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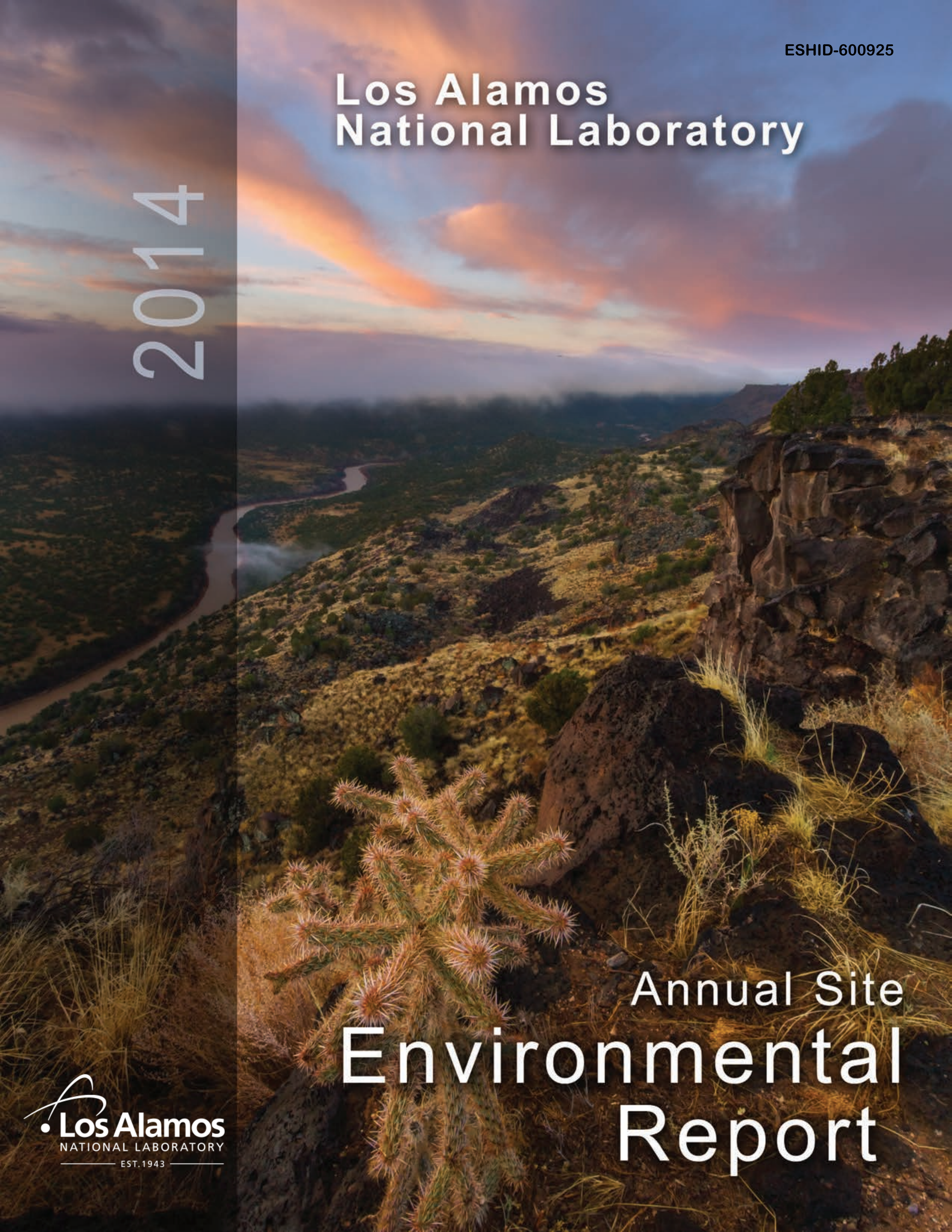
Los Alamos National Laboratory

2014



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.

Environmental sampling

Jemez Mountains salamander

Front cover: View of the Rio Grande. Cover design and photo by Phillip Noll, ENV-ES.

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Issued September 2015

Los Alamos National Laboratory 2014 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
505-667-4873

Environmental Programs Directorate
505-606-2337

Environmental Remediation Program
505-665-3388

Los Alamos
NATIONAL LABORATORY
EST. 1943

Los Alamos National Laboratory's (the Laboratory's) annual site environmental reports are prepared annually by the Laboratory's 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. Chapter 2 reports the Laboratory's compliance status for 2014. Chapter 3 provides a summary of the status of environmental restoration work around the Laboratory. The environmental surveillance and monitoring data are organized by environmental media (air in Chapter 4, ground water in Chapter 5, and surface water and sediments in Chapter 6) in a format to meet the needs of a general and scientific audience. Chapter 7 presents a summary of the radiological dose, chemical exposure risk, and other impacts of Laboratory operations on the local ecosystem. Chapter 8 provides a summary of the maximum radiological dose the public could have potentially received from Laboratory operations and discusses chemical exposures. 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
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or

Los Alamos National Laboratory
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To obtain copies of the report, contact

Environmental Stewardship Communications
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E-mail: lorriel@lanl.gov

FIGURES

TABLES

APPENDICES

LOS ALAMOS NATIONAL LABORATORY 2014 ANNUAL SITE ENVIRONMENTAL REPORT

This year's annual site environmental report (ASER) incorporates some changes to the format and content based on recommendations made by Los Alamos National Laboratory's (the Laboratory's) Environmental Sampling Board. The Environmental Sampling Board issued the "Environmental Sampling Plan for Los Alamos National Laboratory" (LA-UR-14-20735) in February 2014. The sampling plan clearly describes the data quality objective process to which all Laboratory environmental surveillance programs must adhere. In addition, some changes to the ASER format were recommended. Most notably, past chapters on soil monitoring and foodstuffs and biota monitoring were combined into Chapter 7, Ecosystem Health. Also included in Chapter 7 are information on biota dose and risk assessments and a discussion of additional data that could be incorporated into the evaluation of ecosystem health.

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.

The Laboratory's ASER will continue to incorporate recommendations from the Environmental Sampling Board as well as from the annual U.S. Department of Energy ASER guidance document to better communicate the Laboratory's environmental activities and meet environmental reporting requirements.

Abstract/Preface
Sam Loftin

Executive Summary
Sam Loftin

1.0 Introduction
Joe English
Jean Dewart
Deborah Hall
Cathy Hayes
Denny Hjeresen
Sam Loftin
Mike McNaughton
Nita Patel
Ben Poff
Jennifer Payne
Sonja Salzman
Paul Schumann
Marjorie Wright

2.0 Compliance Summary
Marc Bailey
Bob Beers
Michelle Coriz
Albert Dye
Joe English
Mark Everett
David Fuehne
Robert Gallegos
Leslie Hansen
Chuck Hathcock
Ken Hargis
Sam Loftin
Jacob Meadows
Michael McNaughton
Andy Montoya
Dan Pava
Jennifer Payne
Ben Poff
Michael Saladen
Sonja Salzman
Tim Sloan
Shannon Smith
John Valdez
Steve Veenis
Luciana Vigil-Holterman
Walt Wetham
Holly Wheeler
Monica Witt
Marjorie Wright
Timothy Zimmerly

3.0 Environmental Restoration
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Daniel Romero

4.0 Air Quality
Jean Dewart
David Bruggeman
David Fuehne
Aysha McClory
Michael McNaughton

5.0 Groundwater Monitoring
Danny Katzman
Tim Goering

6.0 Watershed Quality
Daria Cuthbertson
Stanislaw Marczak
David Frank
Marina Meneakis
Amanda White

7.0 Ecosystem Health
Philip Fresquez
Mike McNaughton
Leslie Hansen
Chuck Hathcock
Sam Loftin
Shannon Gaukler
David Keller

8.0 Dose and Risk Assessment
Michael McNaughton
Jessica Gillis
Jeff Whicker
Aysha McClory

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 approximately 39-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 for 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 2014, the Laboratory collected samples from air, water, soil, sediment, foodstuffs, and associated biota at approximately 1026 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 2014, 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.

An additional summary of this report can be found in the Los Alamos National Laboratory 2014 Annual Site Environmental Report Summary. The full report and the summary are available on the Laboratory's website: http://www.lanl.gov/community-environment/environmental-stewardship/environmental-report.php.

Los Alamos National Laboratory (the Laboratory) is committed to act as a steward of the environment to achieve the mission in accordance with all applicable environmental requirements. The Laboratory sets continual improvement objectives and targets, measures and documents progress, and shares results with the workforce, sponsors, and public. The Laboratory reduces 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 current mission is "to solve national security challenges through scientific excellence."

Inseparable from the Laboratory's commitment to excellence in science and technology is its commitment to complete all work in an 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 protecting the environment, monitoring and reporting are conducted on how Laboratory activities are affecting that environment. The objectives of this environmental report, as directed by DOE Order 231.1B, 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 performance measures; 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 39-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, 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.

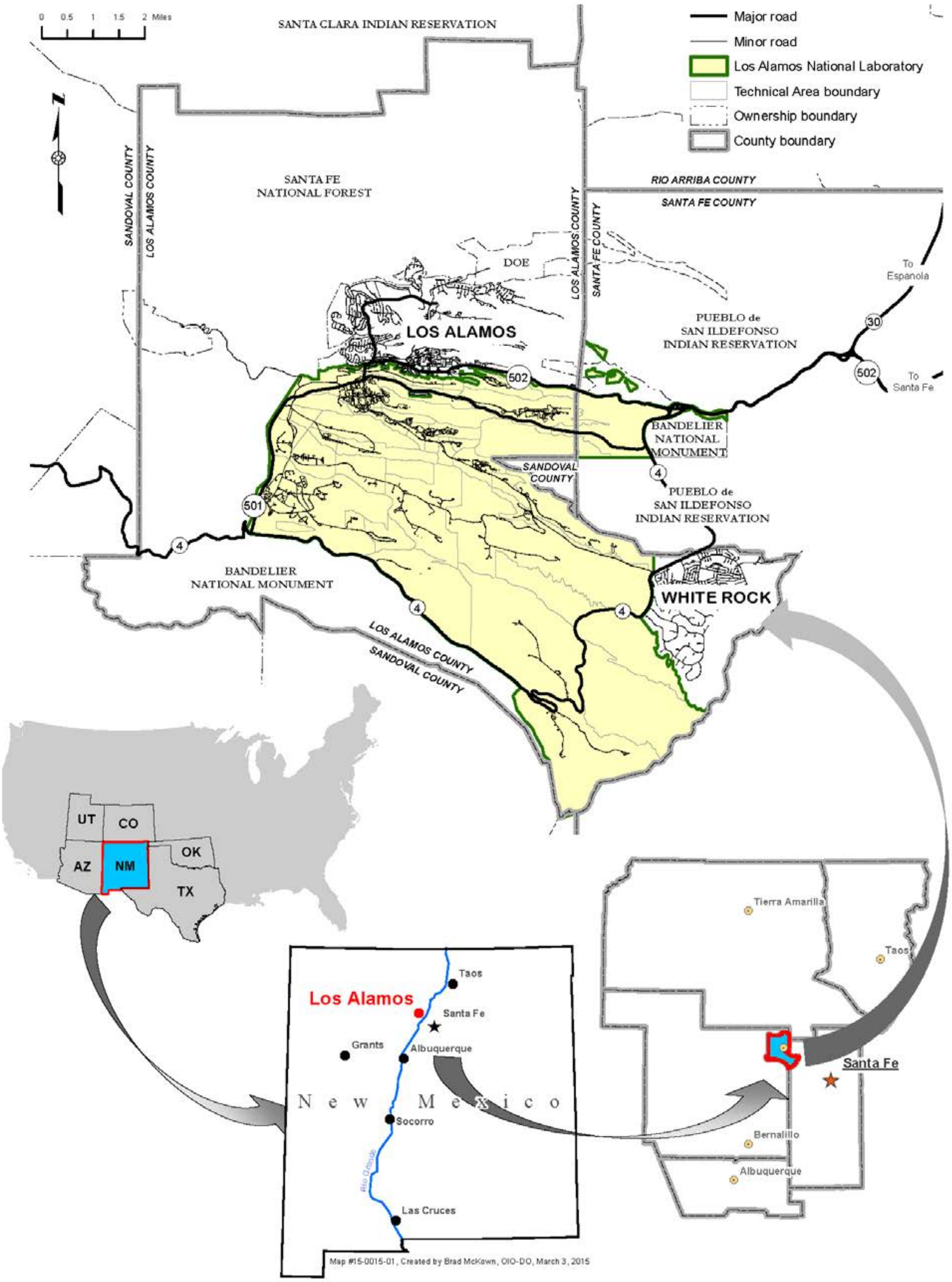


Figure 1-1 Regional location of the Laboratory

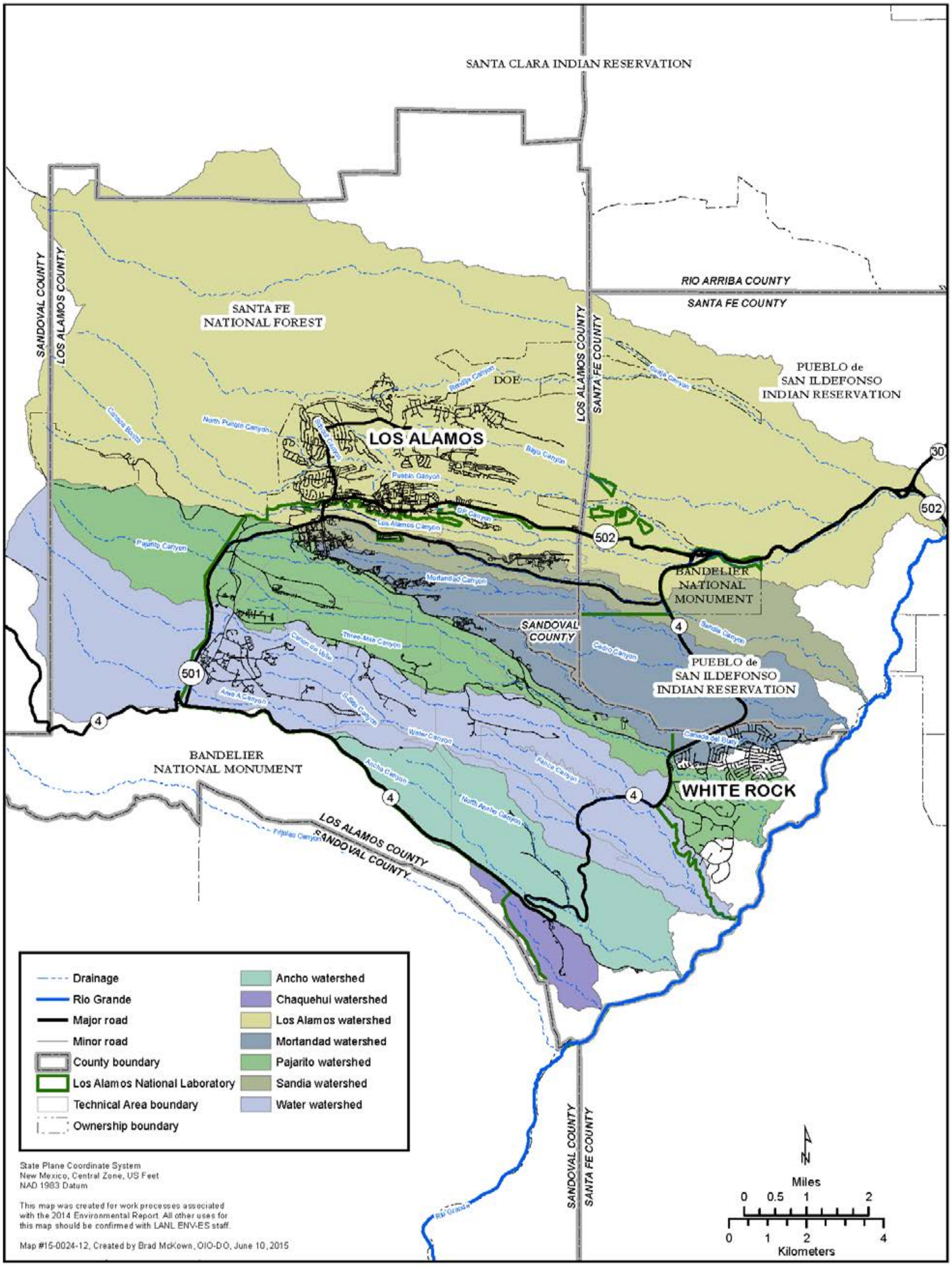


Figure 1-2 Primary watersheds at the Laboratory

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 drought conditions prevalent throughout New Mexico and Los Alamos in the past 15 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, a process projected to continue into the 2050s (Williams et al. 2012).

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 164 of the more than 300 buildings that were evaluated in 2014 have been declared eligible. 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

Legislation creating the National Park Service Manhattan Project National Historical Park was signed by President Obama on December 19, 2014. This new park consists of three units in Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. Park properties will retain original DOE, local government, and private ownership. The Los Alamos park properties listed in the legislation include historic buildings in downtown Los Alamos and 17 LANL properties located in eight technical areas (TAs). LANL properties 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). First year activities include the development of a memorandum of agreement between the Secretary of the Interior and the Secretary of Energy regarding the administration of facilities under the jurisdiction of the DOE, including provisions for enhanced public access, management, interpretation, and historic preservation.

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 34% 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 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 976 structures, with approximately 8.2 million square feet under roof, spread over an area of approximately 439 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.

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.

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.

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 26,058 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.

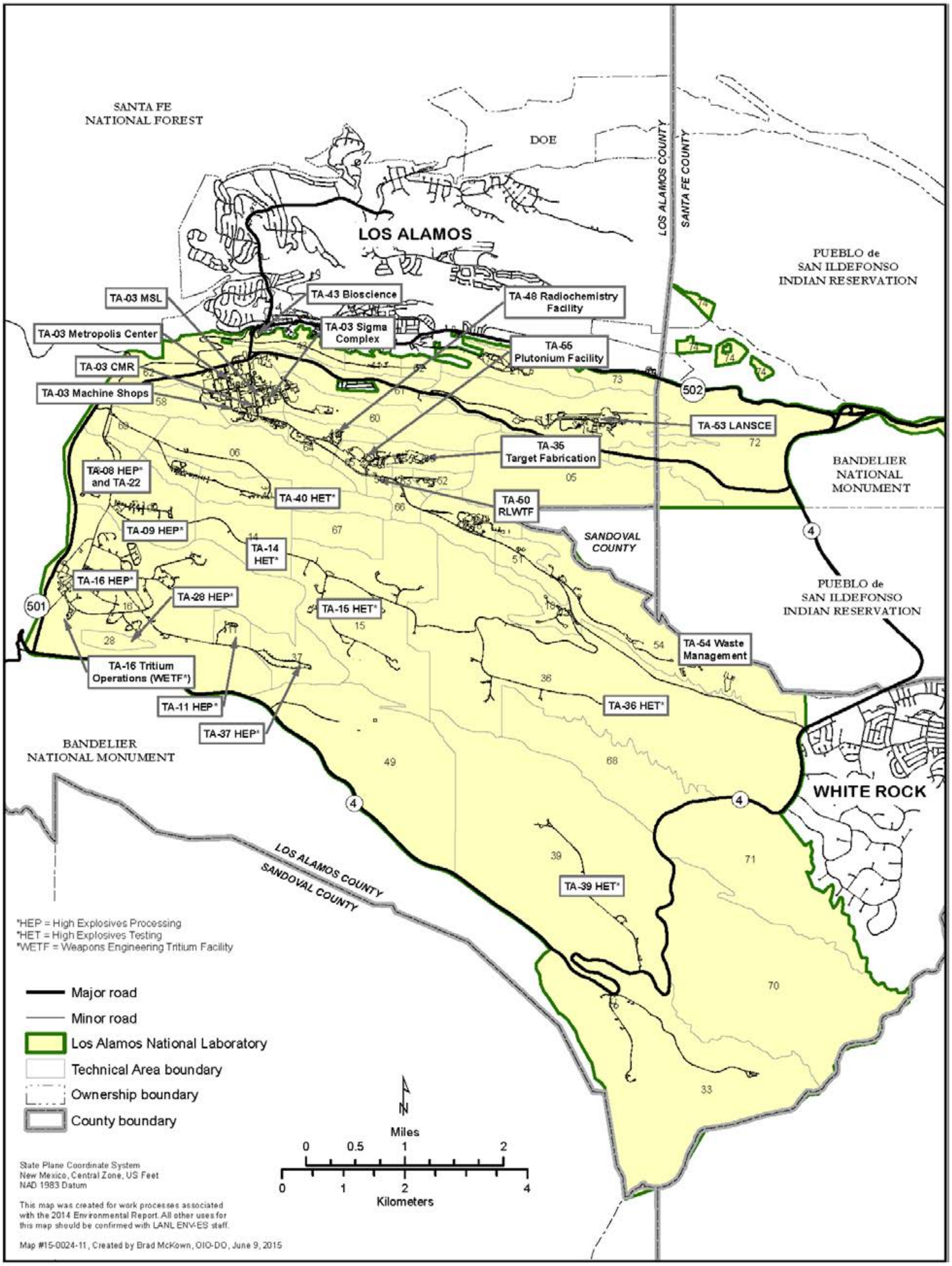


Figure 1-3 TAs and key facilities of the Laboratory in relation to surrounding landholdings

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Environmental protection and compliance with environmental, safety, and health laws and regulations are underlying values for 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 environmental performance.

Institutional management of environment, safety, and health is performed by the Associate Directorate for Environment, Safety, and Health (ADESH), including environmental protection and waste management. Characterization and cleanup of legacy waste and legacy transuranic waste disposition programs are part of the Associate Directorate for Environmental Programs (ADEP). 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…" 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 2014, 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 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 accordance 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 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:

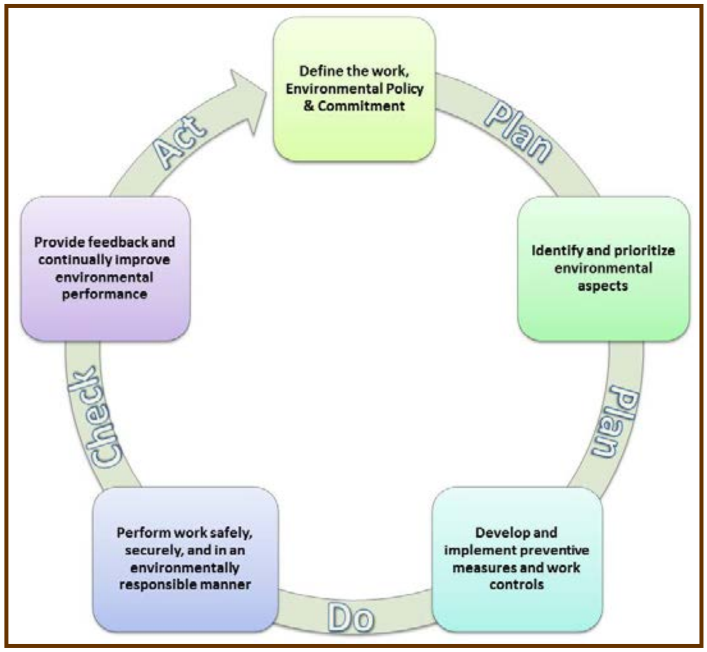
1. Policy and commitment
2. Planning
3. Implementation and operation
4. Checking and corrective action
5. Management review

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 2014.

i. Clean the Past

- Continue to comply with 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 Permit for Storm Water with the U.S. Environmental Protection Agency (EPA)
- Continue to accelerate transuranic (TRU) waste shipments to the Waste Isolation Pilot Plant and meet the milestones in the Framework Agreement with NMED [Note: Due to an underground fire at WIPP facility on February 6, 2014, (See Section 8.b) shipments of TRU waste have been placed on hold until sometime after LANL shipments to WIPP are resumed.



- Reduce "cold and dark" facility footprint (element of Footprint Reduction Program)

ii. Control the Present

- Maintain and improve the LANL environmental compliance program. Fully integrate environmental controls with safety controls through integrated work management requirements and standard work processes. Implement sustainable acquisition (DOE Order 436.1, Resource Conservation and Recovery Act, and SWEIS requirements). Perform pollution prevention with focus on problematic pollutants from all environmental media. Implement an enduring waste management program
- Implement and maintain a legacy cleanout and workplace stewardship program
- Implement and maintain a green infrastructure and maintenance program
- Design and implement an integrated land management strategy

iii. Create a Sustainable Future

- Implement an energy and water conservation program
- Reduce greenhouse gas emissions
- Increase number of high performance sustainable buildings
- Support sustainable local and regional planning
- Develop and deploy new environmental sustainable technologies
- Execute the long-term strategy for environmental stewardship and sustainability

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 2014, the Laboratory developed and managed 351 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

Laboratory mission activities generate a variety of waste streams, including

- solid waste;
- hazardous waste;
- mixed TRU and mixed low-level waste (LLW);
- toxic wastes;
- LLW, both solid and liquid;
- TRU waste;
- medical and infectious waste;
- New Mexico Special Waste; and
- sanitary 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 treated effluent 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 2014 nor have there been since November 18, 2010.

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 Remediation (formerly Corrective Actions) Program

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. Corrective actions for legacy waste sites are subject to the requirements of the Consent Order, and subject to DOE requirements when radionuclides are present. Certificates of completion are granted to indicate corrective actions are complete and adequate to protect human health and the environment. Certificates of completion are granted 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 Environmental Remediation Program. This work also includes investigations of the canyons, as well as sediment, groundwater, storm water, and vapor monitoring.

Program accomplishments for calendar year 2014 are presented in Chapter 3, 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 8 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 Calendar Year 2014

Sample Type or Media	No. of Locations	Frequency of Sampling[a]	No. of Analytes or Measurements
Ambient air	41	Biweekly	2,248
Stack monitoring	29	Weekly	24,770
Vegetation	24	Annually	418
Sediment	17	Annually	7,657
Animal	6	Annually	27,711
Groundwater	181	Quarterly/semiannually/annually	50,126
NPDES outfalls	11[b]	Weekly	1,079
Surface water base flow	22	Quarterly/semiannually/annually	5,432
Surface water storm runoff	94[c]	Following rains	49,547
Neutron radiation	47	Quarterly	188
Gamma radiation	80	Quarterly	320
Environmental restoration soil/rock investigation sampling	91	Annually	10,196
Subsurface vapor monitoring	18	Monthly/quarterly/annually	10,912
Surface soil	25	Annually	538
Benthic macroinvertebrates	17	Every 3 yr	77
Land Transfer soil and sediment	323	One-time assessment	12,829
Totals	**1,026**		**204,048**

Notes: Not all the data counted in the table 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.

[a] Does not include particulate (in air) measurements made by four tapered element oscillating microbalance instruments that calculate particulate concentrations every half hour.

[b] Three of the 11 NPDES outfalls are currently classified as zero liquid discharge.

[c] Monitoring locations include NPDES Multi-Sector General Permit and Individual Storm Water Permit locations (see Chapter 2) as well as Los Alamos/Pueblo Canyon monitoring and storm water gage station monitoring (see Chapter 6).

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. The LANL Environmental Data Process

Note: All environmental data presented in this annual site environmental report can be found in the Environmental Information Management (EIM) Intellus database at http://www.intellusnm.com.

The LANL EIM process starts with sample planning. Each environmental program creates a plan for their sampling events. Events can be planned ad hoc or well in advance, and they follow each environmental program's standard processes (see individual chapters for specific quality assurance process information). Environmental programs plan where, when, what, and by whom samples will be collected based on their program requirements. Field forms and chains of custody are created to support the process. Mobile collection is also supported with mobile instructions sent to mobile field devices.

Upon completion of field sampling, samples collected are delivered to the analytical laboratory following LANL Sample Management Office (SMO) standard procedures. Documentation of the transfer is stored in the EIM system for sample and invoice tracking.

Once analytical laboratories have completed their analysis process, they electronically upload the data results into the EIM system. Data are uploaded, and email notifications are sent to LANL SMO staff indicating the data are ready for LANL to review and process.

Once data arrive in the EIM system, LANL SMO staff perform an electronic data deliverable (EDD) review and auto validation of the electronic data files. Data files are reviewed for errors. If errors are the result of analytical laboratory processing, the laboratory is notified to correct the issues and resubmit the data. If errors are caused by LANL processing (such as a bad location ID), the SMO will fix the issue and auto validate the data. Auto validation of the data entails running a specified electronic review of the data based on defined analytical chemistry review criteria. The analytical results are then flagged with applicable data validation qualifiers and processed to the final data tables in the EIM system.

Data are approved for the final database tables in the EIM system after auto validation is complete. Once data are in the final tables, they are available to LANL environmental programs for review, analysis, and reporting. Data transit time from the holding tables to final tables is typically less than a day during business hours. Email notifications of data availability to environmental program staff occur once the data are present in the final database tables.

Field data (nonanalytical data) are collected in conjunction with analytical data. Such data are not sent to analytical laboratories but imported directly to the EIM system by the collecting programs. Field data are subject to automated format checking and manual quality assurance reviews in accordance with environmental program procedures. Once reviewed, these data are sent to the final database tables for review, analysis, and reporting by environmental program staff.

Once data (both field and analytical) are released to the final database tables, they will automatically be released to the Intellus website (http://www.intellusnm.com) on a nightly basis. This is true for all data in the EIM system except for data associated with LANL's third-party data process and selected data with hold flags manually applied by LANL.

LANL treats data collected at locations owned by third parties in accordance with supplementary agreements between LANL and the land owners. All data associated with a third-party landowner are reviewed and auto validated in the same manner as data located on LANL-owned locations. The only exception to the normal data management process is the delay of the release of third-party data to the Intellus website. Instead of direct nightly release to Intellus, third-party analytical results are sent via email directly to the landowners for their information and review. During the review process, the data are withheld from release to Intellus pending review by the landowner. Once the landowner has finished review or the agreed-upon default holding window has elapsed, the data are then automatically released nightly to Intellus.

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

The Long-Term Strategy for Environmental Stewardship and Sustainability defines Grand Challenges that must be addressed year by year to minimize the impact of Laboratory operations on the environment. These challenges address the overarching strategies to clean up the past, control the present, and create a sustainable future. The formal mechanism to set annual environmental and sustainability objectives and targets and track implementation is the Laboratory's EMS (see Section D.1).

a. Environmental Grand Challenges

The Laboratory's Environmental Grand Challenges are described in Figure 1-4.

Figure 1-4 Environmental Grand Challenges—The Laboratory's goals to live a sustainable future

b. 2014 Accomplishments

Collaborate: In 2014, LANL facilitated 588 environmental outreach activities and fulfilled numerous requests, including 15 technical consultations, 117 meetings, 78 presentations, 62 tours, and49 document and information requests. The web interface to the Intellus database of environmental sampling data was upgraded, improving access to over 14 million environmental data records.

Remove or stabilize pollutants: In 2014, LANL continued activities under its Individual Permit for Storm Water Discharges, covering 405 legacy-waste sites monitored at 250 locations. LANL manages these sites to prevent the transport of legacy wastes via storm water runoff. Staff repaired storm water controls at over 200 sites damaged by severe flooding in September 2013, excavated the Los Alamos Weir, repaired the Pueblo Canyon grade-control structure and improved the Mortandad Canyon sediment traps, constructed a Sandia Canyon grade-control structure, and planted over 10,000 willows in Pueblo Canyon. Staff initiated planning for a boundary protection program to further minimize storm water transport of legacy constituents off LANL property. LANL initiated tests of various remediation strategies for the chromium groundwater plume, including installation of the first large-scale pumping well, and began planning for remediation of the RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) groundwater plume.

Protect water resource quality and reduce water use: LANL continued to implement storm water pollution prevention plans at construction sites and manage liquid discharges from 11 permitted industrial outfalls in compliance with the Laboratory's NPDES outfall permit. Staff began preparation of a formal storm water management plan for TA-03 in 2014. The Laboratory maintained its site-wide storm water gage station network for monitoring flow and collecting storm water samples in all major canyons, and continued operation of the Buckman Direct Diversion project early notification system for storm water flows through Los Alamos Canyon into the Rio Grande. LANL used 307 million gallons of water in fiscal year (FY) 14, which was 80 million gallons less than in FY13 (data are presented by FY to be consistent with DOE Order 436.1 sustainability reporting requirements).

Eliminate emissions, discharges, and releases: The Laboratory worked with the EPA to renew the NPDES permit for 11 mission-critical outfalls in 2014. The new permit includes more monitoring requirements and more stringent limits, some of the toughest in the country. To strengthen compliance, LANL established a centralized cooling tower management and preventive maintenance plan. Of the current 11 permitted outfalls, 2 are managed with no current liquid discharges to the environment.

Manage and restore lands: LANL completed a site plan for management of the newly listed federally endangered Jemez Mountains Salamander. LANL staff also discovered, addressed, and reported on a potentially widespread problem of cavity-nesting birds becoming trapped and dying in open pipes (such as those supporting fence gates) and bollards. LANL completed a forest management plan for the site and continued supporting ongoing wildland fuel mitigation projects. LANL also continued restoring Manhattan Project facilities and initiated an update of its comprehensive site plan. The Laboratory initiated a site cleanup program to remove currently unused equipment and supplies associated with past operations and experiments.

Produce zero radioactive, hazardous, liquid, or solid wastes: During 2014, LANL implemented a "one-stream" recycling approach and increased the number of items/materials that can be recycled by more than three times. LANL also developed a plan to replace oil-containing equipment, specifically vacuum pumps and compressors, to systematically reduce this industrial waste stream.

Use energy efficiently while creating sustainable energy sources: LANL reduced energy intensity (the number of British thermal units used per square foot of LANL facilities) by 18% in FY14 compared with the FY03 baseline. Energy-reduction initiatives include replacing conventional light bulbs with light-emitting diode bulbs; implementing automated night setback schedules for lighting and heating in buildings; and upgrading heating, ventilating, and air conditioning systems and lighting in buildings. The Laboratory has started planning to upgrade its current 23-megawatt combustion turbine. The upgrade will modify the turbine into a high-efficiency dual-cycle unit. Steam will be extracted from the turbine when needed to power a refurbished campus heating system in cogeneration mode. This will allow LANL to meet the growing energy demands of the Laboratory's high-performance computing program with a lower carbon-intense energy source than is currently available in the New Mexico region.

8. Environmental Issues and Actions

a. Metals Moratorium Project

The Metals Moratorium Project addresses a long-standing operational problem that poses serious space utilization, health, environmental, and financial risks to the institution. Since July 2000, when former Energy Secretary Bill Richardson issued a moratorium/suspension, DOE contractors have been prohibited from releasing clean scrap metal managed in radiological areas for the purpose of recycling:

- The moratorium encumbers metals potentially contaminated in volume through activation or melt consolidation.
- The suspension encumbers only scrap metal managed in a radiological area per 10 Code of Federal Regulations 835, Occupational Radiation Exposure, on or after July 13, 2000, regardless of radiological character.

The basis for Secretary Richardson's action in imposing the moratorium/suspension was public concern for potential residual radiation in consumer products. In the ensuing 14 years, the stockpile of clean but encumbered metals has been increasing, and sites have been faced with the options of storing metals indefinitely or disposing of them as low-level or industrial waste. Limited disposition budgets have led to both controlled and uncontrolled storages areas (boneyards), risking the loss of acceptable knowledge, poor utilization of space for mission activities, and increased environmental concerns, including non-point source pollution and pest control. Finally, the loss of resale value for encumbered metals is significant. A 2013 Energy Federal Contractors Group analysis estimated that the difference between the resale of currently clean but encumbered metal and disposition of the metal as LLW ranged from a low of $67.4 million to a high of $191.6 million. The range for LANL is estimated to be $6.8 to $19.3 million.

On September 28, 2011, Energy Secretary Steven Chu released an action memorandum authorizing program offices to resume clearance, contingent on completion of a programmatic environmental assessment. The action memorandum required that sites participate in the programmatic environmental assessment and develop procedures for conducting radiation surveys and documenting the results of the surveys against appropriate authorized limits (DOE Order 458.1, Radiation Protection of the Public and the Environment standard of <1 millirem [mrem] above background).

The LANL Metals Moratorium Project in 2014 was designed to develop the required survey and release procedures and to demonstrate their efficacy on a large scale by clearing metals unencumbered by the moratorium/suspension. Radiation dosimetry experts worked with measuring and monitoring experts to develop two new Laboratory procedures. The first, Data Quality Objectives for Measurement of Radioactivity in or on Items for Transfer into the Public Domain, describes the statistical basis and physics of clearance of both potential surface and volumetrically contaminated materials. The second, Technical Basis Documentation Regarding Health Physics Measurements for the Unrestricted Release of Metals from LANSCE (RPSVS-RIC-TBD-03, Revision 0, October 31, 2013), was issued as a field guide for radiological control technicians to conduct physical sampling of materials prior to clearance and recycling. Separately, the procedures and processes for the implementation of DOE Order 458.1, Radiation Protection of the Public and the Environment, were reviewed by DOE, which issued formal notification that the Laboratory has met the implementation requirements of the order.

Acquisition Services Management and the Material Recycle Facility (MRF) established a new metals recycling contract that will create revenues from recycled metal streams. Chief Financial Office and MRF personnel worked to develop an approved funding model for costs/returns from recycled metals to fund future cleanout projects.

The project implemented a pilot at LANSCE to identify, dismantle, physically assess, and then recycle metals representative of those covered by the moratorium/suspension. This process included identification of over 2000 tons of potentially recyclable metals. Unencumbered metals were identified for the pilot at the TA-53 magnet storage pad (Figure 1-5) and the experimental physics and industrial control system (EPICS) spectrometer in Area A (Figure 1-6).

The project has created the path for what will be a multiyear effort to clear mission workspaces. In 2014, efforts resulted in major site cleanups at TA-51, TA-35, TA-53, and TA-03, with over 103,000 lb of metals recycled.

Figure 1-5 TA-53 Magnet Pad – hundreds of tons of copper, steel, and aluminum exposed to elements and subject to environmental review as a potential non-point source of water pollution

Figure 1-6 EPICS Spectrometer in Area A – over 200 tons of magnet and cold-rolled steel encumbering projected new mission workspace

The project developed critical lift, rigging, and survey techniques for the dismantlement of large sections of equipment (Figure 1-7).

Figure 1-7 Large EPICS spectrometer magnets after initial dismantlement. Each magnet consisted of ten magnet plates, each plate weighing over 10 tons. The Area A space has been repurposed for new experimental activities.

b. Radiological Release at the Waste Isolation Pilot Plant

On February 14, 2014, an airborne radiological release occurred underground at DOE's Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. The WIPP facility is a deep geologic repository mined within a 2000-ft-thick bedded-salt formation. The underground repository is 2150 ft beneath the ground surface (DOE 2015).

An accident investigation board was appointed to determine the cause of the release. The Phase 1 investigation report was issued on April 22, 2014 (DOE 2014), and the Phase 2 report was issued on April 16, 2015 (DOE 2015). As stated in the 2015 report, "The Board identified the direct cause of this accident to be an exothermic reaction of incompatible materials in LANL waste drum 68660 that led to thermal runaway, which resulted in over-pressurization of the drum, breach of the drum, and release of a portion of the drum's contents (combustible gases, waste, and wheat-based absorbent) into the WIPP underground" (DOE 2015). The local root cause was identified as follows: "LANL's use of organic, wheat-based absorbent instead of the directed inorganic absorbent such as kitty litter/zeolite clay . . . resulted in the generation, shipment, and emplacement of a noncompliant, ignitable waste form."

The report describes the origin of the material in the waste drum as "plutonium residues from other recovery operations (e.g., chloride operations), metal preparation, metal fabrication, analytical laboratory operations, and residues from other DOE facilities."

Subsequent investigations (WIPP 2015) concluded that the maximum worker dose at WIPP was 10 mrem compared with the DOE worker limit of 5000 mrem/year, and the public dose was less than 1 mrem compared with the EPA limit of 10 mrem/year. The DOE standard plume-dispersion model (from the National Atmospheric Release Advisory Center) was used to estimate that the on-site deposition was less than 10 disintegrations per minute (dpm) per 100 cm^2 compared with the DOE limit for a contamination area, which is 20 dpm per 100 cm^2 (WIPP 2014).

In July and October 2014, the Laboratory voluntarily reported to NMED the noncompliances under the permit associated with the processing of the nitrate salt-bearing mixed transuranic waste (MTRU) stream inventory at LANL. These self-disclosures resulted in receipt of an NMED-issued Administrative Compliance Order, No. HWB-14-20, on December 6, 2014. As a result, the Laboratory conducted a comprehensive extent of condition review to assess the scope of noncompliances stemming from the deficient procedures used to process nitrate salt-bearing wastes associated with the February 14, 2014, incident at WIPP and issuance of the Administrative Compliance Order. During that review, the Laboratory examined processing of all other legacy MTRU wastes remediated at LANL and found noncompliances similar to those reported to NMED in 2014. The results of the extent of condition review were voluntarily reported to NMED on August 31, 2015.

Based on a technical evaluation of these noncompliances, the Laboratory concluded that they do not present a credible safety concern to workers or the public and do not pose a threat to human health or the environment (see Funk and Clark 2015).

At the time of issuance of this report, shipments to WIPP have been suspended, and drums at the Laboratory similar to the breached drum are stored in standard waste boxes in ventilated containment structures with continuous air monitors and high-efficiency particulate air-filtered exhausts. Radiological control technicians monitor the temperatures as well as the gas to check for the first signs of chemical reactions. All drums at the Laboratory, similar to the breached drum, will be remediated to ensure they meet the waste acceptance criteria for WIPP and applicable NMED requirements.

9. 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 the burned 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. Work to repair and restore gauges damaged in the 2013 flooding event continued in 2014.

b. Fire Mitigation

Tree thinning and mastication were used to create defensible space and to improve forest health. Treatments in 2014 focused on the areas around the TA-35 and TA-50 facilities and along NM 4 between TA-39 (Ancho Canyon) and White Rock.

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.

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2.0 COMPLIANCE SUMMARY

To Read About **Turn to Page**

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 laws are designed to protect human health and the environment by (1) regulating the handling, transportation, and disposal of materials and wastes; (2) regulating impacts to ecological, archaeological, historical, atmospheric, soil, and water resources; and (3) requiring environmental impact analyses. 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 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 2014 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2014. The following sections summarize the Laboratory's regulatory compliance performance during 2014.

Table 2-1
Environmental Permits or Approvals under which the Laboratory Operated during 2014

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Administrative Order	Ordered permittees to develop and implement a LANL nitrate salt-bearing waste container isolation plan and provide regular updates about nitrate salt-bearing waste containers to NMED	May 19, 2014, and modified on July 10, 2014; April 27, 2015; and May 8, 2015	None	NMED
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, and October 1, 2014	September 30, 2014, but administratively continued by EPA. Current permit expires September 30, 2019.	EPA
NPDES Multi-Sector General Permit (MSGP)	Storm water discharges from specific industrial sector activities[a]	September 29, 2008	September 29, 2013, but administratively extended by EPA pending resolution of public comments	EPA
NPDES Individual Permit (IP) for Storm Water	Storm water discharges from 405 specified SWMUs and AOCs	November 1, 2010	October 31, 2015; application for renewal submitted to EPA in 2014; administratively extended by EPA pending issuance of new permit	EPA
Construction General Permit (CGP) for Storm Water	Storm water discharges from certain construction projects	February 16, 2012	February 16, 2017	EPA

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
CWA Sections 404/401	U.S. Army Corps of Engineers (USACE) nationwide permits (NWPs) (5) i. Water Canyon Storm Water controls (NWP No. 43, Stormwater Management Facilities) ii. Sandia Canyon –TA-72 Firing Site Storm Water Controls (NWP No. 43, Stormwater Controls) iii. Sandia Canyon Wetland Grade Controls (NWP No. 38, Cleanup of Hazardous and Toxic Waste) iv. E250 Stream Gage Weir Erosion Repair in Pajarito Canyon (NWP No. 3, Maintenance Activities) v. Mortandad Sediment Traps Erosion Control and Maintenance (NWP No. 43, Stormwater Controls) vi. Pueblo Grade Control Spurs and E060.1 Gage Revitalization (NWP No. 43, Stormwater Controls) vii. Pueblo Canyon Stabilization Project (NWP No. 27, Habitat Restoration) viii. Upper Sandia Canyon Riparian Restoration (NWP No. 27, Habitat Restoration) ix. TA-39 Point 6 Firing Site Stormwater Controls (NWP No. 43 Stormwater Controls) x. Potable Water Line Break (NWP No. 12, Utility Line Activities	i. November 20, 2012 ii. March 25, 2013 iii. March 27, 2013 iv. May 28, 2014 v. June 23, 2014 vi. July 30, 2014 vii. September 16, 2014 viii. September 24, 2014 ix. September 30, 2014 x. November 21, 2014	(i–x) March 18, 2017	USACE/ NMED
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 / Leach Field Systems, DP-1589	Discharge to groundwater	Application submitted April 27, 2006 Application resubmitted June 25, 2010	Approval pending	NMED

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
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 Draft Renewal Operating Permit received December 9, 2014	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
	Chemistry and Metallurgy Research Replacement facility, Radiological Laboratory/Utility/Office Building (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 2014

Date	Purpose	Performing Entity
4/21/14–4/24/14	RCRA compliance evaluation inspection	NMED
9/24/14–9/25/14	Title V Operating Permit compliance inspection	NMED
8/25/14–8/28/14; 9/12/14	Compliance evaluation inspection for IP	NMED
7/23/14–7/26/14	Petroleum storage tanks inspection	NMED
7/22/14	Mortandad sediment traps	USACE

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. 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

The Land Conveyance and Transfer (LC&T) Project is a DOE Los Alamos Field Office project for which LANS provides technical and project management support. The project was authorized by Public Law 105-119 in November 1997. The 10 original tracts, identified for conveyance or transfer at LANL in the environmental impact statement have been subdivided into 32 tracts (DOE 1999). Twenty-one tracts have now been conveyed or transferred: 15 tracts have been conveyed to Los Alamos County, 3 tracts have been conveyed to the Los Alamos County School District, and 3 tracts have been transferred to the Bureau of Indian Affairs. Additional tracts, which may be subdivided, will be conveyed or transferred by September 2022 in accordance with Public Law 105-119.

The LANS LC&T Project Office continues to work with the Field Office and the Associate Directorate for Environment Programs (ADEP) to execute a coordinated schedule for the outstanding compliance activities and requirements associated with conveyance of the remaining tracts.

In fiscal year (FY) 2014, the LANS LC&T Project Office continued to focus on activities needed to convey Tracts A-18-A (lower Pueblo Canyon); A-5-2 (Airport-3 South, in DP Canyon); A-5-3 (Airport-3 South, in DP Canyon); A-14 (Rendija Canyon); and A-16-A (TA-21 West). The LANS LC&T Project Office continued landlord responsibilities and activities at the remaining tracts.

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 completed 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 Final Natural Resource Damage Assessment Plan for Los Alamos National Laboratory was released on April 30, 2014 (LANL Trustee Council 2014, www.lanlnrda.org).

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 administer 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. The Laboratory does not dispose of hazardous or mixed waste on-site.

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 2014, the Laboratory submitted eight Class 1 permit modification packages to the Laboratory's Hazardous Waste Facility Permit. The modifications revised figures from permitted units, 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 an Administrative Order from NMED on May 19, 2014, in response to the February 14, 2014, incident at the Waste Isolation Pilot Plant (WIPP). The order required the permittees to develop a LANL nitrate salt-bearing waste container isolation plan and provide updates associated with the implementation of the plan. As of December 31, 2014, the order had been modified once by letter on July 10, 2014. Daily (week-day) written technical submissions under the order began on June 4, 2014, to document technical phone calls and provide update information on the implementation of the plan. The permittees generated 59 additional transmittals to respond to various informal and formal requests for information from NMED-HWB in 2014. On December 6, 2014, NMED issued an

Administrative Compliance Order (HWB-14-20) for violations of the Hazardous Waste Act and the LANL Hazardous Waste Facility Permit associated with nitrate salt-bearing waste. The Permittees provided a response to NMED in January 2015, and NMED and the permittees continue to evaluate an agreement to address the Administrative Compliance Order and potential permit fines and fees.

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 2014. Other reporting requirements associated with the permit included the submittal in November 2014 of a summary of instances of noncompliance and releases during FY14 and a waste minimization report for FY14 at the Laboratory. Annual training on accessing and using the electronic public reading room was conducted in October 2014, and a community relations plan was also revised annually as required and published on the Laboratory environmental web page after comments were solicited from the public and incorporated. Two reports associated with anticipated noncompliance with the permit and five notifications of characterization discrepancies were submitted to NMED-HWB in 2014. Supplemental addenda to the FY13 report on noncompliance with the permit associated with nitrate salt-bearing waste container characterization and processing were submitted in July and September.

iii. RCRA Compliance Inspections and Notices of Violation

From April 21, 2014, to April 24, 2014, NMED conducted a hazardous waste compliance inspection at the Laboratory. A notice of violation was received from NMED on March 10, 2015, alleging 17 violations that are pending resolution.

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 FY14, the Laboratory shipped approximately 709 m^3 of STP-covered mixed low-level waste (MLLW) and approximately 396 m^3 of covered mixed transuranic (MTRU) waste for treatment and disposal. All shipments of covered MTRU waste inventory to WIPP were suspended in May 2014 because of the WIPP shutdown. NMED has determined that the removal of MTRU waste from the STP will be deferred until more information becomes available and it is determined that the waste currently stored at the off-site facility will not be returned to the Laboratory. Note: MLLW data are reported here on an FY basis to coincide with regulatory reporting requirements.

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 2014 is presented in Chapter 3 of this report.

In 2014, the Laboratory submitted 11 deliverables (plans and reports) required by the Consent Order on time to NMED (see Tables 3-2 and 3-3 in Chapter 3 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 2014, scheduled investigation activities are complete at 8 aggregate areas, in progress at 19 aggregate areas, and pending at 2 aggregate areas.

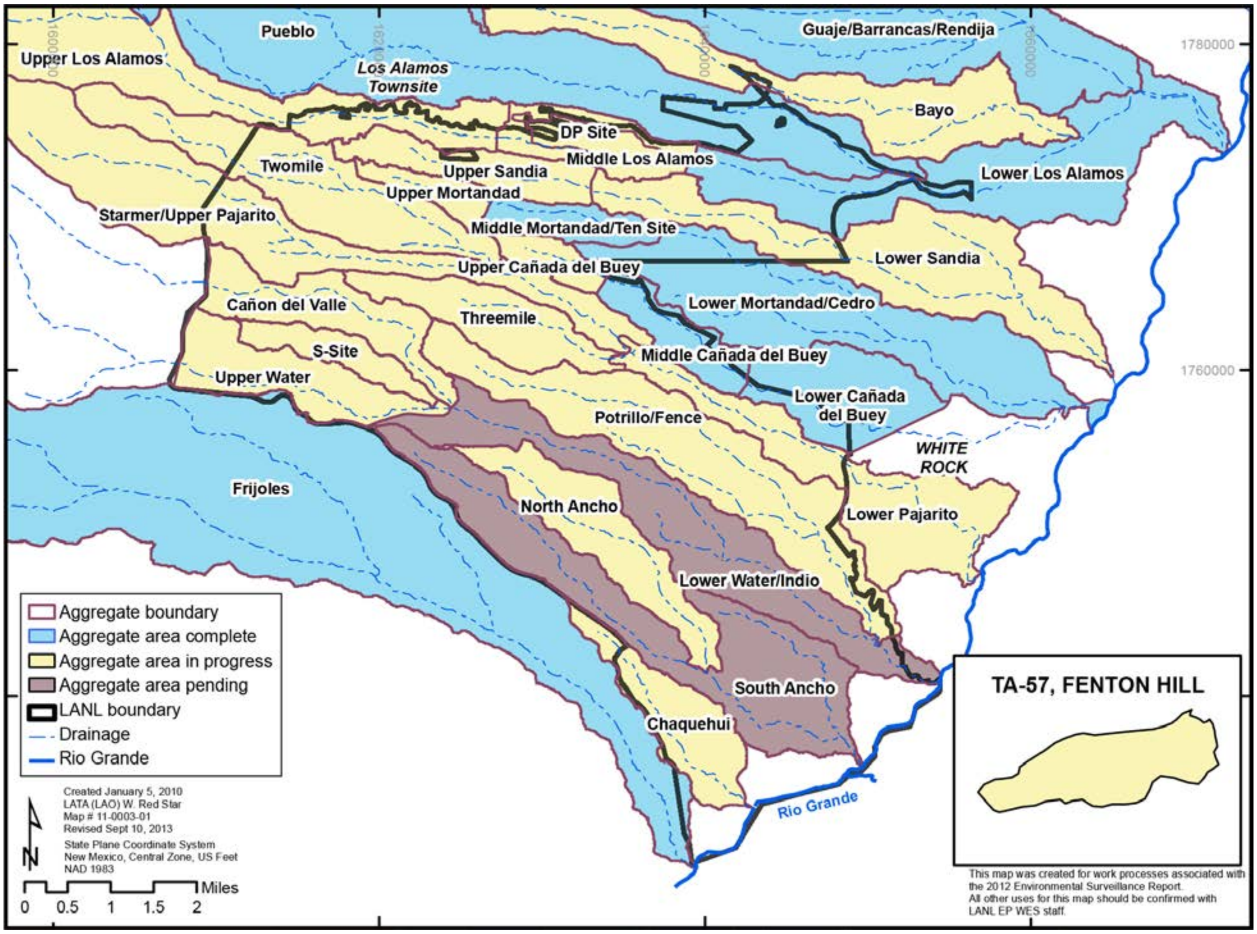

Figure 2-1 Aggregate areas as defined for the Consent Order and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending.

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 solid waste sent to the transfer station in 2014 totaled 479.2 m^3, or 388,654.8 kg.

vii. Reported RCRA Noncompliances

In November 2014, 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. Note: Noncompliance data are reported here on an FY basis to coincide with the Hazardous Waste Facility Permit reporting requirements. From October 1, 2013, through September 30, 2014, there were no releases of hazardous waste or hazardous waste constituents from, or at, a permitted unit. The report detailed 76 instances of noncompliance (nitrate salt-bearing waste containers were reported under separate cover) that were recorded during FY14. The majority of the occurrences of noncompliance were associated with physical permit conditions, such as aisle spacing, secondary containment requirements, tears in the fabric dome, cracks in the asphalt, 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 noncompliances resulted in actual or potential hazards to the environment and human health outside the facility, and no waste or residuals were lost or had to be recovered as a result of any of these incidents.

In July 2014, the permittees submitted an addendum to the facility's reporting on instances of noncompliance for FY12 and FY13 as a result of investigations associated with the February 14, 2014, WIPP incident. This addendum included noncompliance reporting for failing to recharacterize waste when a change was made to the waste stream and treatment occurred by absorption and neutralization. A second addendum was submitted in October 2014 that included more detail on noncompliance with characterization and transport requirements.

viii. Other RCRA Activities

The compliance technical assurance program performed Laboratory self-assessments to determine whether hazardous and mixed wastes are being properly managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. The program communicated findings from these self-assessments to waste generators, waste-management coordinators, and waste managers who help line managers implement appropriate actions to ensure continual improvement in LANL's hazardous waste program. In calendar year (CY) 2014, the Laboratory completed 969 self-assessments.

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 2009a). In both RODs, DOE/NNSA decided to implement the no action alternative with the addition of some elements of the expanded operations alternative analyzed in the SWEIS. The first Supplement Analysis (SA) to the 2008 SWEIS was issued by DOE in October 2009 (DOE 2009b). This SA was prepared to determine if the 2008 SWEIS adequately bounded the off-site transportation of low-specific-activity and low-level waste (LLW) 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 2011b).

The Laboratory reviews all proposed projects and verifies that they will be compliant with the existing SWEIS or other NEPA documents. Approximately 1015 proposed projects were reviewed for NEPA compliance in CY14. In some cases, further NEPA analysis is done, and NEPA documents are prepared. There were no LANL environmental assessments prepared in CY14.

An SA was prepared to support a determination by DOE/NNSA as to whether the analysis in the Environmental Assessment for Lease of Land for the Development of a Research Park at Los Alamos National Laboratory (DOE 1997) was sufficient to support a lease modification to remove the restriction on the use and storage of radioactive material specific to the Samitaur Medical Technologies (Samitaur) proposal, or whether additional NEPA documentation would be required. DOE/NNSA determined that there were no significant new circumstances or information relevant to environmental concerns that warrant preparation of a supplemental or new NEPA document based on the Samitaur proposal. Based on the analysis in this SA, the existing lease between DOE/NNSA and the Los Alamos Commerce Development Corporation could be modified as necessary to allow the Samitaur proposal to proceed at the Los Alamos Research Park (DOE 2014a).

The Laboratory prepared three NEPA reviews proposing the use of DOE categorical exclusions for LANL projects and activities. These NEPA reviews, each signed by the Los Alamos NEPA Compliance Officer during CY14, included the following: Well Pump Tests in Sandia and Mortandad Canyons – Phase II (DOE 2014b); Domestic Source Recovery FY 2015 (DOE 2014c); and Foreign Location Source Recovery FY 2015 (DOE 2014d). The NNSA Reading Room provides further information regarding approved Laboratory NEPA documents at http://nnsa.energy.gov/aboutus/ouroperations/generalcounsel/nepaoverview/nepa/lafo.

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 2014, the Laboratory shipped 39 containers of PCB waste (≥50 ppm) off-site for disposal or recycling. The total volume of PCB waste was 177.074 m^3. 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-authorized treatment or disposal facilities in Veolia, Colorado, and Clean Harbors, Utah. 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 2014, EPA did not perform a PCB site inspection. No TSCA reviews were conducted in 2014 for imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office.

LANL has been tracking the removal of PCB-contaminated equipment and components for more than 16 yr. Items such as transformers, capacitors, and other components using PCB-contaminated dielectric oil have been tracked from identification to removal from service and ultimately to disposal (Figure 2-2). In 2014, the last known PCB-

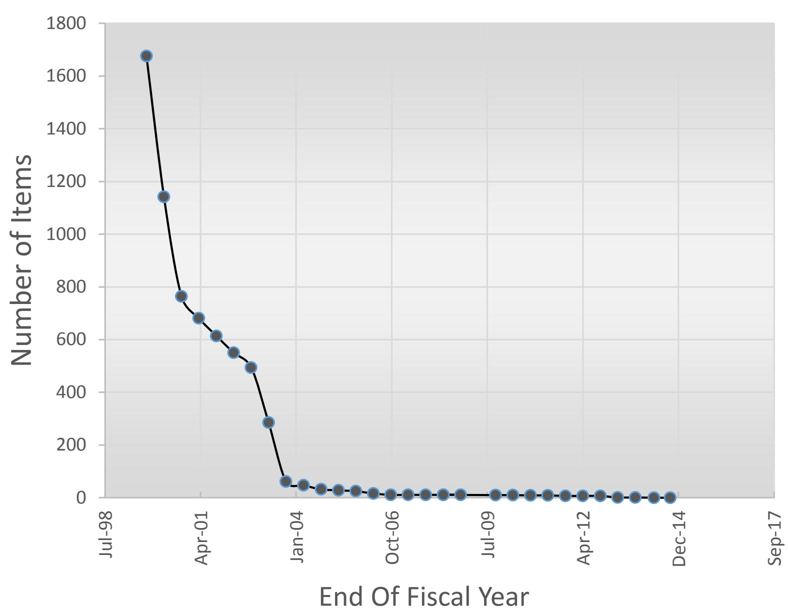

Figure 2-2 Number of PCB items in service at LANL

contaminated item, an RF Oscillator, was removed from service. The device is now one of seven that are being stored at LANL's Chemistry and Metallurgical Research Facility, pending final disposition.

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 2014.

Table 2-3 shows the amounts of pesticides and herbicides the Laboratory used in 2014.

Table 2-3
Herbicides and Pesticides Used at the Laboratory in 2014

Herbicide	Amount (gal.)
Ranger	4.7
Velossa	176.13
Telar	0.09
Insecticide	**Amount (lb)**
Maxforce Granular Insect Bait	0.1
P.I. Contact Insecticide	0.13
Summit B.T.I. Briquets	0.06
Suspend S.C.	0.008
Tempo Ultra WP	0.04
Tempo 20 WP	0.03
Wasp Freeze	0.15
Water Treatment Chemical	**Amount**
Garrett Callahan Formula 314 T	660 lb
Garratt-Callahan Formula 316	180 oz
Houghton Chemical Purobrom Tablets	7230 lb
Sump Buddies	45 oz

3. Radiation Protection

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

During 2014, the Laboratory continued to implement DOE Order 458.1. 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 8, Public 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 (see Chapter 7, Ecosystem Health).

The Laboratory was in compliance with DOE Order 458.1 during 2014. Public and biota dose assessments, ALARA assessments, and the clearance of real and personal property are presented in Chapter 8, Public Dose and Risk Assessment.

b. DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of radioactive wastes: 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 that also contains 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. The hazardous waste component of MLLW and MTRU wastes is also regulated under the New Mexico Hazardous Waste Act, RCRA, and the Laboratory's Hazardous Waste Facility Permit, which provides terms and conditions for the management and storage of these wastes, but does not allow for disposal of hazardous waste on-site. LANL reported no DOE Order 435.1 compliance violations in 2014.

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 RWMB is managed by separate facility operations directors (FODs) or facility/project submittals. Currently, the Los Alamos Field Office is reviewing four ADEP RWMB submittals, and the Waste Management Division will be submitting updates for the following submittals: TA-55 Chemistry and Metallurgy Research, Weapons Facilities Operations– (WFO-) High Explosives, WFO-Dual-Axis Radiographic Hydrodynamic Test Facility, Science and Technology Operations– (STO-) Facility Operations Director, and Utilities and Infrastructure–Facility Operations Director. The RWMB identifies the physical and administrative controls to ensure the protection of workers, the public, and the environment. The RWMB requires 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 at the Nevada National Security Site and at several commercial sites, including EnergySolutions located in Clive, Utah, and the Waste Control Specialists site in Andrews, Texas. Other commercial disposal facilities for LLW are used based on a DOE-approved (DOE Order 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-09-2012	LANL approval, March 2009
PA/CA	Performance Assessment and Composite Analysis for Los Alamos National Laboratory Technical Area 54, Area G, LA-UR-08-6764	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-11-1522, March 2011	Transmitted to Los Alamos Site Office in 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 2014, the Laboratory disposed of a total of 747,000 kg of LLW (Figure 2-3), including waste generated during routine operations and during campaigns, such as environmental restoration cleanups. During 2014, LLW generation significantly decreased in support of future closure at TA-54 in 2044, with projections based on plans that call for MDA G pit and shaft disposal operations to cease at the end of 2015. Approximately 114,000 kg of the total LLW was placed in TA-54, Area G, shafts in 2014. The Laboratory maintained compliance with all aspects of its RWMB during 2014.

The Laboratory has implemented 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.

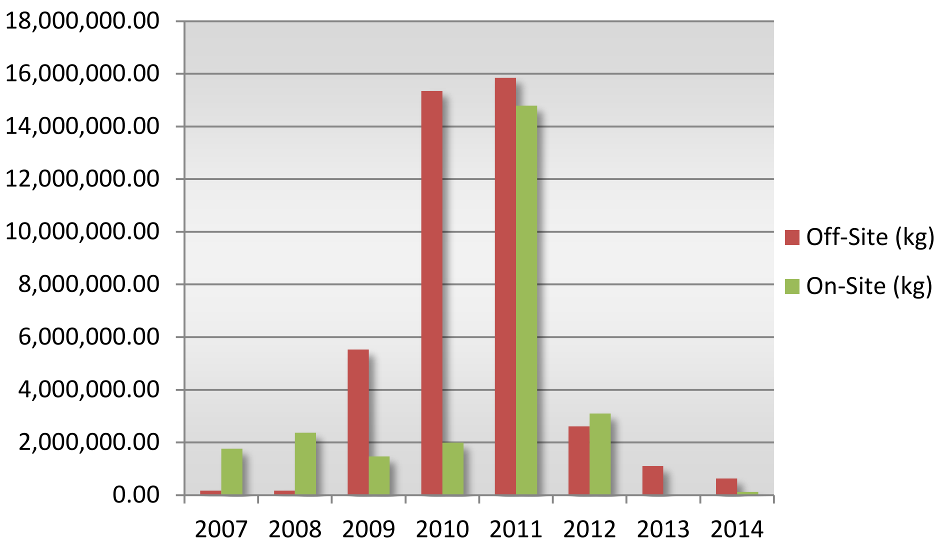

Figure 2-3 **Laboratory CY14 LLW disposition**

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 2-4 presents the cumulative inventory of TRU wastes that have been shipped from Los Alamos. Inventory is summarized by FY rather than CY to be consistent with other reports on TRU waste disposition that are typically reported by FY. 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 FY14, 598 m^3 of TRU waste (including MTRU waste) was shipped to WIPP, and 46 m^3 of TRU waste that was reclassified to MLLW waste was shipped off-site to commercial treatment and disposal facilities, for a total of 644 m^3 shipped during FY14.

Figure 2-4 **TRU waste shipping profile**

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.

An underground fire occurred at WIPP on February 6, 2014, and a release of radioactive contamination from WIPP occurred on February 14, 2014. All shipments to WIPP were curtailed after these events. Although some shipments for storage of LANL TRU waste at the Waste Control Specialists facility located in Andrews County, Texas, were completed during April 2014, all shipments of TRU waste from LANL were placed on hold after issues with LANL nitrate salt waste were identified. The radiological release at WIPP and the cause of the release are discussed in Chapter 1, Section D.8.b. Reported RCRA noncompliance occurrences with LANL remediation of nitrate salt waste containers are discussed in this chapter, Section B.2.b.vii.

When TRU waste shipments were placed on hold, a total of 3327.5 m^3 of the 3706 m^3 of non-cemented aboveground TRU stored at Area G as of October 1, 2011, had been removed. Also at this time, a total of 475 of the 478 containers of newly generated TRU waste received during FY12 and 537 of the 572 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. However, retrieval of belowground TRU waste has been placed on hold until sometime after LANL shipments of TRU waste to WIPP are resumed.

4. Air Quality and Protection

a. Clean Air Act

On December 9, 2014, a draft Title V Operating Permit was received from the NMED Air Quality Bureau. As of December 31, 2014, LANL continued to operate under the Title V Operating Permit P100-R1-M3.

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 and noting any permit deviations that may have occurred. In 2014, the Laboratory had one operating permit deviation; the deviation is associated with the requirement to continually monitor the asphalt plant baghouse differential pressure readings. The differential pressure data-logger communication system failed on two occasions because of power fluctuations. Corrective action was taken to install a backup strip chart recorder. No excess emissions occurred, and the data-logger communication system was scheduled for an upgrade by 2016 to increase system reliability.

No excess emissions occurred from any of the Laboratory-permitted sources, and the Laboratory met all required reporting deadlines during 2014.

The 2014 EPA Greenhouse Gas Emission Report was submitted on March 17, 2015. The report provided emissions of carbon dioxide (CO_2), methane, and nitrous oxide for CY14. The amount of these gases emitted during 2014 was approximately 46,900 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 2014, 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 2014 were still significantly lower than the permit limits; for example, NOx emissions were approximately 17% of the permit limit, CO emissions were 13%, and PM emissions were 3%. R&D activities accounted for most of the VOC and hazardous air pollutant (HAP) emissions. Table 2-5 summarizes these data.

Table 2-5
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2014

Emission Unit	Pollutants (tons)					
	NOx	SOx[a]	PM	CO	VOCs	HAPs
Asphalt plant	0.003	0.001	0.002	0.12	0.002	0.002
TA-03 power plant (3 boilers)	11.0	0.12	1.44	7.6	1.0	0.36
TA-03 power plant (combustion turbine)	0.99	0.07	0.13	0.21	0.04	0.03
R&D chemical use	n/a[b]	n/a	n/a	n/a	10.9	5.1
Degreaser	n/a	n/a	n/a	n/a	0.005	0.005
Data disintegrator	n/a	n/a	0.007	n/a	n/a	n/a
Stationary standby generators[c]	3.44	0.14	0.18	0.78	0.18	0.001
Miscellaneous small boilers[c]	21.83	0.14	1. 76	17.48	1.25	0.42
Permitted generators (7 units)	1.13	0.03	0.04	0.25	0.04	<0.001
Permitted Boilers	3.18	0.02	0.34	1.82	0.23	0.07
TOTAL	**41.6**	**0.52**	**3.9**	**28.3**	**13.65**	**6.0**
Title V Permit Limits	**245**	**150**	**120**	**225**	**200**	**24**

[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 2-5.

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 2-5 depicts a 5-yr history of criteria pollutant emissions. Emissions from 2010 through 2014 are very similar and remain relatively constant.

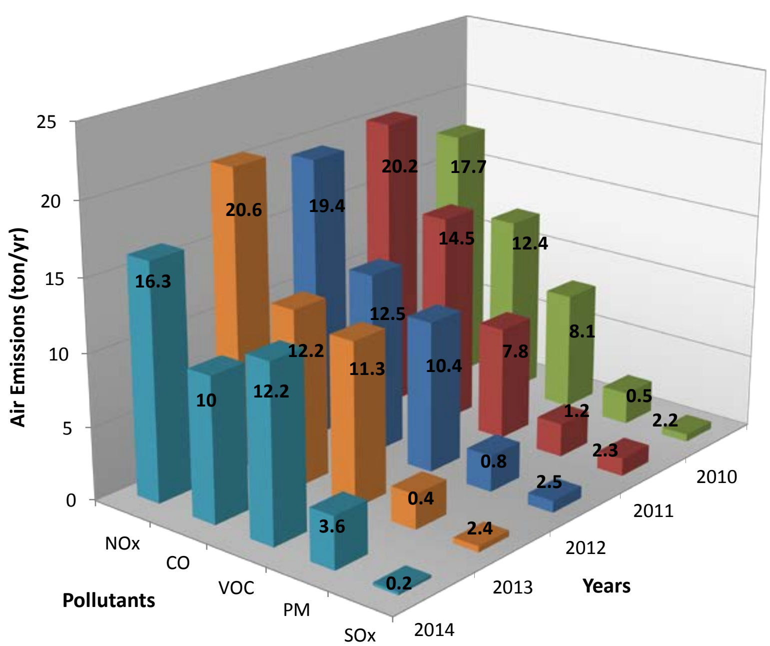

Figure 2-5 **Laboratory criteria pollutant emissions from 2010 through 2014 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.**

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. The Laboratory submitted two exemption notifications to NMED during 2014. The exemptions were for two small stand-by generators and nine small gas-fired comfort heaters. The Laboratory also submitted two No Permit Required (NPR) Determination requests to the NMED Air Quality Bureau in 2014. These NPR requests were for a spray evaporation unit to reduce water volume in existing evaporation ponds and for two soil vapor extraction units to remediate hydrocarbon vapor in soil around a legacy waste site. The NMED Air Quality Bureau approved both NPR decisions. During 2014, the Laboratory operated under the air permits listed in Table 2-1.

ii. Open Burning

The Laboratory may perform open burning under Section A1400, Regulated Sources – Open Burning, of the facility Title V Operating Permit and either 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 2014.

iii. Asbestos

The NESHAP standard 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 2014, 39 large renovation and demolition projects were completed. NMED was provided advance notice for 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 2014, the Laboratory removed approximately 1598 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 2014 air-pathway dose to the maximally exposed individual (MEI) was 0.24 mrem (see Chapter 8, Section B.4.b.i). Other MEI cases are regulated by DOE Order 458.1, which sets a dose limit of 100 mrem/yr (see also Chapter 8, Section B.4.b). For all these cases, the annual doses are less than 0.24 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 NPDES permit requirements 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 and Sanitary Outfall Program

LANS and DOE/NNSA are co-permittees under the NPDES permit covering Laboratory industrial and sanitary outfalls. EPA Region 6 issues and enforces CWA permits because the NMED has not been delegated authority to administer the CWA. However, NMED certifies the EPA-issued permits as being protective of waters of the state and performs some compliance evaluation inspections and monitoring on behalf of the EPA. The Laboratory has been quite successful in eliminating outfalls (discharges to the environment), and as of 2014, there are a total of 11 outfalls on the NPDES permit (Table 2-6). Most (9) of the remaining outfalls are conventional cooling tower and sanitary discharges; however, the Laboratory operates under one of the most stringent permits in the country. To help ensure continued full compliance with the requirements in the current permit, including permit limits that become effective October 1, 2017, and September 20, 2019, the Laboratory is assessing the need for additional treatment technologies. The Laboratory's NPDES Permit No. NM0028355 is available online at http://www.lanl.gov/community-environment/environmental-stewardship/protection/compliance/industrial-permit/index.php.

Table 2-6
Volume of Effluent Discharge from NPDES-Permitted Outfalls in 2014

Outfall No.	Building No.	Description	Watershed (Canyon)	2014 Discharge (gal.)
03A048	53-963/978	LANSCE[a] cooling tower	Los Alamos	15,298,800
051	50-1	TA-50 RLWTF	Mortandad	0
03A022[b]	3-2238	Sigma cooling tower	Mortandad	27,168
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	331,100
03A181	55-6	Plutonium facility cooling tower	Mortandad	1,662,352
13S	46-347	Sanitary wastewater treatment plant	Sandia	see outfall 001[c]
001	3-22	Power plant (includes treated effluent from outfall 13S)	Sandia	57,657,700
03A027	3-2327	Strategic Computing Complex (SCC) cooling tower	Sandia	9,885,700
03A113	53-293/952	LANSCE cooling tower	Sandia	410,710
03A199	3-1837	Laboratory Data Communications Center	Sandia	9,093,100
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2014 Total:	94,366,630

[a] LANSCE = Los Alamos Neutron Science Center.

[b] This outfall's designation was changed from 03A022 to 04A022 in the new permit to reflect only emergency cooling water and roof drain/storm water discharges to the outfall (cooling tower blowdown was diverted to the SWWS collection system).

[c] The discharge amount for Outfall 13S is included in the total for Outfall 001. Beginning October 1, 2014, compliance monitoring is required only if discharge to Cañada del Buey occurs. Discharge to Cañada del Buey did not occur in October, November, or December of 2014.

Outfalls listed on the current permit that did not discharge in CY14 include the following.

- *Outfall 05A055:* The High Explosives Wastewater Treatment Facility currently uses a thermal evaporator.
- *Outfall 051:* The RLWTF currently uses a mechanical 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 2014, none of the 57 samples collected from the SWWS plant's outfall exceeded effluent limits; however, 3 of the 1063 samples collected from industrial outfalls exceeded effluent limits.

The following is a summary of the corrective actions the Laboratory took during 2014 to address the NPDES outfall permit exceedances.

- *Outfall 03A022, May 2, 2014, total copper = 0.163 milligrams per liter (mg/L), permit limit = 0.028 mg/L:* The makeup water float valve that maintains the water level in the circulating water tank became stuck, causing an overflow into the outfall pipe without treatment.

  Corrective actions:

  1. The makeup water float valve was repaired approximately 3.5 hours after discovery of the malfunction.
  2. The makeup water float valve was replaced on July 7, 2014.
  3. The facility identified the source of copper in the circulating water tank as the original heat exchanger and submitted a request in July 2014 to replace the heat exchanger. The action is pending as of December 31, 2014.
  4. Water in the circulating water tank will be recharacterized to compare with the data from the STO Facility's previous characterization. The action is pending as of December 31, 2014.

- *Outfall 001, May 8, 2014, total PCBs = 0.00090 micrograms per liter (µg/L)*: Analysis of a second aliquot of the same sample showed total PCBs at 0.000616 µg/L, below the limit of 0.000640 µg/L. The analytical laboratory reviewed the data for both results and concluded that the quality controls and empirical data for both analyses were within limits and therefore, they could not recommend one result over the other.

  Corrective actions:

  1. Based on the congener method error precision (% error) in the analytical data, the algorithms used to calculate blending ratios from the Sanitary Effluent Reclamation Facility (SERF) to Outfall 001 were adjusted. The adjusted requirements for operating the modulating valve from SERF to Outfall 001 were distributed to the SERF operators via a standing order.

- *Outfall 03A022, August 13, 2014, total copper = 0.0443 mg/L, permit limit = 0.028 mg/L*: Source of discharge is unknown. The observed flow at the time of sample collection was approximately 1 gallon per minute (gpm) and decreased to approximately 0.05 gpm 15 min later. Normal facility walk-downs did not reveal the source or changes to any systems. Facility personnel suspect the source could be contributions from roof drains tied into the outfall pipe, or ground seepage through possible breaks in the clay outfall pipe.

  Corrective action:

  1. A camera was used to investigate the integrity of the interior of the clay outfall pipe. The camera revealed the pipe is broken in several places and roots have infiltrated the pipe, blocking the camera from further inspection. Facility personnel believe that storm water from the roof drains is retained by the roots and is slowly released to the outfall over a long period after a storm event. Facility personnel believe the inside of the clay pipe is contaminated with copper. The flow of approximately 0.07 gpm was sampled for copper

again on August 14, 2014, and September 3, 2014, with results of 0.007 mg/L and 0.008 mg/L, respectively (permit limits = 0.019 mg/L monthly average and 0.028 mg/L daily maximum).

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.

On March 24, 2014, the SWWS plant received NMED approval to operate a compost facility. SWWS sludge is combined with green waste to generate a compost soil amendment. The compost will be land-applied across the Laboratory for landscaping, post-construction remediation, and other beneficial uses.

During 2014, the SWWS plant generated approximately 25.2 dry tons (50,400 dry lb) of sewage sludge. The facility utilized 4.81 dry tons of sludge and 2.1 tons of green waste to generate 2.1 tons of compost in 2014. The remainder of 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 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 NPDES CGP is a "general" permit that applies to all eligible construction projects throughout the State of New Mexico.

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 begins and conducting site inspections once soil disturbance has occurred. An SWPPP describes the project activities, site conditions, best management practices (BMPs) (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.

During 2014, the Laboratory implemented and maintained 31 construction-site SWPPPs and SWPPP addendums and performed 527 storm water inspections at construction sites. Of the 527 site inspections performed, 514 inspections were compliant, for an overall compliance rate of 97.5%. The majority of noncompliant items were because of the subcontractors not meeting the corrective action time frames established in the CGP. Items included meeting site stabilization time requirements and implementing routine maintenance on BMPs. Corrective action items identified in 2014 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 notice of intent 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 pending publication of a new final 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). A final permit was subsequently published in June 2015 and will be reported in the 2015 annual site environmental report. The NPDES MSGP is a "general" permit that applies to all eligible construction projects throughout the State of New Mexico.

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 CY14.

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 CY14 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. 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 Outfall 54-G-4 and was mathematically certain to exceed COD at Outfalls 54-G-1 and 54-G-2. Prowattle™ was installed as a velocity dissipation and erosion control measure at these outfalls.

At the Material Recycling Facility (MRF) located within TA-60, the average concentration from the four most recent monitoring samples exceeded benchmark values for total suspended solids (TSS) and COD. As follow-up to the TSS and COD exceedances, the MRF pond was drained and sediment was removed. Angular rock was added in front of the pond to help prevent the migration of sediment into the pond and Terra Tubes® were placed at the mouth of the pond to act as a filter for COD. Per Part 6.2.1 of the 2008 MSGP, "The benchmark concentrations are not effluent limitations: a benchmark exceedance, therefore, is not a permit violation."

At the TA-60 Asphalt Batch Plant, TSS results exceeded the 30-day average effluent limitation guidelines identified in Part 8.D.4 of the 2008 MSGP. The results were 167 mg/L, 97.2 mg/L, and 45.2 mg/L from storm events on July 15, July 16, and July 19, 2014, respectively. The average of these three events was 103.13 mg/L. TSS also exceeded the daily maximum effluent limit for the monitoring sample collected on August 1, 2014. This sample was collected before analytical results were received for the prior effluent limitation guideline monitoring that exceeded the 30-day average. An exceedance report for numeric effluent limits was sent to EPA as required by Part 6.3.1 of the 2008 MSGP. Two rock check dams of angular rock were installed in the channel on the west end of the retention pond for sediment control. In addition, Terra Tubes® were installed at the east end of the pond to help filter sediment from storm water before it discharges.

The Laboratory has completed 6 yr of required storm water analytical monitoring in accordance with the 2008 MSGP and continues to fulfill all requirements under the administratively continued permit.

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

On February 13, 2009, EPA Region 6 issued NPDES IP No. NM0030759 to co-permittees LANS and DOE. Immediately following issuance of the IP by the EPA, the IP was appealed by a local citizen's group. Following permit modification negotiations in 2009, the EPA issued a new modified IP that became 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 two permit renewal application extension requests, and the existing permit conditions will be in effect until a new permit is issued.

The IP lists 405 permitted sites (SWMUs and AOCs) that must be managed in compliance with the terms and conditions of the IP 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. In some cases, these contaminants are present in soils within 3 ft of the ground surface and can be 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 non-numeric 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, additional corrective actions are required. In summary, the process of complying with the IP can be broken down into five categories: (1) installation and maintenance of control measures; (2) storm water confirmation sampling to determine effectiveness of control measures; (3) additional corrective action (if a TAL is exceeded); (4) reporting results of fieldwork and monitoring; and (5) certification of corrective action complete or requests for alternative compliance.

In 2014, the Laboratory completed the following tasks:

- Published the 2014 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 1367 control measure inspections on all 250 SMAs
- Completed 1453 sampling equipment inspections
- Conducted BMP maintenance at 164 SMAs
- Completed installation of additional controls at 69 SMAs
- Collected baseline confirmation monitoring samples at 17 SMAs
- Collected corrective action enhanced control confirmation samples at 15 SMAs

- Initiated enhanced control monitoring at 13 SMAs
- Initiated corrective action based on TAL exceedances at 17 SMAs
- Completed installation of enhanced control measures at 9 SMAs
- Completed corrective action at 5 sites with certification of no exposure
- Completed recovery activities from the September 13, 2013, flood event
- Submitted a permit renewal application for the IP
- Submitted an alternative compliance request for 1 site associated with 1 SMA
- Received alternative compliance approval for 2 sites associated with 1 SMA
- Held two public and four technical meetings
- Completed website updates and public notifications

A compliance evaluation inspection (CEI) of the LANL IP program was conducted by the NMED Surface Water Quality Bureau, on behalf of EPA, August 25 through August 28, 2014, and September 12, 2014. The Laboratory was evaluated on six subject areas:

Section A – Permit Verification

Section B – Record-keeping and Reporting

Section C – Operation and Maintenance

Section D – Self Monitoring

Section F – Laboratory

Section G – Effluent/Receiving Waters

Findings were rated from marginal to unsatisfactory. DOE and LANS submitted a response to EPA on February 25, 2015, clarifying corrective actions to be taken to address the findings. DOE and LANS have also worked with NMED staff to develop criteria and language for the new IP that would clarify and resolve many of the CEI findings.

For more information on the LANL IP for Storm Water, visit http://www.lanl.gov/community-environment/environmental-stewardship/protection/compliance/individual-permit-stormwater/index.php.

For more information on surface water quality at LANL, see Chapter 6, Watershed Quality.

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 2014, the Laboratory was in full compliance with EPA requirements, but NMED-PSTB compliance inspections of 12 AST systems resulted in the Laboratory receiving "Lists of Compliance Concerns" (LCCs) for 10 of the AST systems. The PSTB regulations require any repair work on ASTs to be completed by New Mexico certified tank installers. Three of the LCCs were corrected in 2014, and the Laboratory worked on obtaining contracts with certified tank installers to repair the remaining 7 AST systems.

Spill prevention, control, and countermeasure (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.

