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Los Alamos National Laboratory

Annual Site
ENVIRONMENTAL REPORT

Published 2017 featuring data from 2016

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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.

Soil sampling at Los Alamos National Laboratory

Bird banding at Los Alamos National Laboratory

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Small mammal studies at Los Alamos National Laboratory

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Environmental Protection and Compliance Division
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Environmental Compliance Programs Group
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Waste Management Programs Group
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Waste Management Services Group
505-667-2001

Associate Directorate for Environmental Management
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Environmental Remediation Program
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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, Administrative Change 1, Environment, Safety, and Health Reporting, and Order 458.1, Administrative Change 3, Radiation Protection of the Public and the Environment.

The following chapters in this report discuss our success in complying with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climate conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Monitoring); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, soil, and vegetation (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

This report follows plain language guidelines, as required for federal agencies by the Plain Language Act of 2010. More information about plain language can be found at http://www.plainlanguage.gov/index.cfm. You will notice we have substantially reduced the use of acronyms and abbreviations and are using active voice and personal pronouns.

We hope you find this report useful. If you have suggestions for improving this report, additional questions, or want a copy of this report, please contact us at envoutreach@lanl.gov, or call Environmental Communication and Public Involvement at 505-667-0216.

This report, its supplemental tables, and the 2016 Annual Site Environmental Report Summary are available at http://www.lanl.gov/environment/environmental-report.php.

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Elizabeth Ruedig
Jeff Whicker

Los Alamos National Laboratory (the Laboratory) is located in Los Alamos County in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. The mission of the Laboratory is to solve national security challenges through scientific excellence. Inseparable from our focus on excellence in science and technology is our 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:

Sandia Canyon at the Laboratory

- characterizes the Laboratory's environmental performance, 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.

The Laboratory's Governing Policy on 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 the public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

Los Alamos National Laboratory has changed substantially during its more than 70-year history. Undoubtedly, the future will continue to bring significant changes to the mission and operations of the Laboratory. Regardless of these changes, we are committed to operating the site sustainably.

Environmental stewardship requires an active management system to provide environmental policy, planning, implementation, corrective actions, and management review. We use an Environmental Management System 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 the Environmental Management System since April 2006.

The following chapters in this report discuss our success in complying with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climate conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Monitoring); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, soil, and vegetation (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

2016 Environmental Performance Summary

Our environmental performance can be summarized as follows:

- The Laboratory operated under 17 different types of environmental permits and legal orders (Table 2-1 in Chapter 2).
- Six different environmental inspections or audits were conducted by external regulators (Table 2-2 in Chapter 2).
- Testing found that zeolite blending was the most effective treatment for removing the hazardous characteristics of ignitability and corrosivity from nitrate-salt-bearing wastes. The Laboratory received a modification of its Hazardous Waste Facility Permit to treat these wastes on July 25, 2016, and a mock facility was set up to develop and practice this waste treatment procedure.
- A new Compliance Order on Consent was issued covering Resource Conservation and Recovery Act corrective actions at the Laboratory in June 2016, replacing the 2005 Compliance Order on Consent.
- The Laboratory was fully in compliance with its Clean Air Act, Title V Operating Permit emission limits.
- We discharged approximately 108 million gallons of liquid effluents from permitted outfalls, and 5 of 1024 samples exceeded outfall permit effluent quality limits.
- The U.S. Environmental Protection Agency's latest National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities changed the benchmark values for some pollutants to New Mexico water quality standards. As such, some pollutant limits are significantly more stringent than under the previous permit, and there were many more exceedances of these permit limits during 2016 than in 2015.
- We continued to implement storm water controls at solid waste management units and areas of concern under the Laboratory's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System.
- The New Mexico Environment Department granted certificates of completion for 34 remedial sites in 2016. Of these, 26 sites were certified complete without controls,

meaning no additional corrective actions or conditions are necessary. Certificates for the remaining 8 sites were for corrective actions complete with controls, which require future site use to be restricted to industrial activities.

- Nine environmental occurrences were reported under DOE Order 232.2, Occurrence Reporting and Processing of Operations Information.
- Radiological doses to the public from Laboratory operations were less than 1 millirem per year, and public health risks from radioactive and chemical releases were indistinguishable from zero.

2016 Environmental Monitoring

During 2016, we found the following:

- At the Area G waste site, the highest plutonium activity detected in air was 11 attocuries per cubic meter, which is lower than previous years, because minimal amounts of soil were moved at Area G during 2016.
- The only locations with measurable gamma and neutron radiation from Laboratory operations are near the Los Alamos Neutron Science Center and Technical Area 54, Area G. The highest public radiation dose at these locations resulting from direct radiation from Laboratory operations is calculated to be 0.1 millirem per year.
- The years 2001–2010 were approximately 1.5°F warmer than the previous 40 years, with the years 2011–2016 continuing to be significantly warmer (approximately 2.5°F) than the 1960–2000 averages. When average temperatures are broken down into summer and winter minimums and maximums, the summer minimum temperatures demonstrate the strongest increasing trend from 1990 onward (an increase of approximately 5°F).
- Site-wide groundwater characterization and monitoring indicates that there are only two notable areas of groundwater contamination at the Laboratory: an RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) plume beneath Cañon de Valle in the Technical Area 16 area and a chromium plume beneath Sandia and Mortandad Canyons.
- Over time, storm-water-related transport of sediments is generally resulting in lower concentrations of Laboratory-derived chemical and radionuclides in sediment than previously existed in the sampled locations.
- Most radionuclide and most chemical concentrations in soil, plants, and wildlife from on-site and perimeter locations were either not detected, similar to background, or below screening levels.
- Mean levels of zinc in sediment from the Sandia Canyon wetland were above the no-effect screening level for field mice. However, the concentrations of zinc were still below the low-effect screening level for field mice, and the numbers of small mammals within the Sandia Canyon wetland 3 years after construction of a grade-control structure were higher than in past studies.

- Biota dose assessments from radionuclide data show that there are no measurable effects from Laboratory-sourced radioactive materials to Pajarito Plateau plant and animal populations.

An additional summary of this report can be found in the Los Alamos National Laboratory 2016 Annual Site Environmental Report Summary. The full report and the summary are available on the Laboratory's website: http://www.lanl.gov/environment/environmental-report.php.

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Los Alamos National Laboratory (the Laboratory) is committed to act as a steward of the environment and to achieve its 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 the public. The Laboratory reduces environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

BACKGROUND AND PURPOSE

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. 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.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved. The current mission is "to solve national security challenges through scientific excellence."

The Atomic Energy Commission took ownership of Los Alamos Laboratory in 1946. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory. The U.S. Department of Energy (DOE) took ownership in 1977, and Los Alamos Scientific Laboratory became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. Federal staff with the National Nuclear Security Administration, a semiautonomous agency within the DOE, have overseen the management and operating contract for the Laboratory since 2000.

From 1943 through May 2006, the Laboratory was operated by the Regents of the University of California. In June 2006, a new organization, Los Alamos National Security, LLC, was contracted to operate the Laboratory. In 2014, the DOE decided to separate cleanup of legacy wastes at the Laboratory from the management and operating contract. Legacy wastes are wastes that were generated at the Laboratory prior to 1999. The legacy waste cleanup work was transitioned to a bridge contract under the DOE's Office of Environmental Management in October 2015. A new legacy waste cleanup contract is in the process of being competitively awarded. Currently, both the National Nuclear Security Administration and the Office of Environmental Management maintain field offices in Los Alamos.

Purpose

This document serves as a consolidated site environmental report, fulfilling the annual reporting requirements of both the National Nuclear Security Administration and DOE's Office of Environmental Management for the site under DOE Orders 231.1B Chg 1, Environment, Safety, and Health Reporting, and 458.1 Chg 3, Radiation Protection of the Public and the Environment.

As part of the Laboratory's commitment to protecting the environment, we monitor and report on how Laboratory activities affect the environment. The objectives of this annual report are to

- characterize the site's environmental performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials;
- summarize environmental occurrences and responses;
- document compliance with environmental standards and requirements;
- highlight significant programs and efforts; and
- summarize property clearance activities.

The chapters in this report discuss our compliance with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climatic conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Monitoring); how we monitor the movement of chemicals and radionuclides by storm-water runoff (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, soil, and vegetation (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

ENVIRONMENTAL SETTING

Location

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (direct distance, see Figure 1-1).

The 36-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep east-to-west-oriented canyons. Mesa tops range in elevation from approximately 7800 feet on the flanks of the Jemez Mountains to about 6200 feet at the edge of White Rock Canyon. Most Laboratory and community developments are confined to the mesa tops. The Rio Grande runs east of the Laboratory and forms part of the Laboratory boundary.

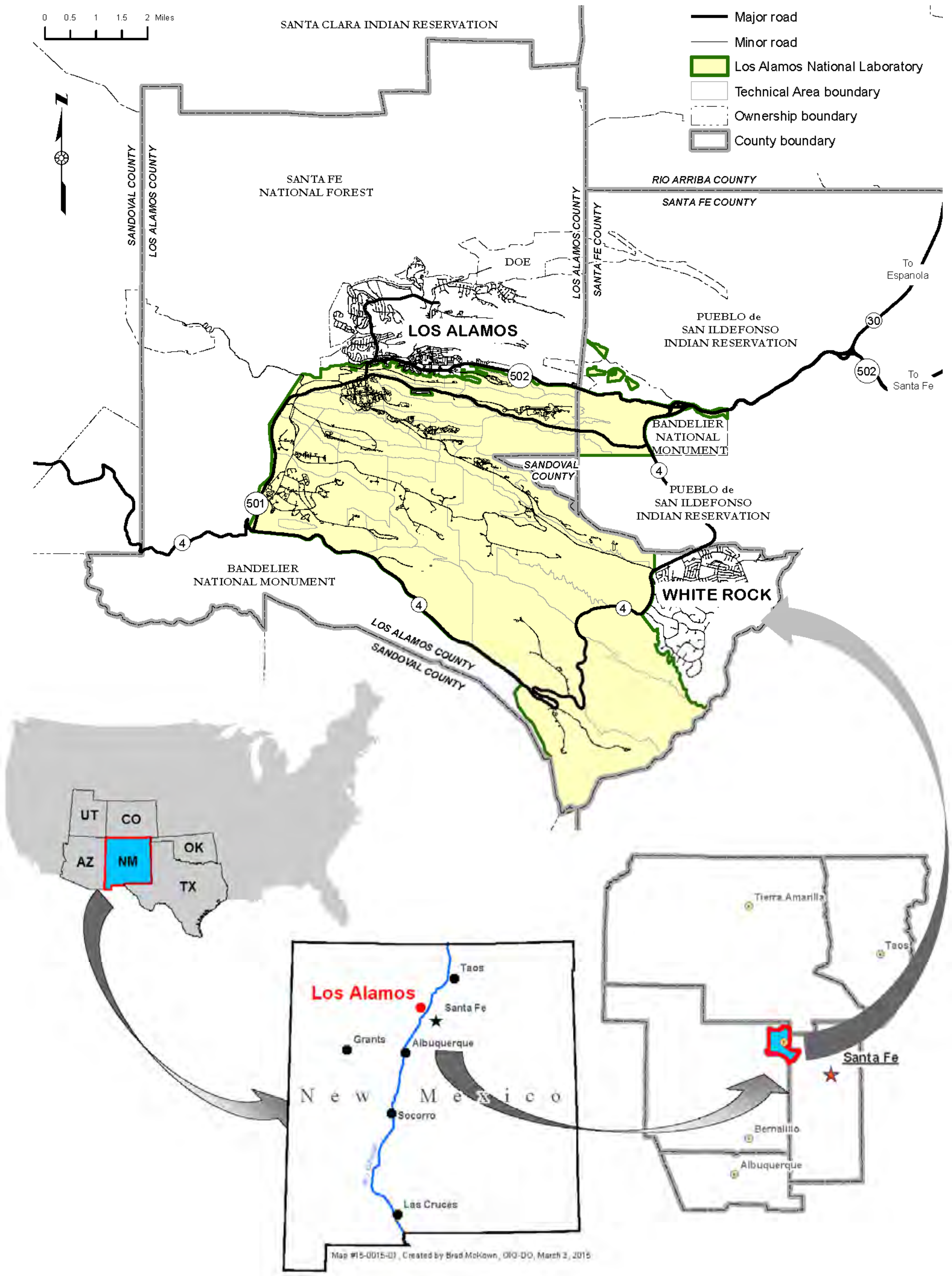


Figure 1-1 Regional location of the Laboratory

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 (Figure 1-2). 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.

Geology

Los Alamos lies along the Rio Grande rift. The Rio Grande rift is a continental rift—a massive crack in the Earth's crust formed by the upwelling of hot rocks deep below the surface. A continental rift becomes an elongated valley in the landscape, bounded by faults. Faults are breaks where rocks that make up the Earth's crust slide past each other. The modern rift boundary in the Los Alamos area consists of a local master fault and three subsidiary faults, known as the Pajarito fault zone. Present and past studies investigate the earthquake hazard associated with these faults (LANL 2007, Larmat and Lee 2017).

The Jemez Mountains are the remnant of a large, collapsed volcanic field. The high levels of volcanic activity in the area are associated with the same geologic forces that produced the Rio Grande rift. The Tschicoma Formation is an older rock layer of volcanic dacite that forms much of the Jemez Mountains. Most of the mesas of the Pajarito Plateau are formed from Bandelier Tuff. Tuff is a type of soft rock that forms from ash released during volcanic eruptions. The Bandelier Tuff is more than 1000 feet thick in the western part of the plateau and thins to about 260 feet eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation of the Jemez Mountains. Eastward near the Rio Grande, a layer of sand and gravel that underlies the Bandelier Tuff, known as the Puye Formation, becomes visible in places. The Puye Formation is important in storing groundwater. Basalt rocks originating from material from the Cerros del Rio volcanos east of the Rio Grande mix with the Puye Formation along the river and extend beneath the Bandelier Tuff to the west in places. These rock formations all overlie the sediments of the Santa Fe Group, which extend between the Laboratory and the Sangre de Cristo Mountains and are more than 3300 feet thick. The Santa Fe Group sediments are also important for groundwater storage.

Hydrology

Surface water in the Los Alamos region occurs primarily as ephemeral flow, associated with individual storms and lasting only a few hours to days, or intermittent flow, associated with events like snow melt and lasting only a few days to weeks. Springs on the edge of the Jemez Mountains that flow year-round do supply continuous water into western sections of some canyons on Laboratory property, but the amount of water is not enough to maintain surface flows to the eastern Laboratory boundary.

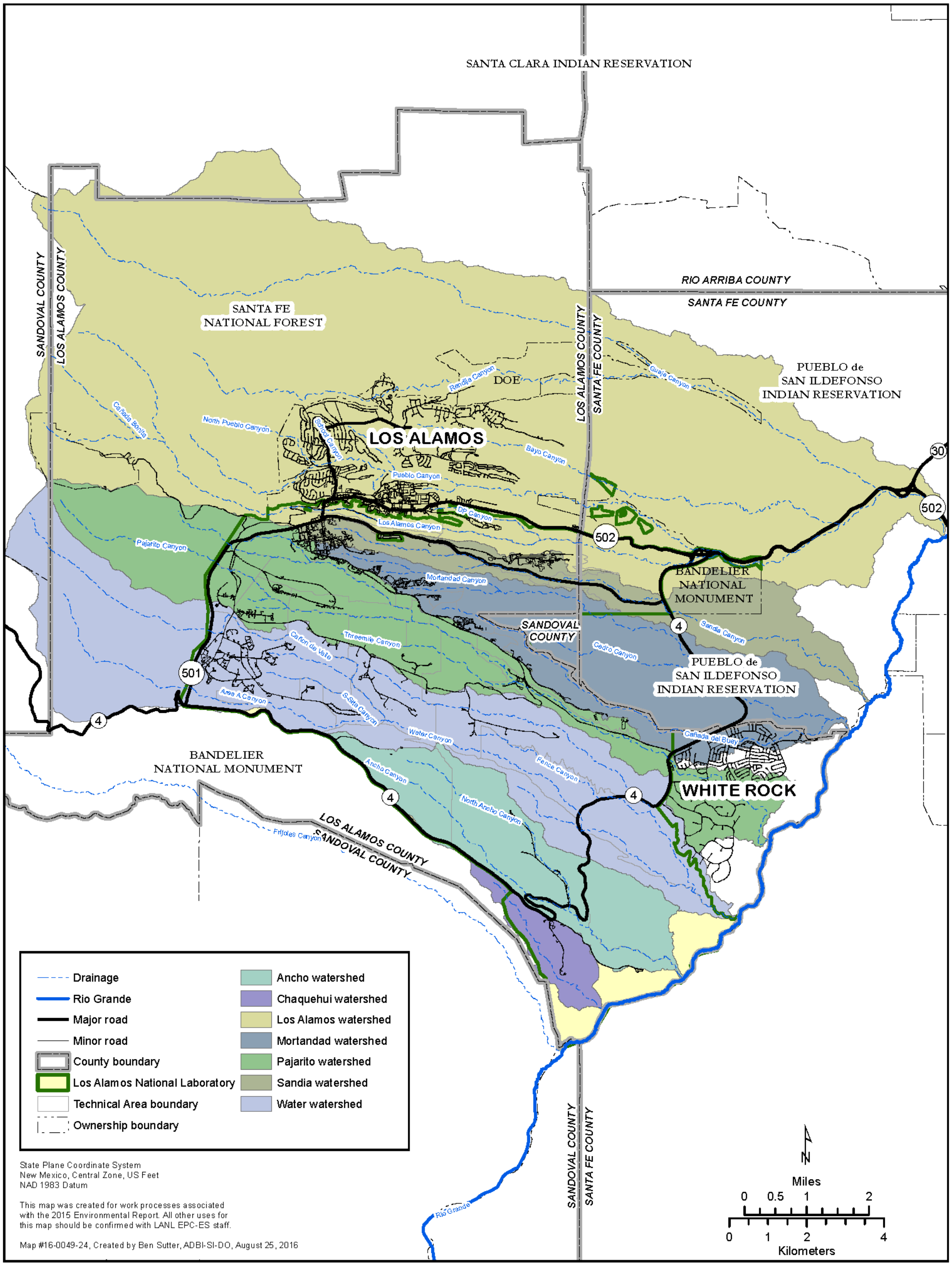


Figure 1-2 Land ownership and primary watersheds around the Laboratory

Groundwater in the Los Alamos area occurs in three modes: (1) water in the near-surface sediments in the bottoms of some canyons (alluvial groundwater); (2) water in porous rock layers underlain by a more solid rock layer, and therefore perched above the regional aquifer (intermediate perched groundwater); and (3) the regional aquifer in the saturated Santa Fe Group sediments.

The regional aquifer is the only aquifer in the area capable of serving as a municipal water supply. The source of most recharge to the regional aquifer appears to be rain and snow that fall on the Jemez Mountains. A secondary source is local infiltration of water in canyon bottoms 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.

Biological Resources

The Pajarito Plateau is very biologically diverse, partly because of the dramatic 5000-foot elevation change from the Rio Grande up to the Jemez Mountains, and partly because of the many steep canyons that dissect the area. The major vegetative cover types in the area include the following: (1) one-seed juniper (*Juniperus monosperma*) savannas along the Rio Grande on the eastern border of the plateau, extending upward on the south-facing sides of canyons at elevations between 5600 and 6200 feet; (2) piñon- (*Pinus edulis*) juniper woodlands, generally between 6200 and 6900 feet in elevation, covering large portions of the mesa tops and north-facing slopes at the lower elevations; (3) ponderosa pine (*Pinus ponderosa*) woodlands and forests on the western portion of the plateau between 6900 and 7500 feet in elevation; and (4) mixed-conifer woodlands and forests, at elevations of 7500 to 9500 feet, overlapping the ponderosa pine community in the deeper canyons and on north-facing slopes and extending onto the slopes of the Jemez Mountains. Local wetlands and riparian areas enrich the diversity of plants and animals found on the plateau.

The frequent drought conditions prevalent throughout New Mexico since 1996 have resulted in the loss 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). Large numbers of mature ponderosa pine and other conifer trees in the area have also died. This mortality of forest trees is projected to continue into the 2050s (Williams et al. 2012).

Two major wildfires have also affected the Laboratory, the Cerro Grande fire in May 2000 and the Las Conchas fire in June and July 2011. Both fires resulted in loss of forest trees on the slopes of the Jemez Mountains west of the Laboratory.

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 sites, and more than 1800 sites have been recorded. Nearly 73% of the sites were constructed and used by Ancestral Puebloan people during the thirteenth, fourteenth, and fifteenth centuries.

Buildings and structures associated with the Manhattan Project and early Cold War period at the Laboratory (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places. More than 300 such buildings have been evaluated for inclusion in this listing, and 158 have been declared eligible. Facilities considered to have national historic significance dating from 1963 to the end of the Cold War in 1990 are also being evaluated. The Manhattan Project National Historical Park, managed by the National Park Service, was created in 2014. This historical park includes 17 Laboratory structures.

Climate

Los Alamos County has a semiarid climate—more water is lost through evaporation and transpiration than is received as annual precipitation. Annual temperatures and amounts of precipitation vary across the site because of the 1000-foot elevation change 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 frequent afternoon thunderstorms. Fall is typically dry, cool, and calm.

Daily temperatures are highly variable. 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, making the occurrence of subzero temperatures rare. On average, summer temperatures range from 70°F to 88°F during the day and from 50°F to 59°F during the night.

From 1981 to 2010, the average annual precipitation (which includes both rain and the water equivalent of snow, hail, or any other frozen precipitation) was 19 inches. The average annual snowfall was 59 inches. The rainy season begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico lifts over the Jemez Mountains. 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.

The complex topography of the Pajarito Plateau influences local wind patterns. Daytime winds in the Los Alamos area are predominately from the south, as heated daytime air moves up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and are typically from the west, a result of prevailing upper-level winds from the west and downslope flow of cooled mountain air.

The climatology of Los Alamos County is summarized in Chapter 4, Air Quality, and explained further in Dewart et al. (2017).

LABORATORY ACTIVITIES AND FACILITIES

The current mission of the Laboratory is to solve national security challenges through scientific excellence. The current goals of the Laboratory are to deliver national nuclear security and broader global security mission solutions and to foster excellence in science and engineering disciplines essential for national security missions by attracting, inspiring, and developing world-class talent to ensure a vital future workplace and by enabling mission delivery through next-generation facilities, infrastructure, and operational excellence. Mission focus areas include

- nuclear deterrence and stockpile stewardship,
- protecting against nuclear threats,
- emerging threats and opportunities, and
- energy security solutions.

The Laboratory is organized into technical areas used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-3 and Appendix C, Descriptions of Technical Areas and their Associated Programs). However, these uses account for less than half of the total land area; many portions of Laboratory land act as buffer areas for security and safety. The Laboratory has about 976 structures, with approximately 8.2 million square feet under roof. The current area of the Laboratory is approximately 36 square miles.

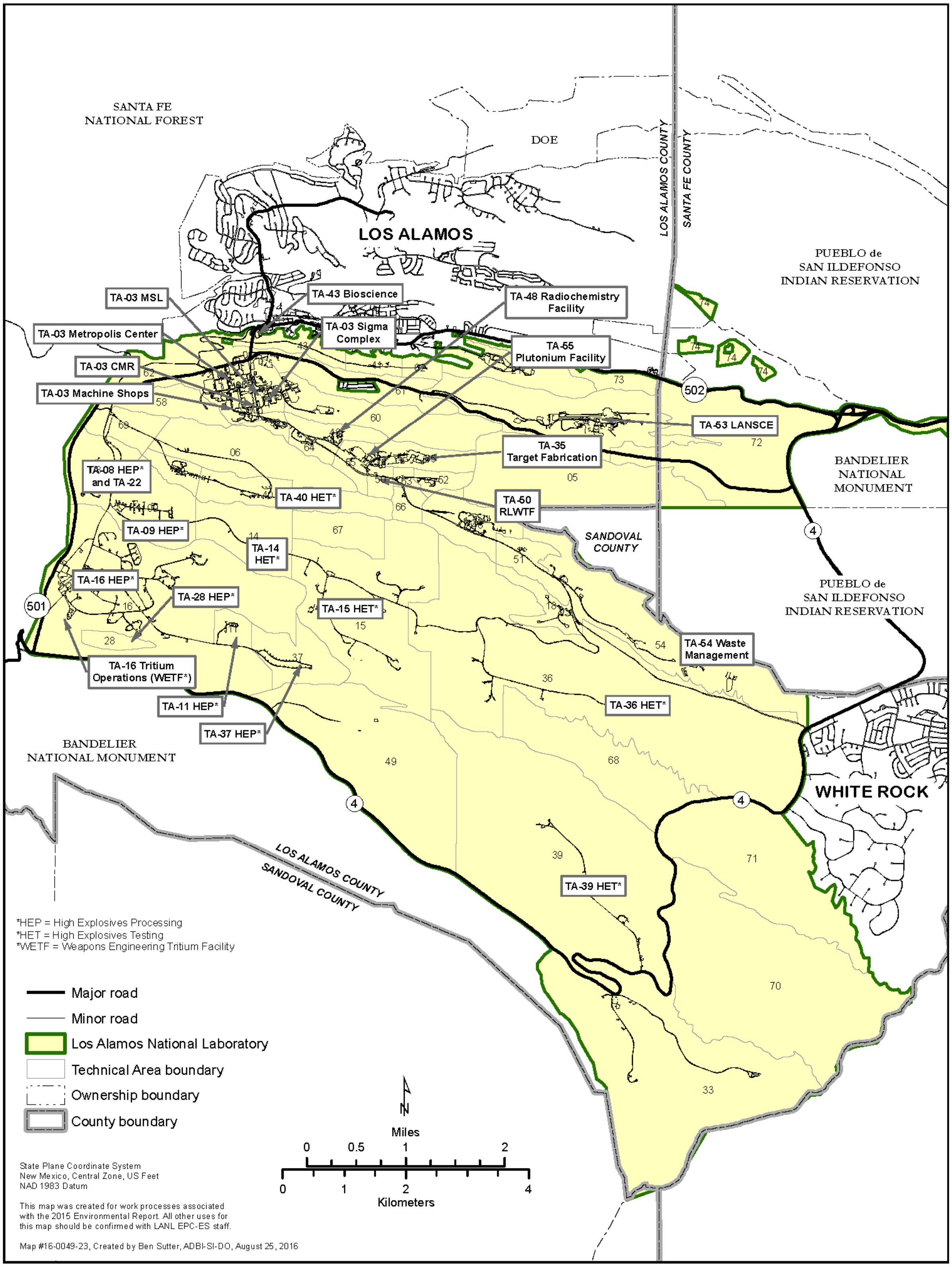
The DOE/National Nuclear Security Administration issued a site-wide environmental impact statement in May 2008 (DOE 2008). In the 2008 Site-Wide Environmental Impact Statement, 15 Laboratory facilities were identified as "Key Facilities" to evaluate the potential environmental impacts of Laboratory operations (Table 1-1). Activities in the Key Facilities represent the majority of environmental impacts associated with Laboratory operations.

Table 1-1
Key Facilities

Facility	Technical Area(s)
Plutonium complex	55
Tritium facilities	16
Chemistry and Metallurgy Research (CMR) building	03
Sigma Complex	03
Materials Science Laboratory (MSL)	03
Target Fabrication Facility	35
Machine shops	03
Nicholas C. Metropolis Center for Modeling and Simulation	03
High-explosives processing (HEP)	08, 09, 11, 16, 22, 37
High-explosives testing (HET)	14, 15, 36, 39, 40
Los Alamos Neutron Science Center (LANSCE)	53
Biosciences Facilities (formerly Health Research Laboratory)	43, 03, 1635, 46
Radiochemistry Facility	48
Radioactive Liquid Waste Treatment Facility (RLWTF)	50
Solid radioactive and chemical waste facilities	50, 54

Note: Data from 2008 site-wide environmental impact statement.

In the 2008 Site-Wide Environmental Impact Statement, the remaining Laboratory facilities were identified as "Non-Key Facilities." The Non-Key Facilities can be found in 30 of the Laboratory's 49 technical areas (LANL 2010). The Non-Key Facilities include the Nonproliferation and International Security Center; the National Security Sciences Building, which is the main administration building; and the Technical Area 46 sewage treatment facility.



See Table 1-1 for acronym definitions.

Figure 1-3 Technical areas and Key Facilities of the Laboratory in relation to surrounding landholdings

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Compliance with environmental regulations and policies is part of Los Alamos National Laboratory's environmental stewardship and helps us attain our overall goal of environmental sustainability.

Environmental 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 biological and cultural resources and air, soil, and water; and

(3) requiring analysis of the environmental impacts of new operations.

Based on these laws, Los Alamos National Laboratory (LANL or the Laboratory) operations comply with regulations, permits, orders, and/or standards. The U.S. Environmental Protection Agency or the New Mexico Environment Department administers most of these laws. U.S. Department of Energy (DOE) orders have requirements for environmental protection and control of radionuclides at DOE facilities. This chapter provides a summary of our compliance with state and federal environmental regulations and permits and DOE environmental orders.

Table 2-1 presents the environmental permits and legal orders the Laboratory operated under in 2016. Table 2-2 lists the environmental inspections conducted by regulating agencies at the Laboratory during 2016. The following sections summarize our compliance performance during 2016.

