cu	Lithium fluoride	LiF
Curium	Cm	Lutetium	Lu
Cyanide	CN	Magnesium	Mg
Carbonate	CO_3	Manganese	Mn
Dysprosium	Dy	Mendelevium	Md
Einsteinium	Es	Mercury	Hg

Molybdenum	Mo	Samarium	Sm
Neodymium	Nd	Scandium	Sc
Neon	Ne	Selenium	Se
Neptunium	Np	Silicon	Si
Nickel	Ni	Silver	Ag
Niobium	Nb	Sodium	Na
Nitrate (as Nitrogen)	NO_3-N	Strontium	Sr
Nitrite (as Nitrogen)	NO_2-N	Sulfate	SO_4
Nitrogen	N	Sulfite	SO_3
Nitrogen dioxide	NO_2	Sulfur	S
Nobelium	No	Tantalum	Ta
Osmium	Os	Technetium	Tc
Oxygen	O	Tellurium	Te
Palladium	Pd	Terbium	Tb
Phosphorus	P	Thallium	Tl
Phosphate (as Phosphorus)	PO_4-P	Thorium	Th
Platinum	Pt	Thulium	Tm
Plutonium	Pu	Tin	Sn
Polonium	Po	Titanium	Ti
Potassium	K	Tritiated water	HTO
Praseodymium	Pr	Tritium	^3H
Promethium	Pm	Tungsten	W
Protactinium	Pa	Uranium	U
Radium	Ra	Vanadium	V
Radon	Rn	Xenon	Xe
Rhenium	Re	Ytterbium	Yb
Rhodium	Rh	Yttrium	Y
Rubidium	Rb	Zinc	Zn
Ruthenium	Ru	Zirconium	Zr

Cave art in Pajarito Canyon

Back cover: Night sky from Los Alamos Canyon during owl survey season. Photo by Phillip Noll, ENV-ES

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 (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

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Technical coordination by Sam Loftin, Environmental Protection, Environmental Stewardship Services

Edited by Pamela Maestas, Regulatory Management Program, Regulatory Support and Performance

Composition by Teresa Hiteman, Environmental Stewardship Services, Environmental Protection


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NATIONAL LABORATORY
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NNSA
National Nuclear Security Administration