The Laboratory completed three modifications to existing and new SPCC plans, and implementation of those modifications is in process. In 2014, the Laboratory conducted approximately 25 annual inspections/assessments of facilities with SPCC plans.

The Laboratory continues to maintain and operate ASTs pursuant to 20.5 NMAC of the NMED-PSTB regulations. The Laboratory paid annual AST registration fees of $100 per AST to the NMED. The Laboratory has 13 tank systems (15 ASTs) that are operational pursuant to 20.5 NMAC. One tank system was placed into permanent closure status and two into temporary closure status pursuant to 20.5 NMAC.

vii. Dredge and Fill Permit Program

1. Section 404 of the CWA requires the Laboratory to obtain permits from USACE to perform work within perennial, intermittent, or ephemeral watercourses. The USACE generally issues three kinds of permits: standard individual permits, NWPs, and emergency regional permits. The NWPs, which are similar to a general permit, are the most commonly issued permits. The NWPs are applicable to projects across the state and cover a range of activities, including installation of storm water controls, bank stabilization, aquatic habitat restoration maintenance, and utility line activities (http://www.spa.usace.army.mil/Missions/RegulatoryProgramandPermits/NWP.aspx).

Section 401 of the CWA requires states to certify that Section 404 permits issued by USACE comply with state water quality 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 2014, Section 404/401 permits were issued for eight construction projects at the Laboratory:

- Sandia Canyon –TA-72 Firing Site Storm Water Controls (NWP No. 43, Stormwater Controls)
- E250 Stream Gage Weir Erosion Repair in Pajarito Canyon (NWP No. 3, Maintenance Activities)
- Mortandad Sediment Traps Erosion Control and Maintenance (NWP No. 43, Stormwater Controls)
- Pueblo Grade Control Spurs and E060.1 Gage Revitalization (NWP No. 43, Stormwater Controls)
- Pueblo Canyon Stabilization Project (NWP No. 27, Habitat Restoration)
- Upper Sandia Canyon Riparian Restoration (NWP No. 27, Habitat Restoration)
- TA-39 Point 6 Firing Site Stormwater Controls (NWP No. 43 Stormwater Controls)
- Potable Water Line Break (NWP No. 12, Utility Line Activities)

The following Section 404/401 permits were issued in 2012 and 2013 and remain open because of an annual monitoring requirement established in the permit authorization.

- Water Canyon storm drain reconstruction project (NWP No. 43, Stormwater Management Facilities)
- Sandia Canyon Wetland Grade Control Structure (NWP No. 38, Cleanup of Hazardous and Toxic Waste)

On July 22, 2014, the USACE conducted a compliance inspection of the Mortandad Sediment Traps project. No compliance issues were identified.

b. Safe Drinking Water Act

In 2014, the Laboratory conducted collaborative monitoring in water-supply wells owned by Los Alamos County to supplement analyses conducted by the county for compliance with the Safe Drinking Water

Act and New Mexico Drinking Water Regulations (20.7.10 NMAC). Monitoring results are presented in Chapter 5, and data can be found online at the Intellus New Mexico environmental database (http://www.intellusnmdata.com/). Monitoring conducted to date in operational water-supply wells shows no evidence of contamination from current or historical Laboratory operations. Los Alamos County publishes additional information on drinking water quality in Los Alamos County.

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 groundwater in New Mexico. NMED determines the applicability of the NMWQCC regulations and may require a facility to 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 2014, 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 2014, 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 the 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 2014, and the current permit has been administratively continued until the renewal permit is issued. NMED toured the TA-46 SWWS Plant, SERF, the SERF evaporation basins, and NPDES Outfalls 001 and 03A027 on July 23, 2014, but the visit was not considered a formal inspection by NMED.

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. During 2014, the Laboratory and NMED held nine negotiation sessions on draft discharge permit DP-1132. Citizen groups—Communities for Clean Water and Concerned Citizens for Nuclear Safety—participated in three of those nine sessions. Issuance of a final discharge permit was pending at the end of 2014.

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 2014, none of the quarterly groundwater samples exceeded NMWQCC groundwater standards. No samples were collected from alluvial well MCO-3 because the well was damaged beyond repair during a flood event in September 2013. No effluent samples were collected in 2014 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 2014 but toured the facility three times.

iv. Domestic Septic Tank/Leach Field 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/leach field systems discharge plan application. Accordingly, on June 25, 2010, the Laboratory submitted an updated discharge plan application for 15 septic tank/leach field systems. The discharge plan application was amended on January 17, 2012. Issuance of a final discharge permit was pending at the end of 2014. NMED did not conduct an inspection of the Laboratory's septic tank / leach field systems in 2014.

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 January 7, 2014, the Laboratory submitted an application amendment to broaden the scope of the original discharge plan. The broader-scoped 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 handling of produced groundwater that requires treatment prior to discharge. Issuance of a final discharge permit was pending at the end of 2014. NMED conducted an inspection of Chromium Project sites in Mortandad Canyon on September 17, 2014.

vi. Groundwater Monitoring Activities

The Laboratory performed groundwater compliance work in 2014 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and installation of monitoring wells. In 2014, the Laboratory completed installation of one new regional aquifer well and one new intermediate aquifer monitoring well, a pumping well for testing hydraulic control in the chromium plume area, and two regional aquifer piezometers. 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 2007) and the habitat management plan (LANL 2014a).

The Laboratory contains potential habitat for three federally endangered species (southwestern willow flycatcher, *Empidonax traillii extimus;* the Jemez Mountains salamander, *Plethodon neomexicanus;* and the New Mexico meadow jumping mouse, *Zapus hudsonius luteus)* and two federally threatened species (Mexican spotted owl, *Strix occidentalis lucida*, and the western population of the yellow-billed cuckoo, *Coccyzus americanus occidentalis).* The southwestern willow flycatcher, yellow-billed cuckoo, 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).

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 2014, the Laboratory reviewed 728 excavation permits, 168 project profiles in the permits and requirements identification process, and 12 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, though encounters of willow flycatchers of unknown subspecies do sometimes occur during spring and fall migration.

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)	T, NMS	High
Zapus hudsonius luteus	New Mexico Meadow Jumping Mouse	E, 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
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
Mentzelia springeri	Springer's Blazing Star	NMSOC, SOC, FSS	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.

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 2014, Laboratory biologists continued annual surveys in all major habitat types in each season (Hathcock and Keller 2012) and continued monitoring at two firing sites and an open-burn site (Hathcock 2014). In addition, biologists completed a fifth 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. In 2014, population numbers increased to levels near the top numbers in 2010. In 2014, a new population monitoring effort was begun in the Sandia Canyon wetland. Bird populations naturally fluctuate because of various environmental factors. According to Palmer Drought Severity Indices, May to August 2013 was the driest on record in the last 120 yr 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. In CY14 there was a decrease in the drought to a more near-normal level of precipitation.

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 2006) available online (http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-04-8964).

In FY14 (October 2013 through September 2014), the Laboratory conducted 21 projects that required some field verification of previous cultural surveys. Five new archaeological sites were identified in FY14. Five 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 LC&T Project. One land tract was conveyed or transferred in CY14 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 2014 where the artifacts from the excavation of 39 LC&T archaeological sites, along with collections from other earlier projects conducted at the Laboratory, are housed.

In support of its 2014 D&D program, Footprint Reduction Program, and operations consolidation, the Laboratory conducted archival documentation for four space-reuse/consolidation projects and continued work on two other projects as required under the provisions of the NHPA. Buildings included in these projects are located at TA-08, TA-14, TA-16, and TA-46. 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.

7. DOE Order 436.1, Departmental Sustainability

a. Introduction

The Laboratory's Environmental Management System (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 FY14. These were to (1) clean up the past, (2) control the present, and (3) 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 each year at the Laboratory yield millions of dollars in cost avoidances and allow hundreds of hours of labor to be spent more productively. The following LANL P2 projects won recognition from NNSA in their 2014 national sustainability competition.

- Green Buildings: High Performance Sustainable Building Integrated Commissioning Team (Best-in-Class award)
- Change Agent: Jean Dewart (Environmental Stewardship award)
- Exceptional Service/Sustainability Champion: Dr. John S. Isaacson – A Sustainability Champion (Environmental Stewardship award)
- Greenhouse Gas Scope 1 and 2: Eliminating Sulfur Hexafluoride in X-Ray Pulsers (Environmental Stewardship award)

The Laboratory tracks its recycling percentages for C&D waste and non-C&D sanitary wastes. The recycling percentages at the Laboratory for CY14 are shown in Table 2-8.

Table 2-8
CY14 Recycling Percentages

LANL Recycling Category	Performance
C&D wastes	93%
Non-C&D wastes	56%

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 meeting DOE's sustainability goals. Performance goals have been established for the Laboratory in these directives, including reductions in energy intensity, potable and industrial water use, GHG emissions, and waste generation. The Laboratory is dependent on the success of a number of projects, including the energy savings performance contract, the SERF expansion, high-performance sustainable building (HPSB) implementation, communication and outreach in conjunction with metering efforts, building automation system night setback scheduling, and the associated footprint reduction efforts to achieve 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 FY15 SSP (LANL 2014b), 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 FY14	Planned Actions and Contribution
28% Scopes 1 and 2 GHG reduction by FY20 from an FY08 baseline	LANL plans to meet this goal. LANL achieved a 19% reduction in Scopes 1 and 2 GHG emissions compared with the FY08 baseline because of the decrease in electricity use on-site and purchase of renewable energy credits.	LANL will 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 maintain the 28% reduction.
13% Scope 3 GHG reduction by FY20 from an FY08 baseline (FY14 target: 19%)	LANL plans to meet this goal. LANL achieved a 25% reduction in Scope 3 GHG emissions because of decreased air and ground travel and employee commuting.	LANL recognizes that the most practical way to reduce Scope 3 GHG emissions is by continuing to reduce commuting. LANL is piloting options for reducing commuting, e.g., revising telecommuting policies and reviewing tax incentives for carpooling.
30% energy intensity (British thermal units per gross square foot) reduction by FY15 from an FY03 baseline (FY14 target: 27%)	LANL did not meet this goal. In FY14, LANL calculated and tracked a rolling 12-mo energy intensity based on a FY03 baseline. A year-end net energy intensity reduction of 16% was reported.	In FY15, LANL 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 FY20, LANL anticipates achieving a cumulative energy intensity reduction of 25%–30% compared with the FY03 baseline.
Energy Independence and Security Act of 2007 (EISA), Section 432, energy and water evaluations	LANL met this goal. LANL completed the EISA "covered" facilities energy and water assessments identified in the 4-yr assessment schedule for FY14.	LANL 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.
Individual building metering for 90% of electricity (by October 1, 2012) and for 90% of steam, natural gas, and chilled water (by October 1, 2015) (2014 target: 90% and 75%, respectively)	LANL met this goal. LANL evaluates the installation of meters using a simple return on investment calculation based on 2% energy savings. LANL completed an upgrade to a new metering software server and migrated all the metering data to capture energy use in a new dashboard system.	LANL will re-evaluate required meter installations when the Federal Energy Management Program issues new metering guidance.
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.	LANL met this goal. All new roofs meet cool-roof requirements per engineering standards. In FY14, there was 36,000 square feet of cool roofing installed.	LANL plans the replacement of approx. 66,000 square feet of roofing for 2015. 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 compliant with the guiding principles (GPs) of HPSB by FY15 (FY14 target: 13%)	LANL did not meet this goal. LANL has an average 65% GP implementation rate within the selected 31 HPSBs. LANL is reporting 2% of the facilities over 5000 gross square feet are compliant with the GPs. In FY14, LANL completed recommissioning activities in 8 HPSBs.	LANL plans to continue implementing the GPs within selected HPSBs focusing on heating, ventilation, and air conditioning and building automation systems recommissioning. LANL is investing approximately $1.3M in HPSBs in FY15 as part of the overall funding to reduce energy use in facilities. The risk of nonattainment is high because LANL will focus on high return on investment energy reduction in order to also make progress in energy intensity reduction.

Table 2-9 (continued)

DOE/NNSA Goal	Performance Status through FY14	Planned Actions and Contribution
All new construction, major renovations, and alterations of buildings greater than 5000 gross square feet must comply with the GPs.	LANL met this goal. DOE provided on-site Leadership in Energy and Environmental Design (LEED) training to over 20 LANL employees, including the TRU Waste Facility project management team. The TRU Waste Facility design projects a LEED platinum facility.	Over 600,000 square feet of major new projects currently in the planning stages are being formulated to be certified as LEED Gold projects. LANL will continue to implement and manage efforts to address the requirement for achieving LEED Gold 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 (FY14 target: 136% cumulative since 2005)	LANL met this goal. In FY14, alternative fuel consumption was 86,754 gal., which is an 876% increase compared with the FY05 baseline.	LANL will continue to purchase and increase utilization of alternative fuel for vehicles using E-85 and B-5 in FY15.
2% annual reduction in fleet petroleum consumption by FY20 relative to an FY05 baseline (FY14 target: 18% cumulative since 2005)	LANL met the cumulative target for this goal. LANL decreased its fleet petroleum use in FY14 by 0.05% compared with FY13 usage and reduced fleet petroleum use by 21% compared with a FY05 baseline.	LANL 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 (for metropolitan statistical areas) (FY00–FY15 target: 75%)	Los Alamos is not located in a metropolitan statistical area. LANL's total fleet consists of 1546 vehicles, of which 772, or 49%, of those are considered LDVs. Of the 772 LDVs, 549, or 71%, are AFVs.	LANL will continue to replace vehicles with AFVs as economically practicable.
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 FY14'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 (FY14 target: 14%)	LANL did not meet the interim target reduction goal. In FY14, LANL's water use reduction was dependent on SERF operations and industrial water reuse at the Strategic Computing Complex (SCC). LANL's total water use in FY14 was approximately 307 million gallons, 80 million gallons less than last year. Water intensity has decreased by approximately 3% compared with the FY07 baseline.	In FY15, SERF operations will avoid consumption of potable water in SCC operations. LANL's sustainability efforts will focus on small, targeted water conservation measures that dovetail with site infrastructure upgrades and also emphasize energy efficiency to reduce LANL's regional impact on water use associated with energy generation. In FY15, LANL plans to maintain water consumption at or below FY14 levels.
20% water consumption (gal.) reduction of industrial, landscaping, and agricultural (ILA) water by FY20 from an FY10 baseline (FY14 target: 8%)	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 on total potable water intensity reduction as described above.
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, by FY15	LANL met this goal. In FY14, LANL diverted 54% of solid, nonhazardous waste.	LANL will continue to identify and implement opportunities for improvement in nonhazardous solid waste recycling/diversion in FY15.

Table 2-9 (continued)

DOE/NNSA Goal	Performance Status through FY14	Planned Actions and Contribution
Divert at least 50% of construction and demolition materials and debris by FY15	LANL met this goal. In FY14, LANL recycled or diverted 93% of construction and demolition waste.	LANL will continue diverting construction and demolition waste in FY15.
Procurements meet requirements by including necessary provisions and clauses in 95% of applicable contracts	In FY14, LANL ensured that the sustainable acquisition clause language was included in its food services contract extension. This contract extension will cover the next 1 to 2 yr as LANL prepares to issue a new request for proposal at that time.	In FY15, LANL will continue to 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. (FY14 target: 90%)	LANL did not meet this goal. LANL has identified 3 "core" data centers: the SCC, the Laboratory Data Communications Center (LDCC), and the Central Computing Facility (CCF). All three facilities have electric meters that feed information to LANL's main metering database. The SCC and LDCC have advanced PUE monitoring systems.	Energy use in the SCC and the LDCC is equivalent to about 87% of the energy used in data centers on-site. The CCF PUE is calculated. Energy use in the CCF is equivalent to about 8% of the energy used in data centers. No action is planned in FY15 pending upgrades in the CCF that may include a PUE monitoring system.
Maximum annual weighted average PUE of 1.4 by FY15 (FY14 target: 1.5)	LANL did not meet this goal. The PUE at the SCC is currently averaging 1.56, and the PUE at the LDCC is averaging at 1.57. The CCF estimated PUE is 1.47. The FY14 annual weighted average PUE for all three major data centers is 1.55.	LANL is planning to upgrade the SCC with Trinity beginning in 2016. The planned PUE for Trinity will be approximately 1.2. With this upgrade, LANL will meet the PUE goal of 1.4 but most likely not until FY16 after Trinity comes online.
Power Management: 100% of eligible personal computers, laptops, and management actively implemented and in use by FY12	LANL met this goal. In FY14, LANL continued to implement power management of Windows desktops and laptops.	In FY15, LANL will continue use of the power management of Windows desktops and laptops on eligible systems.
20% of annual electricity consumption from renewable sources by FY20 and thereafter (FY14 target: 7.5%)	LANL exceeded the 7.5% renewable energy goal in FY14. The Laboratory used approximately 386,000 megawatt hours (MWh) of electricity in FY14, including on-site renewable generation. The purchased renewable energy credit amount (27,000 MWh), in addition to on-site renewable energy, amounts to 12% of the annual electricity consumption.	LANL will continue to purchase renewable energy credits and utilize the on-site renewable sources, such as the Abiquiu dam low-flow turbine, to meet this goal. In addition, LANL is requesting an update to the 2008 renewable energy feasibility study through the Federal Energy Management Program to explore additional renewable investments.

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 2014.

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 2014.

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 41 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2014.

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 2014, 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 2014. There are no compliance violations associated with the reported releases.

Table 2-10
Summary of 2014
Reported Releases under EPCRA Section 313

Reported Release	Lead (lb)
Air emissions	2.88
Water discharges	0.23
On-site land disposal	1503.8
Off-site waste transfers	18,172

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 100 project profiles for potential impacts to watercourses, floodplains, or wetlands. Two floodplain/wetland assessments were prepared in 2014 for proposed work in lower Pueblo Canyon for wetlands and floodplain restoration and stabilization and a new parking area for the ice rink in Los Alamos Canyon. No violations of the DOE floodplain/wetland environmental review requirements were recorded in 2014.

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 2014 are listed in Table 2-11. The order defines 10 groups of occurrences; environmental occurrences are group 5. Environmental occurrences are divided into 2 subgroups: subgroup A, releases, and subgroup B, ecological and cultural resources. There are 4 significance categories within subgroup A and 2 significance categories within subgroup B. All of the 6 environmental occurrences at the Laboratory in 2014 were subgroup A, 5 of these were significance category 2, and 1 occurrence was significance category 3. The applicable categories are described below.

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
CY14 Laboratory Environmental Occurrences

Criterion	Report Title	Action(s)
5A(2)	Fire Suppression Water Discharged to the Environment	Immediate Actions: 1. Maintenance and Site Services–Fire Protection personnel secured the water release. 2. Notifications made to Environmental Protection Division–Environmental Compliance Programs Group (ENV-CP) personnel. 3. ENV-CP verbally notified NMED and EPA of the release and will follow-up with a 7- and 15-day written report. Corrective Action: 1. Reset valve on fire-suppression system. NMED Surface Water Quality Bureau administratively closed the release on 1/6/15.
5A(3)	Mineral Oil Spill from Legacy Equipment Results in an Environmental Release	Immediate Actions: 1. The aluminum box was placed back into its original upright position and appropriate notifications were made. 2. Emergency Management and Response and the Hazardous Materials (HAZMAT) Team responded to assess and clean up the oil spill. 3. The HAZMAT Team placed absorbent pads on the ground and asphalt to mitigate some of the oil released. 4. The STO TA-35 operations management will develop a path forward to resume mitigation activities. 5. LANL environmental personnel were notified and an assessment of the area conducted. Verbal notification of the release was made to NMED and EPA and LANL submitted the required 7- and 15-day written reports. 6. Nuclear Engineering and Nonproliferation Division–Safeguards Science and Technology Group personnel fabricated a cap to cover the end of the pipe to prevent water from entering into the aluminum box. Corrective Action: 1. Impacted soil was removed for proper disposal. Sampling confirmed that remaining soil met appropriate NM soil screening levels. NMED Ground Water Quality Bureau (GWQB) administratively closed the release on 6/24/15.

Table 2-11 (continued)

Criterion	Report Title	Action(s)
5A(2)	Untreated Water Release	Immediate Actions: 1. Earth and Environmental Sciences Division personnel unplugged the sump pump, assessed the extent of the water release, estimated the number of gallons released, and returned residual water back into the poly tank. 2. Notifications were made to LANL ENV-CP personnel. 3. LANL ENV-CP personnel verbally notified NMED and EPA of the release and submitted the required 7- and 15-day written reports. Corrective Action: 1. General fieldwork integrated work documents were modified to address issues that led to the release. NMED-GWQB administratively closed the release on 6/23/15.
5A(2)	NPDES Permit Exceedance at Outfall 001	Immediate Actions: 1. LANL environmental personnel notified NMED and EPA. The required 5-day written report was submitted to EPA and NMED on 7/31/14. 2. LANL environmental personnel will further review the differences in the sampling results. See Section 5.a.i. above.
5A(2)	NPDES Permit Limit for Copper Exceeded at Outfall	Immediate Actions: 1. At 1500 on 5/2/14, maintenance personnel adjusted the makeup water float valve and the discharge stopped. 2. At 1633 and 1637, respectively, on 5/16/14, environmental personnel verbally notified EPA Region 6 and NMED of the maximum daily permit limit exceedance for total copper at Outfall 03A022 pursuant to the Laboratory's NPDES permit requirements. On 5/21/14, the 5-day written report was submitted.
5A(2)	NPDES Permit Limit for Total Copper Exceeded at Outfall	Immediate Actions: 1. At 1558 and 1559, respectively, on 9/15/14, environmental personnel notified EPA Region 6 by email and NMED verbally of the maximum daily permit limit exceedance for total copper at Outfall 03A022 pursuant to the Laboratory's NPDES permit requirements. The required 5-day written report was submitted to EPA and NMED on 9/18/14. 2. Monitoring of Outfall 030A22 will continue with compliance samples being collected as required in the permit. The low-rate discharge (~0.05 ppm) continues at the outfall. Total copper samples were collected 8/14/14 and 9/3/14 with results of 0.00704 mg/L (7.04 µg/L) and 0.00813 mg/L (8.13 µg/L), respectively. Corrective Action: 1. At 1558 and 1559, respectively, on 9/15/14, environmental personnel notified EPA Region 6 by email and NMED verbally of the maximum daily permit limit exceedance for total copper at Outfall 03A022 pursuant to the Laboratory's NPDES permit requirements. The required 5-day written report was submitted to EPA and NMED on 9/18/14. See Section 5.a.i. above.

D. UNPLANNED RELEASES

1. Air Releases

The Laboratory identified two new air-release sources in 2014, both located at the LANSCE facility. One source was a vacuum pump discharge line that failed, discharging a very low amount of air with radionuclides to the environment. The second was a diffuse radionuclide gas source at the Isotope Production Facility. Both will be described in the EPA Rad-NESHAP report. Neither source resulted in an air compliance issue for the Laboratory. As described above, the annual air pathway dose from LANL operations in 2014 was only 0.24 mrem, well below the EPA limit of 10 mrem/yr.

2. Water Releases

No unplanned releases of radioactive liquids occurred on Laboratory land in 2014. There were 20 unplanned (unpermitted) releases of nonradioactive liquids in 2014 that were reported to NMED pursuant to 20.6.2.1203 NMAC (Table 2-12).

Table 2-12
2014 Unplanned Nonradioactive Releases

Material Released	Instances	Approximate Total Release (gal.)
Potable water	9	508,680
Storm water	3	900
Steam condensate	1	10,000
Mineral oil	1	150
Deionized water	1	500
Ethyl acetate and water mixture	1	56
40% ferric chloride solution	1	30
Fire suppression water	1	100
Groundwater	1	75
Heat transfer fluid	1	1

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 2014, the Laboratory was in the process of administratively closing all past release reports for the reportable releases with the NMED's DOE Oversight Bureau. The Laboratory anticipates that these release reports will be closed out after final inspections. Potable water discharge volumes were calculated from the discharge rate for the known duration of the release for instances where an accurate release duration could not be determined.

Volume estimates for two of the storm water incidents could not be determined and flow calculations for the known durations of the releases were provided to NMED.

E. REFERENCES

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DOE 2014d: "Categorical Exclusion for Foreign Location Source Recovery for FY 15," LAN-14-20, Accession Number 19844, Los Alamos, NM (December 2, 2014).

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3.0 ENVIRONMENTAL RESTORATION

To Read About | **Turn to Page**

The Environmental Programs (EP) Directorate investigates sites to determine the nature and extent of the chemicals and radionuclides released into the environment from past operations and to assess the potential human health and ecological risks/doses of the released chemicals and radionuclides. Samples of environmental media are collected, and the analysis of the data is the basis for corrective action decisions at each site. If appropriate, remediation or other corrective measures are implemented to remove or mitigate the presence and/or migration of the chemicals and radionuclides. The accomplishments for the EP Directorate in 2014 include the following:

- The annual monitoring plan for Los Alamos and Pueblo Canyons as well as work plans for soil vapor extraction of volatile organic compounds (VOCs) at Material Disposal Area (MDA) L, sampling for VOCs at MDA B, and soil/tuff sampling of a building footprint at Technical Area 21 (TA-21) were developed.
- Sediment and storm-water monitoring in the canyons was conducted, and the data generally indicate sediment transport is substantially reduced down the canyon, and concentrations of most chemicals of potential concern released from Los Alamos National Laboratory sites decrease downstream from the sources.
- One area of concern (AOC) at TA-01 and two AOCs at TA-57 were evaluated for nature and extent and assessed for potential risk/dose. One of the AOCs at TA-57 was remediated. The three AOCs were recommended for corrective action complete.
- Twenty-seven solid waste management units and AOCs at TA-21 were evaluated for nature and extent and assessed for potential risk/dose. All of these sites were recommended for corrective action complete.
- No VOCs were detected in the soil at MDA B.
- The 2014 VOC and tritium pore-gas monitoring results at MDA C are consistent with previous years' monitoring data. The results indicate there have been no new releases from the disposal units and that contaminants have not migrated downward to impact groundwater.

A. INTRODUCTION

The Environmental Programs (EP) Directorate at 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 (Table 3-1). Additional details on risk and dose to human and ecological receptors are provided in Chapters 7 and 8 of this report. Long-term stewardship activities, including surveillance and monitoring, are implemented when necessary to ensure that there are no changes in potential risk/dose and concentrations.

Table 3-1
Summary of Risk/Dose Assessment Scenarios and Target Levels

Constituent	Scenarios	Soil Screening Basis	Target Levels	Source
Radionuclides	Industrial, construction worker, recreational, residential	Dose	25 mrem/yr	DOE[a] Order 458.1; LANL 2012a
	Ecological	Dose	0.1 rad/d	DOE 2002; LANL 2012b
Chemicals	Industrial, construction worker, recreational, residential	Risk	1×10^{-5} [b] (total excess cancer risk); Hazard Index[c] = 1 (noncancer risk)	NMED 2012; LANL 2012c
	Ecological	Risk	Hazard Index = 1	LANL 2012; NMED 2012b

[a] DOE = U.S. Department of Energy

[b] Corresponds to a 1 in 100,000 chance of developing cancer.

[c] Hazard index is the sum of the hazard quotients, which is the ratio of the soil concentration to the respective screening level.

The EP Directorate's Corrective Actions Program (changed to Environmental Remediation Program in 2015) 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, Technical Area 21 (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.

B. CORRECTIVE ACTIONS PROGRAM

The Corrective Actions Program develops monitoring plans and work plans detailing the monitoring or investigation activities designed to assess site conditions and environmental media and to characterize sites, aggregate areas, and/or canyons. The data are submitted in a report that presents and analyzes the sampling results and recommends additional sampling, remediation, monitoring, or no further action, as appropriate. Table 3-2 summarizes the plans submitted in 2014. The table also provides general information and details regarding the activities to be conducted under these plans when implemented. Table 3-3 presents the reports submitted in 2014 as well as the status of the reports/sites through 2014. 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 the New Mexico Environment Department (NMED). These include periodic monitoring reports, drilling work plans, and well completion reports as well as the annual update to the IFGMP (LANL 2014a).

In 2014, the annual monitoring plan was written for the Los Alamos/Pueblo Canyons system as well as work plans for soil-vapor extraction of volatile organic compounds (VOCs) at MDA L, VOC sampling at MDA B, and sampling of a building footprint at TA-21 (Table 3-2). Reports were written or revised in 2014 for two canyon systems, one aggregate area (27 SWMUs/AOCs), one AOC, and one MDA (Table 3-3). In addition, TA-57 was investigated and SWMU 61-007 was remediated. Table 3-4 presents a summary of the sites, aggregate areas, and canyons investigated and/or reported in 2014. Figure 3-1 shows the sites where environmental characterization, monitoring, and remediation work was conducted in 2014. The results of the 2014 vapor monitoring activities at MDA C are also summarized.

Table 3-2
Summary of Corrective Actions Program Plans Submitted to NMED in 2014

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
Interim Measures Work Plan for Soil Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54 (LANL 2014c)	5/30/2014	See below.	54	See below.	See below.	See below.
Interim Measures Work Plan for Soil Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54, Revision 1 (LANL 2014d)	9/15/2014	n/a*	54	The soil vapor extraction (SVE) interim measure has the following objectives: • Remove VOC mass from the subsurface • Reduce maximum VOC concentrations • Contain the vapor plume within the Bandelier Tuff units For the interim measure, the SVE unit(s) will initially be run continuously for 6 mo. After 6 mo, data will be used to determine whether SVE should be cycled off for a period to allow for plume rebound. The interim measure will run for an initial 1-yr extraction period and evaluated annually before a decision is made about continuing the interim measure.	Baseline sampling will be performed at all the vapor-sampling ports (188 ports in 28 monitoring wells) available for VOC monitoring at MDA L at the beginning and end of a year of SVE operation.	The extraction gas and the vapor concentrations will be monitored at ports near the 2 extraction wells. Sampling ports within the 150-ft radius of influence (87 ports in 14 monitoring wells) of the 2 extraction wells will be monitored quarterly during the first year of the interim measure. Data will be used to guide decision points concerning SVE rates, SVE cycling, and extension of the interim measure beyond 1 yr.
2014 Monitoring Plan for Los Alamos and Pueblo Canyons Sediment Transport Mitigation Project, Revision 1 (LANL 2014b)	6/30/2014	n/a	n/a	Monitoring of storm water and geomorphic changes associated with the mitigation measures conducted to minimize storm-water contaminant transport	Storm-water monitoring will be 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 to be collected will be dependent on a number of factors, including the frequency of precipitation and runoff events.
Drilling Work Plan for Material Disposal Area B Volatile Organic Compound Sampling (LANL 2014e)	8/15/2014	9/16/2014	21	Sampling and analysis appropriate for demonstrating that VOCs are below residential soil screening levels	1 (MDA B)	22 boreholes will be drilled to collect an undisturbed sample for VOC analysis from each borehole at depths between 6 and 12 in. below the clean fill/tuff (Qbt 3) interface of the former excavated trenches.

Table 3-2 (continued)

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
DP Site Aggregate Area Building 21-257 Footprint Letter Work Plan (LANL 2014f)	9/30/2014	Pending	21	The building 21-257 footprint [SWMU 21-011(a)] and associated AOCs 21-001, C-21-005, and C-21-007 within MDA T at TA-21 are addressed. The work plan includes investigation sampling and any necessary soil removal after the concrete slab (the footprint), subsurface structures, and floor drain/outfall lines are removed. Sampling and excavations will be coordinated with demolition activities.	4	Samples will be collected at a minimum of 52 locations and from 3 depths at each location (total of 156 samples). Sampling locations may be adjusted and/or added based on field-screening results and visual inspection performed during demolition activities.

* n/a = Not applicable.

Table 3-3
Corrective Actions Program Reports Submitted to NMED in 2014

Document	Date Submitted	Date Approved	Status
Investigation Report for Area of Concern 01-007(k) in the Upper Los Alamos Canyon Aggregate Area	3/31/2014	n/a[a]	Revised
Investigation Report for Area of Concern 01-007(k) in the Upper Los Alamos Canyon Aggregate Area, Revision 1	11/25/2014	1/5/2015	Investigation complete
Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99	4/30/2014	7/17/2014	CME/CMI activities continue
Storm Water Performance Monitoring in the Los Alamos/Pueblo Canyons Watershed during 2013	6/30/2014	—[b]	Monitoring will continue
Results of 2013 Sediment Monitoring in the Water Canyon and Cañon de Valle Watersheds	6/30/2014	2/18/2015	Monitoring will continue
Letter Report for the Results of Analytical Sampling for Volatile Organic Compounds at Material Disposal Area B	10/24/2014	2/3/2015	Investigation complete
Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99	10/24/2014	—	CME/CMI activities continue
Phase III Investigation Report for DP Site Aggregate Area	12/19/2014	—	Pending NMED review

[a] n/a = Not applicable.

[b] — = Not yet approved.

Table 3-4
Summary of Site, Aggregate Area, and Canyon Investigations Conducted and/or Reported in 2014 under the Corrective Actions Program

Document/ Activity	TA	Number of Sites Investigated	Number of Samples Collected	Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined
Storm Water Performance Monitoring in the Los Alamos/ Pueblo Canyons Watershed during 2013 (LANL 2014g)	n/a[a]	Monitoring is conducted at 13 gage stations located throughout the watershed.	45 sampling events (a sampling event is defined as the collection of one or more samples from a specific gage station during a specific runoff event) resulting in approximately 800 samples collected; storm-water samples also collected above and below the detention basins below the SWMU 01-001(f) drainage	n/a	n/a
Conclusions/Recommendations: Mitigation structures and features are performing as designed in reducing sediment and contaminant transport. Net sediment deposition occurred in most surveyed areas in Los Alamos and DP Canyons experiencing monsoonal flood events in 2013. Pueblo Canyon experienced net erosion, but the grade-control structure and wetlands were effective in decreasing effects of the September 13, 2013, flood. Analytical data collected from storm-water samples indicate that for the 8 analytes exceeding New Mexico water-quality standards, only total polychlorinated biphenyls (PCBs) have 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 and associated sediment retention basins in Los Alamos Canyon were effective at substantially reducing transport of PCBs.					
Results of 2013 Sediment Monitoring in the Water Canyon and Cañon de Valle Watershed (LANL 2014h)	n/a	10 reaches and 3 gage stations	23 sediment samples, 7 storm-water-flow readings	n/a	n/a
Conclusions/Recommendations: Floods during the 2013 monsoon season resulted in more extensive erosion than observed following 2012 monsoon flood events and greater coarse-grained sediment deposition than observed during the previous 2 yr of post–Las Conchas monsoon season flooding. RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocine), and TATB (triaminotrinitrobenzene) were detected in 2013 post-monsoon sediment in more reaches than in 2011 or 2012, indicating greater redistribution of these contaminants by 2013 floods. Barium, high explosives, and PCB concentrations in post–Las Conchas 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 2011b).					
SWMU 61-007 (Upper Los Alamos Canyon Aggregate Area)	61	1	129 subsurface samples collected in 2009, 2012, 2013, and 2014	Approximately 220 yd^3 of PCB-contaminated soil excavated	1
Conclusions/Recommendations: Site remediation was designed to result in no potential unacceptable risk to the construction worker. Details and results of the remediation will be presented in the Phase II investigation report for the Upper Los Alamos Canyon Aggregate Area. The maximum concentration of Aroclor-1260 remaining at the site was 42.6 milligrams per kilogram (mg/kg), which is below the construction worker soil screening level and indicates no potential unacceptable risk to the construction worker exists at the site. The site was restored to approximate original grade and condition and reseeded to match the surrounding area.					

Table 3-4 (continued)

Document/ Activity	TA	Number of Sites Investigated	Number of Samples Collected	Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined
Semiannual Progress Reports for Corrective Measures Evaluation/ Corrective Measures Implementation for Consolidated Unit 16-021(c)-99 (LANL 2014i and 2014j)[b]	16	1	Best management practices inspected (6 significant rain events recorded between April and September 2014); 2 periodic monitoring events conducted as part of the TA-16 260 monitoring group	n/a	n/a
Conclusions/Recommendations: Best management practices were inspected and found to be in good condition; no maintenance or repairs were necessary. Cañon de Valle electrical resistivity geophysical investigation was conducted at the site to map the electrical structure of the vadose zone. Interim measures source-removal testing was conducted at deep perched-intermediate well CdV-16-4ip to determine whether source removal from this zone can be conducted to limit potential migration of RDX and other constituents to the underlying regional aquifer and to determine if long-term pumping in the perched-intermediate zone is a viable source-removal option. Long-term pumping at CdV-16-4ip with the sole objective of removing mass from the deep perched groundwater is not cost-effective because of the relatively low yield of this well (3 gallons per minute) and the limited mass of RDX that would be produced. The extended source-removal test at CdV-16-4ip demonstrated that long-term pumping at the well would remove RDX from the deep perched-intermediate aquifer at TA-16 at a rate of approximately 1 kilogram per year (kg/yr). Perched-intermediate wells CdV-9-1(i) and R-63i and regional aquifer well R-47 were drilled and completed. Groundwater analytical data are presented and discussed in more detail in Chapter 5 of this report.					
Letter Report for the Results of Analytical Sampling For Volatile Organic Compounds at Material Disposal Area B (LANL 2014k)	21	1	22 samples collected	n/a	1
Conclusions/Recommendations: VOCs were not detected in any of the samples collected in 2014. Therefore, the Laboratory has demonstrated that VOC concentrations from samples collected at the site are below residential soil screening levels.					
Investigation Report for Area of Concern 01-007(k) in the Upper Los Alamos Canyon Aggregate Area, Revision 1 (LANL 2014l)	01	1	48 surface and subsurface samples collected in 2008 and 2013	0	1
Conclusions/Recommendations: There is no potential unacceptable risk or dose under the industrial, construction worker, and residential scenarios; no potential ecological risks for any receptor; and the nature and extent of contamination is defined and/or no further sampling for extent is warranted at AOC 01-007(k). The Laboratory recommended no further investigation or remediation activities are warranted, and the site is appropriate for corrective actions complete without controls.					
TA-57 Aggregate Area (Fenton Hill) (LANL 2015)	57	2	52 surface and subsurface samples collected in 2014	Approximately 1.5 yd^3 of soil excavated at AOC 57-007 to remove elevated arsenic	2
Conclusions/Recommendations: There is no potential unacceptable risk or dose under the industrial, construction worker, and residential scenarios; no potential ecological risks for any receptor; and the nature and extent of contamination is defined and/or no further sampling for extent is warranted. The Laboratory recommended no further investigation or remediation activities are warranted, and the sites are appropriate for corrective actions complete without controls.					

Table 3-4 (continued)

Document/ Activity	TA	Number of Sites Investigated	Number of Samples Collected	Cleanup Conducted	Number of Sites Where Extent Defined/Not Defined
Phase III Investigation Report for DP Site Aggregate Area at Technical Area 21 (LANL 2014m)	21	27	Approximately 1300 surface and subsurface samples collected during 3 phases of sampling from 2006 to 2011	3 sites remediated with approximately 43 yd^3 of contaminated soil excavated	27

Conclusions/Recommendations:

Twenty-seven SWMUs/AOCs do not pose a potential unacceptable risk or dose under the industrial, construction worker, and/or residential scenarios either for the entire site or for the mesa-top portion of the site; have no potential ecological risks for any receptor; and have the nature and extent of contamination defined and/or no further sampling for extent is warranted. Fourteen SWMUs/AOCs do not pose potential unacceptable risks to human health under the industrial and construction worker scenarios either for the site as a whole or on the mesa top, and 13 SWMUs do not pose potential unacceptable risks to human health under the residential scenario for the entire site.

No further investigation or remediation activities are warranted at the DP Site Aggregate Area sites evaluated. Based on the sampling results (Phases I, II, and III) and the risk-screening assessments, the Laboratory recommended corrective actions complete for these SWMUs and AOCs.

[a] n/a = Not applicable.

[b] Both progress reports are summarized together.

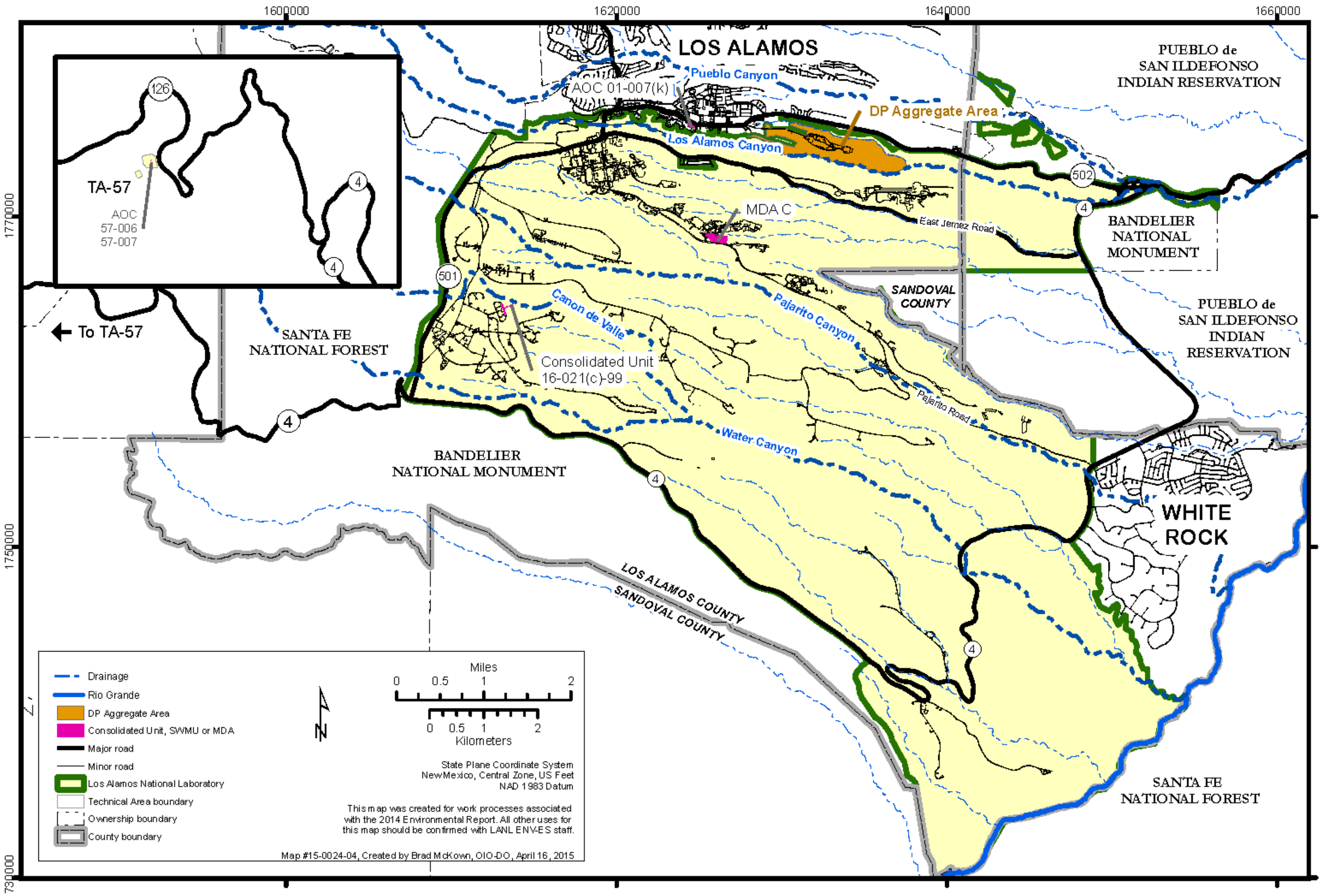

Figure 3-1 Locations of sites and canyons where characterization, monitoring, and remediation work was performed and/or reported in 2014

1. MDA C Subsurface Vapor Monitoring

Subsurface vapor (pore-gas) monitoring was conducted during 2014 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 2012d). Subsurface VOC vapor and tritium data were evaluated as part of the Phase III investigation report for MDA C (LANL 2011a) to determine whether VOCs and tritium pose a risk of groundwater contamination. The Phase III investigation report concluded there was no current risk but recommended continued monitoring to assess any changes in conditions. The monitoring network includes sampling points within and below the plume to determine whether contaminants are migrating vertically downward toward the regional aquifer and shallow sampling points near the disposal units to assess whether new releases have occurred. 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 U.S. Environmental Protection Agency (EPA) Method TO-15 for VOCs and EPA Method 906.0 for tritium.

Subsurface vapor monitoring at MDA C was conducted twice during 2014 at 80 sampling ports within 18 vapor-monitoring wells. Figure 3-2 presents the 18 monitoring wells sampled during 2014 at MDA C. The sampling locations and frequency were specified by NMED (NMED 2011). The first sampling event was conducted during April and May 2014, and the second sampling event was conducted during October and November 2014.

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 2012d). 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 above cleanup levels. The Tier I screening yields conservative SRs because the maximum vapor concentrations are located in the unsaturated zone several hundred feet above the regional groundwater. In addition, the screening evaluation does not account for aquifer dilution.

A Tier II screening process was also developed and applied (LANL 2012d). The Tier II screening accounts for migration of VOCs through the unsaturated zone to the regional aquifer and subsequent dilution within the aquifer. These calculated groundwater concentrations are compared with 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 22 VOCs and tritium were detected in pore gas at MDA C during the first 2014 sampling event; 17 VOCs and tritium were detected in pore gas during the second 2014 sampling event. Table 3-5 lists the VOCs for which the SRs were above 1 during 2014 using the Tier I screening analysis. The maximum Tier I SRs calculated for these VOCs are also listed. The screening evaluation of the 2014 data identified 4 VOCs with vapor concentrations above their respective Tier I screening levels: 2-hexanone; methylene chloride; 1,1,2-trichloroethane; and trichloroethene (TCE).

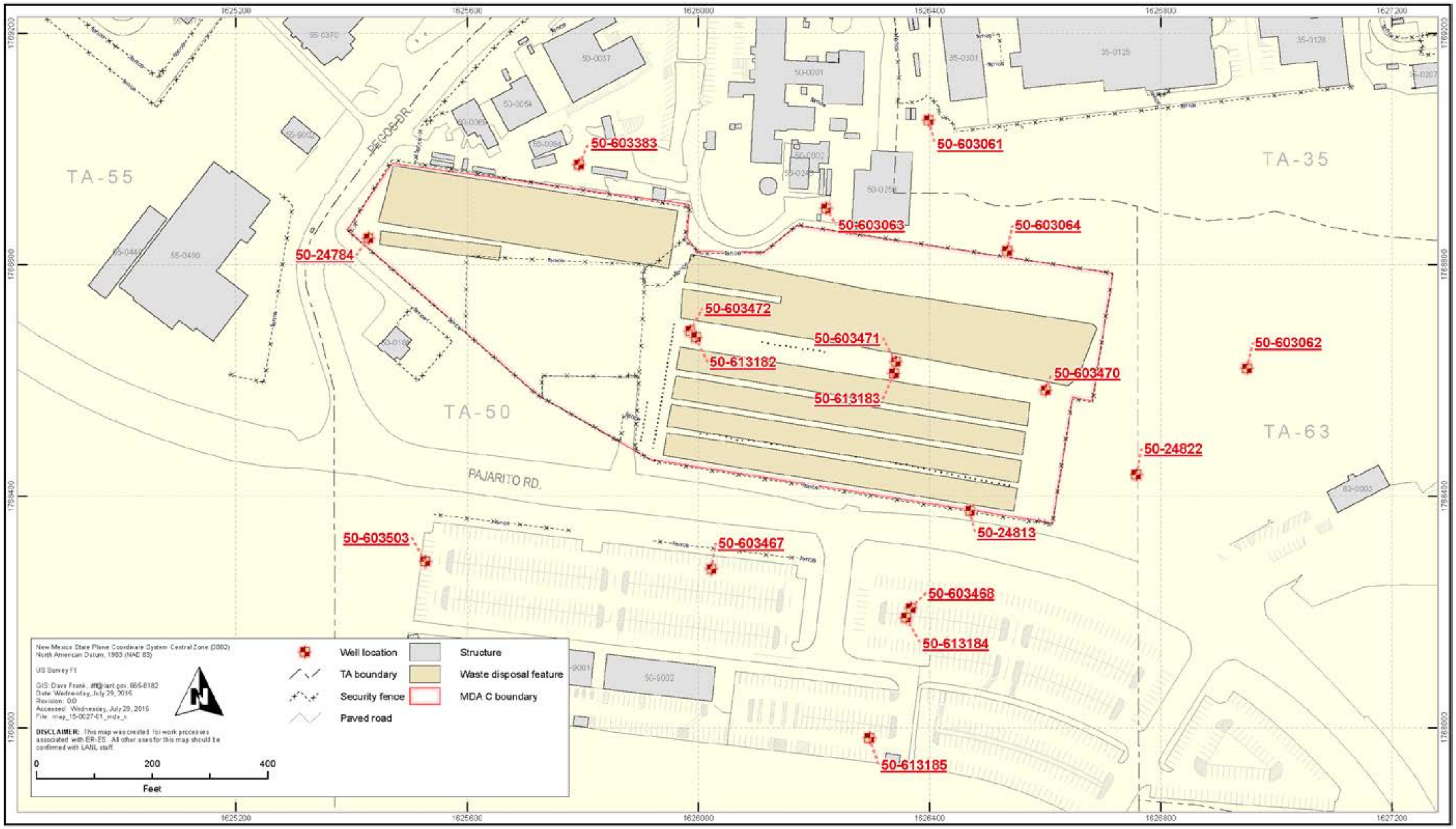

Figure 3-2 **MDA C vapor-monitoring well locations**

Table 3-5
VOCs above Tier I Screening Levels in 2014 Samples at MDA C

VOC	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard, Tier I Screening Level (µg/m³ a)	Maximum Pore-Gas Concentration during First Sampling Event (µg/m³)	Maximum Tier I Screening Ratio for First Sampling Event (unitless)	Maximum Pore-Gas Concentration during Second Sampling Event (µg/m³)	Maximum Tier I Screening Ratio for Second Sampling Event (unitless)
Hexanone[2-]	130	319	1.8	ND[b]	n/a[c]
Methylene Chloride	650	1597	2.5	1666	2.6
Trichloroethane[1,1,2]	ND	n/a	174	170	1.0
TCE[d]	2000	80,557	40.0	75,187	37.6

[a] µg/m³ = 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 2012d).

TCE is the only VOC detected at concentrations above the Tier II screening levels. Figures 3-3 and 3-4 show the TCE vapor data for the first and second 2014 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 dilution in the regional aquifer. Figure 3-3 shows that the Tier II screening levels were exceeded in samples collected at monitoring wells 50-24813 and 50-603471 during April and May 2014. Figure 3-4 shows that the Tier II screening levels were exceeded in samples collected at monitoring wells 50-24813, 50-603470, and 50-603471 during October and November 2014. 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 below ground surface (bgs), which is over 800 ft above the regional aquifer. The results of the 2014 VOC monitoring, including the locations and depths with the highest TCE concentrations, were consistent with previous years' monitoring data (LANL 2012d, 2012e, 2013). The similarity of the VOC results across several years of monitoring indicates there have been no new releases from the disposal units and VOCs have not migrated to groundwater.

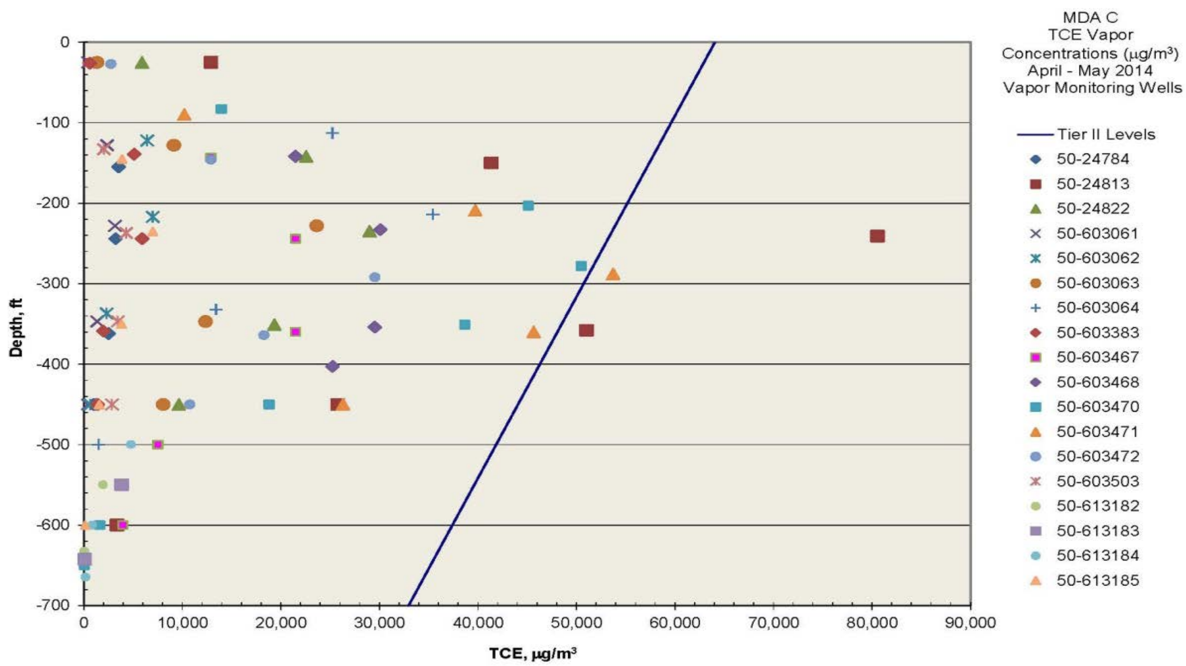

Figure 3-3 **TCE vapor concentrations measured at MDA C during April and May 2014 compared with the depth-dependent Tier II screening levels**

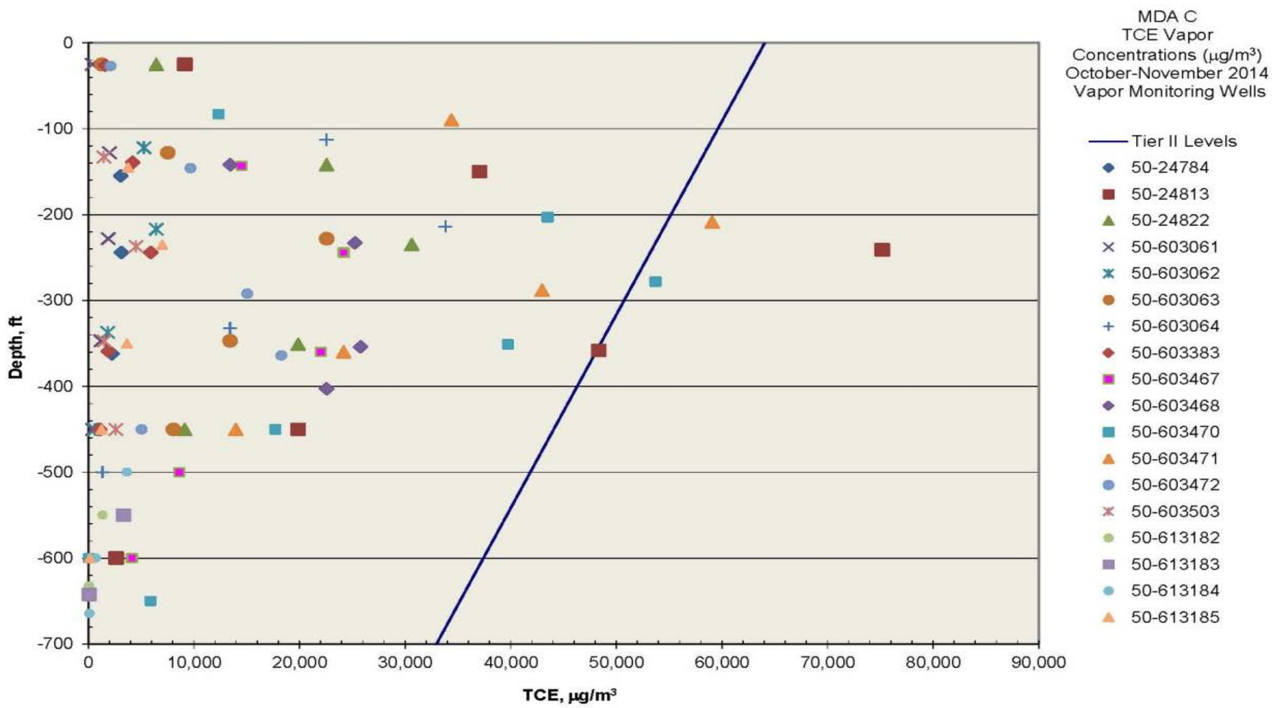

Figure 3-4 TCE vapor concentrations measured at MDA C during October and November 2014 compared with the depth-dependent Tier II screening levels

The vapor plume is associated with disposal trenches and shafts near the eastern end of MDA C that contain wastes with some solvent contamination. Because the TCE plume is presently located over 800 ft above the regional aquifer and the past several years of data show no impact to groundwater, the need to implement corrective actions is not indicated at this time. However, the MDA C 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 SVE be used as a remedy to decrease subsurface vapor concentrations of VOCs, particularly TCE (LANL 2012d).

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 2012d). The Tier II screening level established for tritium does not account for transport in the unsaturated zone. Most tritium activities (>90%) were below the Tier II screening level. Figures 3-5 and 3-6 present the 2014 tritium data for the first and second sampling events, respectively, compared with the Tier II screening level. The figures 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 2014 was 2,728,890 pCi/L in monitoring well 50-603470 at a depth of 83 ft, at the eastern end of MDA C (Figure 3-2), but tritium activities in the ports below this depth were orders of magnitude less (Figures 3-5 and 3-6). The 2014 tritium results are consistent with previous monitoring data and indicate there have been no new releases from the disposal units and tritium has not migrated to groundwater. Because tritium is not impacting groundwater, corrective actions are not necessary at this time.

Vapor monitoring for VOCs and tritium at MDA C will continue on a semiannual basis to support remedy selection.

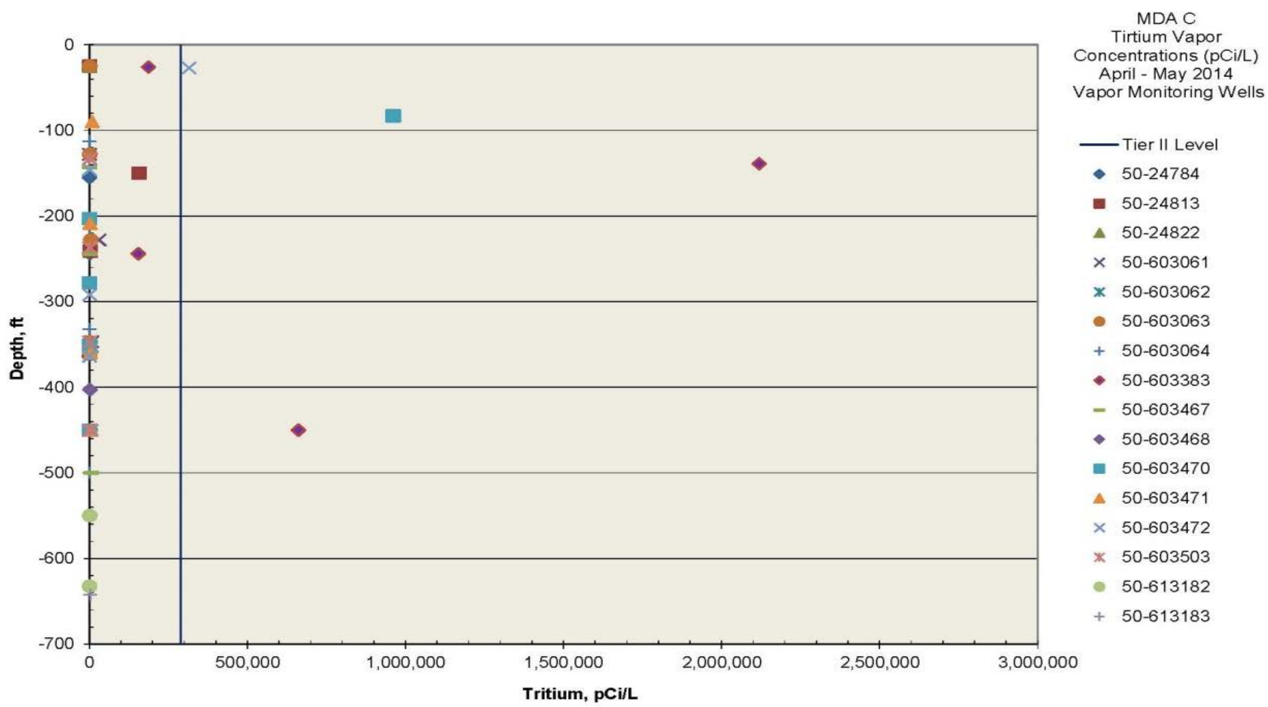

Figure 3-5 **Tritium activities measured at MDA C during April and May 2014 compared with the Tier II screening level**

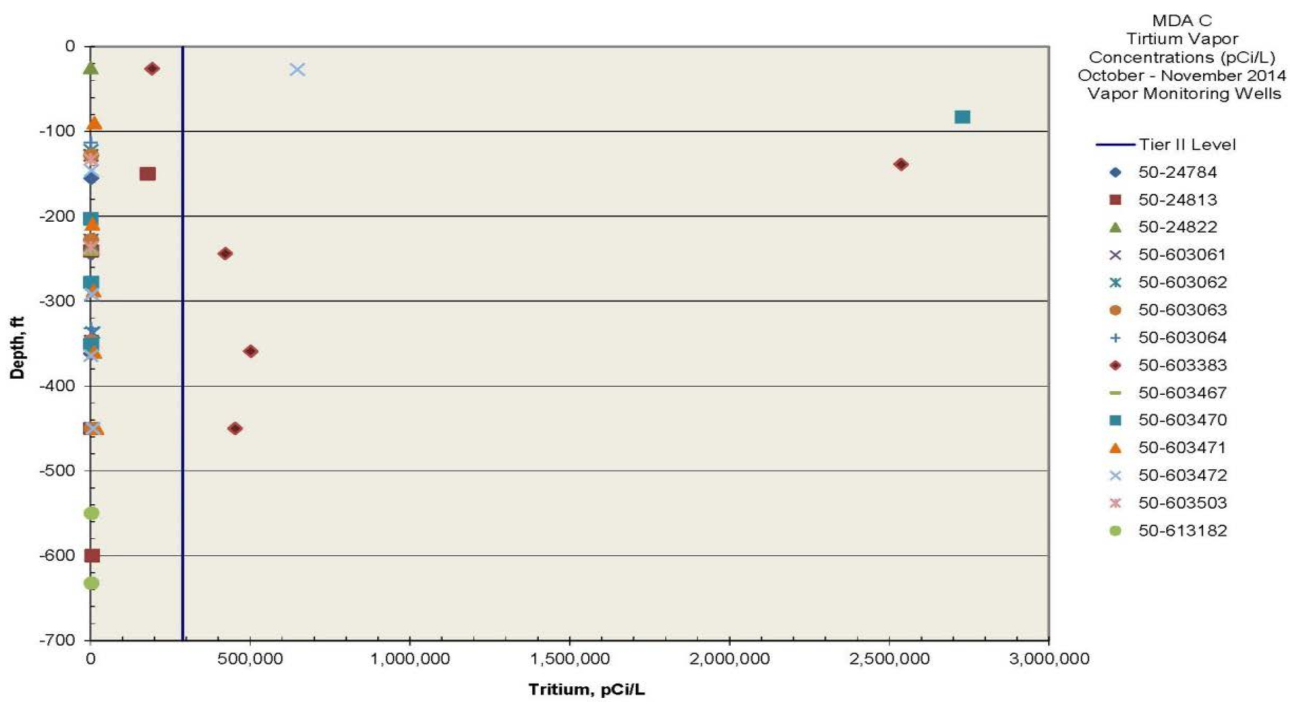

Figure 3-6 **Tritium activities measured at MDA C during October and November 2014 compared with the Tier II screening level**

C. QUALITY ASSURANCE

1. Quality Assurance Program

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 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.

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CONTENTS

FIGURES

TABLES

To Read About — **Turn to Page**

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 and address the question "Are there adverse effects to humans or biota from airborne material or direct radiation in the air?" Air quality is monitored by five interrelated programs, which are described in Sections A through E of this chapter: (A) ambient air sampling at receptor locations, (B) stack sampling at the sources, (C) gamma and neutron radiation monitoring near the sources and near the receptors, (D) nonradiological air monitoring, and (E) meteorology. 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, the results of the 2014 measurements are presented, and the conclusion is that the results were far below the DOE and EPA limits.

A. AMBIENT AIR SAMPLING

1. Introduction

Los Alamos National Laboratory's (LANL's or the Laboratory's) radiological air-sampling network, AIRNET, 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 2 picocuries 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 in aerosolized soil. These background concentrations are similar year to year, and there is no discernible trend.

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

Analyte	Units	EPA* Limit	Annual Average
Tritium	pCi/m^3	1500	1 ± 2
Am-241	aCi/m^3	1900	0 ± 1
Pu-238	aCi/m^3	2100	0 ± 1
Pu-239	aCi/m^3	2000	0 ± 1
U-234	aCi/m^3	7700	17 ± 6
U-235	aCi/m^3	7100	1 ± 1
U-238	aCi/m^3	8300	15 ± 6

*EPA = U.S. Environmental Protection Agency.

Ambient air concentrations greater than background are compared with the EPA's 10-millirem (mrem) annual limit (40 Code of Federal Regulations [CFR] 61, Subpart H) and the U.S. Department of Energy's (DOE's) 100-mrem annual limit.

2. Air-Monitoring Network

During 2014, the Laboratory operated 41 environmental air stations to sample radionuclides by collecting particulate matter. Thirty of these stations also collected water vapor for tritium analysis. AIRNET sampling locations (Figures 4-1 and 4-2) are categorized as regional (>10 km from LANL), perimeter, waste site (Area G), or on-site. The locations are reviewed regularly to ensure good coverage of LANL operations. Several minor changes that were implemented at the beginning of 2015 will be described in the report for 2015.

AIRNET stations are operated continuously; filters are changed out every 2 wk and sent to an analytical laboratory for analysis. The run time for AIRNET stations averaged 99% for the year. Analytical data completeness was 100% for filters and 99% for silica gel.

3. Quality Assurance

AIRNET maintains a quality assurance program that satisfies 40 CFR 61, Appendix B, Method 114. The AIRNET quality assurance project plan and implementing procedures specify the requirements and implementation of sample collection, sample management, chemical analysis, and data management. The requirements follow EPA methods for sample handling, chain of custody, analytical chemistry, and statistical analyses of data.

4. Ambient Air Concentrations

a. Tritium

Tritium is present in the environment primarily as the result of past global nuclear weapons tests and natural cosmogenic processes (Eisenbud and Gesell 1997). The Laboratory measures tritiated water (HTO) because the dose impact is 25,000 times higher than from gaseous tritium, HT or T_2 (ICRP 1978). Water-vapor concentrations in the air and tritium concentrations in the water vapor are used to calculate ambient levels of tritium, which are corrected for blanks, bound water in the silica gel, and isotopic distillation effects.

During 2014, all annual mean concentrations were similar to recent years and well below EPA and DOE guidelines (Table 4-2). The highest annual tritium concentration at any regional or perimeter station was less than 0.2% of the EPA public dose limit.

Table 4-2

Airborne Tritium as Tritiated Water Concentrations for 2014—Group Summaries

Station Grouping	Number of Stations	Mean ± 3 standard deviations (3s) (pCi/m^3)		Maximum Annual Station Concentration (pCi/m^3)
Regional (off-site)	6	2	±2	2
Perimeter	22	2	±2	3
On-site	2	14	n/a*	20
Waste site	1	400	n/a	400

*Not applicable.

The on-site data are from locations close to known sources of tritium such as the weapons engineering tritium facility (station #307). The waste site data are obtained from station #160 (see Figure 4-2), at the southern boundary of Area G, which is a controlled area and not publicly accessible. Since 2001, the tritium concentrations at this location have decreased primarily because of radioactive decay (see Figure 4-3).

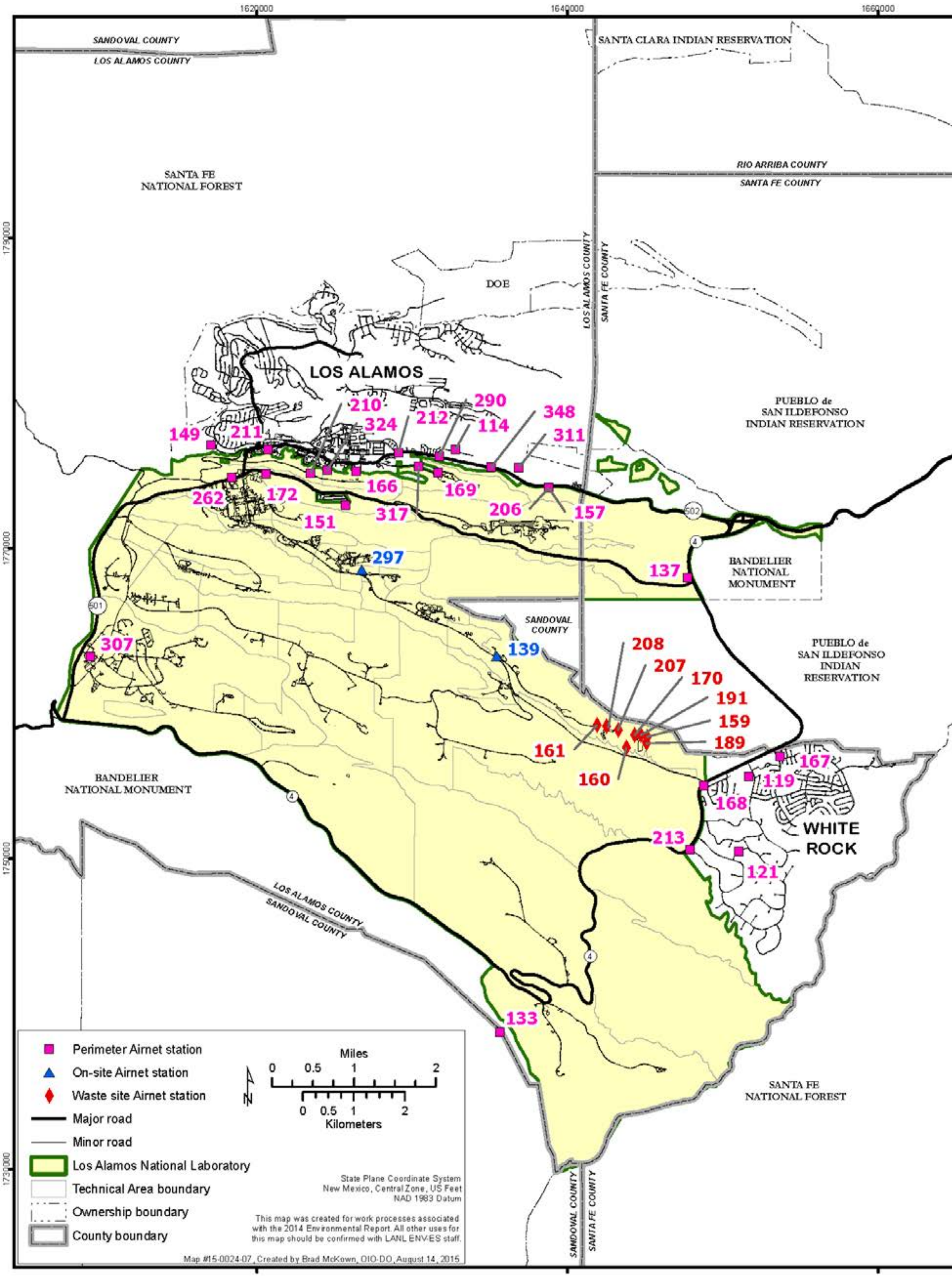
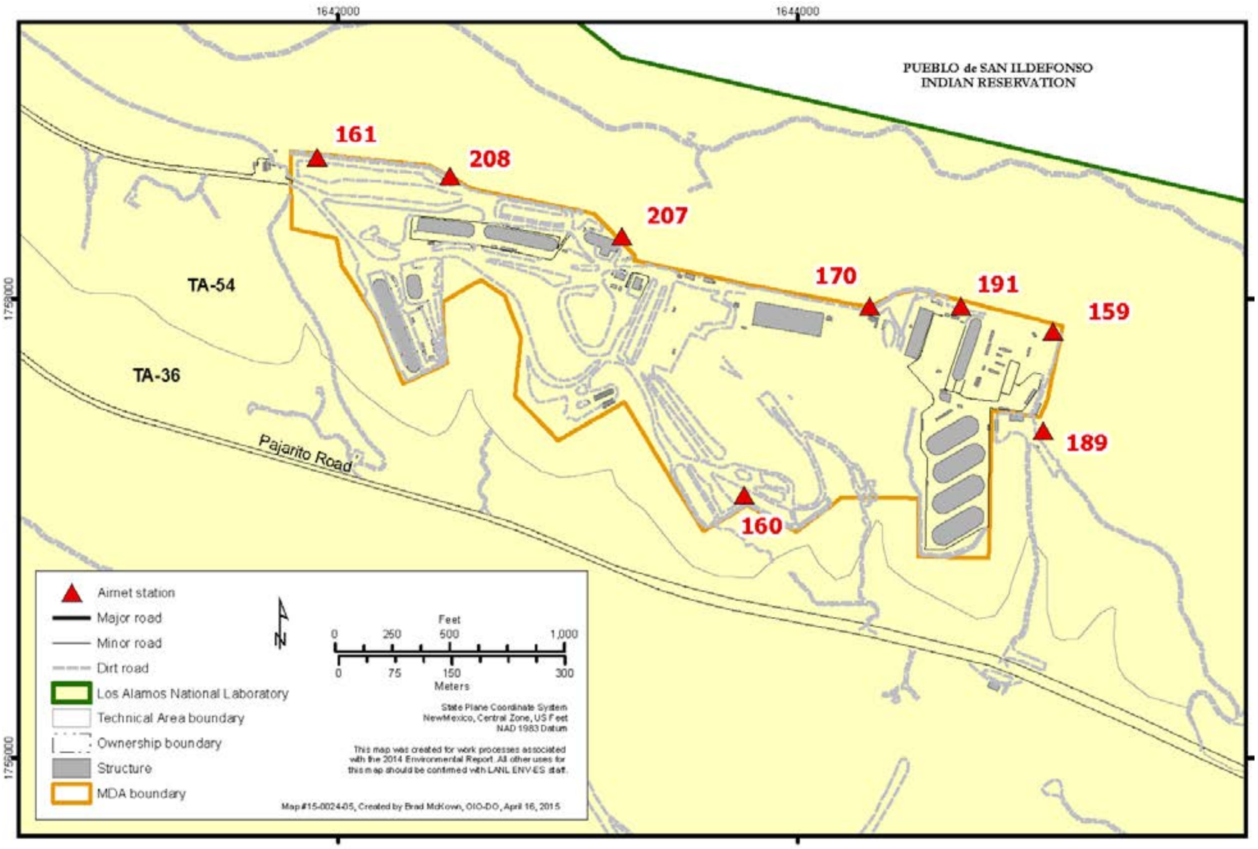


Figure 4-1 AIRNET station locations at and near the Laboratory



MDA = Material disposal area.

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

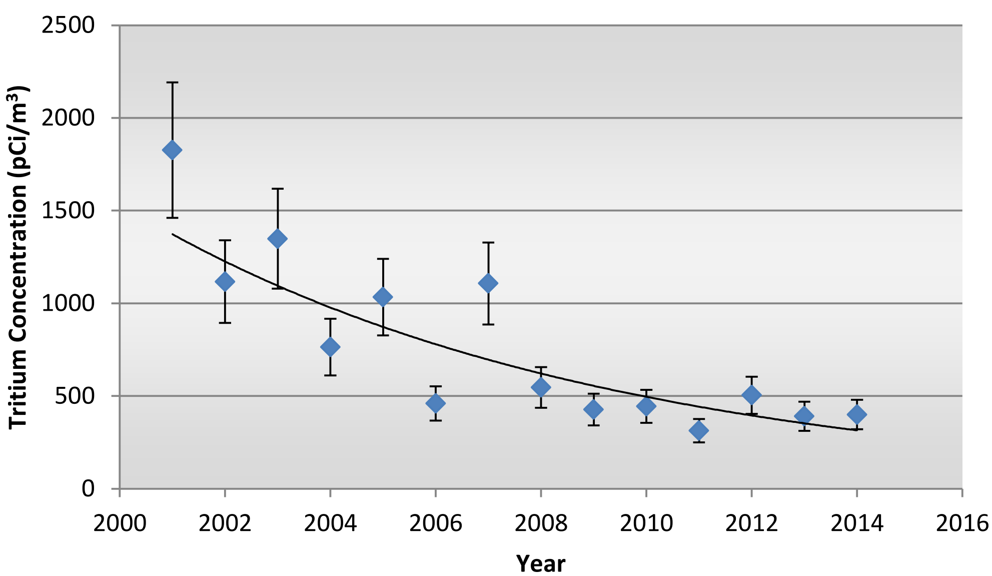


Figure 4-3 **Tritium concentrations at the waste site, Area G, station #160**

b. Americium-241

Americium from global fallout occurs worldwide, in low concentrations. Table 4-3 summarizes 2014 sampling data, which were similar to recent years. The highest annual averages for any regional or perimeter station were less than 0.1% of the public limits and show no distinctive trends.

Table 4-3
Airborne Americium-241 Concentrations for 2014—Group Summaries

Station Grouping	Number of Stations	Mean ± 3s (aCi/m^3)		Maximum Annual Station Concentration (aCi/m^3)
Regional	6	0	±1	0
Perimeter	23	0	±1	1
On-site	4	1	±1	0
Waste site	8	11	±85	81

At the Area G waste site, concentrations were higher than usual as a result of the disposal of soil removed from MDA B but were well below all regulatory limits.

c. Plutonium

Plutonium from global fallout occurs worldwide, in low concentrations. Table 4-4 summarizes the plutonium-238 and plutonium-239/240 data for 2014, which were similar to recent years. Excluding the waste site, which is not publicly accessible, the highest averages were 0.1% of the limits for plutonium-238 and 0.6% of the limits for plutonium-239 and show no distinctive trends.

Table 4-4
Airborne Plutonium-238 and Plutonium-239/240 Concentrations for 2014—Group Summaries

		Group Mean ± 3s (aCi/m^3)		Maximum Annual Station Concentration (aCi/m^3)	
Station Grouping	Number of Stations	Pu-238	Pu-239/240	Pu-238	Pu-239/240
Regional	6	0 ±1	0 ±2	0	2
Perimeter	25	0 ±1	1 ±7	1	12
On-site	2	0 ±1	1 ±6	0	3
Waste site	8	2 ±17	509 ±4270	16	4031

At the Area G waste site, concentrations were higher than usual as a result of the disposal of soil removed from MDA B, but mean concentrations were well below all regulatory limits.

d. Uranium

Uranium-234, -235, and -238 are found in nature, and the highest airborne concentrations are 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 2014. Outside of controlled areas, the uranium concentrations (Table 4-5) were similar to previous years and below 0.5% of the EPA guidelines.

Table 4-5
Airborne Uranium-234, -235, and -238 Concentrations for 2014—Group Summaries

		Group Mean ± 3s (aCi/m^3)		
Station Grouping	Number of stations	U-234	U-235	U-238
Regional	6	18 ±18	1 ±2	17 ±16
Perimeter	25	8 ±8	1 ±1	9 ±9
On-site	2	10 ±8	1 ±1	14 ±23
Waste site	8	16 ±32	1 ±1	17 ±33

e. Gamma Spectroscopy Measurements

For gamma screening, the Laboratory analyzes 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. Of these, only naturally occurring radionuclides were detected.

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 radioactive 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). During 2014, 29 stacks meeting this criterion were identified.

2. Sampling Methodology

In 2014, 29 stacks were continuously sampled 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.

The Laboratory samples 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. Samples are collected weekly and shipped to an off-site analytical laboratory.

Downstream of the glass-fiber filter, 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. The glass-fiber filter (discussed above) removes any particulates from this sample medium before vapor sampling.

Tritium emissions from the Laboratory's tritium facilities are measured with a collection device known as a bubbler. This device enables the Laboratory 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.

The Laboratory measures GMAP emissions from LANSCE activities using real-time monitoring data. A sample of stack air is pulled through an ionization chamber that measures the total amount of radioactivity in the sample.

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 (40 CFR 61, Subpart H). This section discusses the sampling and analysis methods for each type of the Laboratory's emissions.

b. Particulate Matter Emissions

Each week, the glass-fiber filters are removed and replaced and are shipped to an off-site analytical laboratory. Before shipping, each sample filter is screened 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. The data from these composite analyses are used 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

The Laboratory removes and replaces the charcoal canisters weekly and ships 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, tritium bubbler samples are collected and transported 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, the Laboratory uses 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, the relative composition of the emissions is determined.

4. Analytical Results

Measurements of Laboratory stack emissions during 2014 totaled approximately 380 curies (Ci) (compared with 220 Ci in 2013). Of this total, tritium emissions contributed approximately 290 Ci (compared with 73 Ci in 2013), and GMAP from the two LANSCE stacks at TA-53 contributed 90 Ci (compared with 148 Ci in 2013). LANSCE diffuse emissions contributed another 110 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 0.03 Ci (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 total stack emissions in the groupings of GMAP and P/VAP. Table 4-8 presents the half-lives of the radionuclides typically emitted by the Laboratory. During 2014, the LANSCE facility nonpoint source emissions of GMAP comprised approximately 25 Ci of carbon-11 and 85 Ci of argon-41.

Table 4-6
Airborne Radioactive Emissions (Ci) from LANL Buildings with Sampled Stacks in 2014

Building No.	H-3	Am-241	Pu	U	Th	P/VAP	GMAP
TA-03-029		5.3E-07	3.9E-06	2.8E-06	3.9E-08		
TA-16-205/450	2.8E+02						
TA-48-001				1.8E-08		3.2E-02	
TA-50-001			6.0E-08	5.9E-08			
TA-50-069			8.6E-10				
TA-53-003	1.0E+01					2.3E-05	2.9E+01
TA-53-007	2.0E+00					1.2E-03	6.0E+01
TA-54-375				7.1E-09			
TA-54-412				1.7E-09			
TA-55-004	3.8E+00		4.2E-09	3.9E-08			
Total	2.9E+02	5.3E-07	4.0E-06	4.4E-06	3.9E-08	3.3E-02	9.0E+01

Table 4-7
Detailed Results of Activation Product Sampling from LANL Stacks in 2014

Building No.	Nuclide	Emission (Ci)
TA-48-0001	As-73	5.6E-06
TA-48-0001	As-74	4.6E-05
TA-48-0001	Br-77	2.9E-04
TA-48-0001	Ga-68	2.0E-03
TA-48-0001	Ge-68	2.0E-03
TA-48-0001	Hg-197	1.4E-02
TA-48-0001	Se-75	3.2E-02
TA-53-0003	Ar-41	1.2E+00
TA-53-0003	Be-7	2.0E-05
TA-53-0003	Br-77	1.5E-06
TA-53-0003	Br-82	2.2E-05
TA-53-0003	C-11	3.3E+01
TA-53-0007	Ar-41	4.7E+00
TA-53-0007	Br-76	4.4E-05
TA-53-0007	Br-77	1.6E-05
TA-53-0007	Br-82	8.7E-04
TA-53-0007	C-10	1.5E-01
TA-53-0007	C-11	5.4E+01
TA-53-0007	Hg-197	1.6E-04
TA-53-0007	N-13	1.1E+01
TA-53-0007	N-16	2.3E-01
TA-53-0007	Na-24	6.6E-07
TA-53-0007	O-14	2.4E-01
TA-53-0007	O-15	1.1E+01
TA-53-0007	Se-75	8.7E-06

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
Ar-41	1.83 h
Co-60	5.3 yr
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-90	28.6 yr
Cs-134	2.06 yr
Cs-137	30.2 yr
Hg-197	2.67 d
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. Conclusions and Trends

Emission-control systems for particulates such as plutonium and uranium continue to work well, and particulate emissions remain very low, in the microcurie range. Ongoing maintenance on the TA-16 emission-control systems resulted in higher than usual tritium emissions: 280 Ci compared with about 100 Ci in recent years. In 2014, emissions of GMAP continued to trend downward following the change-out of the primary LANSCE target in 2009. GMAP diffuse emissions were 25 Ci of carbon-11 and 85 Ci of argon-41, a total of 110 Ci, which was slightly higher than the stack emissions listed in Table 4-6: 90 Ci. Both of these sources are included in the dose assessment described in Chapter 8, contributing in a total dose to the maximally exposed individual (MEI) that is 2.4% of the EPA limit (Fuehne 2015).