Table 2-1
Environmental Permits and Legal Orders under which the Laboratory Operated during 2016

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Los Alamos National Laboratory Hazardous Waste Facility Permit	A permit regulating management of hazardous wastes at the Laboratory, including storage and treatment. The permit also has standards for closure of indoor and outdoor areas used for hazardous waste storage or disposal. (https://www.env.nm.gov/HWB/Permit.htm)	Renewed November 2010	December 2020	New Mexico Environment Department
Administrative Compliance Order No. HWB-14-20	An order issued for violations of the Hazardous Waste Act and the Laboratory's Hazardous Waste Facility Permit associated with the Waste Isolation Pilot Plant drum breach. As part of the settlement, DOE is funding a series of projects, including road improvements on transport routes to the Waste Isolation Pilot Plant. (http://www.wipp.energy.gov/library/Information_Repository_A/Directives_from_the_Secretary/FINAL_Principles_of_Agreement_4_30_15.pdf)	Issued December 6, 2015 Settlement Agreement and Stipulated Final Order issued on January 22, 2016	None	New Mexico Environment Department
Administrative Order No. 5-19001	An order directing the Laboratory to develop and implement a nitrate-salt-bearing waste container isolation plan and provide regular updates about nitrate-salt-bearing waste containers to the New Mexico Environment Department. https://www.env.nm.gov/documents/LANLOrder5-19001.pdf	Issued May 19, 2014 Modified on July 10, 2014; April 27, 2015; May 8, 2015; and August 12, 2015	None	New Mexico Environment Department
Compliance Order on Consent	An order giving requirements for the investigation, corrective actions, and monitoring of solid waste management units and areas of concern 2005 Compliance Order on Consent - https://www.env.nm.gov/HWB/documents/LANL_10-29-2012_Consent_Order_-_MODIFIED_10-29-2012.pdf 2016 Compliance Order on Consent - https://www.env.nm.gov/wp-content/uploads/2015/12/LANL_Consent_Order_FINAL.pdf	Issued March 1, 2005 Revised October 29, 2012 Replaced by 2016 Compliance Order on Consent on June 24, 2016	None	New Mexico Environment Department

Table 2-1 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Federal Facilities Compliance Order [for Mixed Wastes]	An order requiring the Laboratory to submit an annual update to its site treatment plan for treating all of its mixed hazardous and radiological wastes (mixed waste) (https://www.env.nm.gov/HWB/documents/LANL_10-4-1995_FFCO.pdf and https://www.env.nm.gov/HWB/documents/LANL_FFCO_5-20-1997_Ammendment.pdf)	Issued October 4, 1995 Amended May 20, 1997	None	New Mexico Environment Department
Authorization to Discharge [from Outfalls] Under the National Pollutant Discharge Elimination System	A permit authorizing the Laboratory to discharge industrial and sanitary liquid effluents through outfalls under specific conditions, including water quality requirements and monitoring requirements. (http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-15-23948)	Issued August 12, 2014 Effective October 1, 2014 Modified May 1, 2015	September 30, 2019	U.S. Environmental Protection Agency
National Pollutant Discharge Elimination System Pesticide General Permit	A permit authorizing the discharge of pesticides at the Laboratory that have potential to enter waters of the U.S. (https://www.regulations.gov/document?D=EPA-HQ-OW-2015-0499-0118)	Issued October 31, 2011 Reissued October 31, 2016	October 31, 2021	U.S. Environmental Protection Agency
Clean Air Act, Title V Operating Permit	A permit regulating air emissions from Laboratory operations (i.e., emissions from the power plant, asphalt batch plant, permanent generators, etc.). These emissions are subject to operating, monitoring, and record-keeping requirements. https://cswab.org/wp-content/uploads/2017/04/Los-Alamos-Final-P100R2-Title-V-permit-2015.pdf	Issued August 7, 2009 Reissued February 27, 2015	February 27, 2020	New Mexico Environment Department

Table 2-1 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
New Mexico Air Quality Control Act Construction Permits	Permits regulating construction or modification of air emissions sources, including the following:			
	• Technical Area 03 power plant Permit modification 2 (NSR 2195-B-M2)	Issued September 27, 2000 Reissued November 1, 2011	None	New Mexico Environment Department
	• Asphalt plant at Technical Area 60 Permit revision 1 (GCP3-2195-G)	Issued October 29, 2002 Reissued September 12, 2006	None	New Mexico Environment Department
	• 1600-kilowatt generator at Technical Area 33 Permit revision 4 (NSR 2195-F R4)	Issued October 10, 2002 Reissued December 12, 2013	None	New Mexico Environment Department
	• Two 20-kilowatt generators and one 225-kilowatt generator at Technical Area 33 (NSR 2195-P)	Issued August 8, 2007	None	New Mexico Environment Department
	• Data disintegrator (NSR 2195-H R1)	Issued October 22, 2003 Revised June 14, 2006	None	New Mexico Environment Department
	• Chemistry and Metallurgy Research Replacement facility, Radiological Laboratory/Utility/Office Building Permit revision 2 (NSR 2195-N)	Issued September 16, 2005 Reissued September 25, 2012	None	New Mexico Environment Department
	• LANL exemption notifications - rock crusher removed (NSR 2195)	Issued June 16, 1999	None	New Mexico Environment Department
	• Technical Area 35, building 213, beryllium machining (NSR 632 R1)	Issued December 26, 1985 Revised June 14, 2006	None	New Mexico Environment Department
	• Technical Area 03, building 141, beryllium technology facility (NSR 634 M2R1)	Issued October 30, 1986 Revised June 14, 2006	None	New Mexico Environment Department
	• Technical Area 55 beryllium machining (NSR 1081 M1R7)	Issued July 1, 1994 Revised June 14, 2006	None	New Mexico Environment Department

Table 2-1 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Clean Water Act, Section 404/401 Permits	The U.S. Army Corps of Engineers authorizes certain work within water courses at the Laboratory under Clean Water Act Section 404 permits. The projects below were authorized to operate under a Section 404 nationwide permit with Section 401 certification in 2016.	Effective March 19, 2012 (all current nationwide Section 404 permits)	March 18, 2017 (all current nationwide Section 404 permits)	U.S. Army Corps of Engineers and New Mexico Environment Department (all permits and verifications)
	• Pueblo grade-control spurs and E060.1 gage revitalization	Permit verification received July 30, 2014 Project completed January 26, 2016		
	• Bayo Canyon storm water controls at B-SMA-0.5	Permit verification received April 16, 2016 Project completed May 5, 2016		
	• Chromium injection well pad CrIN-3	Permit verification received April 14, 2016 Project completed June 3, 2016		
	• Pueblo Canyon watershed control at P-SMA-1	Permit verification received May 6, 2016 Project completed June 16, 2016		
	• Cañon de Valle storm water controls at CDV-SMA-1.7	Permit verification received March 25, 2015 Project completed June 24, 2016.		
	• Potrillo Canyon storm water controls at PT-SMA-4.2	Permit verification received May 4, 2016 Project completed September 7, 2016		
	• Sandia Canyon, Technical Area 72 firing site storm water controls	Project modified and permit reverified August 16, 2016 Project completed September 30, 2016		
	• Acid Canyon storm water controls at Acid-SMA-2.5	Permit verification received August 4, 2016 Project completed December 5, 2016		

Table 2-1 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Clean Water Act, Section 404/401 Permits	The following projects had an ongoing annual monitoring requirement:			
	• Sandia Canyon Wetland grade-control structure	Annual monitoring and reporting required through 2018		
	• Sandia Canyon, Technical Area 72 firing site storm water controls	Annual monitoring and reporting required through 2019		
	• Water Canyon storm drain reconstruction project	Annual monitoring and reporting required through 2021		
National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities	A general permit (not LANL-specific) authorizing the discharge of pollutants during construction activities under specific conditions. Conditions include water quality requirements, inspection requirements, erosion and sediment controls, notices of intent to discharge, preparation of storm water pollution prevention plans, and other conditions. (https://www.epa.gov/sites/production/files/2016-09/documents/cgp2012_finalpermitpart1-9-updatedurl.pdf)	Effective February 16, 2012	February 16, 2017	U.S. Environmental Protection Agency
National Pollutant Discharge Elimination System Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity	A general permit (not LANL-specific) authorizing facilities with some industrial activities to discharge storm water and some non-storm-water runoff. The permit provides specific conditions for the authorization, including pollutant limits to meet water quality standards, inspection requirements, compliance with biological and cultural resource protection laws, and other conditions. (http://www.epa.gov/sites/production/files/2015-10/documents/msgp2015_finalpermit.pdf)	Effective June 4, 2015	June 4, 2020	U.S. Environmental Protection Agency

Table 2-1 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
[Individual Permit] Authorization to Discharge [from Solid Waste Management Units and Areas of Concern] Under the National Pollutant Discharge Elimination System	A permit authorizing the Laboratory to discharge storm water from 405 solid waste management units and areas of concern under specific conditions. Conditions include requirements for monitoring and for corrective actions where necessary to minimize pollutants in the storm water discharges. (https://www.env.nm.gov/swqb/documents/swqbdocs/NPDES/Permits/NM0030759-LANLStormwater.pdf)	Issued November 1, 2010	October 31, 2015 Application for renewal submitted to the U.S. Environmental Protection Agency in 2014 Administratively extended by the U.S. Environmental Protection Agency pending issuance of new permit	U.S. Environmental Protection Agency
Groundwater Discharge Permit DP-857	A permit authorizing discharges to groundwater from the Laboratory's sanitary wastewater system plant and the Sanitary Effluent Reclamation Facility	Issued December 16, 2016 Previous permit issued July 20, 1992, and administratively continued until the current permit issued	December 16, 2021	New Mexico Environment Department
Groundwater Discharge Permit DP-1589	A permit authorizing discharges to groundwater from the Laboratory's eight septic tank/disposal systems	Issued July 22, 2016	July 22, 2021	New Mexico Environment Department
Groundwater Discharge Permit DP-1793	A permit authorizing discharges to groundwater from the Laboratory's land application of treated groundwater	Issued July 27, 2015	July 27, 2020	New Mexico Environment Department
Groundwater Discharge Permit DP-1835	A permit authorizing discharges to groundwater from the Laboratory's injection of treated groundwater into six Class V underground injection control wells	Issued August 31, 2016	December 1, 2021	New Mexico Environment Department

Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2016

Date	Purpose	Performing Entity
06/13/16–06/16/16	Resource Conservation and Recovery Act compliance inspection	New Mexico Environment Department
06/22/16	Clean Air Act, Title V Operating Permit compliance inspection	New Mexico Environment Department
10/31/16–11/02/16	Petroleum storage tanks inspection	New Mexico Environment Department
05/05/16	Compliance inspection of Water Canyon grade control corrective actions and maintenance	U.S. Army Corps of Engineers and New Mexico Environment Department
09/19/16–11/30/16	Survey and assessment of Laboratory programs associated with DOE Order 435.1, Radioactive Waste Management, and DOE Order 422.1, Conduct of Operations	National Nuclear Security Administration Los Alamos Field Office and Environmental Management Los Alamos Field Office
10/20/16	Inspection of the Technical Area 46 sanitary wastewater system plant, the Technical Area 03 Sanitary Effluent Reclamation Facility, and the Technical Area 60 Sigma Mesa evaporation basins for compliance with the groundwater discharge permit DP-857	New Mexico Environment Department

MANAGEMENT OF HAZARDOUS AND MIXED WASTES

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act regulates hazardous wastes from generation to disposal. Under the law, hazardous wastes include all solid wastes that are (1) listed as hazardous by the U.S. Environmental Protection Agency; (2) ignitable, corrosive, reactive, or toxic; (3) batteries, pesticides, lamp bulbs, or contain mercury; or (4) a hazardous waste as listed above that has been mixed with a radiological waste (mixed waste).

The Resource Conservation and Recovery Act mandates a hazardous waste facility permit for facilities that treat, store, or dispose of hazardous wastes. The Laboratory's Hazardous Waste Facility Permit was initially granted in 1989 for waste storage and treatment and was renewed in 2010. The Laboratory does not dispose of hazardous or mixed waste on-site.

The Laboratory's Hazardous Waste Facility Permit currently covers 21 hazardous waste storage units, 1 hazardous waste storage and treatment unit, 1 liquid hazardous waste tank system, and 1 hazardous waste stabilization unit. The permit's operating requirements include reporting requirements to the New Mexico Environment Department's Hazardous Waste Bureau and the public.

Permit Modifications, Reports, and Other Activities

In 2016, we submitted 11 Class 1 permit modification packages for the Laboratory's Hazardous Waste Facility Permit to the New Mexico Environment Department. Five permit modifications consisted of only administrative changes, such as updates to organization names and updates to emergency response training requirements. These requested administrative changes included updates to Attachment N (Figures), Attachment G (Closure Plans), Attachment D (Contingency Plan), and Attachment F (Training Plan) of the permit.

Six other permit modification requests were submitted to the New Mexico Environment Department. We sought approval to (1) split 5 solid waste management units into 12; (2) incorporate minor construction changes at the Transuranic Waste Facility; (3) remove structure 224 from the Technical Area 54, Area G, Pad 5 permitted unit; (4) remove structure TA-55-PF-190 from the Technical Area 55 Outdoor Container Storage Pad; (5) remove 3 modular characterization equipment structures from the Technical Area 54, Area G, Pad 10 and Pad 11 permitted units; and (6) conduct treatment by stabilization in containers at the Technical Area 50, building 69 permitted container storage unit. Notices of these modifications were mailed to members of the public on the Laboratory facility mailing list maintained by the New Mexico Environment Department.

As required by the Laboratory's Hazardous Waste Facility Permit, one annual and four quarterly demolition activity notifications were submitted to the New Mexico Environment Department in 2016. In August 2016, we published our community relations plan on the Laboratory's environmental web page after comments from the public were incorporated. In October 2016, the annual training session was conducted for the public on use of the electronic public reading room. Other reporting requirements associated with the Laboratory's Hazardous Waste Facility Permit included the submittal of a waste minimization report and a summary of instances of noncompliance and releases, which were both submitted in November 2016.

Inspections, Noncompliances, and Notices of Violation

Self-assessments are conducted at the Laboratory to determine whether management of hazardous and mixed wastes meets the requirements of federal and state regulations, DOE orders, and Laboratory policy. The findings from these self-assessments are provided to waste generators, waste-management coordinators, and waste managers. In fiscal year 2016, we completed 1090 self-assessments.

From June 13, 2016, to June 16, 2016, the New Mexico Environment Department conducted a hazardous waste compliance inspection at the Laboratory, noting three potential violations at the close of the inspection. A notice of violation for the 2016 inspection was issued and resolved in November 2016. The New Mexico Environment Department determined that the violations cited in the notice of violation were adequately addressed and that no further action was required.

In November 2016, an annual noncompliance report was submitted to the New Mexico Environment Department's Hazardous Waste Bureau. The report listed instances of noncompliance with the Hazardous Waste Facility Permit conditions and any releases from, or at, a permitted unit that did not pose a threat to human health or the environment. The data are reported here by fiscal year to coincide with the Laboratory's Hazardous Waste Facility Permit reporting requirements. From October 1, 2015, through September 30, 2016, there were no releases of hazardous waste or hazardous waste constituents at, or from, a permitted unit. The report detailed 107 instances of noncompliance with the Hazardous Waste Facility Permit that were recorded during fiscal year 2016.

The majority of the occurrences of noncompliance were associated with inconsistencies in the operating record and with container labeling issues. Instances of noncompliance for this time frame, and from past activities at the facility, were communicated to the New Mexico Environment Department's Hazardous Waste Bureau in communications dated February 25, 2016 (Los Alamos National Laboratory Notification of Regulatory Noncompliance at TA-54, AREA G, Pit 38, ADESH-16-021); March 21, 2016 (Response to Ordered Action 1, Attachment A to Settlement Agreement and Stipulated Final Order HWB-14-20, ADESH-16-040); and November 8, 2016 (Notification of Alternative Inspection Requirements for Shed 1028 at Technical Area 54, Area G, Pad 5). The above-mentioned self-disclosures of noncompliance were identified through site-wide compliance assessments, which are intended to identify systemic compliance issues and develop resolutions. None of the instances resulted in any hazards to the environment and human health outside the facility, and no material was lost or had to be recovered as a result of any of these instances.

We have developed improved waste management tools to support compliant operating records and are working to develop additional tools.

LANL's Nitrate-Salt-Bearing Waste Container Isolation Plan

A drum containing nitrate-salt-bearing waste that was generated and processed at the Laboratory was determined to be the container that breached during the February 14, 2014, incident in the underground repository at the Waste Isolation Pilot Plant. In response to this event, the New Mexico Environment Department issued Administrative Order 5-19001, requiring a LANL nitrate salt-bearing waste container isolation plan (Isolation Plan) to isolate, secure, and treat all nitrate-salt-bearing waste at the Laboratory. In 2016, the Isolation Plan was revised three times. Revision 5 allowed for the installation of pressure-relief devices with supplemental filtration to remediated nitrate-salt-bearing waste containers to increase the safety of the waste in storage. Revision 6 allowed additional containers to be equipped with pressure-relief devices with supplemental filtration and incorporated changes for monitoring containers and abnormal instances. Revision 7 described a path forward for remediating nitrate-salt-bearing waste, the requirements and controls for transporting remediated nitrate salt waste to the treatment facility, and safe storage of the waste at the treatment facility.

Efforts to characterize and develop treatment paths for nitrate-salt-bearing wastes at the Laboratory progressed in 2016. Tests determined zeolite blending to be the most effective method for removing the hazardous characteristics of ignitability and corrosivity from the waste. A Class 1 permit modification request was submitted on June 30, 2016, and approved on July 25, 2016, to allow the treatment of nitrate-salt-bearing waste by stabilization in containers at the Waste Characterization, Reduction, and Repackaging Facility. Stabilization of nitrate-salt-bearing waste by the addition of zeolite is intended to meet the deactivation waste treatment standard to remove the U.S. Environmental Protection Agency hazardous waste codes D001 and D002 (ignitability and corrosivity). In June of 2016, a mock facility was set up at Technical Area 50, building 37, to develop and practice the procedure for the treatment of the nitrate-salt-bearing wastes. Formal assessments, both internal and external, to determine operational readiness began in

September 2016. By the end of 2016, two internal assessments were complete and preparation was underway for a contractor readiness assessment in early 2017.

Settlement Agreement and Stipulated Final Order

On December 6, 2014, the New Mexico Environment Department issued an Administrative Compliance Order (HWB-14-20) for violations of the Hazardous Waste Act and the Laboratory's Hazardous Waste Facility Permit associated with nitrate-salt-bearing waste treatment and storage. Settlement Agreement and Stipulated Final Order HWB-14-20 was entered into by the New Mexico Environment Department, DOE, and Los Alamos National Security, LLC, on January 22, 2016. The stipulated final order required the completion of corrective actions associated with waste management at the Laboratory. These nine ordered actions listed within Attachment A to the order were completed, and evidence of completion was submitted to the New Mexico Environment Department for approval in February and March 2016. Progress on ongoing corrective actions is tracked and communicated to the New Mexico Environment Department with monthly summary reports.

The Compliance Order on Consent

The Compliance Order on Consent provides requirements for Resource Conservation and Recovery Act corrective actions at the Laboratory's solid waste management units and areas of concern. Examples of solid waste management units include certain septic tanks, firing sites, landfills, sumps, and areas receiving liquid effluents from outfalls. Areas of concern are not solid waste management units but are areas that may warrant investigation because of the possible migration or release of a hazardous waste or hazardous constituent. Examples include canyon bottoms downstream from historical outfalls.

The first Compliance Order on Consent that applied to the Laboratory was issued in 2005. In June 2016, a new Compliance Order on Consent was issued that supersedes the 2005 version. The 2016 order provides a more efficient process for planning and executing work while providing full protection of human health and the environment. Changes from the 2005 Compliance Order on Consent included an increased focus on the remediation process and removal of many of the fixed, detailed technical requirements. In addition, the corrective action schedules contained in the 2005 order were replaced with an annual prioritization and planning process, with enforceable work milestones established each year. The 2016 order also provides for increased communication and collaboration between the New Mexico Environment Department and DOE during planning and execution of work. Corrective action activities are grouped and prioritized based on risk levels. As with the 2005 order, the 2016 order does not apply to radionuclides, which are regulated by DOE under the Atomic Energy Act, and also does not apply to those solid waste management units and areas of concern that previously received "no further action" decisions from the U.S. Environmental Protection Agency or which were removed from the Hazardous Waste Facility Permit by the New Mexico Environment Department before March 2005.

In 2016, the Laboratory had 970 solid waste management units and 431 areas of concern listed in its Hazardous Waste Facility Permit. Of these, 155 required no further action by the Laboratory, and 275 had certificates of completion. The remaining solid waste management units and areas of concern had investigations and/or corrective actions either in progress or pending or had been deferred until the sites are no longer active. We submitted five reports and completed two site investigations or remediations under the Compliance Order on Consent in 2016 (see Table 3-2 in Chapter 3 of this report).

The solid waste management units and areas of concern have been grouped by geographic location into aggregate areas. Figure 2-1 shows each aggregate area boundary as defined in the Compliance Order on Consent. The figure indicates the status of Laboratory investigations and corrective actions for solid waste management units and areas of concern as a group in these aggregate areas as (1) complete, (2) in progress, or (3) pending. For those aggregate areas presented as complete, 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 have sites or areas where sampling or remediation 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 a work plan has not been approved.

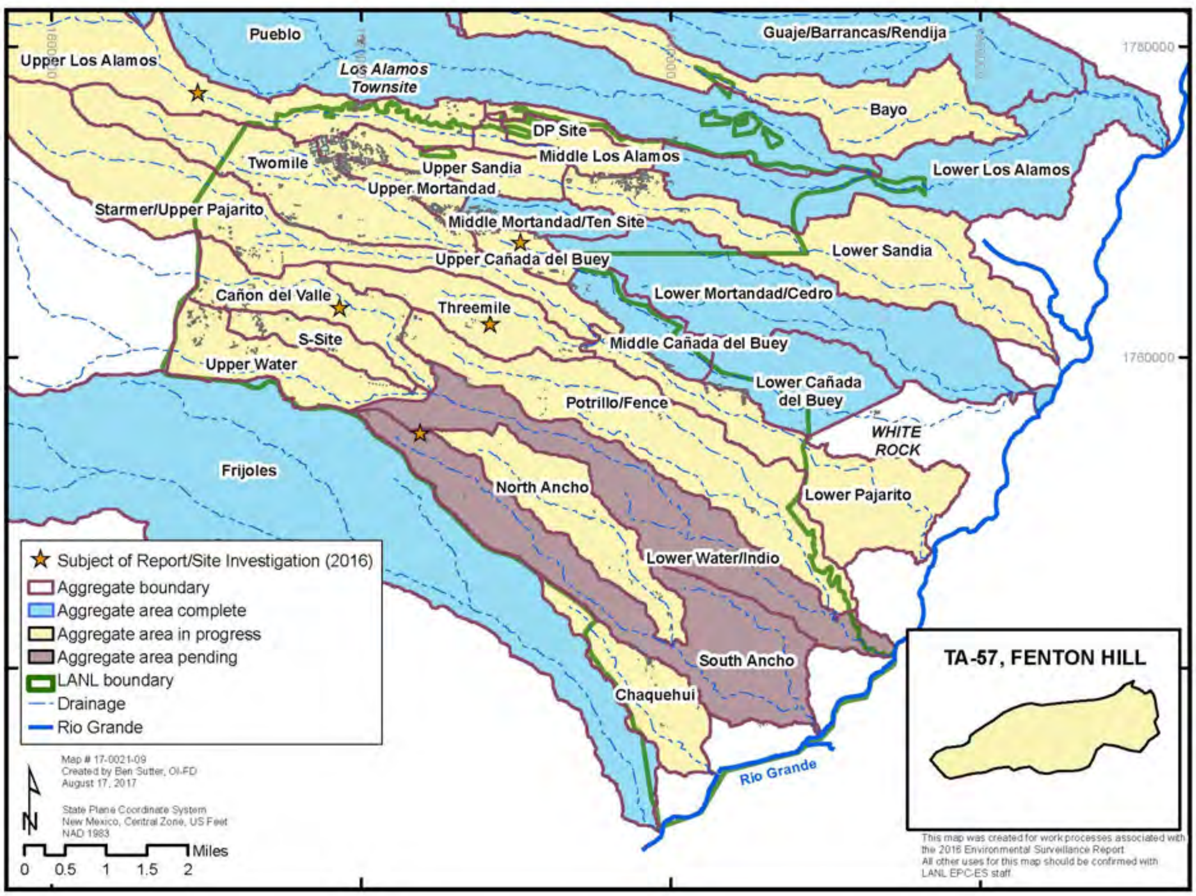

Figure 2-1 **Aggregate areas as defined for the Compliance Order on Consent and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending. Aggregate areas or locations that were the subject of site investigations or reports in 2016 have a star.**

The Compliance Order on Consent also addresses remediation of groundwater containing contaminants that resulted from Laboratory operations. Groundwater remediation activities are discussed in detail in Chapter 5, Groundwater Monitoring.

Federal Facility Compliance Order for Mixed Wastes

In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the Laboratory requiring a site treatment plan for mixed radioactive and hazardous wastes. The annual update to the site treatment plan documents the use of off-site facilities for treating and disposing of mixed waste that has been stored at the Laboratory for more than 1 year. Waste data are reported in this update on a fiscal year basis. In fiscal year 2015, Laboratory shipments of mixed low-level waste (waste containing both hazardous waste and low-level radioactive waste) and mixed transuranic waste (waste containing both hazardous waste and radioactive elements heavier than uranium) were on hold while we addressed safety basis concerns. All shipments of mixed transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, were suspended in May 2014 because of the plant's shutdown. The New Mexico Environment Department has determined that the removal of mixed transuranic waste from the Laboratory's site treatment plan will be deferred until more information becomes available and it is determined that the waste currently stored above grade at the off-site facilities will not be returned to the Laboratory.

Solid Nonhazardous Waste Disposal

We send sanitary solid waste, construction debris, and demolition debris to the Los Alamos County Eco Station for transfer to municipal landfills. Los Alamos County operates this transfer station and is responsible for obtaining all related permits for this activity from the state. Laboratory solid nonhazardous waste sent to the transfer station in 2016 totaled 3934 cubic meters, or 4,631,677 kilograms.

RADIATION PROTECTION AND MANAGEMENT OF RADIOLOGICAL WASTES

DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment

DOE Order 458.1 requires DOE facilities to protect the public and the environment from undue risk from radiological activities. The order directs DOE facilities to ensure the radiological dose to the public from their activities does not exceed 100 millirem in any given year. It also provides dose limits for wildlife and plants. The order requires DOE facilities to keep radiological doses to the public and the environment as low as reasonably achievable and to monitor for releases of radioactive materials. Property released from the facility (for example, property sold as surplus, waste sent for disposal off-site, or land parcels transferred to other owners) cannot exceed dose limits of 25 millirem per year above background for real estate or 1 millirem per year above background for moveable items. DOE Order 458.1 also requires that the public be notified of radiation doses resulting from Laboratory operations and of the release of property that has potential to contain residual radioactivity.

Estimated Maximum Possible Radiological Dose to the Public

During 2016, the estimated maximum radiological dose to a member of the public from Laboratory operations was less than 1 millirem. Radiation doses to wildlife and plants were below the DOE limits of 1 rad/day for terrestrial plants and aquatic animals and 0.1 rad/day for terrestrial animals. Details of the Laboratory's annual radiological dose estimates for the public are presented in Chapter 8, and estimates for wildlife and plants are presented in Chapter 7.

Property Cleared and Released from the Laboratory

Land transfer tract C-3 (the Main Hill Road) was conveyed to Los Alamos County in 2016 (LANL 2015a). The Laboratory also released approximately 1,620,000 pounds of unencumbered metal (i.e., outside the DOE metal moratorium) for recycling. Radiological surveys of these items indicate that they did not contain radioactive materials beyond that which is naturally occurring (Whicker et al. 2017). We also survey and release smaller property items (e.g., tools, furniture, personnel protective equipment) from radiologically controlled areas on an on-demand basis. Once cleared, there are no restrictions on the use of these items.

Authorized limits are established for clearance of any property with residual radioactive material to ensure dose limits are met. Two authorized limits were requested in 2016. We recalculated the screening action levels for radionuclides in soils because of an update to version 7.0 of the dose assessment code RESRAD (Yu et al. 2001) and to use "reference person" dosimetry. The Laboratory asked DOE to evaluate these new screening action levels for use as authorized limits for land conveyance and transfer in 2016. They were approved by DOE in early 2017 (LANL 2016a). We also requested authorized limits for the release of building debris bearing radioactive material from a Technical Area 18 demolition project. These limits were granted by DOE but were not needed to release the material.

DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of wastes containing radioactive materials: low-level radiological waste (low-level waste), mixed low-level waste, transuranic waste, and mixed transuranic waste. The Laboratory disposes of minimal low-level waste on-site; all other radiological and mixed wastes are shipped off-site for disposal. Generated radioactive waste must (1) meet Laboratory on-site storage requirements, and (2) meet requirements for transportation to and disposal at the final facility. All aspects of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1 Chg 1 and DOE Manual 435.1-1. The National Nuclear Security Administration Los Alamos Field Office and the Environment Management Los Alamos Field Office conducted a survey and assessment of Laboratory programs associated with DOE Order 435.1, Radioactive Waste Management, and DOE Order 422.1, Conduct of Operations, in 2016. Findings from the assessment were reported in 2017.

Low-Level Radioactive Waste Disposal

The Laboratory disposes of some low-level waste 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. Disposal of small amounts of low-level waste on-site at Area G is being considered on a case-by-case basis. .

During 2016, we disposed of a total of 2,667,819 kilograms of low-level waste (Figure 2-2). No low-level waste was disposed of at Area G in 2016. The Laboratory continues to implement the strategy of shifting to off-site low-level waste disposal where feasible and cost-effective but continues to store some low-level waste at Area G.

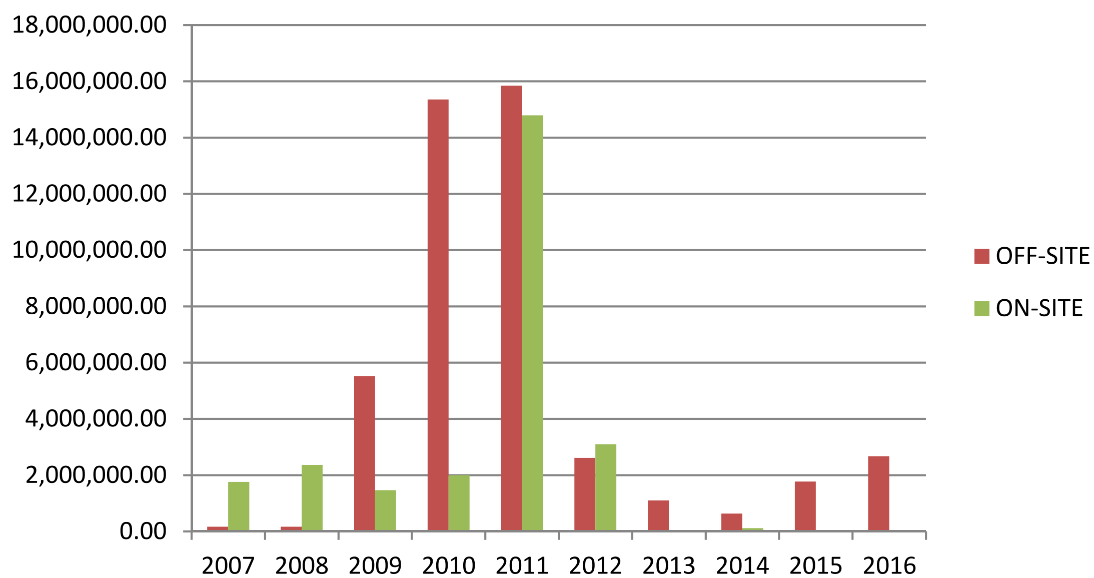

Figure 2-2 LANL low-level waste disposal

Transuranic Waste Disposal

In February 2014, there was a radiological release at the Waste Isolation Pilot Plant resulting from an exothermic reaction in a drum from the Laboratory that contained nitrate-salt-bearing transuranic wastes. As an outcome of investigations into this event, the Accident Investigation Board and a subsequent Los Alamos National Security, LLC, corrective action plan identified 58 corrective actions. The following reports about the investigation results and recommendations are available at http://www.energy.gov/em/waste-isolation-pilot-plant-wipp-recovery.

- "Accident Investigation Report, Phase 1, Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014," U.S. Department of Energy Office of Environmental Management (April 2014).
- "Accident Investigation Report, Phase 2, Radiological Release Event at the Waste Isolation Pilot Plant, February 14, 2014," U.S. Department of Energy Office of Environmental Management (April 2015).

- "Los Alamos National Security, LLC, Corrective Action Plan, Phase 2, Radiological Release Event at the Waste Isolation Pilot Plant," Los Alamos National Laboratory document DIR-15-142 (October 2015).

Figure 2-3 presents the cumulative total amount of transuranic waste that has been shipped from Los Alamos. The amount is reported here on a fiscal year basis to coincide with other transuranic waste reporting. No transuranic waste was shipped from the Laboratory during 2016 because the Waste Isolation Pilot Plant remained closed to shipments of transuranic waste. The focus of activities at Area G, where some of the Laboratory's transuranic waste is stored, has been on performing those actions needed for safe storage, and ultimately treatment, of the nitrate-salt-bearing waste that remains at LANL.

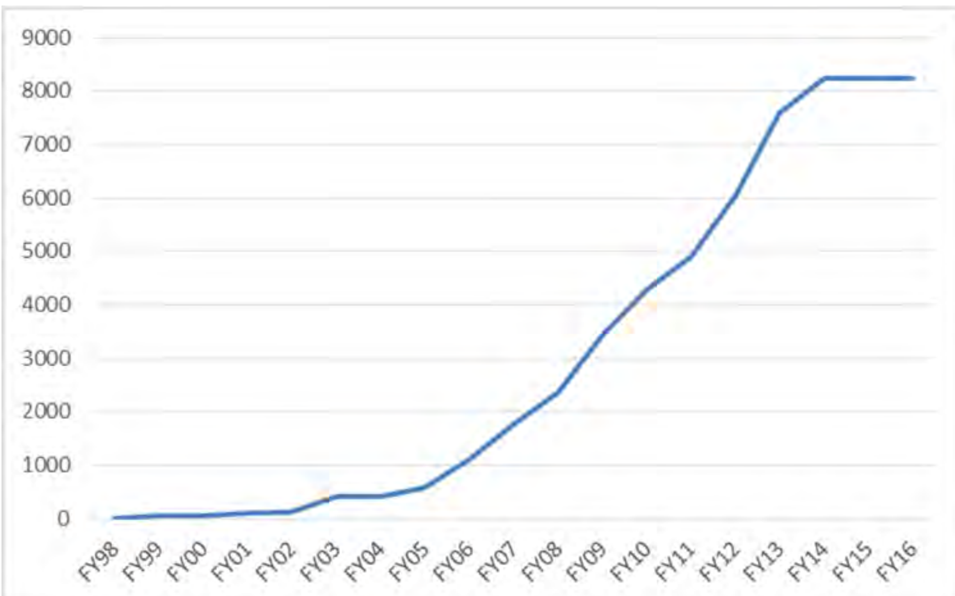

Figure 2-3 Cumulative volume (in cubic meters) of transuranic waste shipped from LANL. No transuranic waste was shipped during fiscal years 2015 or 2016.

AIR QUALITY AND PROTECTION

Clean Air Act

Title V Operating Permit

Under the Clean Air Act, the Laboratory is regulated as a major source of air pollutants, based on its potential to emit nitrous oxides, carbon monoxide, and volatile organic compounds. The Laboratory has a Clean Air Act, Title V Operating Permit, and is required to keep air emissions of these and other regulated pollutants below permit limits. On February 27, 2015, we received a renewal of our Title V Operating Permit (P100-R2). This permit is valid through February 27, 2020. We submitted a Title V permit modification application in July 2016 for five small spray evaporators to replace a larger unit that was taken out of service.

The Laboratory annually certifies its compliance with the Title V Operating Permit and reports all permit deviations that occurred to the New Mexico Environment Department. Deviations occur when any permit condition is not met. In 2016, the Laboratory had one Title V Operating Permit deviation. The deviation was associated with the requirement to conduct monthly opacity measurements at the on-site asphalt plant. In January 2016, the opacity measurements were not completed because the plant operated for less than 2 hours and then ran out of asphalt oil. The asphalt oil delivery was not received until February 2, 2016. Two sets of opacity measurements were taken in February 2016 and both showed 0% opacity. Operating procedures and operator training were also reviewed and updated with an emphasis on this requirement.

The Technical Area 03 power plant as well as boilers and generators located across the Laboratory emit nitrous oxides, carbon monoxide, and particulate matter. The Laboratory's highest levels of emissions in 2016 were significantly lower than the permit limits; for example, nitrogen oxide emissions were approximately 13% of the permit limit, carbon monoxide emissions were 11% of the permit limit, and particulate matter emissions were 3% of the permit limit. No emissions in excess of permit limits occurred from any of the permitted sources.

Table 2-3 summarizes the Laboratory's emissions data.

Table 2-3
Calculated Emissions of Regulated Air Pollutants Reported to the New Mexico Environment Department in 2016

Emission Unit	Pollutants (tons)[a]					
	NOx	SOx	PM	CO	VOCs	HAPs
Asphalt plant	0.004	0.002	0.003	0.15	0.003	0.003
Technical Area 03 power plant (3 boilers)	10.37	0.11	1.36	7.15	0.98	0.34
Technical Area 03 power plant (combustion turbine)	1.62	0.11	0.22	0.34	0.07	0.044
Research and development chemical use	n/a[b]	n/a	n/a	n/a	12.7	6.4
Degreaser	n/a	n/a	n/a	n/a	0.01	0.01
Data disintegrator	n/a	n/a	0.32	n/a	n/a	n/a
Stationary standby generators[c]	3.18	0.14	0.16	0.74	0.16	0.001
Miscellaneous small boilers	15.95	0.095	1.21	13.38	0.85	0.30
Permitted generators (11 units)	1.62	0.048	0.088	1.57	0.20	0.0004
Permitted boilers	2.83	0.019	0.30	1.61	0.23	0.063
TOTAL	**35.57**	**0.52**	**3.66**	**24.94**	**15.20**	**7.16**
Title V Permit Limits	**245**	**150**	**120**	**225**	**200**	**24**

[a] NOx = nitrous oxides; SOx = sulfur oxides; PM = particulate matter; CO= carbon monoxide; VOCs = volatile organic compounds; HAPs = other hazardous air pollutants.

[b] n/a = Not applicable.

[c] The stationary standby generators are no longer sources in the Laboratory's Title V permit. However, they are included in the table for comparability with previous annual site environmental reports.