C. GAMMA AND NEUTRON RADIATION MONITORING

1. Introduction

The objectives of the Direct Penetrating Radiation Monitoring Network (DPRNET) and of the Neighborhood Environmental Watch Network (NEWNET) are to monitor gamma and neutron radiation in the environment, as required by DOE Order 458.1, and to demonstrate compliance with the DOE all-pathway dose limit of 100 mrem/yr.

Short-lived airborne radionuclides cannot be measured by AIRNET, so thermoluminescent dosimeters (TLDs) are deployed at every AIRNET station to monitor short-lived radioactivity as well as radioactive material above the breathing height. In addition, NEWNET stations are situated at key locations. 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/, and the results are consistent with the measurements of LANSCE emissions reported in Section B.

In northern New Mexico, naturally occurring gamma radiation varies from 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.

a. Dosimeter Locations

Eighty TLD stations are located around the Laboratory and in the surrounding communities. There is a TLD at every AIRNET station shown in Figures 4-1 and 4-2. Additional stations are around TA-54, Area G (shown in Figure 4-4); and at TA-53, LANSCE (8 stations).

b. Neutron Dosimeters

Neutron doses are monitored by all TLDs and are measured accurately at 47 TLD stations located near known or suspected sources of neutrons at TA-53 (LANSCE) and TA-54 (Area G).

c. Neutron Background

The neutron background is measured at a location near the offices of the AIRNET team, where it is isolated from anthropogenic neutrons. These background data are supplemented by data from other stations far from Laboratory sources.

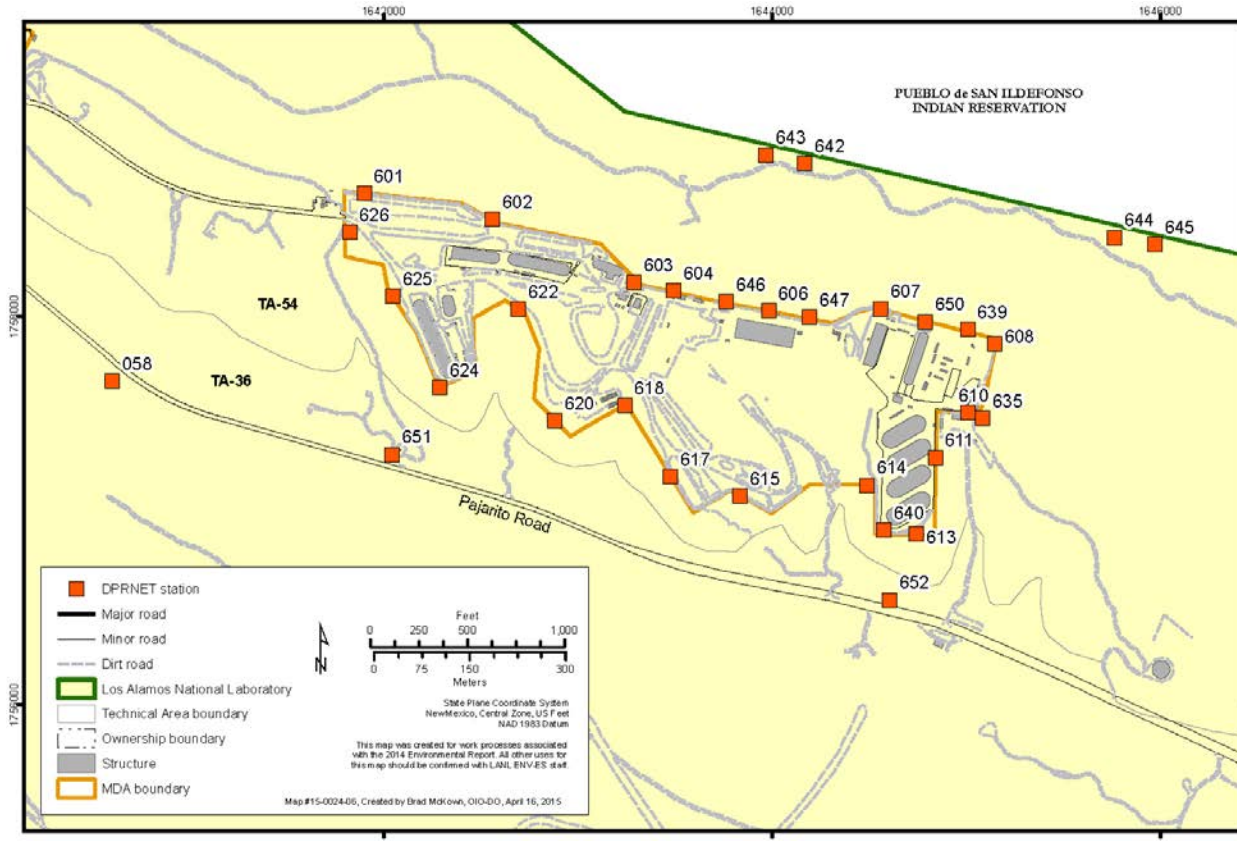


Figure 4-4 TLD locations at TA-54, Area G, as part of DPRNET

2. Quality Assurance

The Radiation Protection (RP) Division calibration laboratory calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited these dosimeters, and RP Division 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 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 [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 TLDs at TA-53 are used to determine this dose.

At TA-53, the only TLD that measures above-background gamma dose is at a location 100 m from the tanks at the east end of TA-53, where the dose was 260 mrem/yr, which is 130 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 the location north of the tanks (McNaughton 2013). Therefore, during 2014, the gamma dose at Jemez Road from the tanks was 0.2% of 130 mrem/yr, which is 0.3 mrem/yr.

This is the dose that would be received by a person who is at the Jemez Road location 24 h/day, 365 days/yr. There are no public facilities near this location, so the occupancy factor is less than 1%, and the gamma dose to a member of the public is less than 0.01 mrem/yr.

The annual neutron dose on the mesa overlooking Jemez Road was 3 mrem above background. Jemez Road is in Sandia Canyon, so it only receives neutrons that are scattered from the air. MCNP calculations show that the annual dose at Jemez Road, 350 m south of the Line D targets, is 10% of the 3-mrem dose on the mesa (McNaughton 2013). After adjusting for occupancy, the potential neutron dose to a member of the public is less than 0.01 mrem.

b. TA-54

Figure 4-4 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 #642 is in Cañada del Buey. After subtracting background, the annual neutron dose measured by TLD #642 was 1.4 mrem. This is the dose that would be received by a person who is at the location of the TLDs 24 h/day, 365 days/yr. As discussed in Chapter 8, an occupancy factor of 1/16 is applied (NCRP 1976), so the public dose near TLD #642 is calculated to be 1.4/16 = 0.1 mrem/yr, which is less than during previous years.

For the past 12 yr, neutron radiation has been a significant contributor to the all-pathway MEI near Area G. From 2010 to 2013, the dose rates near Area G decreased significantly (see Figures 4-5 and 4-6) as waste was shipped off-site to the Waste Isolation Pilot Plant (WIPP). During 2014, WIPP shipments ceased, the transuranic inventory remained essentially constant, and the neutron dose rates did not change significantly. The gamma dose rate increased slightly as a result of activated items from LANSCE, stored near the southern boundary of Area G.

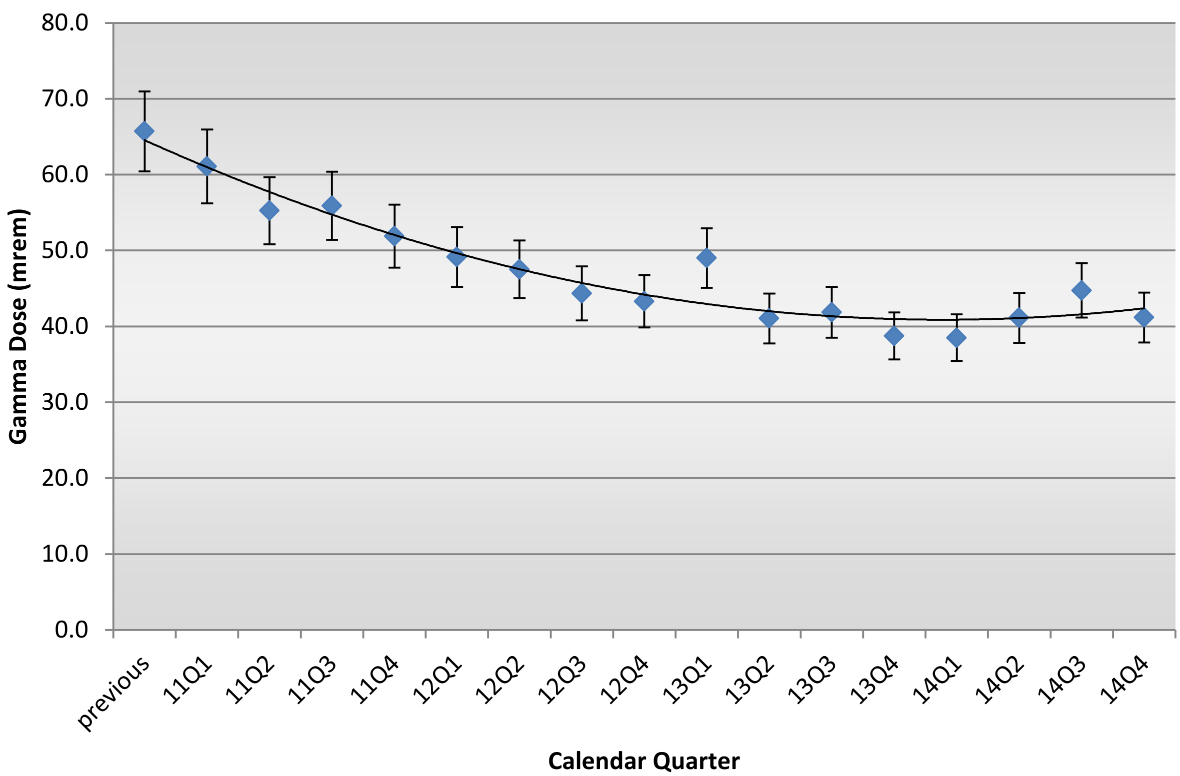


Figure 4-5 Average quarterly gamma doses around the perimeter of Area G for the past 16 calendar quarters. The first point, at 66 ± 4 mrem, is the average of the previous 36 calendar quarters, during which the quarterly doses were approximately constant. Natural background at Area G is about 30 mrem to 35 mrem per quarter.

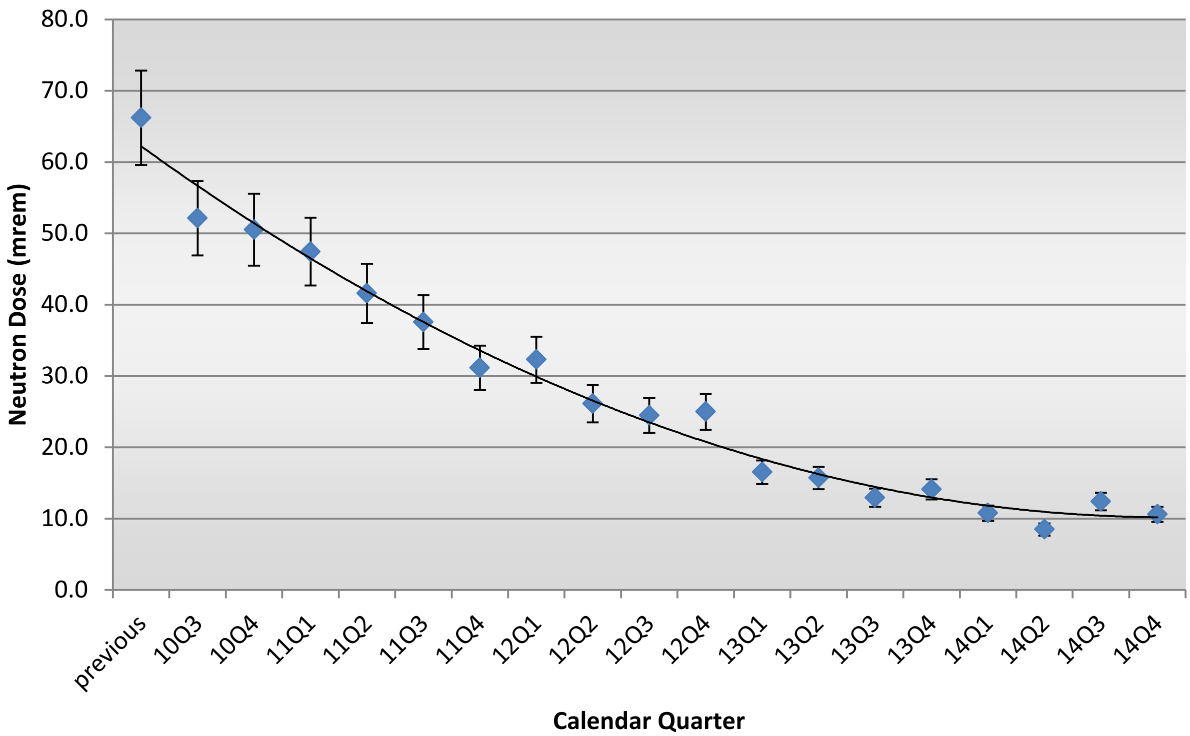


Figure 4-6 **Average quarterly neutron doses (mrem) around the perimeter of Area G for the past 18 calendar quarters. The first point, at 63 mrem, is the average of the previous 14 calendar quarters. Natural background contributes less than 1 mrem to each point.**

4. NEWNET

During 2014, 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. 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 LANL operations.

D. NONRADIOLOGICAL AIR MONITORING

1. Introduction

The nonradioactive ambient air-monitoring network monitors particulate matter smaller than 2.5 micrometers (µm) (PM-2.5) at two locations: the old White Rock Fire Station on Rover Boulevard and the Los Alamos Medical Center.

2. Ambient Air Concentrations

During 2014, the particulate matter concentrations remained well below the EPA standard: 35 micrograms per cubic meter (µg/m^3) for PM-2.5. Typical concentrations (>95% of the time) were less than 10 µg/m^3. The highest concentrations occurred during the spring from windblown dust and during the summer from wildfires in Arizona and New Mexico. During 2014, the maximum 24-h PM-2.5 concentration was 23 µg/m^3.

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 http://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 one in Mortandad Canyon [TA-5 MDCN]). 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.

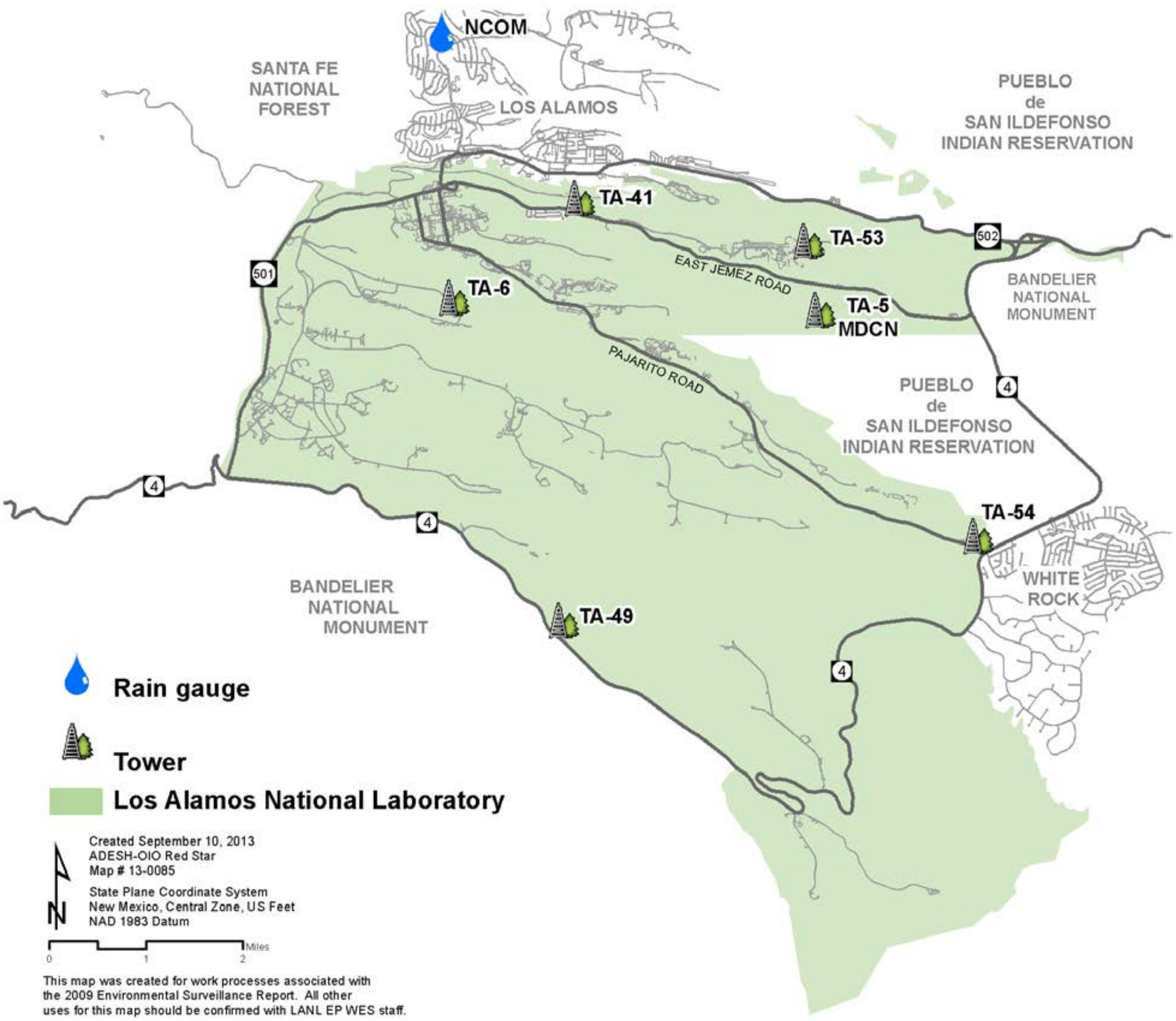


Figure 4-7 Locations of meteorological monitoring towers and rain gages

3. Sampling Procedures, Data Management, and Quality Assurance

The Laboratory places 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 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 (Dewart et al. 2015). 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, the Laboratory has 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 manufacturers' recommendations and operational considerations. All wind instruments are calibrated every 6 mo. All other sensors are calibrated annually, with the exception of solar radiation sensors, which are calibrated every 5 yr according to manufacturer's specifications. An external audit of the instrumentation and methods is performed periodically. An external subcontractor inspects and performs maintenance on the station network structures and hoists on an annual basis.

The meteorology program met American National Standards Institute (ANSI) 2010 standards for data completeness with three exceptions. These instrument issues have been addressed. Data quality and completeness is reported by Dewart et al. (2015).

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. Table 4-9 presents the temperature and precipitations records set for Los Alamos during 1924 to 2014.

Table 4-9
Records set between 1924 and 2014 for Los Alamos

	Record	Date
Low temperature	-18°F	January 13, 1963
High temperature	95°F	June 27, 2013
Single-day snowfall	39 in.	January 15, 1987
Single-season snowfall	153 in.	1986–1987

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. Wintertime arctic air masses that descend into the central United States tend to have sufficient time to heat before they reach Los Alamos's southern latitude, so the occurrence of local subzero temperatures is infrequent. 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. 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.

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. 2014 in Perspective

Table 4-10 presents a tabular perspective of Los Alamos weather during 2014, including snowfall and wind data. Figure 4-8 presents a graphical summary of Los Alamos temperature for 2014 with the daily high and low temperature at TA-06 in comparison with the 1981 to 2010 normal values and record values from 1924 to present. Figure 4-8 shows that more days had temperatures above average than below. The last line of Table 4-10 summarizes the year and shows that the overall average was 2°F above the 1981–2010 average.

Figures 4-9 and 4-10 present graphical summaries of Los Alamos precipitation for 2014. Low precipitation during the winter, spring, and fall led to a dry year. For 10 mo out of the year, Los Alamos experienced below-average precipitation totals. By the end of April, Los Alamos experienced the fifth driest year on record with 1.6 in. of precipitation (39% of normal). The onset of the monsoon in July temporarily relieved the dry year with the third wettest month on record and only four days without any recorded precipitation. The total precipitation during July was 9.04 in., well above the average of 2.82 in. The monsoon season, July through September, had a total precipitation of 10.62 in. in comparison with the 30-yr average of 8.45 in. While the monsoon season provided above-average moisture for Los Alamos, the subsequent months had below-average precipitation until the end of the year. Los Alamos finished the year with just-below-average precipitation. There was a deficit in snowfall during every winter month, resulting in total snowfall amounts for calendar year 2014 of 6.9 in. (12% of normal). The U.S. Drought Monitor determined Los Alamos concluded the year with a moderate drought (http://www.cpc.ncep.noaa.gov/products/Drought/).

Table 4-10
Monthly and Annual Climatological Data for 2014 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	43.2	21.3	32.2	2.8	56	30	8	6	0.02	-0.93	0	-13.3	6.0	1.0	50	WNW	10
February	48.7	26.2	37.4	4.5	63	15	9	6	0.20	-0.66	0.5	-10.4	6.8	1.0	59	SW	19
March	52.9	28.9	40.9	1.5	62	10	19	12	1.08	-0.12	1.1	-9.3	7.6	1.1	51	WNW	27
April	59.4	33.6	46.5	-0.3	71	10	22	4	0.30	-0.76	0	-3.3	8.7	1.1	57	WNW	27
May	67.9	42.4	55.1	-0.9	81	31	25	14	1.48	0.09	0	-0.3	8.1	0.7	44	NW	11
June	82.5	54.1	68.3	3.2	93	30	42	10	0.91	-0.6	0	0	9.1	2.0	46	WNW	4
July	79.6	56.3	67.9	-0.3	89	6	51	4	9.04	6.22	0	0	5.8	0.2	47	S	27
August	77.0	54.0	65.5	-0.3	85	31	47	23	1.28	-2.33	0	0	5.4	-0.3	35	WNW	9
September	77.3	51.2	64.2	4.4	86	2	38	30	0.30	-1.71	0	0	6.7	0.9	39	NW	29
October	66.6	41.4	54.0	4.8	76	6	31	13	0.85	-0.7	0	-2.2	5.6	-0.4	49	WNW	12
November	51.0	27.0	39.0	1.1	64	10	9	13	0.51	-0.47	1.0	-3.9	6.0	0.7	44	NW	23
December	42.0	23.3	32.7	3.3	55	11	8	31	0.85	-0.16	3.3	-8.9	5.3	0.4	55	WNW	22
Year	62.4	38.4	50.4	2.0	93	Jun 30	8	Dec 31	16.82	-2.15	6.9	-50.6	6.8	0.7	59	SW	Feb 19

[a] Data from TA-06, the official Los Alamos weather station.
[b] Departure column indicates positive or negative departure from 1981 to 2010 (30-yr) climatological average.
[c] Departure column indicates positive or negative departure from 1990 to 2010 (21-yr) climatological average.

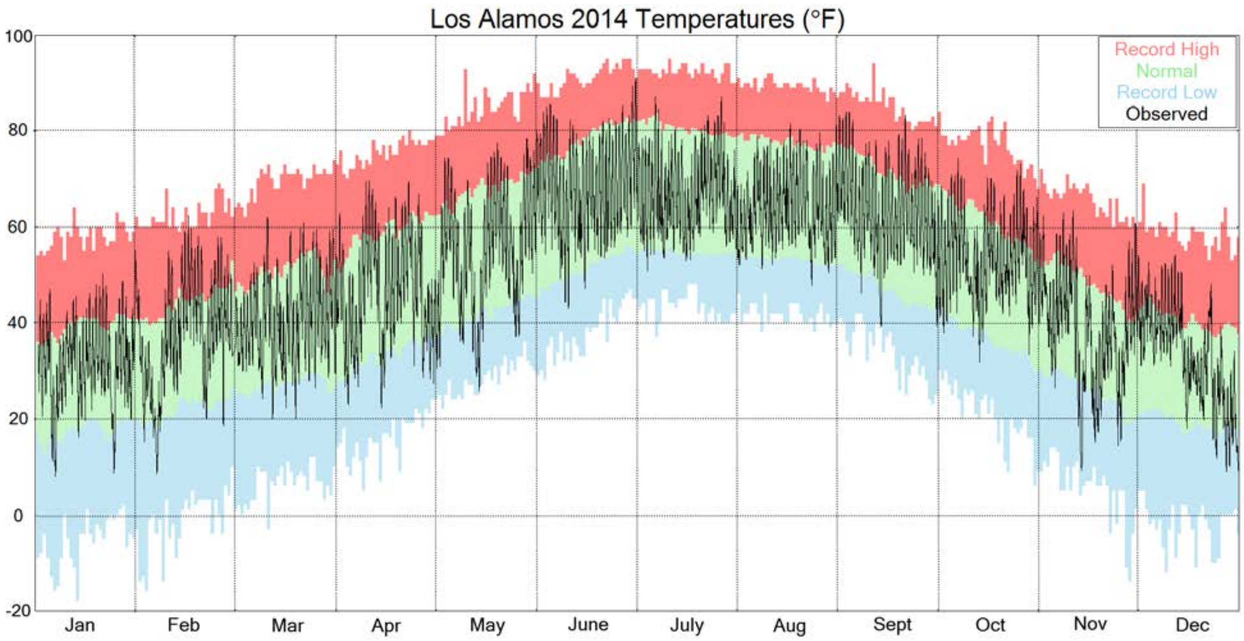


Figure 4-8 **Los Alamos 2014 temperatures in degrees Fahrenheit compared with record values and normal values**

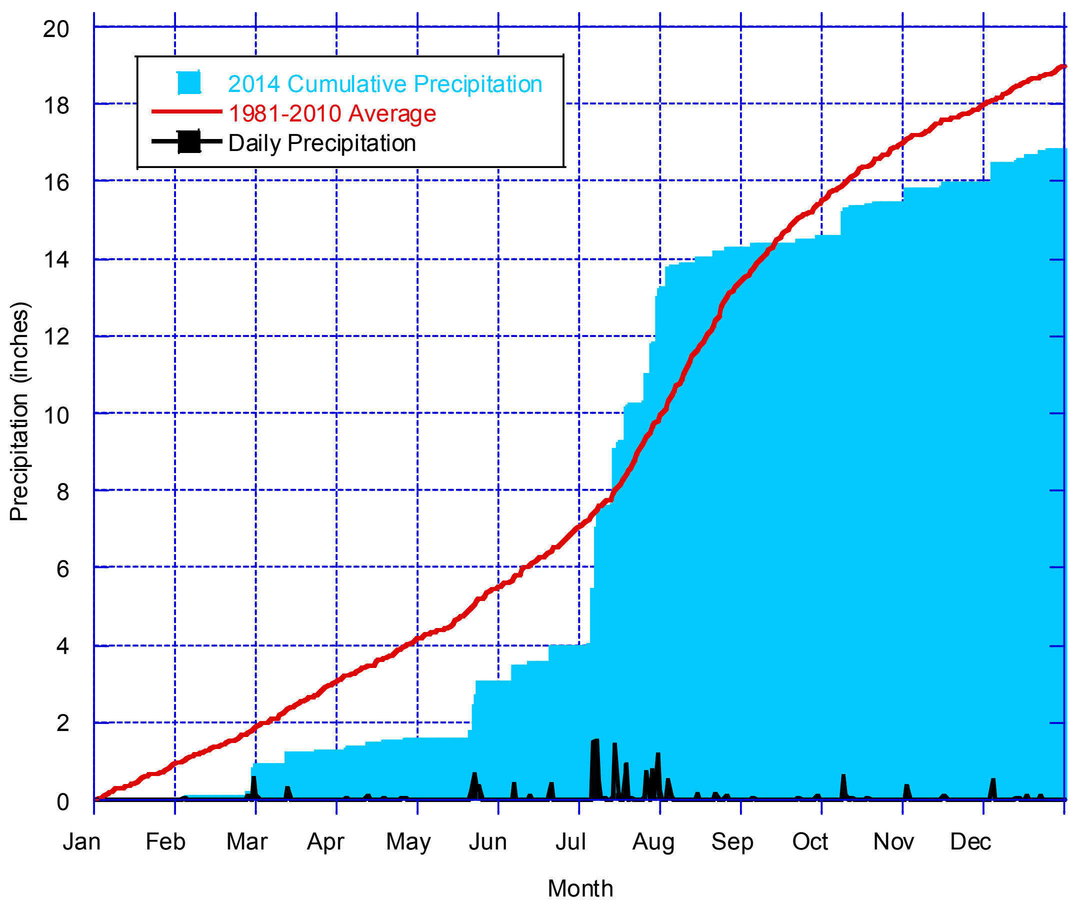


Figure 4-9 **2014 TA-06 cumulative percipitation vs. 30-yr average**

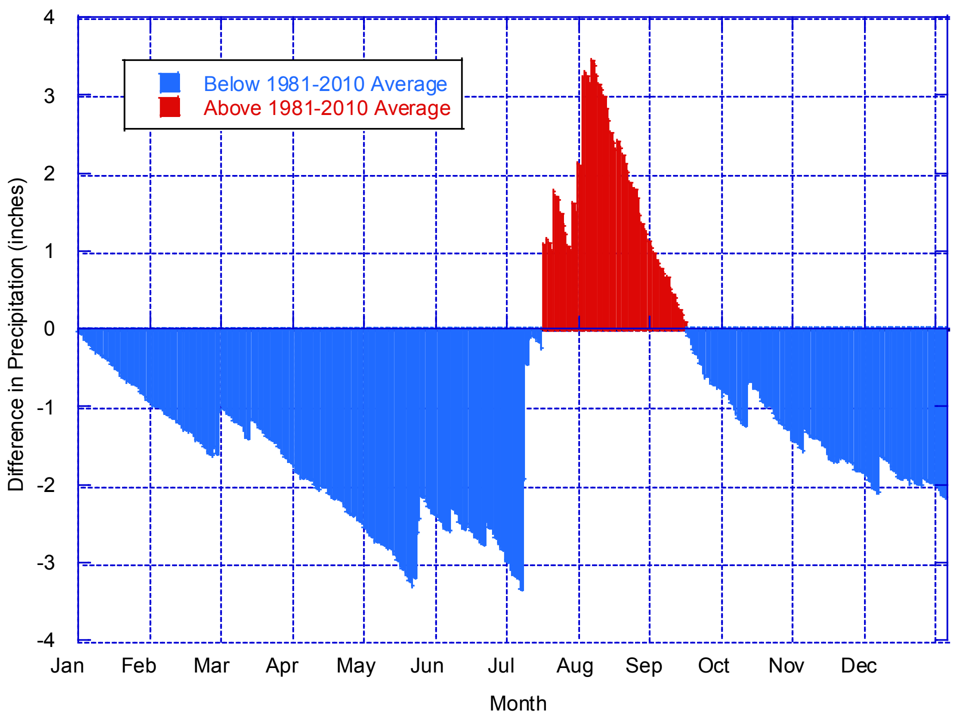


Figure 4-10 Difference between TA-06 precipitation in 2014 and 1981–2010 average precipitation

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-11. The wind roses are based on 15-min-averaged wind observations for 2014 at the four mesa-top stations. Wind roses depict the percentage of time that wind blows from each of 16 direction bins and the distribution of wind speed. For example, TA-06 during the day can be interpreted as measuring calm winds 0.7% of the time. TA-06 has winds directly from the south over 14% of the time. The wind speeds range from 2.5 to 5 meters per second (m/s) approximately 8% of the time, 5 to 7.5 m/s over 2% of the time, and exceed 7.5 m/s only a fraction of 1% of the time. Although not shown here, wind roses from different years are almost identical in terms of the distribution of wind directions, indicating that wind patterns are constant when averaged over a year. Since 2011, higher-than-average wind speeds have been recorded (Table 4-10). Winds during April, May, and June were the highest, with average wind speeds in June being 28% above normal.

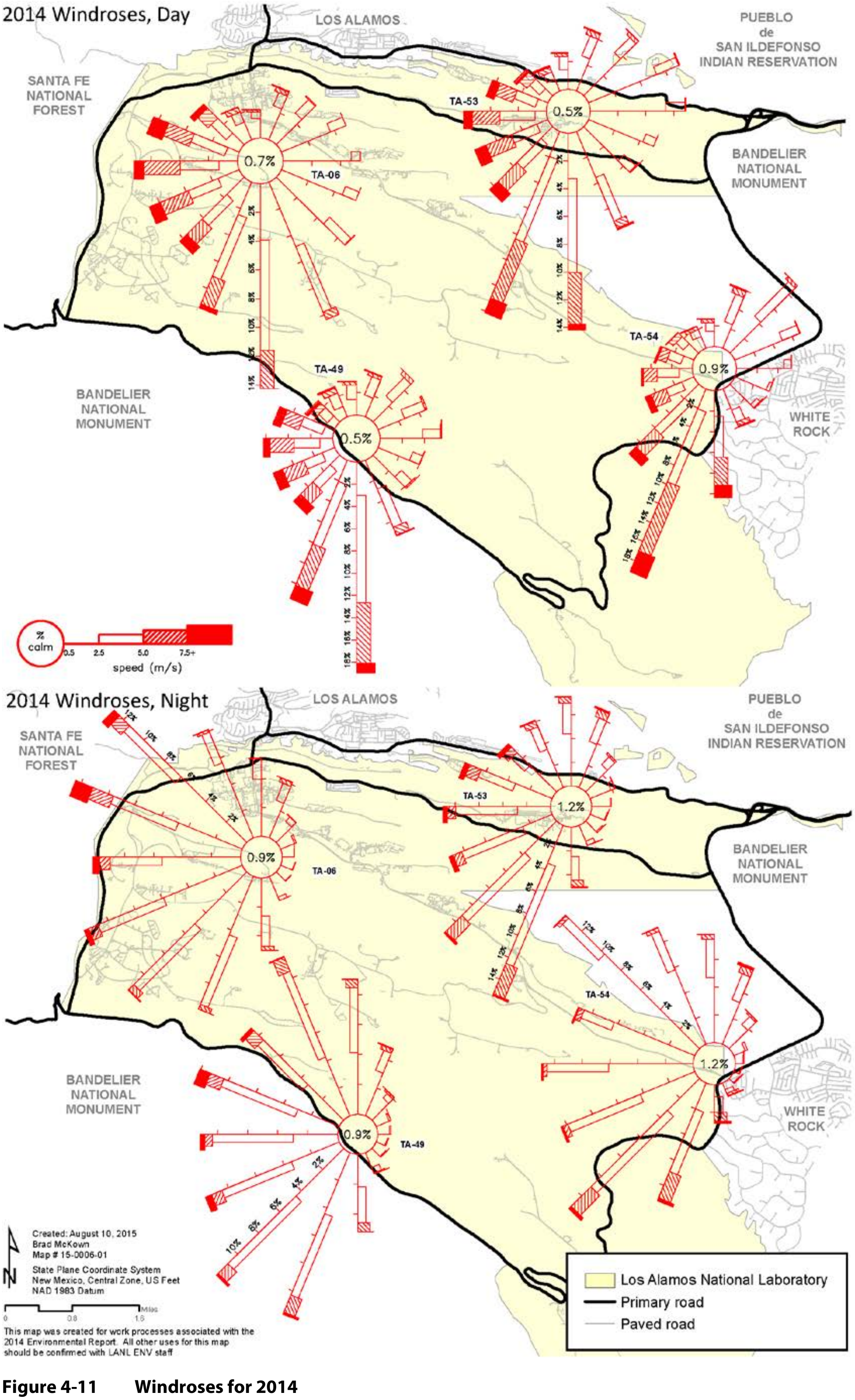


Figure 4-11 Windroses for 2014

6. Long-Term Climate Trends

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-12 shows the historical record of temperatures in Los Alamos from 1924 through 2014. 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 4-12. 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. 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.

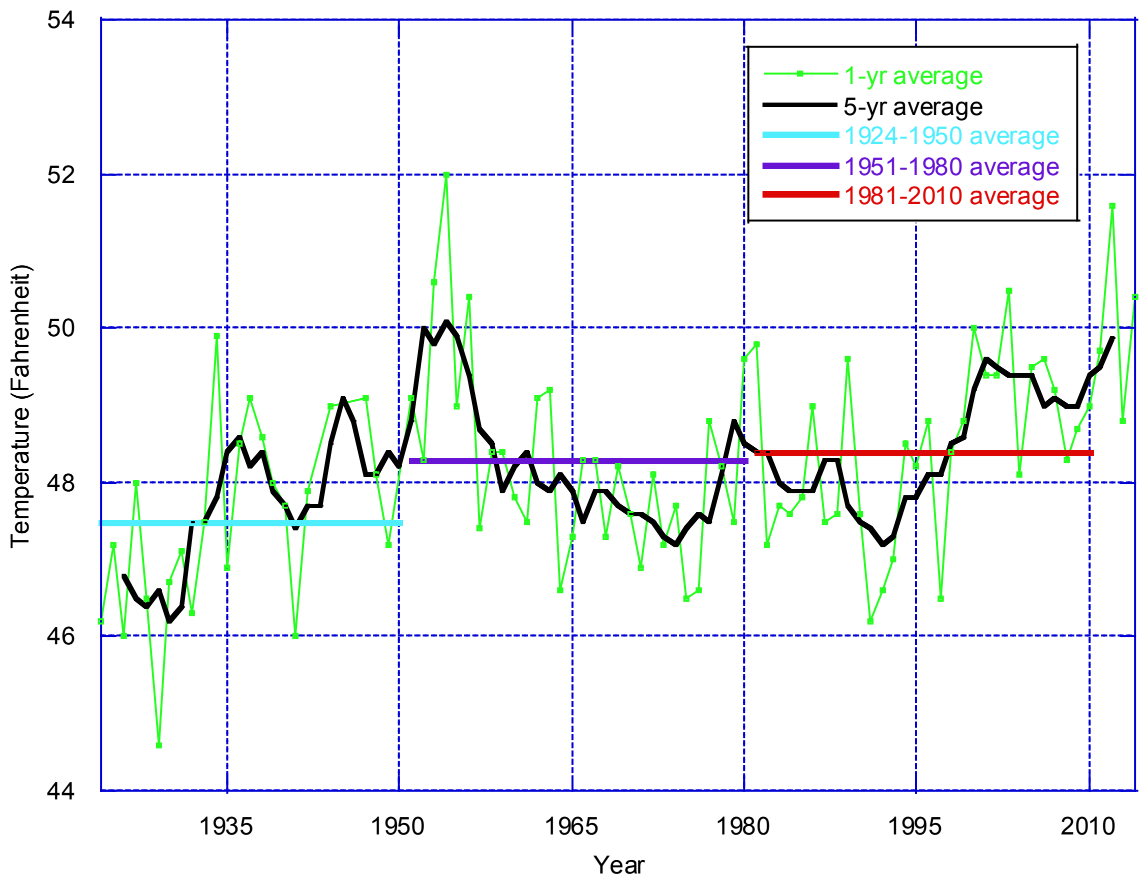


Figure 4-12 Temperature history for Los Alamos

The TA-06 decade average temperatures, along with two times the standard error, are plotted in Figure 4-13 with the annual average temperatures for 2011–2014. Ninety-five percent of the annual average temperatures during each decade are found within the error bars. During the decades between 1960 and 2000, the annual average temperatures in Los Alamos vary only slightly from 48°F. During the 2001–2010 decade, the annual average temperature jumped to above 49°F, and this value can be considered a statistically significantly higher value than previous decades. The annual average temperatures in 2011, 2012, 2013, and 2014 continue to demonstrate a warmer climate for Los Alamos. This is consistent with predictions for a warming climate in the southwestern United States (IPCC 2014).

Figure 4-14 presents the historical record of the annual precipitation at TA-06. The most recent drought has essentially spanned the years 1998 through 2014, although near-average precipitation years occurred from 2004 to 2010. As with the historical temperature profile, the 5-yr running mean and the 30-yr normal values are also shown.

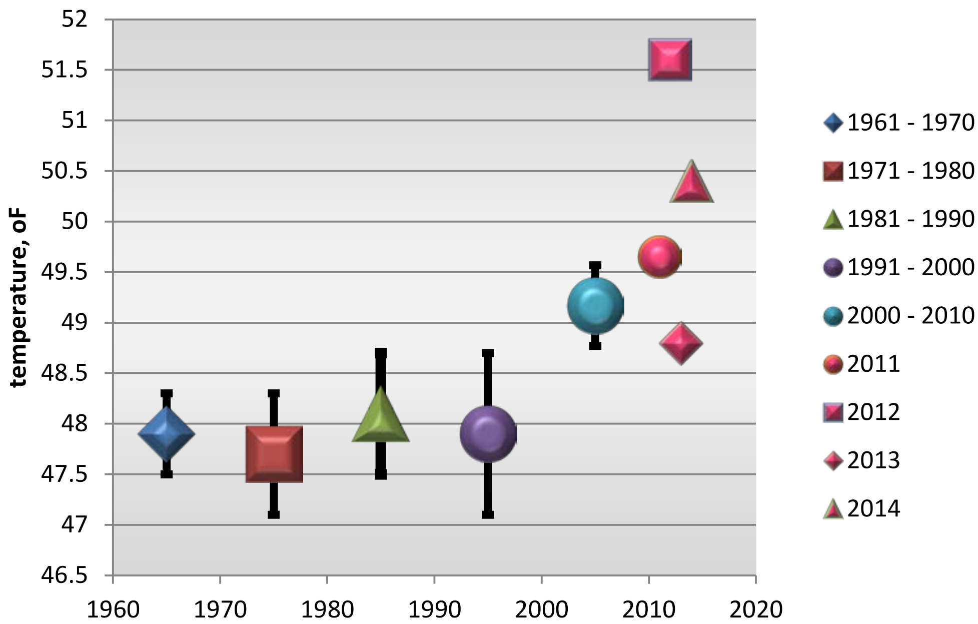


Figure 4-13 TA-06 decade average temperatures and two times the standard error

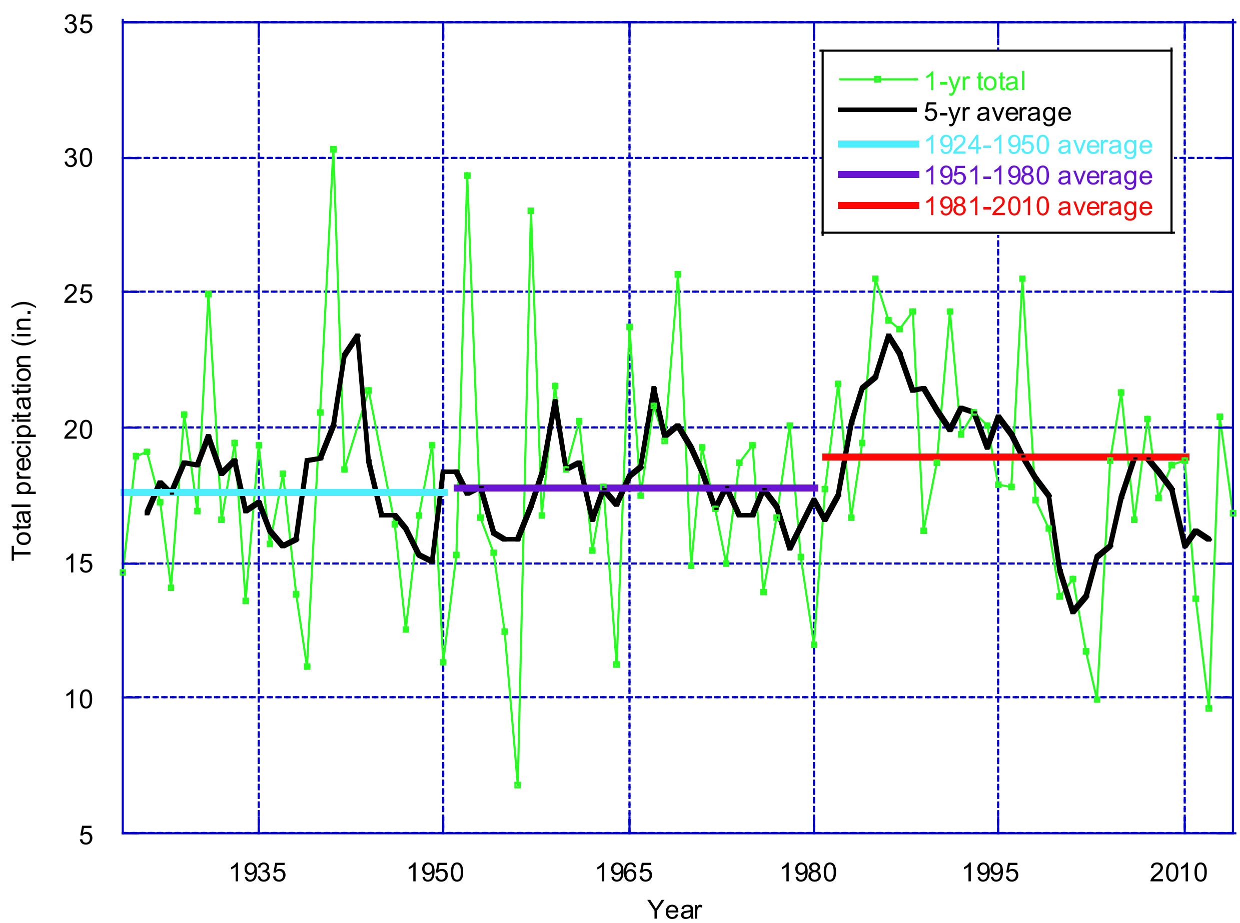


Figure 4-14 Total precipitation history for Los Alamos

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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 potential remedial actions, where necessary. Other wells are used to monitor and ensure protection from 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.

Contaminants from historical Laboratory operations are present in deep groundwater in the intermediate-perched zones and the regional aquifer primarily associated with past liquid effluent discharges. The development of the current site-wide groundwater monitoring network and subsequent monitoring indicates that only two areas have notable groundwater contamination, RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) contamination in the Technical Area 16 (TA-16) area and chromium and perchlorate contamination beneath Sandia and Mortandad Canyons. 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.

RDX contamination primarily associated with past effluent from machining of high explosives at TA-16 has infiltrated into perched-intermediate groundwater beneath Cañon de Valle and locally exceeds the U.S. Environmental Protection Agency regional screening level for tap water (7.0 micrograms per liter [µg/L]).

Hexavalent chromium from discharges that occurred from 1956 to 1972 is present in the regional aquifer beneath Sandia and Mortandad Canyons at concentrations above the 50-µg/L New Mexico (NM) groundwater standard. Perchlorate at concentrations above the 4-µg/L Compliance Order on Consent screening level is also present in the regional aquifer beneath Mortandad Canyon.

The regional aquifer is the source of 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.

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. A regional-scale aquifer is found at depths ranging from 600 to 1200 ft below ground surface. The Los Alamos County public water supply comes from wells that draw water from the regional aquifer. Groundwater protection efforts at the Laboratory focus on the regional aquifer but also include small bodies of shallow perched groundwater found locally within canyon-floor alluvium and in rocks and sediments at intermediate depths between the canyon bottoms and 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 characterization and monitoring 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 2014 was carried out according to the Interim Facility-Wide Groundwater Monitoring Plans (IFGMPs) (LANL 2013, 2014a) 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 portion of the Jemez Mountains (Figure 5-1). 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.

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, which originate primarily from a volcanic center east of the Rio Grande, 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

The Laboratory land sits atop a thick zone of mainly unsaturated rock and sediments, with the regional 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) above the regional aquifer. Perched groundwater is a zone of saturation with limited extent that is retained above less permeable layers and is separated from underlying groundwater by unsaturated rock.

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

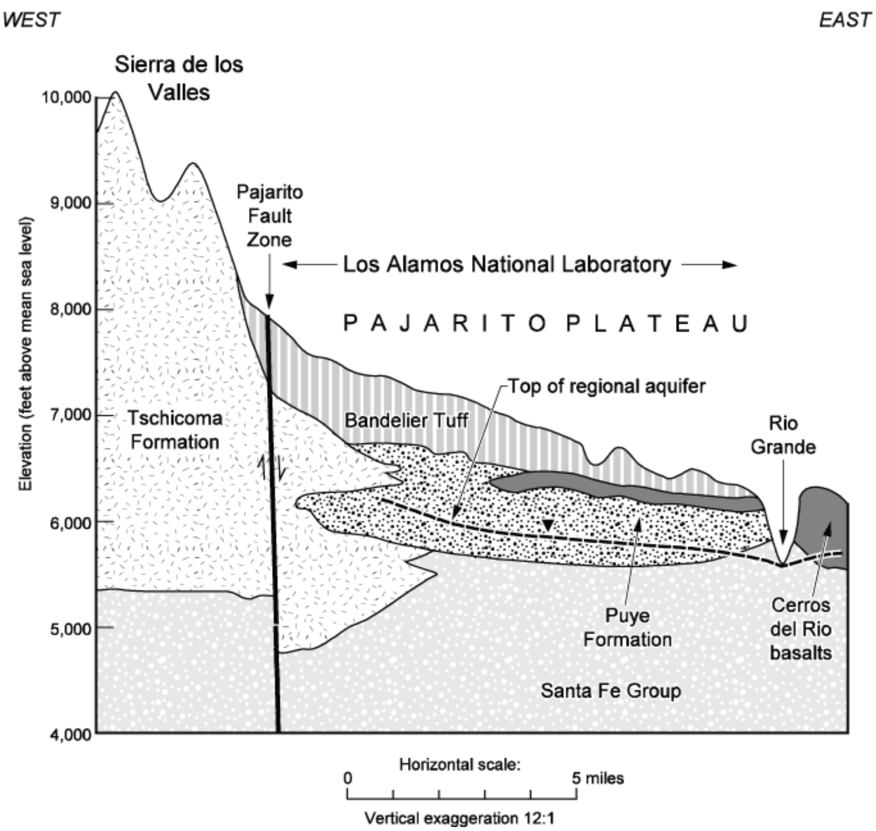

Figure 5-1 **Generalized geologic cross-section of the Pajarito Plateau**

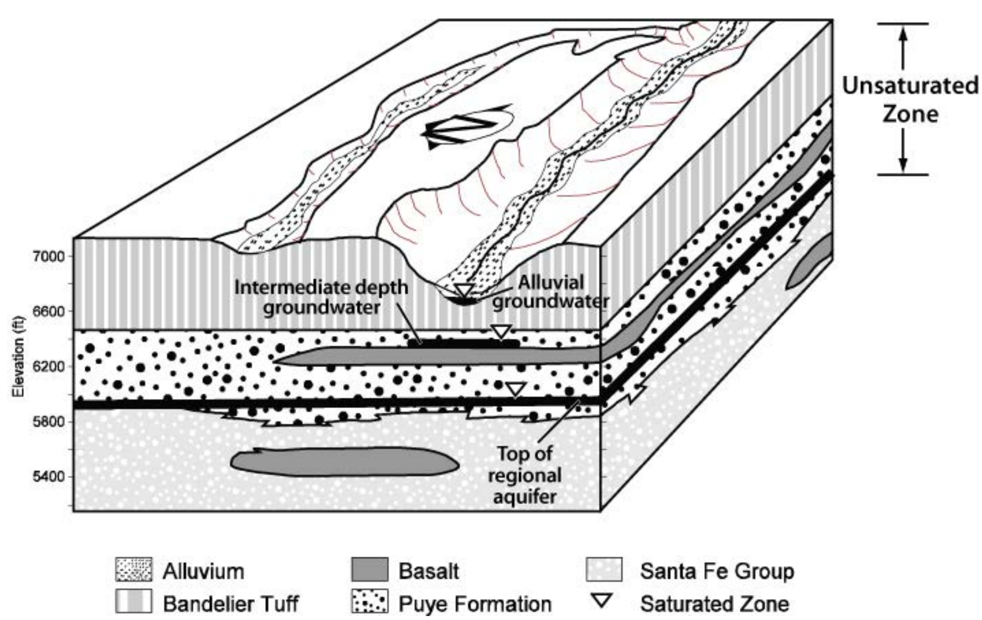

Figure 5-2 **Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence**

Most of the canyons on the Pajarito Plateau have little and infrequent surface water flow and, therefore, little or no alluvial groundwater. A few canyons have limited segments in the western portion of the Laboratory where surface water flow supported by mountain-front runoff creates localized saturation in canyon-bottom alluvium. Mountain-front runoff is also supplemented or maintained by Laboratory discharges in a few instances. 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 areal extent but may extend beneath adjacent mesas. 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. 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 flow velocities vary spatially but are typically 30 ft/yr.

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

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 unsaturated rock that underlies them, restricts their volumetric contribution to recharge reaching the regional aquifer.

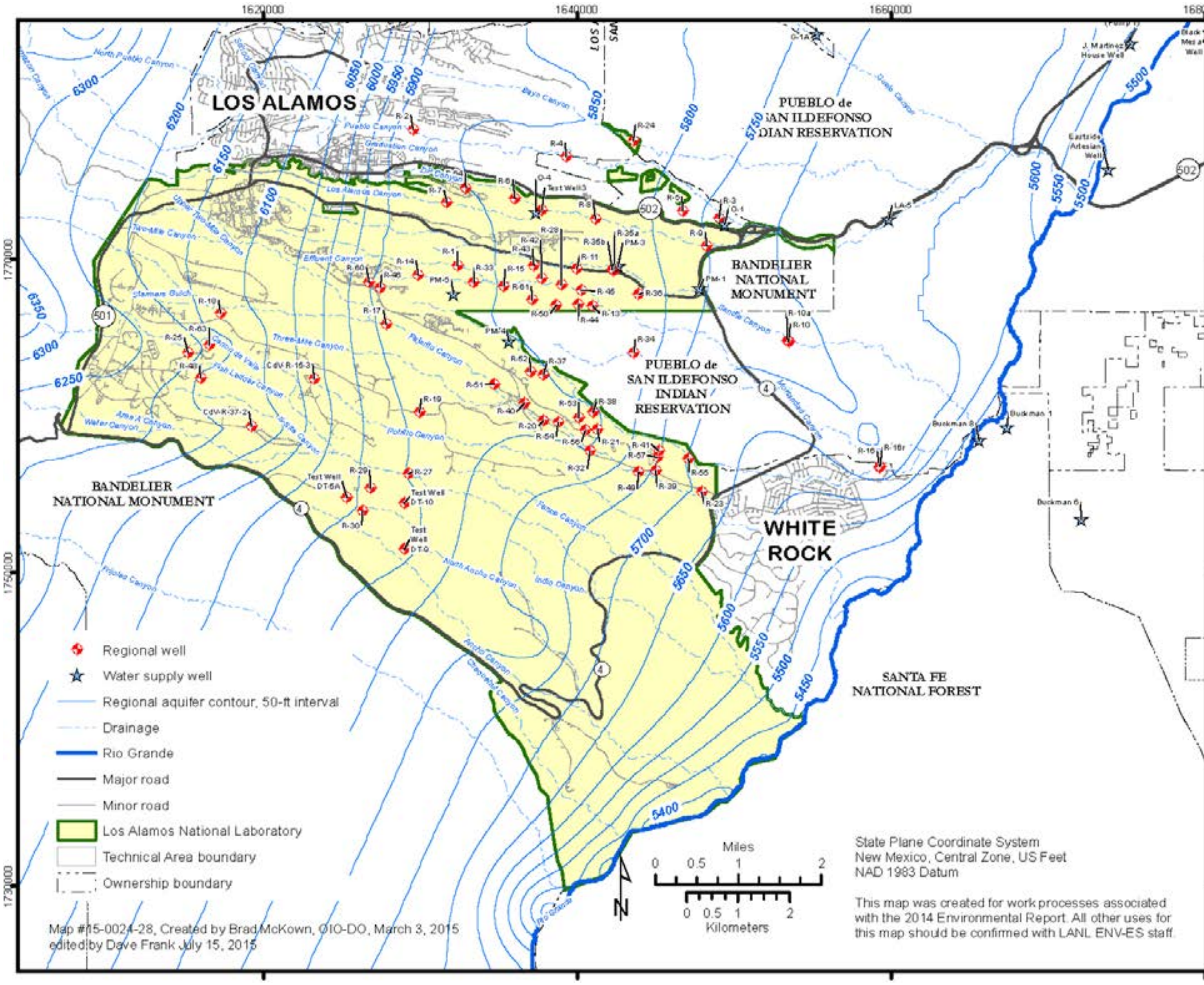

Figure 5-3 **Contour map of average water table elevations for the regional aquifer. This map represents a generalization of the data.**

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.

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.

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.

DOE Order 458.1, Radiation Protection of the Public and the Environment, establishes dose limits for radiation protection and provides derived concentration technical standards (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 2014 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. Procedures for Collecting Groundwater and Surface Water Samples

The Laboratory implements several standard operating procedures (SOPs) to collect groundwater, base-flow, and spring samples. These procedures are listed in Table 5-2. These procedures (or their equivalent used by sampling subcontractors) are used during sampling activities conducted in accordance with the Monitoring Year 2014 IFGMP (LANL 2014a). Current versions of the SOPs are listed at http://www.lanl.gov/community-environment/environmental-stewardship/plans-procedures.php, and are available at the Laboratory's Electronic Public Reading Room at http://eprr.lanl.gov. A more detailed summary is provided in Appendix B of the 2014 IFGMP (LANL 2014a).

3. 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 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. 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.)

Table 5-2
SOPs Used to Collect Groundwater, Base-Flow, and Spring Samples

Procedure Identifier	Procedure Title	Applicability
Collection of Groundwater Samples		
SOP-20032	Groundwater Sampling	Procedure for sampling groundwater using various types of pumps. Procedure also addresses sampling of water-supply wells and domestic wells.
SOP-5225	Groundwater Sampling Using Westbay MP System	Procedure for sampling groundwater using the Westbay multiport (MP) system
SOP-5061	Field Decontamination of Equipment	Procedure for field decontamination of equipment
Collection of Surface Water and Spring Samples		
SOP-5224	Spring and Surface Water Sampling	Procedure for sampling springs and surface water
Sample Preparation, Preservation, and Transportation		
SOP-5056	Sample Containers and Preservation	Procedure specifying sample containers, collection and preservation techniques, and holding times
SOP-5057	Handling, Packaging, and Transporting Field Samples	Procedure for sample packaging and shipping
SOP-5059	Field Quality Control Samples	Procedure for collection of field quality control samples, including field duplicates, equipment rinsate blanks, and trip blanks
SOP-5255	Shipping of Environmental Samples by the WES Sample Management Office (SMO)	Procedure for receiving, packaging, and shipping samples to analytical laboratories

D. POTENTIAL SOURCES OF CONTAMINATION

Historical liquid effluent discharges have affected all three groundwater zones. Contaminants are found in perched-intermediate groundwater and in the regional aquifer associated with historical releases where large amounts of effluent containing large amounts of soluble constituents were discharged. Figure 5-4 shows the key locations where effluent was historically or currently discharged.

Because the alluvial and intermediate-perched groundwater bodies are separated from the regional aquifer by hundreds of feet of unsaturated material, 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. Descriptions of other key effluent locations are found in Chapter 5 of the Laboratory's 2013 annual site environmental report (LANL 2014b).

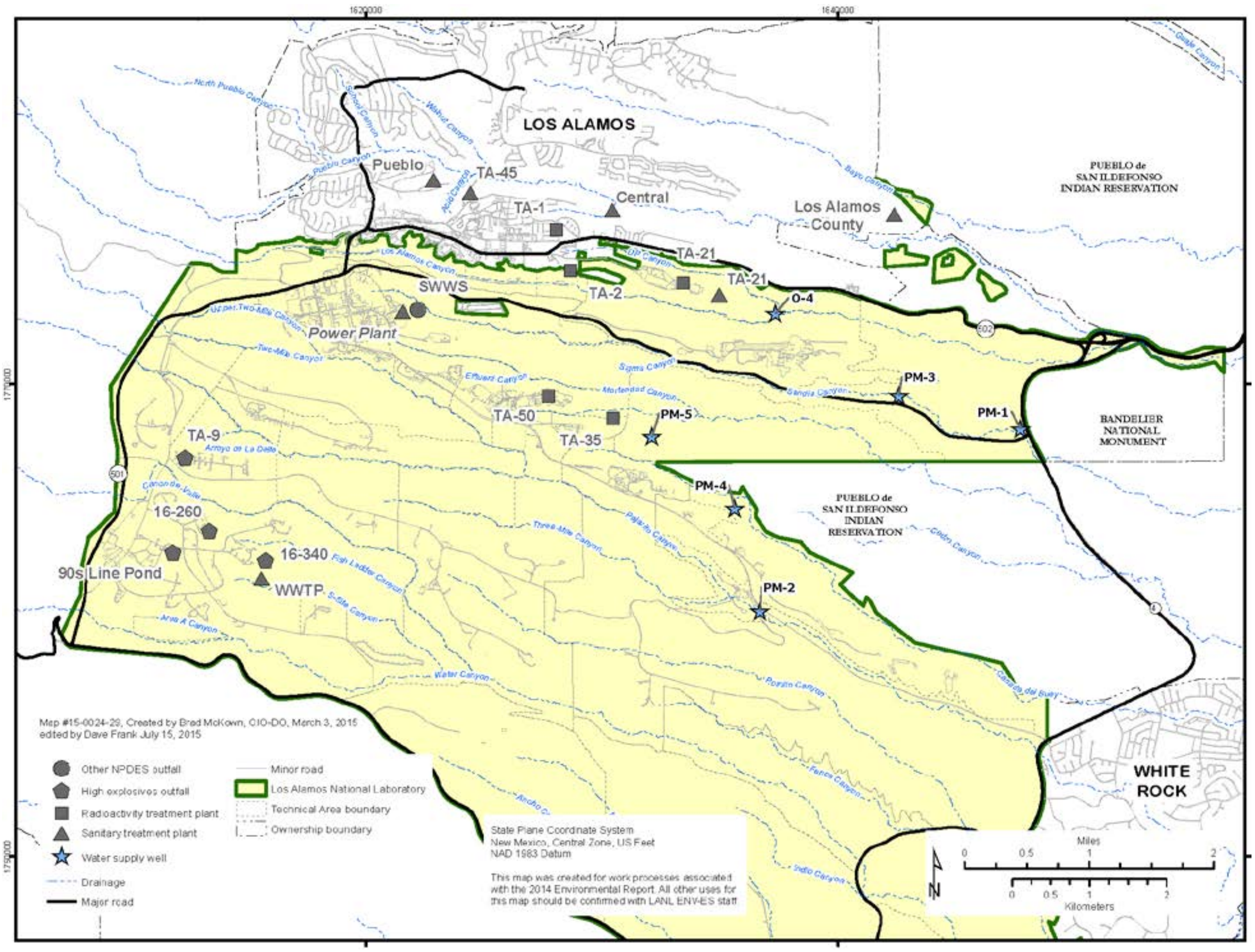

Figure 5-4 **Major liquid release outfalls (effluent discharge) potentially affecting groundwater; most outfalls shown are inactive**

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 2014 was carried out according to two IFGMPs (LANL 2013, 2014a). 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.

Monitoring is conducted at surface water locations, at alluvial, perched-intermediate, and regional aquifer well locations, and at springs that discharge perched-intermediate and regional aquifer groundwater. Monitoring is primarily organized in the IFGMP in area-specific monitoring groups related to project areas (Figure 5-5). Area-specific monitoring groups are defined for Technical Area 54 (TA-54), TA-21, Material Disposal Area (MDA) AB, MDA C, the Chromium Investigation, and the TA-16 260 Outfall. 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). Numerous springs along the Rio Grande are also monitored because they represent natural discharge from perched-intermediate and regional aquifer groundwater that flows beneath the Laboratory into the Rio Grande as shown in Figure 5-7 (Purtymun et al. 1980).

The Laboratory also collects samples from 12 Los Alamos County water-supply wells in 3 well fields that produce drinking water for the Laboratory and the Los Alamos County (Figure 5-7). Additional samples are collected from wells located on Pueblo de San Ildefonso lands and from the Buckman wellfield operated by the City of Santa Fe. This chapter also reports on the Laboratory's supplemental sampling of those wells. 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 represent perched-intermediate groundwater, and wells LLAO-1b and LLAO-4 represent alluvial groundwater.

F. GROUNDWATER INTERPRETATION

The groundwater quality monitoring data for 2014 are available at http://www.intellusnmdata.com.

The analytical laboratory reports results relative to several defined measurement levels. The method detection limit (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 Part 136, Appendix B).

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 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 concentrations (marked with a J flag).

Analytical results for nondetects are reported at the PQL; estimated results are not. 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 considered a detected concentration, a radiological measurement must be greater than the minimum detectable activity.

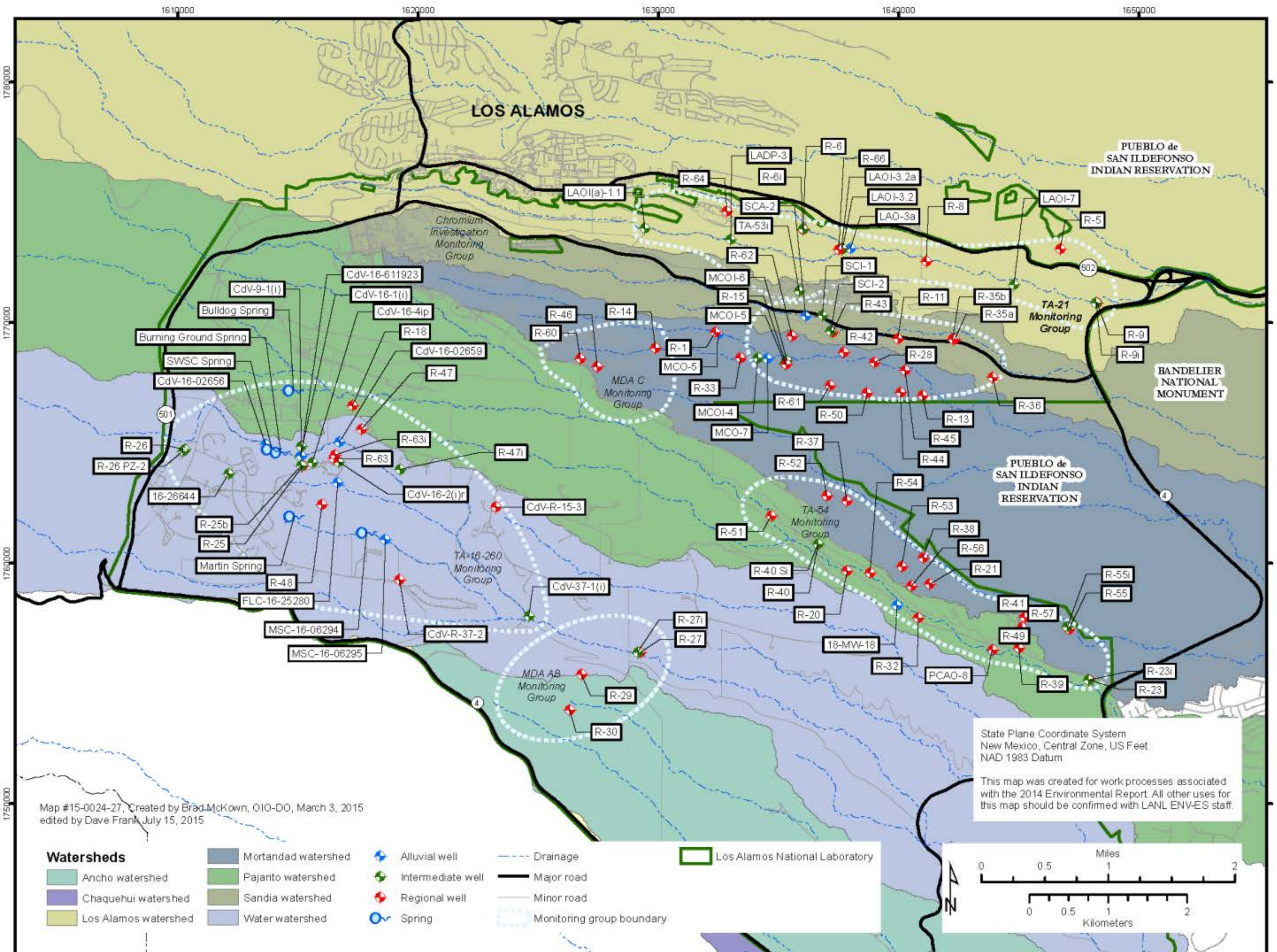

Figure 5-5 Groundwater monitoring wells and springs assigned to area-specific monitoring groups

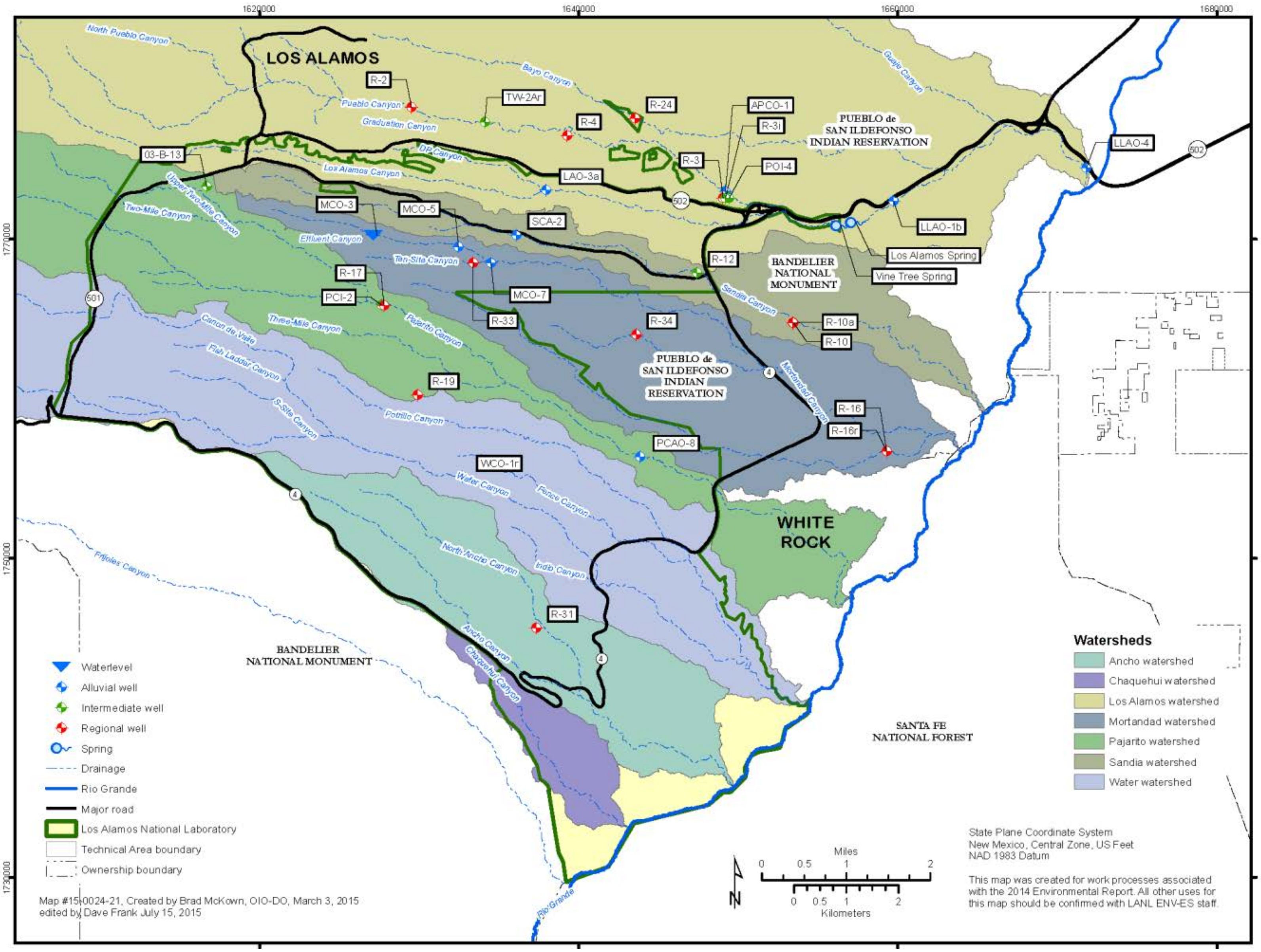

Figure 5-6 Groundwater monitoring wells and springs assigned to the General Surveillance monitoring group

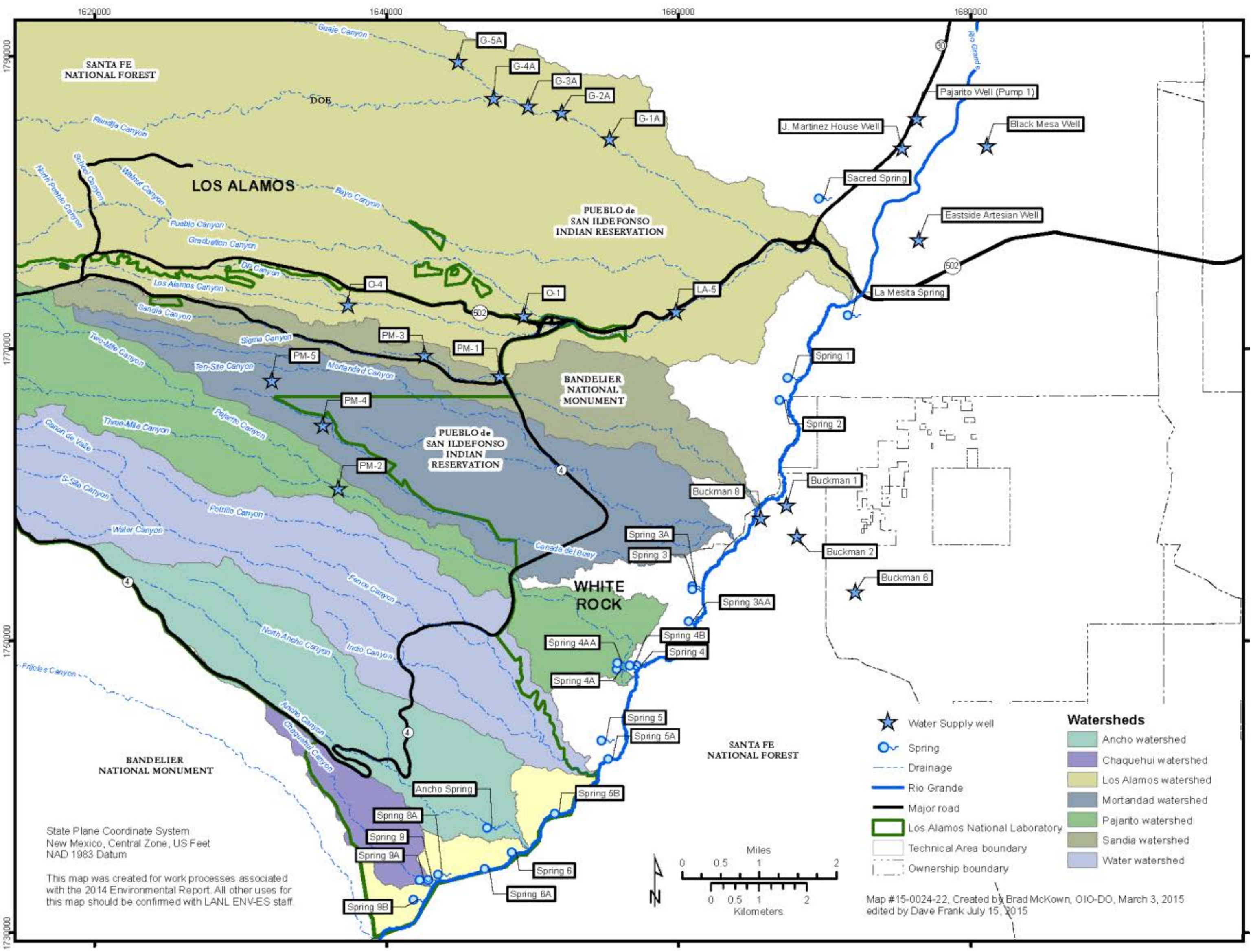

Figure 5-7 **Water-supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon**

G. GROUNDWATER SAMPLING RESULTS BY MONITORING GROUP

The following sections discuss groundwater sampling results for the six area-specific monitoring groups and the General Surveillance monitoring group, springs along the Rio Grande, locations on Pueblo de San Ildefonso, and Los Alamos County and City of Santa Fe water-supply wells. 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 above applicable standards or screening levels. Other constituents that are below standards or screening levels (such as tritium) are discussed in a few cases to track trends where potential Laboratory influences are observed. 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 provide temporal and spatial context for key contaminants.

1. Water-Supply Monitoring

a. Los Alamos County

The Laboratory collects samples from 12 Los Alamos County water-supply wells in 3 well fields that produce drinking water for the Laboratory and the community (Figure 5-7). All drinking water produced by the Los Alamos County water-supply system meets federal and state drinking-water standards. The water-supply wells have long screens at depths up to 1600 ft within the regional aquifer. Water quality samples collected from these wells therefore 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.

Water-supply well G-1A, in the Guaje well field, showed a detection of arsenic at 10.1 µg/L, which is nominally above the EPA's MCL of 10 µg/L. The Guaje well field is located northeast of the Laboratory. Naturally occurring arsenic has often been found in samples at concentrations around 10 µg/L since the well field was developed in the early 1950s. Arsenic is known as a naturally occurring constituent in groundwater and is particularly elevated in groundwater beneath the eastern portion of the Pajarito Plateau. No other water-supply wells showed detections above an applicable groundwater standard.

Perchlorate, presumably from past releases from Acid Canyon (Figure 5-4), has historically been present below the 4-µg/L screening level in water-supply well O-1 and has been steadily declining. The 2014 data show that the trend is maintained (Figure 5-8).

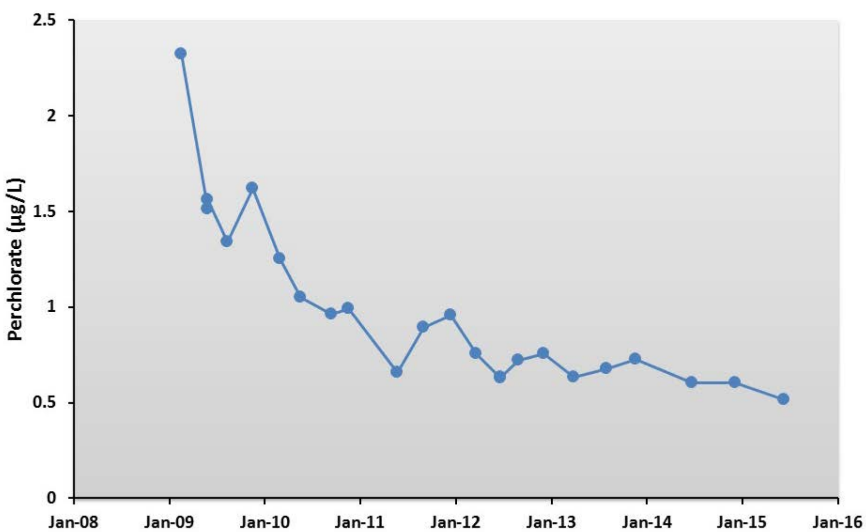

Figure 5-8 Perchlorate at water-supply well O-1 in Pueblo Canyon

b. Pueblo de San Ildefonso

Sampling from Pueblo de San Ildefonso water-supply wells in 2014 did not show any Laboratory constituents above applicable standards (Figure 5-7).

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. Elevated gross-alpha values for these wells are also consistent with the presence of uranium. Naturally occurring uranium concentrations near or exceeding the NM groundwater standard are prevalent in groundwater throughout the Nambe and Pojoaque area (Boukhalfa et al. 2013). The wells also have elevated natural concentrations of boron, fluoride, and arsenic.

c. City of Santa Fe

In 2014, the Laboratory sampled three wells, Buckman-1, -6, and -8 in the City of Santa Fe's Buckman well field. No Laboratory contaminants are present above standards for these locations. However, as in past samples, these wells contain naturally occurring uranium. Elevated gross-alpha values for these wells also reflect the presence of uranium. Naturally occurring arsenic is also elevated in some Buckman well field wells. Samples were also collected from four piezometers in the well field (LANL 2012a).

2. TA-21 Monitoring Group

The TA-21 monitoring group is located in and around TA-21 and is primarily located in upper Los Alamos Canyon (Figure 5-5). 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.

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 (Figure 5-4). 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).

Perched-intermediate groundwater samples from wells R-6i and LAOI-3.2 had perchlorate detections above the screening level of 4 µg/L (Figure 5-9). LAOI-3.2a had perchlorate detections, but they were below the screening level of 4 µg/L. The perchlorate is assumed to be associated with historical releases from SWMU 21-011(k), which was an outfall from industrial waste treatment plants at TA-21. Other contaminants, including nitrate, are present in these same wells but at levels below applicable standards. Perchlorate is not present above the screening level in regional aquifer wells within the TA-21 monitoring group. No action is being taken to address the perchlorate in the perched-intermediate zones at this time.

Gross alpha was detected above the 15-picocuries per liter (pCi/L) standard in well LAOI(a)-1.1. The time series for gross alpha is shown in Figure 5-10. The 2014 result is the highest detected in recent years. The gross alpha is from naturally occurring uranium and its decay products. The 2014 sample from this well showed elevated turbidity, further supporting the assumption that the gross alpha is naturally occurring.

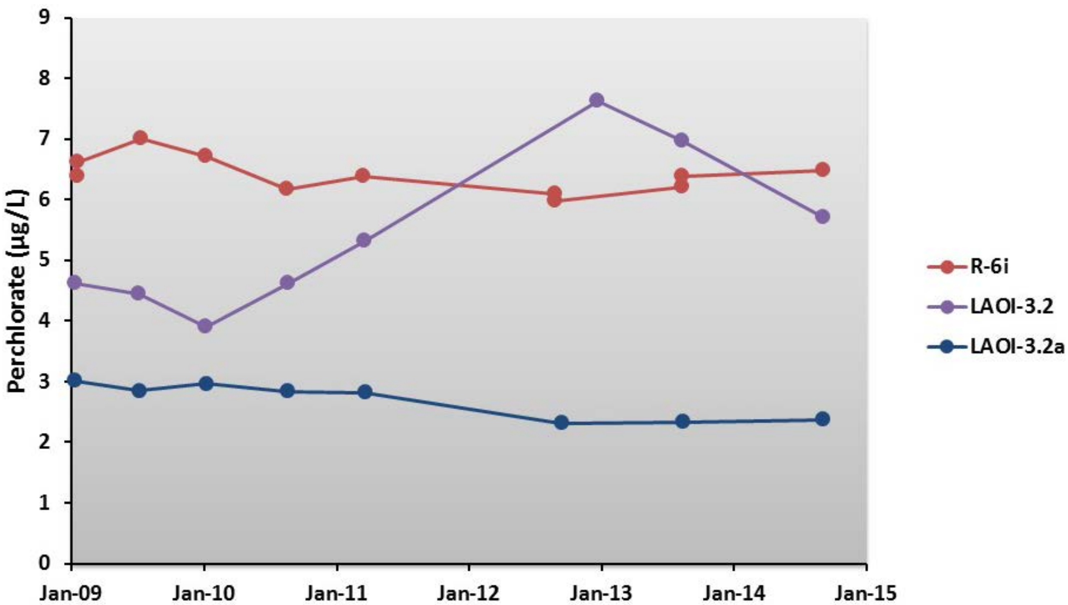

Figure 5-9 **Perchlorate in perched-intermediate groundwater in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

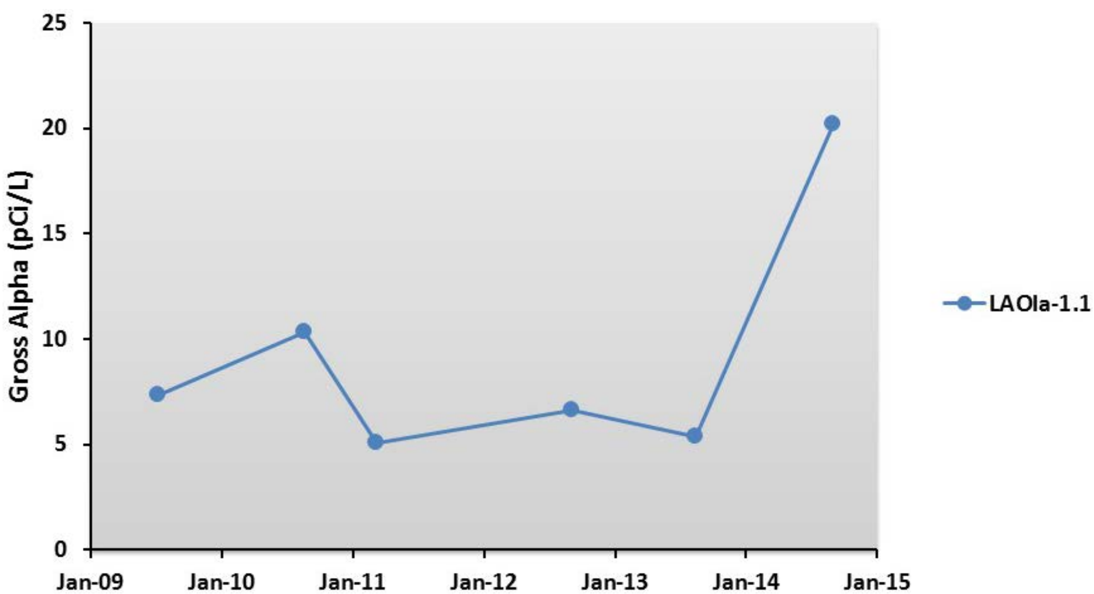

Figure 5-10 **Gross alpha in perched-intermediate well LAOIa-1.1. The gross-alpha measurements are related to naturally occuring uranium and its decay products.**

Several intermediate wells have tritium present in groundwater samples (Figure 5-11) that is likely from SWMU 21-011(k) and/or the Omega West Reactor. 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.

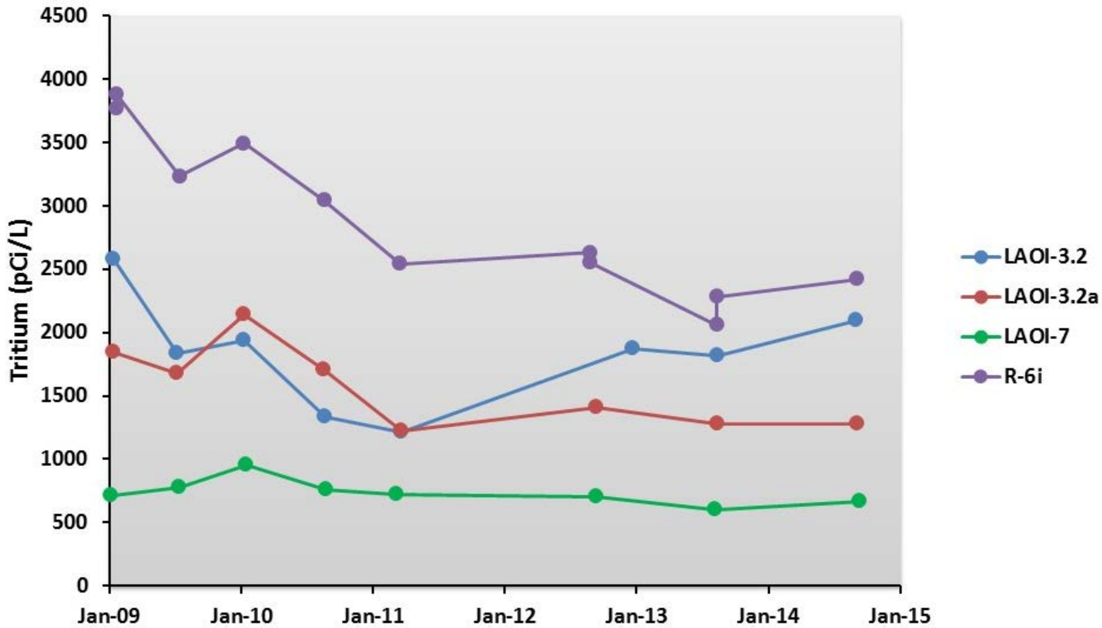

Figure 5-11 **Tritium in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL (which does not apply to these samples) is 20,000 pCi/L.**

3. Chromium Investigation Monitoring Group

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. Monitoring focuses on the characterization and fate and transport of chromium, and related contamination, in perched-intermediate groundwater and within the regional aquifer. The chromium plume in the regional aquifer occupies an area approximately 1 mi in length and about 0.5 mi wide (Figure 5-12). Contaminants within the plume are found within 100 ft or less of the regional aquifer water table as demonstrated by a series of two-screen wells that monitor the plume (LANL 2009a, 2012b).

The distribution of wells in the monitoring group also addresses past releases from National Pollutant Discharge Elimination System (NPDES) Outfall 051, which discharged from the Radioactive Liquid Waste Treatment Facility (RLWTF) into the Mortandad Canyon watershed.

The RLWTF discharged effluent containing radioactivity into Mortandad Canyon from 1963 to 2010 through NPDES Outfall 051 (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).

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. Treated sanitary effluent from the TA-46 Sanitary Wastewater System Plant has been routed to Sandia Canyon since 1992. From 1956 to 1972, potassium dichromate was used as a corrosion inhibitor in the cooling system at the power plant (LANL 1973). These earlier discharges are associated with the hexavalent chromium concentrations observed in perched-intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons. Sandia and Mortandad Canyons lie close together, and water percolating downward beneath Sandia Canyon may have been partially diverted to the south by southwesterly dipping strata before reaching the regional aquifer (LANL 2006a, 2008b, 2009a).

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. Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35.

The 2014 chromium concentrations exceeded the NM groundwater standard of 50 μg/L in five regional aquifer wells: R-28, R-42, R-62, R-50 Screen 1 (S1), and R-43 S1 (Figure 5-13). The trend in chromium concentrations for these wells is shown in Figure 5-14. Although showing high annual variability, the wells within the centroid, R-42 and R-28, show the chromium trend as relatively flat, whereas several wells along the edge of the plume, namely R-45 S1, R-43 S1, and R-50 S1, are showing increasing concentrations of chromium (Figure 5-15). Two perched-intermediate wells also had chromium concentrations above the standard: SCI-2 and MCOI-6. The time series for chromium in these wells is shown in Figure 5-16.

A smaller area with perchlorate contamination is also present in groundwater beneath Mortandad Canyon. Perchlorate exceeded the Consent Order screening level of 4 μg/L in only one actively monitored regional aquifer well within the monitoring group, R-15, and in perched-intermediate wells MCOI-5 and MCOI-6. The perchlorate concentration trend in regional well R-15 is generally flat, following several years of slight increases (Figure 5-17). In the perched-intermediate wells MCOI-5 and MCOI-6, the perchlorate concentration trends are also generally flat (Figure 5-18). The primary source of perchlorate is effluent discharges from the TA-50 RLWTF that occurred from 1963 until improvements in removal of perchlorate from RLWTF effluent in March 2002. Ongoing monitoring will be used to evaluate whether the elimination of the source of perchlorate will manifest as decreasing concentrations in perched-intermediate wells and eventually in the regional aquifer. Other constituents detected at concentrations above screening levels in the Chromium Investigation monitoring group include 1,4-dioxane in perched-intermediate wells MCOI-5 and MCOI-6 (Figure 5-19).

Intermediate wells MCOI-5 and MCOI-6 have tritium concentrations that continue to decline since 2007, reflecting significant improvements in water quality from the RLWTF outfall. These concentrations are far below the EPA MCL of 20,000 pCi/L (Figure 5-20).

A conceptual model for the sources and spatial distribution of these contaminants is presented in the Investigation Report for Sandia Canyon and in the Phase II Investigation Report for Sandia Canyon (LANL 2009a, LANL 2012b). 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 and in the Phase II Investigation Report for Sandia Canyon (LANL 2009a, LANL 2012b).

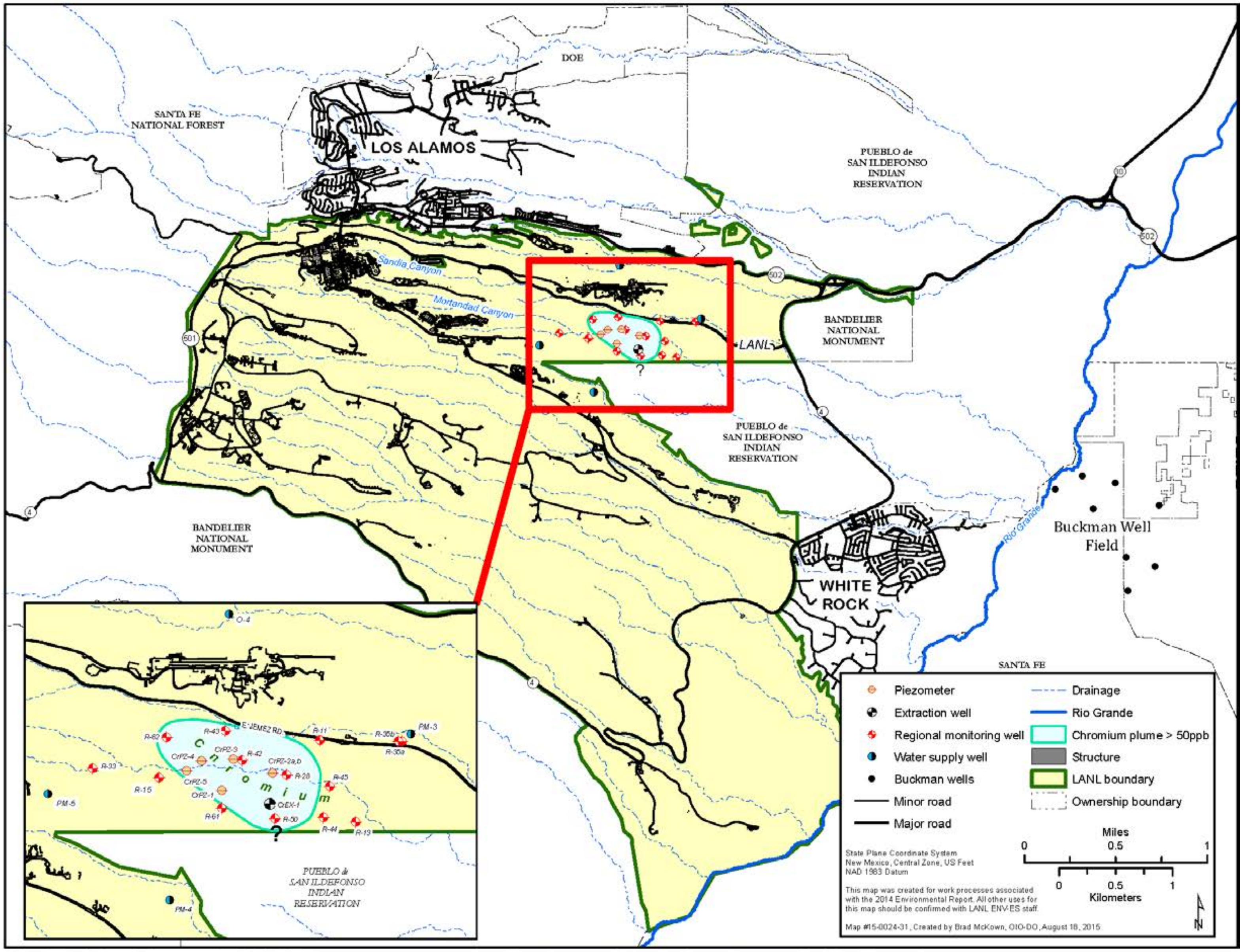

Figure 5-12 Approximation of chromium plume footprint at the Laboratory as defined by 50-µg/L NMED groundwater standard

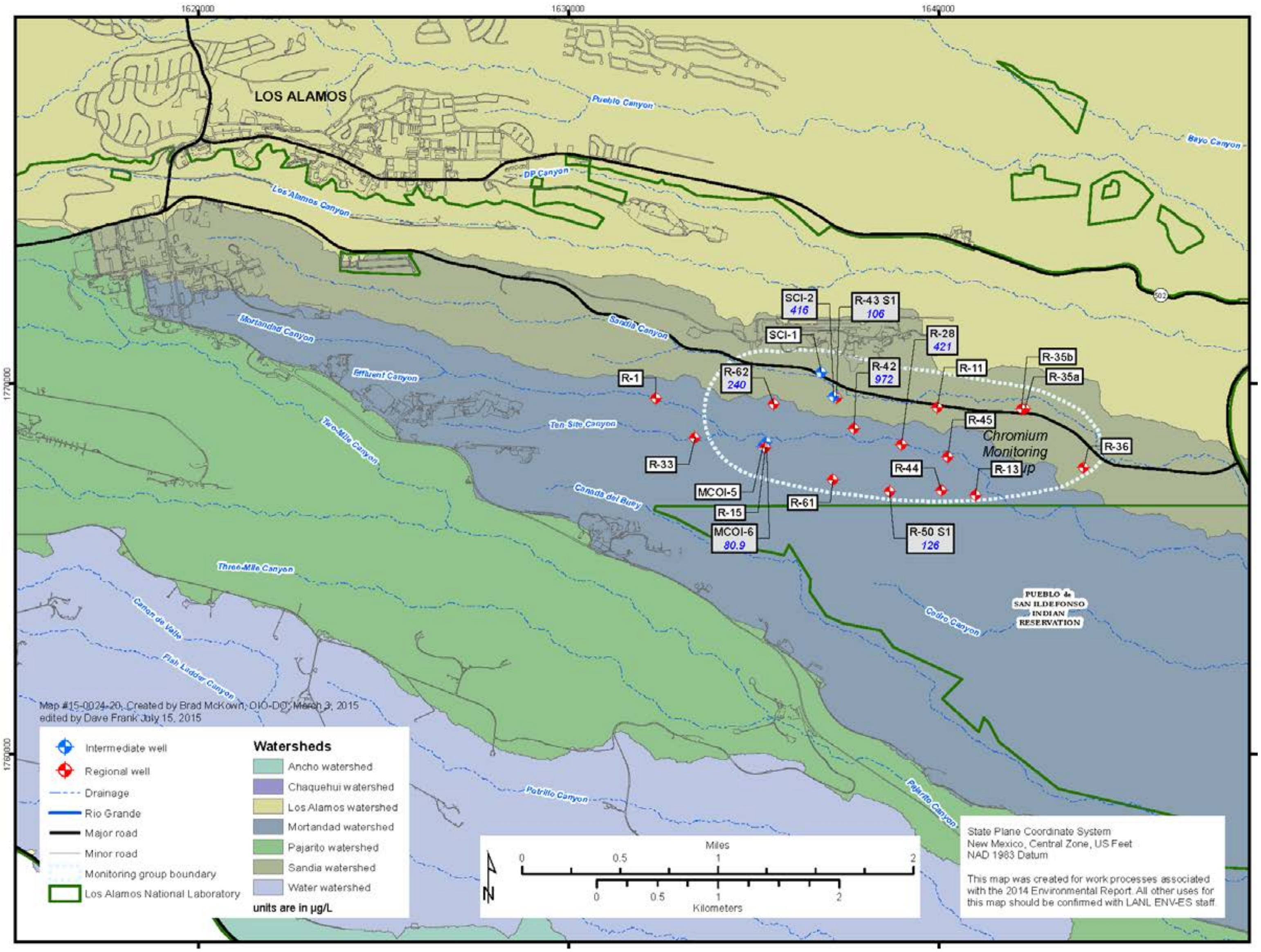

Figure 5-13 Filtered chromium in the Chromium Investigation monitoring group regional aquifer monitoring wells. Labels for the wells also show maximum chromium concentrations detected in 2014. The NM groundwater standard is 50 µg/L.

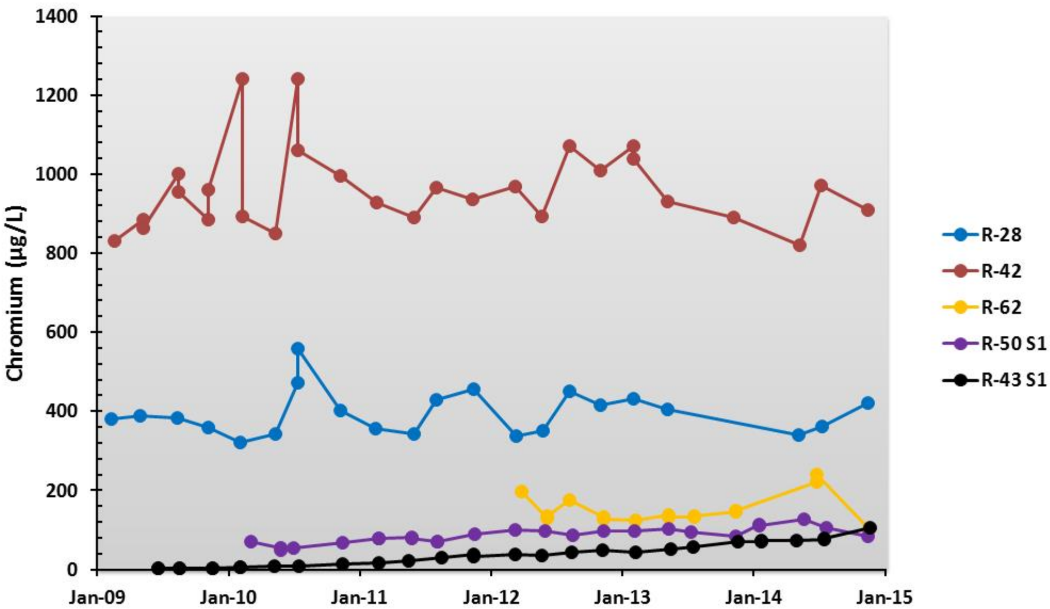

Figure 5-14 Trends in chromium concentrations at five regional aquifer wells that exceeded the chromium standard of 50 µg/L within the Chromium Investigation monitoring group

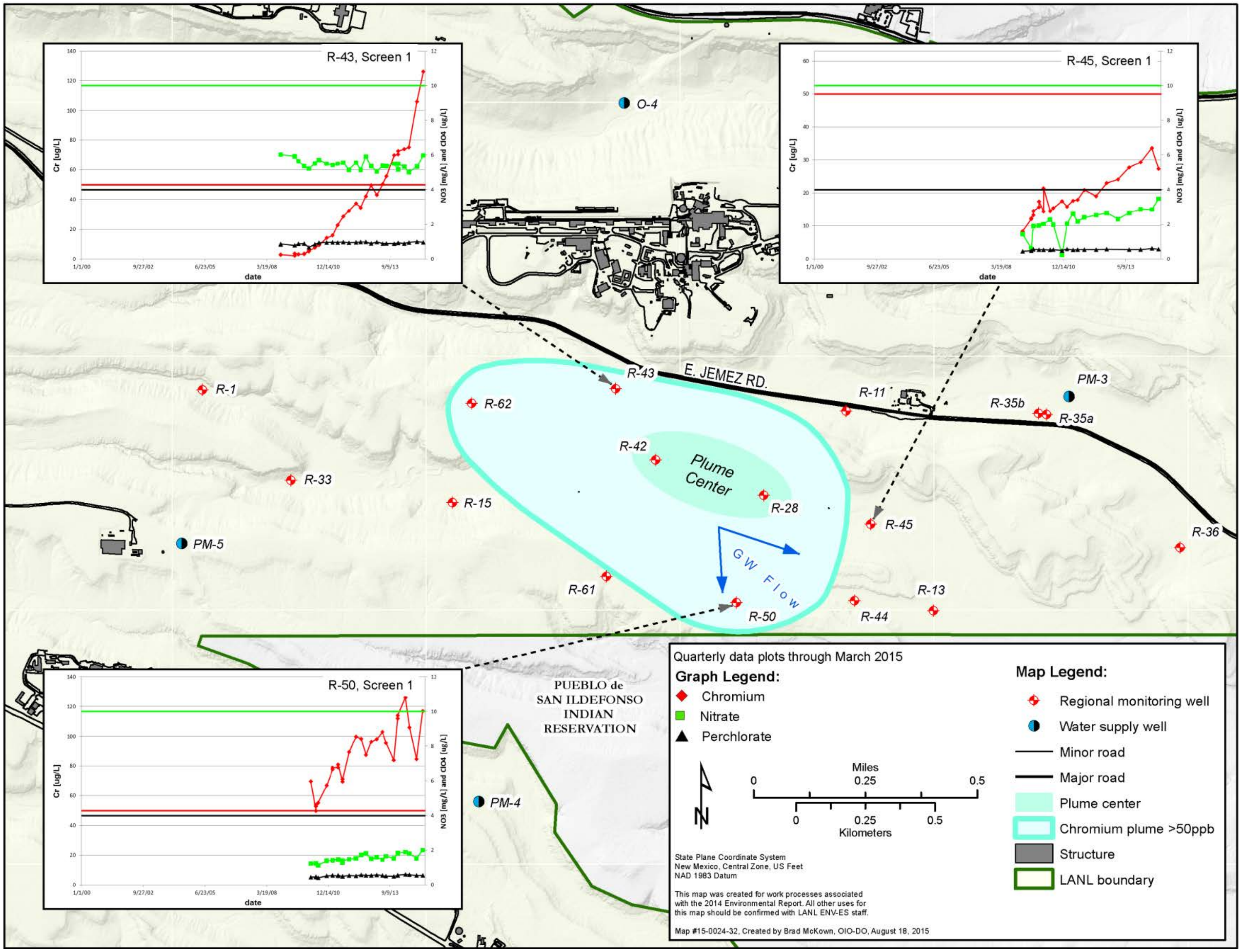

Figure 5-15 **Time-series plots of three regional aquifer wells within the Chromium Investigation monitoring group. Plots show trends for chromium (red), nitrate (green), and perchlorate (black).**

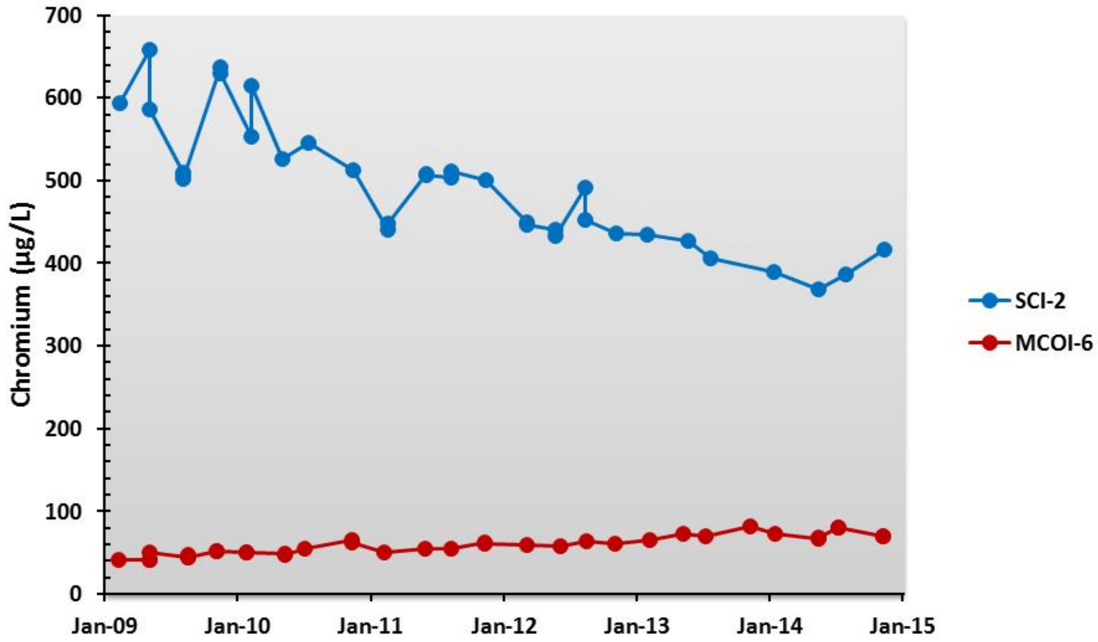

Figure 5-16 Trends in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The NM groundwater standard is 50 µg/L.

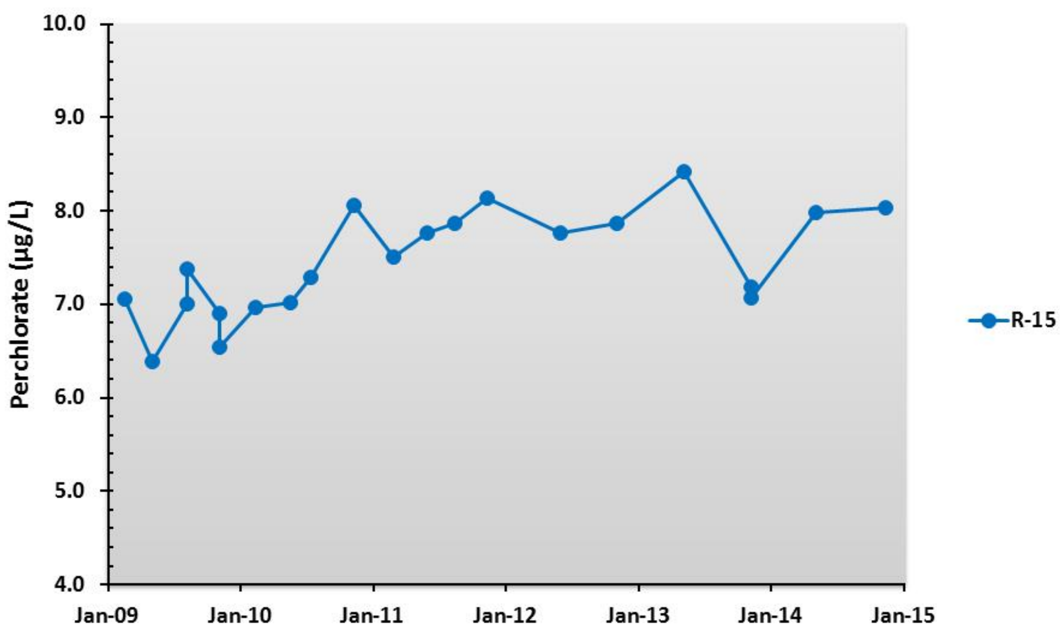

Figure 5-17 Perchlorate at regional aquifer well R-15 in the Chromium Investigation monitoring group. The Consent Order screening level is 4 µg/L.

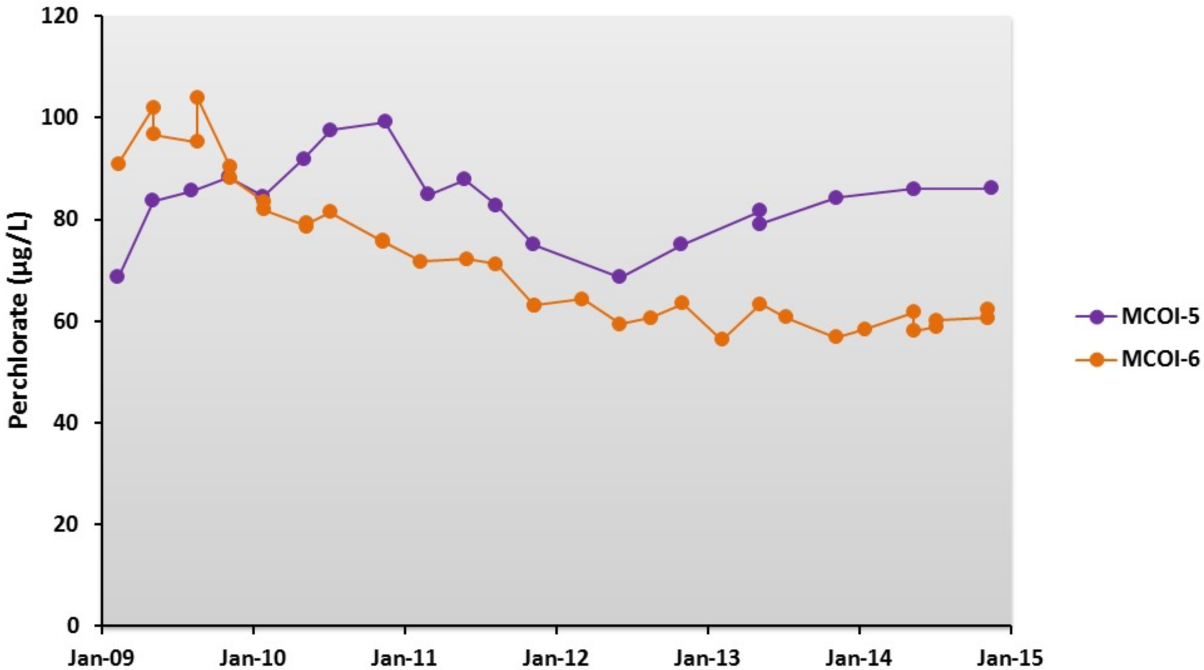

Figure 5-18 Perchlorate in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The Consent Order screening level is 4 µg/L.

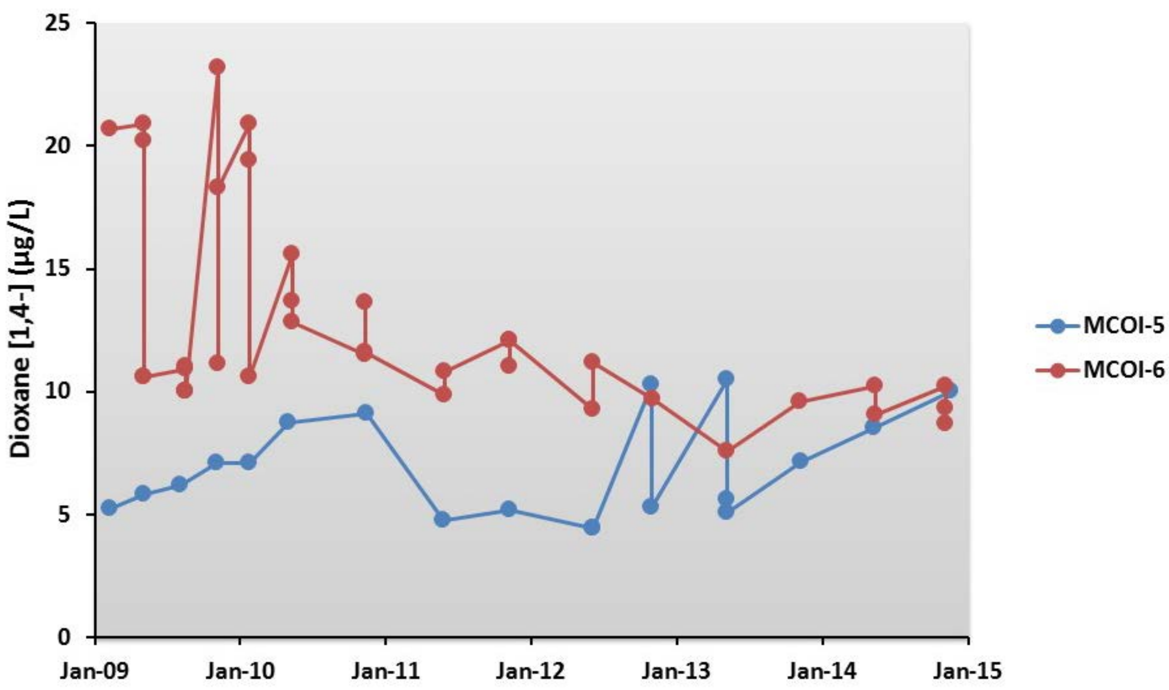

Figure 5-19 Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The EPA MCL for 1,4-dioxane is 7.8 µg/L.

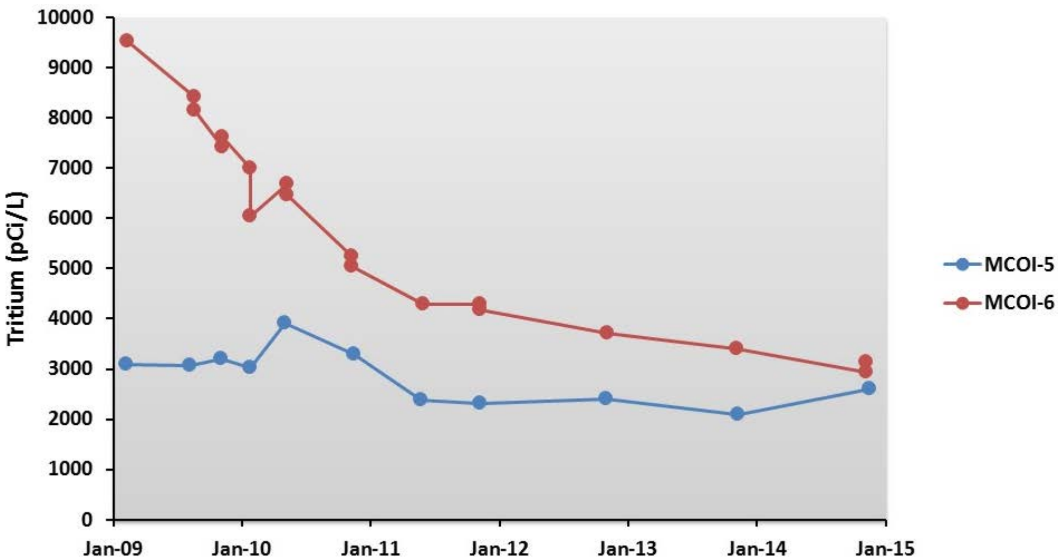

Figure 5-20 Tritium in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The EPA MCL for tritium is 20,000 pCi/L.

4. MDA C Monitoring Group

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 (Figure 5-5). MDA C is an inactive landfill where solid low-level radioactive wastes and chemical wastes were disposed of between 1948 and 1974. Vapor-phase volatile organic compounds (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 immediately downgradient of MDA C, and no perched-intermediate zones have been encountered in the area.

5. TA-54 Monitoring Group

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) Consent Order monitoring 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 includes both intermediate-perched and regional wells in the near vicinity (Figure 5-5).

Pore-gas monitoring data show vapor-phase VOCs 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; and Freon-113. Tritium is also present in the vadose zone (LANL 2005b, 2006b, 2007a).

Data from the groundwater monitoring network around TA-54 show sporadic detections of a variety of contaminants, including several VOCs. However, no contaminants were detected above applicable standards or screening levels. The temporal and spatial nature of the occurrences does not, however, clearly indicate that they are from sources at TA-54 (LANL 2009b). Tritium is also not detected in any of the regional aquifer groundwater monitoring wells in the TA-54 monitoring group, which may suggest sources other than TA-54 for the sporadic hits of other constituents described above. 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, 2011d).

6. TA-16 260 Monitoring Group

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 high-explosives- (HE-) processing sites in TA-16 and TA-09 (Figure 5-4). 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. 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, and other sites at TA-16. The TA-16 260 Outfall discharged HE-bearing water from an HE-machining facility to Cañon de Valle from 1951 through 1996.

Discharges from the former TA-16 260 Outfall at Consolidated Unit 16-021(c)-99 from 1951 to 1996 served as a primary source of HE and inorganic contamination found throughout the site (LANL 1998, 2003, 2011e). Results of the TA-16 260 Outfall corrective measures evaluation report (LANL 2007b) show the drainage channel below the outfall and the canyon bottom, as well as surface water, alluvial groundwater, and deep-perched groundwater, are contaminated with explosive compounds, including RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine); 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 trichloroethylene have been detected in springs, alluvial groundwater, and perched-intermediate groundwater. Low concentrations of tetrachloroethene have also been detected in the regional aquifer in R-25 (screen 5) and in R-18. RDX has also been detected in the regional aquifer in wells R-18 and R-63.

The primary migration pathway for these contaminants is thought to consist of (1) discharge as effluent from the TA-16 260 Outfall, (2) surface flow to Cañon de Valle via a small tributary drainage, (3) downcanyon transport by surface-water flow and alluvial groundwater, and (4) percolation through the vadose zone as recharge to the deep-perched groundwater zones and potentially into the regional aquifer.

RDX is the primary groundwater contaminant at TA-16. RDX concentrations exceeded the EPA regional screening level for tap water (7.0 µg/L) in two springs (Burning Ground Spring and Martin Spring), in one alluvial well (CdV-16-02659), and in three intermediate-perched zone wells (CdV-16-4ip S1, CdV-16-2(i)r, and CdV-16-1(i) (Figure 5-21).

Figures 5-22, 5-23, 5-24, and 5-25 show RDX concentrations in springs, alluvial wells, intermediate-perched zone wells, and regional wells, respectively, during the 5-yr period from 2009 to 2014. These springs represent perched-intermediate groundwater. RDX concentrations in regional monitoring wells R-63 and R-18 were below the EPA screening level.

Discharge from Martin Spring and Burning Ground Spring contains RDX concentrations above the 7.0-µg/L EPA regional screening level for tap water (Figures 5-21 and 5-22). The concentrations are highest in Martin Spring, which shows a long-term declining trend over the last 5 yr (Figure 5-22). RDX concentrations in samples from Burning Ground Spring are significantly lower than concentrations in Martin Spring and have been relatively steady over the last 5 yr (Figure 5-22). In the past, SWSC Spring, located near the former location of the TA-16 260 Outfall, has shown elevated RDX concentrations; however, this spring has gone dry in recent years.

RDX concentrations in alluvial monitoring well CdV-16-02659 exceeded the EPA screening level for tap water, with a maximum concentration of 8.49 µg/L in 2014 (Figures 5-21 and 5-23). RDX concentrations in CdV-16-02659 fluctuate because of seasonal influences. RDX concentrations in samples from other nearby alluvial wells were below the EPA tap water screening level in 2014 (Figure 5-23).

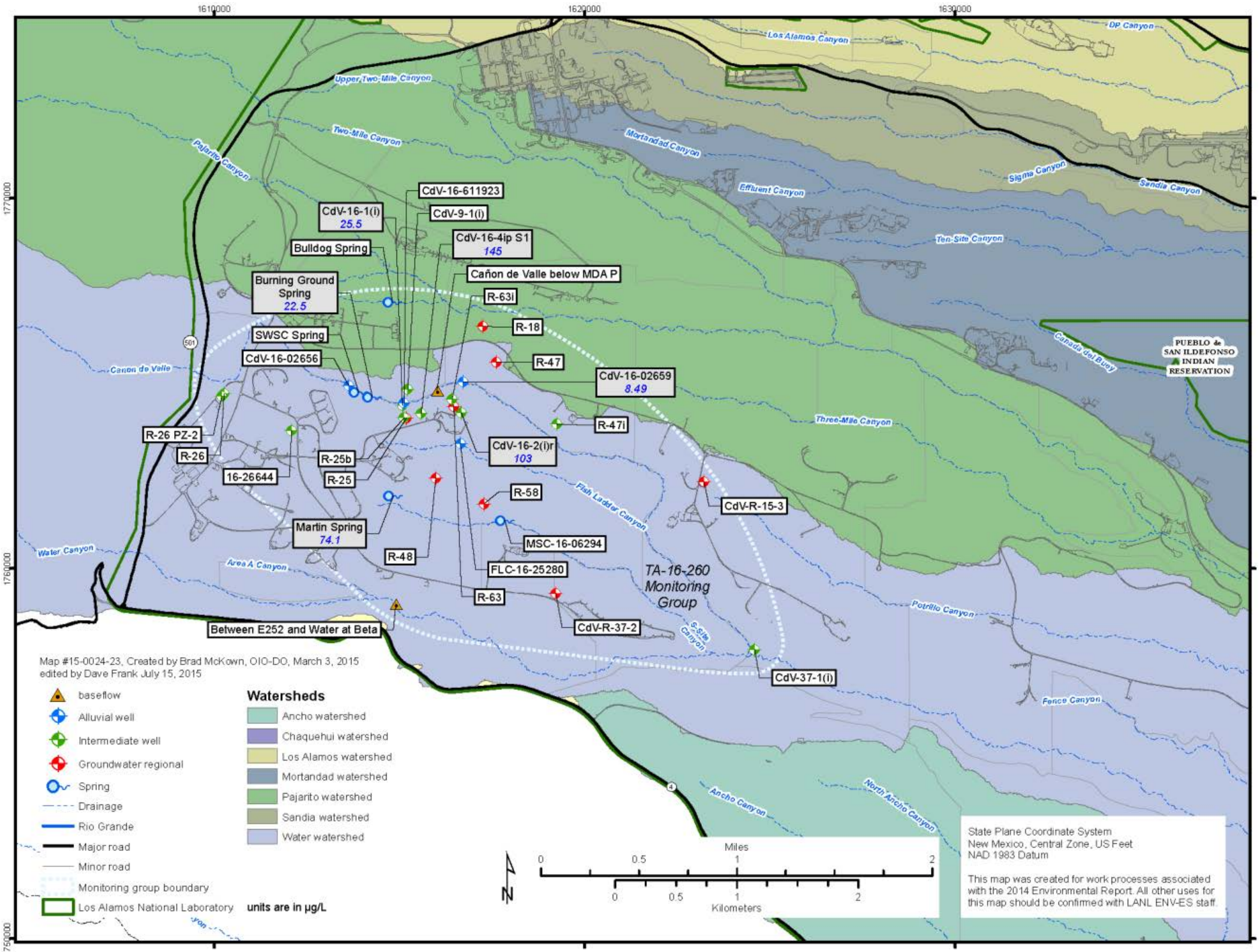

Figure 5-21 **Wells and springs with 2014 RDX concentrations above the 7.0-µg/L EPA tap water screening level. Maximum concentration for the year is shown in µg/L.**

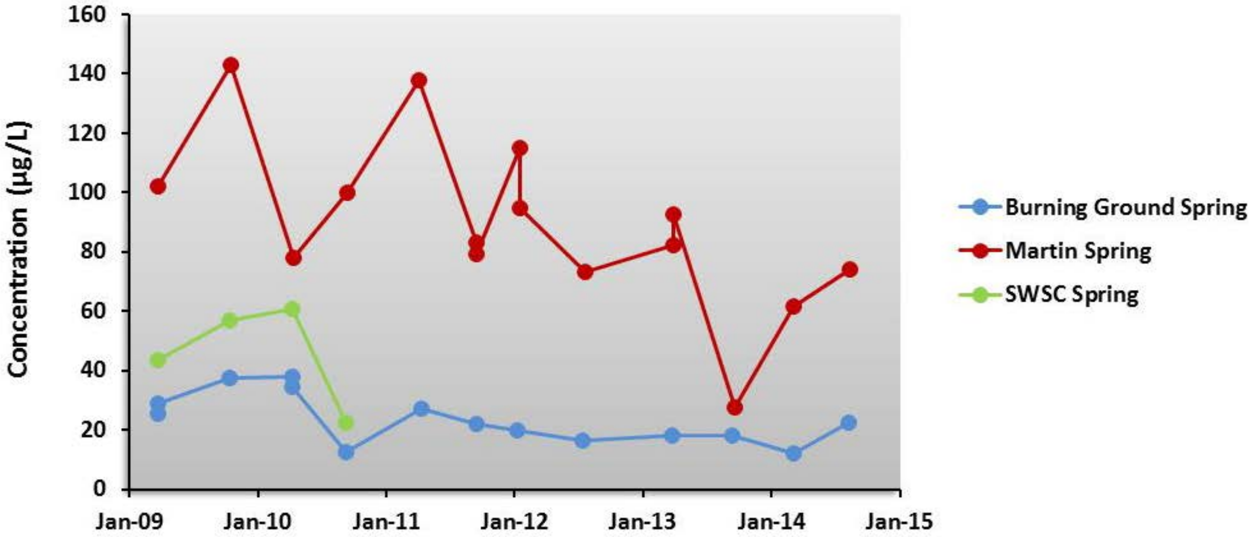

Figure 5-22 RDX concentrations in springs in Cañon de Valle and Martin Spring Canyon. For comparison purposes, the EPA regional screening level for tap water is 7.0 µg/L.

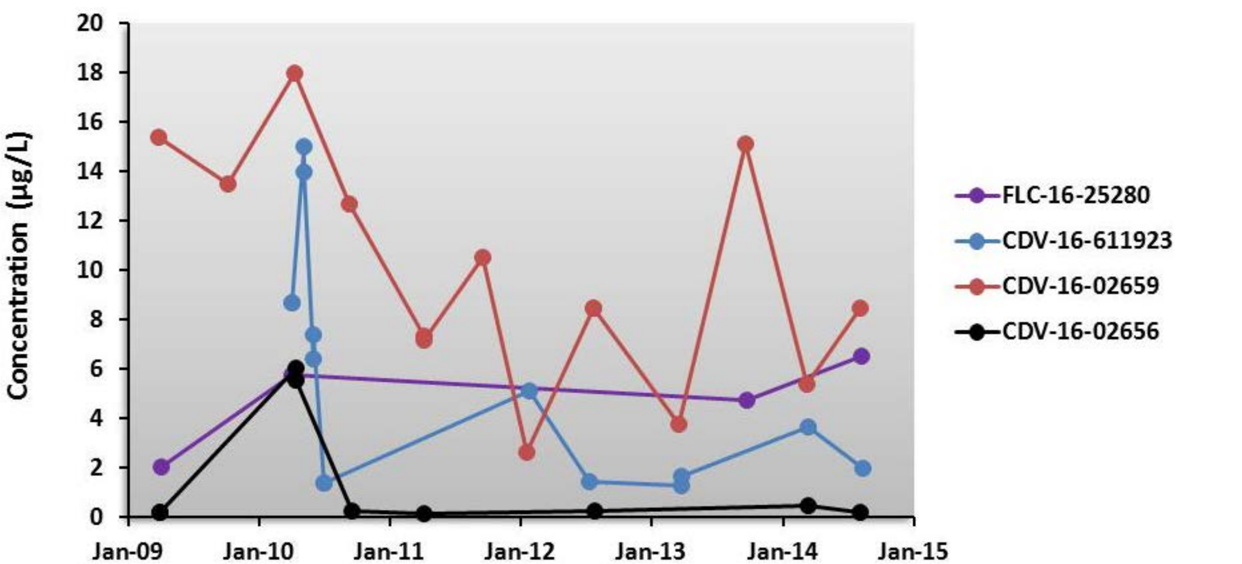

Figure 5-23 RDX concentrations in alluvial wells in Cañon de Valle and Fishladder Canyon. For comparison purposes, the EPA regional screening level for tap water is 7.0 µg/L.

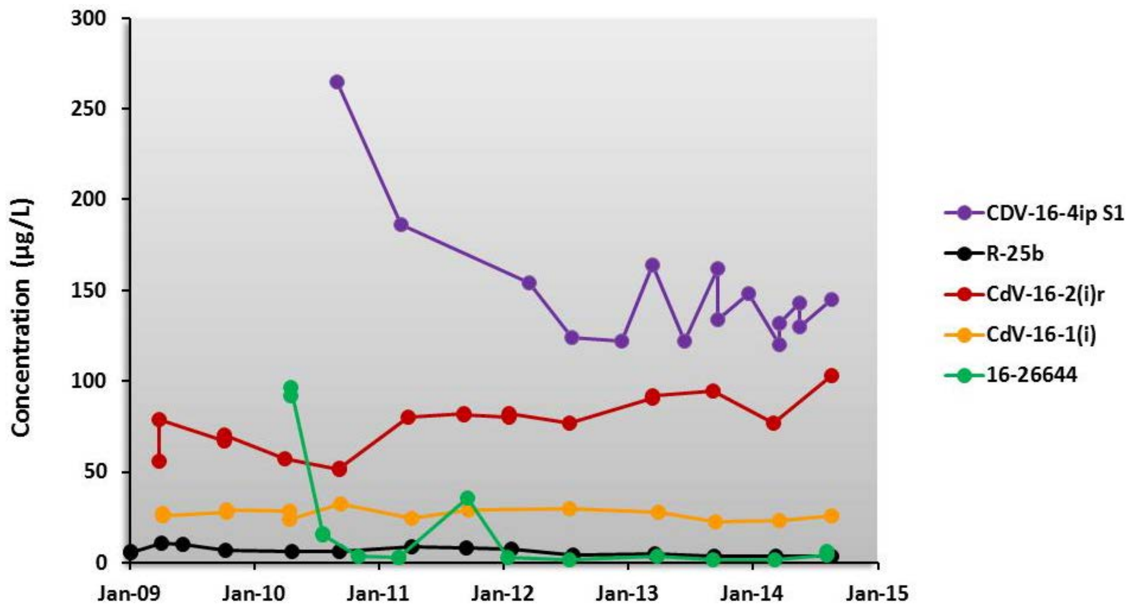

Figure 5-24 **RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. For comparison purposes, the EPA regional screening level for tap water is 7.0 µg/L.**

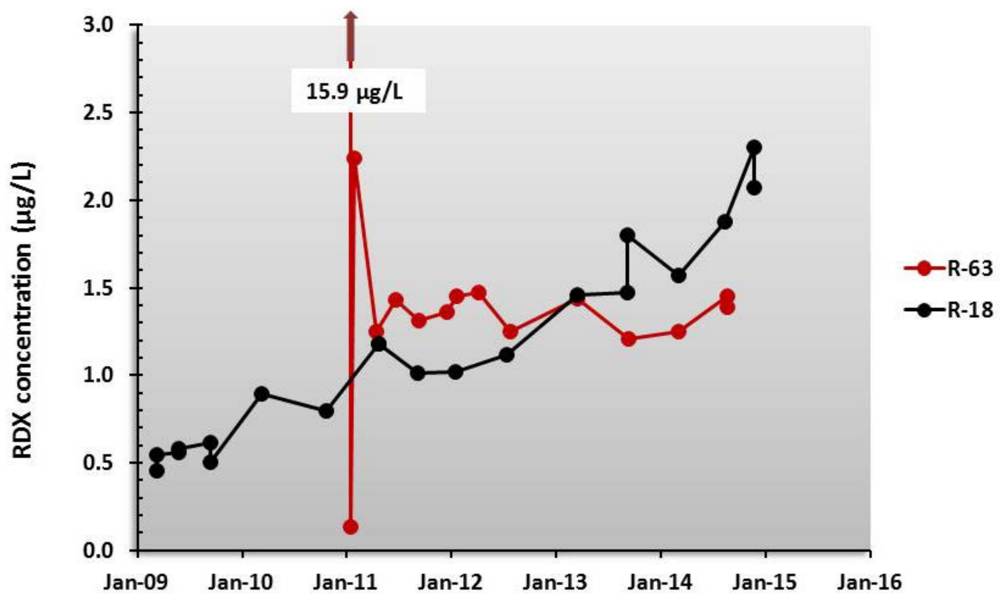

Figure 5-25 **RDX in the TA-16 260 monitoring group in Cañon de Valle regional groundwater. For comparison purposes, the EPA regional screening level for tap water is 7.0 µg/L.**

RDX concentrations at some perched-intermediate groundwater locations are significantly higher than the current RDX concentrations in the Cañon de Valle alluvium. RDX concentrations exceeded the EPA regional tap water screening level in perched-intermediate wells CdV-16-4ip S1, CdV-16-2(i)r, and CdV-16-1(i) (Figures 5-21 and 5-24). RDX concentrations in CdV-16-1(i) and in CdV-16-4ip S1 have been relatively stable in recent years. However, RDX concentrations in CdV-16-2(i)r show a gradual increase with time, increasing over the last 10 yr from around 50 µg/L to a maximum value of 103 µg/L in 2014.

In 2014, RDX was detected at low levels in several monitoring wells completed in the regional aquifer (Figure 5-25). RDX is persistently detected at low levels in monitoring wells R-63 and R-18 at concentrations below the 7.0-µg/L EPA regional screening level for tap water. In 2014, RDX was detected in R-63 at a maximum concentration of 1.45 µg/L; RDX concentrations in R-63 have been relatively steady since the well was installed in 2011, with the exception of the first few samples collected after well construction. In 2014, RDX was detected in regional monitoring well R-18 at a maximum concentration of 2.3 µg/L. RDX concentrations in R-18 show increasing trends since the well was installed in 2006 (Figure 5-25).

Chlorinated solvents are also present in groundwater in the TA-16 260 monitoring group. In 2014, the chlorinated solvents tetrachloroethene and trichloroethene were detected above the EPA MCL of 5 µg/L in alluvial well FLC-16-25280. Concentrations of these VOCs have decreased since 2009 (Figures 5-26 and 5-27). Low concentrations of tetrachloroethene and trichloroethene continue to be detected in Burning Ground Spring and in intermediate wells 16-26644, CdV-16-1(i), CdV-16-2(i)r, and CdV-16-4ip S1 at concentrations below the EPA MCL screening level of 5 µg/L. Trichloroethene also continues to be detected in Martin Spring at concentrations below the EPA MCL screening level. No VOCs are present above applicable groundwater standards in perched-intermediate or regional groundwater.

In 2014, boron was detected in samples from Martin Spring at concentrations above the 750-µg/L NM groundwater standard for irrigation use (Figure 5-28). Discharge from Martin Spring has historically shown elevated concentrations of boron, along with RDX. The source of boron is thought to originate from the laundry detergent borax, which was used at the former laundry facility at TA-16. Boron is also a component of the explosive compound Boracitol, which was processed in a limited number of facilities at TA-16. Boron is not above groundwater standards in perched-intermediate or regional aquifer wells.

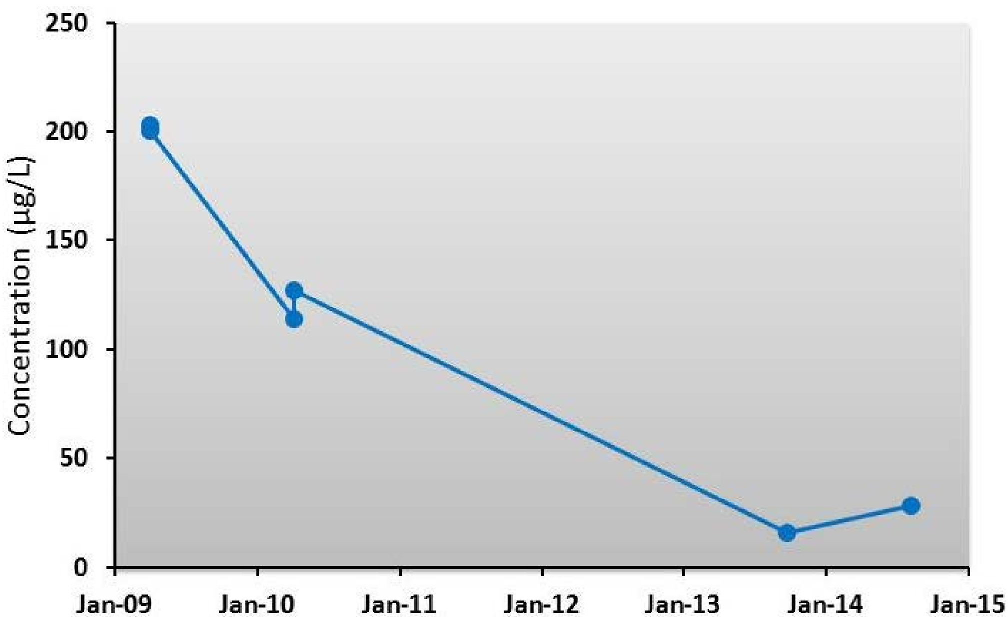

Figure 5-26 Tetrachloroethene in the TA-16 260 monitoring group in Fishladder Canyon alluvial groundwater well FLC-16-25280. For comparison purposes, the EPA MCL screening level is 5 µg/L.

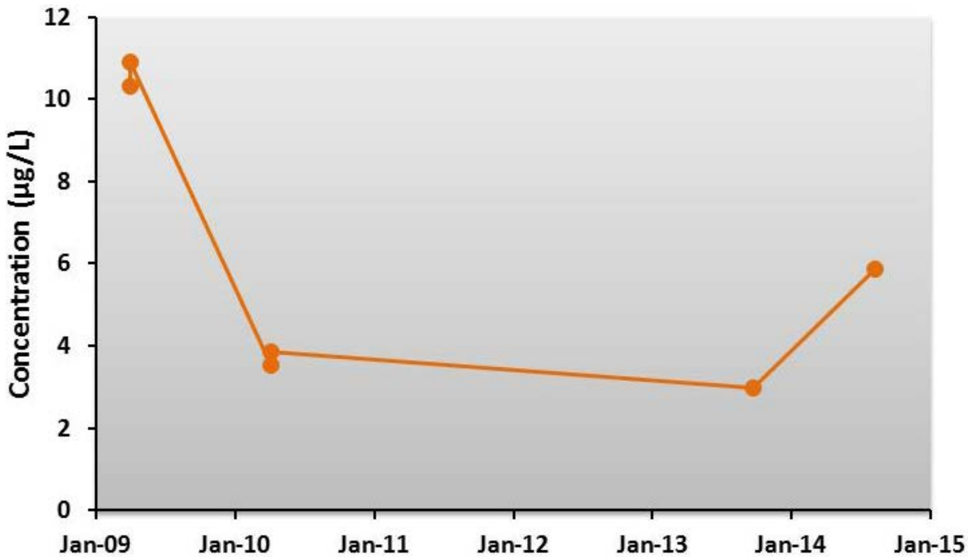

Figure 5-27 **Trichloroethene in the TA-16 260 monitoring group in Fishladder Canyon alluvial groundwater well FLC-16-25280. For comparison purposes, the EPA MCL screening level is 5 µg/L.**

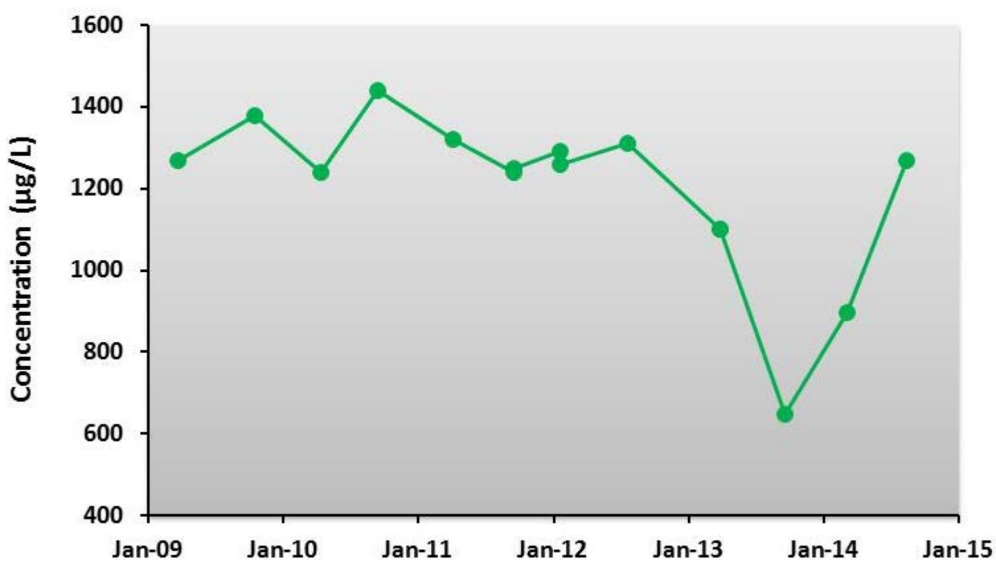

Figure 5-28 **Boron at Martin Spring in Martin Spring Canyon (a Cañon de Valle tributary). The NM groundwater standard for irrigation use is 750 µg/L.**

Barium exceeded the NM groundwater standard of 1000 µg/L in three alluvial wells in Cañon de Valle (Figure 5-29). Barium exceeded the NM groundwater standard in CdV-16-611923, CdV-16-026589, and CdV-16-02656. Barium concentrations in these wells have been fairly steady over the last few years, although in 2010, barium concentrations increased for several sampling periods before dropping to current levels. Barium is associated with an explosive compound, Baratol, which is a mixture of barium nitrate and TNT.

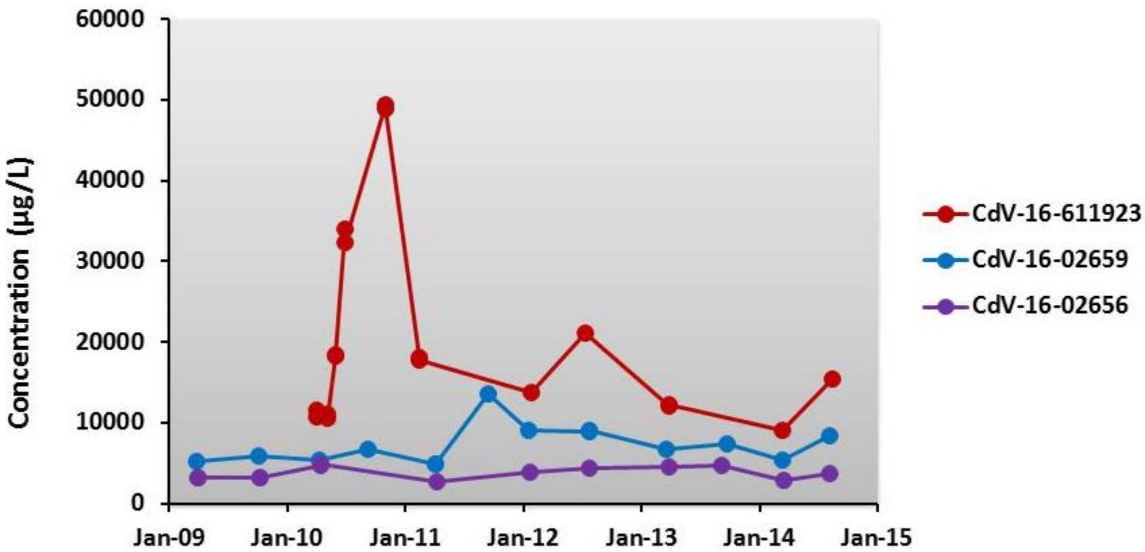

Figure 5-29 **Barium in the TA-16 260 monitoring group in Cañon de Valle alluvial groundwater. For comparison purposes, the NM groundwater standard is 1000 µg/L.**

7. MDA AB Monitoring Group

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 (Figure 5-5). The canyons in the Ancho watershed are mainly dry with little alluvial and no known intermediate groundwater.

MDA AB was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987, LANL 1988). The testing involved large quantities 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 2014, no contaminants were found in MDA AB wells at concentrations above standards.

8. White Rock Canyon Monitoring Group

The springs that issue along and near the Rio Grande in White Rock Canyon are from discharge of predominantly regional aquifer groundwater that flows beneath the Laboratory (Purtymun et al. 1980). The White Rock Canyon springs serve as key monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande (Figure 5-7). A few springs appear to represent discharge of perched-intermediate 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). Consistent with prior years' data, no springs that discharge groundwater from beneath the Laboratory into White Rock Canyon have contaminants that are close to the applicable groundwater standards.

9. General Surveillance Monitoring

a. Los Alamos Canyon General Surveillance Monitoring

Alluvial well LAO-3a in Los Alamos Canyon continues to show strontium-90 activity above the 8-pCi/L EPA MCL screening level (Figure 5-6). Results from filtered and unfiltered samples from the same date are typically similar in the alluvial groundwater setting, so both are shown in Figure 5-30. The source of strontium-90 is SWMU 21-011(k), which was an outfall from industrial waste treatment plants at TA-21. Strontium-90 continues to be found in shallow alluvial groundwater samples at this location because it has been retained on the alluvium by cation exchange (LANL 2004).

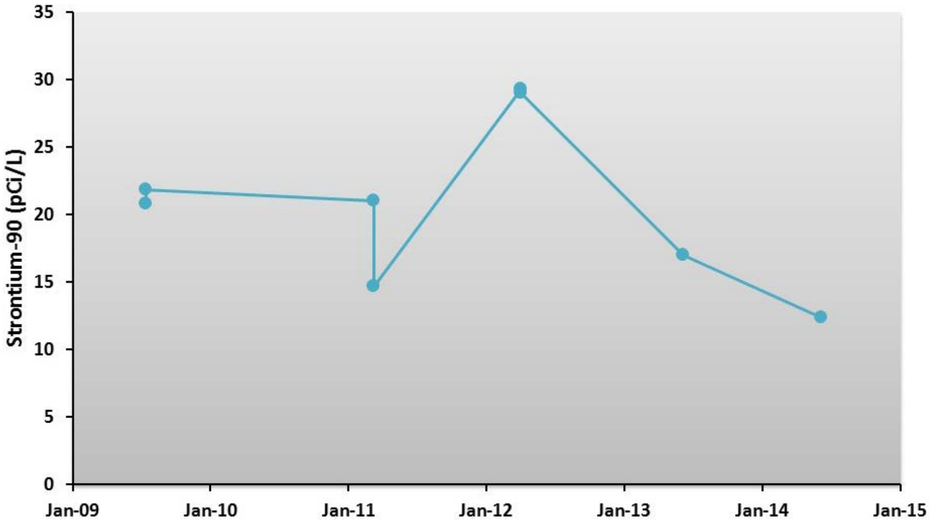

Figure 5-30 Strontium-90 at alluvial monitoring well LAO-3a showing both filtered and unfiltered results. For comparison purposes, the EPA MCL (which does not apply to shallow alluvial groundwater samples) is 8 pCi/L.

b. 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; Basalt Spring apparently dried up around 2010, and discharge began at a nearby location called Vine Tree Spring where subsequent samples have been collected. The perchlorate concentrations since late 2008 in these springs have been near or above the Consent Order screening level of 4 µg/L. In 2014, the maximum concentration for perchlorate at Vine Tree Spring was 6.54 µg/L (Figure 5-31).

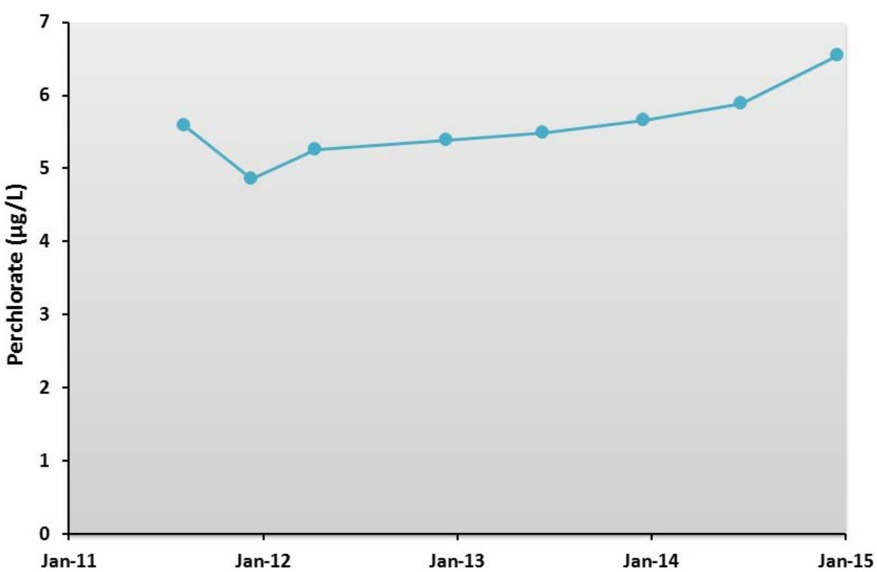

Figure 5-31 Perchlorate in the lower Los Alamos General Surveillance monitoring group location Vine Tree Spring. The Consent Order screening level is 4 µg/L.

c. Sandia Canyon General Surveillance Monitoring

The general surveillance wells located in Sandia Canyon that are not part of the Chromium Investigation monitoring group include regional aquifer wells R-10 and 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 2014. Alluvial wells SCA-2 and SCA-4 were not sampled in 2014 because of damage incurred during the September 2013 flooding.

d. 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 2014.

General surveillance alluvial monitoring well MCO-7 was sampled for radionuclides in 2014 and no detections were found above applicable standards. Before effluent quality improvements were implemented in 1999, radionuclide levels in Mortandad Canyon alluvial groundwater were often present above standards, but in 2014, concentrations of radionuclides were all below standards.

Under the groundwater discharge plan application for the TA-50 RLWTF NPDES outfall, the Laboratory has collected quarterly samples for nitrate, fluoride, perchlorate, and TDS from three alluvial monitoring wells below the outfall in Mortandad Canyon: MCO-4B, MCO-6, and MCO-7. The fourth location sampled under the discharge plan is MCO-3, which was destroyed in flooding that occurred in September 2013. Perchlorate was detected above the Consent Order screening level of 4 µg/L at MCO-4B and MCO-6 (Figure 5-32). Albeit above the 4-µg/L screening level, the recent results remain low relative to past perchlorate concentrations in the Mortandad Canyon alluvial groundwater since the 2002 RLWTF effluent-treatment upgrades. Nitrate, fluoride, and TDS are far below applicable standards for these alluvial wells.

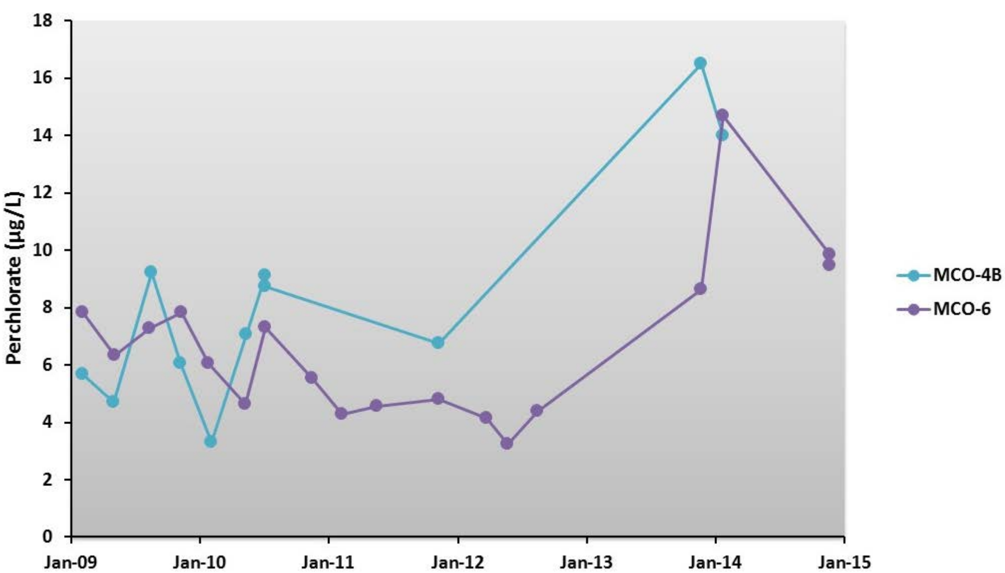

Figure 5-32 Perchlorate at general surveillance and groundwater discharge plan monitoring locations MCO-4B and MCO-6 in Mortandad Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.

d. Cañada del Buey General Surveillance Monitoring

Alluvial well CDBO-6 in Cañada del Buey was dry and not sampled in 2014.

e. Pajarito Canyon General Surveillance Monitoring

Pajarito Canyon has a drainage that extends into the Sierra de los Valles, west of the Laboratory. Saturated alluvium is present throughout portions of Pajarito Canyon, including a reach in lower Pajarito Canyon near the eastern Laboratory boundary, but does not extend beyond the Laboratory boundary at NM 4. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-09. 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.

SWMU 03-010(a) is the outfall area from a former vacuum repair shop. The outfall area is located on a steep slope on the rim of a small tributary to Twomile Canyon about 30 ft west of a warehouse (Building 03-30). A small zone of shallow perched-intermediate 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 sampled at a depth of approximately 21 ft by well 03-B-13. In 2014, samples from this well contained 1,1,1-trichloroethane and 1,4-dioxane above their applicable standards. Figures 5-33 and 5-34 show the history of these two constituents, respectively.

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 2014.

f. Water Canyon General Surveillance Monitoring

Water Canyon has only one general surveillance monitoring location, alluvial well WCO-1r. No constituents were detected above applicable standards in this well in 2014.

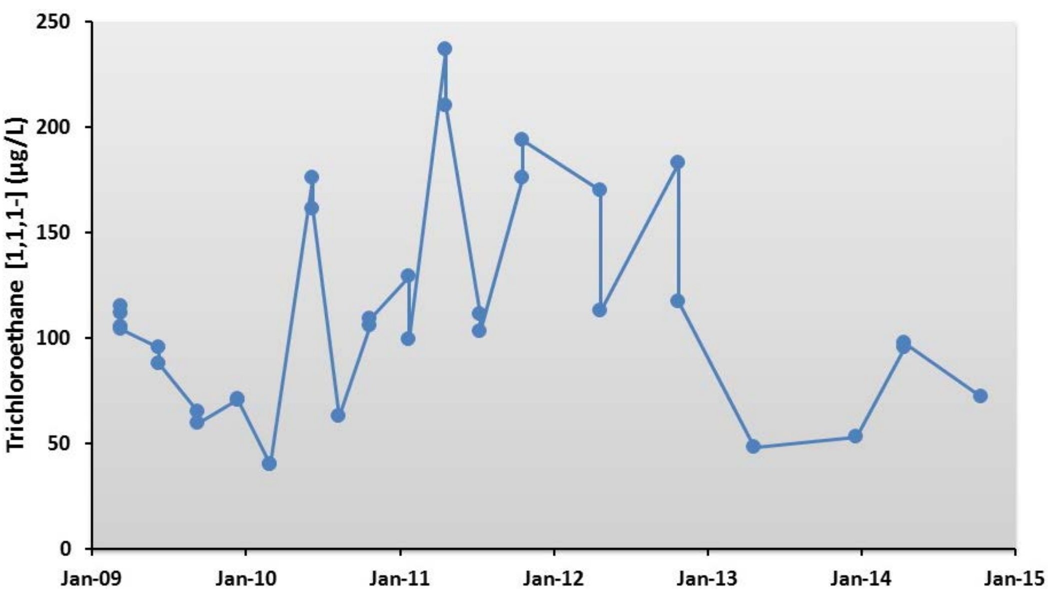

Figure 5-33 Concentrations of 1,1,1-trichloroethane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 60 µg/L.

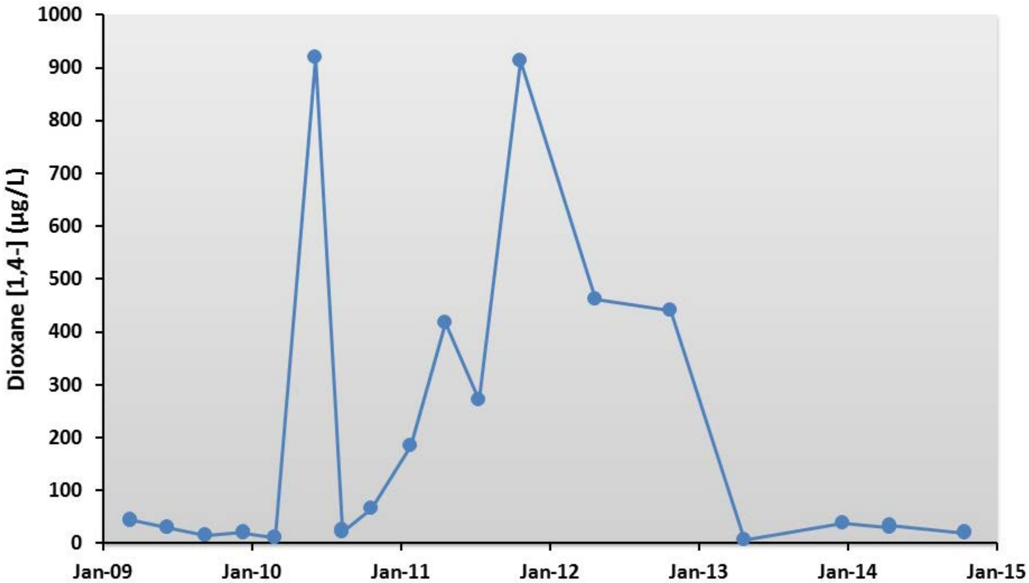

Figure 5-34 Concentrations of 1,4-dioxane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. For comparison purposes, the EPA regional screening level for tap water is 7.8 µg/L.

H. SUMMARY

The Laboratory has been monitoring groundwater for decades. A new focus to expand the groundwater monitoring network has taken place over the last decade. This expanded network has resulted in a significant enhancement to the Laboratory's understanding of the nature and extent of groundwater contamination. As described in this chapter, only two key areas are showing groundwater contaminants that are of sufficient lateral extent to warrant specific attention through further characterization and potential remedial actions: RDX contamination in the TA-16 area and chromium and perchlorate contamination beneath Sandia and Mortandad Canyons. Further characterization work and related studies are ongoing in both of these areas. The regional aquifer is the source of water for Los Alamos County and the Laboratory. Data from wells, which are owned and operated by Los Alamos County, meet federal and state drinking-water standards.

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To Read About **Turn to Page**

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 the transport of legacy contaminants and ongoing Laboratory operations on human and ecological health. 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. 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. While some concentrations of contaminants present in canyon media are above applicable aquatic environment standards, the human health risk assessments in the Canyons IRs have concluded that concentrations of contaminants present in canyon media are below applicable human health limits. The sediment and storm water 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 and storm water data comparisons collected from flood-affected canyons in 2014 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 the potential effects associated with transport of legacy contaminants and ongoing Laboratory operations on human and environmental health. 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. 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 below regulatory or acceptable risk and dose limits (e.g., the Canyons Investigation Reports [IRs]: LANL 2004, 2005, 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 forest fires and floods, and to identify such changes and sources 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, 2011e, 2012a, 2012b, 2013a, 2014a, 2014b, 2015a, 2015b).

Sediment and surface water monitoring and assessments at the Laboratory in 2014 occurred under several programs. Sediment monitoring in 2014 occurred following the annual summer monsoon season and was based on the 2012 sediment sampling and analysis plan (LANL 2012c). Sampling of storm water at gaging stations occurred in Los Alamos and Pueblo Canyons under a plan to monitor the effectiveness of sediment transport mitigation activities (LANL 2014c). Sampling of storm water at gaging stations in Laboratory canyons other than Los Alamos and Pueblo Canyons occurred as part of the Laboratory's Annual Site Environmental Report (ASER) Program. 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) issued by the U.S. Environmental Protection Agency (EPA). 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 NPDES Multi-Sector General Permit (MSGP) Program regulates storm water discharge from identified industrial activities and their associated facilities. The 2008 MSGP authorizes eligible discharges to waters of the Unites 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's current NPDES outfall permit requires weekly, monthly, quarterly, and yearly sampling to demonstrate compliance with effluent quality limits. Data collected under these NPDES permits are presented in the Chapter 2, Compliance Summary.

The 2014 Interim Facility-Wide Groundwater Monitoring Plan (LANL 2013b) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels. These data are not from precipitation-based storm water, thus are not presented in this chapter; data are presented in Chapter 5, Groundwater Monitoring, of this report. In addition, 2014 sampling of storm water occurred in watersheds in urban, developed landscapes in the Los Alamos townsite, and results will be included in a future report evaluating baseline concentrations of particular metals and polychlorinated biphenyls (PCBs) in developed areas.

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. The remainder of the primary watersheds head on the Pajarito Plateau. Only the Ancho Canyon watershed is entirely located on Laboratory land.

In 2014, there was no snowmelt runoff that crossed the eastern boundary of the Laboratory. Total storm water runoff for 2014 measured at downstream gaging stations in the canyons leaving the Laboratory is estimated at 90 acre-feet (ac-ft), most of this occurring in Los Alamos, Pueblo, Water, Cañada del Buey and Chaquehui Canyons. Runoff in Sandia, Pajarito, Ancho, Mortandad, and Potrillo Canyons is minimal compared with the other canyons in 2014. Figure 6-2 shows the estimated storm water runoff volume and seasonal precipitation at the Laboratory for June through October from 1995 to 2014, indicating that the total storm water runoff of the 5-mo period in 2014 (90 ac-ft) was 15 times less than in 2013 (1400 ac-ft). Approximately 1 ac-ft of the 2014 total storm water runoff volume is attributed to effluent from the Los Alamos County Waste Water Treatment Facility (WWTF) that reached gaging station E060.1 during storm events in July and August. Figure 6-3 shows the 1993 to 2013 mean monthly total precipitation (snow water equivalent and monsoonal precipitation) across the Pajarito Plateau throughout each year and the 2014 mean monthly precipitation. Every month in 2014 was drier than normal, with the exception of May, July, and December. In July, the total monthly precipitation was over 200% of the historical mean. In September, the total monthly precipitation was only 20% of the historical mean.