Figure 2-4 depicts a 5-year history of pollutant emissions. Emissions from 2012 through 2016 are very similar and remain relatively constant.

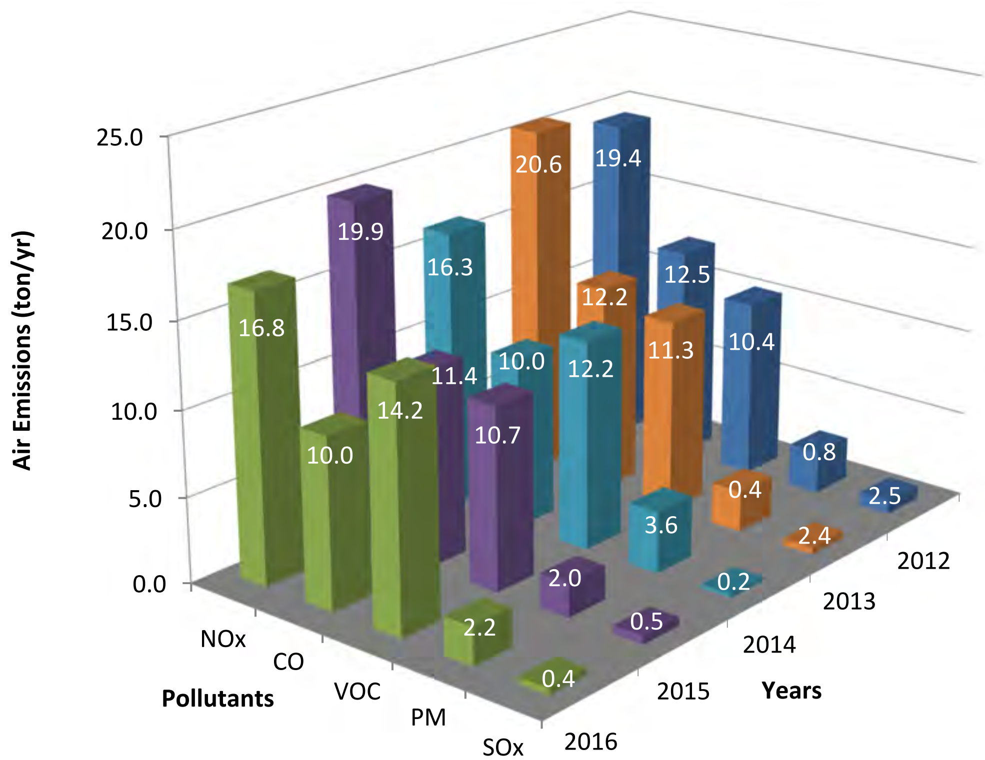

Figure 2-4 LANL criteria pollutant emissions from 2011 through 2016 for annual emissions inventory reporting. These totals do not include small boilers or standby generators.

Management of Refrigerants and Halons under Title VI – Stratospheric Ozone Protection

Title VI of the Clean Air Act regulates ozone-depleting substances, such as halons and refrigerants, as well as other non-ozone-depleting refrigerants, such as hydrofluorocarbons. The regulation prohibits the Laboratory from knowingly venting or otherwise releasing into the environment any regulated refrigerant or halon during maintenance, service, repair, or disposal of refrigeration equipment or fire-suppression systems. Refrigeration equipment includes, but is not limited to, any air conditioner, motor vehicle air conditioner, refrigerator, chiller, or freezer. All technicians who work on refrigeration equipment at the Laboratory, and all of the recovery equipment that they use, are certified by the U.S. Environmental Protection Agency. The Laboratory maintains records of all work involving refrigerants, including their purchase, use, and disposal. We are working to remove refrigeration equipment that uses ozone-depleting substances and hydrofluorocarbons and replace it with equipment that uses environmentally friendly refrigerants listed as acceptable under the U.S. Environmental Protection Agency's Significant New Alternatives Program. In 2016, we removed approximately 800 pounds of Class II ozone-depleting substances and 440 pounds of hydrofluorocarbons. Additionally, the Laboratory has made significant progress in eliminating halon use in fire-suppression systems.

Regulation of Airborne Radionuclide Emissions under the Radionuclide National Emission Standards for Hazardous Air Pollutants

Emissions of airborne radionuclides are regulated under the Radionuclide National Emission Standards for Hazardous Air Pollutants, which sets a dose limit of 10 millirem per year to any member of the public from air emissions. The estimated maximum dose to a member of the public in 2016 via air emissions was 0.12 millirem, 1.2% of the limit (see Chapter 8, Radiological Dose Assessment for the Public section).

New Mexico Air Quality Control Act

New Source Reviews

The State of New Mexico requires that new or modified sources of emissions be evaluated to determine whether they (1) do not require a construction permit because they are exempted under the New Mexico Administrative Code (“exempted”), (2) do not produce sufficient emissions to require a construction permit (“no permit required”), (3) require a notice of intent to construct, or (4) require both a notice of intent to construct and a construction permit. The Laboratory reviews plans for new and modified projects, activities, and operations in order to identify air quality compliance requirements. We submitted three exemption notifications during 2016: one for a vacuum plasma spray chamber, one for seven small gas-fired comfort heaters and boilers, and one for a new emergency stand-by generator at Technical Area 63. We did not submit any “no permit required” determination requests in 2016.

In July 2016, a mechanical spray evaporator was taken out of service, and Laboratory personnel submitted a permit application to modify the Title V Operating Permit to replace this unit with five small evaporators with lower potential to emit. These smaller units were not subject to the requirement for construction permitting under new source review.

Asbestos Notifications

The National Emission Standards for Hazardous Air Pollutants require the Laboratory to provide advance notice to the New Mexico Environment Department for large renovation jobs that involve asbestos and for all demolition projects. The standards also require that facilities conducting activities involving asbestos mitigate visible airborne emissions and properly package and dispose of all asbestos-containing wastes.

We continued to perform renovation and demolition projects in accordance with the requirements for asbestos management and disposal. In 2016, 24 large renovation and demolition projects were completed. The New Mexico Environment Department was provided advance notice for each of these projects. All waste was properly packaged and disposed of at approved landfills.

SURFACE WATER QUALITY AND PROTECTION

Clean Water Act

The primary goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act establishes requirements for National Pollutant Discharge Elimination System permits for several types of effluent and storm water discharges. The permits described below establish specific chemical, physical, and biological criteria and management practices that the Laboratory must meet when discharging water. The U.S. Environmental Protection Agency, Region 6, issues and enforces the Laboratory's Clean Water Act permits. The New Mexico Environment Department certifies the permits as being protective of waters of the state and performs some compliance evaluation inspections and monitoring on behalf of the U.S. Environmental Protection Agency.

LANL's National Pollutant Discharge Elimination System Industrial and Sanitary Point-Source Outfall Permit

As of 2016, there are a total of 11 outfalls on the Laboratory's National Pollutant Discharge Elimination System Industrial and Sanitary Point-Source Outfall Permit (Outfall Permit) (Table 2-4). Six of the outfalls discharge cooling water from conventional cooling towers and one discharges treated sanitary waste. The Laboratory's current Outfall Permit requires weekly, monthly, quarterly, yearly, and term sampling to demonstrate compliance with different effluent quality limits. We report analytical results to the U.S. Environmental Protection Agency and the New Mexico Environment Department at the end of the monitoring period.

Table 2-4
Volume of Effluent Discharged from Permitted Outfalls in 2016

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2016 Discharge (gallons)
03A048	53-963/978	Los Alamos Neutron Science Center cooling tower	Los Alamos	23,016,700
051	50-1	Technical Area 50 Radioactive Liquid Waste Treatment Facility	Mortandad	0
04A022*	3-2238	Sigma emergency cooling system	Mortandad	260,100
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	254,100
03A181	55-6	Plutonium facility cooling tower	Mortandad	2,169,440
13S	46-347	Sanitary wastewater system plant	Sandia	0
001	3-22	Power plant (includes treated effluent from sanitary wastewater system plant)	Sandia	63,926,700
03A027	3-2327	Strategic Computing Complex cooling tower	Sandia	9,497,300
03A113	53-293/952	Los Alamos Neutron Science Center cooling tower	Sandia	224,200
03A199	3-1837	Laboratory Data Communications Center	Sandia	8,942,380
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2016 Total:	108,290,920

* This outfall's designation was changed from 03A022 to 04A022 in the October 1, 2014, permit to reflect only emergency cooling water and roof drain/storm water discharges to the outfall (cooling tower blowdown was diverted to the sanitary wastewater system plant).

Outfalls listed on the Outfall Permit that did not discharge in 2016 included Outfalls 05A055, 051, and 13S. During 2016, five of the 1024 samples collected from industrial outfalls exceeded effluent limits.

The following is a summary of the corrective actions the Laboratory took during 2016 to address the Outfall Permit exceedances.

- *Outfall 001, July 20, 2016, temperature = 24.1°C, permit limit = 24°C.* The exceedance was investigated, but the cause was not determined. The outfall discharge has met the permit limit during weekly compliance monitoring since that date.
- *Outfall 03A027, August 25, 2016, pH = 9.1 standard units, permit limit = maximum of 8.8 standard units.* The pH meter used for monitoring and making operational decisions at the Strategic Computing Complex cooling tower was compared with the one used for compliance monitoring at Outfall 03A027. Readings from the meter used at the Strategic Computing Complex were inconsistent with readings from the compliance monitoring meter. The staff replaced calibration reagents for the operational meter. After the pH meter maintenance, the outfall discharge remained within limits through September 8, 2016, when Outfall 03A027 was directed to Outfall 001.
- *Outfall 001, September 8, 2016, total polychlorinated biphenyl (PCB) congeners = 0.00190 micrograms per liter (µg/L), permit limit = 0.00064 µg/L.* A specific cause of the elevated total PCB congeners remains unknown. Corrective actions included the following:
  - ❖ Continuing PCB sampling at a variety of upstream locations
  - ❖ Installing new Sanitary Effluent Reclamation Facility pond evaporators to improve the evaporation capacity of the ponds
  - ❖ Increasing outfall blended water treatment as much as practical based on total Sanitary Effluent Reclamation Facility pond evaporation capacity.
  - ❖ Adding an additional granulated activated carbon treatment unit at the sanitary wastewater system plant to increase PCB treatment capability to approximately 100 gallons per minute for water being pumped to the Sanitary Effluent Reclamation Facility and Outfall 001 (April 2017)
- *Outfall 03A027, September 8, 2016, total PCB congeners = 0.00240 µg/L, permit limit = 0.00064 µg/L.* A specific cause of the elevated total PCB congeners in the cooling tower discharge remains unknown. See corrective actions above (Outfall 001, September 8, 2016).
- *Outfall 001, September 13, 2016, total PCB congeners = 0.00126 µg/L, permit limit = 0.00064 µg/L.* A specific cause of the elevated total PCB congeners remains unknown. See corrective actions above (Outfall 001, September 8, 2016).

National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites

The National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites (Construction General Permit) regulates storm water discharges from construction sites covering one or more acres. Laboratory compliance with the Construction General Permit includes developing storm water pollution prevention plans before construction and conducting site inspections during construction. A storm water pollution prevention plan describes the project activities, site conditions, best management practices for erosion control, and permanent control measures (such as storm water detention ponds) required for reducing pollutants in storm water discharges. We inspect the location and condition of controls at the site and identify corrective actions if needed.

During 2016, the Laboratory had 25 storm water pollution prevention plans for construction sites, including 1 for a National Nuclear Security Administration project not managed by the Laboratory's management and operating contractor. We performed 653 storm water inspections. Corrective action reports are prepared for all storm water management issues observed during inspections. If an issue is not fixed within the time frame specified in the report, a noncompliance is issued to the project. The inspectors found 99.5% of the inspection items to be in compliance.

National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities

The National Pollutant Discharge Elimination System Multi-Sector General Permit Program regulates storm water discharges from specific industrial activities and their associated facilities. The types of industrial activities conducted at the Laboratory covered under the National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities (Multi-Sector General Permit) include metal and ceramic fabrication, wood product fabrication, hazardous waste treatment and storage, vehicle and equipment maintenance, recycling activities, electricity generation, warehousing activities, and asphalt manufacturing.

The Multi-Sector General Permit requires the implementation of control measures, development of storm water pollution prevention plans, and monitoring of storm water discharges from permitted sites. 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 their impact
- Developing and implementing facility-specific storm water pollution prevention plans
- 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

The U.S. Environmental Protection Agency issued a new Multi-Sector General Permit on June 4, 2015. Los Alamos National Security, LLC, submitted a notice of intent to discharge under the 2015 Multi-Sector General Permit in September 2015, on behalf of the Laboratory, and received coverage in October 2015.

Storm water monitoring required in accordance with the Multi-Sector General Permit occurs from April 1 through November 30 of each year. Under the new permit, the benchmark values for some pollutants are now the same as New Mexico water quality standards. As such, some pollutant limits are significantly more stringent than under the previous permit, and thus there were more exceedances of permit limits in 2016 than in 2015. Some of these permit limit exceedances may be because of natural background conditions. A benchmark exceedance does not trigger a corrective action if it is determined that the exceedance is solely attributable to natural background sources. A study to identify naturally occurring background concentrations is underway. Noncompliances with the Multi-Sector General Permit during 2016 are listed in Table 2-5.

We implemented and maintained 12 storm water pollution prevention plans covering 14 facilities in 2016.

LANL's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (from Solid Waste Management Units and Areas of Concern)

The Laboratory's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (Individual Permit) authorizes discharges of storm water from 405 solid waste management units and areas of concern (sites) at the Laboratory. Site-specific storm water controls that reflect best industry practices are applied at each of the 405 sites to minimize or eliminate discharges of pollutants in storm water. These controls prevent or reduce storm water run-on or runoff at the sites or address the movement of soil from or to the sites. The controls are routinely inspected and maintained as needed.

For purposes of monitoring, sites are grouped into 250 site monitoring areas based on proximity and discharge to a common drainage point. The most representative storm water sampling locations are identified for each site monitoring area. Any storm water samples collected from these locations are analyzed to determine the effectiveness of the storm water controls. Storm water samples are collected when a particular site monitoring area is affected by a storm with sufficient rainfall to cause surface runoff, which does not happen every year. When target action levels for pollutants, based on New Mexico water quality standards, are exceeded in the samples, the Individual Permit requires additional corrective actions at the site. A site is removed from the Individual Permit when the corrective actions for the site are certified as complete by the U.S. Environmental Protection Agency, or when an alternative compliance strategy is approved.

In 2016, we completed the following tasks:

- Published the 2015 update to the Site Discharge Pollution Prevention Plan. It (1) identifies pollutant sources, (2) describes the control measures, and (3) describes the monitoring at all regulated sites.
- Completed 1194 inspections of storm water controls at the 250 site monitoring areas
- Completed 1292 sampling equipment inspections
- Conducted storm water monitoring at 162 site monitoring areas
- Collected post-certification storm water samples at three site monitoring areas and completing the monitoring at those sites
- Collected corrective action enhanced control confirmation samples at four site monitoring areas
- Installed 112 additional control measures at 34 site monitoring areas
- Installed 11 replacement baseline controls at 8 site monitoring areas
- Installed 10 enhanced controls at 2 site monitoring areas
- Completed correction action at four site monitoring areas or sites
- Received certification of completion of corrective action for two site monitoring areas or sites
- Documented two site monitoring areas or sites completed with results less than target action levels
- Submitted alternative compliance requests for 17 sites
- Held one public meeting and one technical meeting with public interest groups
- Completed website updates and public notifications
- Piloted the use of radio telemetry equipment in conjunction with automated samplers to aid in prioritizing sample collection and to improve program effectiveness

For more information on the Laboratory's Individual Permit, visit www.lanl.gov and search under the key words "Individual Permit." For more information on surface water quality at the Laboratory, see Chapter 6, Watershed Quality.

Table 2-5 summarizes the exceedance of water quality parameter limits, benchmarks, guidelines, or target action levels (depending on the type of permit) for all of the Laboratory's National Pollutant Discharge Elimination System permits.

Table 2-5
2016 Exceedances of Limits, Benchmarks, Guidelines, or Target Action Levels for LANL's National Pollutant Discharge Elimination System Permits

Outfall, Discharge Point, or Site Monitoring Area	Date(s) Sampled	Parameter	Result	Limit, Benchmark, or Target Action Level	Reporting Units[a]	Exceedance of Permit Limit?
Industrial and Sanitary Outfall Permit						
Outfall 001	07/20/16	Temperature	24.1	24	degrees Celsius	Yes
Outfall 03A027	08/25/16	pH	9.1	8.8	standard unit	Yes
Outfall 001	09/08/16	Total PCB congeners	0.00190	0.00064	µg/L	Yes
Outfall 03A027	09/08/16	Total PCB congeners	0.00240	0.00064	µg/L	Yes
Outfall 001	09/13/16	Total PCB congeners	0.00126	0.00064	µg/L	Yes
Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities						
MSGP00201	04/19/16 06/04/16	Iron, total	2955[b]	1000	µg/L	Yes
MSGP00201	08/04/16	Iron, total	4860[b]	1000	µg/L	Yes
MSGP00201	04/19/16 06/04/16 08/04/16 10/08/16	Nitrate plus nitrite nitrogen	0.898[b]	0.68	mg/L	Yes
MSGP00201	04/19/16 06/04/16 08/04/16	Aluminum, total recoverable	1604.3[b]	681	µg/L	Yes
MSGP00201	04/19/16 06/01/16 08/08/16 10/08/16	Zinc, dissolved	140.1[b]	76	µg/L	Yes
MSGP00401	04/18/16 06/27/16	Iron, total	4105[b]	1000	µg/L	Yes
MSGP00401	04/18/16 06/27/16 08/03/16	Nitrate plus nitrite nitrogen	1.178[b]	0.68	mg/L	Yes
MSGP00401	04/18/16	Aluminum, total recoverable	9060[b]	1699	µg/L	Yes
MSGP00501	07/01/16	Iron, total	9980[b]	1000	µg/L	Yes
MSGP00501	07/15/16	Iron, total	4450[b]	1000	µg/L	Yes
MSGP00901	05/19/16 06/07/16	Iron, total	4015[b]	1000	µg/L	Yes
MSGP01201	08/04/16	Iron, total	5150[b]	1000	µg/L	Yes
MSGP01201	08/04/16	Aluminum, total recoverable	1040.0	681.0	µg/L	Yes

Table 2-5 (continued)

Outfall, Discharge Point, or Site Monitoring Area	Date(s) Sampled	Parameter	Result	Limit, Benchmark, or Target Action Level	Reporting Units	Exceedance of Permit Limit?
MSGP02001	07/01/16 07/21/16 08/03/16	Zinc, dissolved	150.667[b]	76	µg/L	Yes
MSGP02901	04/15/16	Copper, dissolved	34.4	6.0	µg/L	Yes
MSGP03101	07/21/16	Aluminum, total recoverable	2990.0	1699.0	µg/L	Yes
MSGP03101	07/21/16	Copper, dissolved	11.3	8.0	µg/L	Yes
MSGP03101	07/21/16	Adjusted gross alpha	38.9	15.0	pCi/L	Yes
MSGP04701	05/15/16	Magnesium, total	0.609[b]	0.064	mg/L	Yes
MSGP04701	07/01/16	Magnesium, total	1.69[b]	0.064	mg/L	Yes
MSGP04701	08/03/16	Magnesium, total	0.368[b]	0.064	mg/L	Yes
MSGP04701	10/09/16	Magnesium, total	0.432[b]	0.064	mg/L	Yes
MSGP05001	05/06/16 06/05/16 08/02/16	Chemical oxygen demand	211[b]	120	mg/L	Yes
MSGP05001	05/06/16	Magnesium, total	1.4[b]	0.064	mg/L	Yes
MSGP05001	06/05/16	Magnesium, total	1.95[b]	0.064	mg/L	Yes
MSGP05001	08/02/16	Magnesium, total	1.57[b]	0.064	mg/L	Yes
MSGP05001	10/03/16	Magnesium, total	1.91[b]	0.064	mg/L	Yes
MSGP05101	07/25/16 08/03/16 09/17/16	Chemical oxygen demand	186.333[b]	120	mg/L	Yes
MSGP05101	07/25/16	Magnesium, total	8.79[b]	0.064	mg/L	Yes
MSGP05101	08/03/16	Magnesium, total	1.41[b]	0.064	mg/L	Yes
MSGP05101	09/17/16	Magnesium, total	1.54[b]	0.064	mg/L	Yes
MSGP05101	11/05/16	Magnesium, total	1.05[b]	0.064	mg/L	Yes
MSGP05101	07/25/16	Aluminum, total recoverable	14,100.0	1699.0	µg/L	Yes
MSGP07301	05/15/16	Copper, dissolved	32.5	6.0	µg/L	Yes
MSGP06901	05/15/16 06/23/16 08/03/16 10/08/16	Chemical oxygen demand	187.7[b]	120	mg/L	Yes
MSGP06901	05/15/16	Magnesium, total	0.776[b]	0.064	mg/L	Yes
MSGP06901	06/23/16	Magnesium, total	2.16[b]	0.064	mg/L	Yes
MSGP06901	08/03/16	Magnesium, total	0.547[b]	0.064	mg/L	Yes
MSGP06901	10/08/16	Magnesium, total	3.69[b]	0.064	mg/L	Yes
MSGP07201	07/25/16	Chemical oxygen demand	1220[b]	120	mg/L	Yes
MSGP07201	07/25/16	Magnesium, total	6.9[b]	0.064	mg/L	Yes
MSGP07201	11/21/16	Magnesium, total	1.75[b]	0.064	mg/L	Yes

Table 2-5 (continued)

Outfall, Discharge Point, or Site Monitoring Area	Date(s) Sampled	Parameter	Result	Limit, Benchmark, or Target Action Level	Reporting Units	Exceedance of Permit Limit?
MSGP07501	07/31/16	Aluminum, total recoverable	9240.0	681.0	µg/L	Yes
MSGP07501	07/01/16	Copper, dissolved	24.0	6.0	µg/L	Yes
MSGP07501	07/31/16	Adjusted gross alpha	36.3	15.0	pCi/L	Yes
Individual Permit Authorization to Discharge (from Solid Waste Management Units and Areas of Concern)[b]						
2M-SMA-2.2	07/01/16	Copper	4.8	4.3	µg/L	No
2M-SMA-2.2	07/01/16	Total PCBs	0.00427	0.00064	µg/L	No
ACID-SMA-2	11/04/16	Copper	11.9	4.3	µg/L	No
ACID-SMA-2	11/04/16	Gross alpha	65.3	15.0	pCi/L	No
ACID-SMA-2	11/04/16	Total PCB	0.0341	0.00064	µg/L	No
ACID-SMA-2.1	11/05/16	Aluminum	818	750	µg/L	No
ACID-SMA-2.1	11/05/16	Copper	5.36	4.3	µg/L	No
ACID-SMA-2.1	11/05/16	Total PCB	0.0112	0.00064	µg/L	No
M-SMA-4	08/03/16	Copper	11.5	4.3	µg/L	No
M-SMA-4	08/03/16	Total PCB	0.00897	0.00064	µg/L	No
PJ-SMA-10	07/31/16	Gross alpha	35.1	15.0	pCi/L	No
PJ-SMA-10	08/24/16	Gross alpha	68.1	15.0	pCi/L	No
S-SMA-0.25	06/04/16	Copper	40.4	4.3	µg/L	No
S-SMA-0.25	06/04/16	Gross alpha	28.5	15.0	pCi/L	No
S-SMA-0.25	06/04/16	Total PCB	0.00173	0.00064	µg/L	No
S-SMA-0.25	06/04/16	Zinc	290	42	µg/L	No
S-SMA-6	06/23/16	Aluminum	964	750	µg/L	No
S-SMA-6	06/23/16	Gross alpha	289	15.0	pCi/L	No
S-SMA-6	06/23/16	Total PCB	0.00250	0.00064	µg/L	No

[a] mg/L = Milligrams per liter; pCi/L = picocuries per liter.

[b] Result is an average of 1 to 4 analytical results collected on the reported sample dates, where the average of 4 results or fewer will, or is mathematically certain, to exceed the permit limit.

Aboveground Storage Tank Program

The Laboratory's Aboveground Storage Tank Program staff ensure compliance with the requirements of the U.S. Environmental Protection Agency under the Clean Water Act and with the New Mexico Administrative Code regulations administered by the New Mexico Environment Department's Petroleum Storage Tank Bureau for aboveground storage tanks.

The Laboratory operates 10 tank systems with 12 storage tanks. During 2016, we were in full compliance with the federal Clean Water Act requirements for these tanks.

Petroleum Storage Tank Bureau staff inspected 11 of the aboveground storage tanks at the Laboratory in 2016. The Bureau issued "Lists of Compliance Concerns" that resulted in notices of deficiency for two of the diesel fuel tank systems under the New Mexico

Administrative Code regulations. Tank modifications were developed and coordinated with the Petroleum Storage Tank Bureau and are scheduled to be completed in 2017.

The U.S. Environmental Protection Agency requires spill prevention, control, and countermeasure plans for facilities with aboveground storage tank systems. In 2016, Laboratory staff updated two of these plans and conducted 28 inspections of facilities with plans.

Clean Water Act Section 404/401 Permits

Section 404 of the Clean Water Act requires the Laboratory to receive verification from the U.S. Army Corps of Engineers that proposed work within perennial, intermittent, or ephemeral watercourses complies with nationwide Section 404 permit conditions. Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by U.S. Army Corps of Engineers comply with state water quality standards. The New Mexico Environment Department reviews Section 404/401 permit applications and issues separate Section 401 certification letters, which may include additional permit requirements to meet state stream standards for individual Laboratory projects. Section 404/401 verifications and certifications that were issued or active at the Laboratory in 2016 are listed in Table 2-1.

On September 21, 2015, the U.S. Army Corps of Engineers and the New Mexico Environment Department conducted a compliance inspection of the Technical Area 72 firing site storm water control project and the Pueblo Canyon grade-control spurs and E060.1 gage revitalization project. On September 29, 2015, the U.S. Army Corps of Engineers issued a Notice of Non-Compliance for the Technical Area 72 firing site project for violations related to ammunition fire remaining in the water course and damage to the soil cement channel caused by ammunition fire. On October 29, 2015, we responded by issuing a corrective action plan, which outlined the immediate removal of ammunition from the water course and contained a plan for continued removal until corrective actions were completed by September 30, 2016. The corrective actions and Range 1, 3, and 4 improvements were completed by September 30, 2016. Monitoring for channel stability continued in 2016 and results were provided in the 2016 annual report to the U.S. Army Corps of Engineers.

GROUNDWATER QUALITY AND PROTECTION

Safe Drinking Water Act

The Los Alamos County Department of Public Utilities supplies water for Los Alamos, White Rock, the Laboratory, and Bandelier National Monument. The Department of Public Utilities issues an annual drinking water quality report, as required by the Safe Drinking Water Act. That report is available at https://indd.adobe.com/view/bc77e55e-9218-46ee-8194-13ed0f768a79. For the latest year of publication (2016), the drinking water quality for Los Alamos met all U.S. Environmental Protection Agency regulations.

New Mexico Water Quality Control Commission Groundwater Discharge Regulations

The New Mexico Water Quality Control Commission sets regulations for liquid discharges onto or below ground surfaces to protect groundwater in New Mexico. The New Mexico Environment Department enforces the groundwater discharge regulations and may require a facility that discharges effluents to submit a discharge plan and obtain a permit. In 2016, we had four discharge permits and one discharge permit application pending.

Technical Area 46 Sanitary Wastewater System Plant Discharge Permit DP-857

On December 16, 2016, the Laboratory was issued a renewal and modification for discharge permit DP-857, which applies to combined effluent discharges from the Technical Area 46 sanitary wastewater system plant, the Sanitary Effluent Reclamation Facility, and the Sigma Mesa evaporation basins.

The permit conditions require quarterly, semi-annual, and annual sampling of (1) the sanitary wastewater system plant's treated water product before discharge, (2) effluent from Outfalls 001 and 03A027 (outfalls that can discharge water from the sanitary wastewater system plant), and (3) alluvial groundwater well SCA-3 in Sandia Canyon. During 2016, none of the samples collected exceeded the New Mexico Water Quality Control Commission groundwater standards. On October 20, 2016, the New Mexico Environment Department conducted an unannounced inspection of the Technical Area 46 sanitary wastewater system plant, the Technical Area 03 Sanitary Effluent Reclamation Facility, and the Technical Area 60 Sigma Mesa evaporation basins. The inspectors observed that the facilities met the operation and maintenance conditions required in discharge permit DP-857.

Domestic Septic Tank Disposal Systems Discharge Permit DP-1589

On July 22, 2016, the New Mexico Environment Department issued discharge permit DP-1589 to the Laboratory for discharges from eight septic tank disposal systems. These septic systems (a combined septic tank and leach field) are located in remote areas of the Laboratory where access to the sanitary wastewater system plant's collection system is not practicable. Four of the eight septic tank disposal systems are active; the remaining four systems are inactive because water service to the buildings using the septic tank disposal systems is disconnected.

Discharge permit DP-1589 requires new monitoring and inspections for the Laboratory's septic tank disposal systems. These include, but are not limited to, the following: routine septic tank sampling, septic tank water-tightness testing, inspection of the septic tank for the accumulation of scum and solids, and inspection of the disposal system (leach field). No inspection of the Laboratory's septic tank disposal systems was conducted in 2016.

Technical Area 50 Radioactive Liquid Waste Treatment Facility Discharge Plan and Permit Application DP-1132

On August 20, 1996, the Laboratory submitted a discharge plan and permit application for the Radioactive Liquid Waste Treatment Facility at Technical Area 50. On November 18, 2011, the New Mexico Environment Department requested an updated discharge plan and permit application for the facility and the Technical Area 52 solar evaporative tank. We submitted an application on February 16, 2012, and supplemental information on August 10, 2012. On September 13, 2013, the New Mexico Environment Department issued a draft discharge permit for public review and comment.

During 2016, the Laboratory and the New Mexico Environment Department held two negotiation sessions on the draft discharge permit. Some citizen groups, specifically Communities for Clean Water and Concerned Citizens for Nuclear Safety, participated in one of the two sessions. Issuance of a final discharge permit was pending at the end of 2016.

We have voluntarily conducted quarterly sampling of the Radioactive Liquid Waste Treatment Facility's effluent and of alluvial groundwater monitoring wells MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon since 1999. When liquids are present, we test for nitrate (as nitrogen), fluoride, total dissolved solids, and perchlorate. None of the quarterly groundwater samples from the alluvial wells exceeded the New Mexico Water Quality Control Commission groundwater standards for the tested analytes. No effluent samples were collected in 2016 because the Radioactive Liquid Waste Treatment Facility did not discharge to Mortandad Canyon; all treated water was evaporated on-site. The New Mexico Environment Department did not conduct an inspection of the Radioactive Liquid Waste Treatment Facility in 2016.

Land Application of Treated Groundwater Discharge Permit DP-1793

On July 27, 2015, the New Mexico Environment Department issued discharge permit DP-1793 to the Laboratory for the discharge of treated groundwater by land application (spraying water after treatment onto the surface of the ground). Under the permit, individual work plans must be submitted for approval for each land application project. Groundwater projects involving land application include activities such as well pumping tests, aquifer tests, well rehabilitation, and tracer studies. Work plans are posted to the Laboratory's electronic public reading room for a 30-day public comment period, and each work plan addresses how groundwater will be treated so that constituent concentrations are less than 90% of the New Mexico Water Quality Control Commission groundwater standards before discharge.

In 2016, the Laboratory submitted two work plans to the New Mexico Environment Department for approval. Work Plan #3, for the extraction, treatment, and land application of groundwater contaminated with chromium, was approved by the New Mexico Environment Department on May 24, 2016. All activities under Work Plan #3 were completed on December 15, 2016, with the discharge report submitted to the New Mexico Environment Department on February 13, 2017. Work Plan #4, for the extraction, treatment, and land application of groundwater contaminated with high explosives, was approved by the New Mexico Environment Department on May 27, 2016. All activities under Work Plan #4 were completed on December 21, 2016, with the discharge report submitted to the New Mexico Environment Department on February 13, 2017. In addition, the annual report for DP-1793 was submitted to the New Mexico Environment Department on February 27, 2017. Sample results for all water that was land applied under both work plans demonstrated constituents of concern were below regulatory limits. All reports were submitted within compliance deadlines.

Injection of Treated Groundwater into Class V Underground Injection Control Wells Discharge Permit DP-1835

On August 31, 2016, the New Mexico Environment Department issued discharge permit DP-1835 for the injection of treated groundwater into six Class V underground injection control wells in Mortandad Canyon. Discharge permit DP-1835 authorizes the withdrawal of chromium-contaminated groundwater from three extraction wells, treatment by ion exchange, and the injection of treated groundwater back into the regional aquifer via six underground injection control wells. Treated groundwater is sampled to demonstrate that chromium concentrations are less than 90% of the New Mexico Water Quality Control Commission groundwater standard for chromium (50 μg/L) before injection. Injection of treated groundwater to two of the underground injection control wells occurred under this permit between December 1 and December 21, 2016. All samples of the treated groundwater demonstrated chromium was below regulatory limits.

Compliance Order on Consent Groundwater Activities

The Laboratory performed groundwater protection activities in 2016 as directed by the New Mexico Environment Department under the Compliance Order on Consent. More information is available in Chapter 5, Groundwater Monitoring. Activities included sampling and testing groundwater from wells for general monitoring of groundwater quality, investigating the chromium and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) groundwater plumes, and installing new wells for the interim measure. In 2016, we installed five new injection wells for the chromium project (CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5) and one new extraction well (CrEX-3). A multi-well aquifer test was conducted at three wells [CdV-9-1(i), CdV-16-4ip, and CdV-16-1(i)] in Technical Areas 09 and 16.

OTHER ENVIRONMENTAL STATUTES AND ORDERS

National Environmental Policy Act

The National Environmental Policy Act requires federal agencies to consider the environmental impacts of proposed activities, operations, and projects in decision-making. The act requires the preparation of environmental assessments or environmental impact statements for any projects or activities having the potential for significant environmental impacts and includes a public participation component. The Laboratory operates under a site-specific Site-Wide Environmental Impact Statement and associated Supplement Analyses. DOE issued the 2008 Site-Wide Environmental Impact Statement in May 2008 (DOE 2008a).

Laboratory staff review proposed projects to determine whether they have coverage under the existing Site-Wide Environmental Impact Statement or other existing National Environmental Policy Act documents issued by DOE. Laboratory staff reviewed approximately 1190 proposed projects for National Environmental Policy Act coverage in 2016. Projects or activities that do not have coverage under existing documents require new National Environmental Policy Act analyses.

In 2016, DOE prepared a Supplement Analysis to the 2008 Site-Wide Environmental Impact Statement for the proposal to implement facility modifications in order to maintain safe handling and storage, and to conduct processing studies, of 60 transuranic remediated nitrate salt waste drums at the Laboratory. The proposal included implementing minor building modifications, installing a pressure-release device with supplemental filtration, and conducting tests to determine appropriate treatment methodologies. DOE determined the environmental impacts of the proposed actions were bounded by analyses presented in the 2008 LANL Site-Wide Environmental Impact Statement (DOE 2016a).

DOE prepared a second Supplement Analysis to the 2008 Site-Wide Environmental Impact Statement for the proposal to treat, repackage, transport on-site, and store 89 transuranic waste drums for transport to and disposition at the Waste Isolation Pilot Plant. DOE determined there would be no substantial changes and the proposed actions were bounded by the analyses presented in the 2008 LANL Site-Wide Environmental Impact Statement (DOE 2016b).

Three projects were approved to proceed under existing DOE categorical exclusions: Technical Area 03 Substation Replacement (DOE 2016c), Unmanned Aerial System User Facility (DOE 2016d), and Detection and Analysis of Chemicals (DOE 2016e).

Approved LANL National Environmental Policy Act documents are available at http://nnsa.energy.gov/aboutus/ouroperations/generalcounsel/nepaoverview/nepa/lafo.

National Historic Preservation Act

The National Historic Preservation Act requires federal agencies to consider the effects activities may have on historic properties, including archaeological sites and historic buildings. The act requires evaluation of impacts of a project on any historic properties and mitigation of any adverse effects. A cultural resources management plan, available at http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-04-8964 (LANL 2006), describes the Laboratory's process for implementing the National Historic Preservation Act. During 2016, we continued to update the cultural resources management plan and an associated programmatic agreement for the management of historic properties at the Laboratory.

During fiscal year 2016, we supported 39 projects that needed verification of previous historic property survey results. Five new archaeological sites were identified. Sixty-one archaeological sites were determined eligible for the National Register of Historic Places. The summary of projects is reported here on a fiscal year basis to coincide with other cultural resources reporting requirements.

We conducted the annual inspection of the Museum of Indian Arts and Culture in Santa Fe, New Mexico, to ensure appropriate preservation and curation of artifacts from 39 archaeological sites excavated from LANL property during 2002 through 2006 for the Laboratory's land conveyance and transfer project, along with artifacts from earlier Laboratory projects. These inspections are required under the Code of Federal Regulations, Title 36, Part 79, Curation of Federally-Owned and Administered Archaeological Collections.

We conducted archival documentation for eight projects impacting historic buildings at Technical Areas 03, 16, 22, 39, 40, 54, and 57. This work included interior and exterior inspections of the buildings, digital and archival (black and white photographic prints on acid-free paper) photography, and architectural documentation (collection of all drawings and plans related to the building). Research on the historical uses of the buildings was conducted using source materials from the Laboratory archives and records center, historical photography, the Laboratory's public reading room, and previously conducted oral interviews. Cultural resources staff participated in surveillance and maintenance evaluations of the Laboratory's most significant historic properties, including the 17 buildings and structures referenced in the 2014 Manhattan Project National Historical Park legislation (see Chapter 3).

We continued to conduct consultations with pueblos regarding identifying and protecting traditional cultural properties, human remains, and sacred objects in compliance with the National Historic Preservation Act and the Native American Graves Protection and Repatriation Act.

Endangered Species Act

The Endangered Species Act requires federal agencies to protect federally listed threatened or endangered species, including their habitats. We implement these requirements through our biological resources management plan (LANL 2007), sensitive species best management practices source document (Hathcock et al. 2015, updated March 2015) and habitat management plan (LANL 2015b).

The Laboratory contains habitat for three federally listed species: the southwestern willow flycatcher (*Empidonax traillii extimus),* the Jemez Mountains salamander (*Plethodon neomexicanus),* and the Mexican spotted owl (*Strix occidentalis lucida).* Two other federally listed species occur near the Laboratory: the New Mexico meadow jumping mouse (*Zapus hudsonius luteus)* and the western distinct population segment of the yellow-billed cuckoo (*Coccyzus americanus)*. 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 2-6).

Table 2-6
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	Yellow-billed cuckoo (western distinct population segment)	T, NMS	High
Zapus hudsonius luteus	New Mexico meadow jumping mouse	E, NME	Low
Haliaeetus leucocepahlus	Bald eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed hummingbird	NMT	Low
Amazilia violiceps	Violet-crowned 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, FSOC, FSS	Moderate

[a] C = Federal Candidate Species; E = Federal Endangered; FSOC = Federal Species of Concern; FSS = Forest Service Sensitive Species; NME = New Mexico Endangered; NMS = New Mexico Sensitive Taxa (informal); NMSOC = New Mexico Species of Concern; NMT = New Mexico Threatened; PE = Proposed Endangered; PT = Proposed Threatened; S1 = Heritage New Mexico: Critically Imperiled in New Mexico; T = Federal Threatened.

[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.

We review proposed projects to determine if projects have the potential to impact federally listed species or their habitats. During 2016, we reviewed 887 excavation permits, 221 project profiles in the permits and requirements identification system, 14 minor siting proposals, and 9 storm water pollution prevention plans for potential impacts to threatened or endangered species. If there is a potential for impacts, biological resources staff work with project personnel to either modify the project to avoid the impacts or to prepare a biological assessment for consultation with the U.S. Fish and Wildlife Service. We prepared one biological assessment during 2016. This assessment analyzed the impacts to the Jemez Mountains salamander by a proposed project to dig seismic fault trenches to examine seismic hazards at LANL (LANL 2016b) on the western boundary of the Laboratory and on U.S. Forest Service and Bandelier National Monument properties.

We also conducted surveys for the Mexican spotted owl, southwestern willow flycatcher, and Jemez Mountains salamander. Mexican spotted owls and Jemez Mountains salamanders were found on Laboratory property again in 2016. Two Mexican spotted owl nesting locations were discovered on Laboratory property during 2016, and two owlets were fledged. Southwestern willow flycatchers were not found during surveys, but three willow flycatchers of unknown subspecies were detected.

Migratory Bird Treaty Act

Under 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 project reviews, Laboratory biologists provide specific comments for projects with the potential to impact migratory birds, their eggs, or nestlings. In general, projects that remove vegetation that may contain bird nests are scheduled before or after the bird nesting season.

During 2016, we continued annual breeding season and winter surveys in all major habitat types and continued monitoring avian nest boxes. Staff conducting nest box monitoring have found no significant differences to date between the nesting success of birds in nest boxes near firing sites versus in nest boxes at control sites. In addition, biologists completed bird mist-netting and banding during the breeding season in Sandia Canyon and during fall migration in Pajarito Canyon (Thompson and Hathcock 2016). All of these efforts support the DOE's commitment to "promote monitoring, research, and information exchange related to migratory bird conservation and program actions that may affect migratory birds…" as stated in the September 12, 2013, Memorandum of Understanding between the DOE and the U.S. Fish and Wildlife Service.

Floodplain and Wetland Executive Orders

We comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands, by preparing floodplain and wetland assessment for projects in floodplains or near wetlands. Two floodplain assessments were prepared during 2016 for sediment retention projects in Potrillo (LANL 2016c) and Ancho Canyons (LANL 2016d). No violations of the DOE floodplain/wetland environmental review requirements were recorded in 2016.

Toxic Substances Control Act

The Toxic Substances Control Act addresses the production, importation, use, and disposal of specific chemicals, including PCBs. The Laboratory's responsibilities under the Toxic

Substances Control Act involve record-keeping and reporting on (1) the disposal of PCB-containing substances, including dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills and (2) the import or export of small quantities of chemicals used in Laboratory research activities.

During 2016, the Laboratory shipped 25 containers of PCB-containing wastes off-site for disposal or recycling. The total mass of PCB waste was 2005.8 kilograms. PCB wastes were sent to a U.S. Environmental Protection Agency–authorized treatment and disposal facility in Veolia, Colorado. Five Toxic Substances Control Act import/export reviews were conducted in 2016 for chemicals at the Laboratory's Property Management Group Customs Office. The purpose of these reviews is to ensure that chemicals purchased by or shipped out of the Laboratory are in full compliance with the Toxic Substances Control Act regulations.

We have been tracking the removal of PCB-contaminated equipment and components for more than 18 years. Items such as transformers, capacitors, and other components using PCB-containing dielectric oil have been identified and tracked to disposal. In 2016, there are six remaining items that are being stored at the Laboratory's Chemistry and Metallurgical Research facility pending final disposition.

Federal Insecticide, Fungicide, and Rodenticide Act; New Mexico Pesticide Control Act; and National Pollutant Discharge Elimination System Pesticide General Permit

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the distribution, sale, and use of pesticides. The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the act throughout the state. 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. Pesticide usage in 2016 was reported to the U.S. Environmental Protection Agency in accordance with the National Pollutant Discharge Elimination System Pesticide General Permit.

Table 2-7 shows the amounts of pesticides the Laboratory used in 2016.

Table 2-7
Herbicides and Pesticides

Herbicide	Amount
Velossa	220 gallons
Ranger Pro Herbicide	90 gallons
Insecticide	**Amount**
Maxforce Complete Brand Granular Insect Bait	0.75 pounds
Advion Ant Gel	0.031 pounds
Prescription Treatment Brand P.I. Contact Insecticide Formula 1	0.023 gallons
PT Wasp Freeze II and Hornet Insecticide	0.54 gallons
Water Treatment Chemical	**Amount**
AQUACAR Sump Buddy	3.5 pounds
Garratt-Callahan Formula 316-T	3 pounds
Houghton Chemical Purobrom Tablets	5680 pounds

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 at DOE sites. 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.

DOE Order 232.2, Occurrence Reporting and Processing of Operations Information

DOE Order 232.2, Occurrence Reporting and Processing of Operations Information, requires that abnormal events or conditions that occur during facility operations must be reported. An "occurrence" is one or more event or condition that may adversely affect workers, the public, property, the environment, or the DOE mission.

All reportable environmental occurrences at the Laboratory for 2016 are listed in Table 2-8.

Table 2-8
2016 Environmental Occurrences

Title	Description and Comments	Status
Criterion Significance Category: Criterion 5A(2), Significance Category 4		
Water line leak exceeds New Mexico Environment Department permit at Technical Area 03, building 30 fire protection system	On Friday, February 26, 2016, a water leak was discovered by Laboratory security personnel at Technical Area 03, building 30. Personnel notified the Utilities and Infrastructure facility supervisor. The facility supervisor notified Maintenance and Site Services personnel and the Utilities and Infrastructure water superintendent. The Maintenance and Site Services personnel isolated the water leak to both potable and fire protection water to the affected facilities. Repairs were completed the same day. Environmental Compliance Programs personnel walked down the area impacted by the potable water leak. The release was estimated at approximately 7000 gallons. There was minimal sediment transport on the east side of the building. The water entered a storm drain that is connected to Twomile Canyon. The flow path is well defined in that area and no erosion was observed. Based on the volume of water, the release was reported to the New Mexico Environment Department pursuant to 20.6.2.1203 of the New Mexico Administrative Code.	Closed

Table 2-8 (continued)

Title	Description and Comments	Status
Poly storage tank breach of purge water at Technical Area 60 Sigma Mesa exceeds New Mexico Environment Department permit	On Wednesday, May 25, 2016, the Utilities and Infrastructure Facility Operations Director designee was notified that a 5000-gallon poly holding tank was breached at the Technical Area 60 Sigma Mesa laydown yard when a sub-tier contractor crew was transferring purge water from sampling well locations from a 5-gallon bottle to the large poly tank. The crew and the Environmental Remediation Field Services Manager prevented the flow into the canyon and plugged the tank breach. The crew used the bed of a three-quarter-ton truck to enable the transfer of water from the bottle to the larger tank. When the truck was moved forward to leave the site, its rear wheel came in contact with the poly tank's lower threaded drain plug, located directly below the access port on top of the tank, and the plug was sheared. The tank lost approximately 2800 gallons of purge water not suitable for land application. The majority of the purge water was contained within the Sigma Mesa laydown yard footprint and the fenceline, which is approximately 200 feet from the tank breach. Minimal amounts flowed outside the fenceline, and none of the purge water reached the canyon edge. The subcontractor crew and Environmental Remediation Field Services operators transferred the remaining purge water from the breached tank into a new poly tank and then collected the pooled water from the ground and pumped it into the new tank. Based on the volume and quality of water discharged, the release was reportable to the New Mexico Environment Department pursuant to 20.6.2.1203 of the New Mexico Administrative Code. Environmental Compliance Programs personnel notified the New Mexico Environment Department verbally the day of the spill and followed up with a written report to the New Mexico Environment Department and the U.S. Environmental Protection Agency. Actions taken included implementing a learning team activity.	Closed
Chilled water system release requires remediation	On Sunday, July 3, 2016, at Technical Area 53, Sector A, a chiller gasket failed, releasing approximately 700 gallons of chilled water containing sodium nitrate, which is a corrosion inhibitor and regulated by the New Mexico Environment Department. Approximately 200 gallons reached a water course. Environmental Compliance Programs staff reported the spill to the New Mexico Environment Department under 20.6.2.1203 of the New Mexico Administrative Code. Staff calculated the amount of sodium nitrate in the 700 gallons of water was just over 1 pound, which did not require any further reporting under 40 Code of Federal Regulations 302. Actions taken included the following: • Replacing the damaged gasket and refilling the chiller • Recovering the residual water from the storm sewer system impacted by the release • Applying potable water and a cleaner to the asphalt south of Technical Area 53, building 3, and absorbing the water	Closed
Release of oil to the environment requires a special report to New Mexico Environment Department	On Monday, August 15, 2016, at Technical Area 55, the Radiological Laboratory/Utilities/Office Building central utility building (building 440), it was discovered that chiller number 3 had leaked and released oil onto the roof. The oil, carried by rain water, entered the roof drain, exited the roof drain, entered a storm drain, and traveled to the water retention pond on the southeast side of the facility. Staff from Deployed Environment, Safety, and Health Facilities Support – TA-55 Facility Operations determined that the event would require a special report to the New Mexico Environment Department and considered the release above limits specified by the department. Oil-absorbent booms were placed around all drains and in the retention pond to absorb the oil released. Actions taken included the following: • Troubleshooting and repairing chiller number 3 • Investigating the use of oil-absorbent drain plugs • Reviewing preventive maintenance associated with chillers for adequacy	Closed

Table 2-8 (continued)

Title	Description and Comments	Status
Untreated groundwater spill at Technical Area 16 reported to the New Mexico Environment Department	On September 10, 2016, at Technical Area 16, Environmental Remediation Field Services personnel were conducting operational rounds when they discovered an estimated 50-gallon untreated groundwater leak on a well pad at the Technical Area 16 site for well CdV-16-4ip pump and treat operations. The most recent analytical results collected of the untreated groundwater on September 7, 2016, indicated approximately 165 parts per billion of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine); the New Mexico groundwater quality standard is 6.5 parts per billion. The leak came from a faulty O-ring between the Aqua TROLL multiparameter meter and the flow-through cell. The feed line to the multiparameter probe was immediately shut down and the leak was stopped; no vulnerabilities exist. The majority of the untreated groundwater was mitigated, contained, and pumped into storage tanks. Environmental Compliance Programs personnel determined the leak was reportable to the New Mexico Environmental Department pursuant to 20.6.2.1203 of the New Mexico Administrative Code and under discharge permit DP-1793. Actions taken included the following: • Environmental Remediation Field Services evaluating design of well piping and identifying vulnerabilities • Making necessary changes to piping • Adding periodic inspection and maintenance of the system to the operating procedure	Pending approval of closure
Criterion Significance Category: Criterion 9(1), Significance Category 4		
Receipt of notice of violation associated with 2015 Resource Conservation and Recovery Act inspections	On June 3, 2016, the Laboratory received a notice of violation from the New Mexico Environment Department with a proposed civil penalty of $80,100 for alleged violations of the New Mexico Hazardous Waste Management Regulations (20.4.1 New Mexico Administrative Code) and the Laboratory's Resource Conservation and Recovery Act Hazardous Waste Facility Permit resulting from the Resource Conservation and Recovery Act inspections conducted during 2015. During the week of June 8, 2015, New Mexico Environment Department personnel conducted hazardous waste compliance evaluation inspections at various Laboratory facilities. Based on these inspections and review of the information provided, the notice of violation cited the following alleged violations: (1) failure to keep hazardous waste containers closed at all times during storage at or near the point of generation, except when necessary to add or remove waste; (2) failure to mark satellite accumulation containers as "hazardous waste" or other wording to identify contents; (3) failure to determine applicable hazardous waste code; (4) failure to establish a satellite accumulation area at or near the point of generation; (5) failure to establish a satellite accumulation area at or near point of generation or to meet 90-day storage area requirements; (6) failure to fully characterize hazardous waste; (7) failure to comply with manifest requirements; (8) failure to list the addresses and phone numbers of all persons qualified to act as emergency coordinators in the contingency plan; (9) failure to submit a copy of the contingency plan to all local police and fire departments and hospitals that may be called during an emergency; (10) failure to promptly complete appropriate corrective measures associated with defects and deteriorations at a permitted unit discovered during an inspection; (11) failure to ensure that containers holding free liquids have a "free liquid" label; and (12) failure to maintain secondary containment systems in permitted units used to store waste that contains free liquids. Actions taken included providing a written response with corrective actions to the New Mexico Environment Department by July 1, 2016.	Closed

Table 2-8 (continued)

Title	Description and Comments	Status
Receipt of notice of violation associated with aboveground storage tank regulations, Technical Area 03	On December 20, 2016, the Utilities and Institutional Facilities Facility Operations Director received a notice of violation from the New Mexico Environment Department citing a Class B compliance violation of the Petroleum Storage Tank Regulations, 20.5 of the New Mexico Administrative Code, in reference to an aboveground storage tank system, Tank #38157, designated as TA-3-2459. On October 31, 2016, New Mexico Environment Department personnel conducted an inspection of the subject tank system and observed that the piping associated with the diesel fuel tank system at the point it transitioned into a conduit did not isolate the piping from water; therefore, the tank system was not protected from corrosion. Actions taken included Utilities and Infrastructure Engineering interfacing with the Technical Area 55 staff to determine a consistent and parallel path forward for the violation.	Open
Receipt of notice of violation associated with aboveground storage tank regulations, Technical Area 55	On December 20, 2016, the Technical Area 55 Facility Operations Director received a notice of violation from the New Mexico Environment Department citing a Class B compliance violation of the Petroleum Storage Tank Regulations, 20.5 New Mexico Administrative Code, in reference to the facility's diesel fuel aboveground storage tank system, Tank #38137, designated as TA-55-362. Actions taken included the following: • Submitting a memo to the New Mexico Environment Department to allow corrective actions to be completed and to allow Maintenance and Site Services personnel to install the tank lines • Developing 100% design and execute, once design approval is received from New Mexico Environment Department	Open
Receipt of notice of violation associated with 2016 Resource Conservation and Recovery Act inspections	On November 15, 2016, the Environmental Waste Management Operations Facility Operations Director received a notice of violation from the New Mexico Environment Department for alleged violations of the New Mexico Hazardous Waste Management Regulations (20.4.1 New Mexico Administrative Code) and the Laboratory's Resource and Conservation Recovery Act Hazardous Waste Facility Permit resulting from the June 2016 inspections at Technical Area 54. New Mexico Environment Department personnel cited the following alleged violations: (1) failure to accurately mark an accumulation start date on a drum; (2) failure to mark five drums containing D002 waste with "Free Liquids" labels; and (3) failure to promptly complete appropriate corrective measures associated with defects and deteriorations at a permitted unit discovered during an inspection. Actions taken included the following: • Marking the accumulation start date on the drum • Placing free liquid labels on the five drums • Emphasizing the importance of accurately labeling drums in Environmental Waste Management Operations and Waste Disposition Group All Hands' Meetings • Establishing improvement actions to address the failure to complete appropriate corrective measures associated with defects and deteriorations at a permitted unit	Closed

Criterion significance categories listed in Table 2-8 include the following:

Group 5: Environmental

Criterion 5A(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 9: Noncompliance Notifications

Criterion 9(1): Any written notification from an outside regulatory agency that a site/facility is considered to be in noncompliance with a schedule or requirement.

Significance Category 4: Events or circumstances that were mitigated or contained by normal operating practices but where reporting provides potential learning opportunities for others.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act requires emergency plans for more than 360 hazardous substances if they are present at a facility in amounts above specified thresholds. We are 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 2016.

The act also requires facilities to provide notification of leaks, spills, and other releases of listed chemicals into the environment if these releases exceed specified 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 reporting under the Emergency Planning and Community Right-to-Know Act during 2016.

Under the act, facilities must 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. We submitted a report to the State Emergency Response Commission and the Los Alamos County Fire and Police Departments listing 22 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2016.

Finally, all federal facilities are required to report total annual releases to the environment of listed chemicals that exceed activity thresholds. Laboratory operations exceeded the threshold for use of lead in 2016. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-9 summarizes the reported releases in 2016. There are no compliance violations associated with this use or release of lead.

Table 2-9
Summary of 2016 Total Annual Releases under Emergency Planning and Community Right-to-Know Act, Section 313

Reported Release	Lead (pounds)
Air emissions	3.16
Water discharges	0.26
On-site land disposal	1187
Off-site waste transfers	3805

METEOROLOGY

The National Climate Assessment presents predictions on how the climate of the southwest may change over the next century (Garfin et al. 2014). Predictions are made for temperature, precipitation (including snowpack), and wildland fires. DOE Order 436.1, Departmental Sustainability, directs the Laboratory to determine how its facilities and operations can mitigate risks associated with climatic factors, such as increasing temperatures and increasing wildland fire risk, and to identify the types of facilities/operations that could be impacted.

We began tracking climatic risk indices for the Laboratory in 2015. These indices will assist us in identifying when actions will be necessary to protect facilities and operations. The climatic risk indices are the following:

Temperature

- Annual average (in comparison with historical 30-year averages)
- Summer average minimum and maximum
- Winter average minimum and maximum
- Annual heating and cooling degree days

Precipitation

- Annual average (in comparison with historical 30-year averages)
- Number of days with greater than 0.5 inches of rain
- Number of days with greater than 0.75 inches of rain
- Number of days with greater than 1.0 inch of rain
- Average annual snowfall

Wind

- Annual average wind speed
- Annual peak gust wind speed
- Number of Red Flag Warning days

Indicator Species

- Benthic macroinvertebrates
- Breeding bird phenology
- Vegetative community composition and elevation range

Storm Water Flow

- Volume of water flowing off Laboratory property, normalized to precipitation
- Volume of water flowing onto Laboratory property, normalized by precipitation
- Number of days each boundary storm water gage flows during the year

Not all of these indicators are tracked on an annual basis. For example, benthic macroinvertebrates and breeding bird phenology will only be reported every 3 to 5 years. Below are the results of indices that were available in 2016.

Temperature

Temperature data have been collected in Los Alamos since 1910. Long-term trends in annual average temperatures are reported in the Meteorological Monitoring section of Chapter 4 of this report and are shown in Figure 2-5. The temperatures between 1960 and 2000 had no trend. The years 2001–2010 were approximately 1.5°F warmer than the previous 40 years, with the years 2011–2016 continuing to be significantly warmer (approximately 2.5°F) than the 1960–2000 averages. When average temperatures are broken down into summer and winter minimums and maximums, the summer minimum temperatures (Figure 2-6) demonstrate the strongest increasing trend from 1990 onward (an increase of approximately 5°F).

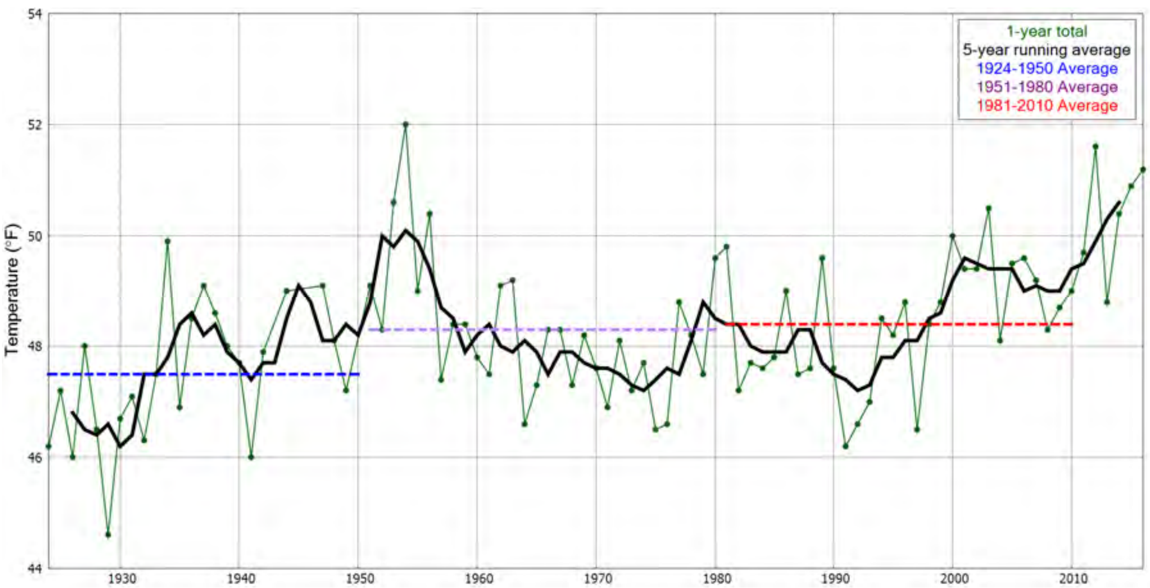

Figure 2-5 **Annual average temperatures for Los Alamos**

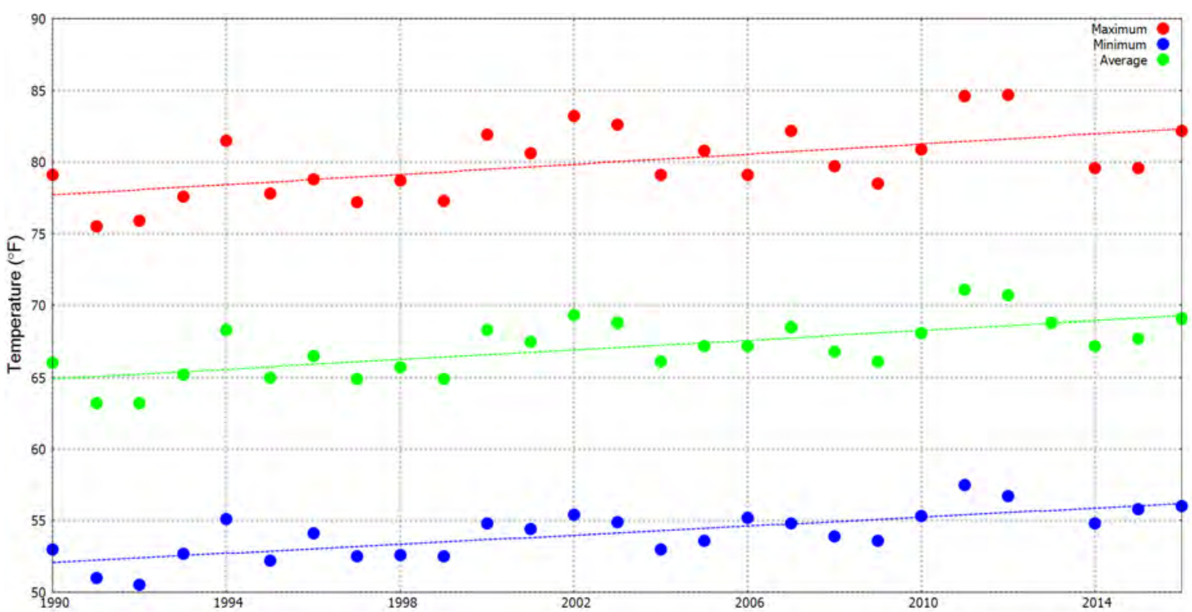

Figure 2-6 **Average summer (June, July, August) Los Alamos temperatures**

Changes in temperature can also be assessed by changes in the number of heating and cooling degree days. Heating and cooling degree days are the yearly sums of the number of degrees per day that the average temperature is either below (for heating degrees) or above (for cooling degrees) 65°F. The number of heating and cooling degree days is used to estimate the annual power usage needed to supply heat or air conditioning in buildings.

Similar to the annual average temperature, heating and cooling degree days did not exhibit any trend during 1950–1990. Since 1990, cooling degree days (Figure 2-7) have increased and heating degree days (Figure 2-8) have decreased.

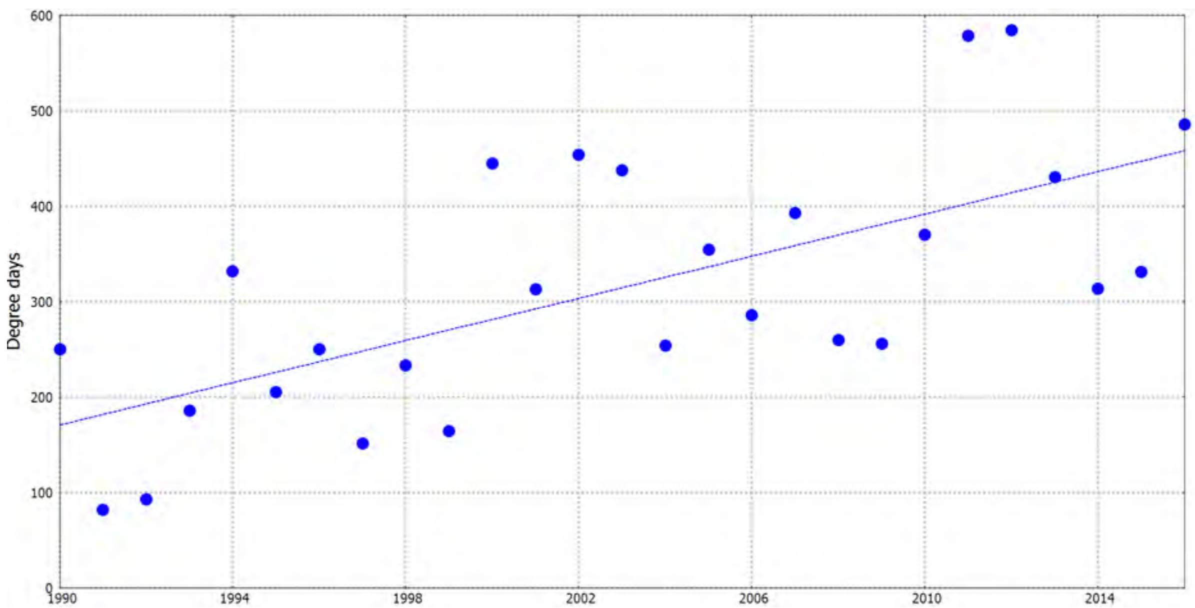

Figure 2-7 Los Alamos cooling degree days

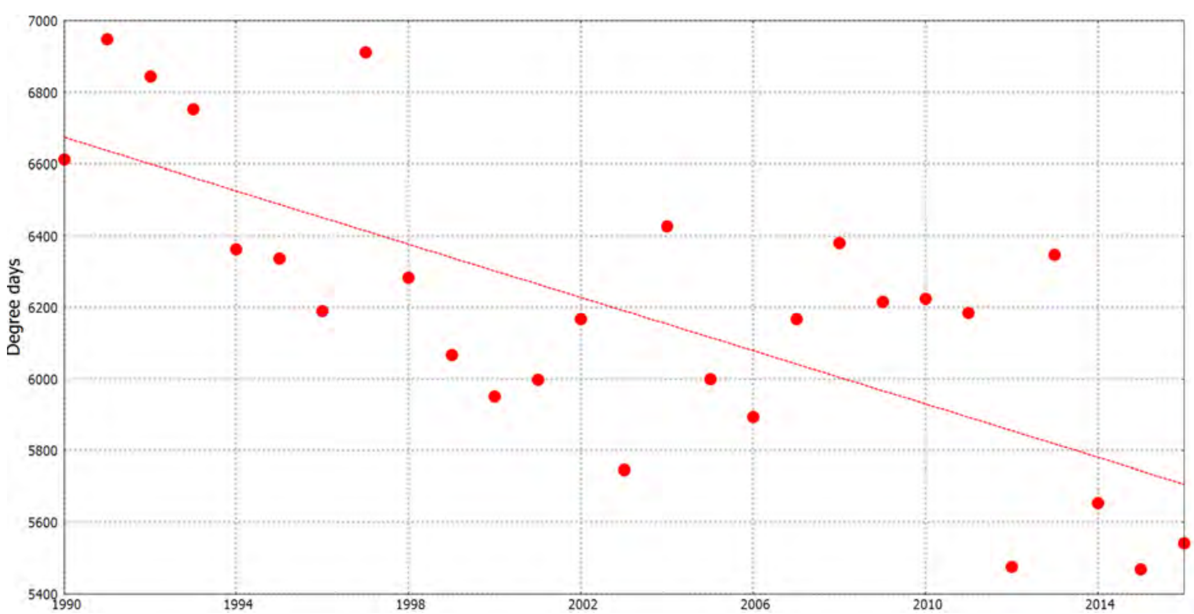

Figure 2-8 Los Alamos heating degree days

Wind Speed

The annual average wind speed measured at the Laboratory's meteorological tower of record at Technical Area 06 has increased approximately 20% over the past 20 years (Figure 2-9). Winds are produced by low- and high-pressure weather systems that move across New Mexico. Near the ground's surface, wind speeds are also influenced by the type of vegetation present (for example, forests versus grasslands). Our current hypothesis is that the extensive loss of trees in the local area caused by wildfires, forest thinning, drought, and bark beetle infestations has led to a decrease in the amount of wind resistance provided by trees, allowing wind speeds near the surface to increase. There is no trend in the annual peak gusts recorded at Technical Area 06 since 1990 (Kelly et al. 2015).