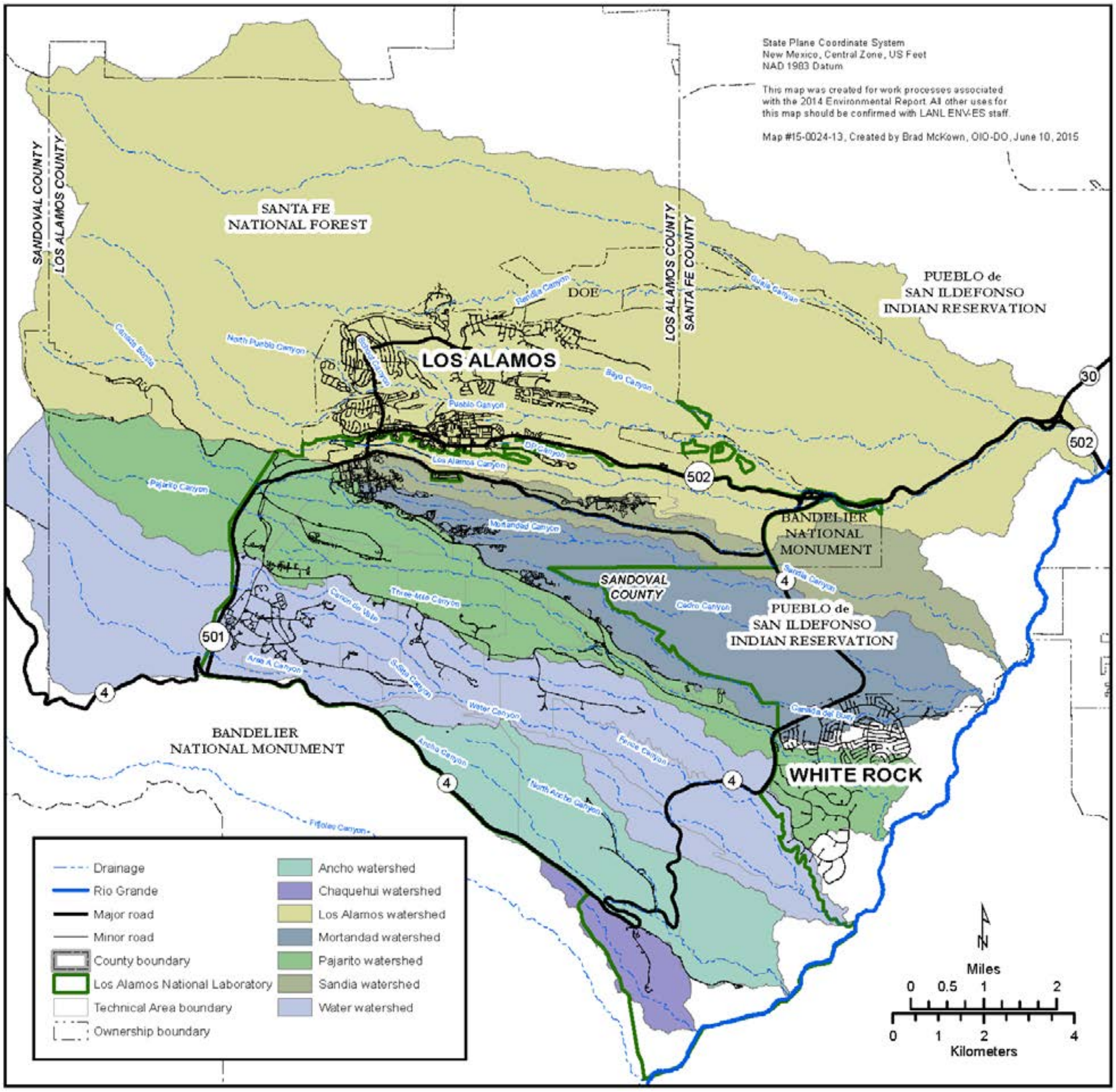


Figure 6-1 Primary watersheds at the Laboratory

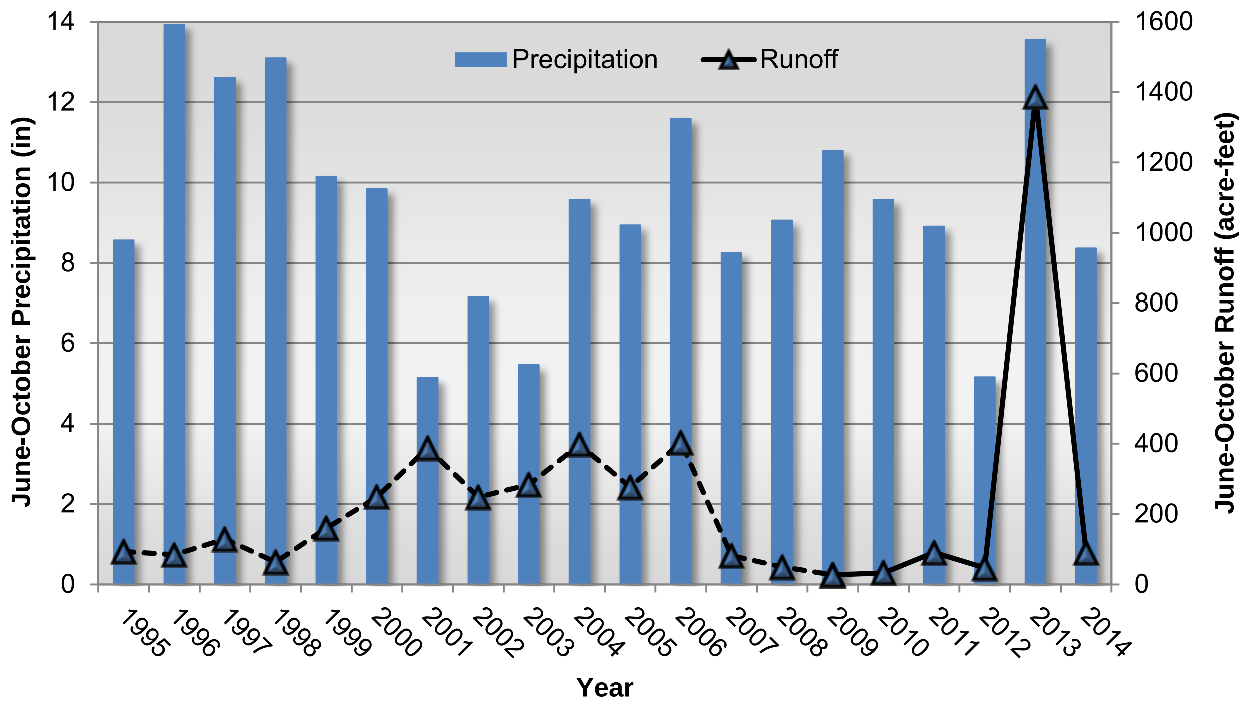


Figure 6-2 **Estimated storm water runoff volume in Laboratory canyons from 1995 to 2014 and total June through October precipitation from 1995 to 2014 averaged across the Laboratory's meteorological tower network (Technical Area 06 [TA-06], TA-49, TA-53, TA-54, and northern community). Dashed lines indicate data with potential issues.**

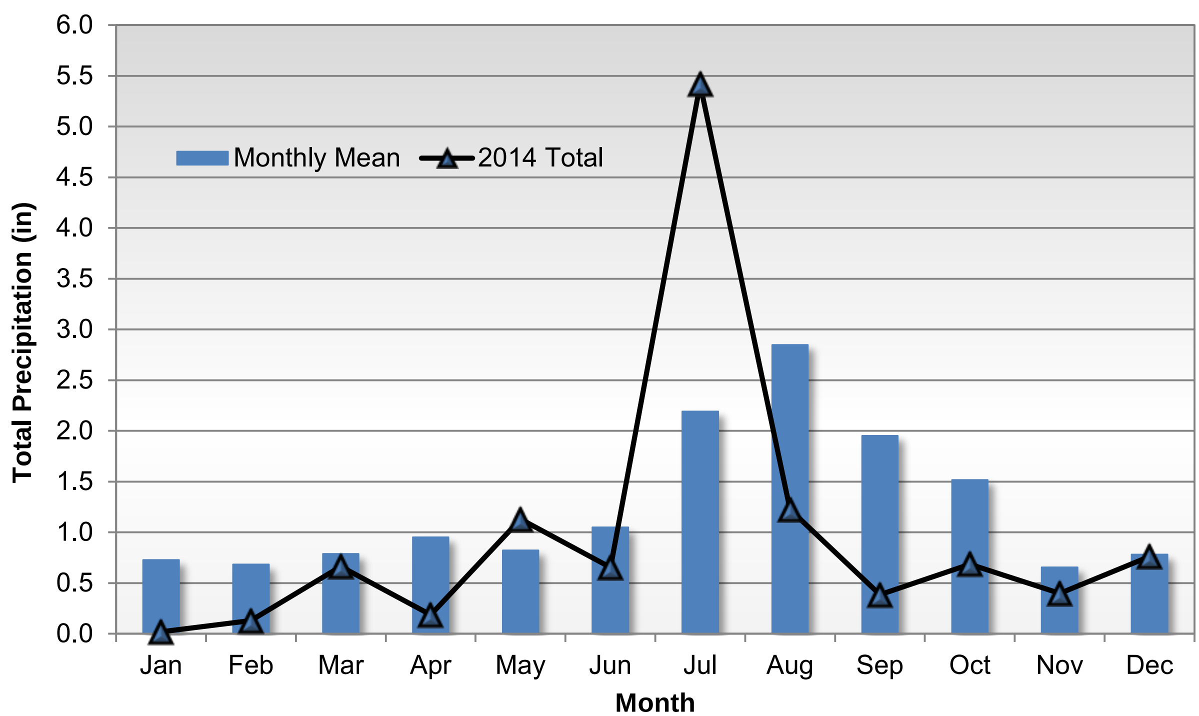


Figure 6-3 **Mean of the monthly total precipitation from the Laboratory's meteorological tower network (TA-06, TA-49, TA-53, TA-54, and northern community) over the period of record 1993 to 2013 and the mean of the monthly total precipitation during 2014**

The Laboratory has installed various sediment control structures to minimize the erosive nature of storm water runoff and to enhance deposition of sediment within the canyons (Figure 6-4). 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 (GCS) 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 dampen flood peaks and slow flood velocities, resulting in sediment deposition and the stabilization of stream channels and banks (LANL 2008a, 2008b). In DP Canyon, a GCS 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; the basin/weir performed in the same manner after the Las Conchas fire in July 2011. Two detention basins were constructed in upper Los Alamos Canyon below SWMU 01-001(f) to capture PCB-contaminated sediment in runoff into the canyon (hereafter, these detention basins will be referred to as the upper Los Alamos Canyon detention basins). In Mortandad Canyon, 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; the structure 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.

After the extremely large flood in September 2013, work began in 2014 to rehabilitate and mitigate damage to the Pueblo Canyon wetlands and GCS, the Mortandad Canyon sediment traps, and numerous gaging stations across the Laboratory. In the Pueblo Canyon wetlands, work accomplished in 2014 includes local bank stabilization, canary reed grass planting, willow planting below the wetlands, and installation of piezometer transects to record alluvial groundwater levels for monitoring willow health and extent. Work planned for 2015 includes installation of a drop structure at the Pueblo Canyon wetland headcut and installation of gaging station E059.8 to monitor storm water downstream of the drop structure. For the Pueblo Canyon GCS, work planned for 2015 includes redirecting the channel, installing spurs for bank protection, and installing erosion protection measures, all downstream of the GCS. In 2014, the Mortandad sediment traps were significantly expanded and reworked and additional sediment traps were constructed in Ten Site Canyon, just above the confluence with Mortandad Canyon.

In addition to the sediment control structures installed in canyon bottoms discussed above, approximately 1800 storm water control measures have been installed on the mesa tops and hillslopes across the Laboratory under the IP. There are numerous types of control measures, including: seed and mulch, natural vegetation, berms and wattles, channels, sediment detention basins, small dams, gabions, ground cover caps, etc. All of these measures reduce the amount of erosion from storm water runoff, and the channels, sediment detention basins, and dams can reduce the peak and time to peak of runoff, thereby reducing the energy associated with the runoff and the erosion downstream. Also, the Laboratory is required to manage storm water runoff from construction sites under the CGP, including developing a storm water pollution prevention plan (SWPPP) and installing control measures prior to construction.

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.

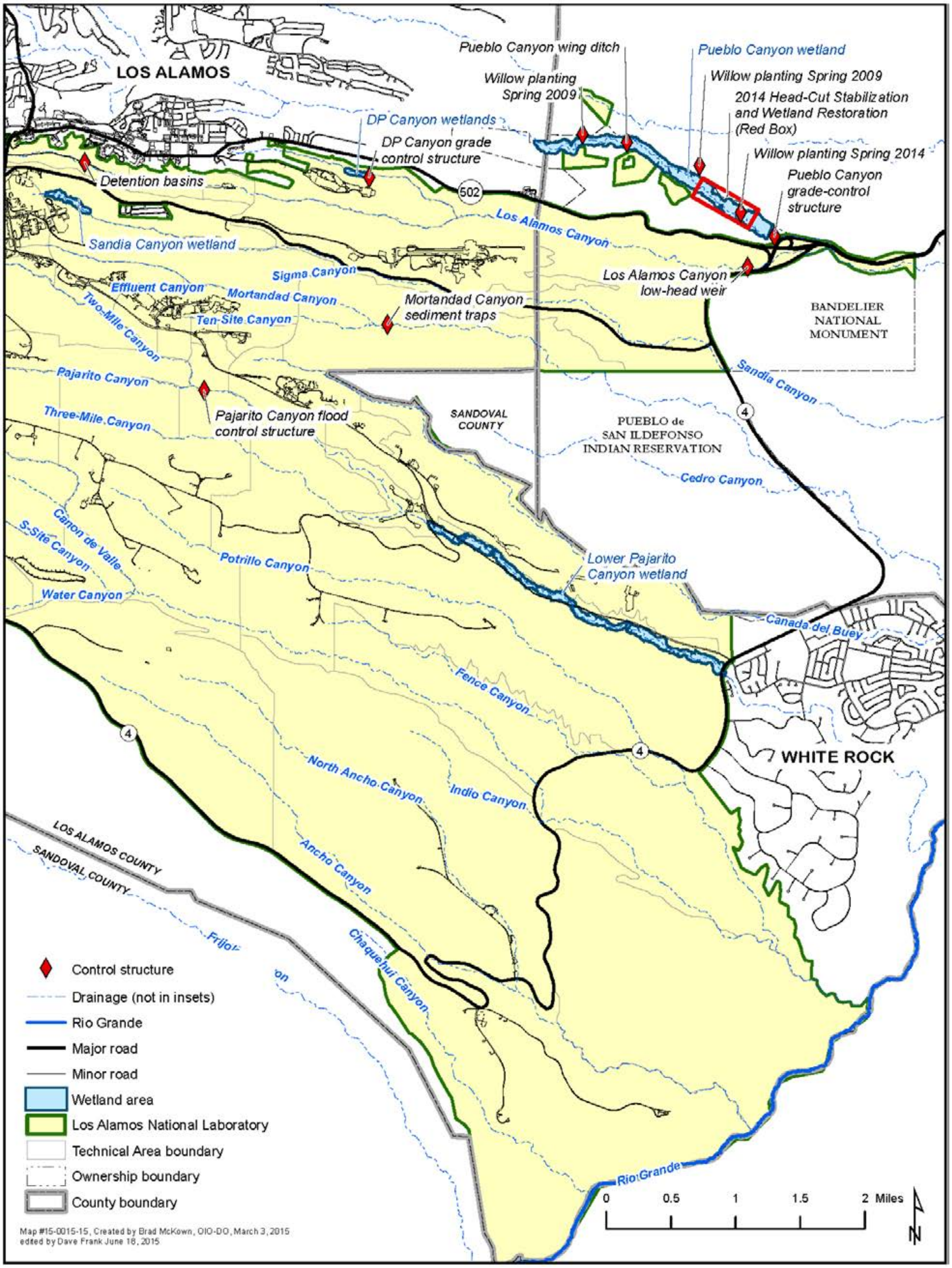


Figure 6-4 Sediment control structures installed by the Laboratory

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. (2013)	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. (2013)	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) (2014)	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 (2014d)	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 6-5, Table 6-2, and NMWQCC 2013). The current standards were approved by EPA on June 5, 2013, and can be found on NMED's website at http://164.64.110.239/nmac/parts/title20/20.006.0004.pdf. Surface water within the Laboratory is not a source of drinking, municipal, industrial, or irrigation water. As described below, under NMAC, 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 and to the Rio Grande).

Under NMAC, 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 designated uses under 20.6.4.126 NMAC. Intermittent and ephemeral portions of channels managed by DOE are assigned 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.

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 gaging stations under the Laboratory's ASER 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 2015).

2. Radionuclides in Surface Water

DOE Order 458.1 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. (2013). For screening purposes, single sample results are compared with BCGs to identify if radionuclides at a location pose a potential risk to biota. For water samples from in or near designated perennial stream segments, BCGs for aquatic or riparian animals are used for evaluation, and for samples from ephemeral or intermittent segments, BCGs for terrestrial animals are used.

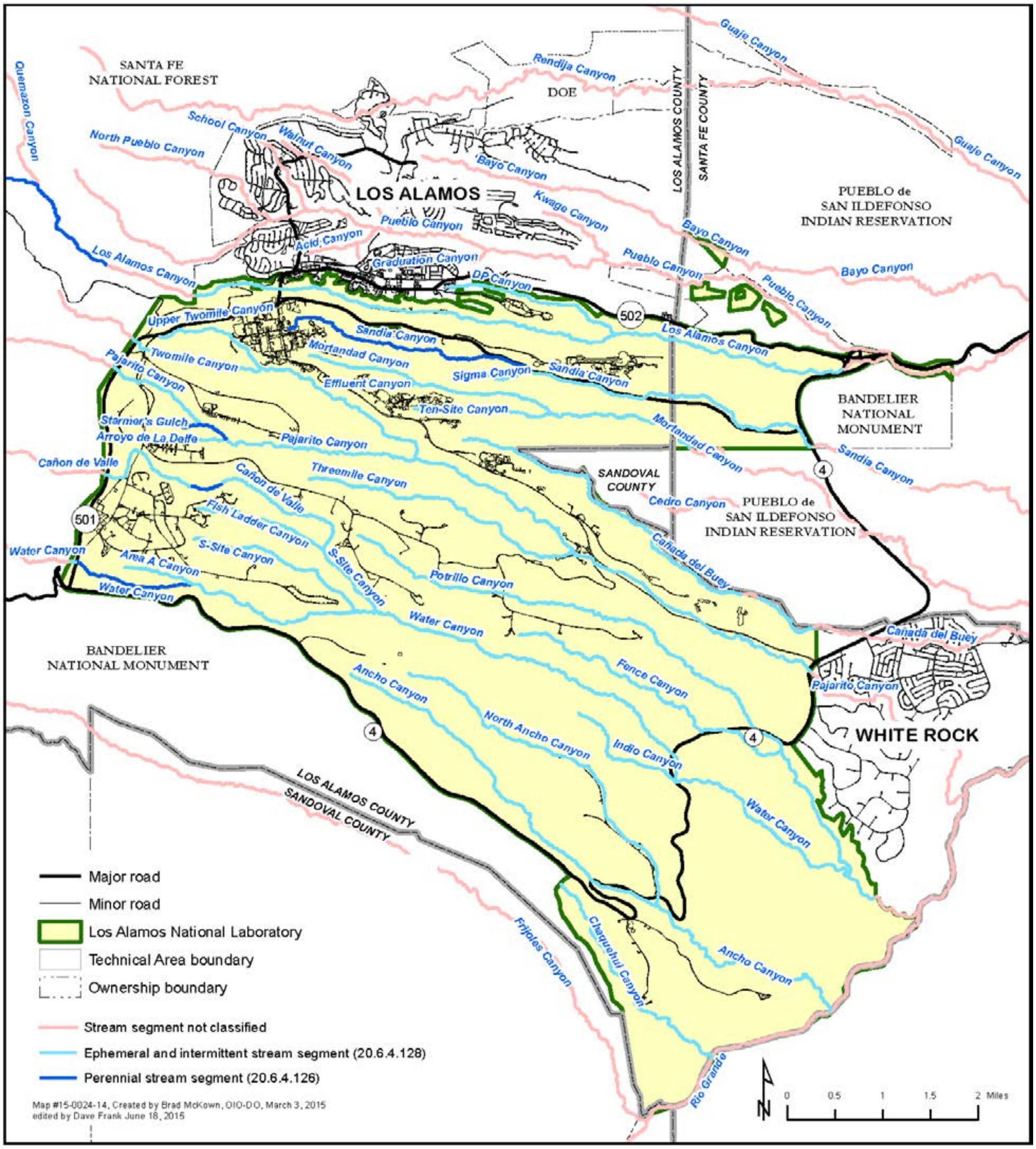


Figure 6-5 Major drainages within Laboratory land showing designated stream segments

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." Designated perennial segments on Laboratory property, including parts of Cañon de Valle, Pajarito, Water, and Sandia Canyons	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact
	Coldwater aquatic life (i.e., chronic aquatic life standard)	Fish, aquatic invertebrates, etc.
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.)" Ephemeral and intermittent segments on Laboratory property	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
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." Intermittent segments not on Laboratory property, i.e., Acid and Pueblo Canyons	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
	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

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 feral 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 sampling locations 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) but not for sediment/soil. 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 2014). 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 3 (LANL 2014d).

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. (2013). 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 forest 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, including at the downstream Laboratory boundary or NM 4. Samples collected include scheduled base flow samples from particular locations where permitted effluent discharges maintain streamflow and storm water samples collected during storm events using automated samplers.

Figure 6-6 shows surface water locations sampled in 2014 as part of the ASER 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 gaging stations but also include storm water samples at sediment detention basins in upper Los Alamos Canyon. Figure 6-7 shows locations of IP SMAs where storm water runoff samples were collected in 2014. Note that discharge from IP SMAs may or may not, depending on the storm event, reach the canyons where the gaging stations are located and where the water is regulated under NMAC.

Figure 6-8 shows sediment locations sampled in 2014 as part of the ASER Program. The Laboratory collected sediment samples from stream channels and adjacent flood plains with new (i.e., 2014) sediment deposits on the Pajarito Plateau to a depth of 0 to 37 cm, depending on the thickness of the uppermost sediment layer. For flowing streams, samples were collected from near the edge of the main channel. Locations outside the main channel were also sampled to variable depths in hand-dug holes.

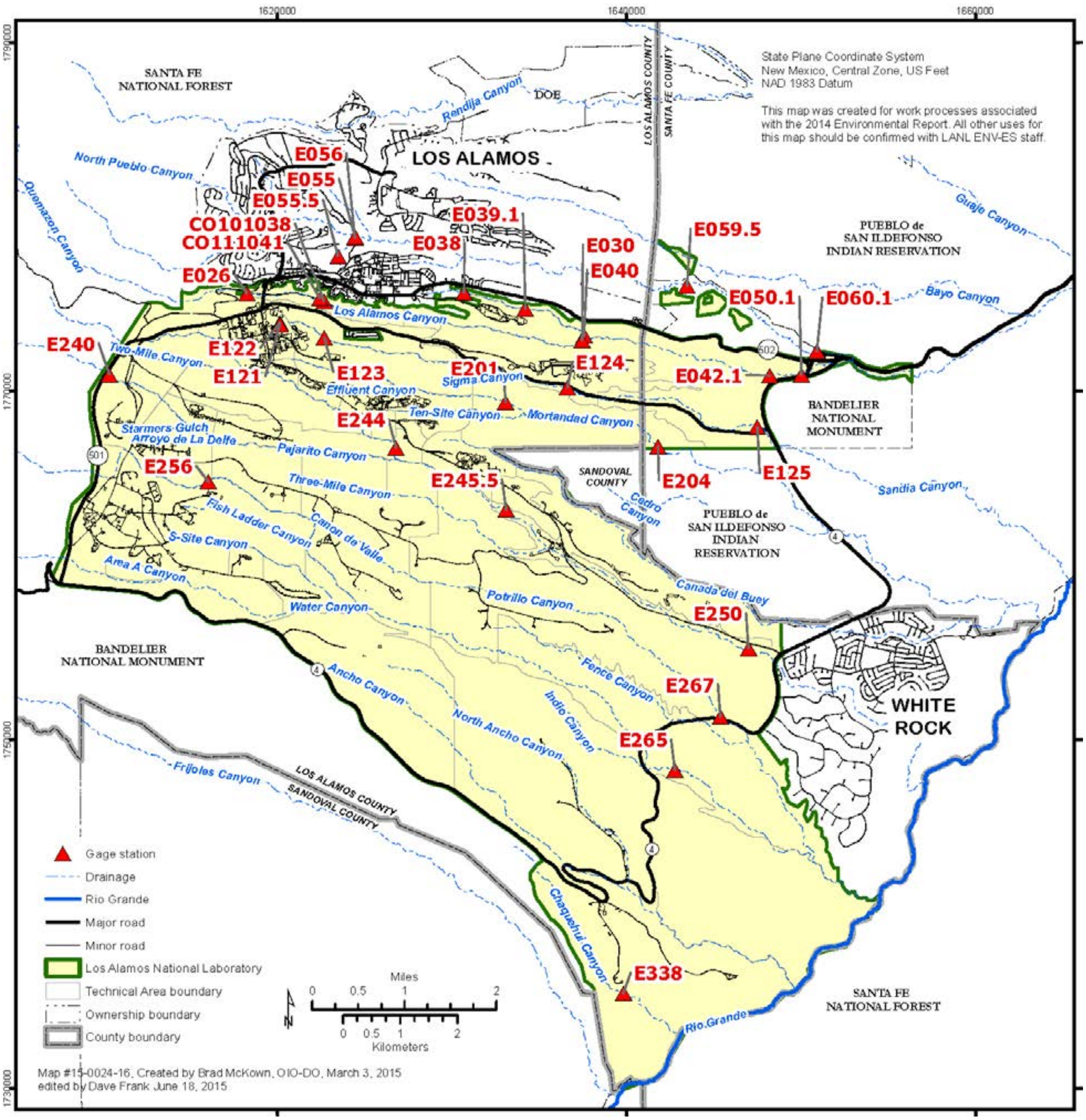


Figure 6-6 Surface water locations sampled in 2014 as part of the ASER Program and the Los Alamos/Pueblo Canyon watershed monitoring plan (locations CO111041 and CO101038 sample run-on into and runoff from the detention basins in upper Los Alamos Canyon, respectively)

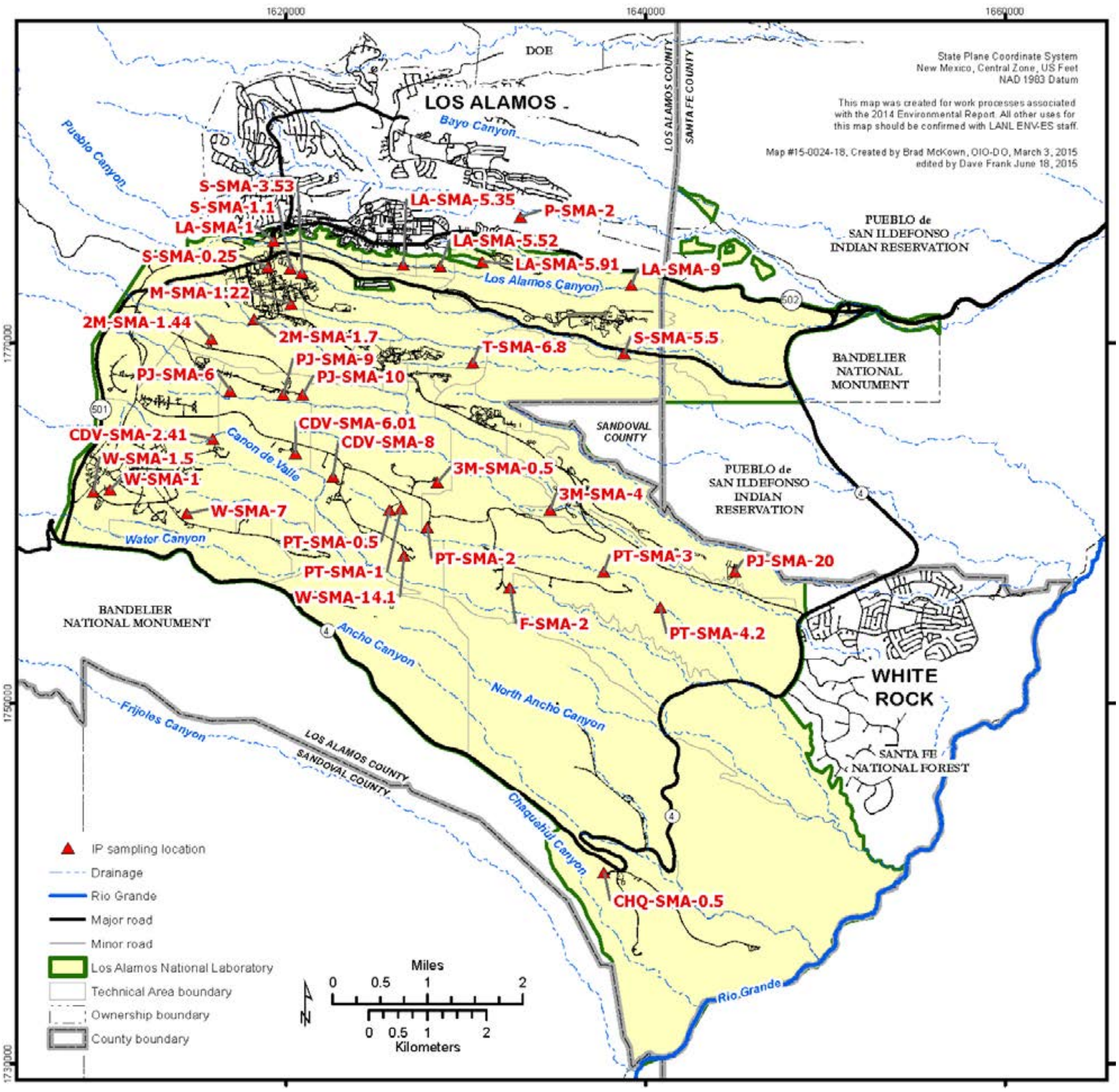
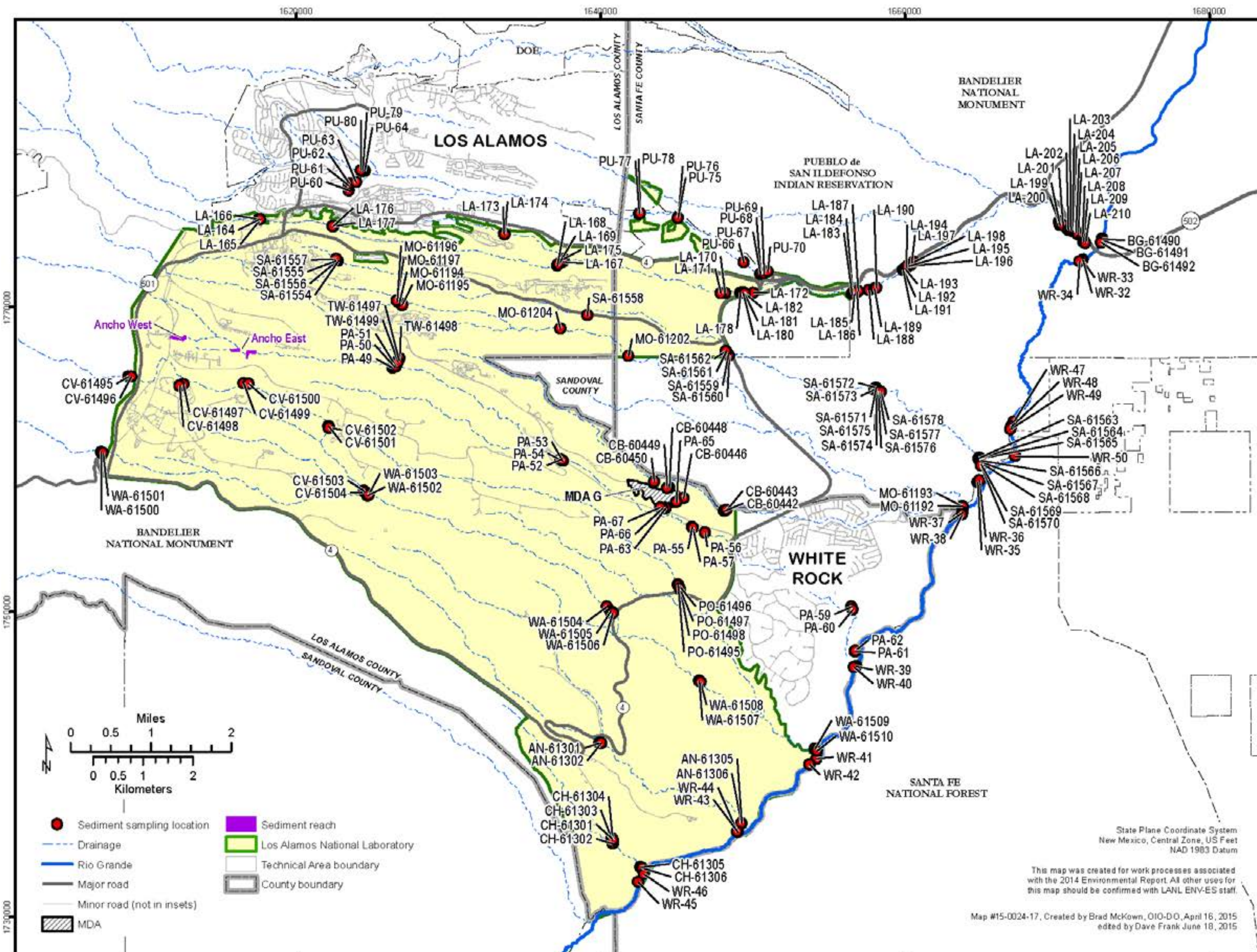


Figure 6-7 Surface water locations sampled in 2014 at IP SMAs



MDA = Material disposal area.

Figure 6-8 Sediment locations sampled in 2014 as part of the ASER Program

1. Quality Assurance

Sampling of storm water and sediment is performed according to written, standard quality assurance and quality control procedures and protocols identified in the following Laboratory standard operating procedures (SOPs) and guides: Installing, Setting Up, and Operating ISCO Samplers (EP-DIV-SOP-10008); Inspecting Storm Water Runoff Samplers and Retrieving Samples (EP-DIV-SOP-10013); Processing Storm Water Samples (EP-DIV-SOP-20217); Operation and Maintenance of Gage Stations for Storm Water Projects (EP-DIV-SOP-10005); Active Channel and Reservoir Bottom Sediment Collection (ENV-WQH-SOP-012); Geomorphic Characterization (ER-GUIDE-20237); and Soil, Tuff, and Sediment Sampling (ER-SOP-20069). These procedures ensure that the collection, processing, and chemical analysis of samples and the validation and verification of analytical data 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. Indeed, the sampling teams collect all samples under full chain-of-custody procedures. Once collected, sediment samples are hand-delivered to the Laboratory's Sample Management Office (SMO), which ships the samples via express mail directly to an external analytical laboratory under full chain-of-custody control. Storm water samples are collected in the field, hand-delivered to the Laboratory's storm water processing facility where samples are preprocessed, then hand-delivered to the Laboratory's SMO, which ships the samples via express mail directly to an external analytical laboratory under full chain-of-custody control. The Laboratory's SMO staff tracks all samples. Upon receipt of data from the analytical laboratory, an automated quality assessment of the data is performed where sample completeness and other variables are assessed. There were no analytical laboratory data quality issues related to the storm water or sediment sampling programs during 2014. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 1, Section 6.

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 at the gaging stations. The grab samples are either filtered or left unfiltered and preserved in the field. Stream gaging stations, 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 2014 was the eleventh year that the first flush of storm water was sampled at many gaging 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 2014. 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 2014, storm water runoff overtopped stream banks in every watershed on Laboratory property during July; therefore, sediment samples were collected in every watershed. Tables 6-3 and 6-4 present results of radionuclides and inorganic/organic chemicals, respectively, in 2014 sediment samples that exceeded the standards/screening levels discussed in Table 6-1. Table 6-5 present results of inorganic/organic chemicals in 2014 storm water samples collected at gaging stations that exceeded the standards/screening levels discussed in Table 6-1. There were no exceedances of screening levels for radionuclides in storm water samples collected at gaging stations. Only analytes exceeding the standards/screening levels are discussed further in this report. Exceedances from the IP storm water data are discussed, but details are provided in the storm water IP annual report (LANL 2015c). 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 2014 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 8, Public Dose and Risk Assessment.

The residential SALs were not exceeded for radionuclides in any sediment samples collected in 2014. The residential SSLs were exceeded in two inorganic sediment samples in upper Sandia Canyon (chromium) and in one organic sediment sample in upper Los Alamos Canyon (PCB-126). All other exceedances of radionuclide, inorganic, and organic sediment screening levels were exceedances of background screening levels. For storm water samples collected in 2014, total PCBs exceeded the wildlife habitat standard, acute and chronic aquatic life standards, and the human health-organism only aquatic life standards throughout the Laboratory; mercury and selenium exceeded the wildlife habitat standard; aluminum, copper, selenium, and zinc exceeded the acute and chronic aquatic life standards; lead exceeded the chronic aquatic life standard; and dioxins, benzo(a)anthracene, benzo(a)fluoranthene, chrysene, and indenopyrene exceeded the human health-organism only aquatic life standard. All other exceedances of radionuclide, inorganic, and organic storm water screening levels were exceedances of background screening levels.

Table 6-3
Summary of Results for Radionuclides in Sediment Samples Collected in 2014

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	32	11	0.112	0.273	0.626	0.04	11	82	0	140	0	990	0	1500	0	4000	0
		Cs-137	16	12	0.118	0.61	1.7	0.9	4	11	0	31	0	39	0	340	0	2000	0
		Pu-238	18	3	0.0367	0.0470	0.0553	0.006	3	84	0	130	0	1300	0	1400	0	—[b]	—
		Pu-239/240	18	14	0.0501	0.339	0.985	0.068	11	79	0	120	0	1200	0	1300	0	6000	0
	DP	Am-241	6	1	0.211	0.211	0.211	0.04	1	82	0	140	0	990	0	1500	0	4000	0
		Cs-137	3	1	1.91	1.91	1.91	0.9	1	11	0	31	0	39	0	340	0	2000	0
		Pu-239/240	3	2	0.0559	0.102	0.149	0.068	1	79	0	120	0	1200	0	1300	0	6000	0
	Acid	Am-241	5	5	0.343	0.49	0.85	0.04	5	82	0	140	0	990	0	1500	0	4000	0
		Pu-238	5	3	0.0239	0.057	0.109	0.006	3	84	0	130	0	1300	0	1400	0	—	—
		Pu-239/240	5	5	1.83	10.7	36.9	0.068	5	79	0	120	0	1200	0	1300	0	6000	0
	Pueblo	Am-241	23	8	0.0373	0.084	0.205	0.04	7	82	0	140	0	990	0	1500	0	4000	0
		Pu-239/240	12	12	0.322	1.15	3.01	0.068	12	79	0	120	0	1200	0	1300	0	6000	0
	Lower Los Alamos	Am-241	62	19	0.253	0.090	0.178	0.04	17	82	0	140	0	990	0	1500	0	4000	0
		Pu-239/240	31	21	0.0268	0.684	2.87	0.068	18	79	0	120	0	1200	0	1300	0	6000	0
		U-235/236	3	2	0.158	0.216	0.273	0.2	1	39	0	100	0	150	0	940	0	3000	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	13	9	0.641	0.837	1.11	0.04	9	82	0	140	0	990	0	1500	0	4000	0
		Cs-137	3	3	2.09	2.33	2.77	0.9	3	11	0	31	0	39	0	340	0	2000	0
		Pu-238	10	6	0.188	0.433	0.717	0.006	6	84	0	130	0	1300	0	1400	0	—	—
		Pu-239/240	10	7	0.0517	0.593	0.745	0.068	6	79	0	120	0	1200	0	1300	0	6000	0
	Cañada del Buey	Am-241	7	4	0.0264	0.105	0.181	0.04	3	82	0	140	0	990	0	1500	0	4000	0
		Pu-238	7	3	0.108	0.581	1.04	0.006	3	84	0	130	0	1300	0	1400	0	—	—
		Pu-239/240	7	4	0.0419	0.179	0.282	0.068	3	79	0	120	0	1200	0	1300	0	6000	0
Pajarito Canyon	Pajarito	Am-241	19	4	0.0384	0.0493	0.0643	0.04	3	82	0	140	0	990	0	1500	0	4000	0
		Pu-239/240	19	5	0.0378	0.100	0.241	0.068	3	79	0	120	0	1200	0	1300	0	6000	0
		Tritium	15	3	0.0174862	0.149647	0.283913	0.093	2	850	0	6.2E04	0	2.0E05	0	7.1E05	0	2.0E04	0
Chaquehui Canyon	Chaquehui	Tritium	7	7	0.0155828	0.156828	0.697181	0.093	3	850	0	6.2E04	0	2.0E05	0	7.1E05	0	2.0E04	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 Sediment Samples Collected in 2014

Major Canyon	Tributary or Subcanyon	Analyte	Number of Analyses	Number of Detects	Minimum (mg/kg[a])	Average (mg/kg)	Maximum (mg/kg)	Sediment Background (mg/kg)	Number Greater than Sediment Background	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
Los Alamos Canyon	Upper Los Alamos	Chromium	16	16	1.78	5.07	11.2	10.5	1	96.6	0	134	0	505	0
		Lead	16	16	5.25	11.6	27.6	19.7	2	400	0	800	0	800	0
		Manganese	16	16	201	324	552	543	1	10,500	0	464	3	160,000	0
		Zinc	16	16	16.4	38.9	63.1	60.2	1	23,500	0	106,000	0	389,000	0
		PCB-126	18	11	7.19E-07	9.76E-05	6.95E-04	—[b]	—	0.000375	1	0.00172	0	0.00177	0
	DP	Zinc	3	2	19.9	43.5	76.5	60.2	1	23,500	0	106,000	0	389,000	0
	Acid	Barium	5	5	30.4	78.5	142	127	2	15,600	0	4390	0	255,000	0
		Cadmium	5	5	0.248	0.302	0.412	0.40	1	70.5	0	72.1	0	1110	0
		Calcium	5	5	836	2640	4970	4420	2	—	—	—	—	—	—
		Copper	5	5	4.02	12.5	25.4	11.2	2	3130	0	14,200	0	51,900	0
		Lead	5	5	22.9	35.6	52.6	19.7	5	400	0	800	0	800	0
		Mercury	5	5	0.0531	0.359	0.981	0.10	2	23.5	0	77.1	0	389	0
		Silver	5	3	0.413	2.96	4.32	1	2	391	0	1770	0	6490	0
		Zinc	5	5	60.8	69.9	84.8	60.2	5	23,500	0	106,000		389,000	0
	Pueblo	Copper	14	14	0.888	2.91	12.8	11.2	1	3130	0	14,200	0	51,900	0
		Lead	14	13	0.698	13.0	66.1	19.7	1	400	0	800	0	800	0
		Manganese	14	14	107	327	723	543	2	10,500	0	464	2	160,000	0
		Zinc	14	14	13.3	41.6	69.4	60.2	2	23,500	0	106,000	0	389,000	0

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)	Sediment Background (mg/kg)	Number Greater than Sediment Background	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
Los Alamos Canyon (continued)	Lower Los Alamos	Antimony	31	1	1.89	1.89	1.89	0.83	1	31.3	0	142	0	519	0
		Calcium	31	31	564	1829	6340	4420	1	—	—	—	—	—	—
		Iron	31	31	4490	8150	14,000	13,800	1	54,800	0	248,000	0	908,000	0
		Lead	31	31	0.633	8.11	24	19.7	1	400	0	800	0	800	0
		Selenium	31	13	0.617	0.766	0.958	0.30	13	391	0	1750	0	6490	0
		Zinc	31	31	3.58	35.9	69.1	60.2	2	23,500	0	106,000	0	389,000	0
Sandia Canyon	Upper Sandia	Antimony	10	2	0.935	0.957	0.978	0.83	2	31.3	0	142	0	519	0
		Barium	10	10	9.28	60.0	195	127	2	15,600	0	4390	0	255,000	0
		Cadmium	10	3	0.125	0.449	0.642	0.40	2	70.5	0	72.1	0	1110	0
		Chromium	10	10	3.07	43.3	165	10.5	7	96.6	2	134	2	505	0
		Cobalt	10	10	0.643	1.94	4.83	4.73	1	23	0	36.6	0	350	0
		Copper	10	10	0.681	10.2	43.5	11.2	2	3130	0	14,200	0	51,900	0
		Iron	10	10	3950	7920	15,400	13,800	2	54,800	0	248,000	0	908,000	0
		Lead	10	10	4.1	14	37.2	19.7	2	400	0	800	0	800	0
		Manganese	10	10	131	478	1680	543	2	10,500	0	464	2	160,000	0
		Mercury	10	6	0.0046	0.098	0.267	0.10	2	23.5	0	77.1	0	389	0
		Nickel	10	10	0.927	3.90	10.9	9.38	1	1560	0	753	0	25,700	0
		Silver	10	7	0.166	3.29	12.5	1	2	391	0	1770	0	6490	0
		Vanadium	10	10	3.1	9.1	23.5	19.7	1	394	0	614	0	6530	0
		Zinc	10	10	24.3	56	140	60.2	2	23,500	0	106,000	0	389,000	0
	Lower Sandia	Calcium	18	18	437	4100	11,800	4420	9	—	—	—	—	—	—
		Chromium	18	18	1.77	9.5	14	10.5	8	96.6	0	134	0	505	0
		Cobalt	18	18	0.99	5	7	4.73	10	23	0	36.6	0	350	0
		Iron	18	18	2610	11,200	32,600	13,800	3	54,800	0	248,000	0	908,000	0
		Magnesium	18	18	324	1950	4420	2370	9	—	—	—	—	—	—

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)	Sediment Background (mg/kg)	Number Greater than Sediment Background	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
Sandia Canyon (continued)	Lower Sandia (continued)	Manganese	18	18	99.8	345	1230	543	1	10,500	0	464	1	160,000	0
		Selenium	18	1	0.343	0.343	0.343	0.30	1	391	0	1750	0	6490	0
		Vanadium	18	18	2.91	19.7	35.3	19.7	10	394	0	614	0	6530	0
		Zinc	17	17	15.9	37.1	128	60.2	1	23,500	0	106,000	0	389,000	0
Mortandad Canyon	Mortandad	Antimony	10	2	0.405	0.677	0.948	0.83	1	31.3	0	142	0	519	0
		Iron	10	10	4240	8580	13,900	13,800	1	54,800	0	248,000	0	908,000	0
		Vanadium	10	10	3.43	9.83	28.7	19.7	2	394	0	614	0	6530	0
		Zinc	10	10	21.8	38.0	68.8	60.2	2	23,500	0	106,000	0	389,000	0
	Cañada del Buey	Lead	7	7	4.76	9.77	25.6	19.7	1	400	0	800	0	800	0
Pajarito Canyon	Pajarito	Barium	19	19	21	100	354	127	6	15,600	0	4390	0	255,000	0
		Beryllium	19	19	0.144	0.558	1.48	1.31	1	156	0	148	0	2580	0
		Cadmium	19	10	0.112	0.333	0.562	0.40	4	70.5	0	72.1	0	1110	0
		Calcium	19	19	496	2980	7520	4420	4	—	—	—	—	—	—
		Chromium	19	19	1.54	5.62	11.6	10.5	1	96.6	0	134	0	505	0
		Cobalt	19	19	1.34	3.75	9.61	4.73	4	23	0	36.6	0	350	0
		Copper	19	19	1.11	7.19	18.9	11.2	4	3130	0	14,200	0	51,900	0
		Iron	19	19	4230	9260	16,400	13,800	3	54,800	0	248,000	0	908,000	0
		Lead	19	19	2.19	11.6	27.8	19.7	4	400	0	800	0	800	0
		Magnesium	19	19	283	1220	2940	2370	2	—	—	—	—	—	—
		Manganese	19	19	136	562	2320	543	5	10,500	0	464	5	160,000	0
		Nickel	19	19	2.22	7.21	16.1	9.38	5	1560	0	753	0	25,700	0
		Potassium	19	19	277	1000	2800	2690	1	—	—	—	—	—	—
		Selenium	19	3	0.41	0.46	0.489	0.30	3	391	0	1750	0	6490	0

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)	Sediment Background (mg/kg)	Number Greater than Sediment Background	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
Pajarito Canyon (continued)	Pajarito (continued)	Silver	19	14	0.104	1.13	4.29	1	5	391	0	1770	0	6490	0
		Vanadium	19	19	5.87	13.4	27.5	19.7	4	394	0	614	0	6530	0
		Zinc	19	19	14	40	69.9	60.2	3	23,500	0	106,000	0	389,000	0
	Twomile	Barium	4	4	59.6	111	151	127	2	15,600	0	4390	0	255000	0
		Chromium	4	4	4.26	9.5	21	10.5	1	96.6	0	134	0	505	0
		Lead	4	4	11.8	17.6	21.2	19.7	2	400	0	800	0	800	0
		Manganese	4	4	351	602	984	543	2	10,500	0	464	2	160,000	0
		Selenium	4	2	0.383	0.390	0.396	0.30	2	391	0	1750	0	6490	0
Water Canyon	Water	Antimony	13	5	0.351	0.620	0.945	0.83	1	31.3	0	142	0	519	0
		Barium	13	13	36.1	194	651	127	7	15,600	0	4390	0	255,000	0
		Beryllium	13	13	0.232	0.817	1.64	1.31	2	156	0	148	0	2580	0
		Calcium	13	13	553	2190	5450	4420	1	—	—	—	—	—	—
		Cobalt	13	13	1.6	3.6	5.68	4.73	2	23	0	36.6	0	350	0
		Copper	13	13	1.28	5.62	12.4	11.2	1	3130	0	14,200	0	51,900	0
		Manganese	13	13	160	393	597	543	3	10,500	0	464	3	160,000	0
		Nickel	13	13	1.61	5.44	9.61	9.38	1	1560	0	753	0	25,700	0
		Potassium	13	13	483	1110	3020	2690	1	—	—	—	—	—	—
	Cañon de Valle	Antimony	11	1	1.34	1.34	1.34	0.83	1	31.3	0	142	0	519	0
		Barium	11	11	34.4	750	1750	127	9	15,600	0	4390	0	255,000	0
		Copper	11	11	1.78	8.18	14.6	11.2	3	3130	0	14,200	0	51,900	0
		Lead	11	11	4.74	13.3	21.6	19.7	1	400	0	800	0	800	0

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)	Sediment Background (mg/kg)	Number Greater than Sediment Background	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
Water Canyon (continued)	**Cañon de Valle (continued)**	Manganese	11	11	244	396	575	543	1	10,500	0	464	3	160,000	0
		Nickel	11	11	2.7	10.0	34.9	9.38	3	1560	0	753	0	25700	0
		Silver	11	9	0.231	2.83	6.68	1	6	391	0	1770	0	6490	0
Ancho Canyon	**North Ancho**	Selenium	2	2	0.446	1.00	1.56	0.30	2	391	0	1750	0	6490	0
Chaquehui Canyon	**Chaquehui**	Cobalt	7	7	1.26	3.67	4.81	4.73	1	23	0	36.6	0	350	0
		Nickel	7	7	1.93	5.29	9.46	9.38	1	1560	0	753	0	25,700	0
		Selenium	7	1	0.313	0.313	0.313	0.30	1	391	0	1750	0	6490	0
		Vanadium	7	7	3.69	15	22	19.7	2	394	0	614	0	6530	0

[a] mg/kg = Milligrams per kilogram.

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

Table 6-5
Summary of Results for Inorganic and Organic Chemicals in Storm Water Samples Collected at Gaging Stations collected in 2014

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	Los Alamos Canyon	Los Alamos Below Ice Rink at E026	Aluminum	1	1	1010	1010	1010	2241	0	245	1	5000	0	—[c]	—	—	—	877	1	—	—	—	—
			Dioxins[d]	1	1	1.7117E-06	1.7117E-06	1.7117E-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	1
			Total PCB	1	1	0.132	0.132	0.132	0.0117	1	0.098	1	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
		LA Ponds Runoff at CO101038	Aluminum	3	3	35.5	162	254	2241	0	245	1	5000	0	—	—	—	—	1600 to 3420	0	—	—	—	—
			Total PCB	3	3	0.0524	0.086	0.106	0.0117	3	0.098	2	—	—	—	—	0.014	3	2	0	—	—	0.00064	3
		LA Ponds Run-on at CO111041	Aluminum	3	3	230	391	694	2241	0	245	2	5000	0	—	—	—	—	200 to 593	1	—	—	—	—
			Copper	3	3	1.87	3.0	5.2	3.43	1	32.3	0	200	0	500	0	—	—	1.9 to 4.0	1	—	—	—	—
			Total PCB	4	4	0.897	6	10	0.0117	4	0.098	4	—	—	—	—	0.014	4	2	3	—	—	0.00064	4
		Los Alamos above DP at E030	Aluminum	2	2	1330	1340	1350	2241	0	245	2	5000	0	—	—	—	—	435 to 616	2	—	—	—	—
			Mercury	2	2	1.28	1.85	2.42	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
			Selenium	2	1	5.07	5.07	5.07	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Dioxins	2	2	3.106E-06	4.719E-06	6.332E-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	2
			Total PCB	2	2	0.0622	0.0931	0.124	0.0117	2	0.098	1	—	—	—	—	0.014	2	2	0	—	—	0.00064	2
		Los Alamos above Low-Head Weir at E042.1	Aluminum	4	4	841	1790	2740	2241	1	245	4	5000	0	—	—	—	—	463 to 1060	3	—	—	—	—
			Mercury	4	4	0.773	1.63	2.13	—	—	—	—	—	—	10	0	0.77	4	—	—	—	—	—	—
			Dioxins[d]	4	4	4.0852E-06	1.518E-05	2.8016E-05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	4
			Total PCB	12	12	0.0465	0.182	0.801	0.0117	12	0.098	6	—	—	—	—	0.014	12	2	0	—	—	0.00064	12
		Los Alamos below Low-Head Weir at E050.1	Aluminum	3	3	808	1190	1420	2241	0	245	3	5000	0	—	—	—	—	593 to 722	3	—	—	—	—
			Copper	3	3	2.32	2.8	3.5	3.43	1	32.3	0	200	0	500	0	—	—	4.0 to 4.6	0	—	—	—	—
			Mercury	3	3	0.365	0.6	1	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Dioxins[d]	3	3	3.8048E-06	5.716E-06	8.5095E-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	3
			Total PCB	7	7	0.0331	0.102	0.132	0.0117	7	0.098	4	—	—	—	—	0.014	7	2	0	—	—	0.00064	7
	DP	DP above TA-21 at E038	Aluminum	5	5	234	747	1680	2241	0	245	3	5000	0	—	—	—	—	305 to 697	3	—	—	—	—
			Total PCB	5	5	0.00873	0.0188	0.0251	0.0117	4	0.098	0	—	—	—	—	0.014	4	2	0	—	—	0.00064	5
		DP below Grade Control Structure at E039.1	Aluminum	6	6	166	685	1020	2241	0	245	5	5000	0	—	—	—	—	370 to 916	3	—	—	—	—
			Copper	6	6	2.12	2.75	3.82	3.43	1	32.3	0	200	0	500	0	—	—	2.91 to 5.43	0	—	—	—	—
			Total PCB	5	5	0.00917	0.0211	0.0475	0.0117	2	0.098	0	—	—	—	—	0.014	2	2	2	—	—	0.00064	5
		DP above Los Alamos at E040	Aluminum	5	5	350	770	1140	2241	0	245	5	5000	0	—	—	—	—	372 to 1940	3	—	—	—	—
			Vanadium	5	5	2.42	6.76	21.2	5.77	1	10.6	1	100	0	100	0	—	—	—	—	—	—	—	—
			Zinc	5	4	3.78	37.6	137	109	1	1120	0	2000	0	25000	0	—	—	36.7 to 110	1	—	—	26000	0
			Total PCB	4	4	0.00601	0.00991	0.0132	0.0117	2	0.098	0	—	—	—	—	0.014	0	2	0	—	—	0.00064	4

Table 6-5 (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)	Upper Pueblo canyon	Pueblo above Acid at E055	Aluminum	1	1	978	978	978	2241	0	245	1	5000	0	—	—	—	—	—	—	128	1	—	—
			Copper	1	1	2.51	2.51	2.51	3.43	0	32.3	0	200	0	500	0	—	—	—	—	2.04	1	—	—
			Lead	1	1	1.42	1.42	1.42	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.366	1	—	—
			Total PCB	1	1	0.0264	0.0264	0.0264	0.0117	1	0.098	0	—	—	—	—	0.014	1	—	—	0.014	1	0.00064	1
		South Fork of Acid at E055.5	Aluminum	1	1	1460	1460	1460	2241	0	245	1	5000	0	—	—	—	—	—	—	117	1	—	—
			Copper	1	1	2.53	2.53	2.53	3.43	0	32.3	0	200	0	500	0	—	—	—	—	1.93	1	—	—
			Lead	1	1	2.18	2.18	2.18	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.341	1	—	—
			Mercury	1	1	1.03	1.03	1.03	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Total PCB	2	2	0.0393	0.0415	0.0437	0.0117	2	0.098	0	—	—	—	—	0.014	2	—	—	0.014	2	0.00064	2
		Acid above Pueblo at E056	Aluminum	3	3	821	1103	1410	2241	0	245	3	5000	0	—	—	—	—	—	—	68.4 to 110	3	—	—
			Copper	3	3	3.06	3.45	3.89	3.43	1	32.3	0	200	0	500	0	—	—	—	—	1.38 to 1.86	3	—	—
			Lead	3	3	1.34	1.71	2.22	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.218 to 0.324	3	—	—
			Mercury	3	3	0.113	0.744	1.42	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Total PCB	3	3	0.0177	0.0493	0.0771	0.0117	3	0.098	0	—	—	—	—	0.014	3	—	—	0.014	3	0.00064	3
	Lower Pueblo Canyon	Pueblo below WWTF at E059.5	Aluminum	3	3	1220	1500	2000	2241	0	245	3	5000	0	—	—	—	—	—	—	214 to 267	3	—	—
			Copper	3	3	2.53	2.9	3.2	3.43	0	32.3	0	200	0	500	0	—	—	—	—	2.8 to 3.2	1	—	—
			Lead	3	3	1.39	1.64	2.12	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.56 to 0.671	3	—	—
			Mercury	3	3	0.351	1.02	1.84	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
			Dioxins	3	3	2.18E-06	5.08E-06	6.639E-06	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.1E-08	3
			Total PCB	7	7	0.00221	0.068	0.184	0.0117	6	0.098	2	—	—	—	—	0.014	6	—	—	0.014	6	0.00064	7
		Pueblo below Grade Control Structure at E060.1	Mercury	1	1	1.63	1.63	1.63	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Selenium	1	1	6.01	6.01	6.01	—	—	—	—	—	—	—	—	5	1	—	—	5	1		
Sandia Canyon	Upper Sandia Canyon	Sandia right fork at Power Plant at E121	Aluminum	16	16	302	738	1570	2241	0	245	16	5000	0	—	—	—	—	—	—	60.9 to 354	15	—	—
			Chromium	16	13	2.23	3.80	7.24	—	—	4.07	4	100	0	1000	0	—	—	—	—	11.5 to 33	0	—	—
			Copper	16	16	2.88	6.08	20.6	3.43	14	32.3	0	200	0	500	0	—	—	—	—	1.28 to 3.85	16	—	—
			Lead	16	15	0.542	0.838	1.29	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.198 to 0.845	12	—	—
			Mercury	17	11	0.076	0.277	1.47	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Nickel	16	16	0.734	1.37	4.46	3.53	1	7.57	0	—	—	—	—	—	—	—	—	7.6 to 22.5	0	4600	0

Table 6-5 (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
Sandia Canyon (continued)	Upper Sandia (continued)	Sandia right fork at Power Plant at E121 (continued)	Vanadium	16	16	2.7	4.1	6.47	5.77	3	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Benzo(a) anthracene	35	5	0.0303	0.124	0.462	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	1
			Benzo(b) fluoranthene	35	6	0.228	0.138	0.602	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	1
			Benzo(k) fluoranthene	35	3	0.0138	0.0312	0.0482	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	0
			Chrysene	35	5	0.031	0.12	0.419	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	1
			Indeno (1,2,3-cd) pyrene	35	2	0.0308	0.182	0.333	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	1
			Total PCB	14	14	0.0183	0.301	1.32	0.0117	14	0.098	11	—	—	—	—	0.014	14	—	—	0.014	14	0.00064	14
		Sandia left fork at Asphalt Plant at E122	Aluminum	8	8	296	486	620	2241	0	245	8	5000	0	—	—	—	—	—	—	87 to 233	8	—	—
			Copper	8	8	1.84	4.15	8.28	3.43	5	32.3	0	200	0	500	0	—	—	—	—	1.61 to 2.96	7	—	—
			Lead	8	7	0.506	0.59	0.77	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.27 to 0.60	6	—	—
			Zinc	8	8	5.69	15.1	32.4	109	0	1120	0	2000	0	25,000	0	—	—	—	—	19.5 to 37.3	1	26000	0
			Benzo(a) anthracene	16	10	0.0207	0.111	0.423	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	2
			Benzo(b) fluoranthene	16	10	0.024	0.15	0.634	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	2
			Benzo(k) fluoranthene	16	6	0.0179	0.0332	0.0732	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	0
			Chrysene	16	10	0.0244	0.103	0.376	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	2
			Indeno (1,2,3-cd) pyrene	16	1	0.0573	0.0573	0.0573	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	0
			Total PCB	8	8	0.0228	0.0903	0.195	0.0117	8	0.098	3	—	—	—	—	0.014	8	—	—	0.014	8	0.00064	8
		Sandia below wetlands at E123	Aluminum	21	21	183	743	1290	2241	0	245	20	5000	0	—	—	—	—	—	—	113 to 384	20	—	—
			Arsenic	21	3	2.05	2.36	2.82	—	—	2.55	1	100	0	200	0	—	—	—	—	150	0	9	0
			Boron	21	15	15.1	25.2	48.7	—	—	47.3	1	750	0	5000	0	—	—	—	—	—	—	—	—
			Chromium	21	19	2.05	3.00	5.75	—	—	4.07	1	100	0	1000	0	—	—	—	—	16.7 to 34.6	0	—	—
			Copper	21	21	3.41	5.58	10.3	3.43	19	32.3	0	200	0	500	0	—	—	—	—	1.89 to 4.05	21	—	—
			Lead	21	20	0.583	0.962	1.45	—	—	3.3	0	5000	0	100	0	—	—	—	—	0.331 to 0.903	19	—	—
			Mercury	21	16	0.078	0.280	1.34	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Nickel	21	21	0.871	1.52	3.74	3.53	1	7.57	0	—	—	—	—	—	—	—	—	11.2 to 23.7	0	4600	0
			Vanadium	21	21	3.4	4.5	8.31	5.77	3	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—

Table 6-5 (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
Sandia Canyon (continued)	Upper Sandia (continued)	Sandia below Wetlands at E123 (continued)	Benzo(a) anthracene	43	4	0.02	0.1	0.356	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	1
			Benzo(b) fluoranthene	43	9	0.0217	0.118	0.404	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	2
			Benzo(k) fluoranthene	43	5	0.0131	0.0275	0.0634	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	0
			Chrysene	43	5	0.0176	0.106	0.317	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	1
			Dibenz(a,h) anthracene	43	1	0.0512	0.0512	0.0512	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.18	0
			Total PCB	21	21	0.0292	0.219	1.19	0.0117	21	0.098	16	—	—	—	—	0.014	21	—	—	0.014	21	0.00064	21
	Lower Sandia	Sandia above Firing Range at E124	Aluminum	2	2	1140	1695	2250	2241	1	245	2	5000	0	—	—	—	—	307 to 564	2	—	—	—	—
			Chromium	2	2	3.29	3.86	4.42	—	—	4.07	1	100	0	1000	0	—	—	135 to 194	0	—	—	—	—
			Copper	2	2	3.11	3.25	3.38	3.43	0	32.3	0	200	0	500	0	—	—	2.56 to 3.89	1	—	—	—	—
			Vanadium	2	2	3.7	5.3	6.88	5.77	1	10.6	0	100	0	100	0	—	—	—	—	—	—	—	—
			Total PCB	2	2	0.0697	0.0969	0.124	0.0117	2	0.098	1	—	—	—	—	0.014	2	2	0	—	—	0.00064	2
		Sandia above SR-4 at E125	Aluminum	1	1	645	645	645	2241	0	245	1	5000	0	—	—	—	—	975	0	—	—	—	—
			Arsenic	1	1	2.75	2.75	2.75	—	—	2.55	1	100	0	200	0	—	—	340	0	—	—	9	0
			Copper	1	1	3.98	3.98	3.98	3.43	1	32.3	0	200	0	500	0	—	—	5.67	0	—	—	—	—
			Mercury	1	1	4.22	4.22	4.22	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Total PCB	1	1	0.691	0.691	0.691	0.0117	1	0.098	1	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
Mortandad Canyon	Upper Mortandad	Mortandad above Ten Site at E201	Aluminum	2	2	1560	1680	1800	2241	0	245	2	5000	0	—	—	—	—	532 to 584	2	—	—	—	—
			Copper	2	2	4.77	4.91	5.04	3.43	2	32.3	0	200	0	500	0	—	—	3.74 to 3.98	2	—	—	—	—
			Mercury	2	2	0.778	1.21	1.65	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
			Total PCB	2	2	0.0304	0.0492	0.0679	0.0117	2	0.098	0	—	—	—	—	0.014	2	2	0	—	—	0.00064	2
	Lower Mortandad	Mortandad at LANL Boundary at E204	Aluminum	1	1	1100	1100	1100	2241	0	245	1	5000	0	—	—	—	—	790	1	—	—	—	—
			Selenium	1	1	41.4	41.4	41.4	—	—	—	—	—	—	—	—	5	1	20	1	—	—	—	—
			Total PCB	1	1	0.00533	0.00533	0.00533	0.0117	0	0.098	0	—	—	—	—	0.014	0	2	0	—	—	0.00064	1

Table 6-5 (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
Pajarito Canyon	Main Channel	Pajarito above Threemile at E245.5	Aluminum	6	6	893	1280	1850	2241	0	245	6	5000	0	—	—	—	—	220 to 419	6	—	—	—	—
			Copper	6	6	1.48	2.21	3.99	3.43	1	32.3	0	200	0	500	0	—	—	2.04 to 3.17	0	—	—	—	—
			Total PCB	5	5	0.00201	0.0177	0.0737	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	5
		Pajarito below SR-501 at E240	Aluminum	3	3	1220	1287	1360	2241	0	245	3	5000	0	—	—	—	—	337 to 1210	3	—	—	—	—
			Mercury	3	3	0.203	1.09	1.86	—	—	—	—	—	—	10	0	0.77	2	—	—	—	—	—	—
		Pajarito above SR-4 at E250	Aluminum	1	1	1770	1770	1770	2241	0	245	1	5000	0	—	—	—	—	388	1	—	—	—	—
			Total PCB	1	1	0.0217	0.0217	0.0217	0.0117	1	0.098	0	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
Water Canyon	Cañon de Valle	Cañon de Valle below MDA P at E256	Aluminum	1	1	669	669	669	2241	0	245	1	5000	0	—	—	—	—	—	—	406	1	—	—
			Boron	1	1	57.7	57.7	57.7	—	—	47.3	1	750	0	5000	0	—	—	—	—	—	—	—	—
			Total PCB	1	1	0.0506	0.0506	0.0506	0.0117	1	0.098	0	—	—	—	—	0.014	1	—	—	0.014	1	0.00064	1
	Lower Water	Water below SR-4 at E265	Aluminum	1	1	1140	1140	1140	2241	0	245	1	5000	0	—	—	—	—	691	1	—	—	—	—
			Mercury	1	1	0.89	0.89	0.89	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Selenium	1	1	7.85	7.85	7.85	—	—	—	—	—	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	1	1	0.0124	0.0124	0.0124	0.0117	1	0.098	0	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
	Potrillo Canyon	Potrillo above SR-4 at E267	Aluminum	1	1	1090	1090	1090	2241	0	245	1	5000	0	—	—	—	—	774	1	—	—	—	—
Chaquehui Canyon	Chaquehui Canyon	Chaquehui at TA-33 at E338	Aluminum	1	1	1110	1110	1110	2241	0	245	1	5000	0	—	—	—	—	1260	0	—	—	—	—
			Arsenic	1	1	2.73	2.73	2.73	—	—	2.55	1	100	0	200	0	—	—	340	0	—	—	9	0
			Mercury	1	1	1.02	1.02	1.02	—	—	—	—	—	—	10	0	0.77	1	—	—	—	—	—	—
			Total PCB	1	1	0.0105	0.0105	0.0105	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 $CaCO_3$/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) and 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 2014 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 gaging 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 gaging 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 (the acute aquatic life standard for a hardness of 30 mg $CaCO_3$/L) in other parts of the Jemez area (NMED 2009). Aluminum concentrations in storm water were similar in magnitude at gaging stations and IP SMAs during 2014. For sampling conducted under the IP, the highest filtered aluminum result was 1360 µg/L at CDV-SMA-8 in Cañon de Valle. The highest filtered aluminum result at a gaging station was 2740 µg/L at Los Alamos above Low-Head Weir (E042.1). In 2014, aluminum concentrations in sediment were not detected above the residential SSL (78,000 mg/kg) or the regional BV (15,400 mg/kg).

Arsenic is associated with the local geology and thus is naturally occurring in storm water and sediment. No filtered storm water samples collected on the Pajarito Plateau in 2014 had arsenic above the human health standard (9 µg/L). Three of 107 storm water samples had filtered arsenic concentrations above the urban area BV (2.55 µg/L): 1 was collected at Sandia below Wetlands (E123) with an arsenic concentration of 2.82 µg/L, 1 was collected at Sandia above SR-4 (E125) with an arsenic concentration of 2.75 µg/L, and 1 was collected at Chaquehui at TA-33 (E338) with an arsenic concentration of 2.73 µg/L. The highest filtered arsenic concentration detected at a gaging station in 2014 was 2.82 µg/L at Sandia below Wetlands (E123). For the sampling under the IP, arsenic was not detected in the 23 filtered samples analyzed for arsenic. In 2014, arsenic concentrations in sediment were not detected above the residential SSL (3.9 mg/kg) or the regional BV (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 2014, copper concentrations in filtered storm water were detected above the chronic aquatic life standard at the following locations: South Fork of Acid (E055.5) in 1 of 1 sample, Acid above Pueblo (E056) in 3 of 3 samples, Pueblo above Acid (E055) in 1 of 1 sample, Sandia right fork at Power Plant (E121) in 16 of 16 samples, Sandia left fork at Asphalt Plant (E122) in 7 of 8 samples, and Sandia below Wetlands (E123) in 21 of 21 samples. Copper concentrations in filtered storm water were detected above the acute aquatic life standard at the following locations: the run-on into the upper Los Alamos detention basins (CO111041) in 1 of 3 samples, Sandia above Firing Range (E124) in 1 of 2 samples, and Mortandad above Ten Site (E201) in 2 of 2 samples. Most of these locations receive a large percentage of runoff from developed areas. Also, 46 of 107 gaging station storm water samples had filtered copper concentrations greater than the Bandelier Tuff BV (3.43 µg/L), but none of the 107 samples had concentrations greater than the urban area BV (32.3 µg/L). Before 2014, every watershed across the Laboratory had recorded elevated copper concentrations in storm water, including all of the Laboratory's upgradient boundary gaging stations, indicating that copper most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. In addition, since the implementation of the IP, 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 gaging 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 45.5 μg/L at PT-SMA-1 in Potrillo Canyon and is associated with Laboratory operations. The highest filtered copper result detected at a gaging station in 2014 was 20.6 μg/L at Sandia right fork at Power Plant (E121). In 2014, copper concentrations in sediment were not detected above the residential SSL (3130 mg/kg).

Cyanide is observed in ash from forest fires as a result of incomplete combustion of cellulosic materials. Cyanide was not analyzed in gaging station storm water samples in 2014, as it had been more than 3 yr since the Las Conchas fire, and the fire-affected watersheds have recovered to a large degree, attested to by the decline of total cyanide concentrations at the gaging stations over the past 3 yr. This trend is similar to what was observed following the Cerro Grande fire in May 2000 (Gallaher and Koch 2004, 2005). In 2014, cyanide was detected in 3 of 9 Chaquehui Canyon sediment samples and 2 of 7 Potrillo Canyon sediment samples, none of which exceeded the regional BV for sediment (0.83 mg/kg) or the residential SSL (1220 mg/kg). For comparison, in 2011, cyanide was detected above the regional BV in 41 of 58 samples collected in fire-affected watersheds, although no cyanide concentrations in sediment were above the residential SSL. For sampling under the IP, the highest result for total cyanide (weak acid dissociable) in 2014 was 0.00219 μg/L at S-SMA-1.1 in Sandia Canyon.

Manganese is associated with the local geology and thus is naturally occurring in storm water and sediment. Filtered manganese concentrations were not detected above the acute or chronic aquatic life standards in storm water samples collected in 2014. Manganese concentrations in sediment were above the industrial SSL (464 mg/kg) in 21 of 226 samples and above the regional BV (543 mg/kg) in 17 of 226 samples, 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).

Selenium is associated with the local geology and thus is naturally occurring in storm water and sediment. Total selenium concentrations were detected above the wildlife habitat standard (5 μg/L) in 4 of 110 gaging station storm water samples collected in 2014. Total selenium concentrations did not exceed the IP TAL (5 μg/L) in any of the 24 samples collected in 2014. The highest total selenium result detected at a gaging station in 2014 was 41.4 μg/L in Mortandad at LANL Boundary (E204). In 2014, selenium concentrations in sediment were not detected above the residential SSL (391 mg/kg), but selenium was detected above the regional BV for sediment (0.3 mg/kg) in 21 of 226 samples collected. Laboratory operations did not generate or release significant quantities of selenium. Total selenium concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005).

Elevated zinc concentrations are associated with developed areas, particularly compounds associated with tires and galvanized metals. In 2014, filtered zinc concentrations in gaging station storm water samples were above the chronic aquatic life standard in 1 of 49 samples (Sandia left fork at Asphalt Plant [E122]) and above the acute aquatic life standard in 1 of 58 samples (DP above Los Alamos [E040]); however, none were above the Bandelier Tuff BV (109 μg/L) or the urban area BV (1120 μg/L). Since implementation of the IP, every watershed has had MTAL (42 μg/L) exceedances of zinc concentrations in IP-related filtered storm water samples. In 2014, only one SMA exceeded the MTAL for zinc, S-SMA-0.25, with a filtered zinc concentration of 103 μg/L. Prior to 2014, 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 gaging stations, indicating that zinc also likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. No 2014 zinc concentrations in sediment were above the residential SSL (23,500 mg/kg), and only 19 of 226 samples exceeded the sediment BV (60.2 μg/L).

In 2014, gaging station storm water samples analyzed for gross-alpha radioactivity were collected at Los Alamos below Low-Head Weir (E050.1) with gross-alpha concentrations of 161 pCi/L, 189 pCi/L, and 309 pCi/L, all of which were above the livestock watering standard (15 pCi/L) and urban area BV (32.5 pCi/L), but below the Bandelier Tuff BV (1490 pCi/L). In previous years, many storm water samples had gross-alpha concentrations above the livestock watering standard. Indeed, in 2011, 2012, and 2013, the highest concentrations of gross alpha in storm water (6200 pCi/L, 1260 pCi/L, and 8730 pCi/L, respectively) were measured in samples containing ash and sediment from the Las Conchas fire and were particularly high after the extremely large September 2013 flood. For sampling under the IP in 2014, the highest detected gross-alpha concentration was 4400 pCi/L at PT-SMA-1 in Potrillo Canyon. The analytical results from 2014 support earlier conclusions that the majority of the alpha radioactivity in storm water on the Pajarito Plateau is from the decay of naturally occurring isotopes in sediment and soil, 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 2014, gaging station storm water samples analyzed for radium-226 and radium-228 radioactivity were collected at Los Alamos below Low-Head Weir (E050.1) with radium-226 + radium-228 concentrations of 5.12 pCi/L, 7.32 pCi/L, 11.6 pCi/L, and 15 pCi/L, all of which were below 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 + radium-228 concentrations above the livestock watering standard. Indeed, in 2011, 2012, and 2013, the highest concentrations of radium-226 + radium-228 in storm water (109 pCi/L, 122 pCi/L, and 885 pCi/L, respectively) were measured in samples containing ash and sediment from the Las Conchas fire and were particularly high after the extremely large September 2013 flood. For sampling under the IP in 2014, the highest detected radium-226 + radium-228 concentration was 95.9 pCi/L at PT-SMA-4.2 in Potrillo Canyon. The analytical results from 2014 support earlier conclusions that the majority of the radium-226 and radium-228 found in storm water on the Pajarito Plateau is from the decay of naturally occurring isotopes in sediment and soil, 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 2014 storm water and sediment samples and the relationship of their concentrations to preexisting concentrations and spatial distributions.

Figures 6-9 and 6-10 illustrate the relationships between 2014 constituent concentrations in storm water and sediment to those prior to 2014. Only results for total PCBs and plutonium-239/240 are presented in these figures because they are the two major analytes of potential concern from historical activities at the Laboratory and because of limited space. In these figures, the x-axis is reversed because the Rio Grande is to the east of the Laboratory; thus, water flows to the east (i.e., right) through the Laboratory. Plotted results were part of Canyons IRs, ASERs, or were results from IP SMAs. All results are plotted relative to their along-river 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-2014 results for each subwatershed are identified using a unique color, and results obtained in 2014 are in green. In the storm water figures, results collected as part of the IP are identified with a circle, and canyon gaging stations results are identified with a triangle. In the sediment figures, results collected as part of Canyons IRs are identified with a circle, and ASER results are identified with a triangle. Results from the 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 gaging station storm water samples collected in 2014 was in Cañon de Valle below MDA P (E256, 757 µg/L), which is below sources of barium from the synthesis, processing, and testing of high explosives (LANL 2011c). However, gaging station DP above Los Alamos (E040) also had a high result for filtered barium in 2014 (216 µg/L), and historical Laboratory operations associated with barium contamination were not performed in this canyon. Pre-2014 barium concentrations in sediment were above the residential SSL (15,600 mg/kg) in Cañon de Valle; however, 2014 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-2014 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. In 2014, 37 of 48 samples in Sandia Canyon (E121, E122, and E123) and 8 of 8 samples in Acid/Pueblo Canyon (E055, E055.5, E056, and E059.5) 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 2014, the highest result for filtered lead was 2.22 µg/L at PT-SMA-2 in Potrillo Canyon. The highest filtered lead result at gaging stations in 2014 was 2.64 µg/L at Los Alamos above Low-Head Weir (E042.1). Concentrations of lead in storm water collected during 2014 were highest where lead had been detected in sediment associated with historical Laboratory operations in Acid and Pueblo below Acid, DP, lower Los Alamos, and Twomile Canyons (LANL 2005 and 2009a). Los Alamos, Pajarito, and Water Canyon watersheds had pre-2014 lead concentrations in sediment that were above the regional BV (19.7 mg/kg) but below the residential SSL (400 mg/kg). No 2014 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-2014 gaging station 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 have historical Laboratory operations associated with mercury contamination; Pajarito Canyon does not have a Laboratory source for mercury). For 2014, unfiltered mercury concentrations in storm water were above the wildlife habitat standard in Chaquehui, Los Alamos, Acid, Pueblo, Mortandad, Sandia, Pajarito, and Water Canyons, and IP samples exceeded the average TAL (0.77 µg/L) at LA-SMA-5.52 (0.994 µg/L) in Los Alamos Canyon. Mercury concentrations are generally similar at gaging stations and IP SMAs. The highest unfiltered mercury result detected at the gaging stations in 2014 was 4.22 µg/L in Sandia above SR-4 (E125). Mercury concentrations decreased from their sources in Acid and S-Site Canyons (LANL 2005, 2011c) to below background in sediment collected near the Laboratory boundary. One pre-2014 mercury concentration in sediment was above the residential SSL of 23.5 mg/kg in Threemile Canyon (LANL 2009b). No 2014 mercury concentrations in sediment were above the residential SSL.

d. Silver

In pre-2014 gaging station 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. In 2014, silver was not detected in any filtered gaging station storm water samples or IP samples. No pre-2014 or 2014 sediment concentrations of silver were above the residential SSL (391 mg/kg). 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 99% of gaging station storm water samples collected in 2014; 116 of 119 samples had concentrations above the human health standard (0.00064 µg/L), and 100 of 119 samples had concentrations above the chronic aquatic life standard of 0.014 µg/L (Figures 6-9a through j; Ancho and Chaquehui Canyons are not presented because of the minimal amount of 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.* Twenty-nine of the 119 storm water samples collected at gaging stations in 2014 fall into this category. In 10 of the 29 samples, the total PCB concentrations were below the nonurban upper threshold limit (UTL) of 0.013 µg/L identified in the PCB background report (LANL 2012d), and in the other 19 samples, the total PCB concentrations (0.0183 µg/L to 0.0859 µg/L) were above the nonurban UTL. 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.* Thirty-six of the 119 storm water samples collected at gaging stations in 2014 fall into this category. These samples were collected at gaging stations that receive townsite runoff (Los Alamos and Pueblo Canyons); however, the total PCB concentrations (0.00221 µg/L to 0.0927 µg/L) for these samples were below the urban 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.* Fifty-four of the 119 storm water samples collected at gaging stations in 2014 fall into this category. The total PCB concentrations in these samples (0.0982 µg/L to 10 µg/L) were above the urban UTL of 0.098 µg/L identified in the PCB background report (LANL 2012d), potentially indicating a presence of sources of PCBs. These samples were collected in Los Alamos, Pueblo, Sandia, and Twomile Canyons.

The highest total PCB concentrations were detected in storm water runoff entering the detention basins below SWMU 01-001(f) in Los Alamos Canyon. These detention basins 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 0.897 µg/L to 10 µg/L, and the total PCB concentrations at the outlet of the lower retention basin ranged from 0.0524 µg/L to 0.106 µg/L, indicating that the detention basins are reducing the total PCB concentrations in storm water runoff. The detention basins/low-head weir in Los Alamos Canyon also capture sediments and reduce PCB concentrations; above the low-head weir (E042.1) the total PCB concentrations ranged from 0.0465 µg/L to 0.801 µg/L, and below the low-head weir (E050.1) the total PCB concentrations ranged from 0.0331 µg/L to 0.132 µg/L. Concentrations of PCBs in runoff from Las Conchas burned areas are as high as 0.132 µg/L in upper Los Alamos Canyon (E026), indicating that PCBs continue to be concentrated in fire-influenced sediment-laden runoff. All 9 IP samples exceeded the average TAL for total PCBs. In sediment, PCBs were detected in 188 of 206 samples, with the only nondetects being on the Rio Grande above Otowi Bridge, lower Los Alamos Canyon above the confluence with the Rio Grande, and along the Rio Grande between Los Alamos and Sandia Canyons. Concentrations of PCB Aroclor mixtures do not directly correspond to PCB congener concentrations and thus are not presented.

f. RDX

Over the past 5 yr of IP monitoring, only one sample exceeded the average TAL (200 µg/L) and was collected at CDV-SMA-1.7 (908 µg/L) in 2013. At the gaging stations in 2014, there was one detection of RDX (0.155 µg/L) in Water Canyon below SR-4 (E265) and one detection of RDX (0.322 µg/L) in Pajarito below SR-501 (E240). In Cañon de Valle, pre-2014 RDX concentrations in sediment were above the residential SSL (58.2 mg/kg) and are associated with former high-explosives-machining facilities, including MDAs, burning grounds, and settling ponds (LANL 2011c). In 2014, no RDX concentrations in sediment were above the residential SSL, and RDX was detected in only one sample (0.267 mg/kg), collected in Cañon de Valle. The detections in storm water and sediment and the exceedance in an IP-related storm water sample might indicate the movement of RDX-laden sediment in Cañon de Valle.