Note: m/s = Meters per second.

Figure 2-9 Technical Area 06 annual average wind speed at 12 meters above the ground

Annual Red Flag Warnings

The National Weather Service began counting the number of Red Flag Warnings per year for the Los Alamos area in 2012 (Figure 2-10). A Red Flag Warning is established when the National Fire Danger Rating System is high to extreme, and the following weather conditions are forecast for the coming day:

- sustained wind average of 15 miles per hour or greater,
- relative humidity less than or equal to 25%, and
- temperature greater than 75°F.

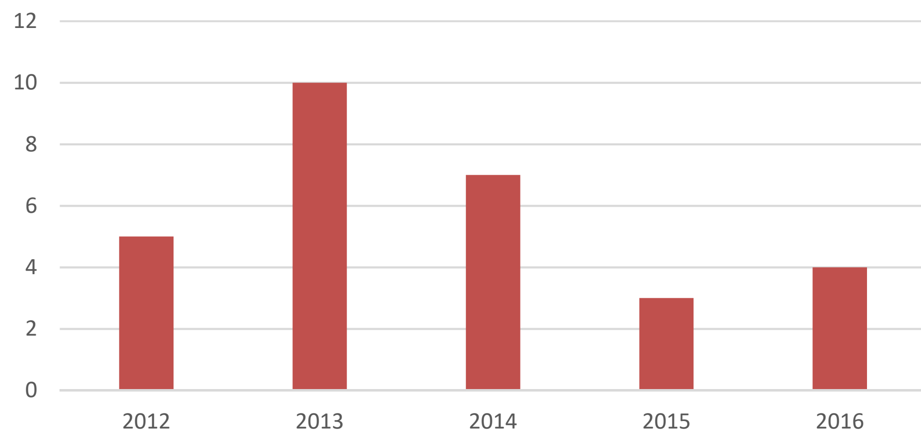

Figure 2-10 Number of National Weather Service Red Flag Warning days for zone 102 (Los Alamos)

We will continue to track Red Flag Warning days as a possible indicator of effects of climate change. Some Laboratory operations, including explosives testing, are restricted on days with Red Flag Warnings.

Precipitation

We have analyzed the annual average precipitation and the number of days per year with heavy rain events. Long-term trends in annual average precipitation are presented in the Meteorological Monitoring section of Chapter 4 and are shown in Figure 2-11. From 1924 through 2010, the annual average precipitation was 18 inches with a standard deviation of 4.4 inches. A long-term drought began in 1998, with significantly below-average precipitation under 15 inches between 2000 and 2003 and again in 2011 and 2012. Annual precipitation values were as low as 10 inches in 2003 and 2012.

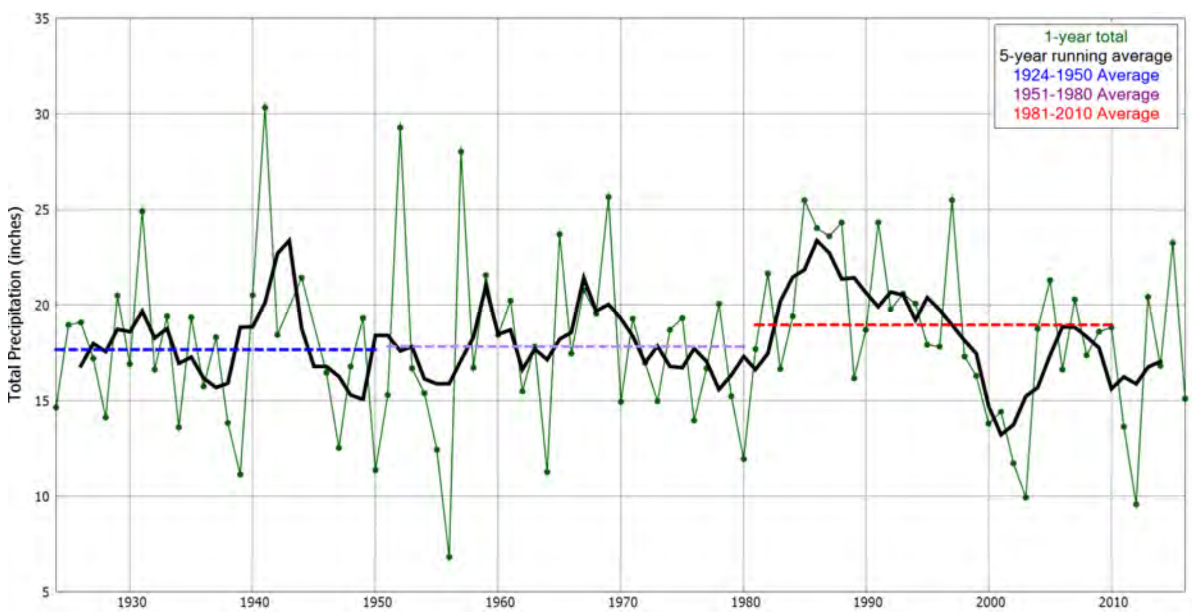

Figure 2-11 Annual precipitation totals for Los Alamos

The frequency of heavy rain events (Figure 2-12), defined as precipitation greater than 0.5 inches in one day, does not demonstrate a significant long-term trend over the past 50 years. Although not shown here, there is also no trend in the heaviest events (precipitation >0.75 inches or >1.0 inch per day) in the past 50 years.

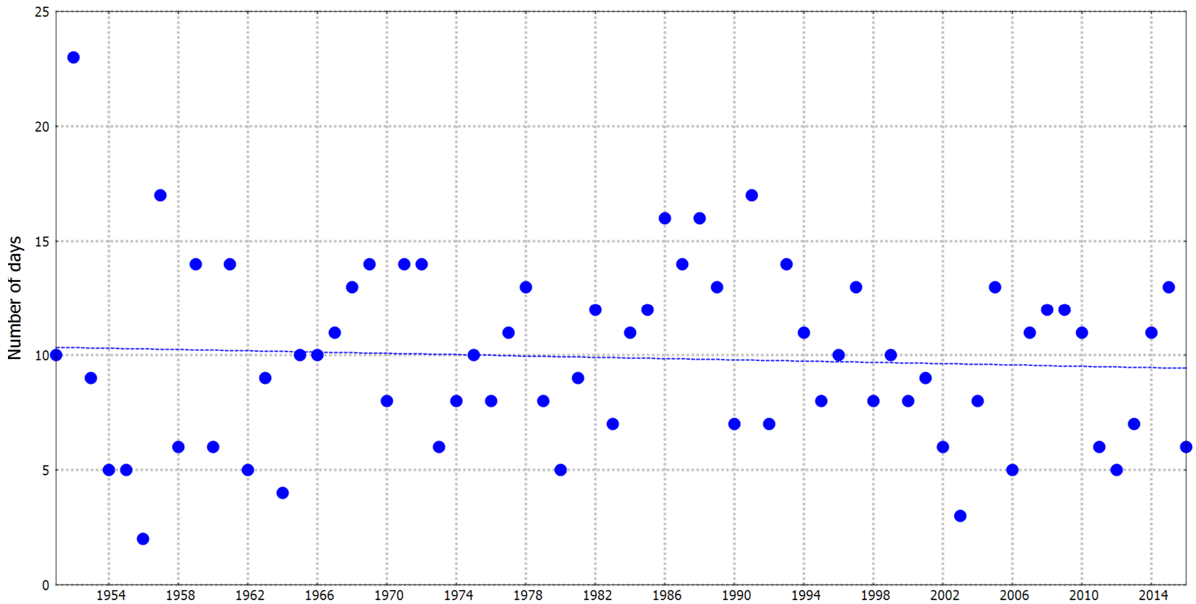

Figure 2-12 Number of days per year with precipitation >0.5 inches

Annual average snowfall (Figure 2-13) does not demonstrate a significant long-term trend. However, since the drought began in 1998, there have been only 3 years with above-average recorded snowfall (1981–2010 average = 57 inches).

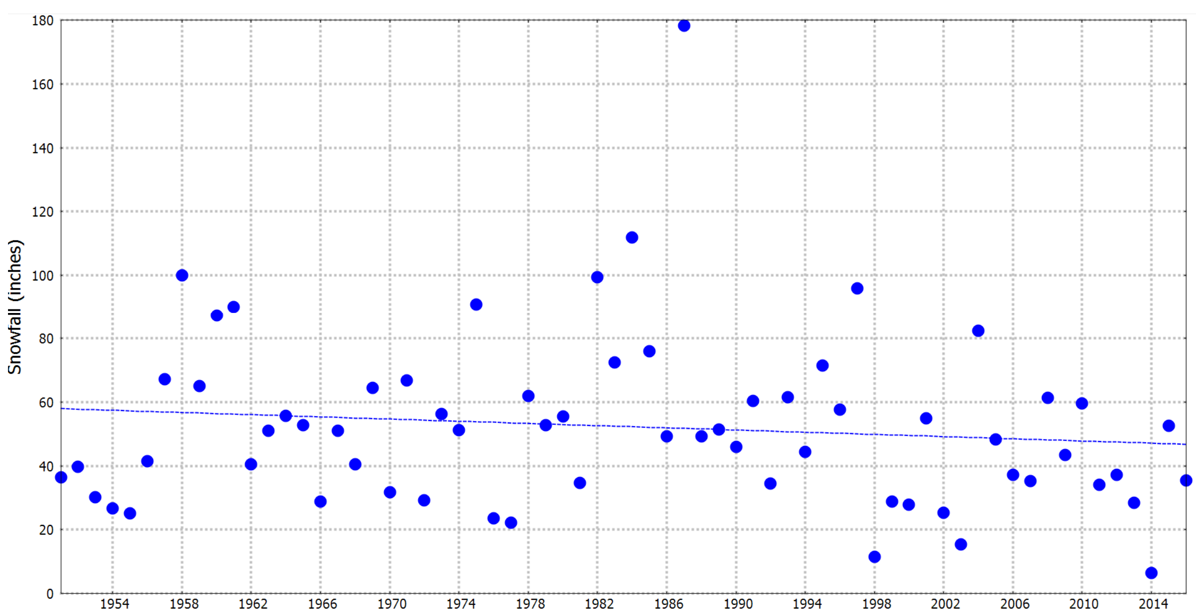

Figure 2-13 Annual average Los Alamos snowfall

Benthic Macroinvertebrates

The purpose of monitoring a benthic macroinvertebrate community is to provide an indication of the water quality within a water system (EPA 1998). Changes in benthic macroinvertebrate communities can serve as effective indicators of environmental changes and stress (Hilsenhoff 1987). Three studies have been completed since 2009 along the Rio Grande upstream and downstream of the Laboratory (LANL 2015c). Each study measured the number of organisms, species richness, and species diversity. The data are presented as an average of both reaches within the Rio Grande in Table 2-10. There is no apparent trend in 3 years of sampling.

Table 2-10
Sampling Results for Benthic Macroinvertebrates

Year, Method, and Number of Sampled Sites	Abundance per Square Mile	Species Richness per Square Mile	Diversity Index
2009, rock basket, 10 sites	80	4.4	2.5
2011, kick net, 12 sites	173	3.2	1.4
2014, kick net, 15 sites	84	5.7	3.5

Climatic Summary

Average temperatures in Los Alamos have increased over the past 15 to 25 years, consistent with the predictions of the National Climate Assessment for the southwestern United States. The average temperatures are predicted to rise by 2.5°F–5.5°F by 2041–2070, and the temperatures measured at Los Alamos indicate that our data are consistent with these predictions. Increases in cooling degree days and reductions in heating degree days will produce increased summer air-conditioning costs and reduced winter heating costs.

Although the predictions of precipitation changes are less certain than temperature predictions, the National Climate Assessment predicts decreasing winter and spring precipitation in the southwest. Our Los Alamos data are consistent with these predictions, in particular over the last 18 years, with below-average snowfall in 83% of the years. The National Climate Assessment does not make a specific prediction for the southwest for heavy precipitation events. Our data do not show a trend in heavy precipitation events in Los Alamos.

The National Climate Assessment predicts increasing wildland fires in the southwest as a result of warming, drought, and insect outbreaks. The Laboratory has been impacted by two major wildland fires in recent years: one in 2000 (Cerro Grande fire) and one in 2011 (Las Conchas fire). Precursors to these fires included warm, dry years, and local bark beetle infestations (LANL 2012). The Los Alamos data are consistent with the predictions of increasing wildland fires. The annual average wind speed has been increasing, probably related to the reduction in forest cover caused by tree mortality and thinning activities. Increases in average wind speeds affect emergency planning in the event of an aerial release of hazardous substances.

At this time, we do not see trends in the benthic macroinvertebrate community in the Rio Grande.

UNPLANNED RELEASES

Air Releases

There were no unplanned air releases during 2016.

Liquid Releases

No unplanned releases of radioactive liquids occurred on Laboratory property in 2016.

There were 18 total reports made to the New Mexico Environment Department in 2016. Sixteen of these reports were releases of nonradioactive liquids to the environment, and these were reported to the New Mexico Environment Department as required by the New Mexico Water Quality Control Commission regulations (Table 2-11). Additionally, two instances of groundwater detections in excess of the New Mexico groundwater quality standards were also reported to the New Mexico Environment Department.

Table 2-11
2016 Unplanned Water Releases

Material Released	Number of Instances	Approximate Total Release (gallons)
Potable water	6	1,003,000
Boiler water	1	600
Steam condensate	1	5760
Compressor oil	1	1
Concrete wash water	1	400
Cooling system water	1	200
Diesel fuel	1	15–20
Electrical insulation oil	1	52
Treated sanitary effluent	1	150
Well purge water, development water, and calibration fluids	1	3300
Groundwater discharge	1	50

Potable water discharge volumes included in Table 2-11 were calculated from the discharge rate for the known duration of the release when the start time of the release could not be precisely determined.

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3.0 Environmental Programs

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Los Alamos National Laboratory's governing policy on the environment is the following:

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

INTRODUCTION

At Los Alamos National Laboratory (LANL or the Laboratory), good environmental performance means compliance with all applicable environmental laws, regulations, and policies. We maintain dedicated or "core" programs and staff to address tasks such as protection of air, water, cultural, and biological resources; management of waste; and environmental remediation. In addition, we have deployed staff and resources to support environmental performance within all Laboratory organizations. This chapter describes the processes and programs that the Laboratory uses to manage its environmental performance and 2016 accomplishments.

The Principal Associate Director for Operations is the senior manager responsible for environmental performance at the Laboratory. This individual chairs the Environmental Senior Management Steering Committee. The committee sets institutional objectives and annual targets for the Laboratory's environmental performance. The three institutional objectives for our environmental performance are (1) clean the past, (2) control the present, and (3) create a sustainable future.

Within these three objectives, the Laboratory's Environmental Senior Management Steering Committee identified the following 17 targets for 2016.

Clean the Past

- Continue to comply with the requirements of the Compliance Order on Consent with the New Mexico Environment Department
- Protect surface water runoff through implementation of the Individual Permit for Storm Water with the U.S. Environmental Protection Agency
- Design and commence implementation of remediation activities for the chromium plume in groundwater beneath Sandia and Mortandad Canyons

- Implement the institutional facility Footprint Reduction Plan

Control the Present

- Maintain and improve the Laboratory's environmental and waste management compliance programs
- Fully integrate environmental controls with safety controls through integrated work management requirements and standard work practices
- Identify and perform activities that improve communication about environmental work risks, controls, and requirements
- Implement federal sustainability requirements, including the Laboratory's Site Sustainability Plan, sustainable acquisition, and pollution prevention, across all environmental media
- Implement an enduring waste management program
- Implement and maintain a Site Cleanup and Workplace Stewardship Program
- Implement and maintain a "green" maintenance program
- Implement and maintain integrated site planning and management processes consistent with the Laboratory's Environmental Management System objectives

Create a Sustainable Future

- Plan and implement an integrated, geospatial governance model within a consolidated geographic information system for Laboratory operations
- Plan for adaptation to climate change and implement controls (reduce greenhouse gas emissions)
- Implement a new Cultural Resources Management Plan for the Laboratory
- Develop and deploy new environmentally sustainable technologies
- Execute the long-term strategy for environmental stewardship and sustainability

INSTITUTIONAL PROCESSES

Certification to the International Organization for Standardization's 14001 Standard, Environmental Management System

The Laboratory is certified to the International Organization for Standardization's 14001:2004 standard, Environmental Management System. Certification is maintained through a regular program of self-assessments and external audits. We have retained independent, third-party certification for the International Organization for Standardization's 14001:2004 standard since April 2006. Certification must be renewed at 3-year intervals and was successfully renewed in 2009, 2012, and 2015.

The Laboratory maintains and annually updates an institutional list of the significant environmental aspects that may be associated with activities on-site. Table 3-1 lists and describes the environmental aspects identified for 2016, along with some example activities.

Managers and teams from each Laboratory directorate develop environmental action plans each year using the institutional objectives and targets along with their evaluation of their own work activities. In 2016, we developed and tracked 306 actions in 15 of these action plans.

Table 3-1
LANL Significant Environmental Aspects

Environmental Aspects	Description	Examples
Air emissions	Activities that release or have the potential to release material into the air	• Point-source air emissions from stacks, vents, ducts, or pipes • Use of greenhouse gas contributors such as refrigerants, vehicles, and energy consumption
Interaction with surface water and storm water	Activities that release or have the potential to release pollutants into a watercourse or through direct discharge to or contact with storm water (for example, discharge onto the ground near a waterway)	• Discharges from permitted outfalls • Spills and unintended discharges
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.	• Laboratory sinks • Kitchens and bathrooms • Wastewater collected and transported to a wastewater facility
Interaction with drinking water supplies/systems or groundwater	Activities that release or have the potential to release material into the groundwater. This includes planned or unplanned releases onto the ground or into surface water that have the potential to migrate to groundwater.	• Potable water use in kitchens, bathrooms, and laboratory settings • Cooling tower water supply use • Installation or abandonment of groundwater wells or associated systems • Landscape watering • Land application of water or injection of treated water into an aquifer • Septic systems and sanitary holding tanks • Permitted wastewater storage basins • Water treatment systems
Work within or near floodplains and wetlands	Construction of structures or impoundments in a floodplain or wetland, or activities that release or have the potential to release material onto or into a floodplain, wetland, or area of overland flow	• Monitoring well operations • Building structures in a floodplain or wetland • Activities that disrupt the integrity of a floodplain or wetland
Interaction with wildlife and/or habitat	Activities that impact or have the potential to impact federally protected wildlife or their habitats, migratory birds, and other wildlife not managed under any federal law	• Landscape development • Removal of weeds, trees, brush, or invasive species • Road easement maintenance • Installation and operation of fencing, buildings, power lines, towers, drainage, or other structures • Installation and operation of outdoor lighting • Work operations that generate noise
Biological hazards	Activities that generate, use, or dispose of biological agents. This excludes human viral, bacterial, or blood-borne pathogens.	• Management of medical materials and by-products

Table 3-1 (continued)

Environmental Aspects	Description	Examples
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.	• Aboveground or belowground water, sewer, gas, or wastewater lines; chemical or liquid storage tanks; equipment (such as transformers) • Ground-disturbing activities, for example, construction, utility line repair, or maintenance of dirt roads • Operations that result in point source air emissions from stacks, vents, ducts, or pipes • Operations that are sources of diffuse air emissions such as open burning / open detonation, remediation activities, and decontamination and decommissioning projects • Installation and maintenance of surface-water and storm-water controls • Physical removal of wood for fire suppression and control; introduction or removal of vegetation (native or non-native)
Spark- or flame-producing activities	Activities that cause or have the potential to start a fire or wildfire	• Off-road vehicle use • Construction or outdoor maintenance work activities • Outdoor spark- or flame-producing operations • Forest fuel mitigation activities • Outdoor recreational and other activities during high wildland fire risk season • Smoking
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, traditional cultural properties, and historic homesteads and trails.	• Expansion of existing developed areas (trails, walkways, clearings, roads) • Ground-disturbing activities below grade or surface areas • Maintenance, modification, or demolition of potential or designated historic structures • Off-road vehicle use • Vegetation removal and weed mitigation activities • Archaeological excavations
Visual resources	Activities that impact or have the potential to impact visual landscapes	• Construction of access roads, fencing, utility corridors, and power transmission systems through nonurban areas • Construction, management, and maintenance of staging areas, storage yards, debris piles, litter, and other "eye-sores" • Design, construction, management, and maintenance of buildings, towers, stacks, domes, signs, etc. • Smoke, steam, dust • Tree thinning • Security or after-hours lighting
Hazardous or radioactive material waste packaging and transportation	Activities that handle, package, or transport hazardous waste or radioactive materials	• Transportation of chemicals • Transportation of low-level radiological waste, mixed low-level waste, or transuranic waste

Table 3-1 (continued)

Environmental Aspects	Description	Examples
Radioactive waste generation and management	Activities that generate or manage (handle, store, or dispose of) radioactive waste	• Laboratory or research and development procedures using or generating radioactive material • Cleanup of historical waste disposal areas • Development of alternative processes or controls that reduce radioactive materials utilization and/or cross-contamination
Hazardous or mixed-waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) hazardous or mixed waste	• Laboratory or research and development procedures using or generating hazardous materials • Disposal of unused, unspent laboratory chemicals • Development of alternative processes or controls that reduce the quantity of radioactive or hazardous materials used or reduce radioactive or hazardous characteristics
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 wastes (nonhazardous or nonradioactive) • All objects that are potentially waste that are not hazardous or radioactive
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 areas, radiological sites, nuclear facilities, or high-explosive sites.	• Construction activities • Remediation activities • Demolition activities • Open-detonation activities
Chemical (industrial and laboratory) use and storage	Activities that result in the purchase, use, management, or storage of chemicals	• Chemical use in research laboratories • Vehicle operation and maintenance (fuels, coolants, lubricants, etc.) • Building cleaning and maintenance (janitorial supplies)
Radioactive material use and storage	Activities that handle or store radioactive materials	• Radioactive material machining or processing • Change in location of activities or operations involving work with radioactive materials • Evaluation of processes and operations to increase efficient use of materials
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 • Managing (storing, using, recycling, reusing, disposing of) surplus property • Cleanup and recommissioning of work areas • Decontamination and decommissioning facilities • Furniture, laboratory equipment, all material stock/supply, storage, and staging

Table 3-1 (continued)

Environmental Aspects	Description	Examples
Resource use and conservation	Activities or practices that impact resource use and affect conservation; that may increase or reduce demand or generation of wastes; or that 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, cool roofs, natural lighting, insulated glass, recycled or low-impact building materials • Procuring alternative energy or fuel sources for the Laboratory • Amount or change in the amount of energy or water required for a scope of work • Reusing and repurposing materials, equipment, and supplies • Purchasing "green" or environmentally preferable products
Storage of materials in tanks	Activities that handle or store materials in tanks	• Operating or maintaining aboveground tanks in accordance with the Laboratory's hazardous waste permit
Engineered nanomaterials	Activities that create nanoparticles, which are intentionally created particles with two or three dimensions between 1 and 100 nanometers. This definition includes (1) biomolecules (proteins, nucleic acids, and carbohydrates), (2) nanoscale forms of radiological materials, (3) nanoparticles incidentally produced by human activities or natural processes, and (4) ultrafine particles such as those produced by diesel engines and forest fires.	• Nanotechnology research and development that generates nanoparticles requiring environmental controls, for example, o an exhaust system with high-efficiency particulate air filtration for airborne particulates or o disposal of nanoparticulate waste as Resource Conservation and Recovery Act–regulated waste or as New Mexico special waste.

The Environmental Management System program undertakes external audits and internal assessments every year. All findings and corrective actions generated from these audits and assessments are tracked to closure in an institutional tracking system. Findings from two external certification audits and two internal assessments during 2016 generated actions that will support improvements to project review activities and to outdoor storage areas.

More information on the Laboratory's Environmental Management System is available at http://www.lanl.gov/environment/protection/environmental-management-system.php.

The Long-Term Strategy for Environmental Stewardship and Sustainability

The Long-Term Strategy for Environmental Stewardship and Sustainability was created in 2012 to help plan for a sustainable future at the Laboratory. The Long-Term Strategy for Environmental Stewardship and Sustainability sets forth seven long-term environmental grand challenges, described in Figure 3-1, that address the overarching strategies to clean up the past, control the present, and create a sustainable future.

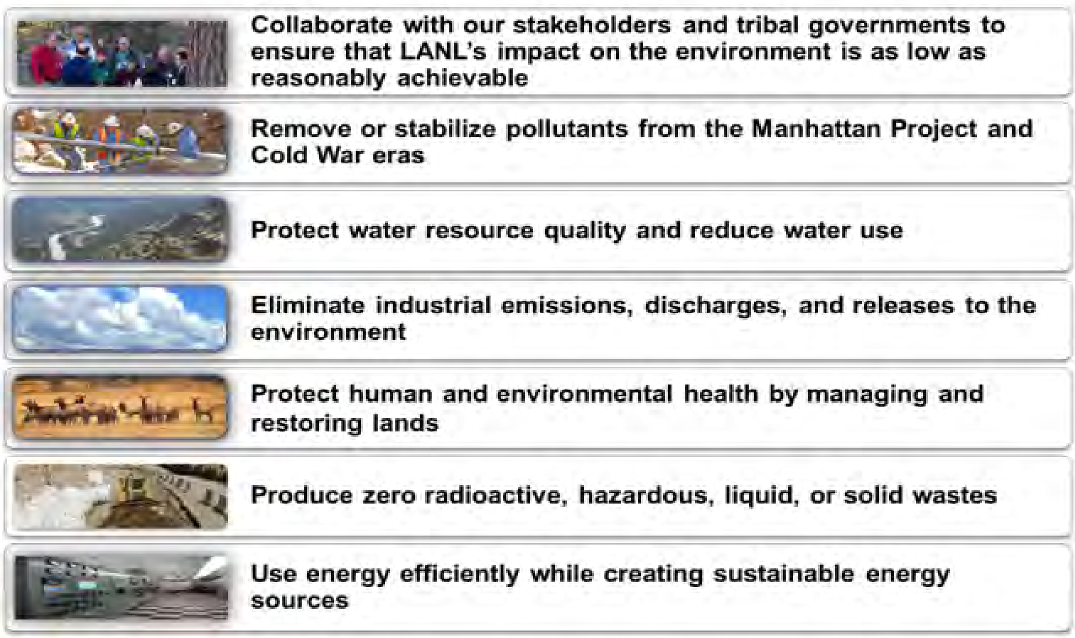

Figure 3-1 Environmental Grand Challenges—The Laboratory's goals for a sustainable future

Targets and objects are established pertaining to these seven grand challenges through the Laboratory's certified Environmental Management System. Specific achievements of the Long-Term Strategy for Environmental Stewardship and Sustainability Implementation Core Team during 2016 included the following:

- Completing a land cover map for planning and for natural and cultural resources management at the Laboratory
- Completing a soil erosion risk model that will assist in determining areas where erosion could be problematic, particularly from climate-change-like events
- Incorporating recommendations from the Environmental Sampling Board pertaining to content and structure into the annual site environmental report, with particular emphasis on the ecosystem health chapter
- Developing and implementing a consistent definition of detection status for radiological measurements with the input of the Environmental Sampling Board

More information on the Laboratory's Long-Term Strategy for Environmental Stewardship and Sustainability is available at http://www.lanl.gov/projects/long-term-environmental-strategy/index.php.

Pollution Prevention

The Laboratory's Pollution Prevention program develops institutional initiatives that support the Grand Challenges, reduce costs, and reduce environmental liabilities. Specific target areas for projects include green chemistry and chemical use reduction, green procurement, and support for the Site Sustainability Plan. The program also

- compiles the hazardous waste minimization report required by the New Mexico Environment Department hazardous waste facility operating permit,

- works in conjunction with the Site Cleanup and Workplace Stewardship Program to prevent equipment and materials from becoming waste whenever possible, and
- funds Laboratory workers to conduct pollution prevention projects that are expected to reduce waste generation or have some other significant environmental benefit.

The 2016 Laboratory pollution prevention award ceremony recognized 41 projects involving nearly 300 individuals from across the Laboratory.

In fiscal year 2016, pollution prevention projects realized an estimated cost avoidance of $3.2 million. Benefits from these projects include reuse of over 3000 pounds of computer hardware, savings of over 10 million kilowatt-hours of electricity, and recycling of over 1 million pounds of metal and 500 cubic meters of sediment.

The following are brief descriptions of some of the Laboratory-funded projects in fiscal year 2016.

- Waste Segregation at the Chemistry and Metallurgy Research Building

  This team gave additional training to their researchers to improve segregation of radioactively contaminated items so that fewer items needed to be handled as transuranic waste. The team also organized their waste collection system so that radiological control technicians and waste management coordinators worked together and could verify which containers could be handled as low-level waste instead of transuranic waste, resulting in cost savings associated with waste disposal.

- Acquisition and Testing of Equipment and Software for Green-is-Clean

  The Green-is-Clean program analyzes waste from radiological areas that is suspected to be uncontaminated based on acceptable knowledge. This team purchased new equipment and software for analyzing bags of low-density waste that are suspected to be uncontaminated. Waste that is verified to be uncontaminated does not have to be handled as low-level waste, which avoids significant costs associated with waste disposal.

- Develop Volumetric Radionuclide Criteria for Recycling LANL Metals and Concrete

  Metals and concrete are frequently sampled and analyzed for surface contamination, particularly when buildings are demolished. This team investigated what criteria could be used to evaluate potential contamination of metals and concrete from buildings where neutron radiation may have induced radioactivity inside building materials. Verifying which materials are clean and can be recycled avoids significant expenses.

- Reduced Mixed Low-Level Waste Generation by Reducing Instrument Sample Requirement

This team purchased new equipment that can perform the same chemical analyses with much smaller samples. Because smaller samples can be used, much less mixed low-level waste is generated following the analyses, which will avoid thousands of dollars in waste disposal costs every year.

Site Sustainability

Executive Order 13693, Planning for Federal Sustainability in the Next Decade, and the U.S. Department of Energy (DOE) Strategic Sustainability Performance Plan provide sustainability goals for DOE, including

- planning, executing, evaluating, and continually improving operations to maximize sustainable use of energy and water;
- developing cost-effective energy efficiency and renewable energy projects;
- improving the performance of existing facilities and planning for net-zero energy consumption, water consumption, and waste production in facilities;
- using low greenhouse-gas-emitting energy sources to replace existing grid energy;
- preventing pollution and reducing or eliminating the generation of waste; and
- planning for climate resiliency.

We prepared the 2017 Site Sustainability Plan to describe progress toward the goals established in this executive order. In addition, per the requirements of DOE Order 436.1, Departmental Sustainability, the Laboratory uses its International Organization for Standardization 14001:2004 certified Environmental Management System to establish sustainability objectives.

Successes and Challenges

The 2017 Site Sustainability Plan builds on fiscal year 2016 accomplishments and outlines fiscal year 2017 actions that enable the Laboratory to continue progress toward DOE's sustainability goals and reporting requirements. Successes include the following:

- The Laboratory has 34 facilities that are High Performance Sustainable Building candidates with an average of 90% compliance with guiding principles.
- Ten of the High Performance Sustainable Building–candidate facilities are 100% compliant with the guiding principles.
- We upgraded building automation systems from old pneumatic to digital control in three facilities.
- We completed recommissioning efforts in four facilities.
- The Sanitary Effluent Recovery Facility sent over 23 million gallons of reclaimed wastewater to the Strategic Computing Complex for reuse within its cooling towers.
- SkySpark software was implemented for five buildings to maintain energy savings by identifying issues needing attention.

- We initiated a new Smart Labs Program for energy efficiency in Laboratory space, which was modeled after the University of California, Irvine.
- We piloted new tablet software for energy and water audits called EMAT.
- We defined the scope for the new steam plant acquisition and selected three finalists for the energy service company to perform the preliminary assessment for an energy savings performance contract project.

The Laboratory reduced its water intensity (gallons used per square foot of building) by 9% compared with fiscal year 2007 and reduced its energy intensity (energy used per square foot of building) by 1% compared with last fiscal year (2015). Although we did not meet the annual target of a 2.5% energy intensity reduction, major emphasis was placed on the Smart Labs Program, modeled after the University of California's successful energy efficiency program for laboratory facilities. Time and effort spent to develop these long-term initiatives will drive the Laboratory closer to meeting the fiscal year 2025 greenhouse gas emission reduction goals and will better position us to adapt and compete for future mission work. The Laboratory's sustainability investments, including increased power production capability, are designed to limit growth in energy demand while supporting hiring and mission growth. Strategically planned energy efficiency projects combined with a phased approach to increasing renewable power purchases support our commitment to an additional 1% reduction in energy intensity during fiscal year 2017.

Through investments in building automation systems, lighting, and other efficiency projects, the Laboratory plans to achieve the following goals in fiscal year 2017:

- Reduce energy intensity by an additional 1%
- Maintain water use at or below fiscal year 2016 levels

More information on the Laboratory's Site Sustainability Plan is available at http://www.lanl.gov/environment/sustainability/goals/index.php.

Site Cleanup and Workplace Stewardship Program

Materials and equipment abandoned after projects are completed or staff retire are a recurring institutional problem. The Laboratory has established a Site Cleanup and Workplace Stewardship Program to assist with the removal and disposition of these items and to prevent similar issues from occurring in the future. The program partners with the responsible organizations to develop work plans, clean indoor and outdoor spaces, and consult on sustainable housekeeping practices. They also develop tools and processes to implement cleanup efficiently and to prevent future issues.

In 2016, the Site Cleanup and Workplace Stewardship Program achieved the following:

- Added an initiative to the Enduring Mission Waste Management Plan to improve management of storage structures starting in 2017. This will include
    - ❖ validating the owning organization and location of approximately 1400 storage structures,

- attaching bar codes to the storage structures and assigning an individual owner in the Laboratory's property management system,
- adding a point-of-contact sign to each storage structure, and
- working with the owning organizations to clean out and remove unneeded storage.

- Supported the release of approximately 500,000 pounds of metal from the Los Alamos Neutron Science Center for recycling
- Funded approximately 25 cleanup projects across the Laboratory. Examples include
    - consolidating approximately 1 million tons of metal and shielding from the Los Alamos Neutron Science Center and moving it into controlled staging areas;
    - moving the historic Antares Laser from uncontrolled outdoor storage to controlled staging at Technical Area 18, preserving a piece of Cold War history;
    - consolidating and cleaning up the iron workers' laydown yard;
    - cleaning up and removing abandoned storage structures (semi-trailers, transportainers, and utility trailers) on Mercury Road;
    - disposing of approximately 500 unneeded radioactive sealed sources; and
    - cleaning up and removing storage structures and abandoned materials from Sigma Mesa at Technical Area 60.

Greenhouse Gas Reduction

The 2016 Greenhouse Gas Emissions Report was submitted to the U.S. Environmental Protection Agency on March 30, 2017. The Laboratory emitted approximately 43,838 metric tons of carbon dioxide equivalents of carbon dioxide, methane, and nitrous oxide in 2016.

In fiscal year 2016, we achieved a 32% reduction in emissions of greenhouse gases directly owned or controlled by the Laboratory, compared with the fiscal year 2008 baseline. This reduction was achieved mainly through purchase of renewable energy credits and increases in energy efficiency. In fiscal year 2016, we purchased over 105,000 megawatt-hours of renewable energy credits. The Laboratory's energy use is expected to steadily increase over the next 10 years as high-performance computing and expanded programmatic activities at the Los Alamos Neutron Science Center consume greater quantities of electrical power. We are pursuing a 10-megawatt solar photovoltaic installation to increase on-site power production and reduce greenhouse gas emissions by 12,500 metric tons of carbon dioxide equivalents. We are also pursuing installation of a combined heat and power plant to replace the existing steam plant.

In fiscal year 2016, the Laboratory achieved a reduction of 22% in indirect greenhouse emissions. This reduction exceeds the 2016 target of 7% reduction. The overall commuting patterns were similar to those found during fiscal year 2015, but greenhouse gas emissions related to commuting were slightly higher because there were more employees. Some employees are occasionally allowed to work from home at the discretion of their group-level management. In addition to greenhouse gas reductions, telecommuting may also contribute to a reduction in infrastructure operating costs, assist the Laboratory's footprint reduction initiative, and improve employee work/life benefits.

Integrated Project Review

Any new or modified activity or project conducted at the Laboratory must be reviewed for environmental compliance and other requirements. The Integrated Review Tool is a web-based application where work owners or planners enter their project information, and subject matter experts identify applicable permits and requirements needed for the work. The Integrated Review Tool includes excavation/fill/soil disturbance permitting and permits and requirements identification. During 2016, 903 projects at the Laboratory were reviewed for excavation, fill, and soil disturbance, and 220 projects were reviewed for permits and requirements identification.

The Integrated Project Review program coordinates environmental subject matter expert reviews and interacts with work owners and planners. The goal of this program is to identify environmental requirements during the early planning stages of a project so that requirements can be addressed, permits can be obtained, and projects can proceed as scheduled. The program is represented by subject matter experts from the following Laboratory compliance programs: Air Quality, Biological Resources, Cultural Resources, Environmental Health Physics, National Environmental Policy Act, Waste and Materials Management, and Water Quality.

Over the last several years, the Integrated Project Review program has championed the integration of project review processes and improvements into the Integrated Review Tool. Beginning in 2016, an environmental requirements summary was generated for all projects reviewed in the permits and requirements portion of the tool to improve communication of environmental requirements to workers in the field. Improvements to the excavation portion of the tool and process continued in 2016, including automating several steps in the permitting process, clarifying subject lines and actions for clearer email communication, and reviewing and updating criteria and definitions in the tool. This means the screening and posting portion of excavation permit requests is faster and has less potential for human error.

DEDICATED "CORE" PROGRAMS

Air Quality Programs

The Laboratory maintains a rigorous air quality compliance program for the emissions of both radionuclide and nonradionuclide air pollutants. The air-monitoring and compliance efforts consist of three main parts: compliance and permitting, stack monitoring, and ambient air monitoring.

Compliance and Permitting. We operate under a number of air emissions permits issued by the New Mexico Environment Department and approvals for construction of new facilities or operations by the U.S. Environmental Protection Agency. These permits and approvals require pollution-control devices, stack-emissions monitoring, and routine reporting.

We are authorized to operate air-emission sources under the terms and conditions defined in its Title V Operating Permit. The permitted sources include a steam plant, combustion turbine, boilers and heaters, emergency generators, beryllium operations, chemical use, degreasing, data destruction (paper shredder), and a small asphalt batch plant. As part of compliance with the Title V Operating Permit, we report emissions and provide monitoring records from permitted sources twice a year to the New Mexico Environment Department. In addition, the New Mexico Environment Department inspects the Laboratory annually for compliance.

Stack Monitoring. As described in greater detail in Chapters 2 and 4, the Laboratory rigorously controls and monitors emissions of radioactivity from building stacks, as required by the Clean Air Act. We evaluate these operations to determine potential for impacts of stack emissions on the public and the environment. Twenty-six stacks were continuously sampled for the emission of radioactive material to the air.

Ambient Air Monitoring: The Laboratory operates an extensive network of ambient air quality monitoring stations to detect other possible radioactive emissions (discussed further in Chapter 4). The network includes stations located on-site, in adjacent communities, and in regional locations. During 2016, we operated 38 ambient air quality monitoring stations at distances up to 25 miles from the Laboratory.

Water Quality Programs

The Laboratory has multiple programs dealing with the quality of surface waters. We maintain compliance with five National Pollutant Discharge Elimination System permits: the outfall permit, the individual permit for storm water discharges, the construction general permit, the multi-sector general permit, and the pesticide general permit (discussed further in Chapter 2). The Laboratory conducts environmental surveillance monitoring on base flow, storm water flow, and deposited sediments (Chapter 6).

In 2016, we continued the process for renewal of the individual permit for storm water discharges. The individual permit renewal application was submitted to the U.S. Environmental Protection Agency on March 27, 2014. A draft permit was issued on March 19, 2015. The current permit has been administratively continued until a new final permit is issued. We also diverted all discharge and capped the pipe at Outfall 03A027 in 2016 as part of our effort to reduce the number of Laboratory outfalls.

During 2016, the Laboratory conducted work pursuant to four groundwater discharge permits by the New Mexico Environment Department. These permits covered discharges from the sanitary wastewater system plant and the sanitary effluent reuse facility, discharges from eight septic tank systems, land application of treated groundwater, and injection of treated groundwater into the aquifer through six underground injection control wells.

We maintained the Laboratory's site-wide storm water gage station network for monitoring flow and collecting storm water samples in all major canyons, and we continued operation of the Buckman Direct Diversion project early notification system for storm water flows through Los Alamos Canyon into the Rio Grande. Additionally, canyon performance reports for the Los Alamos/Pueblo Canyon watershed and the Sandia Canyon wetland were submitted to the New Mexico Environment Department to document effectiveness of installed sediment-control measures.

Sanitary Sewage Sludge Management

On March 24, 2014, the New Mexico Environment Department Solid Waste Bureau approved the Laboratory's application to operate a compost facility at the Technical Area 46 Sanitary Waste Water System Compost Facility. Full-scale operations began in late 2014. In 2016, the facility produced 32 tons of composted biosolids. The final compost will be land-applied at the Laboratory for beneficial use. This includes landscaping, post-construction remediation, and range land restoration. Before compost can be land-applied, it must meet pollutant concentration limits, Class A pathogen requirements, and vector attraction reduction requirements as specified in the U.S. Environmental Protection Agency's Standards for the Use or Disposal of Sewage Sludge in 40 Code of Federal Regulations Part 503. As a result of this project, sewage biosolids will no longer be transported off-site for landfill disposal.

In 2016, finished compost was stockpiled at the Sanitary Wastewater System Compost Facility. In 2017, a new in-vessel composter will be brought on-line. All compost produced to this point will be composted a second time through the in-vessel system. The in-vessel system provides better control of environmental conditions such as temperature, moisture, and airflow. In 2017 and beyond, compost will be land-applied at predetermined sites within Laboratory boundaries. Final disposition of compost is subject to site selection criteria, management practices, administrative controls, and application rates. For example, compost will not be applied in canyon bottoms, wetlands, or in areas with shallow perched alluvial groundwater. Application rates will not exceed agronomic rates provided by the New Mexico State University Cooperative Extension Service.

Cultural Resources Management

Approximately 90% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, resulting in the identification of more than 1800 sites. Nearly 73% of the Laboratory's cultural resources are Ancestral Puebloan sites that date from the thirteenth, fourteenth, and fifteenth centuries. Ancestral Puebloan sites, Homestead period sites, and Laboratory buildings used during Manhattan Project and early Cold War periods (1943–1963) are potentially eligible for the National Register of Historic Places. Eligible sites and buildings, whether or not they are listed on the register, are protected under the National Historic Preservation Act.

Current cultural resources management initiatives include

- surveying the remaining unsurveyed DOE land,
- completing eligibility evaluations of the Laboratory's historic buildings, and
- completing the revision of the Laboratory's Cultural Resources Management Plan.

Revisions to the Cultural Resources Management Plan include a streamlined approach to compliance with the National Historic Preservation Act and identification of specific objectives for historic preservation, including National Historic Landmark nominations, a site-wide monitoring plan, and identification of a Cold War–period preservation district.

In 2016, cultural resource staff conducted archaeological site recording and marking for a wide variety of ground-disturbing projects and completed archaeological site assessment reports for the Environmental Restoration Operable Unit 1111 project, wildfire hazard reduction projects, and the Technical Area 16 paleoseismic trenching project. The condition of Nake'muu Pueblo was assessed and photographed in September 2016. Cultural resource staff supported monthly technical meetings with the Pueblo de San Ildefonso and with Santa Clara Pueblo and joint quarterly environmental meetings with the Pueblo de San Ildefonso, Santa Clara Pueblo, Cochiti Pueblo, and Jemez Pueblo. Five cultural resource staff members received Wildland Fire Red Card training and certification to support emergency operations in case of wildfire on Laboratory property. Cultural resource staff conducted seasonal monitoring of recreational use trails in Technical Areas 70 and 71 and of DOE preservation easements in Pueblo Canyon.

In 2016, specialists knowledgeable about historic buildings supported decontamination and decommissioning projects in several technical areas. They completed the Technical Area 03 Sigma Complex evaluation report, the Technical Area 57 decontamination and decommissioning report, and the Technical Area 33, Building 0016, decontamination and decommissioning report. They continued working with the Bradbury Museum to integrate the Laboratory's historic artifacts into the museum's catalog system.

Manhattan Project National Historical Park

Legislation creating the Manhattan Project National Historical Park was passed on December 19, 2014. This new national park consists of units at Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. The Los Alamos unit includes buildings used during the Manhattan Project in downtown Los Alamos and 17 Laboratory sites. The Laboratory sites include buildings and structures associated with the design and assembly of the "Gadget" (the atomic bomb tested at Trinity Site), the "Little Boy" weapon (the bomb detonated over Hiroshima), and the "Fat Man" weapon (the bomb detonated over Nagasaki). Cultural resources staff worked with DOE Los Alamos Field Office staff to develop the scope for an Interagency Agreement for preservation assistance between the National Park Service and the Los Alamos Field Office and worked to develop Manhattan Project National Historical Park interpretive materials.

Biological Resources Management

The goal for biological resources management at the Laboratory is to minimize impacts to sensitive species and their habitats and to ensure all activities and operations comply with federal and state requirements for biological resources protection. The Laboratory contains habitat for three species federally listed as either threatened or endangered. Two of these species, the Mexican spotted owl and the Jemez Mountains salamander, live on the site and are monitored annually.

2016 Accomplishments

Biologists annually inform and educate the Laboratory workforce about timing and location restrictions on activities to protect threatened and endangered species from disturbance. They also provide information on impacts to migratory birds from vegetation removal projects and other known hazards such as open pipes and bollards.

Laboratory biologists conducted Jemez Mountains salamander surveys on U.S. Department of Agriculture, Santa Fe National Forest Service, and Bandelier National Park properties in support of LANL seismic hazard investigations. Biology interns at the Laboratory provided two interactive workshops on their bird research at the Expanding Your Horizons Conference at the Santa Fe Convention Center. Expanding Your Horizons is a conference for girls in the fifth through ninth grade that includes hands-on activities in science, technology, engineering, and math.

In September 2016, an intern wrote an article for the Los Alamos Living magazine describing the endangered species management at the Laboratory. The article emphasized annual surveys conducted at the Laboratory and the precautions taken when endangered species are found in an area.

To improve wildlife safety, flashing light signs were installed along Pajarito Road to warn drivers to beware of large animals, such as elk, potentially crossing the road.

In 2016, two pairs of federally threatened Mexican spotted owls on Laboratory property fledged two baby owls. One Jemez Mountains salamander was found during surveys.

2016 Biological Resources Program Reports and Publications

Reports and publications included the following:

- "Floodplain Assessment for Corrective Actions in Potrillo Canyon, Technical Area 36, Los Alamos National Laboratory, Los Alamos, New Mexico," Los Alamos National Laboratory document LA-UR-16-20393 (March 2016).
- "Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2010–2015," Los Alamos National Laboratory document LA-UR-16-21876 (March 2016).
- "Biological Assessment of the Effects of the Paleoseismic Trenching Project to Conduct a Probabilistic Seismic Hazard Analysis of the Pajarito Fault System around Los Alamos National Laboratory," Los Alamos National Laboratory document LA-CP-16-20525 (October 2016).
- "Floodplain Assessment for Corrective Actions in Ancho Canyon, Technical Area 39, Los Alamos National Laboratory, Los Alamos, New Mexico," Los Alamos National Laboratory document LA-UR-16-26253 (October 2016).

Wildland Fire Management

The Laboratory focuses fuel mitigation actions (forest thinning and mowing) on the LANL perimeter, in support of mission activities such as firing sites, and on the defensible space around buildings and roads.

The Wildland Fire Management Program conducted hazard assessments by mapping predicted fire behavior and spread. Flame lengths, rate of spread, and crown fire activity were all modeled to determine which parts of the Laboratory have the greatest risk from wildfire. These maps are used to plan fuel mitigation projects and the replacement of infrastructure with more fire-resistant materials.

We maintain a Wildland Fire Management web-based mapping interface that allows users to quickly query essential information before, during, and after an incident. As part of the web-based mapping interface, the Wildland Fire Management Program maintains a set of computerized incident response plans. The incident response plans are a comprehensive set of maps and information designed to provide first responders with current information about facilities. The information is presented visually and in list format for quick reference.

The Laboratory Wildland Fire Management Program Office is collocated with the U.S. Forest Service and the National Park Service at the New Mexico Interagency Fire Base on the southern boundary of LANL next to Bandelier National Monument. Coordination with other agencies is supported through an Interagency Wildfire Management Team, interagency agreements, the New Mexico Joint Powers Agreement, and other interorganizational councils and teams that support preservation of natural resources.

Wildland fire fuel mitigation projects planned or completed in 2016 included the following:

- Mowing grass and shrubs adjacent to major roads around the Laboratory, including NM 4, East and West Jemez Road, and Pajarito Road
- Conducting defensible space thinning at Technical Area 54, Area G
- Creating a low-fuel zone in Cañada del Buey near Area G
- Maintaining thinning treatments at the Weapons Engineering Tritium Facility by removing ladder fuels
- Creating a low-fuel zone in Technical Area 36 around the Lower Slobbovia firing site
- Maintaining thinning treatments along West Jemez Road
- Conducting hazardous fuels removal in Technical Area 61 near the Elk Ridge mobile home park

Waste Management

Enduring Mission Waste Management Plan

The Laboratory produces several types of regulated wastes as part of its operations, including low-level radioactive wastes, mixed hazardous and low-level radioactive wastes, transuranic wastes, New Mexico special wastes, and others. The ongoing objective of the Enduring Mission Waste Management Plan is to manage wastes of all types from enduring Laboratory mission activities and work-for-others operations. Enduring mission wastes are separate from the legacy wastes (wastes generated before 1999) that became the responsibility of the DOE Office of Environmental Management on October 1, 2015, under a legacy cleanup bridge contract with Los Alamos National Security, LLC. Discussion of legacy wastes, including the remediated nitrate salt wastes, is covered in Chapter 2 in the Resource Conservation and Recovery Act section.

The annual update of the Enduring Mission Waste Management Plan continues a process of waste management planning that began in 2009. Many of the strategies described in earlier versions of the plan have been implemented. Waste minimization efforts have eliminated many sources of radioactive and hazardous waste. Off-site shipping to government and commercial treatment, storage, and disposal facilities has minimized on-site waste disposal. A Transuranic Waste Facility was constructed that will allow the staging of transuranic waste for off-site shipment. Replacement of the aging Radioactive Liquid Waste Treatment Facility was approved, and planning and construction have begun on low-level radioactive and transuranic liquid waste facilities.

Overarching strategies described in 2016 for the Enduring Mission Waste Management Plan annual update address the Laboratory's most urgent needs for managing waste:

- Minimize waste from ongoing operations
- Phase out on-site disposal of all waste types and ship off-site
- Resume shipment of transuranic waste to the Waste Isolation Pilot Plant
- Treat Area G as a closure site and relocate enduring operations
- Replace the Radioactive Liquid Waste Treatment Facility
- Improve the cost efficiency of waste operations

Optimize the waste compliance and tracking system for efficient, cost-effective waste management operation and compliance support

During 2016, disposal pathways and funding were identified for problematic low-level waste products that have remained at the Laboratory, in some cases for decades. These include radioactive sources, radioactive animal tissues, Culligan water filtration bottles with detectable radioactivity, and a tritium-containing glovebox. Efforts are underway to resolve safety, handling, and disposal issues associated with flanged tritium waste containers.

The Laboratory has worked closely with the DOE Carlsbad Field Office, Central Characterization Project, the National Transuranic Waste Program, and other National Nuclear Security Administration laboratories to integrate Waste Isolation Pilot Plant waste acceptance criteria requirements into operational procedures and resume transuranic waste shipments to the Waste Isolation Pilot Plant.

Natural Phenomena Hazard Assessment

DOE Order 420, Facility Safety, requires that nuclear facility structures, systems, and components must effectively perform their intended safety functions under the effects of natural phenomena hazards. As a part of this requirement, occurrences of natural phenomena hazards (earthquakes, floods, winds, etc.) are reviewed every 10 years to determine if major modifications to nuclear facilities are required by significant increases in risk from natural phenomena. During 2015, we reviewed the return period peak winds, rainfall, and snowfall values based on current Laboratory site meteorology data (Kelly et al.

2015). The data evaluation did not identify increases in return period weather phenomena that would require modifications to nuclear facility design. No additional meteorological assessments were conducted in 2016. An updated seismic hazard analysis of the Pajarito fault system around the Laboratory is currently underway and expected to be complete before 2019.

Environmental Remediation Program

In accordance with the 2016 Compliance Order on Consent, the Environmental Remediation Program at 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 chemical risk or radiological dose to human health or the environment. (For more information about the 2016 Compliance Order on Consent, please see Chapter 2, The Compliance Order on Consent section.) Sampling is conducted to determine if releases have occurred and, if so, whether the nature and extent are defined or further sampling is warranted. 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 further sampling is not warranted and the chemicals and radionuclides present do not pose an unacceptable risk or dose to humans, plants, or wildlife. The New Mexico Environment Department granted certificates of completion for 34 sites in 2016. The certificates for 26 sites were for corrective actions complete without controls, meaning no additional corrective actions or conditions are necessary, and certificates for eight sites were for corrective actions complete with controls, which require future site use to be restricted to industrial activities. Table 3-2 presents a summary of the reports submitted and site investigations conducted in 2016 under the Environmental Remediation Program in support of the Compliance Order on Consent. Below is a brief summary of the annual vapor monitoring at Material Disposal Area C for 2016.

Material Disposal Area C Subsurface Vapor Monitoring

Pore gas, or subsurface vapor, is the gas stored within the pore spaces of soils or rocks. Subsurface monitoring was conducted during 2016 beneath and in the area surrounding Material Disposal Area C. Subsurface vapor-monitoring samples have been collected at the site since 2004. Monitoring data indicate volatile organic compounds and tritium are present in the pore gas (LANL 2012a). Although there is no current risk to humans from the volatile organic compounds or tritium in the subsurface vapor, the pore gas beneath Material Disposal Area C continues to be monitored to assess any changes in conditions. The analytical data are available on the IntellusNM website (http://www.intellusnmdata.com).

Subsurface vapor monitoring at Material Disposal Area C was conducted twice during calendar year 2016 at 80 sampling ports within 18 vapor-monitoring wells (Figure 3-2). The sampling locations and frequency were specified by the New Mexico Environment Department (NMED 2011). The first sampling event was conducted during April 2016, and the second sampling event was conducted during October 2016.

Table 3-2
Summary of Reports Submitted and Site Investigations Conducted in 2016 under the Environmental Remediation Program

<table>
<tr><th>Document/Activity</th><th>Technical Area</th><th>Number of Sites</th><th>Sampling and Remediation</th></tr>
<tr><td>Threemile Canyon Aggregate Area supplemental investigation report (LANL 2016a)</td><td>14, 15, 36, 12</td><td>25</td><td>The 2009–2010 investigation data for 25 sites proposed for Phase II investigation were reevaluated under the Compliance Order on Consent framework agreement (January 2012), and the results are presented in this supplemental investigation report.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: There are no potential unacceptable risks or doses to humans under the industrial, construction worker, and residential scenarios; no potential ecological risks for any species evaluated; and the nature and extent of contamination is defined or no further sampling for extent is warranted for 21 sites. The sites are appropriate for corrective actions complete without controls. Additional sampling is needed to define the extent of contamination at 4 sites, of which 2 sites are also recommended for remediation. A Phase II investigation work plan will be developed based on the conclusions and recommendations presented.</td></tr>
<tr><td>Technical Area 49 inside and outside the nuclear environmental site boundary supplemental investigation reports (LANL 2016b,c)</td><td>49</td><td>10/3</td><td>The 2009–2010 investigation data for 10 sites inside the nuclear environmental site boundary and 3 sites outside the nuclear environmental site boundary at Technical Area 49 proposed for Phase II investigation were reevaluated under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: The Laboratory recommended no further investigation/remediation activities for five sites inside the nuclear environmental site boundary; four of those sites are appropriate for corrective actions complete without controls and one site is appropriate for corrective actions complete with controls. A corrective measures evaluation is recommended for five sites for which extent is defined and which pose no unacceptable present-day human-health risk under the industrial and/or residential scenarios but which have substantial radionuclide inventories that could pose potential future risk. The Laboratory recommended no further investigation/remediation activities are warranted for one site outside the nuclear environmental site boundary; the site is appropriate for corrective actions complete without controls. Additional sampling is recommended to define the extent of contamination at two sites outside the nuclear environmental site boundary. A Phase II investigation work plan will be developed for the two sites outside the nuclear environmental site boundary based on the conclusions and recommendations presented in the supplemental investigation report.</td></tr>
<tr><td>Upper Cañada del Buey Aggregate Area supplemental investigation report (LANL 2016d)</td><td>46, 52</td><td>49</td><td>The 2010 investigation data for 49 sites proposed for Phase II investigation were reevaluated under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: The Laboratory recommended no further investigation or remediation activities for 39 sites; 32 of those sites are appropriate for corrective actions complete without controls, and 7 sites are appropriate for corrective actions complete with controls. Additional sampling is needed to define the extent of contamination at 9 sites, and 2 sites (including 1 site requiring additional sampling and analysis) are recommended for remediation. A Phase II investigation work plan will be developed based on the conclusions and recommendations presented in this supplemental investigation report.</td></tr>
<tr><td>Cañon de Valle Aggregate Area, Technical Area 14 supplemental investigation report (LANL 2016e)</td><td>14</td><td>18</td><td>The 2011 investigation data for 18 sites proposed for Phase II investigation were reevaluated under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: The Laboratory recommended no further investigation or remediation activities for 17 sites; the sites are appropriate for corrective actions complete without controls. One site is recommended for delayed characterization: Area of Concern 14-001(g), which was sampled during the 2011 investigation to describe the migration of constituents in the drainages but was not completely characterized because it is an active firing site.</td></tr>
</table>

Table 3-2 (continued)

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Upper Los Alamos Canyon Aggregate Area sampling and remediation	01	7	Sampling and remediation of sites within the Upper Los Alamos Canyon Aggregate Area, particularly sites associated with the former Los Alamos Inn property, were conducted. Approximately 133 cubic yards of plutonium-239/240-contaminated soil was excavated at Solid Waste Management Units 01-001(g), 01-006(b), 01-007(a), and 01-007(b). In addition, 98 surface and subsurface samples and 10 treated lumber samples were collected from 6 solid waste management units and 1 area of concern.
Conclusions/Recommendations: Remediation was designed to result in no potential unacceptable risk/dose to human health (all scenarios) and the environment. The activities of plutonium-239/240 remaining at the sites within the relevant depth intervals are below the screening action levels and indicate no potential unacceptable dose to human receptors. An "as low as reasonably achievable" analysis for three sites located within the former Los Alamos Inn property indicated the radiation exposures to the public are as low as reasonably achievable and further soil removal is not warranted. The radiation exposures to the public at the other sites within the former Los Alamos Inn property are less than 3 millirem per year and are as low as reasonably achievable per the Laboratory's As Low As Reasonably Achievable program description. The activities remaining also do not pose a potential risk to plants or wildlife. Details and results of the sampling and remediation were presented in an investigation report on the sites within the former Los Alamos Inn property or will be presented in the Phase II investigation report for the Upper Los Alamos Canyon Aggregate Area. The investigation report on the sites within the former Los Alamos Inn property was submitted to the New Mexico Environment Department in January 2017 (LANL 2017).			

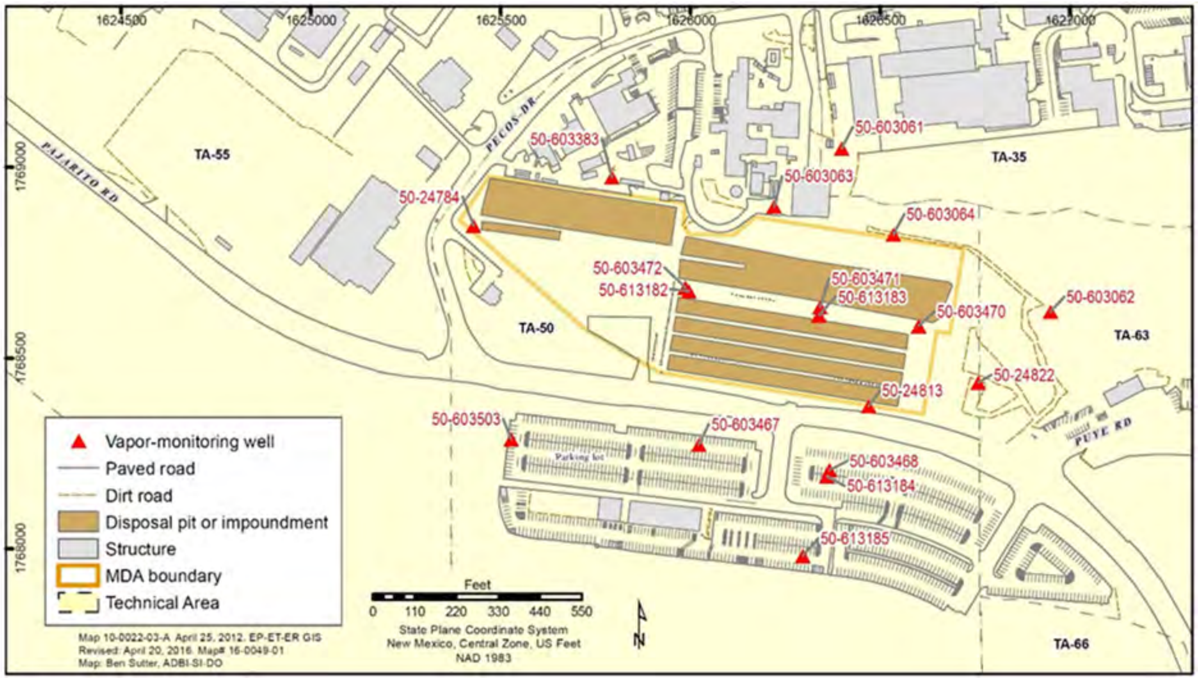

Figure 3-2 Material Disposal Area C vapor-monitoring well locations in 2016

Because no regulatory criteria currently exist for vapor-phase contaminants in soil, we evaluated volatile organic compound pore-gas data using a Tier I and Tier II screening analysis (LANL 2012a). The Tier I screening analysis has routinely been used to evaluate the pore-water concentration that would be in equilibrium with the maximum pore-gas concentration of each volatile organic compound detected. The Tier II screening analysis expands on the Tier I screening analysis by considering the migration (dilution and attenuation) of volatile organic compounds to the water table and subsequent mixing with groundwater. The Tier II screening levels, therefore, are more representative of conditions at Material Disposal Area C. 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 19 volatile organic compounds and tritium were detected in pore gas beneath Material Disposal Area C during the first 2016 sampling event, and 18 volatile organic compounds and tritium were detected in pore gas during the second 2016 sampling event. Trichloroethylene was the only volatile organic compound detected at concentrations above the Tier II screening levels in 2016. Tier II screening levels for trichloroethylene were exceeded in samples collected at monitoring wells 50-24813, 50-603470, and 50-603471 during April 2016. Tier II screening levels for trichloroethylene were exceeded in samples collected at monitoring wells 50-24813 and 50-603471 during October 2016. The locations with the highest trichloroethylene concentrations were consistent with previous monitoring data (LANL 2012b, 2013, 2014, 2015, 2016f).

The vapor plume is associated with disposal trenches and shafts near the eastern end of Material Disposal Area C. Although the vapor plume is presently located over 800 feet above the regional aquifer, there is some uncertainty associated with the future transport of vapor-phase contaminants through the fractured dacite rock layer beneath the plume. Therefore, soil vapor extraction has been recommended as a remedy to decrease subsurface vapor concentrations of volatile organic compounds, particularly trichloroethylene (LANL 2012a).

Tritium activity was detected in vapor samples collected at Material Disposal Area C. At most locations, the tritium activity decreased with depth. A Tier II screening level for tritium (288,800 picocuries per liter) has been calculated as the product of the Tier I screening level (20,000 picocuries per liter) and an aquifer dilution factor of 14.44 (LANL 2012a). Most tritium activities (>84%) were below the Tier II screening level. However, the Tier II screening level for tritium does not account for transport in the unsaturated zone. Tritium activities exceeded the Tier II screening level at monitoring wells 50-603470, 50-603383, and 50-603472 for both sampling events. These results are consistent with previous sampling data.

Vapor monitoring at Material Disposal Area C will continue on a semiannual basis to support remedy selection.

Supplemental Environmental Projects

In 2014, the New Mexico Environment Department's Hazardous Waste Bureau issued compliance orders for New Mexico Hazardous Waste Act violations stemming from the improper treatment of transuranic waste shipped from the Laboratory to the Waste Isolation Pilot Plant. A settlement agreement was signed in 2016. The settlement agreement between DOE and the New Mexico Environment Department includes five projects, which the Laboratory will implement in the next 2 years.

- Roads project – Improve routes at the Laboratory used for the transportation of transuranic waste to the Waste Isolation Pilot Plant.
- Triennial review project – Conduct an independent, external triennial review of environmental regulatory compliance and operations.
- Watershed enhancement project – Design and install engineering structures in and around the Laboratory to slow storm water flow and decrease sediment load to improve water quality in the area.
- Surface water sampling project – Conduct increased sampling and monitoring capabilities for storm water runoff in and around the Laboratory with the results of sampling and monitoring shared with the public and the New Mexico Environment Department.
- Potable water line replacement project – Replace aging potable water lines and install metering equipment for Laboratory potable water systems. These improvements would reduce potable water losses, minimize reportable spills, and enhance water conservation.

Land Conveyance and Transfer Project

Section 632 of Public Law 105-119 directed DOE to transfer excess land at the Laboratory to Los Alamos County and to the Secretary of the Interior in trust for the Pueblo de San Ildefonso. To date, 16 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 to be held in trust for the Pueblo de San Ildefonso.

The Land Conveyance and Transfer project staff continues to work with the DOE National Nuclear Security Administration Los Alamos Field Office to complete the outstanding compliance activities and requirements needed to convey the remaining tracts. In 2016, accomplishments included the following:

- Sampling and analysis plans were completed and confirmatory sampling performed for several tracts proposed for conveyance to Los Alamos County, in accordance with DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment:
  - ❖ A sampling and analysis plan was prepared for Tract A-16-d in February 2016. The tract was sampled in May 2016, and confirmatory sampling was completed in late 2016.
  - ❖ A sampling and analysis plan was prepared for Tract A-16-e in August 2016, and confirmatory sampling was completed in late 2016.
  - ❖ A sampling and analysis plan was prepared for Tract A-16-c in June 2016. The tract was sampled in September 2016, and confirmatory sampling was completed in late 2016.
- Environmental baseline survey reports were prepared for four tracts: C-2, C-3, C-4, and A-16-a.
- Tract C-3 (Front Hill Road) was conveyed to Los Alamos County.
- Work was completed to correct erosion issues on a trail segment within Tract A-14-c in Rendija Canyon.
- New authorized limits were developed for DOE Headquarters review and approval. The new authorized limits address DOE's request that the Laboratory use an alternate dosimetry method.