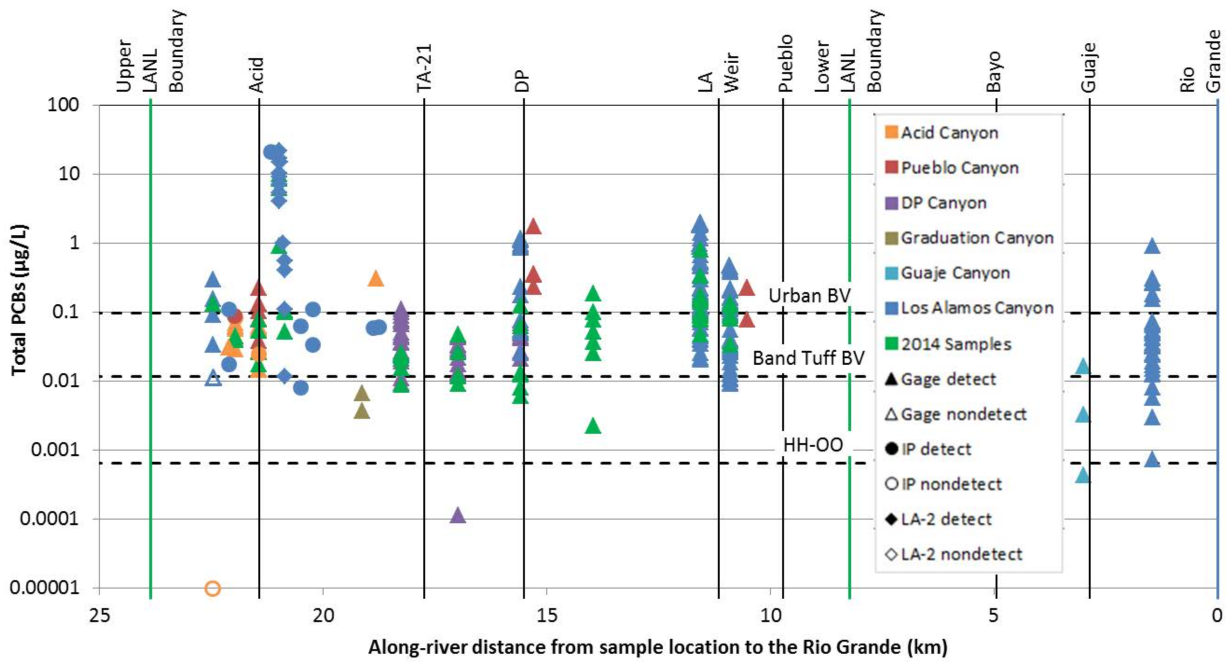


Figure 6-9a Los Alamos Canyon watershed total PCB concentrations in unfiltered storm water from SMA stations (2011–2014) and gaging stations (2009–2014). A diamond indicates the upper Los Alamos detention basins (LA-2).

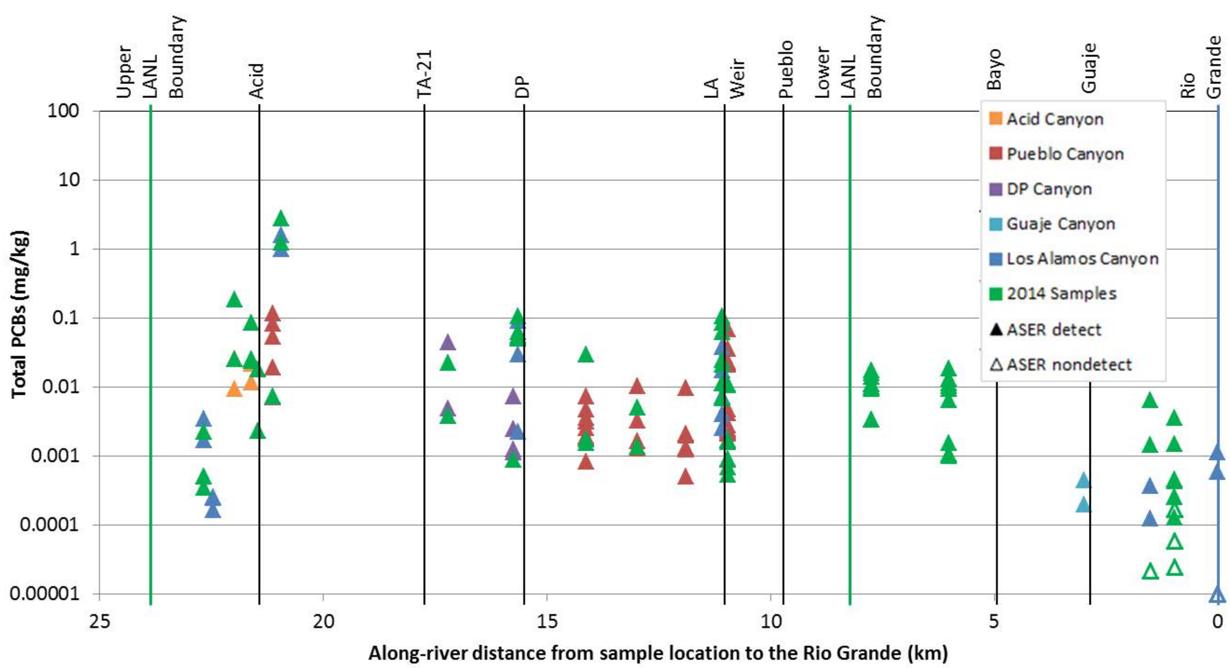
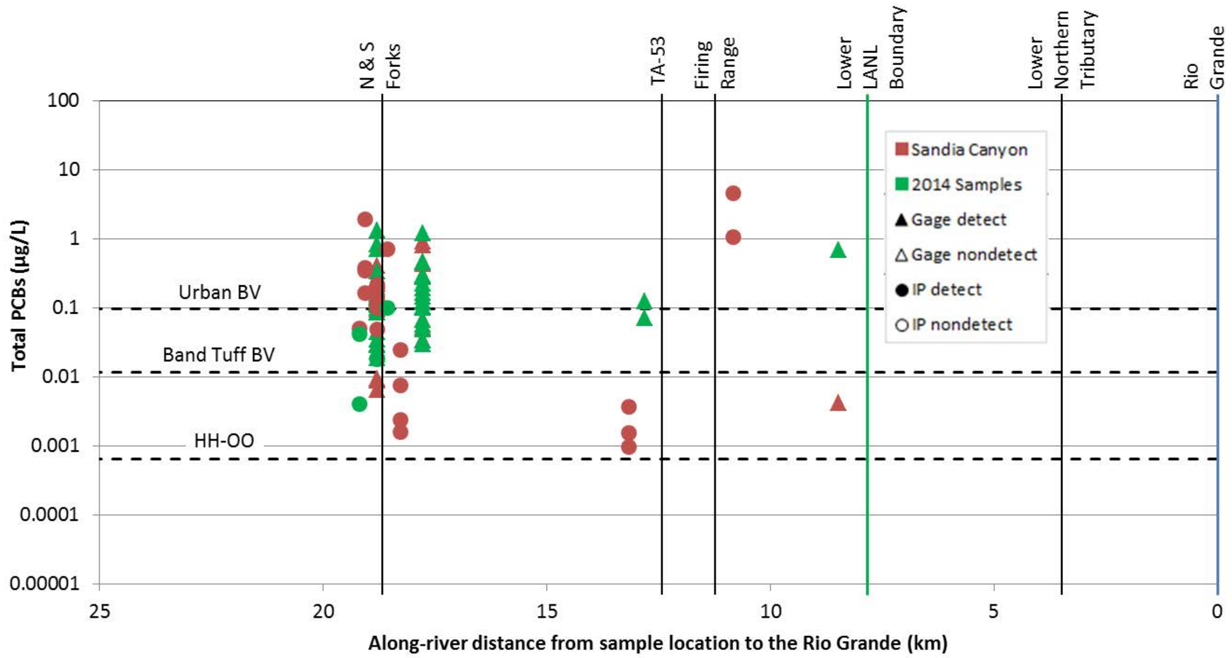


Figure 6-9b Los Alamos Canyon watershed total PCB concentrations in sediment from ASERs (2009–2014). PCB congeners were not analyzed in Los Alamos Canyon before 2011; thus, there are no canyon IR data. There is no residential SSL or BV for PCBs in sediment.



HH-OO = Human health-organism only (aquatic life standard).

Figure 6-9c **Sandia Canyon watershed total PCB concentrations in unfiltered storm water from SMA stations and gaging stations (2010–2014)**

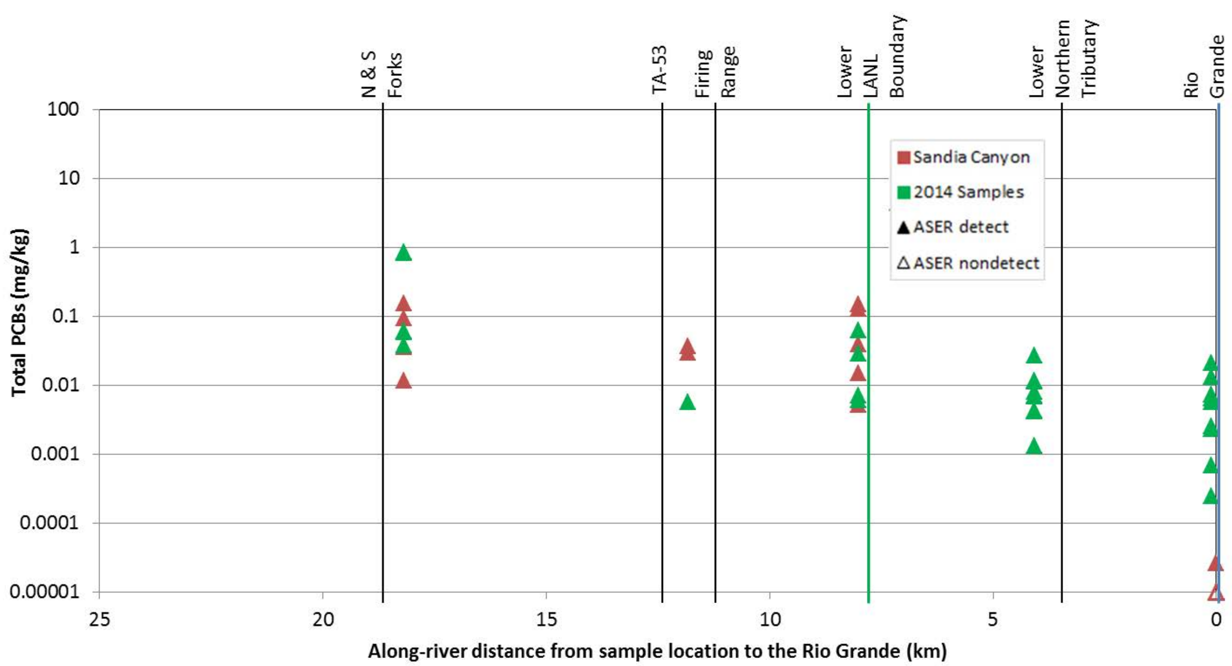


Figure 6-9d **Sandia Canyon watershed total PCB concentrations in sediment from ASERs (2012–2014). PCB congeners were not analyzed in Sandia Canyon before 2011; thus, there are no canyon IR data. There is no residential SSL or BV for PCBs in sediment.**

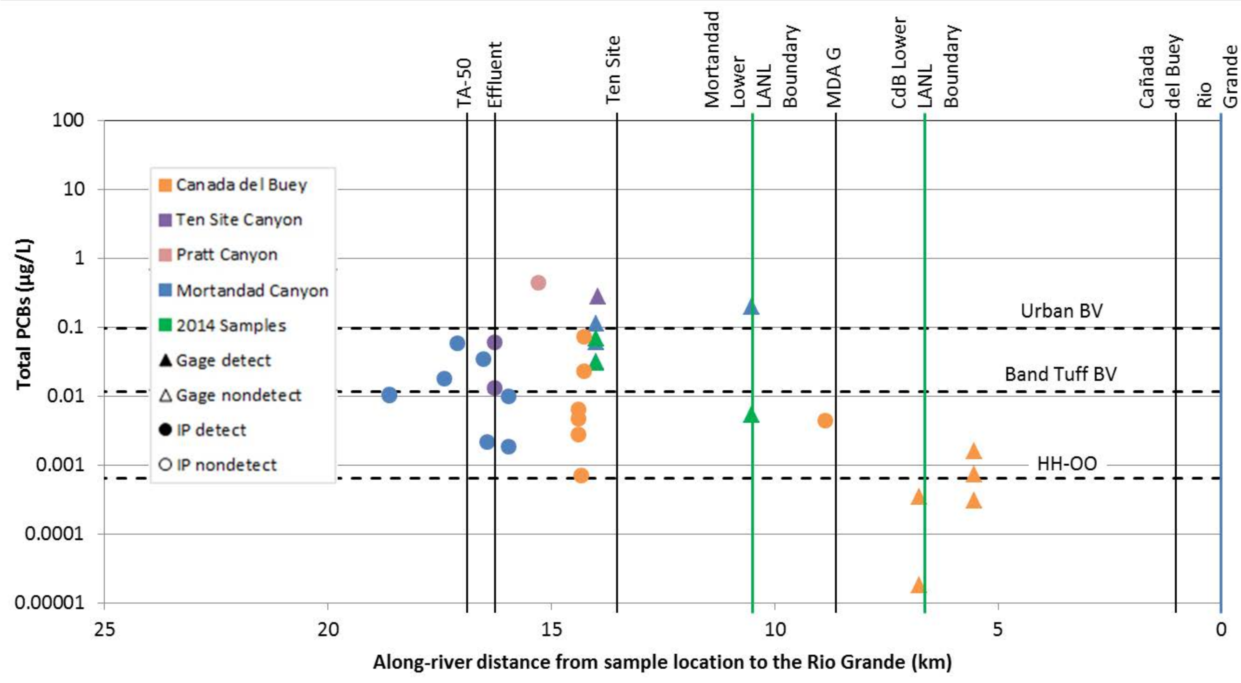


Figure 6-9e Mortandad Canyon watershed total PCB concentrations in unfiltered storm water from SMA stations (2011–2014) and gaging stations (2009–2014)

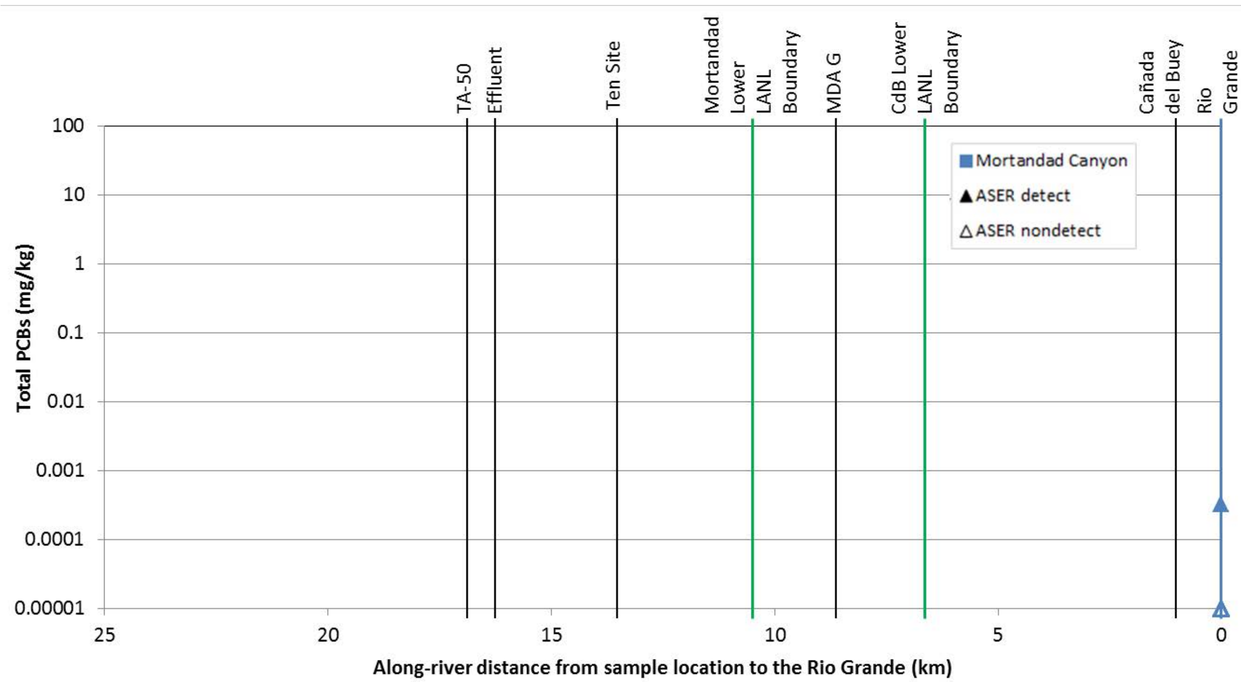


Figure 6-9f Mortandad Canyon watershed total PCB concentrations in sediment from ASERs (2012–2014). PCB congeners were not analyzed in Mortandad Canyon before 2011; thus, there are no canyon IR data. There is no residential SSL or BV for PCBs in sediment.

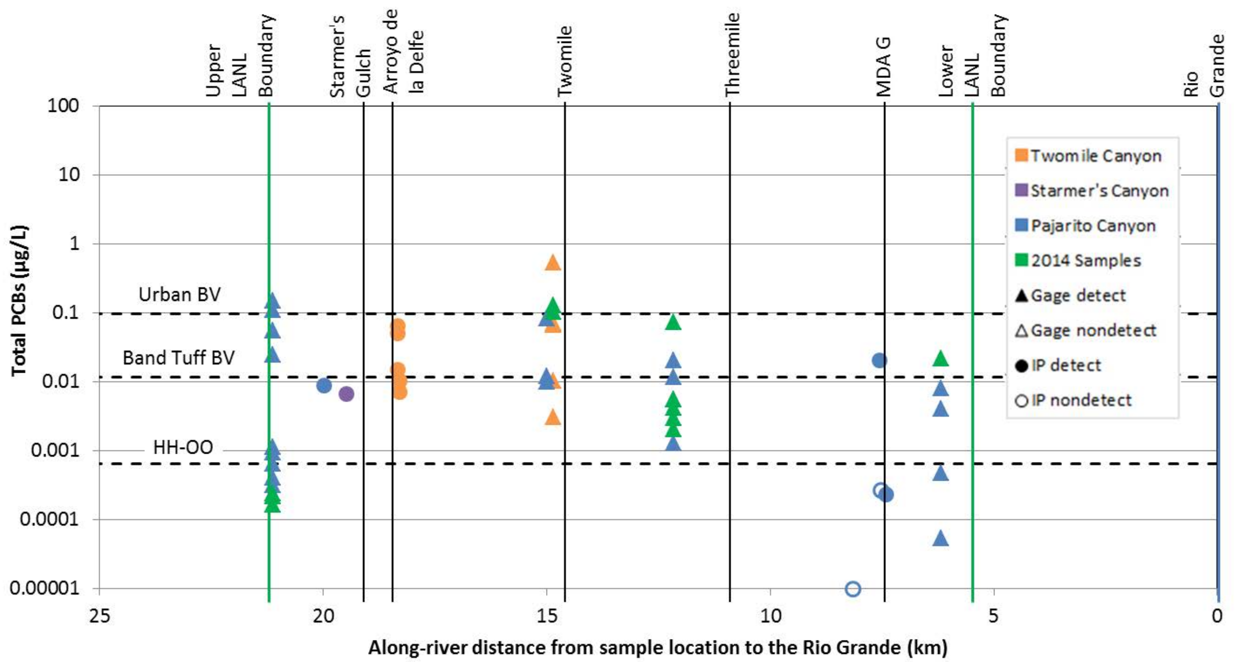


Figure 6-9g Pajarito Canyon watershed total PCB concentrations in unfiltered storm water from SMA stations (2011–2014) and gaging stations (2010–2014)

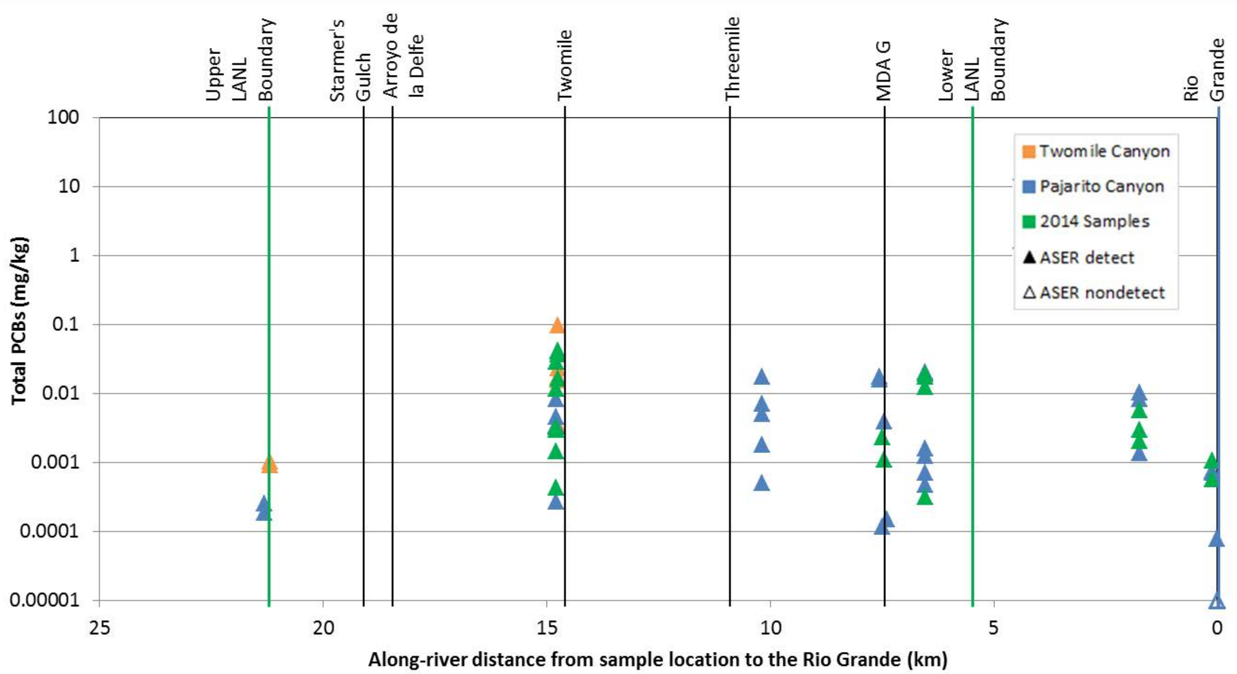


Figure 6-9h Pajarito Canyon watershed total PCB concentrations in sediment from ASERs (2011–2014). PCB congeners were not analyzed in Pajarito Canyon before 2011; thus, there are no canyon IR data. There is no residential SSL or BV for PCBs in sediment.

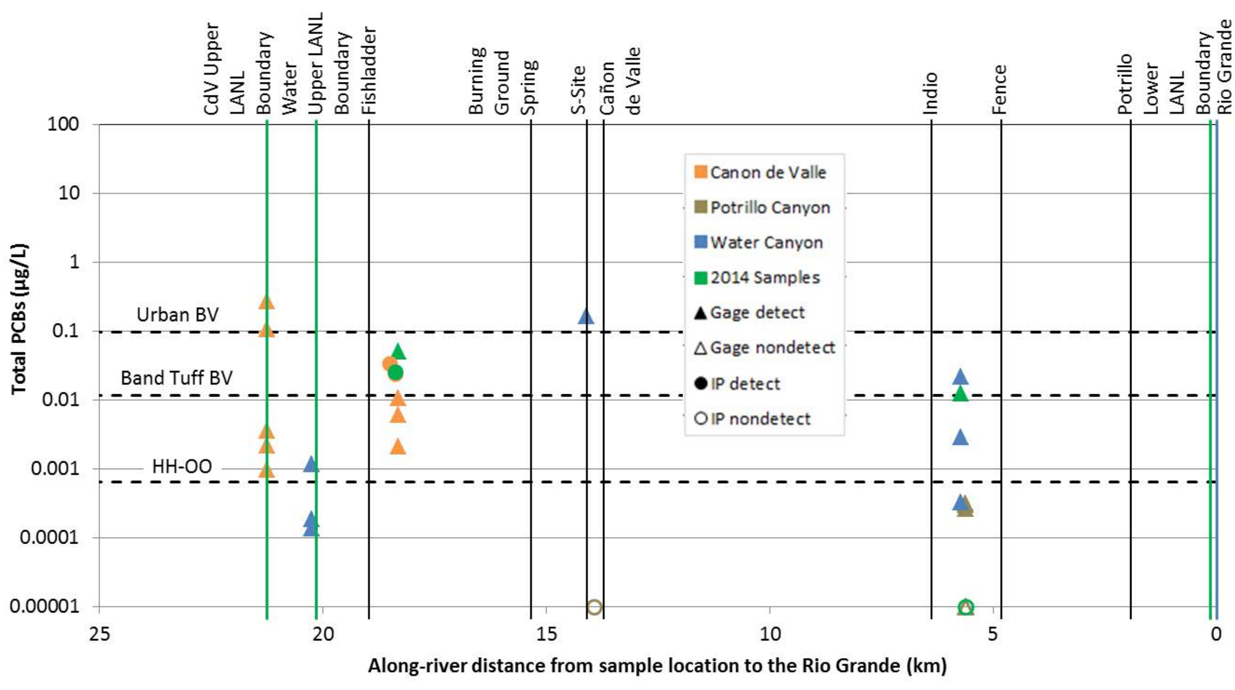


Figure 6-9i Water Canyon watershed total PCB concentrations in unfiltered storm water from SMA stations (2011–2014) and gaging stations (2010–2014)

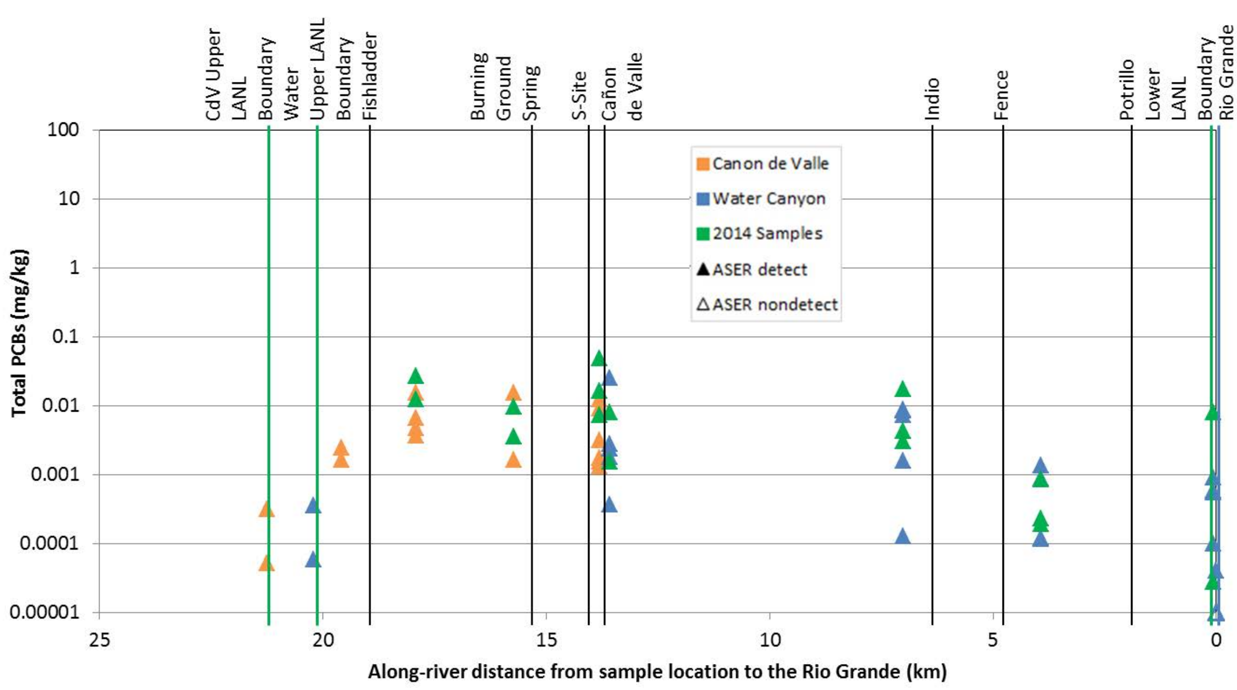


Figure 6-9j Water Canyon watershed total PCB concentrations in sediment from ASERs (2011–2014). PCB congeners were not analyzed in Water Canyon before 2011; thus, there are no canyon IR data. There is no residential SSL or BV for PCBs in sediment.

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. The Las Conchas fire was in July 2011, and while the magnified concentrations of radionuclides from the fire have decreased, the effects can still be seen. In addition, the extremely large flood event during September 13, 2013 may have mobilized radionuclides that continued to move downstream in 2014.

h. Plutonium-238 and Plutonium-239/240

No gaging station storm water samples collected on the Pajarito Plateau from 2004 to 2014 had plutonium-238 or plutonium-239/240 concentrations (Figures 6-10a through j) above the terrestrial DOE BCG for water (200,000 pCi/L). In 2014, the highest concentration of plutonium-238 in storm water (60.3 pCi/L) was at Mortandad above Ten Site (E201), and the highest concentration of plutonium-239/240 in storm water (156 pCi/L) was at Pueblo below WWTF (E059.5). In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), elevated concentrations of plutonium-238 and plutonium-239/240 in storm water at the upgradient boundary stations in 2011 through 2013 are related to fire-influenced sediment-laden runoff from Las Conchas fire burn areas. Elevated concentrations of plutonium-238 and plutonium-239/240 in storm water at the lower boundary of Los Alamos Canyon in 2011 through 2013 are potentially associated with the following: Guaje Canyon runoff that contained sediment from Las Conchas fire burn areas, elevated concentrations of plutonium from historical Laboratory activities in Acid Canyon, and erosion in the Pueblo Canyon wetland during the September 13, 2013 flood where elevated concentrations of plutonium exist (LANL 2004 and 2005). In Mortandad Canyon, elevated concentrations of plutonium-238 and plutonium-239/240 in storm water in 2014 are potentially related to historical Laboratory sources at TA-50 and Effluent Canyon (LANL 2006).

In Los Alamos Canyon, no pre-2014 sediment samples had plutonium-238 concentrations above the Laboratory residential SAL (84 pCi/g). Pre-2014 plutonium-238 concentrations in sediment decreased from the historical Laboratory sources in Acid Canyon, DP Canyon, and TA-53 (LANL 2005) to near regional background (0.006 pCi/g) or nondetectable concentrations before reaching the confluence with the Rio Grande. Pre-2014 plutonium-239/240 concentrations in Los Alamos Canyon watershed were above the Laboratory residential SAL (79 pCi/g) in Acid and Pueblo Canyons, yet decreased from these historical source sites to near regional background concentrations (0.068 pCi/g) at the confluence with the Rio Grande. In Mortandad Canyon, pre-2014 concentrations 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 or nondetectable concentrations at the confluence with the Rio Grande. In Pajarito Canyon, no pre-2014 concentrations of plutonium-238 and plutonium-239/240 in sediment were above the Laboratory residential SALs, although MDA G had concentrations above regional BVs. From the historical Laboratory source at MDA G (LANL 2009b), the pre-2014 plutonium-238 and plutonium-239/240 concentrations in sediment decreased to near regional BVs before the Laboratory boundary and were at nondetectable concentrations at the confluence with the Rio Grande.

In 2014, sediment samples collected in Los Alamos, Mortandad, and Pajarito Canyons had plutonium-238 or plutonium-239/240 concentrations above the regional BVs but below the Laboratory residential SALs. Concentrations of plutonium isotopes are present above the BVs in 2014 sediment deposits below the Laboratory boundary in Los Alamos and Mortandad Canyons. In all of these canyons, the elevated concentrations may be associated with historical Laboratory sources, as discussed 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 concentrations are potentially associated with erosion during the September 13, 2013 flood in Acid Canyon, the Pueblo wetlands, and the Mortandad Canyon sediment traps. The highest plutonium-238 and plutonium-239/240 concentrations in 2014 sediment samples were in Cañada del Buey north of MDA G (1.04 pCi/g) and at the head of Acid Canyon (36.9 pCi/g), respectively.

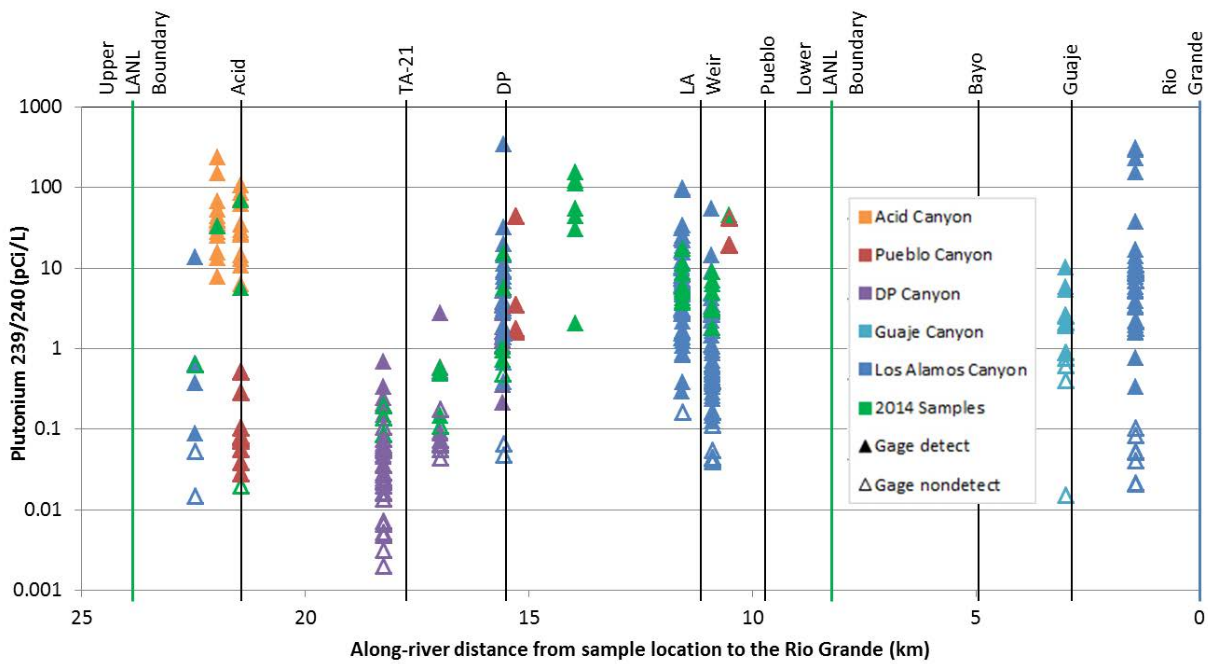


Figure 6-10a Los Alamos Canyon watershed plutonium-239/240 radioactivity concentrations in unfiltered storm water from gaging stations (2004–2014). Plutonium -239/240 was not analyzed at SMA stations; there is no BV for plutonium-239/240 in storm water and the terrestrial BCG for water is 200,000 pCi/L.

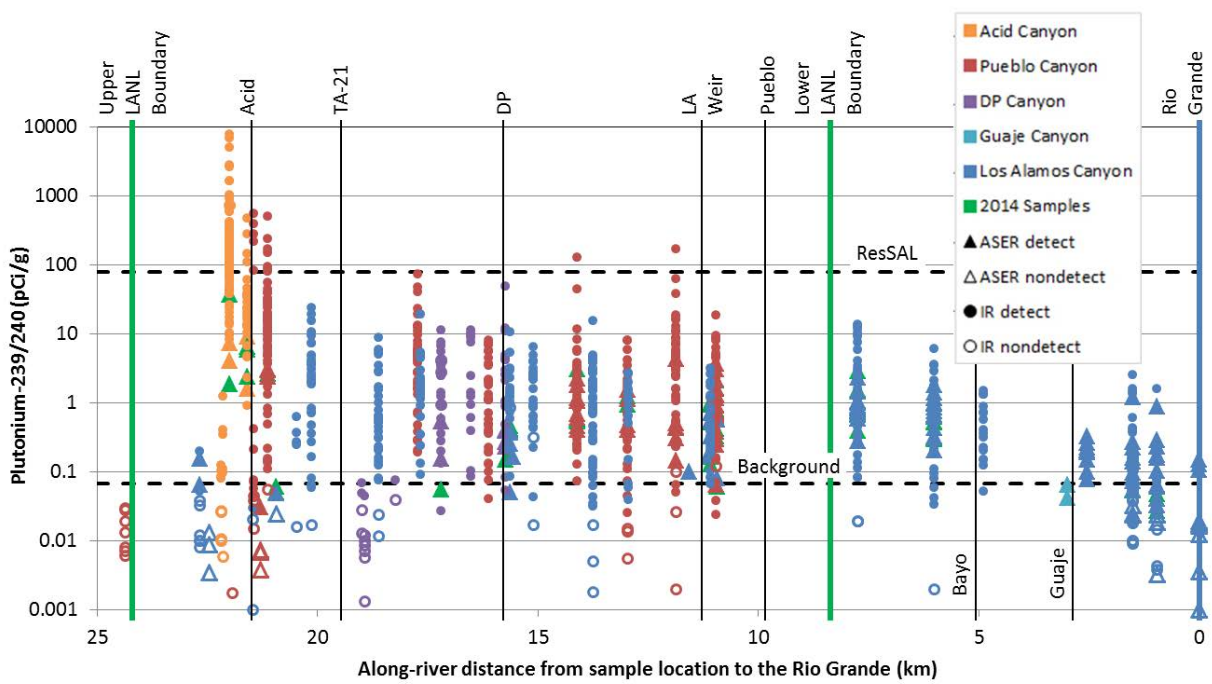


Figure 6-10b Los Alamos Canyon watershed plutonium-239/240 radioactivity concentrations in sediment from the canyon IR (1996–2003) and ASERs (2003–2014)

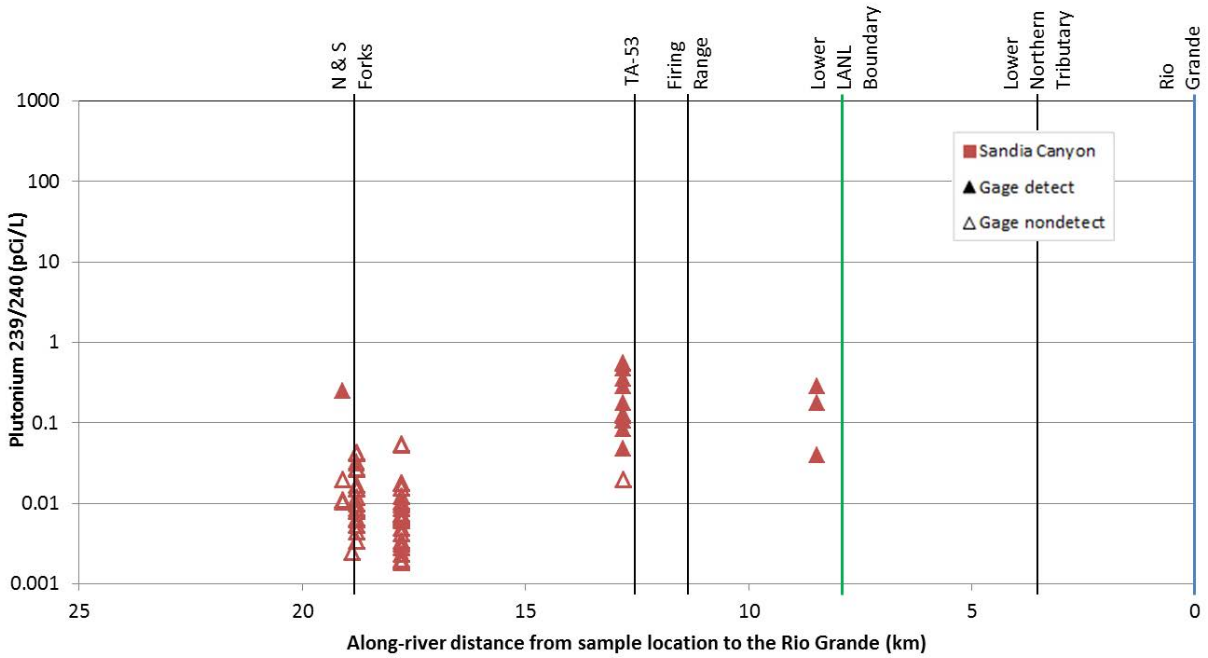


Figure 6-10c Sandia Canyon watershed plutonium-239/240 radioactivity concentrations in unfiltered storm water from gaging stations (2004–2013). Plutonium -239/240 was not analyzed at SMA stations; there is no BV for plutonium-239/240 in storm water, and the terrestrial BCG for water is 200,000 pCi/L.

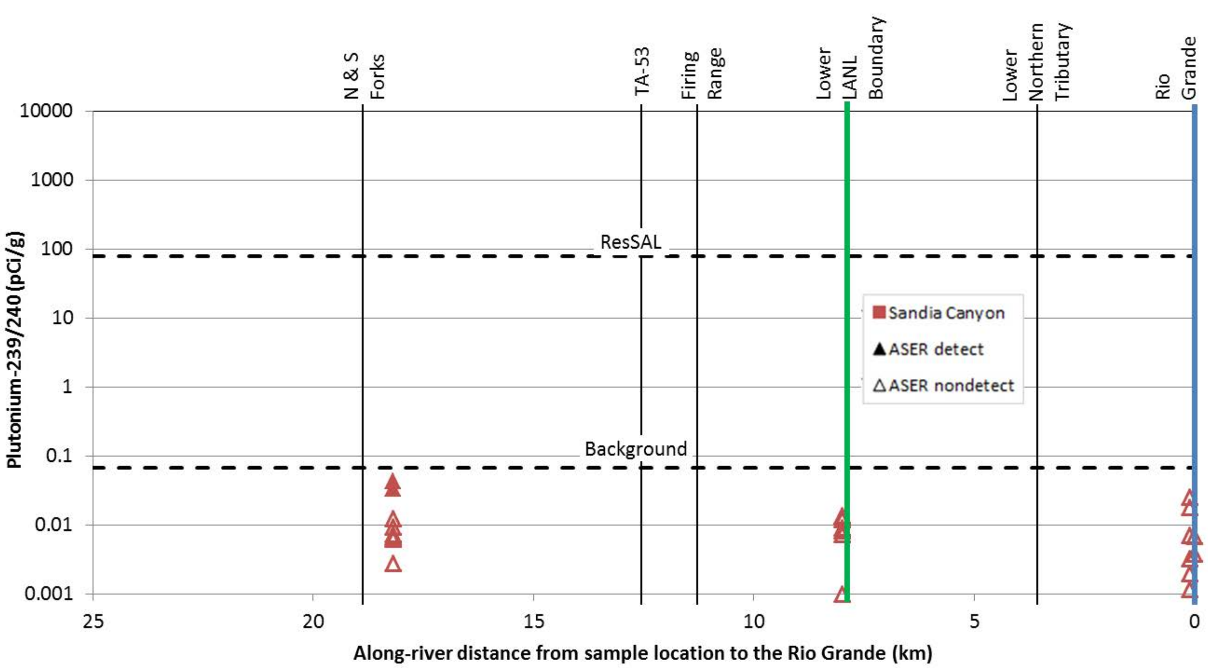


Figure 6-10d Sandia Canyon watershed plutonium-239/240 radioactivity concentrations in sediment from ASERs (2003–2013). Plutonium-239/240 was not analyzed in the canyon IR for Sandia.

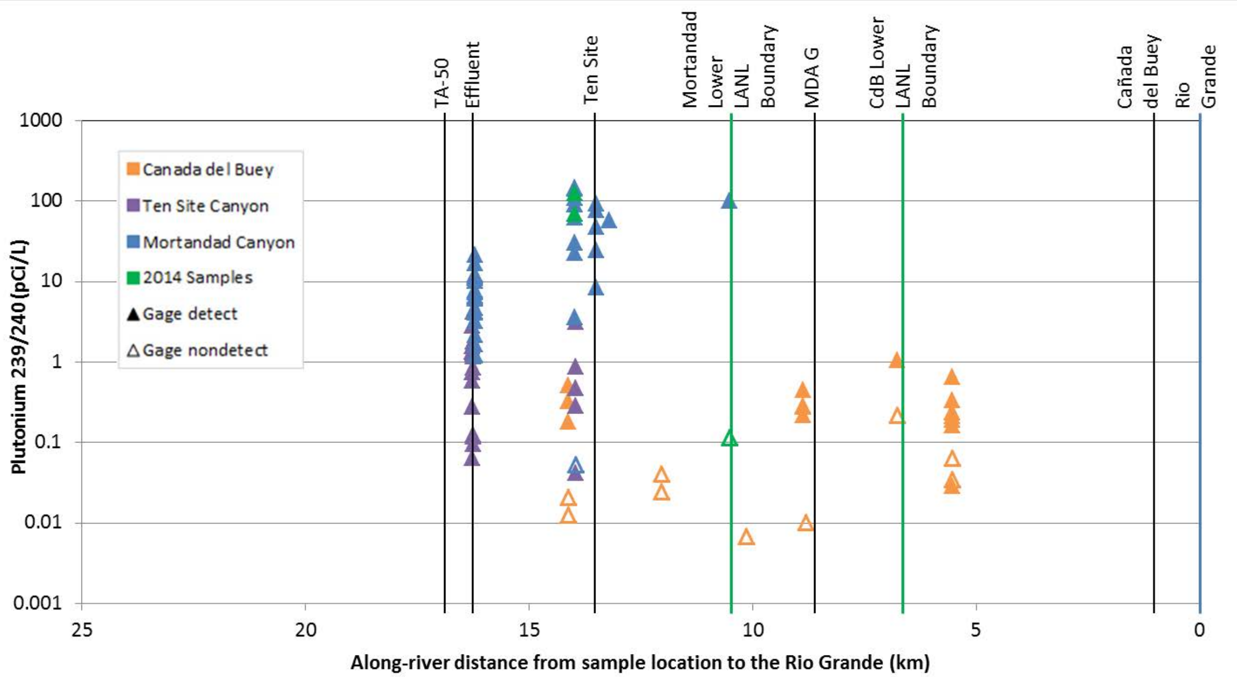


Figure 6-10e Mortandad Canyon watershed plutonium-239/240 radioactivity concentrations in unfiltered storm water from gaging stations (2004–2014). Plutonium -239/240 was not analyzed at SMA stations; there is no BV for plutonium-239/240 in storm water, and the terrestrial BCG for water is 200,000 pCi/L.

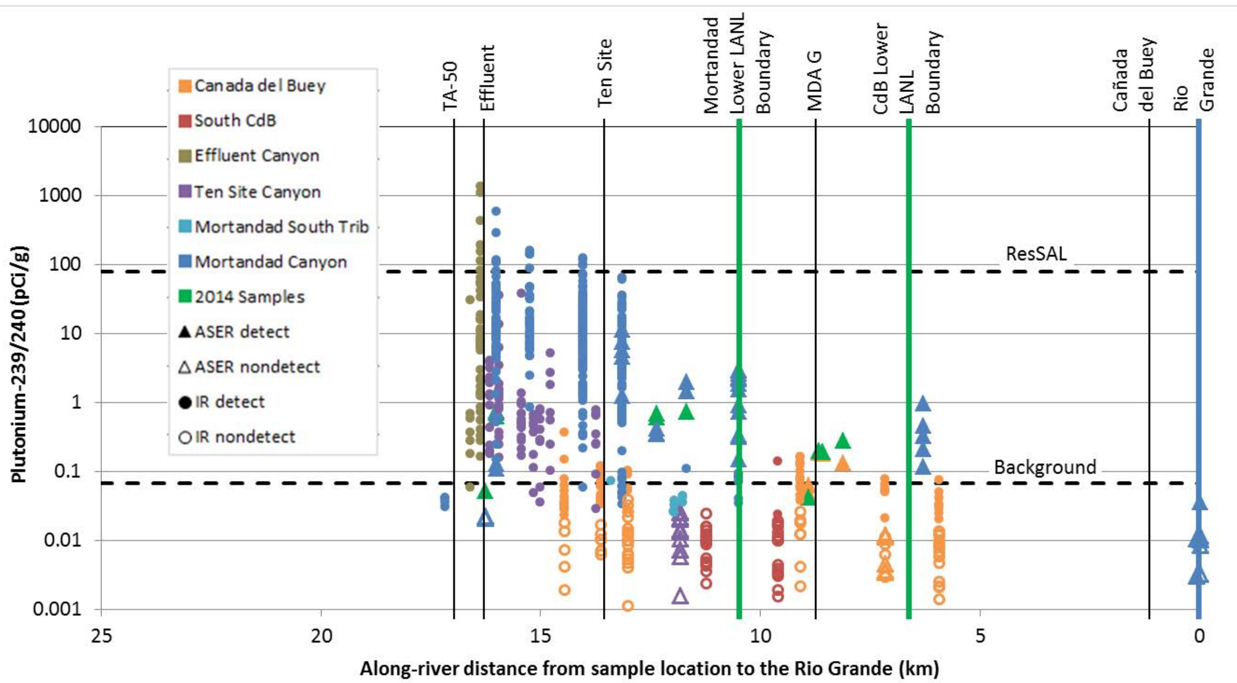


Figure 6-10f Mortandad Canyon watershed plutonium-239/240 radioactivity concentrations in sediment from the canyon IR (1998–2008) and ASERs (2003–2014)

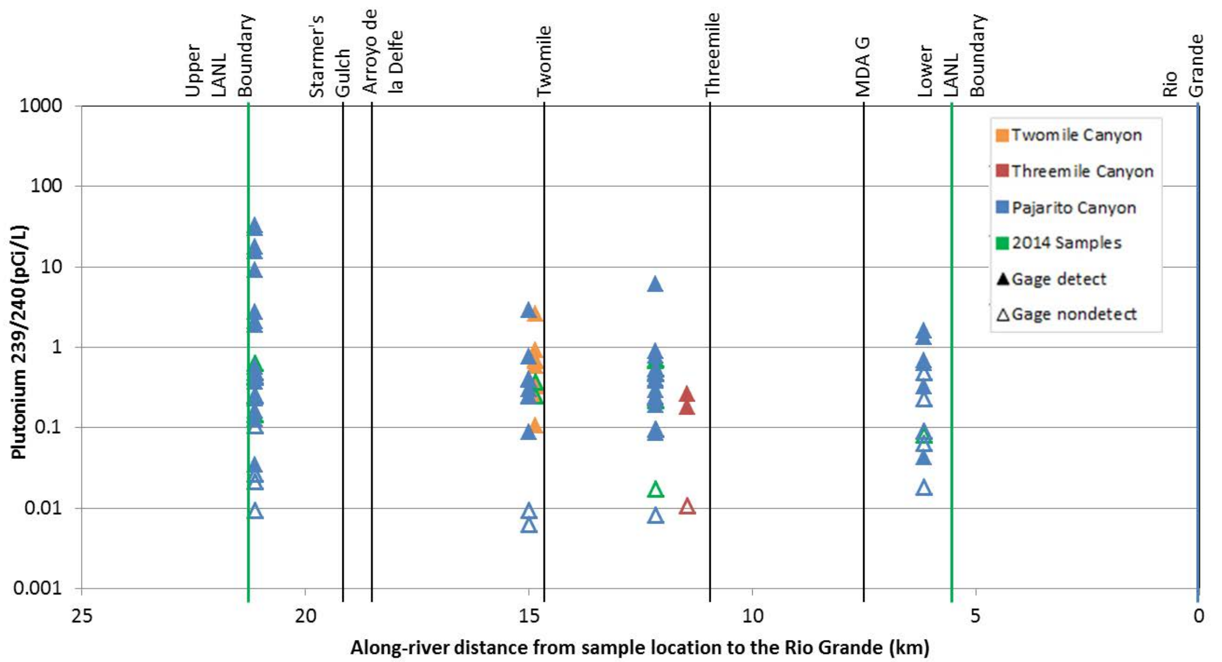


Figure 6-10g Pajarito Canyon watershed plutonium-239/240 radioactivity concentrations in unfiltered storm water from gaging stations (2004–2014). Plutonium -239/240 was not analyzed at SMA stations; there is no BV for plutonium-239/240 in storm water, and the terrestrial BCG for water is 200,000 pCi/L.

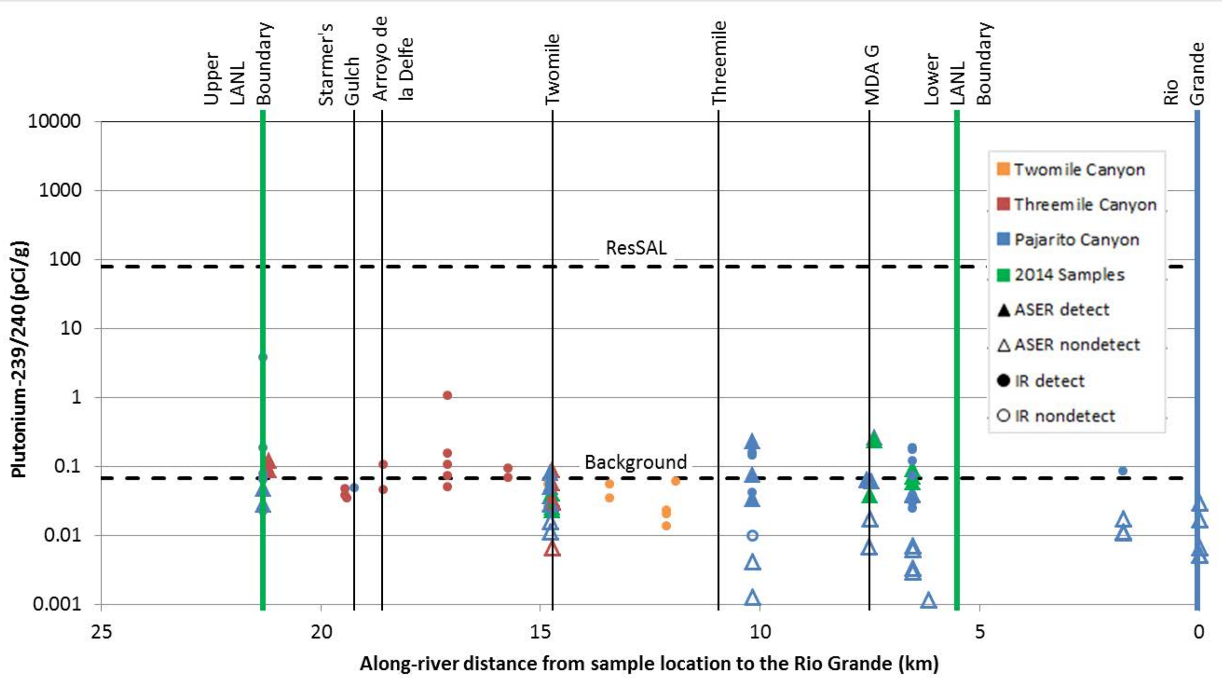


Figure 6-10h Pajarito Canyon watershed plutonium-239/240 radioactivity concentrations in sediment from the canyon IR (2000–2007) and ASERs (2003–2014)

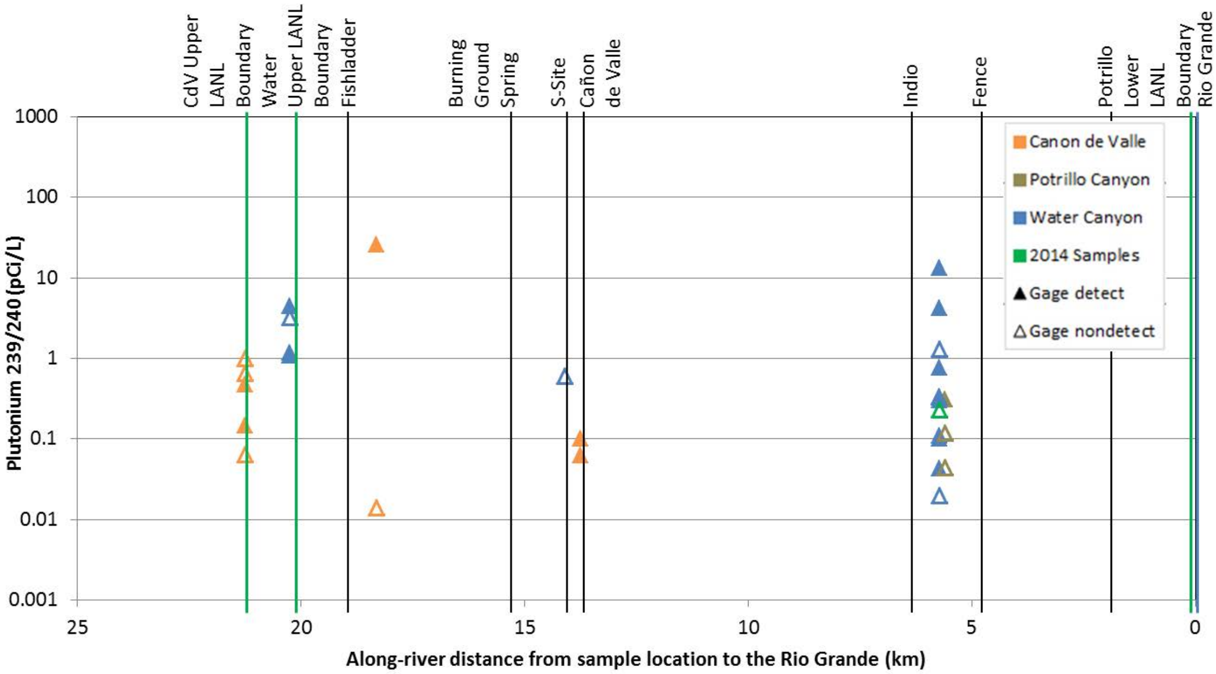


Figure 6-10i Water Canyon watershed plutonium-239/240 radioactivity concentrations in unfiltered storm water from gaging stations (2004–2014). Plutonium- 239/240 was not analyzed at SMA stations; there is no BV for plutonium-239/240 in storm water, and the terrestrial BCG for water is 200,000 pCi/L.

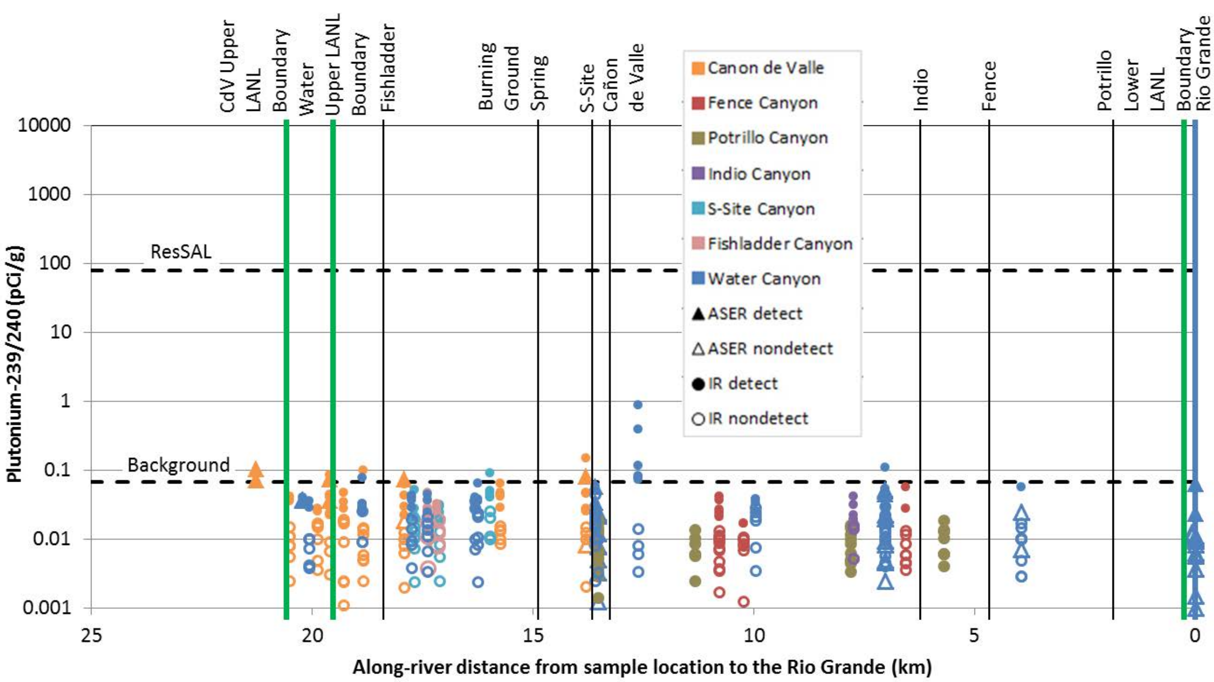


Figure 6-10j Water Canyon watershed plutonium-239/240 radioactivity concentrations in sediment from the canyon IR (2000–2011) and ASERs (2003–2012)

i. Uranium-234 and Uranium-238

No gaging station storm water samples collected on the Pajarito Plateau from 2004 to 2014 had uranium-234 or uranium-238 radionuclide concentrations above the terrestrial DOE BCG for water (400,000 pCi/L). In 2014, the highest concentration of uranium-234 (25.6 pCi/L) and uranium-238 (28.6 pCi/L) in storm water was at Twomile above Pajarito (E244). In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), elevated concentrations of uranium-234 and uranium-238 in storm water at the upgradient boundary stations in 2011 through 2014 are related to runoff from Las Conchas burn areas. Elevated concentrations 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, and elevated concentrations of uranium from historical Laboratory activities in Acid Canyon (LANL 2004 and 2005). Elevated concentrations of uranium-234 and uranium-238 at the lower boundary of Water Canyon are most likely associated with Las Conchas fire burn areas and historical Laboratory firing sites (LANL 2011c).

In Los Alamos, Pajarito, and Water Canyons, no pre-2013 sediment samples had uranium-234 or uranium-238 concentrations above the Laboratory residential SALs (270 pCi/g and 150 pCi/g, respectively). In fact, almost all sediment samples had uranium-234 and uranium-238 concentrations below or near background concentrations (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 concentrations in Los Alamos, Pajarito, and Water Canyons originating from the historical Laboratory sources in Acid (LANL 2005), Threemile (LANL 2009b), and Potrillo Canyons (LANL 2011c) were below BVs at the Laboratory boundary and the confluence with the Rio Grande. In post-Las Conchas fire sediment samples collected in Los Alamos, Pajarito, and Water Canyons in 2011 through 2014, uranium-234 and uranium-238 concentrations were below the Laboratory residential SALs and below to near regional BVs. All post-fire uranium-234 and uranium-238 concentrations in sediment decreased to near background before the Laboratory boundary and the confluence with the Rio Grande. In 2014, the highest uranium-234 concentration in sediment (1.76 pCi/g) was in Los Alamos Canyon near the Rio Grande confluence, and the highest uranium-238 concentrations in sediment (1.7 pCi/g) were in samples from Los Alamos Canyon near the Rio Grande confluence and Pueblo Canyon above the GCS. All 2014 sediment samples had concentrations of uranium-234 and uranium-238 below BVs. The elevated, though still below background, concentrations of uranium-234 and uranium-238 in lower Los Alamos Canyon may indicate that Las Conchas fire-affected sediments continue to migrate downstream.

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

No gaging station storm water samples collected in Los Alamos or Mortandad Canyons from 2004 to 2014 had americium-241, cesium-137, or strontium-90 concentrations above the terrestrial DOE BCGs for water (200,000 pCi/L, 20,000 pCi/L, and 30,000 pCi/L, respectively).

In Los Alamos Canyon, elevated concentrations of americium-241, cesium-137, and strontium-90 in storm water samples collected in 2011 through 2014 are associated with runoff from Las Conchas fire burn areas. Indeed, elevated concentrations 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 below the Guaje Canyon confluence, are associated with ash and sediment, as well as historical Laboratory activities in Acid and DP Canyons (LANL 2004 and 2005). In 2014, the highest concentrations of americium-241, cesium-137, and strontium-90 in storm water in Los Alamos Canyon were 10.7 pCi/L, 34.8 pCi/L, and 30.2 pCi/L, respectively, at Los Alamos above Low-Head Weir (E042.1). In Mortandad Canyon, elevated concentrations of americium-241, cesium-137, and strontium-90 in storm water samples are associated with historical Laboratory sources at TA-50 and Effluent Canyon (LANL 2006). In 2014, the highest concentrations of americium-241, cesium-137, and strontium-90 in storm water in Mortandad Canyon (and across the Laboratory) were 289 pCi/L, 445 pCi/L, and 27.4 pCi/L, respectively, at Mortandad above Ten Site (E201). In Pajarito Canyon, the highest concentrations of cesium-137 and strontium-90 in storm water were 20 pCi/L at Twomile above Pajarito (E244) and 5.65 pCi/L at Pajarito below SR-501 (E240), respectively. The elevated concentrations of strontium-90 at the upper boundary gaging station in Pajarito indicates that Las Conchas fire effects can still be seen. In Water Canyon, the highest concentration of strontium-90 in storm water was 1.86 pCi/L at Water below SR-4 (E265).

In Los Alamos Canyon, pre-2014 sediment samples had americium-241, cesium-137, and strontium-90 concentrations above the Laboratory residential SALs (82 pCi/g, 11 pCi/g, and 15 pCi/g, respectively) in Acid, DP, Pueblo, and downstream Los Alamos Canyons because of historical Laboratory sources (LANL 2004 and 2005), yet decreased to near or below regional background concentrations (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 2014, americium-241, cesium-137, and strontium-90 concentrations were below the Laboratory residential SALs and were mostly near background concentrations, with the exception of one sediment sample collected in 2011 above the low-head weir which had a strontium-90 concentration above the Laboratory residential SAL and is associated with ash and sediment from Las Conchas burn areas. All other 2011 through 2014 sediment samples collected in Los Alamos Canyon had strontium-90 concentrations below background concentrations with the exception of two 2013 sediment samples that were slightly above BVs (1.07 pCi/g and 1.26 pCi/g), both below the confluence of Los Alamos and DP Canyons.

In Mortandad Canyon, pre-2014 sediment samples had americium-241, cesium-137, and strontium-90 concentrations 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 concentrations at the Laboratory boundary and above the confluence with the Rio Grande. In 2014, sediment samples in Mortandad Canyon had americium-241 and cesium-137 concentrations above regional BVs but below the Laboratory residential SALs, and strontium-90 concentrations were all below BVs.

The highest concentrations of americium-241, cesium-137, and strontium-90 in 2014 sediment samples were collected in Mortandad Canyon at the Laboratory Boundary (1.11 pCi/g), Mortandad Canyon at the Laboratory Boundary (2.77 pCi/g), and Los Alamos Canyon above the Bayo Canyon confluence (0.884 pCi/g), respectively. The elevated, though still below background, concentrations of strontium-90 in lower Los Alamos Canyon may indicate that Las Conchas fire-affected sediments continue to migrate downstream.

F. CONCLUSIONS

Human health and ecological risk assessments have been performed as part of each of the Canyons IRs conducted under the Consent Order. While some concentrations of contaminants present in canyon media are above applicable aquatic environment standards, the human health risk assessments in the Canyon IRs have concluded that concentrations of contaminants present in canyon media are below applicable human health limits. The sediment and storm water 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 and storm water data comparisons collected from flood-affected canyons in 2014 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, 2013 flood, concentrations of constituents in sediment deposits were not significantly different in magnitude in 2014 as compared with historical values.

For sediment samples collected in 2014, residential SALs were not exceeded for any radionuclides. The residential SSLs were exceeded in two inorganic sediment samples in upper Sandia Canyon (chromium) and in one organic sediment sample in upper Los Alamos Canyon (PCB-126). All other exceedances of radionuclide, inorganic, and organic sediment screening levels were exceedances of background screening levels. For storm water samples collected in 2014, total PCBs exceeded the wildlife habitat standard, acute and chronic aquatic life standards, and the human health-organism only aquatic life standards throughout the Laboratory; mercury and selenium exceeded the wildlife habitat standard; aluminum, copper, selenium, and zinc exceeded the acute and chronic aquatic life standards; lead exceeded the chronic aquatic life standard; and dioxins, benzo(a)anthracene, benzo(a)fluoranthene, chrysene, and indenopyrene exceeded the human health-organism only aquatic life standard. All other exceedances of radionuclide, inorganic, and organic storm water screening levels were exceedances of background screening levels.

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 2014. Ash and sediment accumulate in storm water during active flooding and in floodplain deposits after monsoonal rains. 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 2014 downgradient of burned areas contained increased concentrations of background and fallout constituents transported with ash and sediment in storm water, though much less than in 2011 through 2013.

The sediment control structures throughout the Laboratory performed as designed in 2014.The Pueblo Canyon wetland reduced storm water discharge such that the gaging station downstream of the wetland and GCS (E060.1) measured only two storm events on July 31 and August 1. The Los Alamos Canyon low-head weir reduced peak discharges and storm water concentrations of many constituents. 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 have been quite effective at reducing the total PCB concentrations in storm water runoff from the contaminated hillslope since they were constructed (during 2014 no runoff overtopped the basins). The Mortandad and Ten Site Canyon sediment traps, which are also not associated with burn areas, were effective at reducing discharge and removing sediment, as only one storm event on July 31 produced enough discharge to get close to, but not cross, the Laboratory boundary.

The 2014 sediment samples taken in flood plain deposits generally do not show highly elevated levels of contaminants. Detections in storm water and sediment of RDX and the exceedance in an IP-related storm water sample might indicate the movement of RDX-laden sediment in Cañon de Valle. In Los Alamos, Mortandad, and Pajarito Canyons, elevated concentrations of plutonium-238 and plutonium-239/240 in sediment samples may be associated with historical Laboratory sources and are potentially associated with erosion during the September 13, 2013 flood in Acid Canyon, the Pueblo wetlands, and the Mortandad Canyon sediment traps; in Los Alamos and Pajarito Canyons, these elevated concentrations may also be associated with Las Conchas fire burn areas. Elevated, but below background, concentrations of uranium-234, uranium-238, and strontium-90 in sediment in lower Los Alamos Canyon beyond the Laboratory boundary may indicate that Las Conchas fire-affected sediments continue to migrate downstream. Elevated, but below terrestrial DOE BCGs for water, concentrations of americium-241, cesium-137, and strontium-90 in storm water samples in Mortandad Canyon are associated with historical Laboratory sources at TA-50 and Effluent Canyon. Sediment samples in Mortandad Canyon at the Laboratory boundary had elevated americium-241 and cesium-137 concentrations above regional background levels but below the Laboratory residential SALs, indicating the movement of contaminated sediments in Mortandad Canyon.

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To Read About **Turn to Page**

Los Alamos National Laboratory (LANL or the Laboratory) is committed to long-term stewardship of the surrounding environment. To this end, potential impacts to both terrestrial and aquatic ecosystems were assessed.

Terrestrial ecosystem health was assessed by collecting soil, sediment, and biota (vegetation and small mammal) from within and around the Laboratory and analyzing for radionuclides, metals, and/or organic compounds. All parameters measured were compared with background levels (reference levels), screening levels protective of biota, and standards. All radionuclide and chemical concentrations in soil, sediment, and biota from on-site locations were either similar to background or below screening levels. Additionally, avian abundance and diversity were assessed around three firing sites and one burning ground site at LANL, and results show no impacts.

Aquatic ecosystem health was assessed by evaluating radionuclide and chemical constituents in sediment and fish, comparing metrics related to benthic macroinvertebrate (BMI) abundance and diversity, and by conducting a sediment toxicity bioassay from samples collected from the Rio Grande upstream and downstream of LANL. All radionuclide levels in sediment were far below screening levels. Fish tissues collected from Abiquiu (upstream) and Cochiti (downstream) reservoirs and from the Rio Grande directly above and below Los Alamos Canyon indicated no measurable impact from LANL. BMI metrics and sediment toxicity bioassays from upstream and downstream reaches were statistically similar to each other and metrics indicate the highest bioassessment score of nonimpaired for the Rio Grande.

A biota dose assessment of mesa, canyons, and the Rio Grande was performed, and results reveal that doses to biota are far below terrestrial and aquatic U.S. Department of Energy standards.

Collectively, the results of biological surveys, measurements of radionuclides and chemicals in the environment, and toxicity testing show that LANL operations are not impacting the health of regional terrestrial and aquatic ecosystems.

A. INTRODUCTION

An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment interacting as a system (Smith and Smith 2012). The condition of an ecosystem can vary as a result of disturbances from fire, flooding, drought, invasive species, climate change, chemical spills, and a host of other factors (Rapport 1998).

Los Alamos National Laboratory (LANL or the Laboratory) is home to a wide range of biota (plants and animals), and U.S. Department of Energy (DOE) Orders 436.1 and 458.1 mandate the monitoring of these resources within and around DOE facilities for the protection of ecosystems.

An ecosystem encompasses a complex and changing network of interactions among organisms, and if a management objective for the ecosystem is known (e.g., fish health), targeted measurements (e.g., water, sediment, and fish tissue chemistry, etc.) may provide an estimate of the health and condition of the system for that purpose (Palmer and Febria 2012). Various structural (e.g., chemical, physical, and biological measurements) and functional (e.g., productivity/reproduction/growth, nutrient cycling, etc.) metrics as they relate to a reference site have been employed for the assessment of rivers (Davies et al. 2010, Fresquez and Jacobi 2012), lakes (Shear et al. 2003), and forests (Covington et al. 1997).

The objective of the Laboratory's Ecosystem Health Program is to determine if LANL is impacting the environment. This is accomplished by the following:

1. Measuring concentrations of historically used radionuclides and chemicals in soil and biota from on-site and perimeter locations and comparing concentrations with background, screening levels, and standards;
2. Evaluating trends in radionuclide and chemical concentrations in soil and biota over time;
3. Assessing populations, diversity, and composition of biota species potentially impacted by Laboratory operations; and
4. Estimating radiation dose and chemical risk to biota.

This chapter reports measurements of chemical levels in soil and biota as well as abundance and diversity of organisms at various locations within and around the Laboratory over time. Chemical concentrations in fish tissue were determined from two reservoirs and from the Rio Grande. Additionally, toxicity bioassays of sediment collected from the Rio Grande downstream of the Laboratory were used to quantify survival and growth of two model aquatic organisms. Finally, an overall biota radiation dose was calculated for organisms occupying mesa tops, canyon bottoms, and Rio Grande waters. All parameters are compared with background levels (reference levels), screening levels, and federal dose standards to assess the impact of LANL operations on the surrounding environment.

B. TERRESTRIAL HEALTH ASSESSMENT

1. Soil and Biota Monitoring

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 (DOE 2015). Soil is an integrating medium that may receive substances released to the atmosphere and are subsequently deposited, particles resuspended and transported by wind, and substances in water used for irrigation. Consequently, soil data may provide information about several potential exposure pathways.

Detection of contaminants in biota may indicate that they may be entering contaminated areas or that material is moving out of contaminated areas, while the number, diversity, and types of biota may indicate environmental changes and stress (DOE Orders 436.1 and 458.1).

a. Soil and Biota Comparison Levels Related to Ecosystem Health

To evaluate the presence and potential effects of Laboratory-derived radionuclides and chemicals in surface soil and biota, individual on-site (within LANL boundaries) and perimeter (at LANL boundary) results are compared with regional statistical reference levels (RSRLs). RSRLs are the upper-level background concentrations (the mean plus three standard deviations) for radionuclides and chemicals in soil and biota collected from regional locations more than 9 mi away from the Laboratory (DOE 2015). These RSRL samples are collected from locations that surround the Laboratory in all major directions. The concentrations of radionuclides and chemicals in soil and biota collected from these regional background locations are the result of worldwide fallout, other non-Laboratory sources, and natural sources.

Statistical testing is conducted to test for differences from regional background concentrations. In cases where multiple samples ($n > 3$) are collected from a defined sample population/location, the mean concentrations are compared with mean (historic) background concentrations using a Mann-Whitney nonparametric statistical test at the 0.05 probability level. Temporal trends were analyzed by a Mann-Kendal nonparametric test at the 0.05 probability level.

If individual or mean results in soil exceeded the appropriate statistical test, the concentration(s) of radionuclides and chemicals were then compared with ecological screening levels (ESLs). The first screen is compared with the lowest no effect (NE) ESL reported among the many biota receptors listed in the ECORISK database (LANL 2014). NE-ESLs are derived from the literature and reflect concentrations in the soil that are not expected to produce an adverse effect on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on the soil. Listed biota receptors include avian and mammalian carnivores, herbivores, insectivores, and omnivores; soil dwelling invertebrates (earthworms); and autotrophic producers (plants). In general, the lowest NE-ESLs are associated with either earthworms or plants. If a constituent in the soil exceeds the lowest NE-ESL, then the levels are compared to the accompanying low effect (LE) ESL. LE-ESLs reflect the exposure level in the soil that may produce an adverse effect to the selected biota receptor.

Similarly, the concentrations of radionuclides and chemicals in biota tissue are compared with biota dose screening levels (BDSLs) and with lowest observable adverse effect levels (LOAELs), respectively. Radionuclide BDSLs, expressed in concentrations, were set at 10% of the regulatory DOE biota dose standard (McNaughton 2006), and LOAELs, similar to LE-ESLs for soil, reflect the lowest exposure level in the tissue that may produce an adverse effect between the exposed population and its appropriate control group (EPA 2014).

If a radionuclide in soil or in biota is detected at a concentration that is higher than the appropriate screening level, then the dose to biota using all of the available data is calculated using RESRAD-BIOTA (version 1.5) (http://web.ead.anl.gov/resrad/home2/biota.cfm). This calculated dose is compared with DOE limits: 1 rad/day (rad/d) for terrestrial plants and 0.1 rad/d for terrestrial animals (DOE 2002). An overall summary of all screening levels and standards used to compare soil and biota in relation to ecosystem health are found in Table 7-1.

Table 7-1
Application of Screening Levels and Standards to LANL Soil and Biota Monitoring Data

Media	Constituent	Receptor	Screening Level	Standard (rad/d)
Soil	Radionuclides	Terrestrial plants	ESL	1
		Terrestrial animals	ESL	0.1
	Chemicals	Terrestrial biota	ESL	n/a*
Biota	Radionuclides	Terrestrial plants/aquatic animals	BDSL	1
		Terrestrial animals	BDSL	0.1
	Chemicals	Terrestrial biota	LOAEL	n/a
		Aquatic animals	LOAEL	n/a

*Not applicable.

2. Site-Wide Soil and Vegetation Monitoring (Institutional)

The purpose of site-wide soil and vegetation monitoring is to measure the nature and extent of LANL-produced radionuclides and chemicals outside areas designated as solid waste management units (SWMUs), to assess the effects of those constituents on biota, and to compare the results of models that predict transport pathways with actual results. Soil data reveal the extent of transport by wind and surface water, while vegetation data reveal the uptake of substances buried in material disposal areas and deposition on leaves from wind and water.

The ratio of the biota-to-soil concentrations is important to determine the bioaccumulation factors for biota dose and risk assessment and to investigate the possibility of bio-magnification of contaminants in the food chain.

Soil samples from 17 on-site, 11 perimeter, and 6 regional background locations have been analyzed for radionuclides since the early 1970s (Purtymun et al. 1980, 1987). On-site samples are collected from undisturbed locations downwind of major operations and facilities at LANL, and perimeter locations are located on all sides, including Los Alamos and White Rock townsites, of the LANL boundary. The last comprehensive soil and vegetation survey occurred in 2012 (Fresquez 2013a). All radionuclide and chemical constituents in soil and vegetation at all locations were below the relevant screening levels protective of biota. The next large scale soil and vegetation sampling undertaking will occur in 2015.

3. Soil and Biota Monitoring within LANL (the Facility)

The purpose of the facility monitoring program is to measure the nature and extent of LANL-produced radionuclides and chemicals within areas designated as SWMUs or influenced directly by SWMUs. These areas, sampled on an annual basis, include Area G, a waste disposal area, the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility, a firing site, and two sediment-control structures located in Los Alamos and Pajarito Canyons.

a. Area G at Technical Area 54

Area G is a potential source for environmental contamination at LANL, specifically the radionuclides contained in the buried waste. As such, the Laboratory has conducted soil and biota (vegetation and small mammals) monitoring at Area G since 1980 to determine whether and how far radionuclides migrate beyond the waste burial area (LANL 1981, Mayfield and Hansen 1983). Established in 1957, Area G, approximately 63 acres in size and is the Laboratory's primary low-level radioactive solid waste burial and storage site located on the east end of Mesita del Buey at Technical Area 54 (TA-54) (Hansen et al. 1980, Soholt 1990, Lechel 2007) (Figure 7-1). Tritium, plutonium, americium, and uranium are the main waste materials at Area G (DOE 1979) and have been detected in soil, vegetation, and small mammals adjacent to the facility (Bennett et al. 2002, Nyhan et al. 2004).

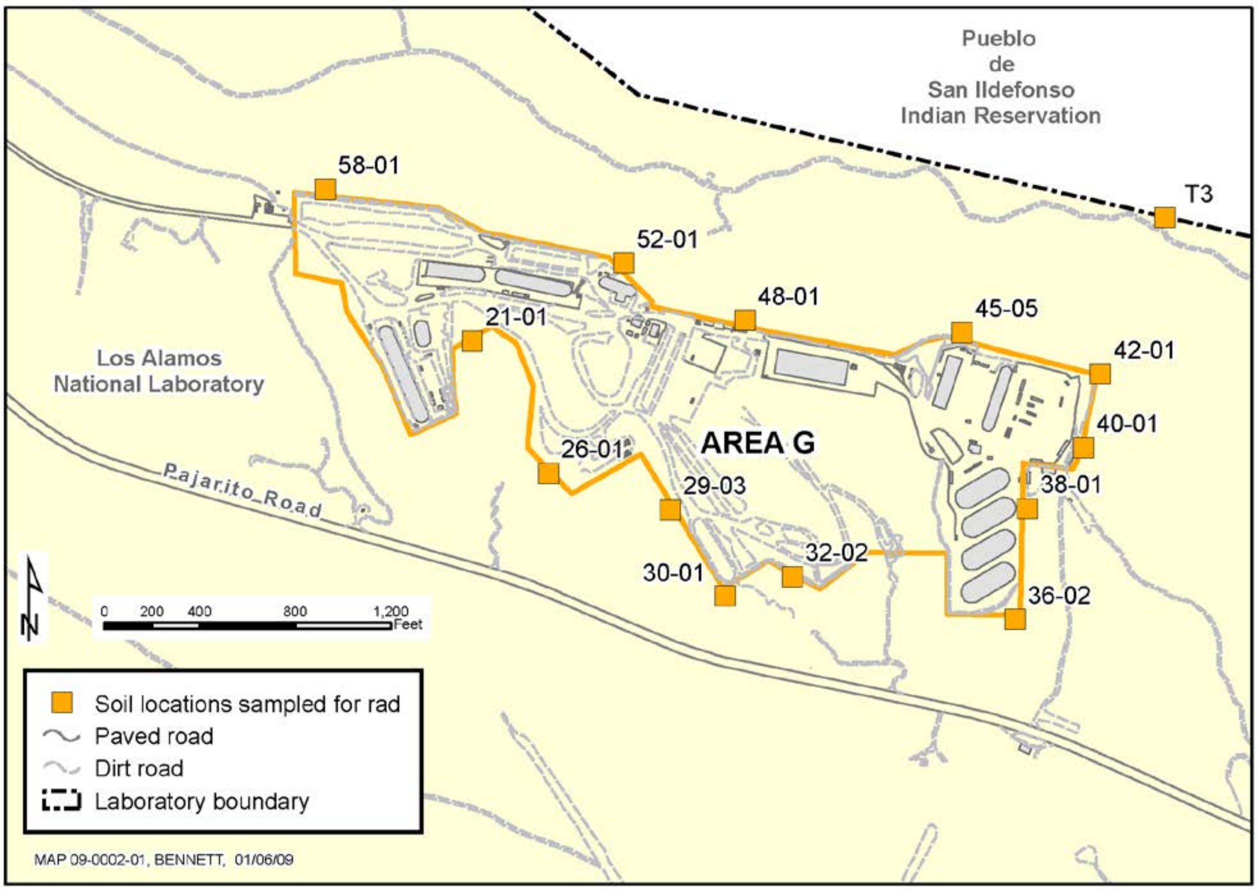

Figure 7-1 Locations of soil and vegetation samples collected around Area G in 2014

Thirteen surface soil grab samples and composite overstory vegetation samples were collected in April 2014 at designated locations around the perimeter of Area G, and one other soil/plant sample (Figure 7-1, 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. All samples were analyzed for tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238.

i. Radionuclide Results for Area G

Detections of tritium, americium-241, plutonium-238, and plutonium-239/240 in soil were consistent with data from previous years. Concentrations were above the RSRLs (based on 2002–2012 data, n = 25) in several of the 13 soil samples collected around the perimeter fenceline of Area G in 2014 (Supplemental Table S7-1).