AWARDS AND RECOGNITION

- In 2016, we received a Gold-Level GreenBuy award from DOE. This award recognizes excellence in sustainable acquisition, which involves preferentially purchasing products that contain recycled content or are environmentally preferable in some other respect.
- We received five Pollution Prevention awards from the National Nuclear Security Administration in 2016. These awards recognize excellence in projects that improve the environment or enhance sustainability. Two of these projects won Best-in-Class recognition within the National Nuclear Security Administration complex. The titles of the winning projects are as follows:
  - ❖ Continuous Improvement in Chemistry Research

- ❖ Consolidating Thousands of Data Servers into a Private Cloud Service Saves Over 10 Million Kilowatt Hours
- ❖ Championing Sustainability in a Rural Scientific Environment
- ❖ Water Management at Los Alamos National Laboratory
- ❖ A Modern Strategy for an Aging Campus

LABORATORY ENVIRONMENTAL DATA PROCESS

Analytical chemical and radiological data presented in this annual site environmental report can be found in the IntellusNM database at http://www.intellusnm.com.

The data collection process starts with sample planning. Field collection forms and chains of custody are generated ahead of time. When field sampling is complete, the samples are delivered to the Sample Management Office at LANL following standardized procedures. The Sample Management Office tracks the samples and ships them to the designated analytical laboratory.

Once analytical laboratories have completed their analyses, they electronically upload the results into LANL's Environmental Information Management System. Email notifications are sent to the Sample Management Office indicating the data are ready for us to review and process. Staff review and auto-validate the electronic data files. 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 qualifiers and processed to the final data tables in the Environmental Information Management System.

If any errors are found that are the result of analytical laboratory processing, the analytical laboratory is notified to correct the issues and resubmit the data. If errors are the result of LANL processing (such as incorrect location identification), the Sample Management Office fixes the issue. Once data validation is complete, data in the Environmental Information Management System are available to our environmental programs for review, analysis, and reporting.

Nonanalytical field data (such as soil type or texture) may be collected in conjunction with analytical sample data. Field data are imported directly into a working database and are subject to automated format checking and manual quality assurance reviews in accordance with the responsible environmental program's standard operating procedures. Once reviewed, these data are also available in the Environmental Information Management System.

Once data (field and analytical) are validated and available in the Environmental Information Management System, they are released to the IntellusNM website (http://www.intellusnm.com). This is true for all data except for data associated with third parties and selected data with hold flags manually applied by LANL.

We treat data collected at locations owned by third parties in accordance with supplementary agreements between the Laboratory and the land owners. All data associated with a third-party landowner are reviewed and auto-validated in the same manner as data from LANL locations. However, instead of direct nightly release to the IntellusNM website, third-party analytical results are sent via email to the landowners for their information and review. During the review process, the data are withheld from release to IntellusNM. Once the landowner has finished review or the agreed-upon holding time frame has elapsed, the data are released to the IntellusNM website.

DOE Consolidated Audit Program

LANL uses off-site analytical laboratories for radiological and chemical analysis of environmental samples. The services of these laboratories are procured though a formal contract. The performing analytical laboratories are required to have a documented quality assurance/quality control program and to participate in DOE Consolidated Audit Program. The DOE Consolidated Audit Program is a DOE-Headquarters program that conducts annual audits of analytical laboratories and commercial waste treatment, storage, and disposal facilities that provide services to DOE sites throughout the complex.

The audits cover data quality and defensibility and ensure the integrity of the analytical laboratory in functional areas such as quality assurance management systems and general laboratory practices, radiochemistry, organic analysis, inorganic and wet chemistry analysis, laboratory information management systems, and hazardous and radioactive material management. The audit rating system documents Priority I Findings (deficiency from a requirement), Priority II Findings (deviation from a requirement), and Observations (opportunity for improvement). The analytical laboratory is responsible for corrective actions resulting from audit findings. All corrective actions are in the laboratories' documented response and are evaluated based upon root cause analysis, correction, and prevention from recurrence by the next scheduled audit.

The DOE Consolidated Audit Program's audit reports and corrective actions plans are available through their SharePoint electronic data system. DOE employees and DOE contractor personnel may request access to the electronic data system and receive authorization from the DOE Office of Science, Office of Information Technology and Services.

Audits by the DOE Consolidated Audit Program are one of the methods that DOE uses to meet the requirements in DOE Order 414.1D, Quality Assurance, specifically paragraph 1b(3), where it states that DOE's goal is to achieve quality work based on certain principles. Audits also ensure that quality and reliable data are available for decision-making to support on-going mission-critical operations and functions, environmental remediation, clean-up projects, and environmental surveillance at the Laboratory.

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The purpose of Los Alamos National Laboratory's (the Laboratory's) air-quality surveillance program is to protect the environment and public health and to address the question "Are there adverse effects to humans, plants, or animals from Laboratory-produced radioactive airborne materials or direct radiation?" Air quality is monitored through five programs: (1) air sampling for radionuclides at locations used by people, plants, or animals; (2) air sampling of emission exhaust stacks at Laboratory facilities; (3) gamma and neutron direct radiation monitoring near radiation sources and near locations used by people, plants, and animals; (4) nonradiological air monitoring for particulate matter concentrations; and (5) monitoring of local climate and weather. One of our primary objectives is to measure levels of airborne radiological materials in order to calculate radiological doses to humans, plants, and animals. We compare these dose results with U.S. Department of Energy and U.S. Environmental Protection Agency standards. **During 2016, the radiological doses from Laboratory operations were far below the U.S. Department of Energy and U.S. Environmental Protection Agency limits.**

AMBIENT AIR SAMPLING

Introduction

Los Alamos National Laboratory's (LANL's or the Laboratory's) air-sampling network measures levels of airborne radionuclides in order to monitor releases from Laboratory operations. We compare radioactivity levels in air with the U.S. Environmental Protection Agency's 10-millirem (mrem) annual dose limit (EPA 1989) and the U.S. Department of Energy's (DOE's) 100-mrem annual dose limit (DOE 2011).

The atmosphere contains naturally occurring radionuclides and also contains radioactive materials from aboveground testing of nuclear weapons and from large-scale nuclear accidents (global fallout). All these components contribute to background airborne radioactivity. We measure background airborne radioactivity at regional monitoring stations located more than 6 miles from the Laboratory. Background results are summarized in Table 4-1.

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

Analyte	Units	U.S. Environmental Protection Agency Limit	Average Background Activities
Tritium	pCi/m^3 [a]	1500	1 ± 1
Americium-241	aCi/m^3 [b]	1900	0 ± 1
Plutonium-238	aCi/m^3	2100	0 ± 1
Plutonium-239/240	aCi/m^3	2000	0 ± 1
Uranium-234	aCi/m^3	7700	13 ± 10
Uranium-235	aCi/m^3	7100	1 ± 2
Uranium-238	aCi/m^3	8300	12 ± 11

[a] pCi/m^3 = Picocuries per cubic meter.
[b] aCi/m^3 = Attocuries per cubic meter.

Air-Monitoring Network

During 2016, the Laboratory operated 38 environmental air-monitoring stations to sample radionuclides in airborne particulate matter (Figures 4-1 and 4-2). Sampling locations are categorized as regional (>6 miles from the Laboratory), perimeter, waste site (Area G), or on-site. These stations are operated continuously; filters are changed out every 2 weeks and sent to an analytical laboratory for analysis.

Quality Assurance

The quality assurance program satisfies 40 Code of Federal Regulations 61, Appendix B, Method 114 (EPA 1989). The 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 U.S. Environmental Protection Agency methods for sample handling, chain of custody, analytical chemistry, and statistical analyses of data.

Radionuclide Levels in Air

Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and of natural processes by which high-energy cosmic rays interact with atoms (Eisenbud and Gesell 1997). Water-vapor concentrations in the air and tritium levels in the water vapor (corrected for blanks, bound water in the silica gel, and isotopic distillation effects) are used to calculate air activities of tritium.

During 2016, annual mean tritium activities were similar to recent years and well below U.S. Environmental Protection Agency and DOE guidelines (Table 4-2). The highest annual tritium activity at any station not on Laboratory property was 0.3% of the U.S. Environmental Protection Agency public dose limit (1500 pCi/m^3).

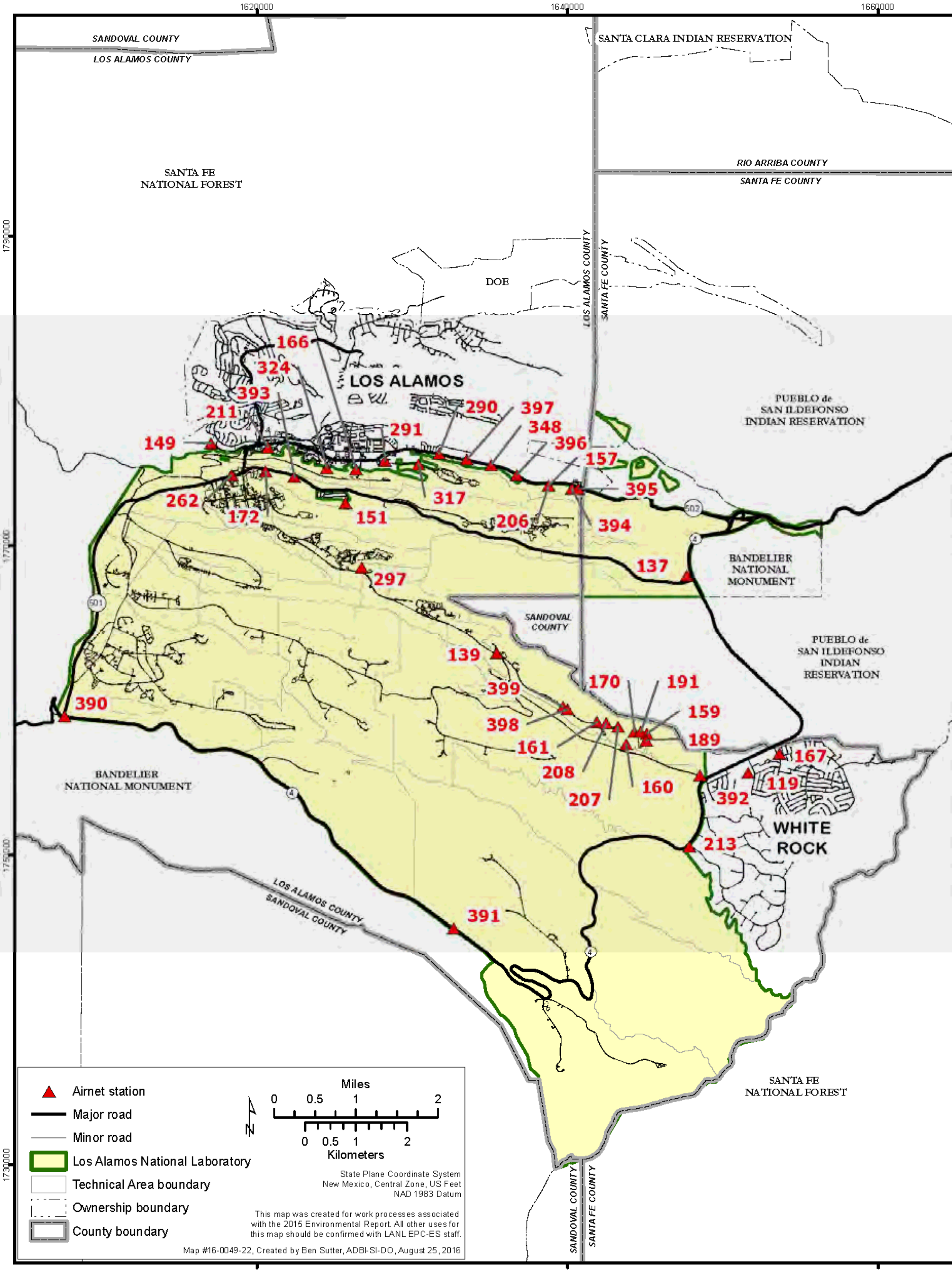
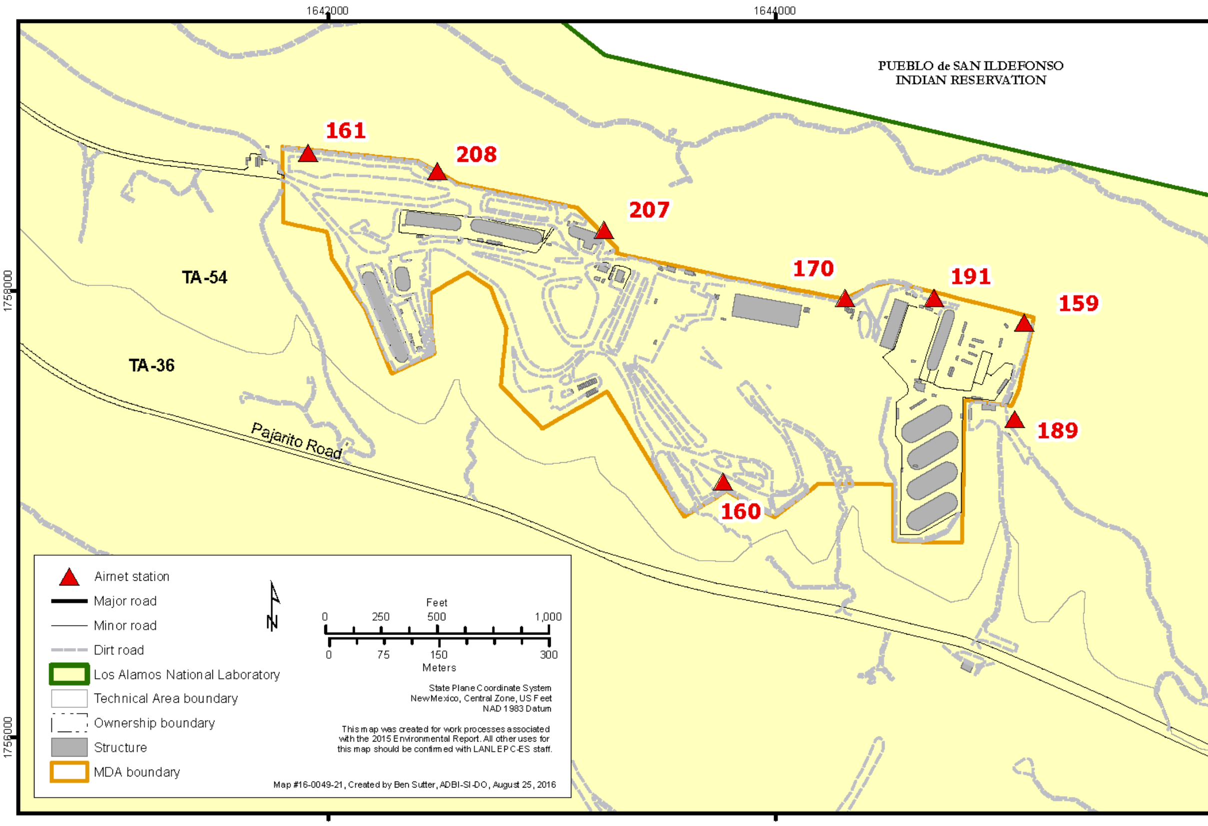


Figure 4-1 Environmental air-monitoring stations at and near the Laboratory



Notes: MDA = Material disposal area. TA = Technical area.

Figure 4-2 Environmental air-monitoring stations at the Laboratory's Technical Area 54, Area G

Table 4-2
Airborne Tritium as Tritiated Water Activities for 2016—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (pCi/m³)		Maximum Annual Station Activity (pCi/m³)	U.S. Environmental Protection Agency Public Dose Limit (pCi/m³)
Regional	3	1	±2	2	1500
Perimeter	25	1	±2	4	1500
On-site	2	9	±10	16	1500
Waste site	1	670	360	670	1500

The waste site data are measured at a location at the southern boundary of Area G (station 160; Figure 4-2), which is a controlled area and not publicly accessible.

The analytical methods comply with U.S. Environmental Protection Agency requirements in 40 Code of Federal Regulations 61, Appendix B, Method 114 (EPA 1989).

Americium-241

Table 4-3 summarizes the 2016 sampling data for americium-241, which are similar to recent years, less than 0.1% of the regulatory limits, and not significantly different than zero.

Table 4-3
Airborne Americium-241 Activities for 2016—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (aCi/m³)		Maximum Annual Station Activity (aCi/m³)
Regional	3	0	±1	0
Perimeter	25	0	±1	1
On-site	2	0	±1	0
Waste site	8	0	±1	1

Plutonium

Plutonium from global fallout occurs worldwide at low levels. Table 4-4 summarizes the LANL plutonium-238 and plutonium-239/240 data for 2016, which are similar to recent years.

Table 4-4
Airborne Plutonium-238 and Plutonium-239/240 Activities for 2016—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m³)		Maximum Annual Station Activity (aCi/m³)	
		Plutonium-238	Plutonium -239/240	Plutonium -238	Plutonium -239/240
Regional	3	0 ±1	1 ±1	0	1
Perimeter	25	0 ±1	1 ±5	1	10
On-site	2	0 ±1	1 ±3	0	2
Waste site	8	0 ±1	2 ±7	1	11

South of the original Manhattan Project Technical Area 01, soil in Los Alamos Canyon has elevated plutonium-239/240 levels. Dust that gets blown into the air from the canyon slope causes detectable levels of plutonium-239 in the air; the average plutonium-239 activity was 10 aCi/m³ in 2016. Near the historical location of the plutonium facility at Technical Area 21, the plutonium-239 activity was 2 aCi/m³. These activities are much less than 1% of the regulatory limits.

At the Area G waste site, the highest plutonium activity was 11 aCi/m³, which is lower than most previous years because minimal amounts of soil were moved at Area G during 2016.

Uranium

The uranium isotopes -234, -235, and -238 are found in nature. Natural uranium has constant and known ratios of these three isotopes: in natural uranium, uranium-238 activity is generally equal to uranium-234 activity (Walker et al. 1989). Uranium that has been enriched by processing (enriched uranium) has higher levels of uranium-235, and uranium that has been depleted by processing (depleted uranium) has higher levels of uranium-238. Only natural uranium was detected in 2016. The uranium activities (Table 4-5) were similar to previous years and below 0.5% of the U.S. Environmental Protection Agency guidelines.

Table 4-5
Airborne Uranium-234, -235, and -238 Activities for 2016—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m^3)		
		Uranium-234	Uranium -235	Uranium -238
Regional	3	13 ±10	1 ±2	12 ±11
Perimeter	25	8 ±8	0 ±1	8 ±8
On-site	2	8 ±2	1 ±1	7 ±2
Waste site	8	10 ±10	1 ±1	11 ±12

Gamma Spectroscopy Measurements

Gamma rays are one type of natural radioactivity. Gamma rays are similar to x-rays. For gamma screening, we analyze for the following gamma-ray-producing radionuclides: 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. During 2016, only naturally occurring radionuclides were detected.

Conclusion

Near the Laboratory, measured activities of airborne radioactive material were far below all regulatory limits.

EXHAUST STACK SAMPLING FOR RADIONUCLIDES

Introduction

Because radioactive materials are used in certain Laboratory operations, the facilities that house those operations have the potential to vent radioactive materials to the environment through an exhaust stack or other release point. Using engineering calculations and radioactive materials usage information, the Laboratory's stack monitoring team identifies each emission point with the potential to release a public dose greater than 0.1 mrem in a year. Each stack identified with this potential is sampled in accordance with 40 Code of Federal Regulations 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities (EPA 1989).

Sampling Methodology

Radioactive stack emissions can be one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, or (4) gaseous mixed activation products. For each of these emission types, the Laboratory employs an appropriate sampling method as described below.

Emissions of radioactive particulate matter are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. Samples are collected weekly and shipped to an off-site analytical laboratory.

Charcoal cartridges are used to sample emissions of vapors and volatile compounds generated by operations at the Technical Area 53 Los Alamos Neutron Science Center, in shielded nuclear radiation containment chambers at the Chemistry and Metallurgy Research Building, and at Technical Area 48.

Tritium emissions are measured with collection devices known as bubblers to determine the total amount of tritium released and also whether it is in the elemental or oxide form. The bubblers pull a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects any tritium oxide that may be part of a water molecule. The air is then passed through a palladium catalyst that converts the elemental tritium to the oxide form. The sample is then pulled through three additional vials containing ethylene glycol, which collect the newly formed tritium oxide.

We measure gaseous mixed activation products emissions from Los Alamos Neutron Science Center 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.

Data Analysis

Methods

This section discusses the analysis methods for each type of the Laboratory's emissions. The methods comply with U.S. Environmental Protection Agency requirements in 40 Code of Federal Regulations 61, Appendix B, Method 114 (EPA 1989).

Particulate Matter

Each week the glass-fiber filters are collected, and the total activity is measured before the filters are shipped to an off-site analytical laboratory and analyzed using spectrometry to identify radionuclides. These data are used to quantify emissions of radionuclides. We compare the results of the isotopic analysis with total activity measurements to ensure that the requested analyses identify all significant radiological activity.

Vaporous Activation Products

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.

Tritium

Each week, tritium bubbler samples are collected and transported to the Laboratory's Health Physics Analysis Laboratory, where the amount of tritium in each vial is determined by liquid scintillation counting.

Gaseous Mixed Activation Products

Continuous monitoring is used for gaseous mixed activation products at the Los Alamos Neutron Science Center. There are two reasons for the use of continuous monitoring. First, standard filter paper and charcoal filters will not collect gaseous emissions. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-site. The monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. 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 accelerator operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these gaseous mixed activation products emissions. Using decay curves and energy spectra to identify the various radionuclides, the relative composition of the emissions is determined.

Analytical Results

Measurements of Laboratory stack emissions during 2016 totaled approximately 254 curies (compared with 126 curies in 2015). These increases were the result of increased operations during 2016. Of this total, tritium emissions contributed approximately 63 curies (compared with 38 curies in 2015), and gaseous mixed activation products from Los Alamos Neutron Science Center stacks contributed 191 curies (compared with 88 curies in 2015). Diffuse emissions from the Los Alamos Neutron Science Center contributed another 34 curies of gaseous mixed activation products. Combined airborne emissions of particulate materials such as plutonium, uranium, americium, and thorium were about 0.00001 curies. Emissions of particulate matter plus vapor activation products were about 0.02 curies (short-lived progeny are included in the 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 gaseous mixed activation products and particulate matter plus vapor activation products. Table 4-8 presents the half-lives of the radionuclides typically emitted by the Laboratory. During 2016, the Los Alamos Neutron Science Center facility nonpoint source emissions of gaseous mixed activation products (emissions that did not come out of an exhaust stack) comprised approximately 10 curies of carbon-11 and 23 curies of argon-41. These short-lived isotopes are the main contributors to the off-site dose discussed in Chapter 8.

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. Emissions of other radionuclides, although higher in the number of curies, contribute a small dose to humans and biota. These doses are assessed and reported in Chapter 8.

Table 4-6
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2016

Building Number	Tritium (curies)	Americium-241 (curies)	Plutonium (curies)	Uranium (curies)	Thorium (curies)	Particulate Matter plus Vapor Activation Products (curies)	Gaseous Mixed Activation Products (curies)
TA-03-029		8.1E-07	2.8E-06	3.6E-06	4.1E-07		
TA-16-205/450	4.0E+01						
TA-48-001				1.6E-09		1.2E-02	
TA-50-069			5.4E-9				
TA-53-003	1.8E+01					1.5E-04	5.2E+01
TA-53-007	3.9E+00					2.7E-03	1.1E+02
TA-54-375				4.1E-09			
TA-54-231/412			3.9E-10	8.2E-10	1.5E-09		
TA-55-004	1.3E+00		1.6E-09	2.3E-08	2.4E-08		
Total	6.3E+01	8.1E-07	2.8E-06	3.6E-06	4.3E-07	1.5E-02	1.6E+02

Table 4-7
Detailed Results of Activation Product Sampling from LANL Stacks in 2016

Building No.	Nuclide	Emission (curies)
TA-48-001	Arsenic-73	1.8E-05
TA-48-001	Arsenic -74	6.8E-05
TA-48-001	Bromine-76	4,3E-04
TA-48-001	Bromine -77	1.1E-03
TA-48-001	Bromine -82	6.1E-06
TA-48-001	Gallium-68	4.4E-03
TA-48-001	Germanium-68	4.4E-03
TA-48-001	Mercury-197	8.3E-04
TA-48-001	Mercury-197m	8.3E-04
TA-48-001	Iodine-131	1.6E-06
TA-48-001	Selenium-75	1.2E-04
TA-53-003	Argon-41	2.1E+00
TA-53-003	Beryllium-7	7.4E-05
TA-53-003	Bromine -76	7.4E-06
TA-53-003	Bromine -77	3.5E-06
TA-53-003	Bromine -82	5.2E-05
TA-53-003	Carbon-11	5.0E+01
TA-53-003	Sodium-24	1.1E-05
TA-53-007	Argon-41	9.4E+00
TA-53-007	Bromine -76	1.2E-04
TA-53-007	Bromine -82	1.9E-03
TA-53-007	Carbon -10	2.2E-01
TA-53-007	Carbon -11	4.7E+01
TA-53-007	Mercury-197	3.4E-04
TA-53-007	Mercury-197m	3.4E-04
TA-53-007	Nitrogen-13	2.7E+01
TA-53-007	Nitrogen -16	3.9E-01
TA-53-007	Oxygen-14	5.4E-01
TA-53-007	Oxygen -15	2.1E+01
TA-53-007	Osmium-191	5.7E-07

Table 4-8
Radionuclide Half-Lives

Nuclide	Half-Life
Tritium	12.3 years
Beryllium -7	53.4 days
Carbon -10	19.3 seconds
Carbon -11	20.5 minutes
Nitrogen -13	10.0 minutes
Nitrogen -16	7.13 seconds
Oxygen -14	70.6 seconds
Oxygen -15	122.2 seconds
Sodium-22	2.6 years
Sodium-24	14.96 hours
Argon-41	1.83 hours
Cobalt-60	5.3 years
Arsenic -73	80.3 days
Arsenic -74	17.78 days
Bromine -76	16 hours
Bromine -77	2.4 days
Bromine -82	1.47 days
Selenium-75	119.8 days
Strontium-90	28.6 years
Cesium-134	2.06 years
Cesium-137	30.2 years
Osmium-191	15.4 days
Mercury-197	2.67 days
Mercury-197m	23.8 hours
Uranium-234	244,500 years
Uranium-235	703,800,000 years
Uranium-238	4,468,000,000 years
Plutonium-238	87.7 years
Plutonium-239	24,131 years
Plutonium-240	6569 years
Plutonium-241	14.4 years
Americium-241	432 years

GAMMA AND NEUTRON RADIATION MONITORING

Introduction

The objectives of the direct penetrating radiation monitoring network and of the neighborhood environmental watch network are to monitor gamma and neutron radiation in the environment, as required by DOE Order 458.1 Chg 3, and to demonstrate compliance with the DOE all-pathway dose limit of 100 mrem/yr.

Short-lived airborne radionuclides cannot be measured by the radiological air-sampling network, so thermoluminescent dosimeters are deployed at every environmental air-monitoring station to monitor short-lived radioactivity as well as radioactive material above the breathing height. In addition, neighborhood environmental watch network stations are situated at key locations.

The primary sources of gamma and neutron radiation at the Laboratory are the Los Alamos Neutron Science Center at Technical Area 53 and Area G at Technical Area 54. The Los Alamos Neutron Science Center only produces radiation when the accelerator is on, and short-lived activation products such as carbon-11 are only detected when the wind blows from the source to the detector. These fluctuations are apparent in the real-time neighborhood environmental watch network station displays at http://environweb.lanl.gov/newnet/, and the results are consistent with the measurements of Los Alamos Neutron Science Center emissions reported in the Exhaust Stack Sampling for Radionuclides section of this chapter.

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. Measurements are made both at public locations and close to potential sources, and the data are compared with models of radiation levels as a function of distance (McNaughton 2013). Thus, radiation from the Laboratory is distinguished by higher levels close to the sources and also from the trend of the radiation levels with distance from the source.

Dosimeter Locations

Eighty thermoluminescent dosimeters are located around the Laboratory and in the surrounding communities. Dosimeters are located at the environmental air stations shown in Figure 4-1, and additional thermoluminescent dosimeters are located around Technical Area 54, Area G, as shown in Figure 4-3.

Neutron Radiation

Neutron doses are monitored near known or suspected sources of neutrons using neutron dosimeters.

The background level of neutron radiation is measured at a location where it is isolated from human-produced neutrons. These background data are supplemented by data from other locations far from Laboratory sources.

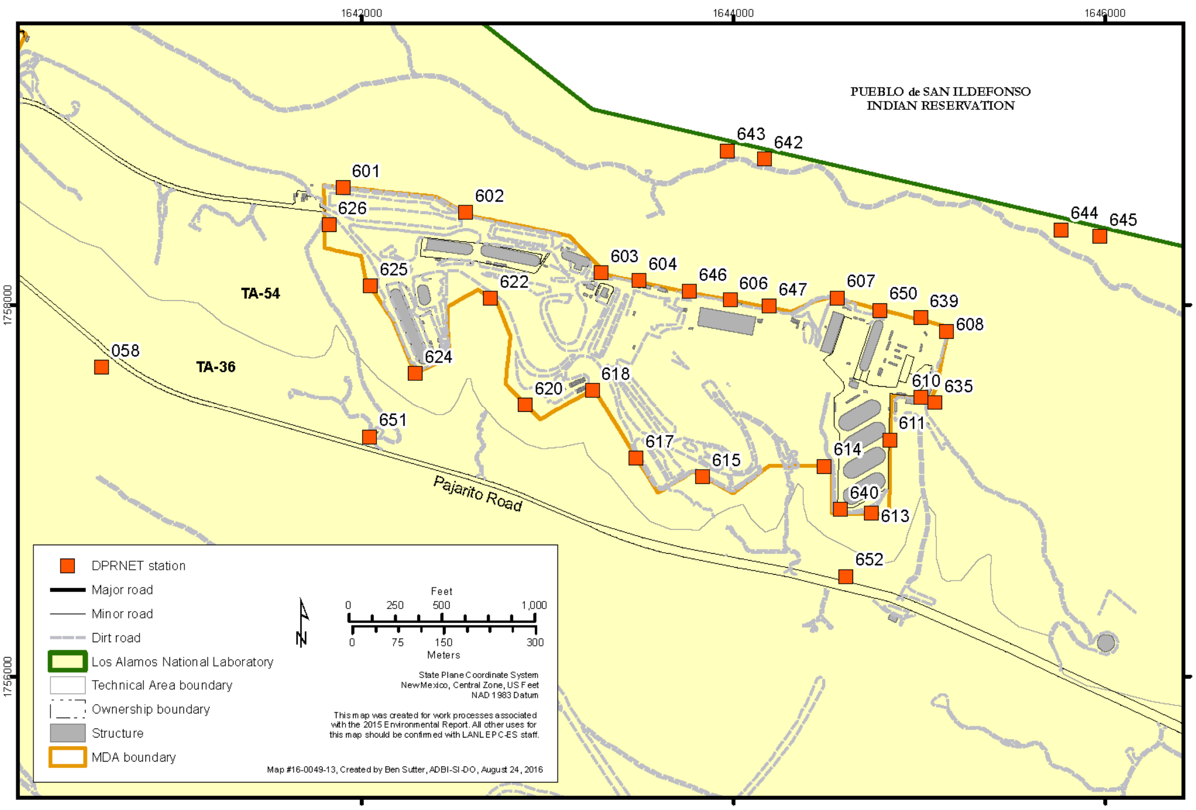


Figure 4-3 **Locations of thermoluminescent dosimeters at Technical Area 54, Area G, that are part of the direct penetrating radiation monitoring network (DPRNET)**

Quality Assurance

The Radiation Protection Division calibration laboratory at LANL calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited this calibration laboratory. The Radiation Protection Division provides quality assurance for the dosimeters. The uncertainty in the thermoluminescent dosimeter data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall uncertainty (one standard deviation) is 8%.

Results

The doses at most locations are consistent with natural background radiation. The locations with a measurable contribution from Laboratory operations are discussed below.

Los Alamos Neutron Science Center at Technical Area 53

DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, requires DOE radiological facilities to determine the doses to a hypothetical maximally exposed individual member of the public, both on-site and off-site. Previous studies have shown that the only on-site location where a member of the public could receive a measurable dose is along East Jemez Road, in the bottom of Sandia Canyon, near the Los Alamos Neutron Science Center, which is located on an adjacent mesa top (McNaughton 2013). Therefore, thermoluminescent dosimeters at the Los Alamos Neutron Science Center are used to determine this on-site dose.

Away from the Los Alamos Neutron Science Center buildings, the only thermoluminescent dosimeter at Technical Area 53 that measures an above-background gamma dose is at a location 100 meters from the tanks at the east end, where the dose was 170 mrem/yr, 40 mrem/yr above the background of 130 mrem/yr. East Jemez Road in Sandia Canyon does not receive direct radiation from the Los Alamos Neutron Science Center. However, the road receives photons that are scattered from the air, known as "sky shine." The Monte Carlo N-Particle program was used to calculate the sky-shine gamma dose on East Jemez Road, 500 meters south of the tanks. The dose at East Jemez Road is 0.2% of the dose at the thermoluminescent dosimeter location (McNaughton 2013). Therefore, during 2016, the gamma dose at East Jemez Road from the tanks was 0.2% of 40 mrem/yr, which is 0.1 mrem/yr. This is the dose that would be received by a person who is at this location 24 hours per day, 365 days per year. There are no public facilities near this location, so the occupancy factor (the percentage of the time a member of the public would spend at this location) is less than 1%, and the gamma dose to a member of the public is less than 0.001 mrem/yr.

Similarly, the annual neutron dose on the mesa overlooking East Jemez Road at the Los Alamos Neutron Science Center was 5 mrem above background. Since East Jemez Road is in Sandia Canyon, it only receives neutrons that are scattered from the air. Monte Carlo N-Particle calculations show that the annual dose at East Jemez Road, 350 meters south of the accelerator line D targets, is 10% of the 5-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.

Technical Area 54, Area G

Figure 4-3 shows the locations of the thermoluminescent dosimeters at Technical Area 54, Area G. Situated south of the line of dosimeters 601 to 608, Area G is a controlled-access area, so the Area G data do not represent a potential public dose. Dosimeters 642 through 645 are in Cañada del Buey. After subtracting background, the annual neutron dose measured by these thermoluminescent dosimeters was 1.8 mrem. This is the dose that would be received by a person who is at the location of the dosimeters 24 hours per day, 365 days per year. As discussed in Chapter 8, an occupancy factor of 1/16 is applied (NCRP 1976), so the public dose in Cañada del Buey at the dosimeters is calculated to be 1.8/16 ≈ 0.1 mrem/yr, which is similar to previous years.