Specifically, tritium was detected above the RSRL (0.77 picocuries per milliliter [pCi/mL]) at four locations, similar to years past. These areas are located along the southern side of Area G near tritium buried in underground shafts; site 29-03 had 1187 pCi/mL, site 30-01 had 51 pCi/mL, and site 32-02 had 1.7 pCi/mL. The highest level of tritium in surface soil at Area G was below the lowest NE-ESL for plants and animals (LANL 2014). These data are within the range of activities detected in past years and are not statistically increasing over time (Figure 7-2). The tritium activity decreases greatly with distance from the shafts; at 100 m, the tritium levels are not significantly different from background (Fresquez et al. 2003, Fresquez 2014a).

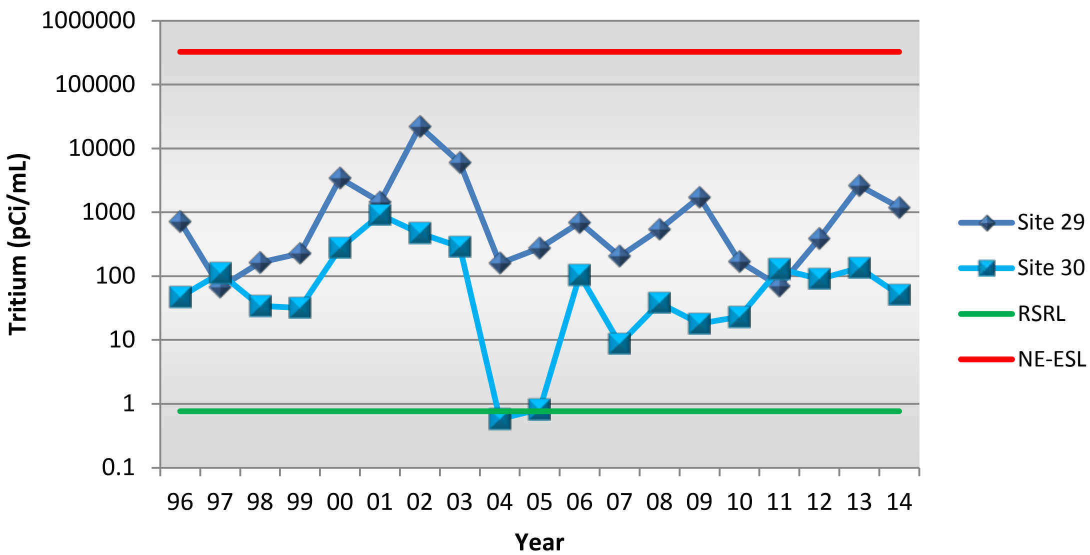

Figure 7-2 Tritium in surface soil samples collected from the southern portions of Area G at TA-54 from 1996 to 2014 compared with the RSRL and the lowest NE-ESL (plant). Note the logarithmic scale on the vertical axis.

The highest activities of americium-241 (2.9 pCi/g dry), plutonium-238 (0.45 pCi/g dry), and plutonium-239/240 (18 pCi/g dry) were all detected at site 38-01, which is located on 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 below the lowest NE-ESLs for plants and animals (LANL 2014), and the activities of most radionuclides at most sites are generally not statistically increasing over time (Figures 7-3, 7-4, and 7-5). 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 in later years (2005–2014; average = 8.7 pCi/g) than in earlier years (1996–2004; average = 0.79 pCi/g) (Figure 7-5). 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 disposal areas. 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 (Fresquez 2013a).

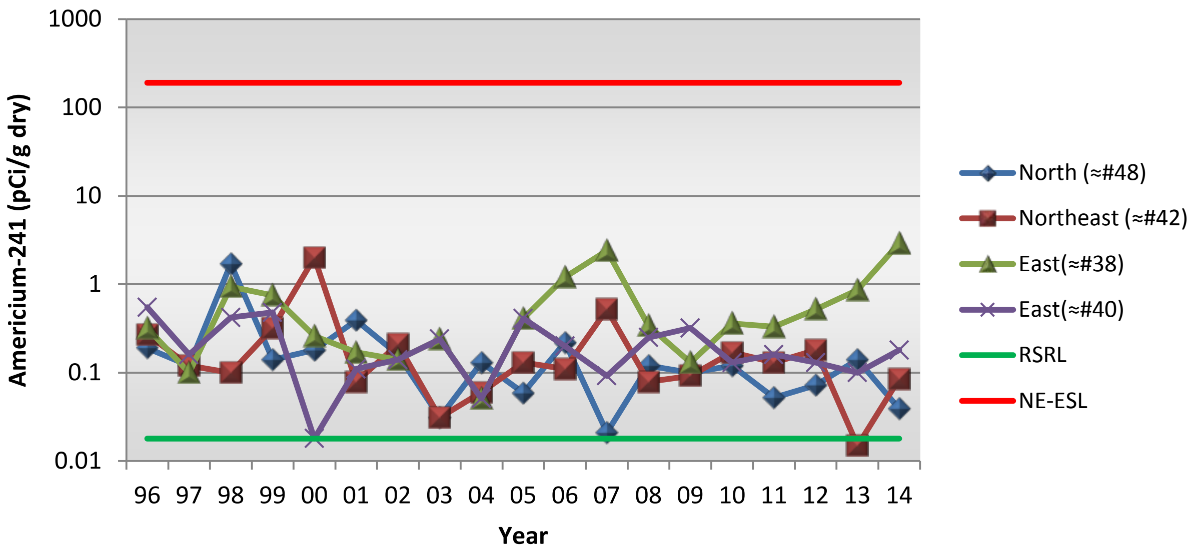

Figure 7-3 **Americium-241 activities in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 to 2014 compared with the RSRL and the lowest NE-ESL (earthworm). Note the logarithmic scale on the vertical axis.**

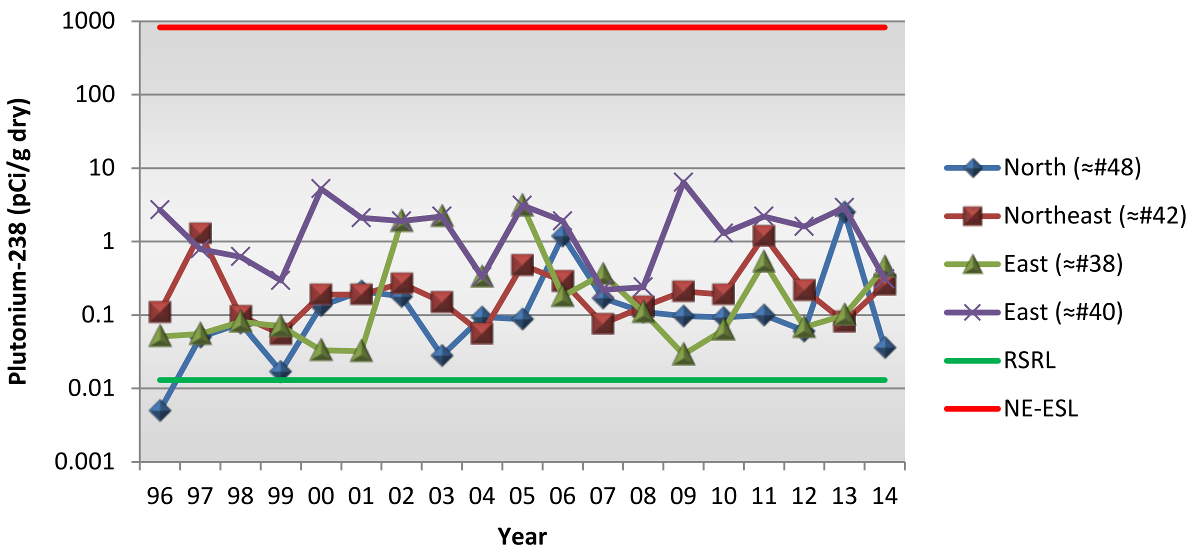

Figure 7-4 **Plutonium-238 activities in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 to 2014 compared with the RSRL and the lowest NE-ESL (earthworm). Note the logarithmic scale on the vertical axis.**

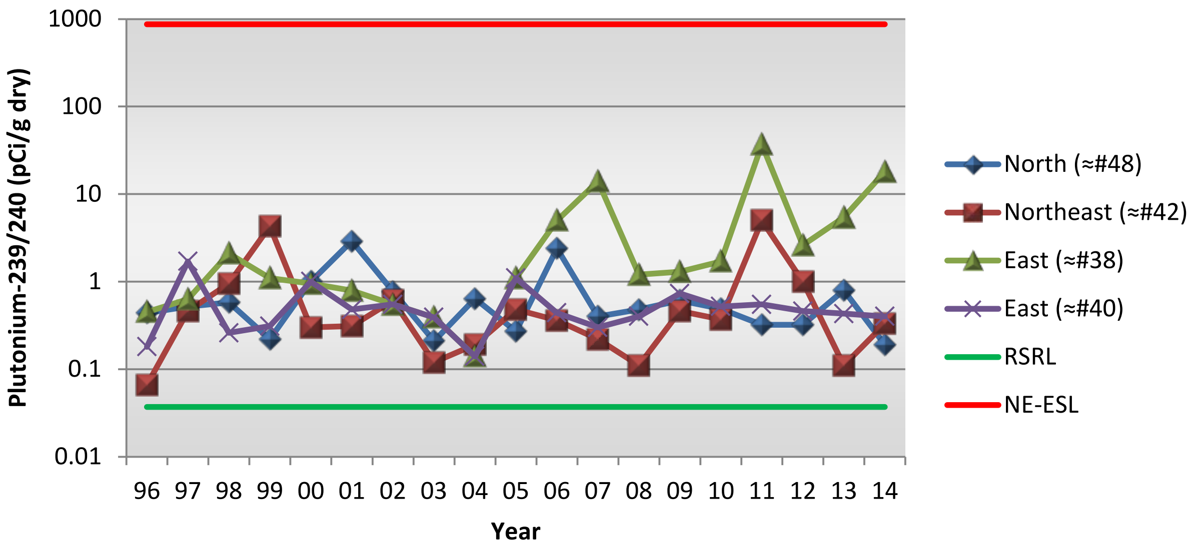

Figure 7-5 **Plutonium-239/240 activities in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 to 2014 compared with the RSRL and the lowest NE-ESL (earthworm). Note the logarithmic scale on the vertical axis.**

Native overstory vegetation samples (branches and needles of mostly juniper trees), an indicator of both deep root uptake (as in the case of tritium) and foliar deposition of radionuclides, were collected and analyzed for the same radionuclides at the same general locations as the soil samples (Figure 7-1). However, because of a firebreak between the fenceline and the trees (>10 m from the fenceline), samples of overstory vegetation are collected at various distances away from the fence around Area G. Results for tritium in vegetation are reported on a pCi/mL basis, and results for the other radionuclides are reported on a pCi/g ash-weight basis.

Tritium, plutonium-238, and plutonium-239/240 concentrations in many overstory samples collected around the perimeter of Area G were above the RSRLs (based on 1998–2009 data, n = 15) (Table S7-2). Americium-241 and the uranium isotopes were either not detected or detected below the RSRLs.

Tritium was detected above the RSRL in over 50% of the tree samples collected around the perimeter of Area G with the highest amounts (up to 458 pCi/mL) occurring in trees growing in the southern sections (site 29-03) near the tritium disposal shafts. These data are consistent with the soil surface data. All levels of tritium in trees in 2014, however, are significantly lower than in the past 2 yr and below the BDSL for plants. The overall trend, based on the average on the south side, is highly variable from year to year and not significantly increasing over time (Figure 7-6).

Like the soil results, plutonium-239/240 was detected above the RSRL in many overstory tree samples (46%) around the perimeter of Area G. The mode of transport of plutonium-239/240 to the trees is mostly a function of windblown dust to the foliar portions of the plant rather than by root uptake (Menzel 1965). The highest amount (0.66 pCi/g ash) was detected in tree foliage on the northwest side of Area G (site 58-01) and may be a result of the dust generated by the use of soil transported from MDA B as filler material for the burial of contaminated waste near site 58-01. Nevertheless, the amounts of plutonium-239/240 in trees growing around the perimeter of Area G, including those in the northwest corner, were below the BDSL for plants and are not impacting the vegetative community.

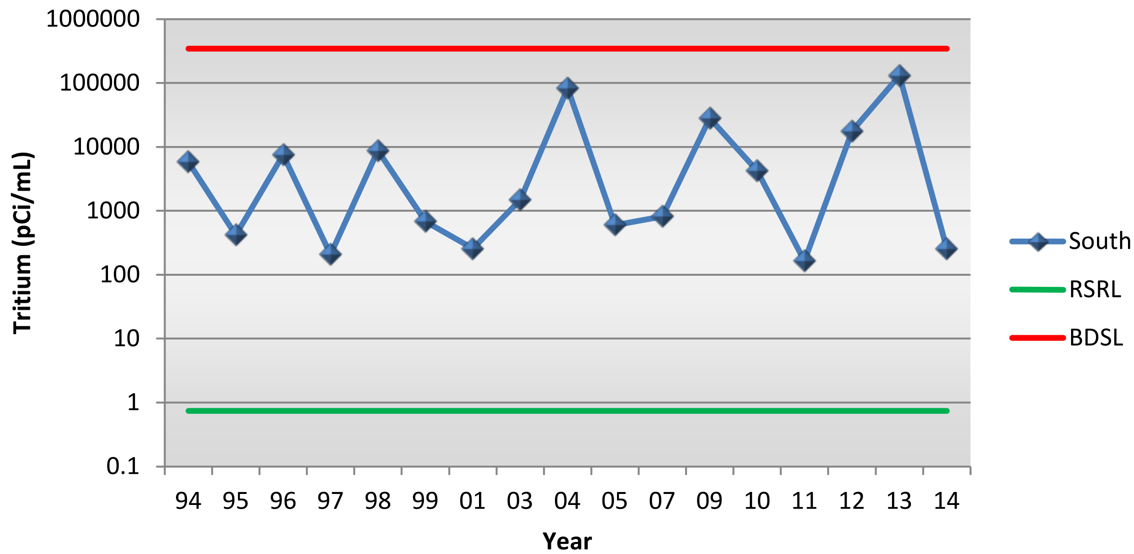

Figure 7-6 **Mean concentrations of tritium in overstory vegetation collected from the south side of Area G at TA-54 (site 29-03 and 30-01) from 1994 to 2014 compared with the RSRL and the BDSL. Note the logarithmic scale on the vertical axis.**

ii. Radionuclide Results in Cañada del Buey

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 (Figure 7-1, Site T3) were either not detected or were detected below the RSRLs (Table S7-1).

The overall long-term pattern of the three most common actinides detected around the perimeter of Area G (i.e., americium-241, plutonium-238, and plutonium-239/240) at the Laboratory/Pueblo de Ildefonso boundary were mostly lower than past years and are not increasing over time (Figures 7-7, 7-8, and 7-9).

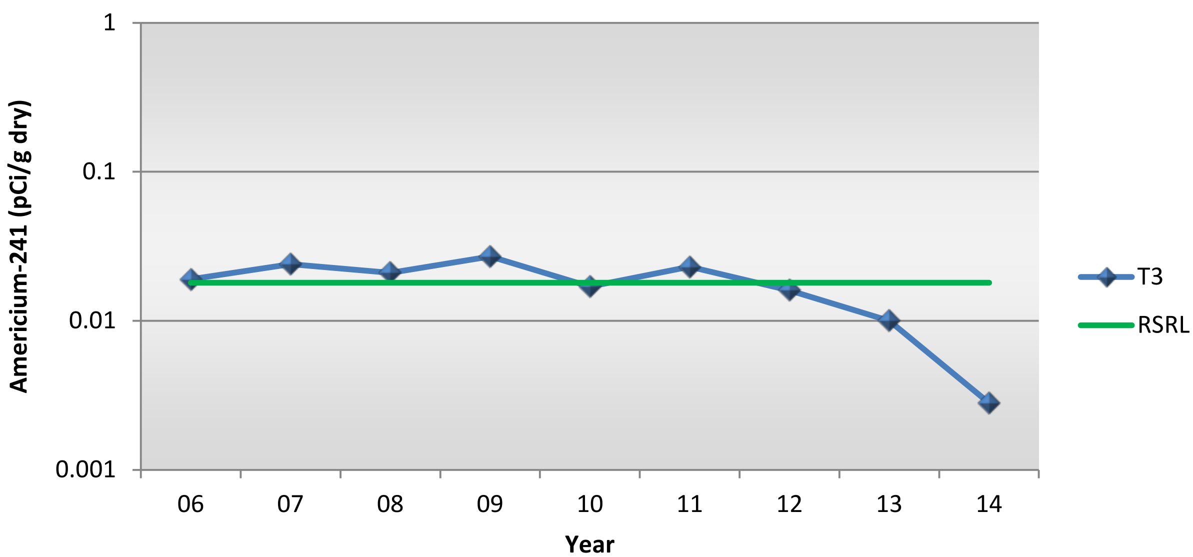

Figure 7-7 **Americium-241 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 to 2014 compared with the RSRL. Note the logarithmic scale on the vertical axis.**

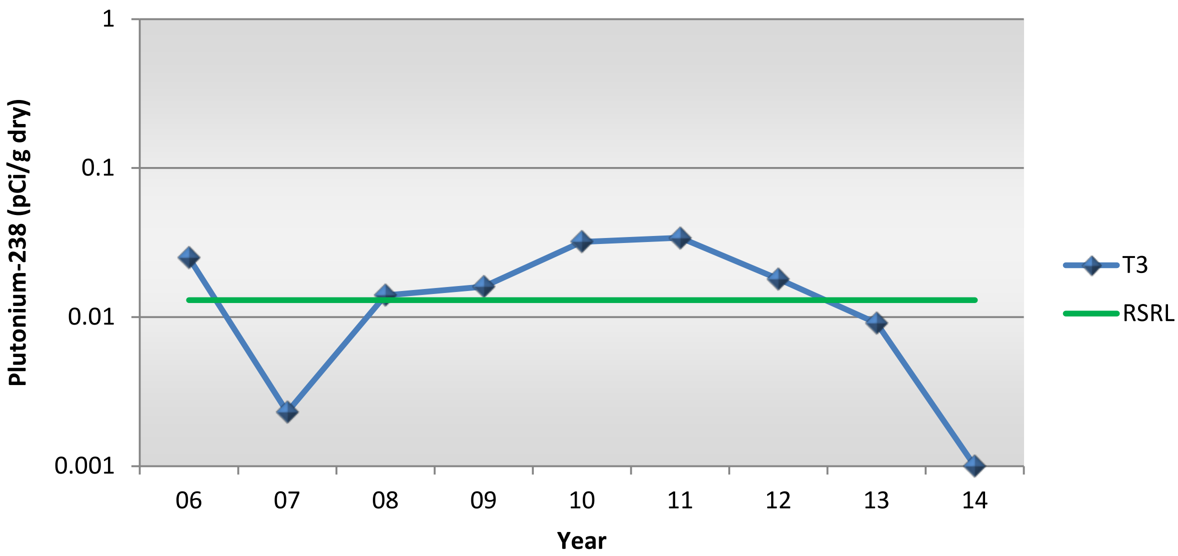

Figure 7-8 **Plutonium-238 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 to 2014 compared with the RSRL. Note the logarithmic scale on the vertical axis.**

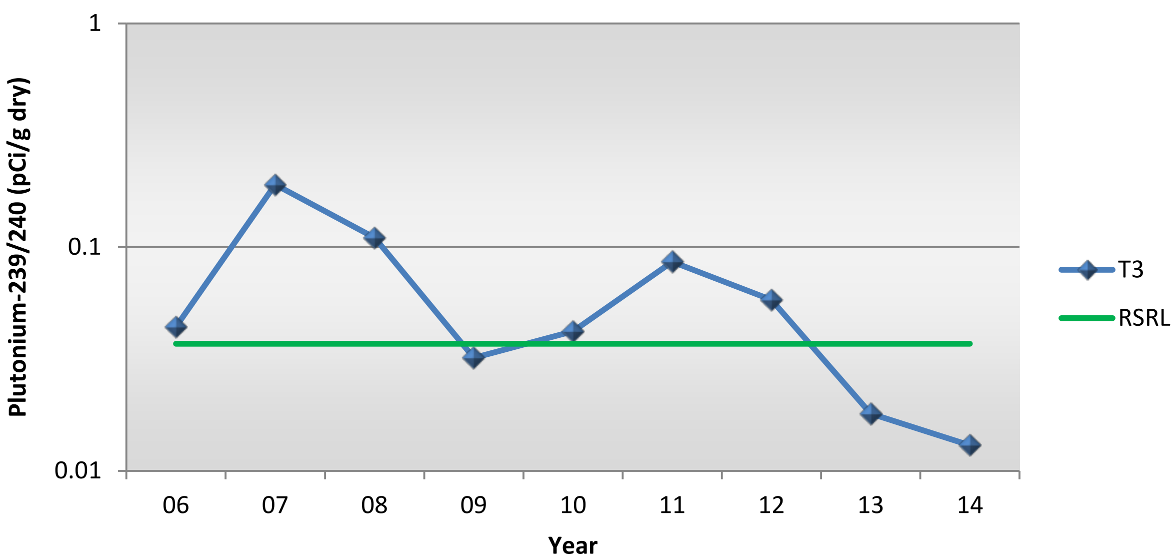

Figure 7-9 **Plutonium-239/240 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at TA-54 from 2006 to 2014 compared with the RSRL. Note the logarithmic scale on the vertical axis.**

Most 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 detected below the RSRLs (Table S7-2). The levels of tritium (1.8 pCi/mL) in tree samples collected at the Laboratory/Pueblo de San Ildefonso boundary were just above the RSRL but orders of magnitude below the BDSL for tritium in plants.

b. DARHT at TA-15

The purpose of monitoring at DARHT, the Laboratory's principal firing site, is to ensure that releases of constituents are consistent with expectations and are not impacting biota.

The Laboratory has conducted soil, sediment, and biota monitoring on an annual basis at the DARHT facility since 1996 to fulfil the requirements of the mitigation action plan (MAP) (Nyhan et al. 2001). Open-air detonations occurred from 2000 to 2002, detonations using foam mitigation were conducted from 2003 to 2006, and detonations within closed steel containment vessels were conducted starting in 2007. Contaminants of potential concern include radionuclides, beryllium (and other metals), and organic chemicals such as polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), high explosives (HE), and dioxins/furans.

Soil composite samples (five subsamples per site) were collected in late April 2014 on the north, east, south, and west sides of the DARHT perimeter along the outside fenceline (Figure 7-10). An additional soil sample was collected about 75 ft north of the firing point. Sediment grab samples were collected on the north, east, south, and southwest sides. All soil and sediment samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, target analyte list (TAL) elements, and HE. The sample nearest the firing point was also analyzed for dioxins and furans. PCBs and SVOCs were not detected in soil or sediment samples collected within and around the perimeter of the DARHT facility in 2007 (Fresquez 2008).

The biota samples collected at DARHT in past years included overstory vegetation, field mice, bees, and birds. Starting in 2014, soil plus one biota component (on a rotating basis) will be collected per the MAP. This year (2014), overstory vegetation and bird sampling was conducted. Vegetation samples are collected for chemical analysis, whereas birds are live captured and released for abundance and diversity estimates.

Overstory samples (branches plus needles) were collected on four sides of the DARHT perimeter and analyzed for radionuclides and TAL elements. Vegetation samples were analyzed for the same radionuclides and TAL elements as the soil. Results for tritium 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 in vegetation are reported on a mg/kg dry-weight basis.

Results of most of the biota chemical analyses were compared with the baseline statistical reference levels (BSRLs) per the MAP (DOE 1996). The BSRLs for soils and sediment are the concentrations of radionuclides and inorganic chemicals (the mean plus three standard deviations) collected from around the DARHT facility from 1996 through 1999 before the start-up of DARHT operations in 2000 (Nyhan et al. 2001). The BSRLs for biota, at the 3-sigma levels, are based on summaries provided by Fresquez et al. (2001) for vegetation, Haarmann (2001) for bees, and Bennett et al. (2001) for small mammals. Similarly, the population, composition, and diversity of birds collected from DARHT were compared with bird samples collected before the operation of the DARHT facility (Fresquez et al. 2007a). In cases where there are no BSRLs, the biota chemical analysis results were compared with RSRLs.

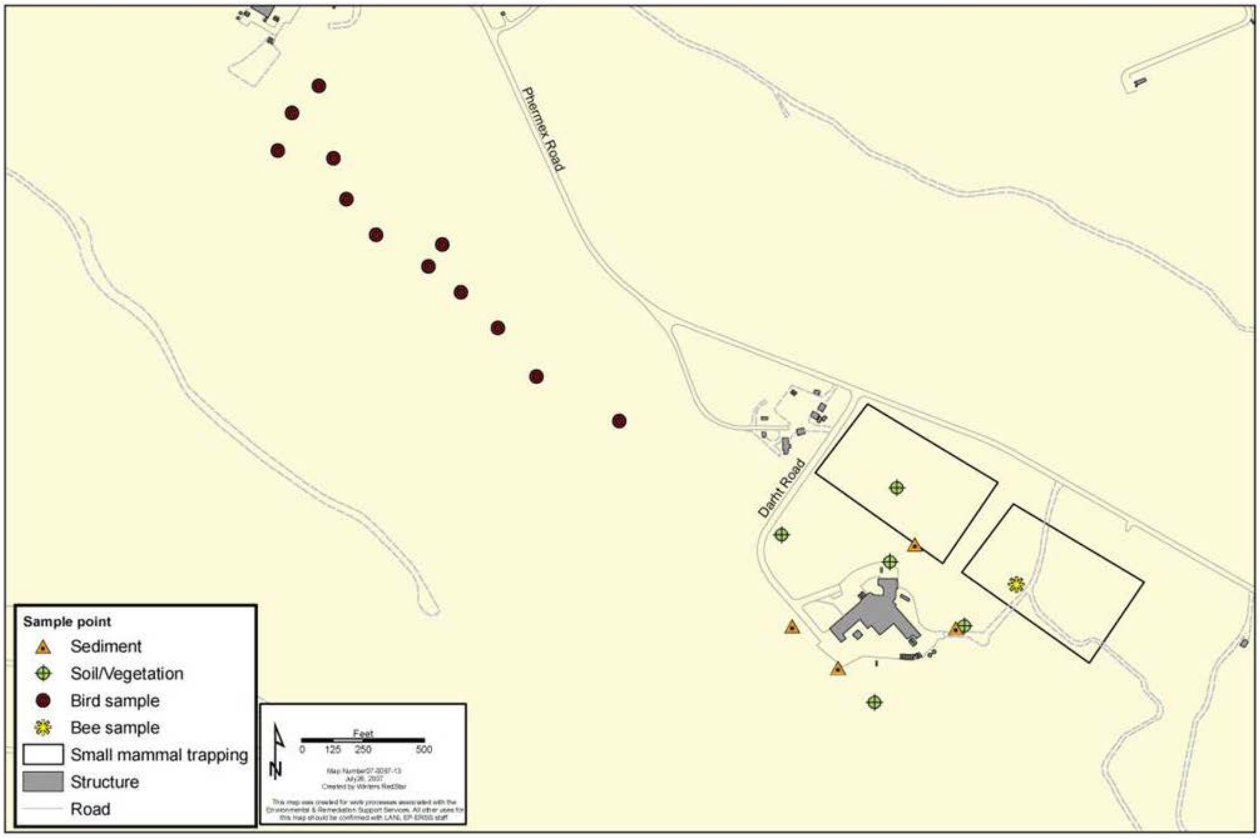

Figure 7-10 Soil, sediment, and biota sample locations at DARHT

i. Soil and Sediment 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 the BSRLs and the RSRLs (Table S7-3). The few radionuclides, including uranium-238, that were detected above the statistical reference levels, however, were far below the lowest NE-ESLs and thus do not pose an unacceptable dose to any biota.

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. Operations have changed to include the use of closed containment vessels and subsequent cleanup of debris around the site; consequently, the uranium-238 activity within the facility has decreased dramatically to BSRLs (Figure 7-11).

Most of the TAL elements, with the exception of selenium, in the soil and sediment samples collected within and around the DARHT facility were below the BSRLs and the RSRLs (Table S7-4). The highest selenium concentration (1.1 mg/kg) is above the lowest NE-ESL of 0.52 mg/kg (plant) but below the LE-ESL of 3 mg/kg (plant).

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. 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 and sediment samples collected within and around the perimeter of the DARHT facility, including the sample closest to the firing point (Table S7-5). Also, most dioxin and furan congeners were not detected above the method detection limits (MDLs) in the soil sample nearest the firing point (Table S7-6). Trace amounts of 1,2,3,4,6,7,8-heptachlorodibenzodioxin; 1,2,3,4,6,7,8,9-octachlorodibenzodioxin; and some tetrachlororodibenzofuran were detected above the MDLs but below the detection limits. Similar trace amounts of the two dioxin congeners were detected in 2012 and 2013.

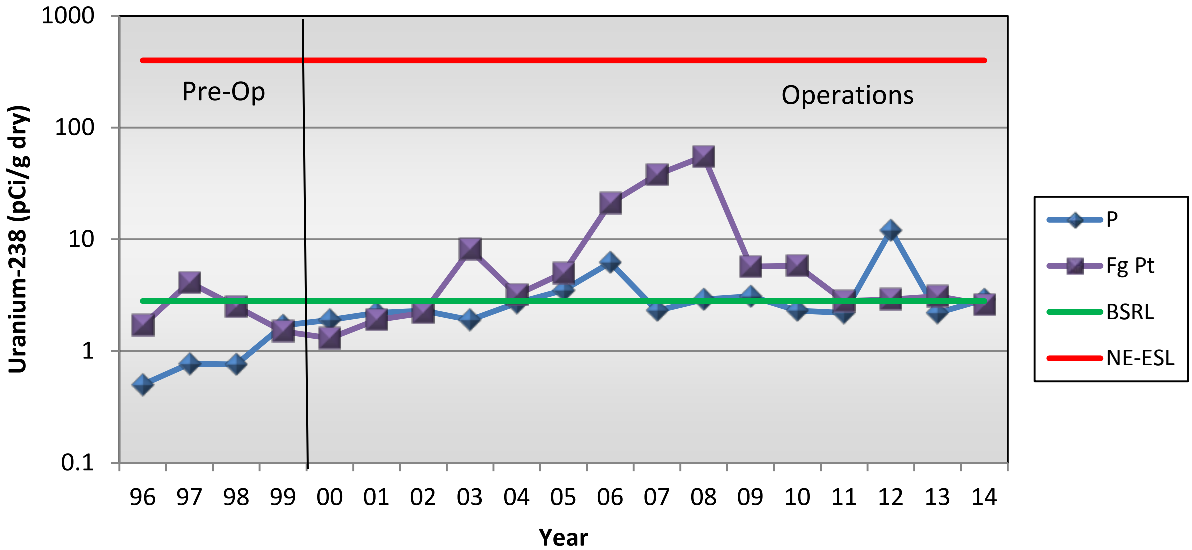

Figure 7-11 Uranium-238 activities in surface soil collected within (near the firing point [Fg Pt]) and around the DARHT perimeter (P) (north-, west-, south-, and east-side average) at TA-15 from 1996 to 1999 (preoperations) and from 2000 to 2014 (operations) compared with the BSRL and the lowest NE-ESL (plant). Note the logarithmic scale on the vertical axis.

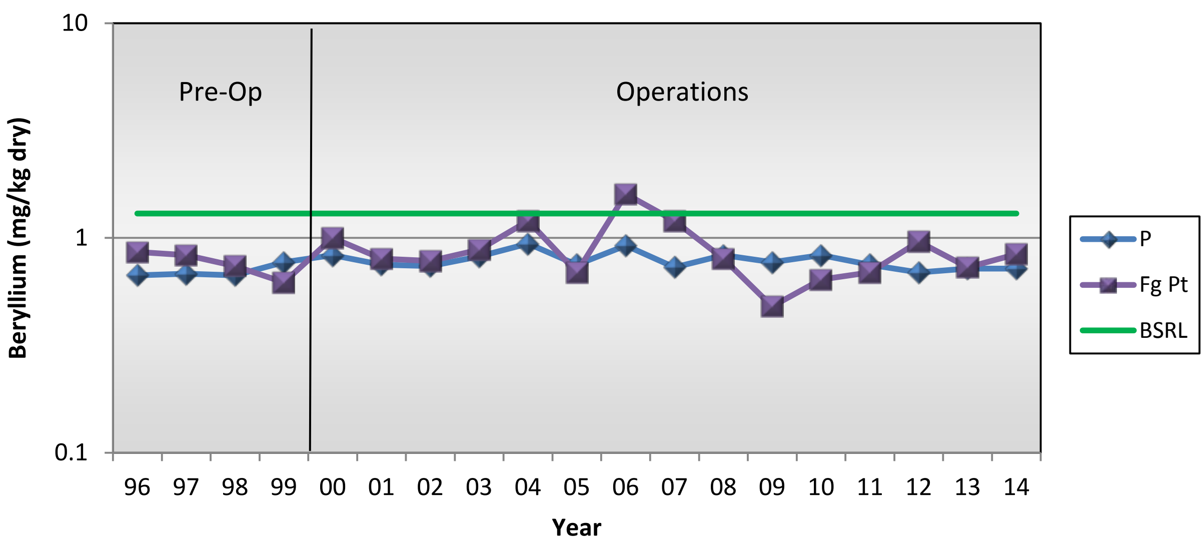

Figure 7-12 Beryllium concentrations in soil collected within (near the firing point [Fg Pt]) and around the DARHT perimeter (P) (north-, west-, south-, and east-side average) at TA-15 from 1996 to 1999 (preoperations) and from 2000 to 2014 (operations) compared with the BSRL and the lowest ESL (plant). Note the logarithmic scale on the vertical axis.

ii. Vegetation Results for DARHT

All radionuclide concentrations in overstory vegetation collected from around the perimeter of the DARHT facility were either not detected or detected below the BSRLs or RSRLs (Table S7-7). Since 2007 the concentrations have generally decreased on all sides of the DARHT perimeter. This general decrease in uranium-238 activities results from 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 7-13). The rapid decrease in a few years indicates that the uranium-238 was on the surface of the vegetation and has since been washed off by rain.

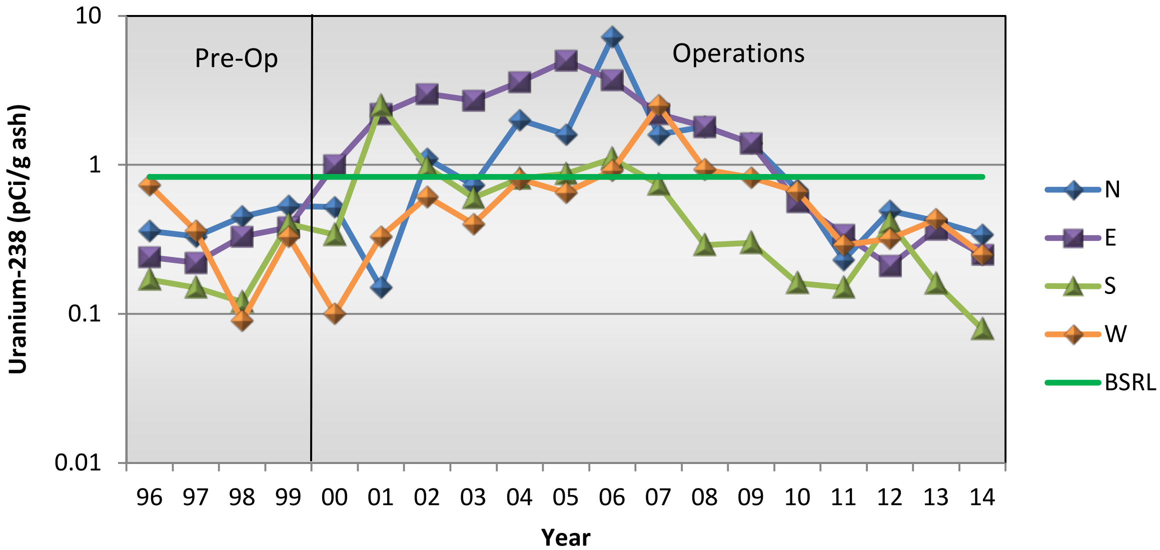

Figure 7-13 Uranium-238 activities in overstory vegetation collected from the north (N), east (E), south (S), and west (W) sides of the DARHT facility at TA-15 from 1996 to 1999 (preoperations) and 2000 to 2014 (operations) compared with the BSRL. Note the logarithmic scale on the vertical axis.

The TAL element results in overstory vegetation collected from around the DARHT facility are summarized in Table S7-8. All of the elements, including selenium, were either not detected or were consistent with the RSRL.

iii. Bird Results for DARHT

Populations, diversity, and species composition of birds collected just west of the DARHT facility during operations in 2014 compared with average results from 1997 through 1999 (preoperational phase) are presented in Table S7-9. 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 of birds collected in 2014 are similar or higher than those collected before the start-up of operations at DARHT (Figures 7-14 and 7-15). However, the species of birds collected at DARHT have changed since the late 1990s/early 2000s, likely because the site has exhibited gradual change from a ponderosa pine– (*Pinus ponderosa*–) dominated plant community to a more piñon/juniper (*Pinus edulis*/*Juniperus monosperma*) open grassland habitat as a result of drought, wildland fire, and bark beetle activity.

The top seven most common birds found during the preoperational period included the Chipping Sparrow, Virginia's Warbler, Western Bluebird, Broad-tailed Hummingbird, Pygmy Nuthatch, Mountain Chickadee, and Gray Flycatcher. In 2014, the top four birds found included the Chipping Sparrow, Rock Wren, Virginia's Warbler, and Western Bluebird. Birds not collected during the preoperational period but present in recent years (2012–2014) include the American Robin, Black-chinned Hummingbird, Blue-gray Gnatcatcher, Brown-headed Cowbird, Cordilleran Flycatcher, MacGillivray's Warbler, 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.

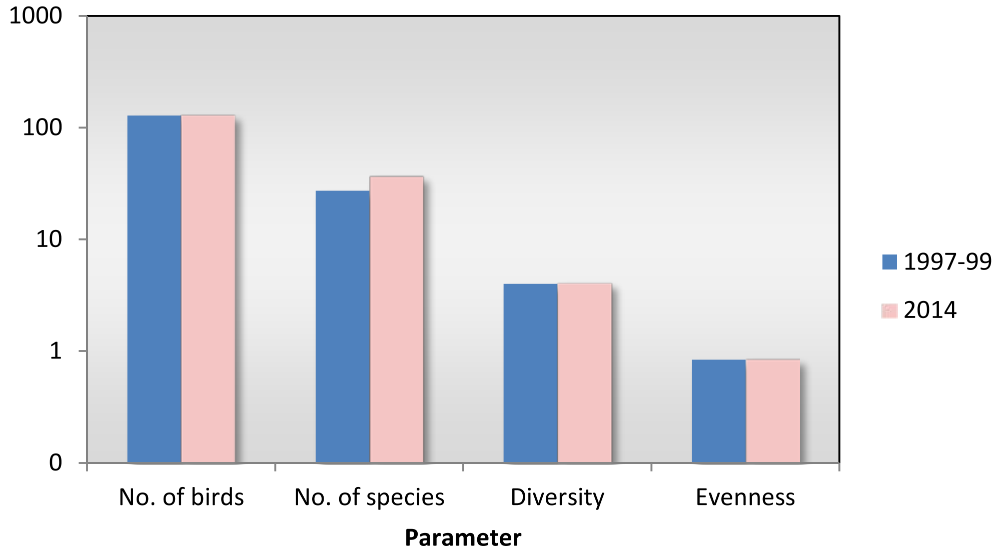

Figure 7-14 **Number of birds, number of species, diversity, and evenness of birds occurring before (1997–1999) and during (2014) operations at DARHT. Note the logarithmic scale on the vertical axis.**

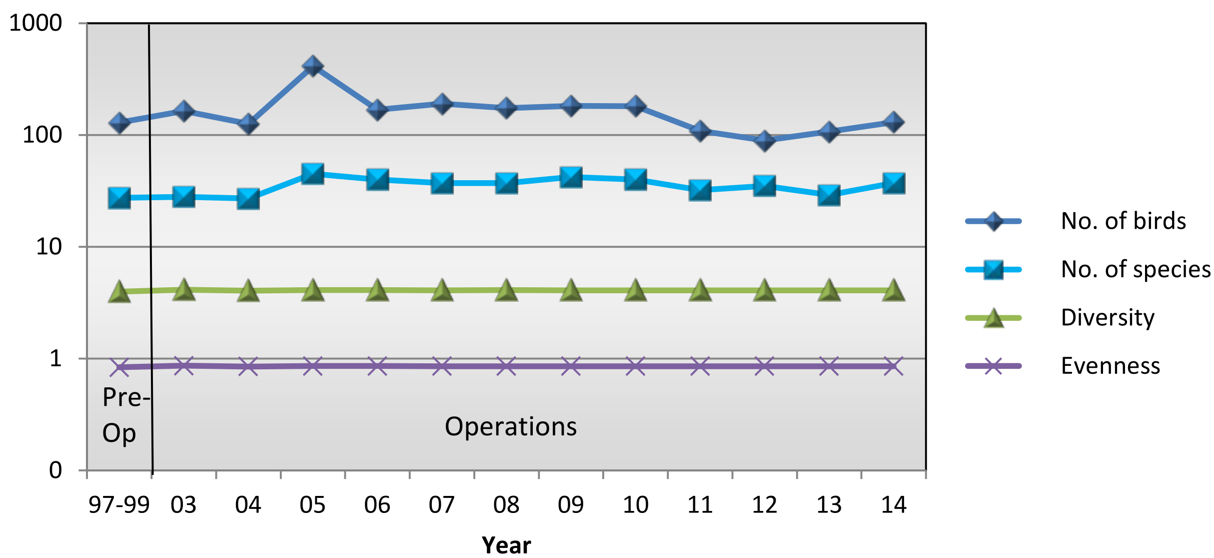

Figure 7-15 **Number of birds, number of species, diversity, and evenness of birds occurring before (1997–1999) and during (2003–2014) operations at DARHT. Note the logarithmic scale on the vertical axis.**

c. Biota Monitoring in the Canyons

i. Monitoring Network

Los Alamos Canyon has received legacy waste releases from TA-01, TA-21, and the historical townsite, while Pajarito Canyon has received material from TA-03 and the Pajarito corridor. Storm-water flows have transported these constituents downstream in canyon bottoms. Sediment-retention structures such as the Los Alamos Canyon Weir (LACW) and the Pajarito Canyon Flood Retention Structure (PCFRS), built following the Cerro Grande Fire in 2000, accumulate these sediments. The sediments contain radionuclides, metals, and PCBs.

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. One of the tasks identified in the plan 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 constituent concentrations in these areas adversely impact biota.

To this end, the Laboratory collects native understory vegetation and field mice (mostly deer mice, *Peromyscus* spp.) in the retention basin of the LACW and the 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 field-mouse (whole-body) samples for radionuclides (composite of five animals) and TAL elements (n = 3). PCBs (congeners, homologs, and totals) in whole-body field mice were analyzed by Cape Fear Analytical. The following two sections report the 2014 results of this monitoring.

ii. Los Alamos Canyon

The LACW was installed in late 2000 and was excavated for accumulated sediments in 2009, 2011, 2013, and 2014 (Figure 7-16). Excavated sediment in 2009 was placed on the west side of the basin and stabilized, whereas sediments in 2011, 2013, and 2014 were removed from the immediate area.

Figure 7-16 LACW structure after sediment excavation in 2014

This year, vegetation and small mammals were collected in late May 2014, approximately 1 mo after excavation of the sediments.

The radionuclide and TAL element concentrations in a composite understory vegetation sample collected within the LACW retention basin can be found in Tables S7-10 and S7-11, 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 detected 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 BDSL. These data, along with activities of the other actinides, plutonium-238 and americium-241, vary widely from year to year (Figure 7-17). 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 on the leaves and stems as a result of high-runoff events. Sediment on plant material may alter radionuclide content significantly. Strontium-90 is statistically decreasing over time, whereas the other radionuclides show no distinctive up or down trends. All TAL elements in understory vegetation were below or similar to the RSRLs (based on 2012 data, n = 6).

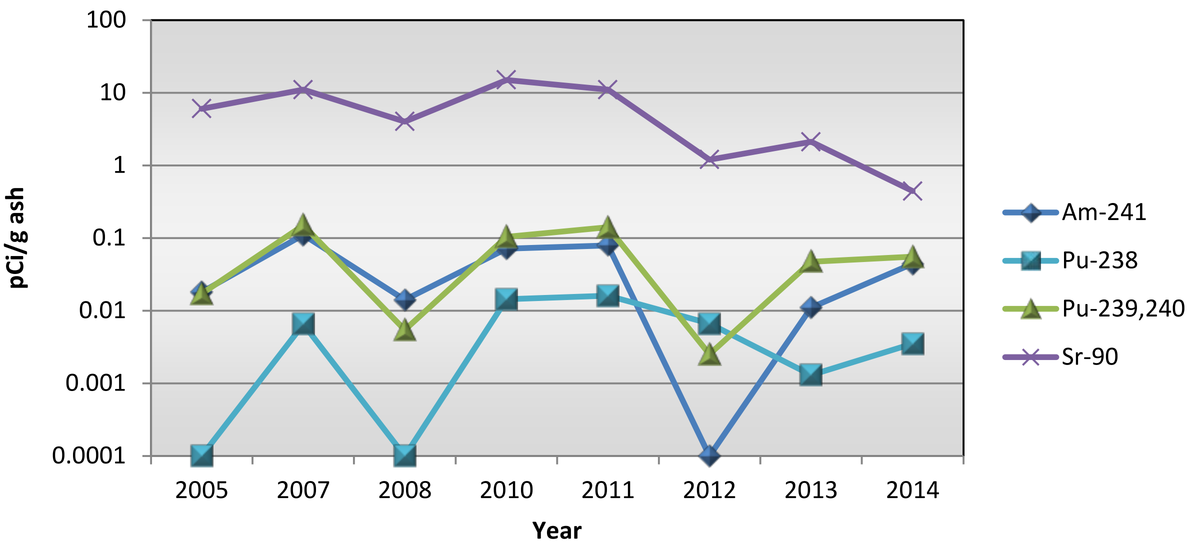

Figure 7-17 Americium-241, plutonium-238, plutonium-239/240, and strontium-90 concentrations in understory vegetation collected on the upgradient side (retention basin) of the LACW from 2005 to 2014. Note the logarithmic scale on the vertical axis.

The activities of cesium-137, strontium-90, tritium, and the uranium isotopes in a composite field-mouse sample (n = 5) collected from within the LACW retention basin were either not detected or similar to RSRLs (based on 2002–2013 data, n = 8) (Fresquez 2013b) (Table S7-12). In contrast, the concentrations of americium-241 and the plutonium isotopes were higher than the RSRLs. All radionuclides, however, were far below BDSLs and are not increasing over time. (Figure 7-18).

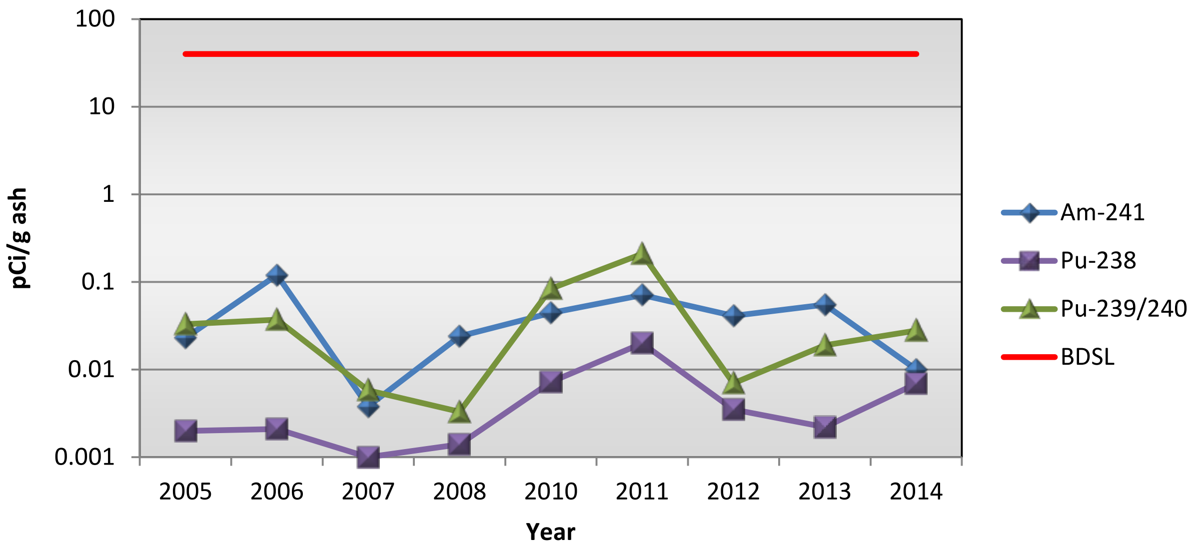

Figure 7-18 Americium-241, plutonium-238, and plutonium-239/240 in composite whole-body field-mouse samples (n >5) collected on the upgradient side (retention basin) of the LACW from 2005 to 2014 compared with the BDSL. Note the logarithmic scale on the vertical axis.

Results of TAL elements in whole-body field mice can be found in Table S7-13. All mean TAL element concentrations in field mice (n = 3) collected on the upgradient side of the LACW were not statistically different from historic regional background concentrations.

Concentrations of total PCBs in whole-body field-mouse samples (n = 3) collected upgradient from the retention-basin side of the LACW were statistically higher than historical regional background concentrations (Table S7-14). However, the highest individual total PCB concentration (22,700 picograms per gram [pg/g] wet) in field mice collected from the retention basin in 2014 was far below the average whole-body amount (2,500,000 pg/g wet) reported at PCB-contaminated sites where field-mouse populations were negatively affected (Batty et al. 1990). Thus, the current PCB levels are not expected to significantly impact the field-mouse population.

The levels of total PCBs in whole-body field mice decreased from 2008 through early 2013 (Figure 7-19) and may be a result of the many sediment control mitigations (sediment traps, willow plantings, and sediment removal) implemented by the Laboratory upgradient of the LACW over the past years (Fresquez 2014b). The sharp spike in total PCBs in whole-body field mice in early 2014, however, may be a result of the large amount of rainfall received in the latter months of 2013 (e.g., 8.7 in. from September 2013 alone) (Dewart et al. 2014), which may have overwhelmed the sediment-control structures in Los Alamos Canyon. The higher-than-normal rainfall events may have resulted in large amounts of sediment migrating down Los Alamos Canyon and accumulating behind the LACW. For example, approximately 7500 yd^2 of sediment was removed from the weir after the flooding events of 2013.

A comparison of the mean PCB homolog distribution in field mice collected within the LACW shows that the pattern was mostly within the Aroclor-1260 profile formulation (Figure 7-20). Aroclor-1260 has been the most consistently detected PCB formulation in sediment collected upgradient of the LACW (Fresquez et al. 2007b, Fresquez 2008, Reneau and Koch 2008).

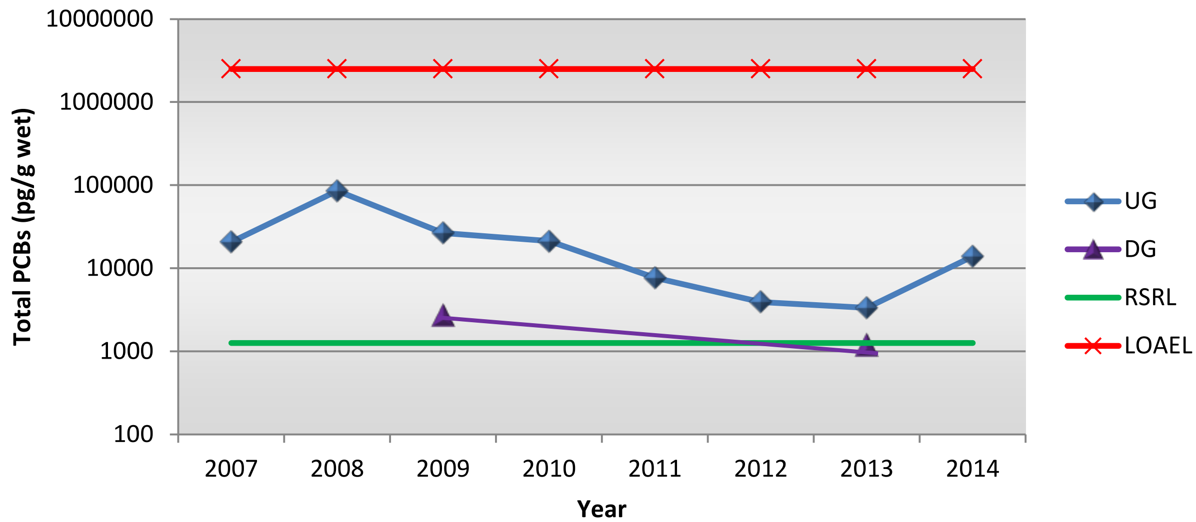

Figure 7-19 **Mean total PCB concentrations in whole-body field mice collected on the upgradient (UG) (retention basin) and 4.5 mi downgradient (DG) of the LACW from 2007 to 2013 compared with the RSRL (1262 pg/g wet) and LOAEL.**

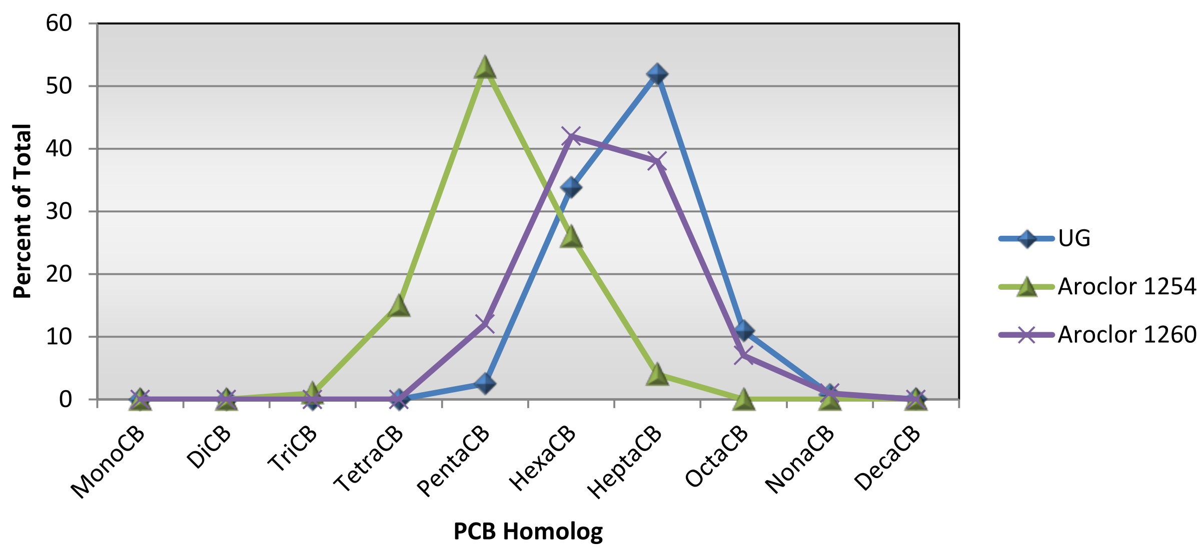

Figure 7-20 **The mean total PCB homolog distribution for whole-body field-mouse samples collected upgradient of the LACW in 2014 compared with Aroclor-1240 and Aroclor-1260**

iii. Pajarito Canyon

Radionuclide activities and TAL element concentrations in native understory vegetation (grasses and forbs) and PCBs in field-mouse samples collected from within the sediment retention basin (upgradient side) of the PCFRS in June 2014 are presented in Tables S7-15 through S7-17.

All of the radionuclides and TAL elements in a composite understory vegetation sample collected from the upgradient side of the PCFRS were either not detected or were detected below the RSRLs. These data are similar to past years.

Radionuclide evaluations in field mice were not conducted this year because the success of trapping was low. However, no radionuclides in whole-body field mice above detection levels have been reported in the past.

The mean concentrations of total PCBs in whole-body field mice collected upgradient of the PCFRS (n = 3) were statistically higher than regional background. The highest amount (5110 pg/g wet), however, was far below the average whole-body amount (2,500,000 pg/g wet) reported at PCB-contaminated sites that has resulted in negative field-mouse population attributes (Batty et al. 1990).

PCB concentrations have been quite variable over the years, probably because of the varying amounts of sediment with storm events; however, the trend is not increasing over time (Figure 7-21).

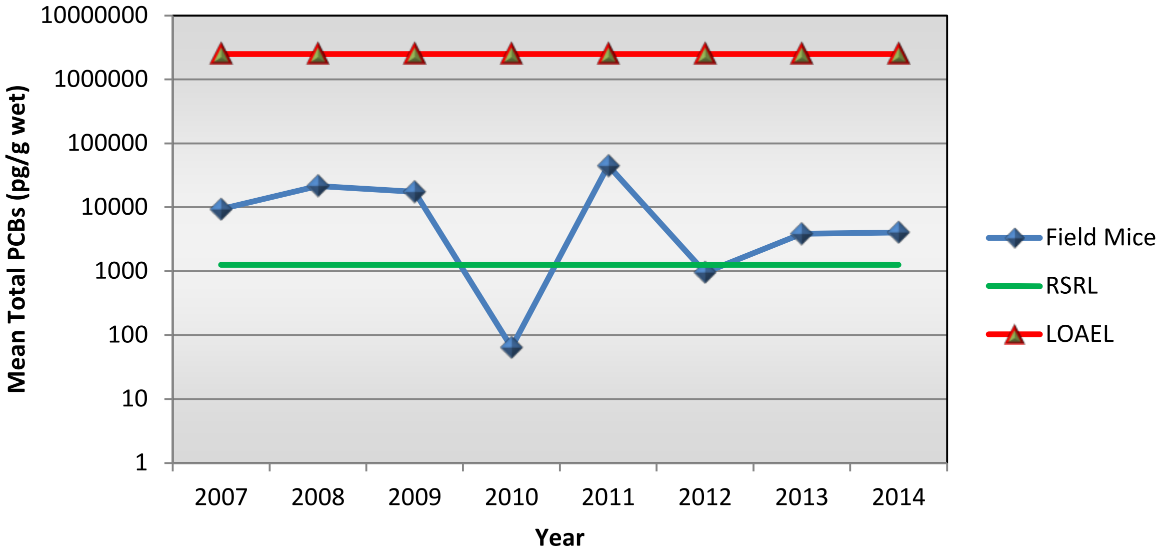

Figure 7-21 **Mean total PCB concentrations in whole-body field-mouse samples collected on the upgradient side (retention basin) of the PCFRS from 2007 to 2014 compared with the RSRL and LOAEL. Note the logarithmic scale on the vertical axis.**

The mean PCB homolog distribution of field mice collected from the PCFRS mostly overlaps the distribution pattern of Aroclor-1260 (Figure 7-22). Trace amounts of Aroclor-1254 and Aroclor-1260 have been detected in sediment collected upgradient (Fresquez et al. 2007b, Fresquez 2008, Reneau and Koch 2008) and downgradient of the PCFRS in past years (LANL 2008).

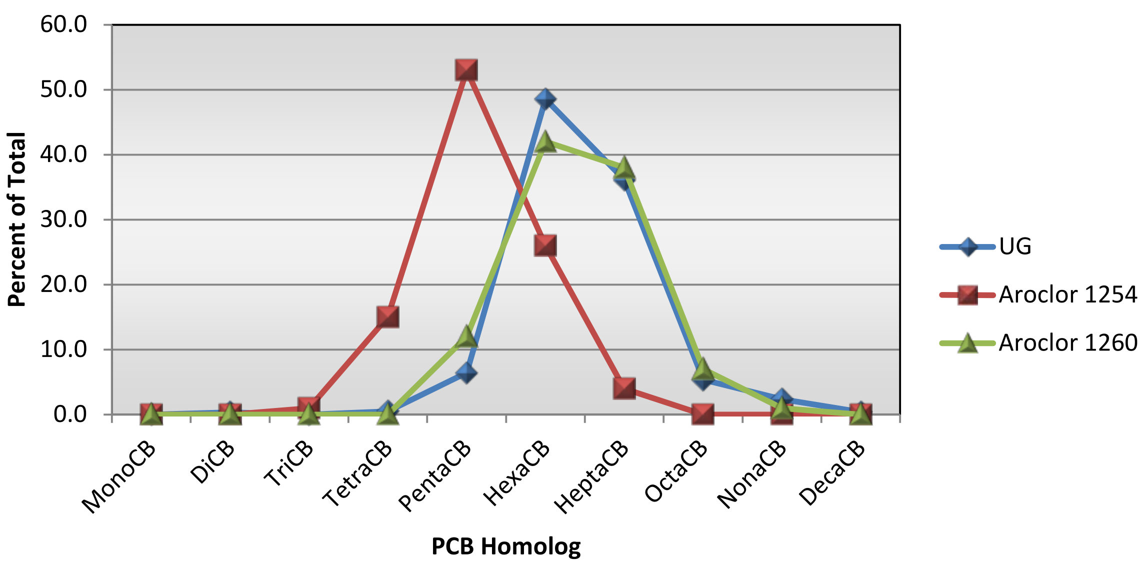

Figure 7-22 **Mean PCB homolog distribution of whole-body field-mouse samples collected on the upgradient side of the PCFRS in 2014 compared with Aroclor-1254 and Aroclor-1260**

d. 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 multiyear monitoring program for migratory birds in 2013 to monitor avifauna at two open-detonation sites and one open-burn site at LANL. The objectives of this ongoing study are to monitor patterns and trends of bird abundance and diversity over time at these sites as a general measure of ecosystem health. LANL biologists completed the second year of this effort in 2014.

Three surveys were completed at each of the study sites, the TA-36 Minie Site, the TA-39 Point 6, and the TA-16 Burn Ground, between May and July 2014. A total of 588 birds representing 54 species were recorded. Of the 54 species detected at the three study sites, all but one is protected under the Migratory Bird Treaty Act.

Results from 2014 indicate that the avian abundance and diversity at the three study sites were comparable to or significantly greater than that of the control sites. The control sites were undisturbed areas on LANL property similar to the habitat of the study sites. Continued monitoring will produce trends over time in avian abundance and diversity that can be compared with local, regional, and national data. See Hathcock (2014) for more detailed information.

C. AQUATIC HEALTH ASSESSMENT

1. Fish Monitoring

a. Monitoring Network

Fish tissues have been collected for radionuclide analyses from two reaches in the Rio Grande as they relate to the location of LANL since 1981 (Fresquez et al. 1994); these locations are upstream of LANL (background) (north of NM 502 to Abiquiu Reservoir [AR]) and downstream of LANL (Los Alamos Canyon [LAC] to Cochiti Reservoir [CR]) (Figure 7-23).

For 2014, background fish samples were collected from (1) AR on the Rio Chama and (2) along the Rio Grande as it passes through the Pueblo de San Ildefonso (SI) lands to the Otowi Bridge (north of NM 502).

Downstream samples were collected in 2013 and 2014 from (1) Rio Grande below the confluence of LAC (0.30 mi) and (2) CR.

Two types of fish were collected based on their principal feeding strategy: predatory fish and bottom-feeding fish. Predatory fish are mostly carnivorous (eat other fish and other animals) and were collected solely from AR and CR. These fish included the northern pike (*Esox lucius*), white bass (*Morone chrysops*), smallmouth bass (*Micropterus dolomieui*), white crappie (*Pomoxis annularis*), and walleye (*Stizostedion vitreum*). Bottom-feeding fish are mostly omnivorous (eat anything) and feed at the bottom of lakes and rivers. These fish were collected from every upstream and downstream location and include the white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*). Table 7-2 is a summary table showing all locations and the number and types of fish collected in 2013 and 2014.

Fish were collected using gill nets and rods and reels. At each collection site, fish were processed according to standard operating procedures to obtain samples for analyses of radionuclides, TAL elements, and PCBs. In general, samples of fish for radionuclide analysis were processed by removing the viscera and head, rinsing the fish thoroughly, and then placing the remaining muscle plus bone tissues into Ziploc plastic bags. (Note: A fish sample for radionuclide analysis sometimes contained more than one fish of the same species in order to obtain an adequate sample size; about 3 lb of material is required.) Samples for TAL elements and PCB analysis were obtained from a single fish. A fillet (muscle plus skin) for TAL elements was collected from one side of the fish and placed in a Ziploc bag, and a sample for PCB analysis was collected from the other side of the fish and placed into a 500-mL amber glass jar. All samples were labeled, sealed with chain-of-custody tape, placed into a cooled ice chest, and submitted under full chain-of-custody procedures to the Sample Management Office (SMO), where they were then sent to ALS Laboratory Group for radionuclide and TAL element analyses, and to Cape Fear Analytical, LLC (Wilmington, North Carolina) for PCB analysis of congeners.

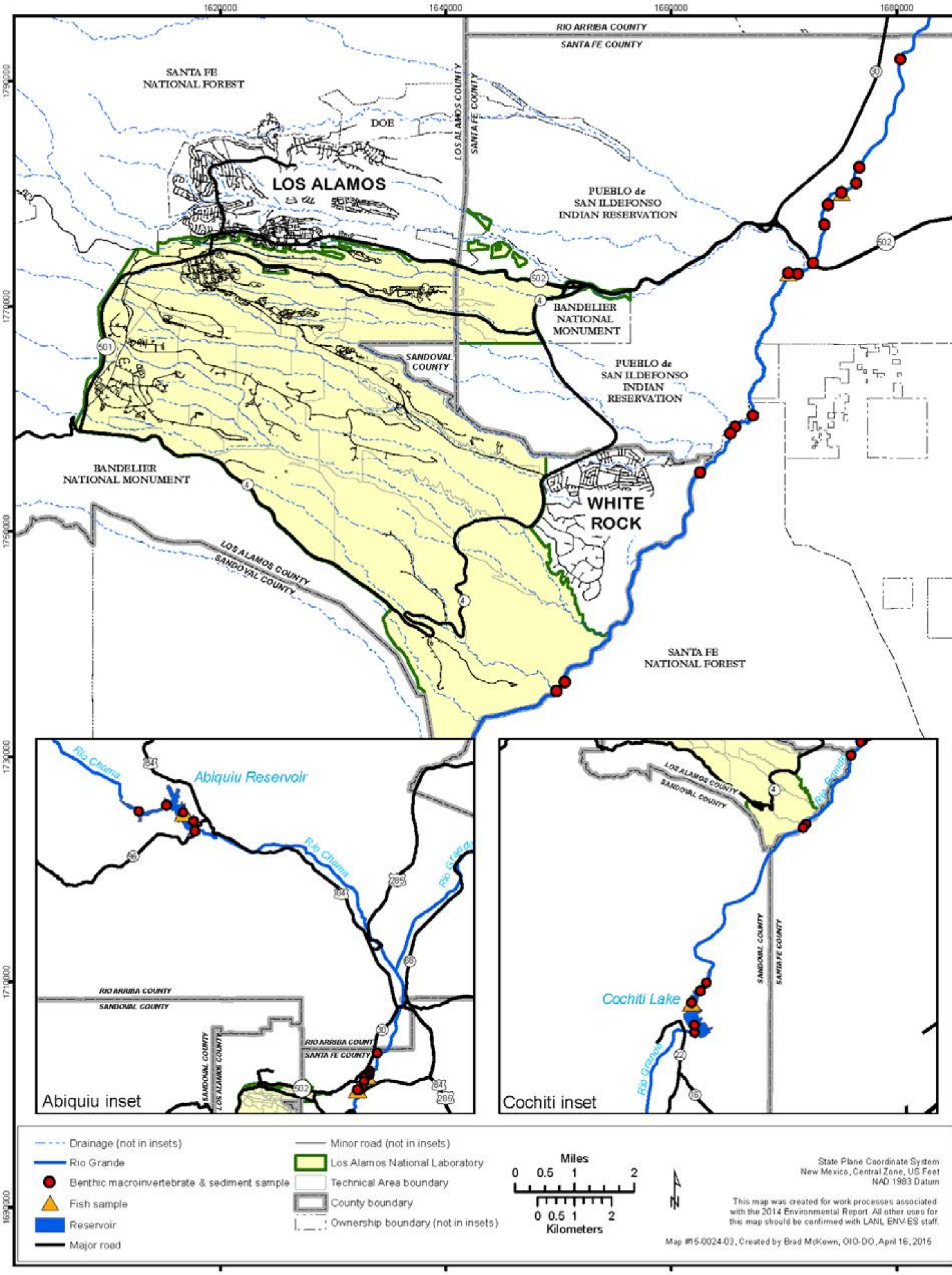

Figure 7-23 Locations of fish, benthic macroinvertebrates (BMIs), and sediment collected at Abiquiu Reservoir, Cochiti Reservoir, and the Rio Grande

Table 7-2
Locations and Types of Fish Collected in 2013 and 2014

River System/Location	Location as Related to LANL Confluences	Type and Number of Samples Analyzed
Rio Chama/Abiquiu Reservoir	Approximately 44 mi upstream of Los Alamos Canyon (Los Alamos Canyon is the first and most significant canyon that passes through LANL.)	Predatory (2) and bottom feeders (3)
Rio Grande/San Ildefonso	Approximately 2 mi upstream of Los Alamos Canyon (north of NM 502 [Otowi Bridge]).	Bottom feeders (1)
Rio Grande/Los Alamos Canyon	Los Alamos Canyon (0.30 mi downstream)	Bottom feeders (3)
Rio Grande/Cochiti Reservoir	Downstream of all LANL/canyon confluences	Predatory (12) and bottom feeders (13)

The radionuclides analyzed were tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, uranium-238, radium-226, and radium-228. Tritium concentration results are reported on a per mL basis. Results of the other radionuclides were reported in pCi/g dry after multiplying the results obtained from the analytical laboratory (in ash) by the ash-to-dry weight conversion factor of 0.12 for predatory fish and 0.095 for bottom-feeding fish (Fresquez et al. 2007c).

TAL elements analyzed were aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury. These elements are reported on a wet weight basis in mg/kg.

PCBs were analyzed for 209 possible chlorinated congeners; a congener is a specific PCB compound with a certain number of chlorine atoms in certain positions around a biphenyl ring (EPA 1996). For summary and reporting purposes, PCB congeners were grouped together into 10 homologs; a homolog is a group of congeners with the same number of chlorine atoms, which allows visual comparison of similarities or differences among samples or groups of samples. The designations for the 10 homologs range from monochlorobiphenyl (monoCB) to decachlorobiphenyl (decaCB). Homologs and total PCBs are reported on a pg/g (parts per trillion) wet weight basis.

To statistically assess upstream versus downstream differences in fish, past and present results (pre-2014) of background fish that generally approximate the number of fish collected from downstream locations in 2014 were used to aid in comparisons.

If a radionuclide or chemical in a fish collected downstream of LANL was significantly higher than background, then the levels are compared with the appropriate BDSL or LOAEL, respectively, as described in Section B.1.a and Table 7-1.

b. Radionuclide Results

Most individual radionuclides in both predatory and bottom-feeding fish collected on the Rio Grande downstream of LANL in 2013–2014 were not detected (Tables S7-18 and S7-19). Moreover, the mean concentration of most radionuclides in fish from CR, with the exception of the uranium isotopes in the predatory fish, were not statistically higher than mean concentrations from upstream reaches (2008–2014, n = 15). The concentrations of the uranium isotopes in the predatory fish collected from CR were statistically higher than fish from AR. However, the composition of uranium in these fish indicated the uranium is of natural origin (U234:U238, 1:1 ratio) and not a Laboratory contribution. Nevertheless, all concentrations of uranium isotopes in predatory fish from CR were orders of magnitude below the BDSLs and not a health concern to the fish. These data from downstream reaches are similar to past results (Fresquez 2012).

A comparison of radionuclides in bottom-feeding fish from AR and CR over a 30-yr span shows that there are generally no radionuclides that are increasing in concentrations in fish from CR that are independent of AR from 1981 to present (Figures 7-24 to 7-29). In fact, a decreasing trend in cesium-137 and strontium-90 concentrations in bottom-feeding fish from both AR and CR is clearly evident and is probably related to the relatively short half-lives (30 yr) of these radionuclides (Whicker and Schultz 1982). These findings indicate that the potential transport of legacy materials from the LANL site are not affecting the radionuclide concentrations in fish tissues at CR.

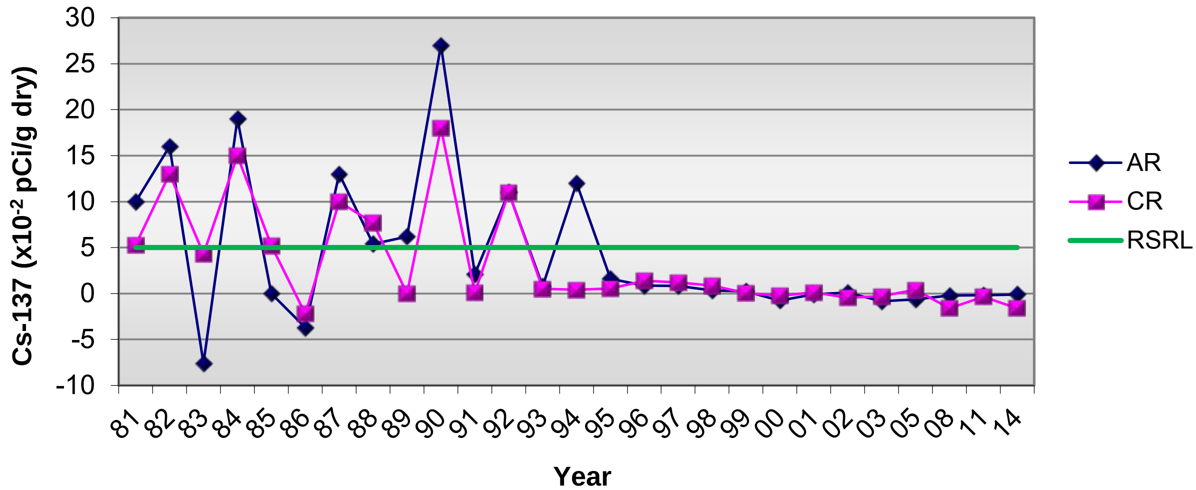

Figure 7-24 Mean cesium-137 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 to 2014 compared with the RSRL. (Note: The high variability during the early years compared with the latter years was mainly because of the stabilization of instrument background, normalization in counting times, and improvements in the counting technology.)

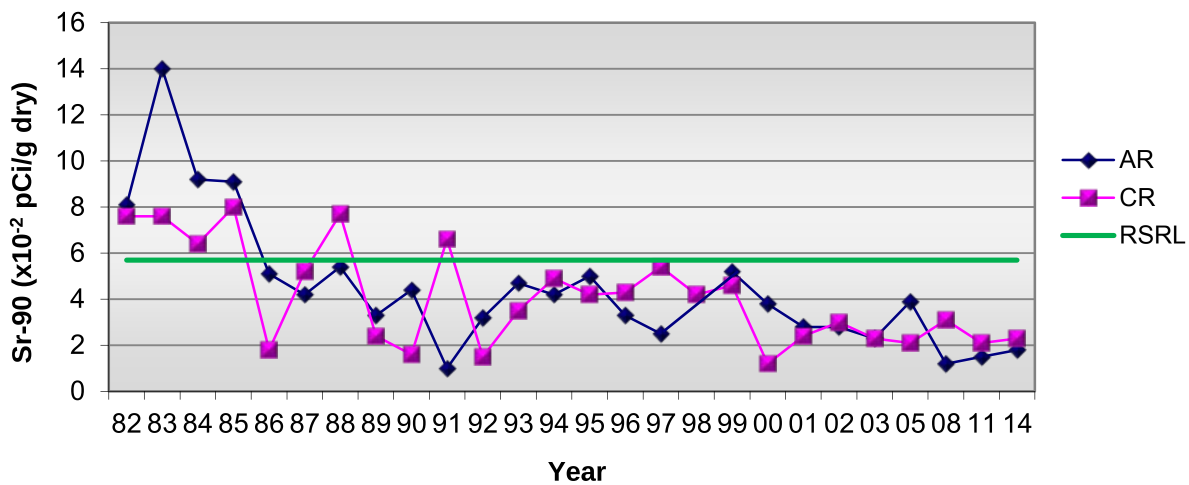

Figure 7-25 Mean strontium-90 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1982 to 2014 compared with the RSRL

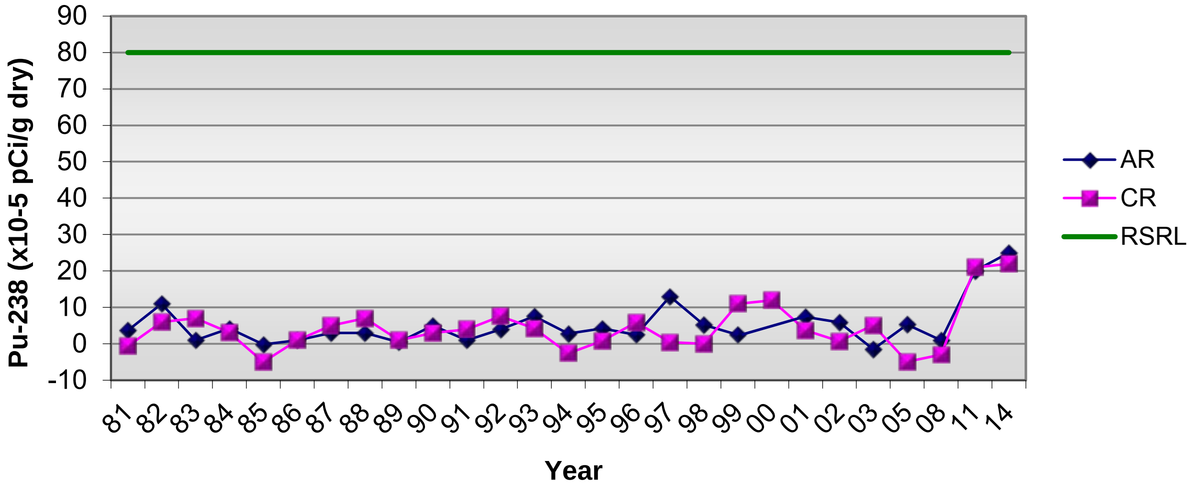

Figure 7-26 **Mean plutonium-238 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 to 2014 compared with the RSRL**

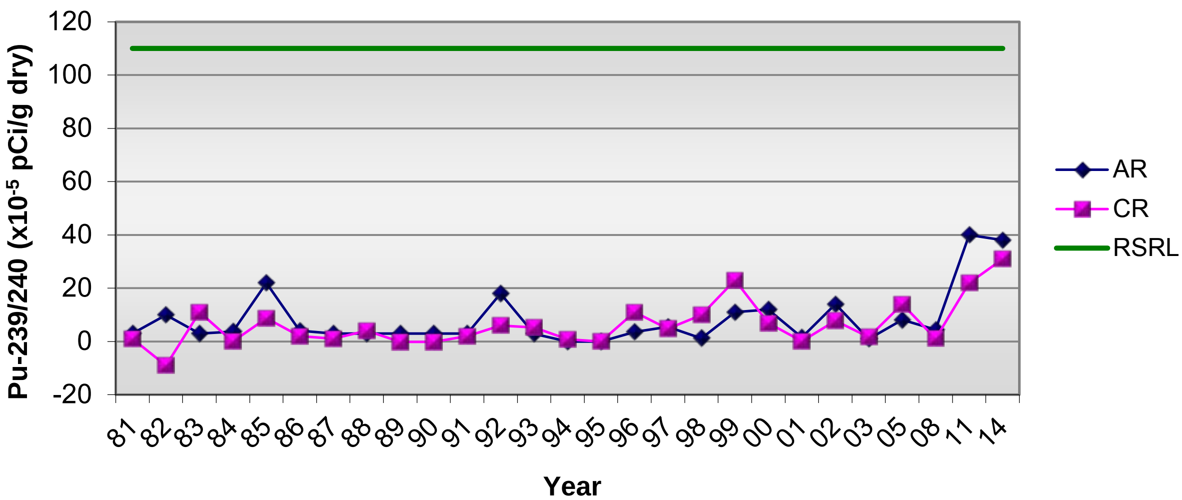

Figure 7-27 **Mean plutonium-239/240 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 to 2014 compared with the RSRL**

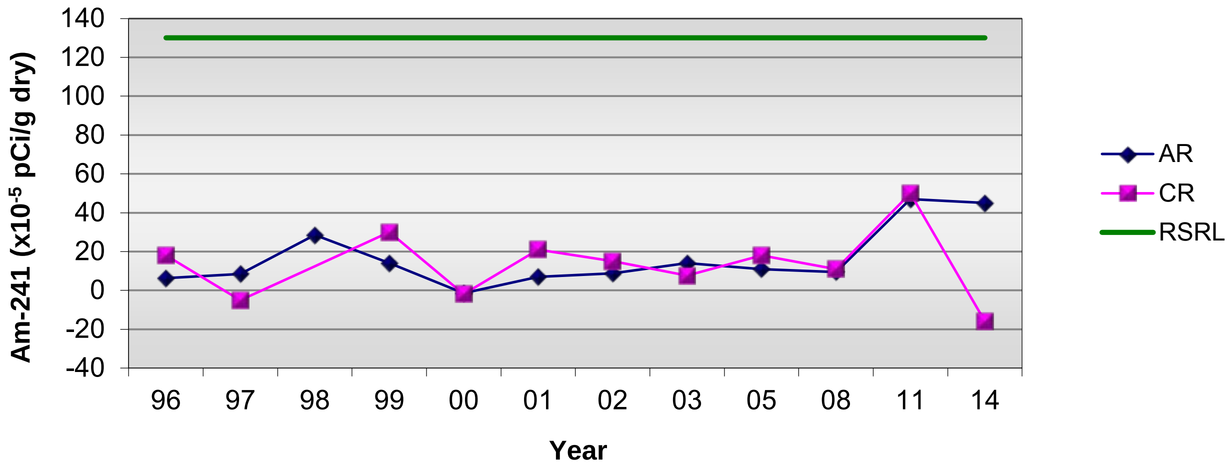

Figure 7-28 **Mean americium-241 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1996 to 2014 compared with the RSRL**

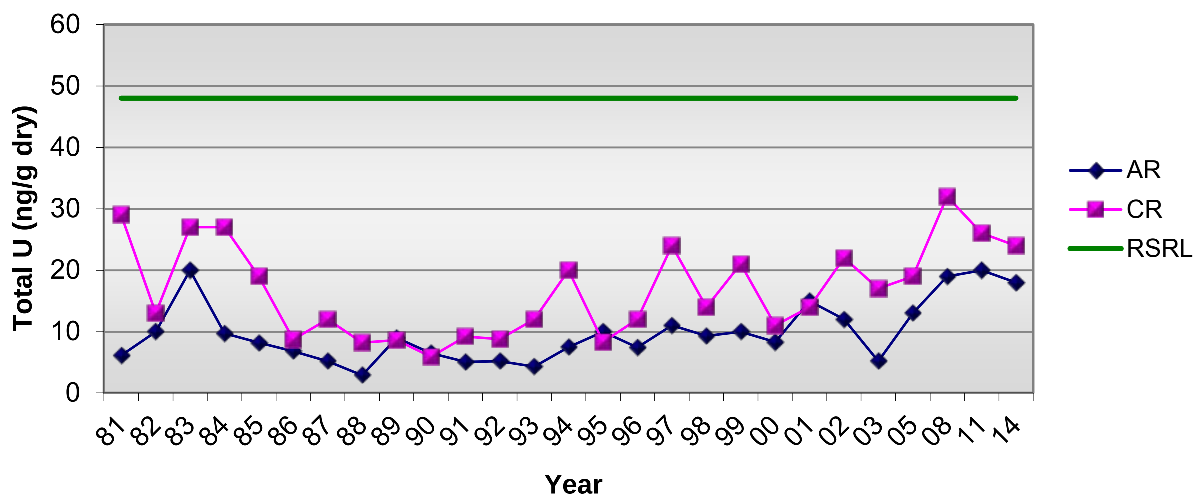

Figure 7-29 **Mean total uranium concentrations (all isotopes combined) in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 to 2014 compared with the RSRL**

c. TAL Element Results

The mean concentrations of the 23 TAL elements, including mercury, in the muscle fillet of both predatory and bottom-feeding fish collected along the Rio Grande downstream of LANL to CR were not statistically different from fish that have been historically collected upstream of LANL (Tables S7-20 and S7-21). The highest level of mercury in muscle tissue of fish was below the LOAEL of 5 mg/kg for muscle tissue (Scherer et al. 1975). These data are similar to past results (Fresquez 2012).

In general, the predatory fish from the reservoirs contained higher mercury concentrations than the bottom-feeding fish from the same reservoirs, and the bottom-feeding fish from the reservoirs were higher in mercury concentrations than the bottom-feeders from the river system. Predatory fish would be expected to contain more mercury than the bottom-feeding fish because mercury normally biomagnifies up the food chain (Figure 7-30). Also, because the conversion of inorganic mercury to methyl mercury is primarily conducted by bacteria under anaerobic conditions, it is expected that there would be higher amounts in reservoir fish than in river fish (Bunce 1991, Driscoll et al. 1994).

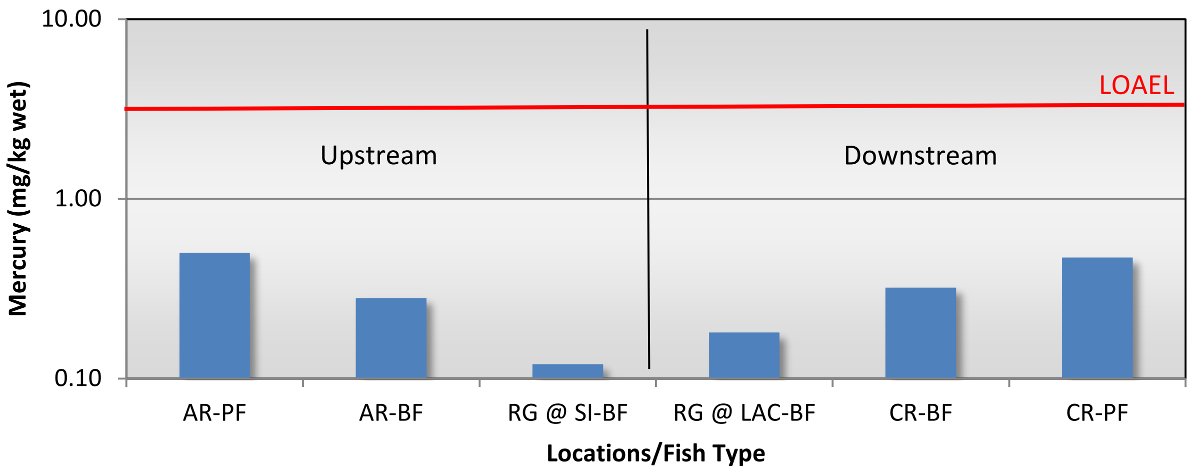

Figure 7-30 **Mean total mercury concentrations in predatory (PF) and bottom-feeding (BF) fish upstream (AR and Rio Grande at San Ildefonso [RG @ SI]) and downstream (Rio Grande at Los Alamos Canyon [RG @ LAC] and CR), in 2014 as compared with the LOAEL of 5 mg/kg.**

Based on the long-term trend (1991 to 2014), the concentrations of mercury in predatory fish from both AR and CR show a highly variable pattern from year to year (Figure 7-31).

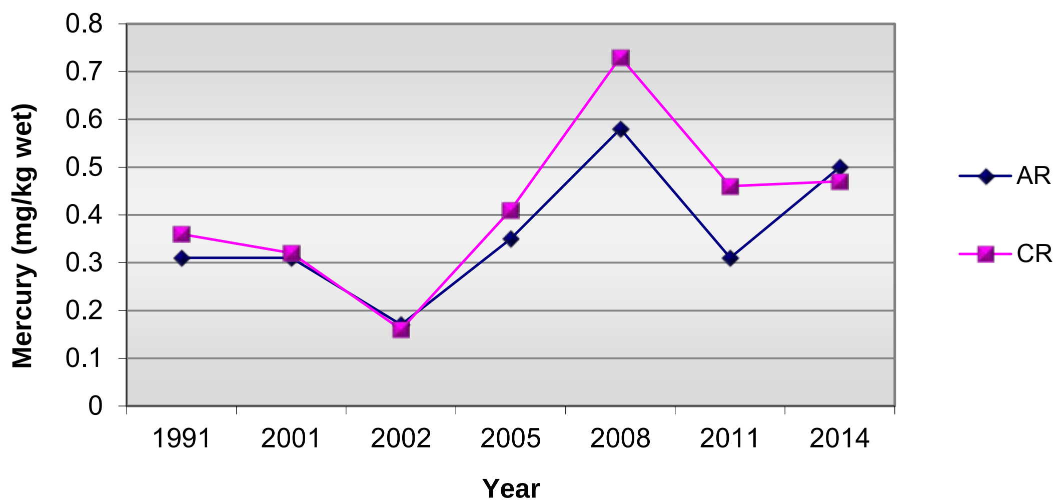

Figure 7-31 **Mean mercury concentrations in predatory fish collected upstream (AR) and downstream (CR) of LANL from 1991 to 2014**

Likewise, the trend line for mercury in bottom-feeding fish from both reservoirs tends to be highly variable from year to year (Figure 7-32). However, regardless of the variability of mercury in fish from year to year, there are no increasing trends in any of the fish types at CR that are independent of AR.

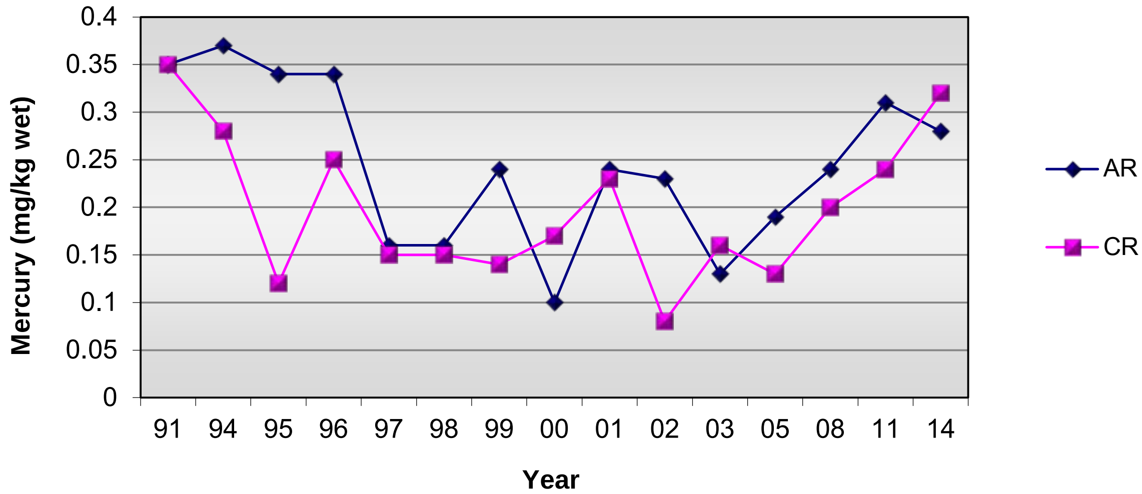

Figure 7-32 **Mean mercury concentrations in bottom-feeding fish collected upstream (AR) and downstream (CR) of LANL from 1991 to 2014**

d. PCB Results

i. Predatory Fish

Table S7-22 is a summary table showing homolog and total PCB concentrations for each of the predatory fish from AR and CR collected in 2014. As a group, the mean concentration of total PCBs in predatory fish tissues from CR were not statistically higher than fish tissues from AR (2005–2014, n = 14). The concentrations of total PCBs in fish tissue from CR were similar to past results and were far below the LOAEL of 34,000,000 pg/g wet (Freeman and Idler 1975) (Figure 7-33).

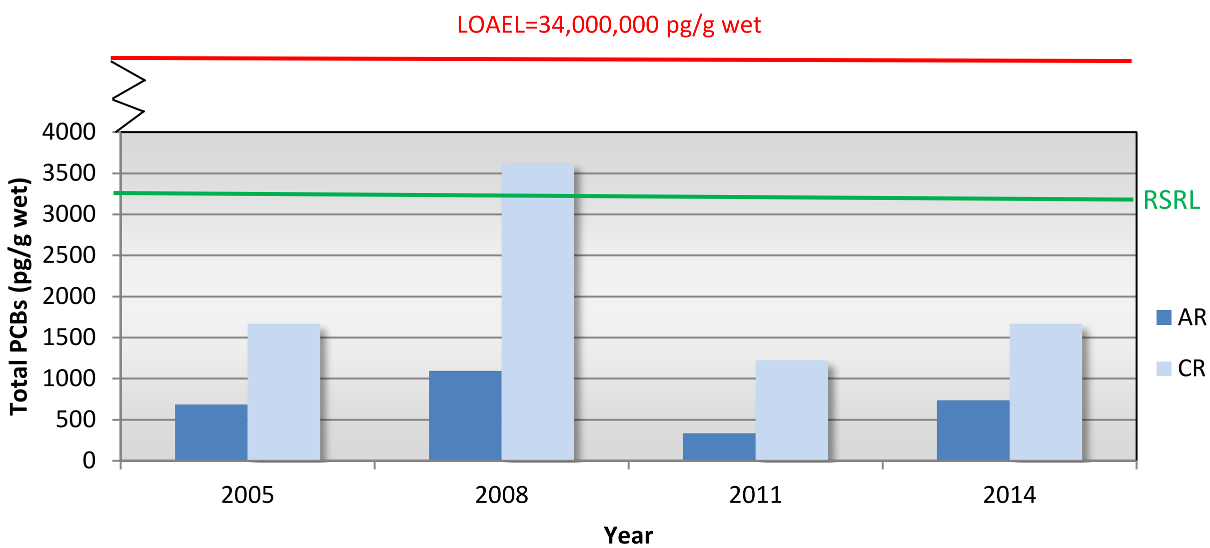

Figure 7-33 **Mean total PCBs in muscle fillets of predatory fish collected from AR (upstream of LANL) and CR (downstream of LANL) in 2005 to 2014 compared with the RSRL and LOAEL**

A comparison of the mean PCB homolog distributions in muscle fillets of predatory fish between AR and CR (Figure 7-34) shows that the profiles are generally similar to one another and are within the PCB patterns of both Aroclor-1254 and -1260. These data agree with the PCB homolog pattern for predatory fish from CR obtained in 2005 (Gonzales and Fresquez 2006), 2008 (Fresquez et al. 2009), and 2011 (Fresquez et al. 2012).

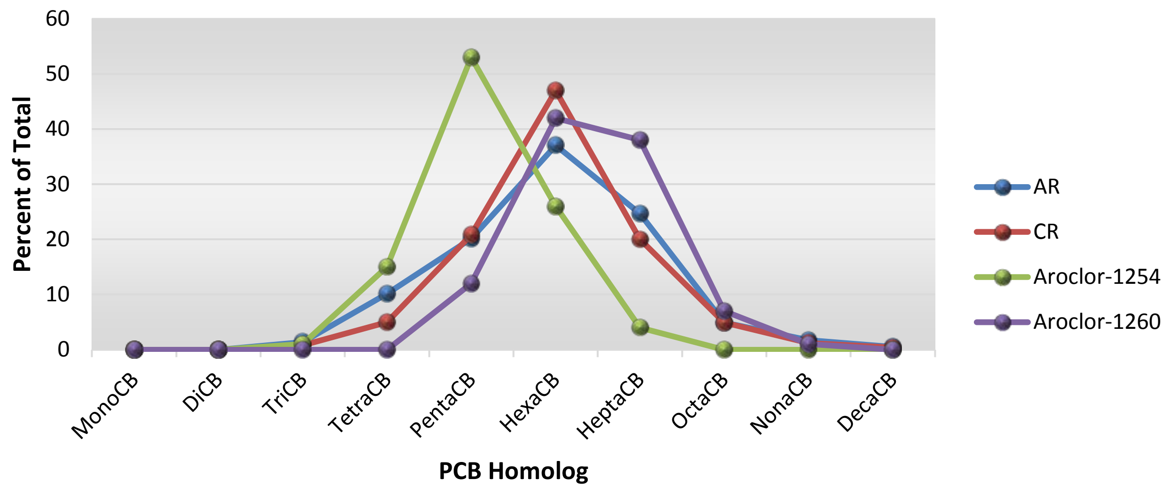

Figure 7-34 The mean homolog distribution in muscle fillets of predatory fish collected upstream (AR) and downstream (CR) of LANL in 2014 compared with Aroclor-1254 and Aroclor-1260

ii. Bottom-Feeding Fish

Table S7-23 summarizes homolog and total PCB concentrations in muscle fillets in bottom-feeding fish from two upstream locations (AR and RG @ SI) and two downstream locations (RG @ LAC and CR) relative to LANL in 2014.

The mean concentration of total PCBs in bottom-feeding fish 0.30 mi below LAC (RG @ LAC) was not statistically higher than the mean concentration of total PCBs from bottom-feeding fish collected from upstream locations at AR and RG @ SI (2011–2014, n = 22) (Figure 7-35). Conversely, the mean total PCBs in the fillets of bottom-feeding fish from CR was statistically higher than the mean total PCB concentrations in bottom-feeding fish from the upstream locations. The total amounts of PCBs in bottom-feeding fish from CR, however, are orders of magnitude below the LOAEL of 34,000,000 pg/g wet (Freeman and Idler 1975).

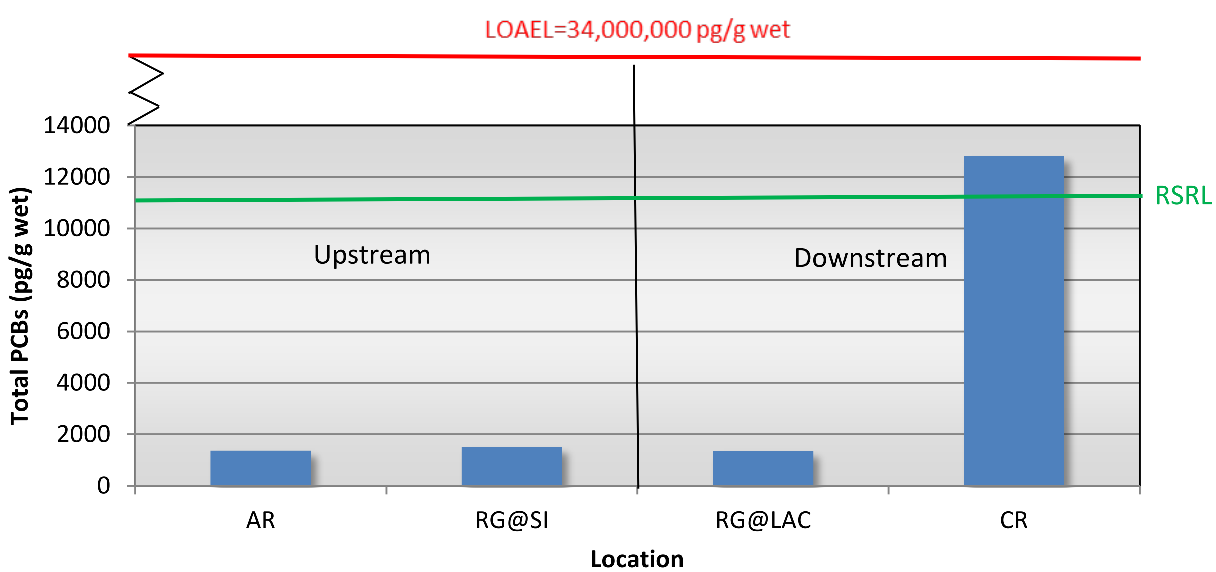

Figure 7-35 Mean total PCB concentrations in muscle fillets of bottom-feeding fish collected upstream (AR and Rio Grande at San Ildefonso [RG @ SI]) and downstream (RG @ LAC and CR) of LANL in 2014 compared with the RSRL and LOAEL

The homolog distribution pattern for bottom-feeding fish at CR is different from AR but generally similar to the profiles of fish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LAC (Figure 7-36). These data imply a PCB source between AR and RG @ SI. PCB homolog patterns in bottom-feeding fish from RG @ SI, RG @ LAC, and CR are within both Aroclor-1254 and -1260 profiles and are similar to past years (Fresquez et al. 2012).

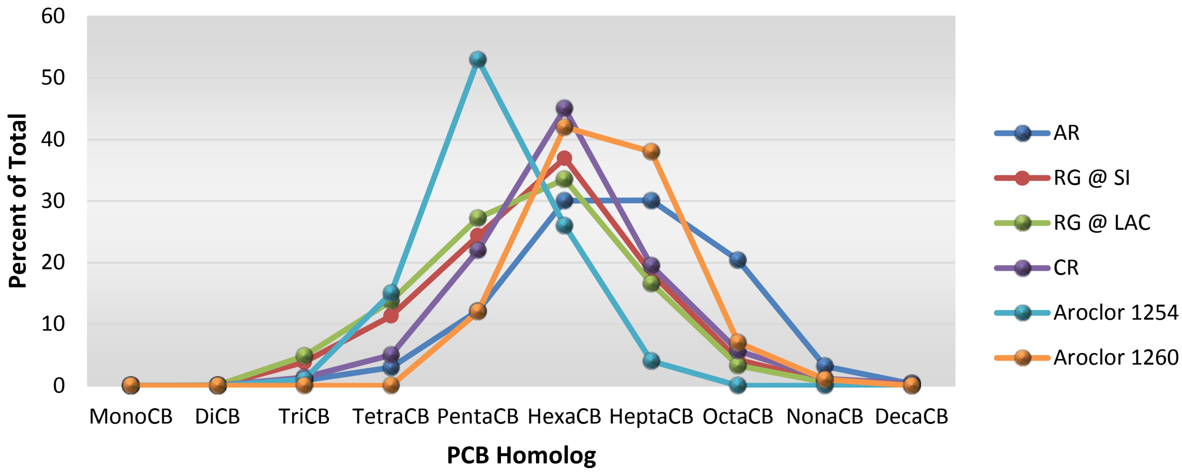

Figure 7-36 The mean homolog distribution in the muscle tissues of bottom-feeding fish collected upstream (AR and RG @ SI]) and downstream (RG @ LAC and CR) of LANL in 2014 as compared with Aroclor-1254 and -1260

These data, particularly those directly upstream and downstream of LANL, are in agreement with other water and sediment studies, mainly the following: (1) the placement of stationary semipermeable membrane devices (e.g., artificial fat bags) upstream (RG @ SI) and downstream (RG @ LAC) of LANL that showed similar PCB concentrations between locations (Gonzales and Montoya 2005) and (2) the collection of sediment samples along the same general reach of waters upstream and downstream of LANL in previous years that showed mean PCB concentrations and homolog patterns generally similar to those of the 2014 data (Reneau and Koch 2008, Drakos et al. 2011).

There is considerable variability in total PCB concentrations in bottom-feeding fish from CR as compared with AR over time (Figure 7-37). The high variability in total PCB concentrations in bottom-feeding fish from CR is probably a result of several factors, including (1) the number and intensity of flooding events and (2) the amount of total watershed area and potential PCB sources from CR versus AR. PCBs are common and persistent, and one way they enter waterways is through storm-water runoff from urbanized and industrial areas and landfills (ATSDR 2001). CR, which is influenced by two rivers (Rio Chama and Rio Grande), contains more watershed area than AR, whose only source is the Rio Chama. Above Abiquiu Reservoir, the Rio Chama only encounters one urbanized area—Chama. Above Cochiti Reservoir, the Rio Grande and its tributaries encounter several urbanized areas, including Abiquiu, Hernandez, Velarde, Ojo Caliente, and Española. Consequently, the mean total PCBs levels in bottom-feeding fish from AR are considerably lower than CR and do not vary widely from year to year.

The mean total PCBs in bottom-feeding fish collected from CR and the Rio Grande directly above (RG @ SI) and below LANL (RG @ LAC) have decreased over time, particularly in the last 2 to 3 yr, respectively. Current PCB concentrations in bottom-feeding fish at CR have decreased since 2008, and PCB concentrations in bottom-feeding fish from the Rio Grande (RG @ SI and RG @ LAC) have significantly decreased from 2002 to 2014.

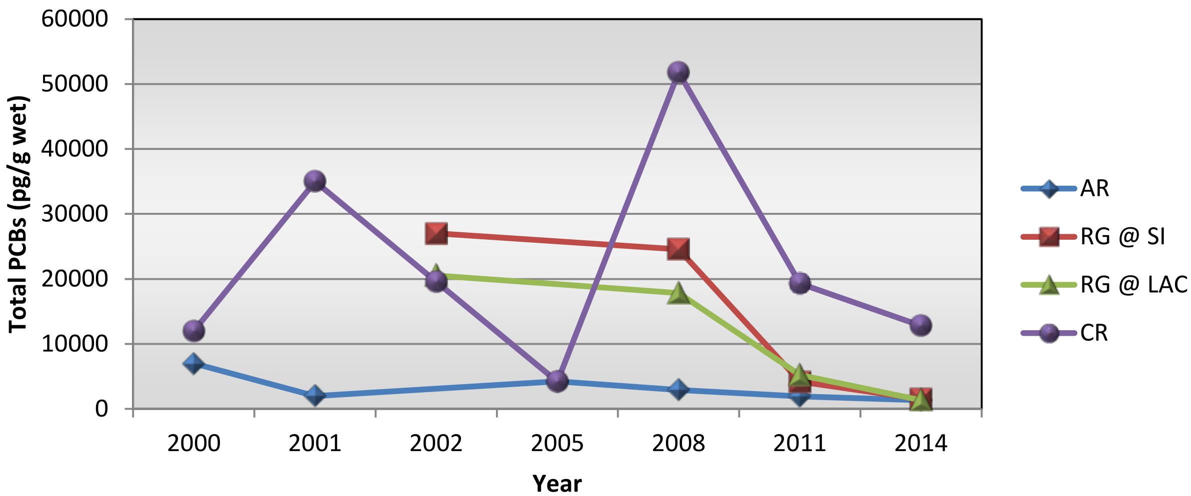

Figure 7-37 Mean total PCB concentrations in bottom-feeding fish collected upstream (AR and RG @ SI) and downstream (RG @ LAC and CR) of LANL from 2000 to 2014

2. Benthic Macroinvertebrate Monitoring of the Rio Grande

a. Monitoring Network

The purpose of the identification and classification of the benthic macroinvertebrate (BMI) community is to provide an indication of the water quality within a water system (EPA 1998). Because they are continually exposed during their life cycles to extremes in the environment, BMIs can serve as effective indicators of environmental changes and stress (Hilsenhoff 1987).

BMIs are defined as insects, oligochaetes, leeches, mollusks, and crustaceans that live on the river or lake bottom. The Laboratory samples BMIs retained by a Standard No. 35 sieve (0.50-mm opening). This year (2014), samples of BMIs and accompanying sediment were collected within two water habitats (reservoirs and river) associated with the Rio Chama/Rio Grande system upstream and downstream of LANL (Figure 7-38). The first study involved the collection of BMIs and sediment from AR (upstream) and CR (downstream), and the second study involved the collection of BMIs and sediment along the length of two reaches (upstream and downstream) relative to Los Alamos Canyon (and LANL) in the Rio Grande.

Figure 7-38 Collecting a sediment sample with a Ponar grab sampler

b. AR and CR Study

In July 2014, along the lengths of AR and CR from the mouth to the dam and representing various but similar water depths between reservoirs, five locations at each reservoir were sampled for sediment using a stainless-steel (9 × 9 in.) Ponar sampler (at AR, 20, 40, 50, 52, and 88 ft deep; at CR, 15, 40, 43, 60, and 88 ft deep)

(Figure 7-38). At each general location, six grab samples were collected. Three grab samples in a rotating manner were individually processed for BMI identification and enumeration to the lowest practical taxonomic level (15 each for AR and CR equals 30 total samples), and the other three samples were composited for the analysis of chemical/physical properties and percent survival and growth of BMI organisms (e.g., sediment toxicity bioassay) (5 each for AR and CR equals 10 total samples).

Some of the samples for chemical/physical measurements were submitted 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, uranium-238, radium-226, radium-228, 23 TAL elements, total organic carbon (TOC), and percent sand, silt, and clay. Samples for the analysis of PCB congeners were submitted to Cape Fear Analytical, LLC (Wilmington, North Carolina), and samples for the ecotoxicology bioassay were submitted to Pacific EcoRisk (Fairfield, California).

The sediment toxicity bioassay followed U.S. Environmental Protection Agency (EPA) guidelines to determine the percent survival and growth of two BMI species, *Chironomus dilutes* (larval midge) and *Hyalella azteca* (10-day-old amphipod scud), in sediment collected at AR and CR over a 10-day test period (EPA 2000). In general, each sediment sample was replicated eight times for each species. Each replicate contained 100 mL of homogenized sediment, clean overlying water, and 10 organisms and was placed in a temperature-controlled room at 23°C for 10 days. After 10 days, percent survival and growth of the two species was determined.

i. BMI Results in AR and CR Sediments

No statistical differences in populations and the number of species of BMIs were observed between AR and CR sediments (Table S7-24). Sixteen different taxa of BMIs were identified from the two reservoirs; 11 were found in CR and 9 were found in AR. Nine of the taxa were midges. Midges dominated in AR, while worms were the dominate organism in CR. Other taxa included a biting midge (Ceratopogonidae) in AR, and a roundworm (Nematoda) and fingernail clam (Sphaeriidae) in CR. Taxa listed are typical representatives of reservoir benthos (White 2014). Generally, deep water benthos are dominated by worms, and shallow water benthos are dominated by midges (McGuire 1984). However, changes in reservoir levels and the variable flow-through nature of these main stem reservoirs change sediment composition and location. These shifting conditions alter BMI densities as well as taxa composition (Kaster and Jacobi 1978, Furey et al. 2006).

ii. Chemical/Physical Properties of AR and CR Sediments

The mean concentrations of americium-241, plutonium-239/240, radium-226, uranium-234, and uranium-238 in sediment collected from CR were statistically higher than in sediment collected upstream at AR (Table S7-25). Whereas at least 50% of the actinide total is from Laboratory sources and have been reported in the past with depth (Gallaher et al. 1999), the radium-226 and uranium isotopes are from naturally occurring sources. In general, higher concentrations of americium-241 and plutonium-239/240 were detected at CR on the southern end near the dam. All radionuclides, however, are far below the lowest NE-ESLs for sediment (LANL 2014).

All 23 TAL elements, including the metals (Table S7-26) and percent sand, silt, and clay (Table S7-27) in sediments from AR and CR were statistically similar to each other. The reservoir sediments were composed mostly of clay and silt, and TOC in CR sediment was statistically higher by five times than TOC in sediment from AR. These results confirm that CR receives more organic debris than AR.

AR contained no PCBs in the five sediment samples collected, whereas CR contained very small amounts of PCBs in two of the five samples for a mean concentration of 6.2 pg/g wet (Table S7-28). The low amounts of PCBs in sediment as compared with the relatively high amounts of PCBs in bottom-feeding fish at CR may reflect, again, the changing sediment loads and composition, especially as a result of the high flooding events that took place in late 2013; this may have affected the bottom sediment composition on a short-term basis.

iii. Toxicity Bioassay (10-day) Results of AR and CR Sediment

Mean survival and growth of *Chironomus dilutes* (midge) and *Hyalella azteca* (scud) over a 10-day period in sediment collected at various depths from reservoirs upstream (AR) and downstream (CR) of LANL in 2014 can be found in Table S7-29. Percent survival and growth of the two test species in sediments collected at various depths from AR and CR over the 10-day period were statistically similar to each other.

c. Rio Grande Study

In September of 2014, the Laboratory collected 15 composite BMI and sediment samples from along two reaches—upstream (north of NM 502 to the Black Mesa area, n = 7) and downstream (south of the Los Alamos Canyon to Ancho Canyon, n = 8) relative to the location of Los Alamos Canyon (and other LANL canyon confluences) (Figure 7-23). The distances upstream from Los Alamos Canyon were 0.30, 1.0, 1.4, 1.8, 2.0, 2.4, and 4.4 river miles. The downstream distances from Los Alamos Canyon (and location of other LANL canyon/confluences) were 0.0, 0.30, 2.8, 3.2 (Sandia Canyon), 3.3, 4.2 (Mortandad Canyon), 9.0, and 9.2 (Ancho Canyon) river miles.

Figure 7-39 Collecting BMIs in the Rio Grande with a kick net

At each site, BMIs were collected using kick nets from shallow riffle locations (Figure 7-39). A composite sample consisted of six subsamples collected in a downstream direction along a 20-ft-long transect at the 0.50-ft to 0.75-ft depth. Using a Turtox® bottom kick net, 0.75 ft by 1.5 ft in size (with a 0.50-mm mesh), a subsample was collected by holding the net approximately 3.3 ft (1 m) downstream and then waddling/shuffling towards the net; BMIs were lofted into the net. The total sample area was approximately 10 ft^2 (3 m^2). Sample processing is described in Fresquez and Jacobi (2012).

A list of species and their occurrence was generated, and from this list 10 metrics/indices, including Shannon diversity and evenness (Zar 1974) and the Hilsenhoff Biotic Index (Hilsenhoff 1987), was calculated. The relationship (percent similarity) of these metrics in the downstream reach and the upstream reference site was used to calculate an overall biological condition score, which is compared with the following four designations: nonimpaired (>83% similarity), slightly impaired (54%–79%), moderately impaired (21%–49%), and severely impaired (<19%) (Fresquez and Jacobi 2012).

The sediment samples were collected near the site of the BMI collections in the active channel. Using a flat shovel, the top portion of sediment (0–2 in. depth) was collected until approximately one-half of a 5 gal. poly bucket was filled. The sediment was mixed well and then poured into the appropriate sample containers for the analysis of the same chemical/physical properties and sediment toxicity bioassays, as described in section C.2.b above.

i. BMI Results of the Rio Grande

The numbers and types of BMIs collected upstream and downstream of LANL can be found in Table S7-30, and a summary of some standard (bioassessment) metrics/indices calculated from the data can be found in Table S7-31.

There was a wide range in total numbers of BMIs collected in upstream collections (11 to 436), with an average of 195 organisms per sample. The average number of organisms per sample (302) was higher at the downstream reach, with collection numbers ranging from 192 to 524. There was no statistical difference between standing crops at the two locations.

Taxa numbers per sample ranged from 14 to 26 downstream and from 7 to 19 upstream. More total taxa were collected downstream (38) than upstream (30), but mean numbers of taxa at each location were not statistically different from one another.

The bioassessment indicated the two locations, upstream and downstream of Los Alamos Canyon, contained similar BMI communities (Table S7-31). Similarities were in the Hilsenhoff Biotic Index (intermediate tolerances for each community); number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa; EPT/EPT + Chironomidae; percent dominant taxon; and functional feeding groups. The community loss metric was low. The downstream location contained 96% of the community attributes of the upstream location, which correlated to the highest bioassessment score of nonimpaired.

When the current (September) 2014 kick-net collections were compared with past kick-net collections (2011) (Fresquez and Jacobi 2012), some differences were evident. In 2011 sampling, which was conducted less than 2 mo after severe flooding events following the Las Conchas fire, more taxa were collected upstream than downstream, 36 versus 23, while in 2014, more taxa were collected downstream than upstream, 38 versus 30. Collections in 2011 were dominated by the mayfly *Baetis tricaudatus*, which accounted for 78% and 82% of the total numbers, upstream and downstream, respectively. Diversity indices were therefore low in 2011 (1.6 and 1.2) upstream and downstream, respectively. This was because of the loss of the filterer-collector feeding group (predominantly the caddisfly *Hydropsyche occidentalis)* and the dominance of filterer-gatherers, such as *B. tricaudatus*. This loss was also evident in the high ratio of scrapers/scrapers + filterer collectors. In 2014, major shifts were evident: the dominant taxa upstream were *H. occidentalis* (27%) and *B. tricaudatus* (21%). Downstream, the dominant taxa were *B. tricaudatus* (22%), *Tricorythodes* sp. (another mayfly) (14%), and *H. occidentalis* (12%). The diversity indices were high and of similar values in 2014, upstream (3.4) and downstream (3.5) of Los Alamos Canyon. This indicated a more diverse community structure than was shown in 2011 after severe flooding events followed the Las Conchas fire.

ii. Chemical/Physical Properties of Rio Grande Sediment

All mean radionuclides (Table S7-32), TAL elements (Table S7-33), TOC, and percent sand, silt and clay (Table S7-34) concentrations in sediment collected downstream of Los Alamos Canyon were statistically similar to concentrations in sediment collected upstream of Los Alamos Canyon. There were virtually no PCBs in the active channel sediment samples collected from the Rio Grande regardless of the location (Table S7-35). In fact, only one sample from each reach contained any PCBs—the mean total concentration from the downstream reach was 1.2 pg/g wet and the mean total concentration from the upstream reach was 1.7 pg/g wet. These data support the BMI bioassessment score of nonimpaired.

iii. Toxicity Bioassay (10-day) Results of Rio Grande Sediment

Mean survival and growth of *Chironomus dilutes* (midge) and *Hyalella azteca* (scud) over a 10-day period in sediment collected from the Rio Grande upstream and downstream of LANL can be found in Table S7-36. Both mean percent survival and growth levels of the two BMI species in sediment collected from the Rio Grande were statistically similar between upstream and downstream reaches. These data support the BMI bioassessment score of nonimpaired.

D. BIOTA DOSE ASSESSMENT

a. Introduction

The purpose of the biota dose assessment is to ensure that biota populations are well protected from the effects of LANL radioactive materials, as required by DOE Order 458.1. The assessment follows the guidance of DOE-STD-1153-2011 (DOE 2002) and uses the standard DOE program, RESRAD-BIOTA, incorporating the data from Chapters 6 and 7 of the ASER.

Previous biota dose assessments have been reported in Chapter 3 of past ASERs and show that the biota doses at LANL have been consistently well below the DOE limits. During 2014, there were no events or releases with the potential to significantly increase biota doses within the LANL boundaries, so the previous assessments apply to present conditions. Nevertheless, in the following sections assessments are repeated for the on-site locations where continuing LANL operations have the greatest potential for possible increases: Area G at TA-54 and DARHT at TA-15.

In the canyons, the material contributing to biota dose is legacy waste material. Ongoing remediation and radioactive decay generally result in decreasing trends, so a decreasing trend in biota doses is expected. However, movement of legacy wastes as reported in Chapter 6 may cause an accumulation of radioactive material at some places, such as the LACW. The dose at this location is assessed in Section B.3.c.ii.

Finally, the radiological dose to fish in the Rio Grande is assessed. The new data allow calculating of the dose from natural radium and obtaining preliminary information about possible bioaccumulation.

b. Mesa Top

i. Area G

In Section B.3.a.i of this chapter, the Laboratory reported new measurements of the soil and vegetation around Area G. The concentrations are generally comparable to previous years, with the exception of location #38 to the east of Area G (Figure 7-1). At this location, the dose from soil concentration of radionuclides is increasing; however, it is <1% of the screening value for terrestrial animals and <0.2% of the screening value for plants, so there is no effect on biota.

As recommended by the DOE standard (DOE-STD-1153-2002), the largest concentration values were entered into RESRAD-BIOTA, and the results are reported in Table 7-3. At Area G, there is no surface water or obvious source of drinking water, so small animals, such as mice, get most of their water from moisture in and on plants and from the water that is produced by metabolism. This may be supplemented occasionally by small puddles after rainfall, which were calculated using the distribution coefficients, K_d, listed in Table 6.5 of the DOE standard.

For this assessment, the internal doses are calculated directly from the tissue data, so bioaccumulation factors, B_{iv}, which are described in Module 3, Section 4.1 of DOE-STD-1153-2002, are not used.

The results in Table 7-3 show that the biota doses at Area G are well below the DOE limits of 0.1 rad/d for animals, and Table 7-4 shows doses are also below the limit of 1 rad/d for plants. Overall there are no measurable impacts to biota.

Table 7-3
Dose to Terrestrial Animals at Area G for 2014, Including Internal and External Dose Contributions from Water and Soil

Dose to Terrestrial Animals at Area G for 2014					
	External		Internal		
Nuclide	Water (rad/d)	Soil (rad/d)	Water (rad/d)	Soil (rad/d)	Nuclide Total (rad/d)
Am-241	8.53E-10	8.53E-06	2.86E-07	6.62E-05	7.50E-05
H-3	6.73E-08	3.50E-04	1.33E-04	3.46E-04	8.96E-04
Pu-238	5.70E-11	2.28E-07	1.19E-07	8.31E-06	8.66E-06
Pu-239	1.28E-09	5.11E-06	4.48E-06	2.89E-04	2.99E-04
U-234	1.06E-08	1.06E-06	7.89E-06	3.01E-05	3.91E-05
U-235	2.01E-08	2.01E-06	5.03E-07	1.87E-06	4.40E-06
U-238	5.60E-07	5.60E-05	5.35E-06	2.00E-05	8.19E-05
Medium Total	**6.79E-05**	**4.23E-04**	**1.52E-04**	**7.61E-04**	**Overall Dose 1.40E-03**

Table 7-4
Dose to Terrestrial Plants at Area G for 2014,
Including External Dose Contributions from Water and Soil
and Internal Dose Calculated from Tissue Data

Dose to Terrestrial Plants at Area G for 2014				
	External		Internal	
Nuclide	Water (rad/d)	Soil (rad/d)	Tissue (rad/d)	Nuclide Total (rad/d)
Am-241	8.53E-10	8.53E-06	5.13E-06	1.37E-05
H-3	6.73E-05	3.50E-04	1.33E-04	5.50E-04
Pu-238	5.70E-11	2.28E-07	3.97E-06	4.20E-06
Pu-239	1.28E-09	5.11E-06	7.97E-05	8.48E-05
U-234	1.06E-08	1.06E-06	4.16E-05	4.26E-05
U-235	2.01E-08	2.01E-06	4.13E-06	6.16E-06
U-238	5.60E-07	5.60E-05	3.35E-05	9.00E-05
Medium Total	**6.79E-05**	**4.23E-04**	**3.01E-04**	**Overall Dose 7.92E-04**

ii. DARHT

At DARHT, soil concentrations continue to decrease as a result of improved procedures and strict containment of the radioactive material. At this location, the soil concentrations are generally lower than at Area G and are well below the screening values. Nevertheless, the largest values were entered into RESRAD-BIOTA, and the results are reported in Table 7-5.

Table 7-5
Dose to Terrestrial Animals at DARHT for 2014,
Including Internal and External Dose Contributions from Water and Soil

Dose to Terrestrial Animals at DARHT for 2014					
	External		Internal		
Nuclide	Water (rad/d)	Soil (rad/d)	Water (rad/d)	Soil (rad/d)	Nuclide Total (rad/d)
Am-241	5.29E-12	5.29E-08	1.78E-09	4.11E-07	4.65E-07
Cs-137	3.49E-08	3.49E-05	2.52E-07	2.24E-06	3.74E-05
H-3	1.19E-07	2.26E-07	2.35E-07	2.24E-07	8.04E-07
Pu-238	1.65E-12	6.59E-09	3.44E-09	2.40E-07	2.50E-07
Pu-239	2.77E-12	3.41E-08	9.72E-09	1.93E-06	1.97E-06
Sr-90	3.86E-07	4.11E-05	2.41E-05	1.64E-04	2.30E-04
U-234	1.85E-08	2.51E-06	1.38E-05	7.15E-05	8.79E-05
U-235	2.37E-08	3.47E-06	5.95E-07	3.23E-06	7.31E-06
U-238	1.59E-06	1.96E-04	1.52E-05	7.01E-05	2.83E-04
Medium Total	**2.17E-06**	**2.78E-04**	**5.41E-05**	**3.14E-04**	**Overall Dose 6.49E-04**

Similar to Area G, there is no surface water at DARHT, so water concentrations were calculated using the distribution coefficients, K_d, listed in Table 6.5 of the DOE standard. For plants, the internal doses are calculated directly from the tissue data, whereas for animals the bioaccumulation factors, B_{iv}, as described in Module 3, Section 4.1 of DOE-STD-1153-2002, were used. The doses are reported in Table 7-5 and Table 7-6.

The results show that the biota doses at DARHT are well below the DOE limits of 0.1 rad/d for animals and 1 rad/d for plants. Therefore, there are no measurable impacts to biota.

Table 7-6
Dose to Terrestrial Plants at DARHT for 2014, Including External Dose Contributions from Water and Soil and Internal Dose Calculated from Tissue Data

Dose to Terrestrial Plants at DARHT for 2014				
	External		Internal	
Nuclide	Water (rad/d)	Soil (rad/d)	Tissue (rad/d)	Nuclide Total (rad/d)
Am-241	5.29E-12	5.29E-08	5.13E-06	5.18E-06
Cs-137	3.49E-08	3.49E-05	7.80E-07	3.57E-05
H-3	1.19E-07	2.26E-07	2.15E-07	5.60E-07
Pu-238	1.65E-12	6.59E-09	1.82E-06	1.82E-06
Pu-239	2.77E-12	3.41E-08	6.42E+06	6.45E-06
Sr-90	3.86E-07	4.11E-05	8.67E-06	5.02E-05
U-234	1.85E-08	2.51E-06	4.11E-05	4.36E-05
U-235	2.37E-08	3.47E-06	4.22E-06	7.71E-06
U-238	1.59E-06	1.96E-04	3.44E-05	2.32E-04
Medium Total	**2.17E-06**	**2.78E-04**	**1.03E-04**	**Overall Dose 3.83E-04**

c. Canyons

Los Alamos Canyon Weir

The LACW receives drainage from the hillsides south of the original technical area, TA-01; from TA-02, which was the site of the early Los Alamos reactors; and from TA-21, which was the plutonium-processing site from 1945 through the 1970s. The accumulated soil trapped by the weir includes slightly elevated concentrations of cesium-137, plutonium-239, and americium-241, each about 1 pCi/g, which is far below all screening levels.

For this area, animal and plant tissue data were used instead of the bioaccumulation factors, B_{iv}. Generally, maximum values were used to calculate a reasonable upper limit for the dose. However, storm-water data are, by their nature, worst-case-event data that represent the conditions for less than 0.1% of a year, so in this case the data were averaged for the four largest storms to obtain a more reproducible result.

The total biota doses shown in Table 7-7 (animals) and Table 7-8 (plants) are less than 1% of the DOE limits and are mostly from naturally occurring material. Therefore, there are no measurable impacts to biota.

Table 7-7
Dose for 2014 to Terrestrial Animals in Los Alamos Canyon at the Weir, Including External Dose Contributions from Water and Soil and Internal Dose Calculated from Tissue Data

Dose to Terrestrial Animals in Los Alamos Canyon for 2014				
	External		Internal	
Nuclide	Water (rad/d)	Soil (rad/d)	Tissue (rad/d)	Nuclide Total (rad/d)
Am-241	1.00E-08	1.15E-06	2.28E-06	3.44E-06
Cs-137	3.78E-07	6.89E-05	1.13E-07	6.94E-05
H-3	4.41E-08	8.82E-08	7.55E-08	2.08E-07
Pu-238	7.86E-11	1.88E-08	1.70E-06	1.72E-06
Pu-239	1.03E-09	2.81E-07	6.42E-06	6.70E-06
Sr-90	3.08E-07	9.26E-06	1.43E-06	1.10E-05
U-234	4.72E-09	6.86E-07	1.26E-05	1.36E-05
U-235	7.66E-09	1.46E-06	9.18E-07	2.39E-06
U-238	2.98E-07	4.94E-05	1.30E-05	6.27E-05
Medium Total	**1.05E-06**	**1.31E-04**	**3.88E-05**	**Overall Total 1.71E-04**

Table 7-8
Dose for 2014 to Terrestrial Plants in Los Alamos Canyon at the Weir, Including External Dose Contributions from Water and Soil and Internal Dose Calculated from Tissue Data

Dose to Terrestrial Plants in Los Alamos Canyon for 2014				
	External		Internal	
Nuclide	Water (rad/d)	Soil (rad/d)	Tissue (rad/d)	Nuclide Total (rad/d)
Am-241	1.00E-08	1.15E-06	7.98E-06	9.14E-06
Cs-137	3.78E-07	6.89E-05	3.73E-07	6.97E-05
H-3	4.41E-08	8.82E-08	1.07E-07	2.40E-07
Pu-238	7.86E-11	1.88E-08	5.67E-07	5.86E-07
Pu-239	1.03E-09	2.81E-07	9.63E-06	9.91E-06
Sr-90	3.08E-07	9.26E-06	8.09E-07	1.04E-05
U-234	4.72E-09	6.86E-07	1.68E-05	1.75E-05
U-235	7.66E-09	1.46E-06	4.59E-07	1.93E-06
U-238	2.98E-07	4.94E-05	1.34E-05	6.31E-05
Medium Total	**1.05E-06**	**1.31E-04**	**5.02E-05**	**Overall Total 1.83E-04**

d. Rio Grande

In Section C.1.b., measurements of fish in the Rio Chama and the Rio Grande both upstream and downstream of Los Alamos Canyon are reported. For the dose assessment, only the fish downstream of Los Alamos Canyon and in CR were considered because they are more likely to show the influence of materials from LANL.

Tissue data, rather than B_{iv}, and K_d, were used to calculate the water concentration from the sediment data. As discussed in DOE-STD-1153-2002, most of the dose comes directly from the sediment, and the water contributes less than 1% of the dose.

Most of the dose is from natural radium and its decay products, such as polonium and bismuth. Materials from LANL contribute less than 0.2% of the dose.

The radium data show that the bioaccumulation factor is less than 1.0. Radium is chemically similar to calcium, and fish take up radium when they cannot get enough calcium (Eisenbud and Gesell 1997). However, calcium is abundant in the Rio Grande, so this relatively small bioaccumulation factor is reasonable.

The total dose is approximately 0.1% of the DOE limit, so there are no measurable impacts of radioactive material to the fish (Table 7-9).

Table 7-9
Dose to Terrestrial Animals in the Rio Grande for 2014, Including External Dose Contributions from Water and Sediment and Internal Dose Calculated from Tissue Data

Dose to Aquatic Animals in Rio Grande for 2014				
	External		Internal	
Nuclide	Water (rad/d)	Sediment (rad/d)	Tissue (rad/d)	Nuclide Total (rad/d)
Am-241	3.82E-12	1.91E-08	5.70E-08	7.61E-08
Cs-137	1.42E-08	7.10E-06	1.43E-07	7.25E-06
H-3	3.82E-08	3.82E-08	7.55E-08	1.52E-07
Pu-238	5.58E-13	1.12E-09	8.51E-07	8.52E-07
Pu-239	5.04E-12	1.01E-08	1.23E-06	1.24E-06
Ra-226	1.72E-06	1.21E-04	4.13E-04	5.36E-04
Ra-228	6.50E-07	4.55E-05	5.09E-04	5.55E-04
Sr-90	1.06E-07	3.18E-06	5.32E-07	3.82E-06
U-234	9.90E-09	4.95E-07	3.81E-05	3.86E-05
U-235	1.33E-08	6.66E-07	1.10E-06	1.78E-06
U-238	6.99E-07	3.50E-05	2.19E-05	5.76E-05
Medium Total	**3.25E-06**	**2.13E-04**	**9.86E-04**	**Overall Dose 1.20E-03**

e. Conclusion

Previous biota dose assessments have shown that the doses are far below the DOE limits, and the 2014 data indicate similar results and do not indicate the need for more detailed analysis. It is concluded that there are no measurable effects from radioactivity on the Pajarito Plateau biota populations.

E. SPECIAL STUDIES AND FUTURE DIRECTIONS

1. Avian Nest-Box Monitoring

In 1997, an avian nest-box monitoring program was established within LANL and the surrounding area. One goal of this monitoring network is to collect data that can be used to evaluate population health of avian species utilizing these boxes. Today, this network consists of over 600 nest boxes that have been distributed over areas that are either affected by historical releases of wastes from LANL operations or are unimpacted. These nest boxes provide nesting sites to several secondary-cavity nesting species and most commonly, to the Western Bluebird (*Sialia mexicana*). Over the years, nonviable eggs have been collected, and many of these have been evaluated for a number of constituents, including metals, radionuclides, PCBs, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, and other chemicals. These data will be analyzed to determine if LANL has had an impact on concentrations of the constituents listed above in Western Bluebird eggs. Additionally, these data are an important parameter to consider and will be integrated into the ecosystem health assessments.

2. LANL Forest Management Plan and 2015 Vegetation Cover Type Map

Between 1996 and 2014, the Los Alamos region experienced four major wildfires, losses of up to 90% of piñon trees because of drought and a bark beetle outbreak, and a higher-than-normal ongoing rate of tree mortality for all species of trees (Breshears et al. 2005, Goeking et al. 2014). LANL operations must take into account changing environmental influences. These types of weather-related events and their consequences, including wildfire, flash flooding, and soil erosion, present challenges for maintenance of Laboratory infrastructure, mission activities, environmental compliance, and management of wastes and legacy releases.

Current climate modeling indicates that northern New Mexico is on a trajectory of continually increasing temperatures, with no concurrent long-term increase in precipitation (Garfin et al. 2013, Llewellyn and Vaddey 2013). LANL and other researchers predict that many native conifer trees in the Southwest will be dead by 2050 (Williams et al. 2010, Jiang et al. 2013, Williams et al. 2013). Projected climate changes and mortality of trees will lead to increased loss of forest cover, continued high risks of severe wildfire, and higher soil erosion rates in the LANL region.

In 2014, LANL published a forest management plan (Hansen et al. 2014). The purpose of the forest management plan is to manage the landscape at LANL to reduce impacts to Laboratory operations from these climate-driven events. The plan presents forest health prescriptions to meet the following objectives:

- Minimize soil erosion
- Maintain piñon-juniper, ponderosa pine, and mixed conifer woodland and forest types in a healthy condition for as long as possible
- Support wildfire fuel mitigation efforts

These forest health prescriptions support LANL's framework for long-term forest management and overall goals of protecting LANL facilities and assets, minimizing off-site sediment transport and achieving water-quality compliance goals, protecting existing plant communities and soils, and minimizing negative impacts of future transitions to new plant communities.

As part of forest management plan implementation, during 2015 LANL is working on updating its vegetation cover type map (last produced in 2003). This updated map will be derived from August 2014 WorldView 2 satellite imagery and extensive ground-truthing data. The updated vegetation cover type map may be used for the following applications at LANL:

- Accurate wildfire model simulations and risk assessment, including decision-making during a wildfire event
- Measuring and modeling climate change impacts on LANL, including changes in wildfire risk
- Planning forest and fuels management actions
- Flood risk modeling
- Carbon storage estimation
- Benchmarking of dynamic vegetation models
- Benchmarking of surface and subsurface water-cycle models
- Defining changes in endangered species habitat boundaries
- Meteorological modeling of plume dispersion behavior
- Dose assessment modeling of wind dispersion of aerially transported chemicals or radionuclides
- Environmental impact evaluation of projects for planning and National Environmental Policy Act assessment

Periodic updating of LANL's vegetation cover type map will allow analysis of changes in all of these applications over time as the vegetation responds to climate change effects.

3. Watershed Analyses

Laboratory personnel are working to finalize a new vegetation cover type map (see above) that will characterize the spatial distribution of vegetation and other forms of land cover. The Laboratory also has new high-resolution light detection and ranging data for the site. One potential application of these data would be watershed-scale modeling and assessment of the current soil erosion, sediment transport, and hydrologic parameters (e.g., timing, magnitude, and duration of flow). A number of models exist that could be used for this purpose. The Soil and Water Assessment Tool (SWAT) was developed and is supported by the U.S. Department of Agriculture–Agricultural Research Service (USDA-ARS). The SWAT is described as a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. The Automated Geospatial Watershed Assessment (AGWA) tool is a geographic information systems interface jointly developed by the EPA, the USDA-ARS, and the University of Arizona that could also be used to conduct hydrologic modeling and watershed assessments at multiple temporal and spatial scales. The Revised Universal Soil Loss Equation, Version 2 (RUSLE2) and its precursors were developed by the USDA Natural Resources Conservation Service and can be used for soil and water conservation management, point-source and non-point-source pollutant management, sediment load assessment, and sediment control design.

These tools could also be applied to the 2003 land cover map information with assumptions of predevelopment conditions. This would provide a time series analysis that would permit an evaluation of changes in watershed condition and a baseline to evaluate against in the future. The Laboratory proposes, at least initially, to focus this analysis on Sandia Canyon and incorporate additional watersheds as funding and interest dictate.

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)
- 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)

Also, procedures and protocols for biota dose can be found in the "Quality Assurance Project Plan for the Biota Dose Assessment," QAPP-05, Revision 0, 2009.

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, samples are hand-delivered to the Laboratory's SMO, which ships the samples via express mail directly to an external analytical laboratory under full chain-of-custody control. The project leader of the SMO 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 2014 was 100%.

3. Analytical Laboratory Quality Assessment

There were no analytical laboratory data quality issues related to the SFB sampling program during 2014. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 1, Section 6. Analytical data completeness for soil sampling programs was 100% in 2014.

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To Read About **Turn to Page**

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, and foodstuffs to answer the question, "What is the potential dose and risk to various populations from the Laboratory's operations?" These assessments show that during 2014 all doses to the public were far below all regulatory limits and guidance and that members of the public are well protected.

A. INTRODUCTION

In this chapter, dose and risk are assessed to ensure all members of the public are protected and to demonstrate compliance with U.S. Department of Energy (DOE) Order 458.1.

In all cases, the 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 to the public.

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, 2015; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). The estimated risk of contracting cancer is 8×10^{-7} per millirem (mrem) received (DOE 2003, BEIR 2006).

This chapter assesses dose to the public. Dose to biota is assessed in Chapter 7.

DOE regulations 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 (DOE 1999) or from storage of waste. The annual dose received by the public from airborne emissions of radionuclides is limited to 10 mrem by the U.S. Environmental Protection Agency's (EPA's) "National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities" (Rad-NESHAP) (40 Code of Federal Regulations [CFR] 61, Subpart H). Annual doses from community drinking water supplies are limited by the Clean Water Act to 4 mrem (40 CFR 141, 142).

To place these limits in context, the dose from natural background and medical/dental procedures is about 800 mrem per year (mrem/yr) (Section B.3). Doses from Laboratory operations are below the regulatory limits and are generally less than 1 mrem/yr. Doses from a single pathway are sometimes less than 0.1 mrem/yr, which is too small to measure (Section B.4).

2. Exposure Pathways

Potential doses to the public are determined by evaluating all exposure pathways from present or past LANL operations. Doses are evaluated for three principal exposure pathways: (a) direct photon or neutron radiation, (b) inhalation, and (c) ingestion of water or foodstuffs.

a. Direct Radiation

The Laboratory monitors direct external radiation from gamma photons and neutrons at 84 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 within 400 m of Technical Area 53 (TA-53) and TA-54 as reported in Chapter 4, Section C.3.

b. Inhalation

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, the Laboratory uses 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, doses are calculated 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 TA-53 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.

The air-pathway dose assessment is described in detail in the annual Rad-NESHAP report (Fuehne 2015), in Chapter 4, and in Section 4 below.

c. Ingestion

Ingestion includes drinking water and eating plants and animals. Measurements of water are reported in Chapters 5 and 6, and measurements from plants and animals are reported in Chapter 7.

Local drinking water contains small amounts of naturally occurring uranium but no measurable material 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” (Los Alamos County 2015).

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. 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. The soil and food are measured every 3 yr, and no measurable radionuclides from LANL have been detected. Also, road-killed deer and elk are measured when they become available, and no measurable radionuclides from LANL have been detected.

The conclusion is that the ingestion dose is too small to measure and is essentially zero.

3. Dose from Naturally Occurring Radiation

Near Los Alamos, the annual dose from naturally occurring sources includes cosmic rays, terrestrial radiation, radon, and internal materials such as potassium-40 (Figure 8-1). 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.

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, Gillis et al. 2014). 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 about 300 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 such as potassium-40, which is present in all food and living cells.

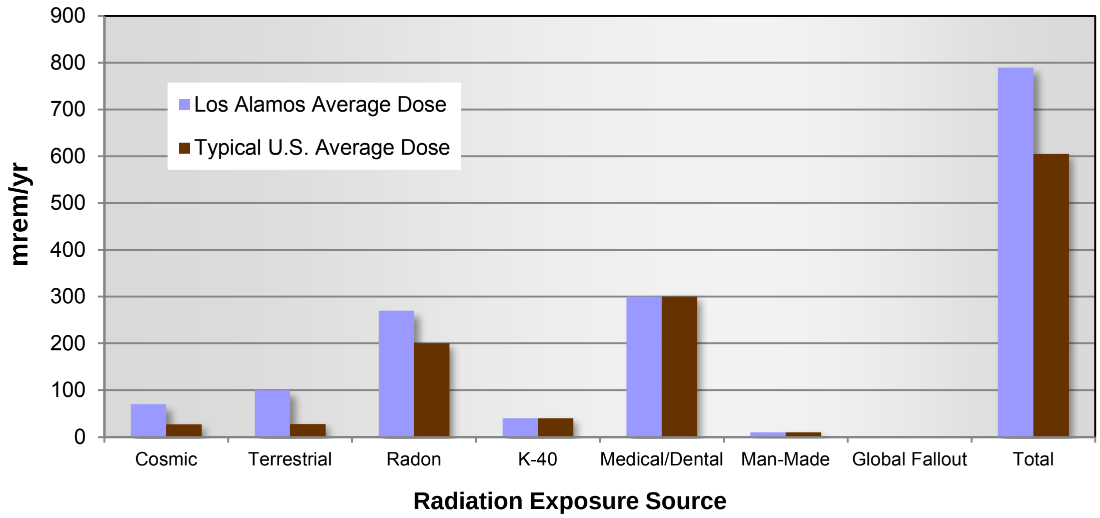

Figure 8-1 Average Los Alamos County radiation background dose compared with average U.S. radiation background dose

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 about 800 mrem for a typical Los Alamos resident. Figure 8-1 compares the average radiation background in Los Alamos with the average background dose in the United States.

4. Dose Calculations and Results

The objective of this section is to calculate doses to the public from Laboratory operations. Therefore, contributions from naturally occurring radioactive material, from global fallout, from consumer products, or from medical sources are not included.

Doses from the Laboratory to the following members of the public are calculated:

a. The total population within 80 km (50 mi) of the Laboratory

b. The maximally exposed individual (MEI)

For the MEI, the following cases are considered:

i. The air-pathway MEI, as required by the Clean Air Act (40 CFR 61, Subpart H)

ii. The on-site MEI, as required by DOE Order 458.1

iii Other locations with measurable dose

iv The off-site MEI, also required by DOE Order 458.1

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. The collective dose was calculated 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 2014 collective population dose to persons living within 80 km of the Laboratory is 0.284 person-rem (Fuehne 2015). Averaged over the 343,000 people who live within 80 km (McNaughton 2012), the dose is less than 0.001 mrem per person, which is much less than the background doses shown in Figure 8-1. Tritium contributed almost 80% of the dose, and short-lived activation products, such as carbon-11 from the Los Alamos Neutron Science Center (LANSCE), contributed almost 20% of the dose. Americium, plutonium, and uranium contributed much less than 1%. Collective population doses for recent years are shown in Figure 8-2. The downward trend is the result of improved engineering controls at LANSCE and the tritium facilities.

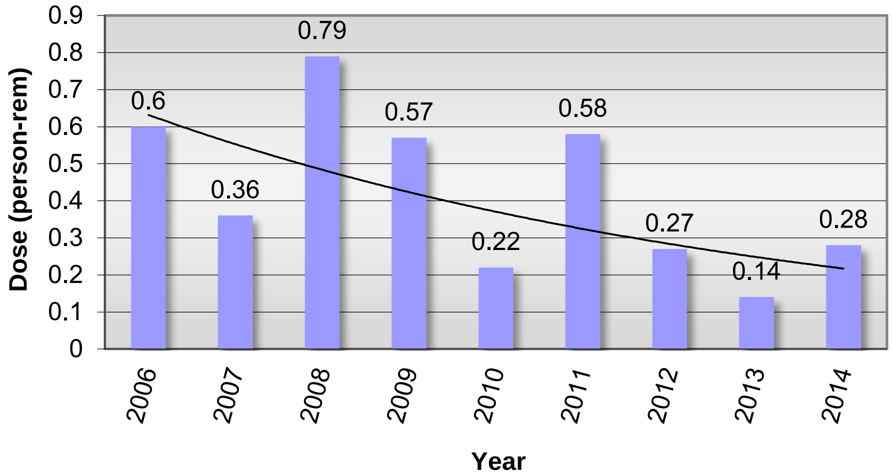

Figure 8-2 **Annual collective dose (person-rem) to the population within 80 km of the Laboratory**

b. Dose to the MEI

The MEI is a hypothetical member of the public who receives the greatest dose from Laboratory operations (40 CFR 61, Subpart H). To determine the MEI, all exposure pathways that could cause a dose and all publicly accessible locations are considered, both on-site and off-site.

First the air pathway is considered, which is described in Chapter 4 and in the annual Rad-NESHAP report (Fuehne 2015). Then the doses from all other exposure pathways are added.

Next, the direct-radiation pathway is considered. As reported in Chapter 4, Section C, the only locations where external radiation from the Laboratory can be distinguished from natural background are near TA-53 and TA-54, so Jemez Road and Cañada del Buey are considered. At these locations, the external dose is measured or calculated, then doses from the other pathways are added.

Finally, the total doses at these locations are compared to determine the on-site and off-site MEI doses.

i. Air-Pathway MEI

The air-pathway dose calculations are described in the annual Rad-NESHAP report (Fuehne 2015). For 2014, the location was the residence or place of business closest to TA-53. For most of the past 20 yr, this location has been called East Gate, but following new developments, the MEI location is at 95 Entrada Drive, close to AIRNET station #311 (Chapter 4, Figure 4-1), and the total dose was 0.24 mrem (Fuehne 2015).

Contributions to this dose were from short-lived activation products from the LANSCE stacks (0.01 mrem), diffuse emissions of short-lived activation products from LANSCE (0.09 mrem), AIRNET measurements (0.02 mrem), and the potential dose contribution from unmonitored stacks (0.12 mrem). Doses from ingestion and direct radiation were much less than 0.01 mrem.

MEI doses for recent years are shown in Figure 8-3. The downward trend is the result of improved engineering controls at the LANSCE accelerator.

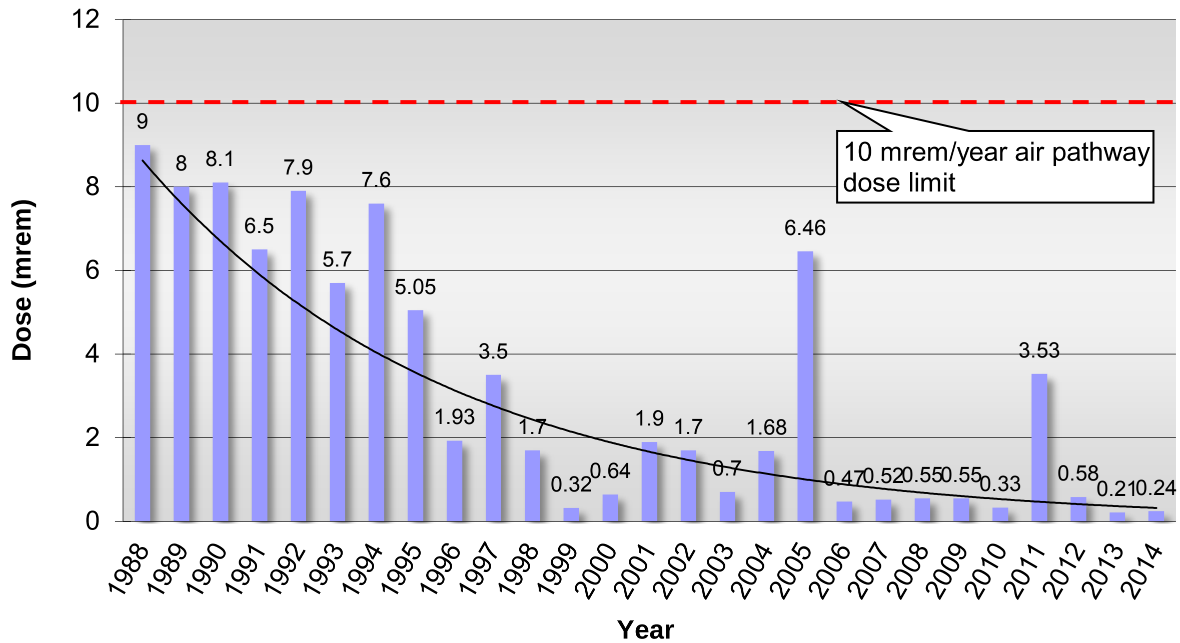

Figure 8-3 Annual MEI dose. The 3.53-mrem dose in 2011 resulted from the remediation of MDA B and was described in the 2011 annual site environmental report (ASER). The 6.46-mrem dose in 2005 resulted from a leak at TA-53 and was discussed in the 2005 ASER.

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 2014 the neutron dose was 0.3 mrem, and the gamma dose was 0.3 mrem, for a total of 0.6 mrem. The dose from stack emissions was much 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. Other Locations with Measurable Dose

As reported in Chapter 4, Section C.3, the neutron dose was measured in Cañada del Buey, 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 in Cañada del Buey was 1.4 mrem. After applying the standard factor of 1/16 for occasional occupancy (NCRP 1976), the individual neutron dose was 1.4/16 = 0.09 mrem.

The dose from Laboratory stack emissions was 0.01 mrem/16 ≈ 0.001 mrem. At Area G, the average plutonium-239 concentration was 509 attocuries per cubic meter (aCi/m^3) (Chapter 4, Table 4-4), and the concentrations of plutonium-238 and americium-241 were much less. Using the dose conversion factors from DOE Standard 1196, and assuming 1/16 occupancy, the annual dose was ≈0.01 mrem. The dose in Cañada del Buey is much less than at Area G. Thus, the total MEI dose at this location was ≈ 0.1 mrem, which is less than the 0.24-mrem air-pathway MEI dose.

iv. MEI Summary

At the air-pathway MEI location, the direct-radiation and ingestion doses are essentially zero (Section B.2), so the largest all-pathway dose for 2014 was the same as the air-pathway dose, 0.24 mrem.

The largest MEI dose of 0.24 mrem in 2014 is far below the 10-mrem Rad-NESHAP limit (40 CFR 61, Subpart H) and the 100-mrem DOE limit (DOE 1999). The MEI dose is less than 0.1% of the average U.S. background radiation dose shown in Figure 8-1.

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 either from present Laboratory operations or from releases of legacy contamination are much smaller (Table 8-1) 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 8-1
LANL Radiological Doses for Calendar Year 2014

Pathway	Dose to MEI (mrem/yr)	Percentage of DOE 100-mrem/yr Limit	Estimated Population Dose (person-rem)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	0.24	0.24%	0.28	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	0.24	0.24%	0.28	~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. NONRADIOLOGICAL RISK ASSESSMENT FOR THE PUBLIC

1. Overview

This section assesses the potential human health risk from nonradiological materials released from the Laboratory. The Clean Air Act regulates nonradiological air pollutants, as discussed in Chapter 2, Section B.4. The applicable standards for water are summarized in Table 5-1 (Chapter 5), Table 6-1 (Chapter 6), and Appendix A. Air emissions data are reported in Chapter 2, and water data are reported in Chapters 5 and 6.

2. Results

a. General Considerations

Off-site concentrations of nonradiological contaminants 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. The permits issued by the New Mexico Environment Department (NMED) are effective in controlling emissions of potentially hazardous air pollutants from the Laboratory, and the data reported in Chapter 2 show that the actual emissions are below the permitted amounts. As a result, there are no measurable health effects to the public from Laboratory emissions.

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 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, hexavalent chromium has been detected 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 concentrations from Laboratory operations were detected off-site. Furthermore, the sediment data show that previous assessments represent an upper bound of potential risks. The conclusion is that there is no current risk to the public from surface water and sediment exposure because of either current or legacy Laboratory releases.

vi. Foodstuffs Sampling

Foodstuffs are sampled regularly and reported in the ASER. No contamination from LANL has been detected in foodstuffs grown on public land. Road-kill such as elk and deer are tested whenever they are found near Los Alamos. In the last 10 yr, no contamination from LANL has been found in elk, deer, or other animals normally hunted or eaten.

During 2014, fish were sampled from Cochiti Lake, the Rio Grande, and Abiquiu Lake (Chapter 7). The data were similar to past results (Fresquez 2012). The concentrations of key elements were statistically similar upstream of LANL compared with downstream, indicating sources other than LANL.

Mercury is a particular concern. Currently, there are fish consumption advisories for many New Mexico lakes and rivers (https://www.env.nm.gov/swqb/advisories/FishConsumptionAdvisories-2012.pdf). The main sources are naturally occurring compounds in the earth's crust and coal-burning power plants (http://www.epa.gov/mercury/about.htm). In predator fish, concentrations of mercury exceeded the EPA screening level of 0.3 milligrams per kilogram (mg/kg) in both Abiquiu and Cochiti reservoirs (Chapter 7, Figures 7-30 through 7-32) with the highest concentration, 0.9 mg/kg, in a walleye at Abiquiu reservoir. Generally, the concentrations are statistically similar upstream and downstream of LANL, indicating that any possible LANL contributions are small.

As discussed in Chapter 7, polychlorinated biphenyls (PCBs) continue to enter the environment as a result of leaks from electrical equipment, runoff from urban areas, and atmospheric deposition. PCBs accumulate in sediment and are absorbed and retained by fish. In general, total PCBs in fish are similar to past surveys, though there is a downward trend since 2008 (Chapter 7, Figure 7-37). In the Rio Grande between Santa Clara Canyon and Frijoles Canyon, the mean concentrations of PCBs upstream of LANL were statistically similar to those downstream, indicating that LANL is not a major source. In Cochiti Lake, the concentrations are higher than in Abiquiu reservoir, though they are decreasing with time. This indicates that sources of PCBs in the watershed are decreasing as a result of remediation and improved controls.

In summary, cleanup and improved controls have been effective, and currently LANL is not a major source of PCB or mercury contamination.

3. Conclusion

The environmental data collected in 2014 show that at present there is no measurable harm to the public from materials released from the Laboratory.

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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, concentrations of radioactive and chemical constituents in air and water samples are compared 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, Environment, 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. 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).

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).

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.

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. 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 and New Mexico Drinking Water Regulations, Sections 206 and 207. 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.

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.

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. DCGs apply to concentrations in excess of those occurring naturally or from worldwide fallout.

[b] pCi/L = Picocuries per liter.

[c] Drinking water DCGs are 4% of the DCGs for nondrinking water.

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, available at 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 2014a); screening levels for nonradionuclides are found in an NMED document (NMED 2009). 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. 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 2014b).

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).

REFERENCES

DOE 1999: "The Long-Term Control of Property: Overview of Requirements in Orders DOE 5400.1 & 5400.5," U.S. Department of Energy Brief EH-412-0014/1099 (October 1999) http://www.hss.energy.gov/sesa/environment/guidance/aea/doe5415b.pdf

DOE 2002: "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," U.S. Department of Energy Standard DOE-STD-1153-2002 (July 2002).

EPA 2001: "Water Quality Criterion for the Protection of Human Health: Methylmercury," U.S. Environmental Protection Agency, Office of Science and Technology, EPA-823-R-01-001 (2001).

EPA 2007: "Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition, Risk Based Consumption Limit Tables," U.S. Environmental Protection Agency, available at http://www.epa.gov/waterscience/fishadvice/volume2/v2ch4.pdf (2007)

FDA 2000: "Action Levels for Poisonous or Deleterious Substance in Human Food and Animal Feed," Food and Drug Administration, Washington, DC (2000).

LANL 2014a: "Derivation and Use of Radionuclide Screening Actions Levels, Revision 3" Los Alamos National Laboratory document LA-UR-14-29225 (December 2014).

LANL 2014b: "ECORISK Database," Release 3.2, on CD, Los Alamos National Laboratory number LA-UR-14-28010 (October 2014).

NMED 2009: "Technical Background Document for Development of Soil Screening Levels, Revision 5.0," New Mexico Environment Department report (December 2009).

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-1
Approximate Conversion Factors for Selected U.S. Customary Units

Multiply U.S. Customary Unit	by	to Obtain SI (Metric) Unit
degrees Fahrenheit (°F)	5/9 - 32	degrees Celsius (°C)
inches (in.)	2.54	centimeters (cm)
cubic feet (ft^3)	0.028	cubic meters (m^3)
acres	0.4047	hectares (ha)
ounces (oz)	28.3	grams (g)
pounds (lb)	0.453	kilograms (kg)
miles (mi)	1.61	kilometers (km)
gallons (gal.)	3.785	liters (L)
feet (ft)	0.305	meters (m)
parts per million (ppm)	1	micrograms per gram (µg/g)
parts per million (ppm)	1	milligrams per liter (mg/L)
square miles (mi^2)	2.59	square kilometers (km^2)
picocuries (pCi)	37	millibecquerel (mBq)
rad	0.01	gray (Gy)
millirem (mrem)	0.01	millisievert (mSv)

Table B-2 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^3, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the **right** of its present location. The number would then read 2000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the **left** of its present location. The result would be 0.00002.

Table B-3 presents abbreviations for common measurements.

DATA HANDLING OF RADIOCHEMICAL SAMPLES

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

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 $100 \times 0.12 =$ 12 mrem.
Maximum individual dose	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Los Alamos National Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.
population dose	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1000 people each received a radiation dose of 1 rem, their population dose would be 1000 person-rem.)
whole body dose	A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).
effluent	A liquid waste discharged to the environment.
EIS	Environmental impact statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
emission	A gaseous waste discharged to the environment.
environmental compliance	The documentation that Los Alamos National Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of Los Alamos National Laboratory's environmental monitoring and surveillance programs.
environmental monitoring	The sampling of contaminants in liquid effluents and gaseous emissions from Los Alamos National Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.

environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.
EPA	U.S. Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (1/2 × 1/2), after three half-lives, one-eighth remains (1/2 × 1/2 × 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.

3s	three sigma (three standard deviations)
ac/ft	acre feet
aCi/m^3	attocuries per cubic meter
ADEP	Associate Directorate for Environment Programs
ADESH	Associate Directorate for Environment, Safety, and Health
AIRNET	ambient air monitoring network
AFV	alternative-fuel vehicle
AGWA	Automated Geospatial Watershed Assessment
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
AOC	area of concern
AQA	Analytical Quality Associates, Inc.
AR	Abiquiu Reservoir (sampling location name)
ARSL	American Radiation Services, Inc.
ASER	annual site environmental report
AST	aboveground storage tank
BCG	biota concentration guide
BDD	Buckman Direct Diversion (Project)
BDSL	biota dose screening level
BEIR	Biological Effects of Ionizing Radiation
bgs	below ground surface
BMI	benthic macroinvertebrate
BMP	best management practice
BRMP	Biological Resources Management Plan
BSRL	baseline statistical reference level
BV	background value
C&D	construction and demolition
CA	composite analysis
CAA	Clean Air Act
CAP88	Clean Air Act Assessment Package-1988
CCF	Central Computing Facility
CD	Critical Decision

CEI	compliance evaluation inspection
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
Ci	curies
CME	corrective measures evaluation
CMI	corrective measures implementation
CMR	Chemistry and Metallurgy Research (facility)
CMRR	Chemistry and Metallurgy Research Replacement (facility)
CO	carbon monoxide
CO_2	carbon dioxide
COD	chemical oxygen demand
Consent Order	Compliance Order on Consent
COPC	chemical of potential concern
CR	Cochiti Reservoir (sampling location name)
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DARHT	Dual-Axis Radiographic Hydrodynamic Test (facility)
DCG	derived concentration guide
DCS	derived concentration technical standard
decaCB	decachlorobiphenyl
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DPRNET	Direct Penetrating Radiation Monitoring Network
EDD	electronic data deliverable
EIM	Environmental Information Management
EIS	Environmental Impact Statement
EISA	Energy Independence and Security Act of 2007
EMS	Environmental Management System
ENV-CP	Environmental Protection Division–Environmental Compliance Programs Group

EO	Executive Order
EOC	Extent of Condition
EP	Environmental Programs (Directorate)
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPICS	experimental physics and industrial control system
ESL	ecological screening level
fCi/m^3	femto-curies per cubic meter
FCRS	Flood Control Retention Structure
Fg Pt	firing point (sampling location name)
FOD	Facility Operations Director
FR	Federal Register
FY	fiscal year
GCS	grade-control structure
GEL	General Environmental Laboratory
GHG	greenhouse gas
GMAP	gaseous mixed activation products
GP	guiding principle
HAP	hazardous air pollutant
HAZMAT	hazardous materials
HE	high explosives
HEP	High Explosives Processing
HET	High Explosives Testing
HEWTF	High Explosives Wastewater Treatment Facility
HH-OO	human health-organism only
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
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
IFGMP	Interim Facility-Wide Groundwater Monitoring Plan
ILA	industrial, landscaping, and agricultural
IP	Individual Permit
IR	investigation report
ISO	International Organization for Standardization
kg/yr	kilograms per year
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)
LCC	lists of compliance concerns
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
LCS	laboratory control sample
LC&T	Land Conveyance and Transfer (Project)
LDCC	Laboratory Data Communications Center
LDV	light-duty vehicle
LE-ESL	low effect ecological screening level
LEED	Leadership in Energy and Environmental Design
LLW	low-level waste
LOAEL	lowest observable adverse effect level
MAP	mitigation action plan
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
mg $CaCO_3$/L	milligrams calcium carbonate per liter

mg/kg	milligrams per kilogram
mGy/day	milligray per day
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
MLLW	mixed low-level waste
monoCB	monochlorobiphenyl
µR/h	microroentgen/hour
mrem	millirem
MRF	Material Recycling Facility
MS	matrix spike
MSGP	Multi-Sector General Permit
MSL	Materials Science Laboratory
MTAL	maximum target action level
MTRU	mixed transuranic
MWh	megawatt hour
MY	monitoring year
N_20	nitrous oxide
n/a	not applicable
NCOM	North Community
NCRP	National Council on Radiation Protection
ND	nondetect
NE-ESL	no effect ecological screening level
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
NM	New Mexico
NMAC	New Mexico Administrative Code
NME	New Mexico Endangered
NMED	New Mexico Environment Department
NMED-GWQB	New Mexico Environment Department - Ground Water Quality Bureau
NMED-HWB	New Mexico Environment Department - Hazardous Waste Bureau
NMED-PTSB	New Mexico Environment Department - Petroleum Storage Tank 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
NPR	No Permit Required
NRC	Nuclear Regulatory Commission
NRDA	Natural Resource Damage Assessment
NSSB	National Security Sciences Building
NTU	nephelometric turbidity units
NWP	nationwide permit
ODS	ozone-depleting substances
ORP	oxidation-reduction potential
OSRP	Off-Site Source Recovery Project
P	perimeter (sampling location name)
P2	Pollution Prevention (Program)
PA	performance assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCFRS	Pajarito Canyon Flood Retention Structure
pCi/L	picocuries per liter
pCi/m^3	picocuries per cubic meter
pg/g	pictograms per gram
PM	particulate matter
ppm	parts per million
ppb	parts per billion
PQL	practical quantitation limit
PUE	power utilization effectiveness

P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
R&D	research and development
rad/d	rad per day
Rad-NESHAP	National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other than Radon
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RESRAD	residual radioactivity (computer model)
RLUOB	Radiological Laboratory/Utility/Office Building
RLWTF	Radioactive Liquid Waste Treatment Facility
ROD	Record of Decision
RP	Radiation Protection (Division)
RSL	residential screening level
RSRL	regional statistical reference level
RUSLE2	Revised Universal Soil Loss Equation, Version 2
RWMB	radioactive waste management basis
SA	Supplement Analysis
SAL	screening action level
SCC	Strategic Computing Complex
SDPPP	Site Discharge Pollution Prevention Plan
SDWA	Safe Drinking Water Act
SERF	Sanitary Effluent Reclamation Facility
SFB	soil, foodstuffs, and biota
SI	Pueble de San Ildefonso (sampling location name)
SI	International System of Units
SL	screening level
SMA	site monitoring area
SMO	Sample Management Office
SOP	standard operating procedure

SOW	statement of work
SPCC	spill prevention, control, and countermeasure
SR	screening ratio
SSC	suspended sediment concentration
SSL	soil screening level
SSP	site sustainability plan
SSPP	Strategic Sustainability Performance Plan
STO	Science and Technology Operations
STP	site treatment plan
SV	screening value
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWAT	Soil and Water Assessment Tool
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 System (Plant)
TA	technical area
TAL	target action level (under the Individual Permit)
TAL	target analyte list
TATB	triaminotrinitrobenzene
TCDD	tetrachlorodibenzodioxin
TCDF	tetrachlorodibenzofuran
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TRU	transuranic
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, or disposal facility
TSS	total suspended solids

UI	Utilities and Infrastructure Facilities
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA-ARS	U.S. Department of Agriculture–Agricultural Research Service
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
WWTF	Waste Water Treatment Facility
WWTP	wastewater treatment plant

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

Cavates in Mortandad Canyon

Back cover: Photo by Aysha McClory, 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
- Environmental Remediation Program

Previous reports in this series are LA-UR-14-27564, LA-UR-13-27065, LA-14427-ENV, LA-13775-ENV, LA-13861-ENV, LA-13979-ENV, LA-14085-ENV, LA-14162-ENV, LA-14239-ENV, LA-14304-ENV, LA-14341-ENV, LA-14369-ENV, LA-14407-ENV, LA-14427-ENV, LA-14445-ENV, and LA-14461-ENV.

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