Neighborhood Environmental Watch Network

During 2016, the neighborhood environmental watch network did not record any doses above the normal background, which indicates that the public dose from gamma-emitting radionuclides produced by Laboratory operations was well below 1 mrem/yr and far below the U.S. Environmental Protection Agency limit of 10 mrem/yr.

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 Laboratory operations.

NONRADIOLOGICAL AIR MONITORING

Introduction

Particulate matter is monitored at two locations: the old White Rock Fire Station on Rover Boulevard and the Los Alamos Medical Center.

Ambient Air Particulate Matter Concentrations

During 2016, the particulate matter concentrations remained well below the U.S. Environmental Protection Agency standard: 35 micrograms per cubic meter ($\mu g/m^3$) for particulate matter smaller than 2.5 micrometers. Typical concentrations (>95% of the time) were less than 10 $\mu g/m^3$. The highest concentrations occurred during the spring from windblown dust and during the summer from wildfires in Arizona and New Mexico.

METEOROLOGICAL MONITORING

Introduction

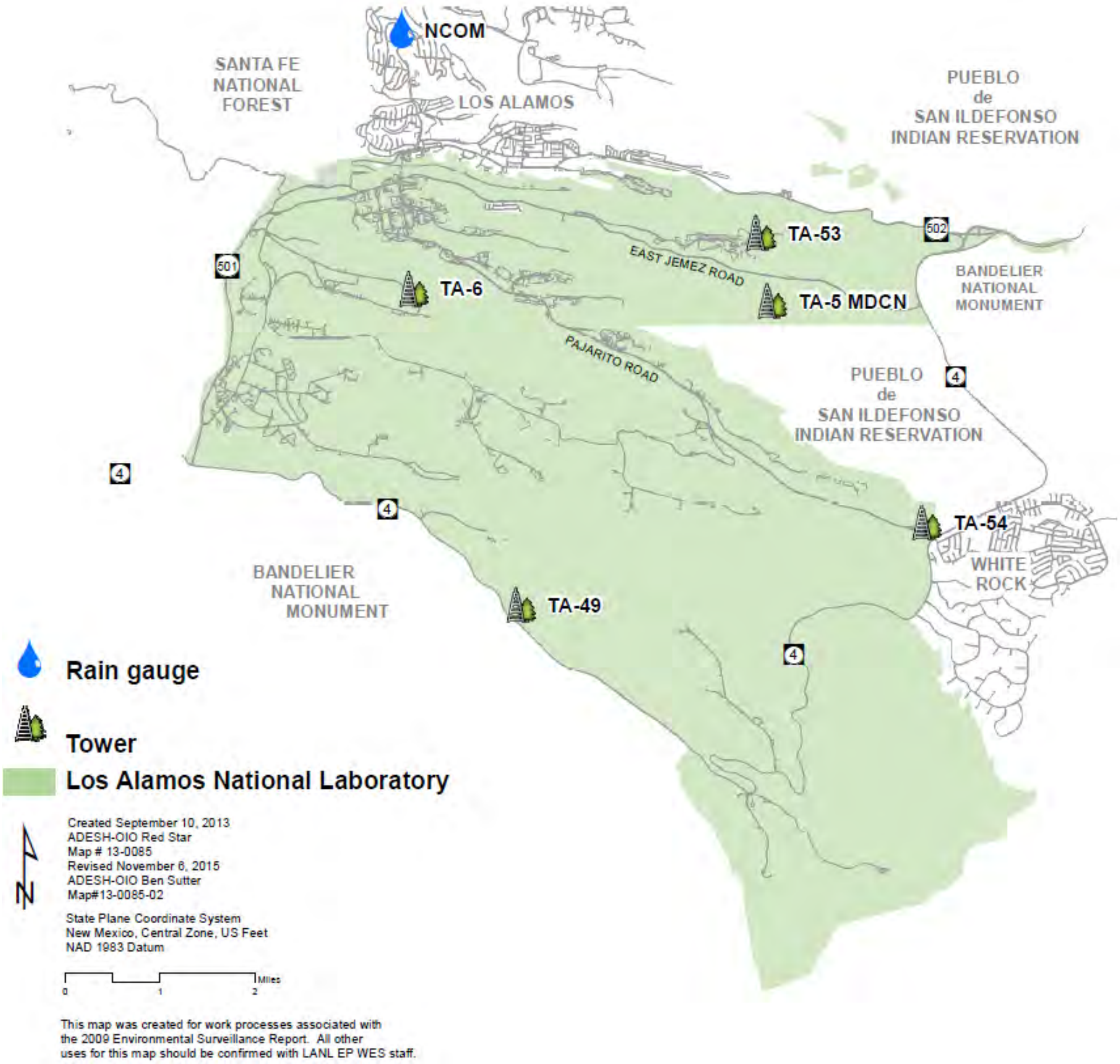
Weather data are important for many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. The meteorological monitoring program measures wind speed and direction, temperature, pressure, relative humidity and dew point, precipitation, cloud cover, and solar and terrestrial radiation, among other factors. 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/.

Monitoring Network

Currently, five towers are equipped to gather meteorological data at the Laboratory (Figure 4-4). Four of the towers are located on mesa tops (Technical Areas 06, 49, 53, and 54), and one is in the bottom of Mortandad Canyon (Technical Area 05). An additional precipitation gauge is located in the North Community of the Los Alamos townsite. The Technical Area 06 tower is the official meteorological measurement station for the Laboratory.

Sampling Procedures, Data Management, and Quality Assurance

We place the weather instruments in areas with good exposure, usually in open fields, to avoid impacts on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open-lattice towers at Technical Areas 06, 49, 53, and 54. The multiple levels provide a vertical profile important in assessing wind speed and direction at different heights above ground and in assessing air stability conditions. The multiple levels also provide redundant measurements that support data quality checks. Boom-mounted temperature sensors on the towers are shielded and aspirated (provided with constant air circulation) to minimize effects from direct sunlight. The Mortandad Canyon station includes a 10-meter tripod tower that measures wind only at the top of the tower. Temperature and humidity are measured at ground level at all stations except the North Community station, which only measures precipitation.



Notes: MDCN = Mortandad Canyon. NCOM = North community.

Figure 4-4 Locations of meteorological monitoring towers and rain gauge

Data loggers at the stations sample most of the instrument results, store the data, average the sample results over a 15-minute period, and transmit the data by network connection, telephone modem, or cell phone to a UNIX workstation. The workstation automatically edits measurements that fall outside of realistic ranges (Bruggeman et al. 2017). Time-series plots of the data are also generated for a meteorologist's data quality review. Daily statistics of certain meteorological variables (e.g., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. For more than 50 years, we have provided these daily weather statistics to the National Weather Service. In addition, cloud type and percentage cloud cover are logged daily.

Calibration frequency varies by instrument, following manufacturers' recommendations and operational considerations. All wind instruments are calibrated every 6 months. All other sensors are calibrated annually, with the exception of solar radiation sensors, which are calibrated every 5 years. An external audit of the instrumentation and methods is performed periodically. An external subcontractor inspects and performs maintenance on the station structures on an annual basis.

The LANL meteorology program met American National Standards Institute 2015 standards for data completeness with 13 exceptions. Eight of the failures were a result of upgrading to a new data logger and a bent connection on the tower at Technical Area 06. Other failures were a result of failed calibrations in wind direction at Technical Area 49 and failed calibrations in wind direction and vertical wind speed at Technical Area 54. These instrument issues have been addressed. Data quality and completeness are reported by Bruggeman et al. (2017).

Climate

Los Alamos has a temperate, semiarid mountain climate. Humidity is low, and clear skies are present about 75% of the time. These conditions lead to high solar heating during the day and strong 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 Laboratory's meteorology program and following Bowen (1990 and 1992) and Dewart et al. (2017).

Average precipitation is based on a 30-year average from 1981 to 2010 as measured at the official Laboratory station at Technical Area 06. Other Laboratory stations do not have data going back to 1981, which are necessary for a consistent averaging period. Table 4-9 presents the temperature and precipitation records set for Los Alamos from 1924 to 2016.

Table 4-9
Records Set between 1924 and 2016 for Los Alamos

Type of Measurement	Record	Date
Low temperature	-18°F	January 13, 1963
High temperature	95.5°F	June 19, 2016
Single-day rainfall	3.52 inches	September 13, 2013
Single-day snowfall	39 inches	January 15, 1987
Single-season snowfall	153 inches	1986–1987

December and January are the coldest months, when 90% of minimum temperatures are between 4°F and 31°F. Ninety percent of maximum temperatures, which are usually reached in midafternoon, are between 25°F and 55°F. Wintertime arctic air masses that descend into the central United States usually warm somewhat 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, when 90% of maximum temperatures are between 67°F and 89°F. During the summer months, 90% of minimum temperatures are between 45°F and 61°F.

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.97 inches. The average annual snowfall is 57.5 inches. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are occasionally enhanced as a result of orographic lifting of the storms by the high terrain.

The rainy season typically begins in early July and ends in mid-September. Precipitation in July and August accounts for 34% of the annual precipitation. 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 daily cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow uphill. During the night, cool air that forms close to the ground tends to flow downhill. As the daytime breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerly winds of the Pajarito Plateau. Nighttime airflow 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 and from the east during the day. Winds on the Pajarito Plateau are faster during the day than at night. This is a result 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.

2016 in Perspective

Table 4-10 presents Los Alamos weather values during 2016. Figure 4-5 presents a graphical summary of Los Alamos temperature for 2016 with the daily high and low temperature at Technical Area 06 in comparison with the 1981 to 2010 normal values and record values from 1924 to the present. The missing observations in Figure 4-5 during June and July are a result of upgrading to a new data logger at Technical Area 06. On June 19, 2016, the maximum temperature record for Los Alamos was broken at 95.5°F. The previous record was 95°F in June 1998 and June 2013. The last line of Table 4-10 summarizes the year and shows that the overall average temperature was 2.8°F above the 1981 to 2010 averages and total precipitation was 3.88 inches below the averages. For the year, Los Alamos broke or tied 38 daily temperature records. Los Alamos measured only 2 months with below-average mean temperatures (May and August). It was the third warmest year on record, following 2012 and 1954.

Table 4-10
Monthly and Annual Climatological Data for 2016 at Los Alamos

	Temperatures (°F)[a]								Precipitation (inches)[a]				12-meter[b] Wind (miles per hour)[a]				
	Averages				Extremes						Snowfall				Peak Gusts		
Month	Daily Maximum	Daily Minimum	Overall	Departure[c]	Highest	Day	Lowest	Day			Total	Departure[c]			Speed	From	Day
January	39.2	20.3	29.7	0.3	55	30	8	11	0.28	-0.67	5.1	-8.2	5.1	0.1	47	W	20
February	50.3	26.6	38.5	5.6	64	20	4	4	0.82	-0.04	11.8	0.9	5.2	-0.6	45	SW	18
March	57.9	30.8	44.3	4.9	67	21	20	27	0	-1.20	0	-10.4	8.3	1.8	57	NW	23
April	60.1	35.7	47.9	1.1	72	22	25	19	1.95	0.89	10.1	6.8	7.4	-0.2	50	SSW	23
May	67.8	42.1	54.9	-1.1	78	13	31	2	0.82	-0.57	1.4	1.1	7.6	0.2	46	SW	16
June	84.9	56.5	70.7	5.6	96	19	46	2	0.62	-0.89	0	0	7.0	-0.1	45	WNW	7
July	86.8	59.4	73.1	4.9	93	14	52	2	2.12	-0.70	0	0	7.2	1.6	36	SE	4
August	74.8	52.2	63.5	-2.3	82	12	46	25	3.43	-0.18	0	0	5.7	0	44	W	27
September	74.5	49.4	62.0	2.2	83	21	35	24	1.33	-0.68	0	0	6.1	0.3	33	WSW	5
October	69.2	42.4	55.8	6.6	77	15	30	20	0.45	-1.10	0	-2.2	5.8	-0.2	40	WSW	17
November	51.5	31.0	41.2	3.3	66	15	12	30	2.04	1.06	0.8	-4.1	6.0	0.7	56	SW	17
December	42.1	22.4	32.2	2.8	58	15	9	19	1.23	0.22	4.8	-7.4	5.3	0.8	58	WNW	17
Year	63.3	39.1	51.2	2.8	96	Jun 19	4	Feb 4	15.09	-3.88	34.0	-23.5	6.4	0.3	58	WNW	Dec 17

[a] Data from Technical Area 06, the official Laboratory weather station.
[b] Wind data measured at 12 meters above the ground.
[c] Departure column indicates positive or negative departure from 1981 to 2010 (30-year) climatological average.
[d] Departure column indicates positive or negative departure from 1990 to 2010 (21-year) climatological average.

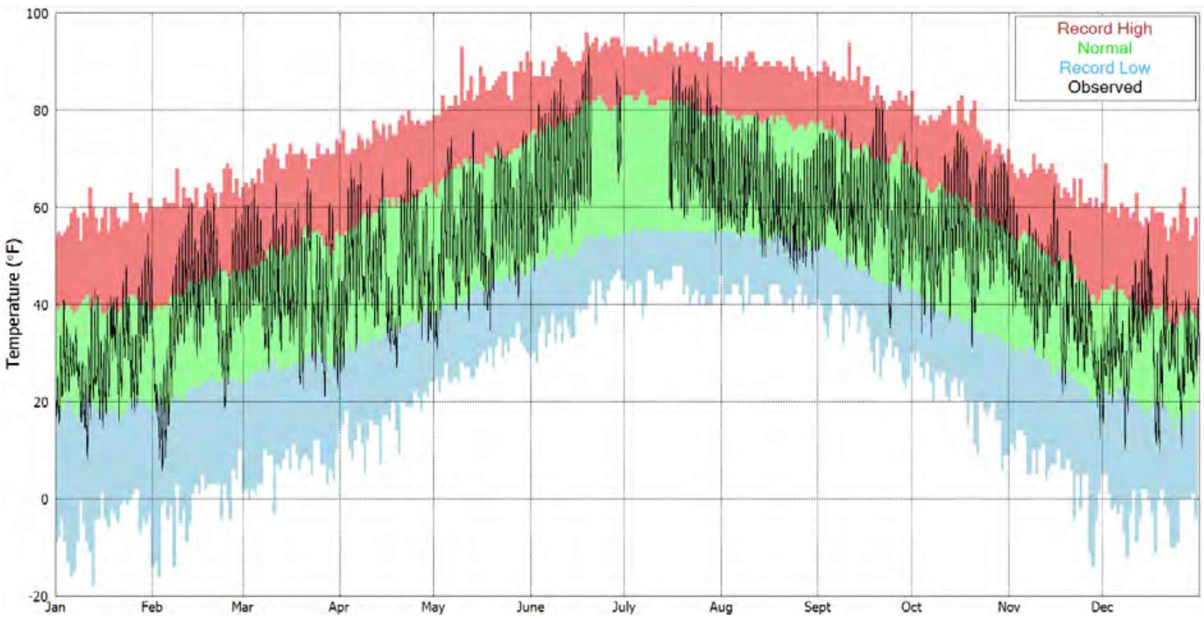


Figure 4-5 Los Alamos temperatures in degrees Fahrenheit from 2016 compared with record values and normal values

Figures 4-6 and 4-7 are graphs of Los Alamos precipitation for 2016. Los Alamos had below-average precipitation for the entire year, with the largest cumulative deficit in October and November. The monsoon season, July through September, had a total precipitation of 6.88 inches in comparison with the 30-year average of 8.45 inches. The main winter months (December, January, February) had below-average snowfall, while only February and April recorded above-average snowfall, resulting in 34 inches for the year (59% of normal). Since records began in 1910, 2016 was the first time Los Alamos measured only a trace of precipitation (less than 0.01 inches) in March, based on a complete month of observations. For the year, Los Alamos received 15.09 inches of precipitation (3.88 inches below average). The U.S. Drought Monitor determined Los Alamos had abnormally dry conditions from March to November 2016 (http://droughtmonitor.unl.edu).

Figure 4-8 presents the annual and monsoon precipitation in 2016 at the Laboratory's monitoring stations across Los Alamos. Shown across the Laboratory, approximately 50% of the annual precipitation falls during the summer monsoon season (based on the National Weather Service definition of June 15 to September 30). Typically, more precipitation is measured closer to the Jemez Mountains, and the Technical Area 54 tower near White Rock measures the least precipitation.

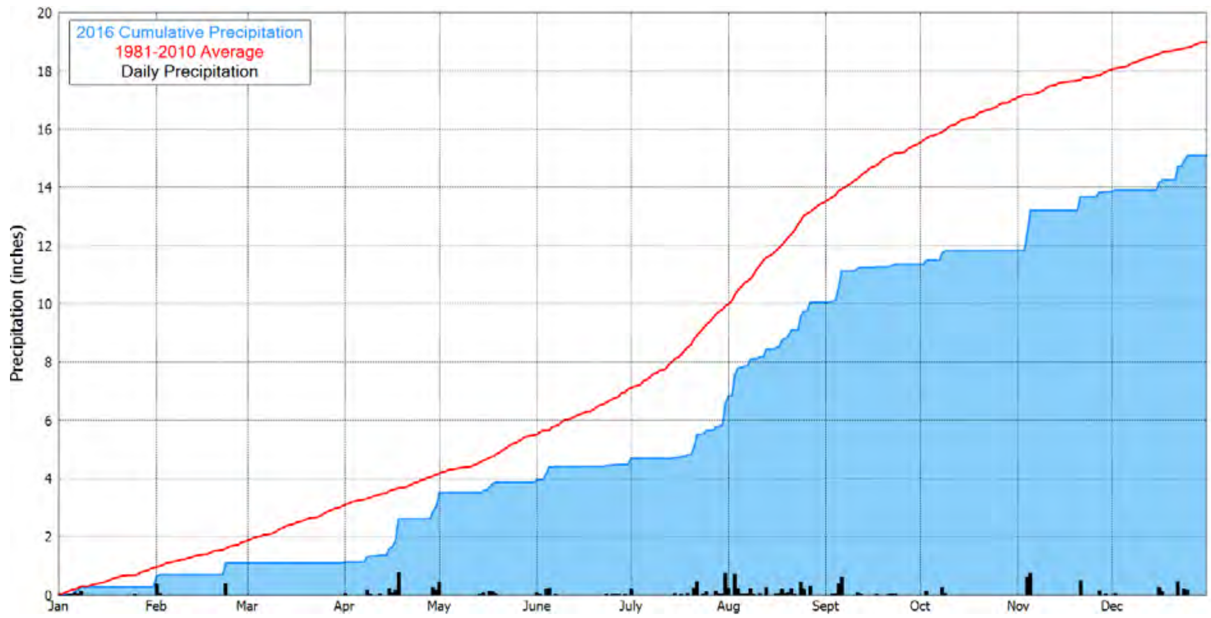


Figure 4-6 Technical Area 06 cumulative precipitation in 2016 versus 30-year average

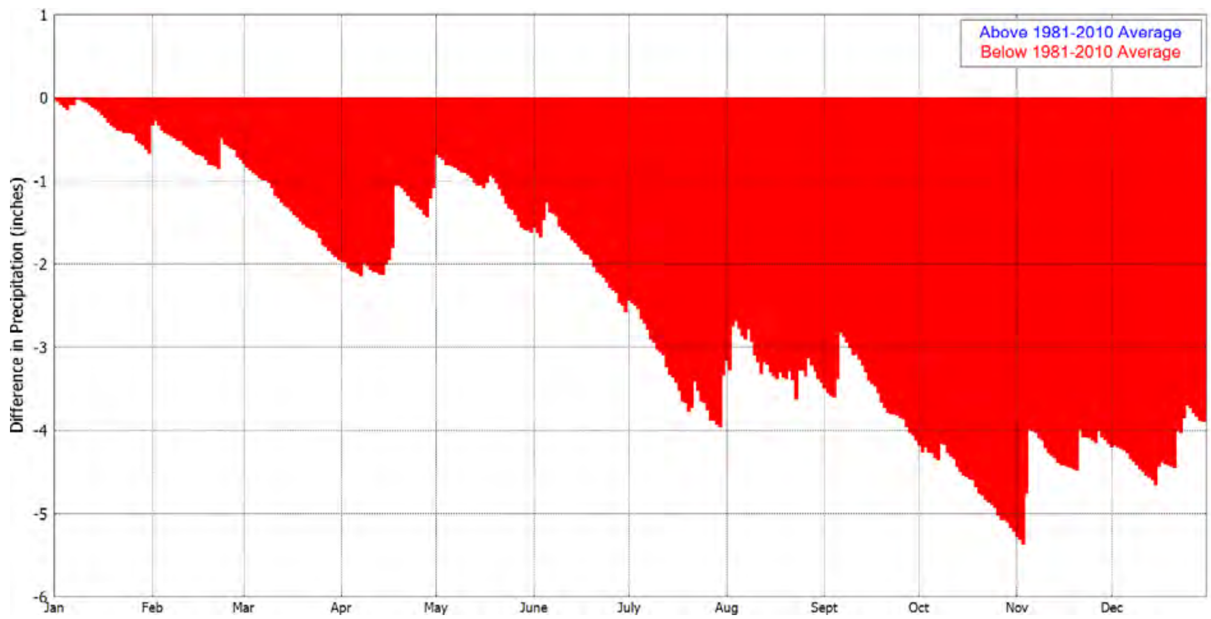


Figure 4-7 Difference between Technical Area 06 precipitation in 2016 and 1981–2010 average precipitation

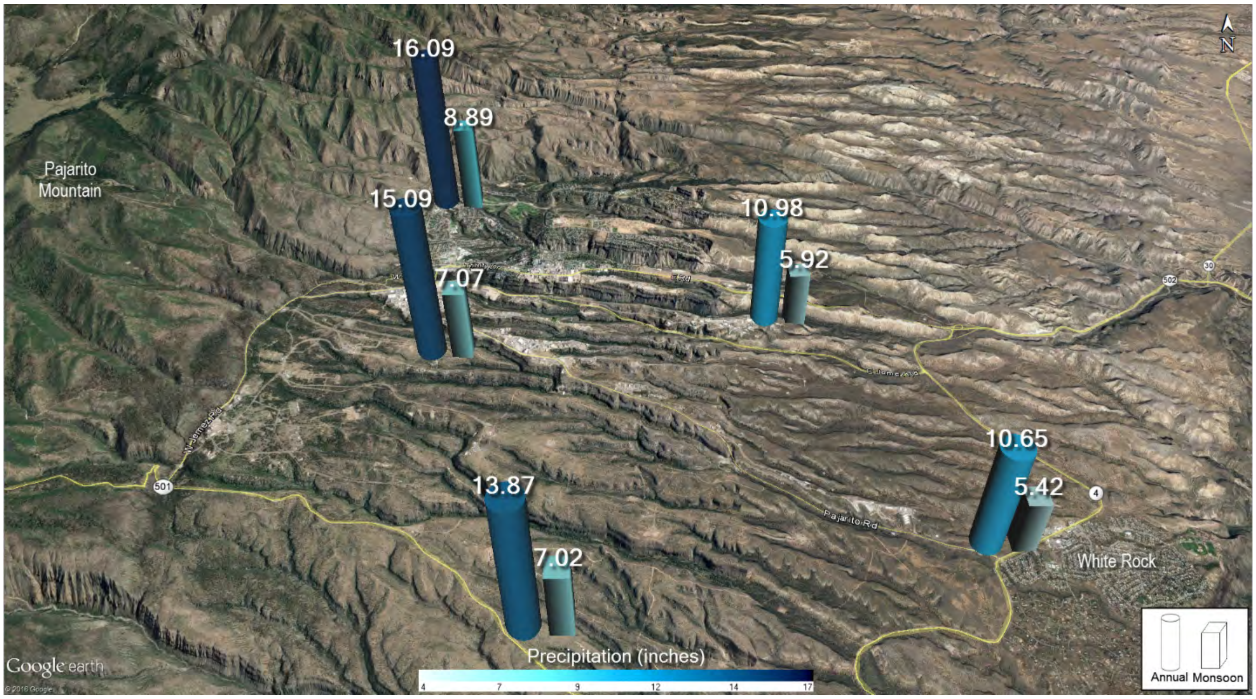


Figure 4-8 Annual and monsoon precipitation in 2016 across Los Alamos

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-9. The wind roses are based on 15-minute average wind observations for 2016 at the four mesa-top stations. Wind roses depict the percentage of time that wind blows from each of 16 directions and the distribution of wind speed. 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.

Long-Term Climate Trends

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-10 shows the historical record of temperatures in Los Alamos from 1924 through 2016. The annual average temperature is the midpoint between daily high and low temperatures, averaged for the year. One-year averages are shown in green in Figure 4-10. To aid in showing longer-term trends, the 5-year running average is also shown in black. With 5-year averaging, for example, it appears that the warm spell during the past 15 years 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 (June, July, August) average temperature on record was 71.1°F, recorded during 2011.

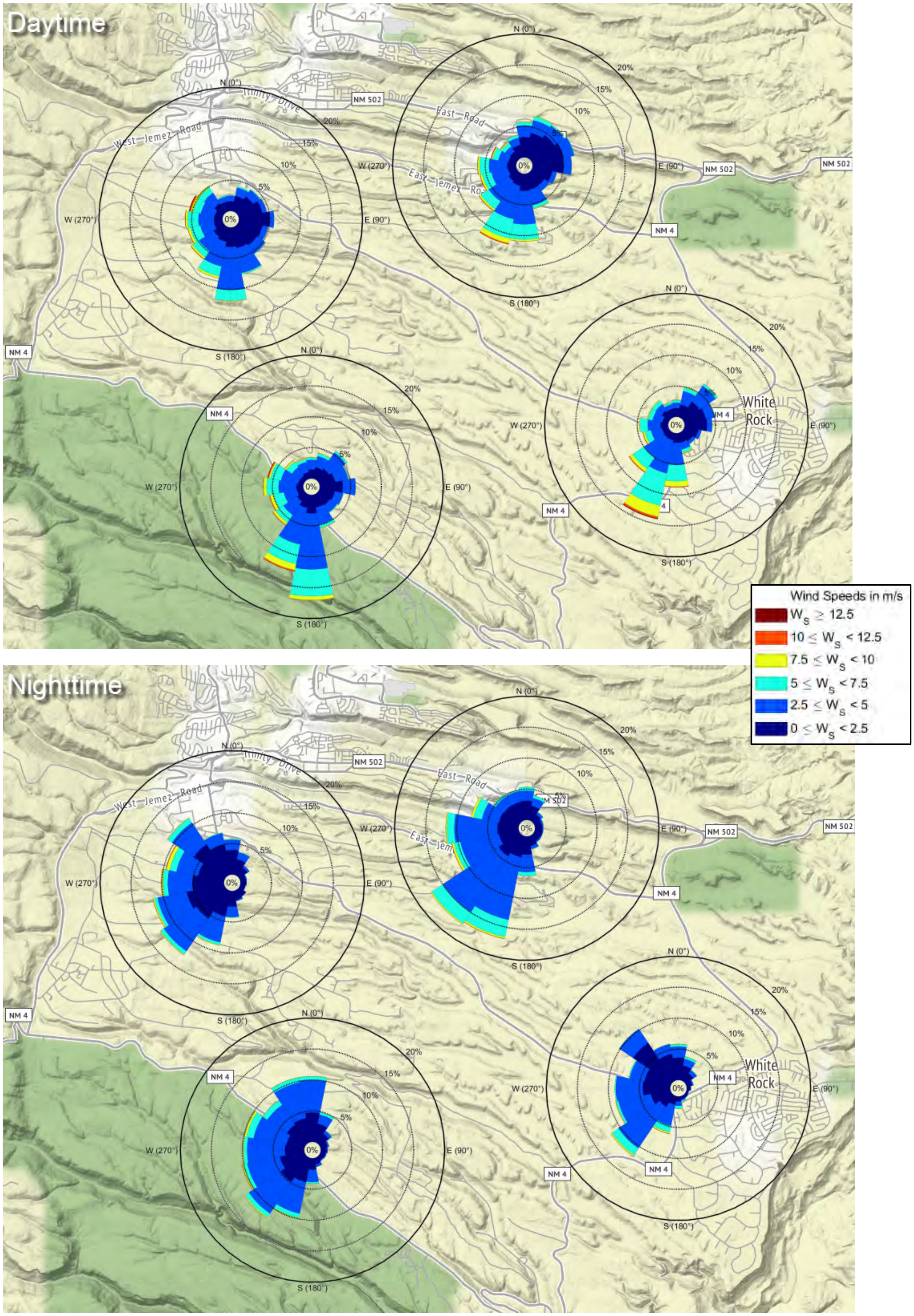


Figure 4-9 Wind roses for 2016

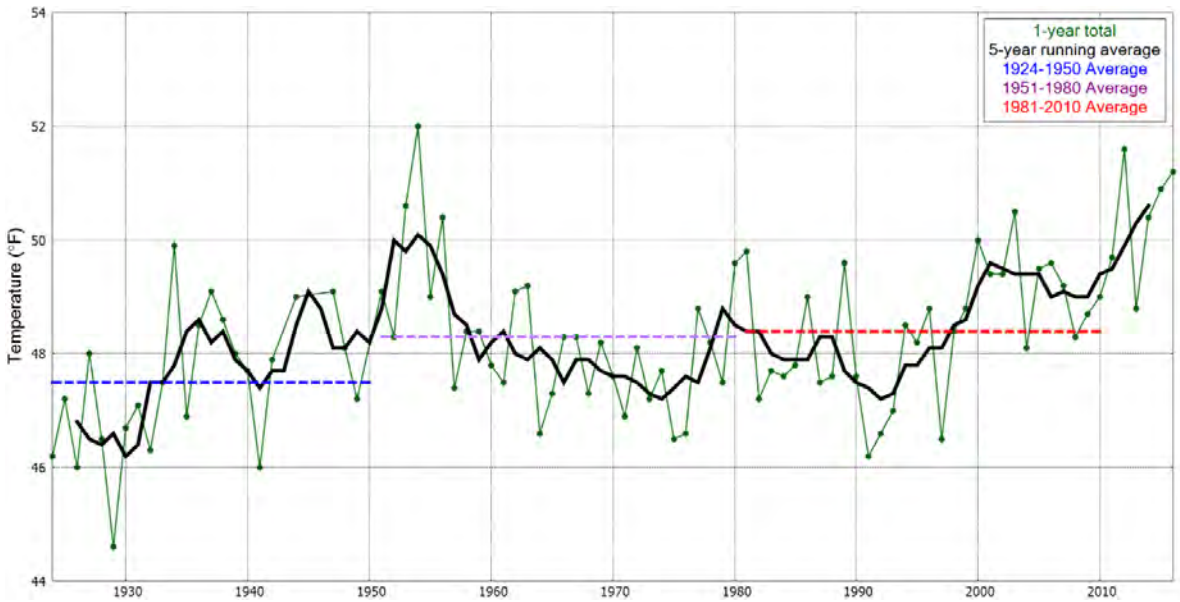


Figure 4-10 Temperature history for Los Alamos

The average temperatures per decade, recorded at Technical Area 06, along with two times the standard error, are plotted in Figure 4-11 with the annual average temperatures for 2011–2016. 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 varied only slightly from 48°F. During the 2001–2010 decade, the annual average temperature increased to above 49°F, and this value can be considered a statistically significantly higher value than previous decades. The annual average temperatures from 2011 to 2016 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).

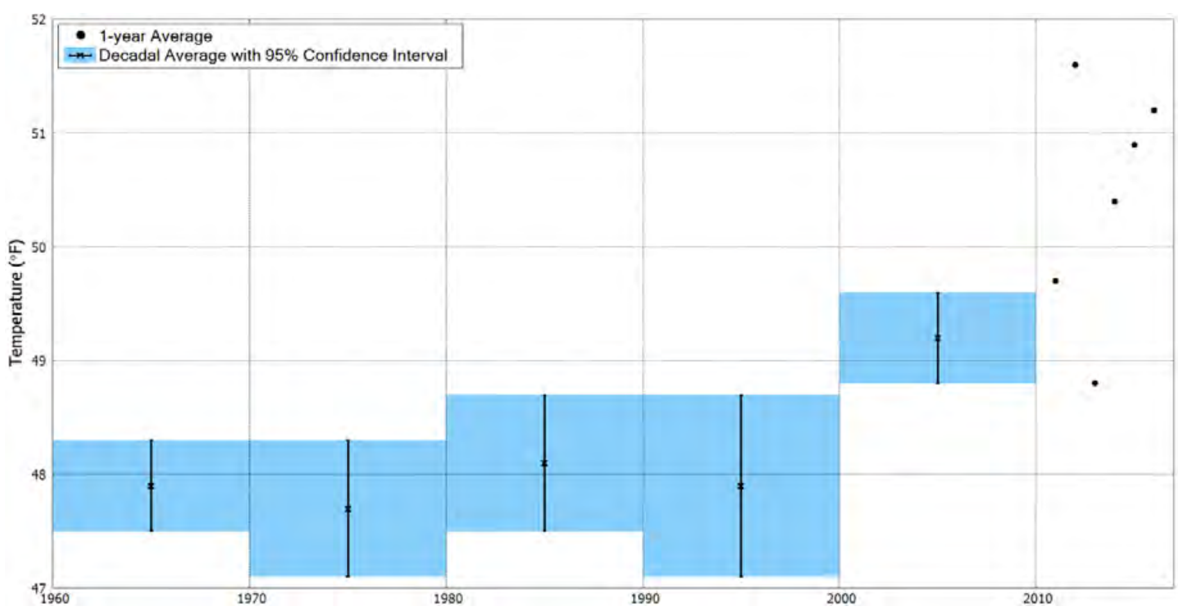


Figure 4-11 Technical Area 06 decadal average temperatures with two times the standard error and 1-year averages for 2011 to 2016

Figure 4-12 presents the historical record of the annual precipitation at Technical Area 06. As with the historical temperature profile, the 5-year running average and the 30-year average values are also shown. The most recent drought has essentially spanned the years 1998 through 2014, although near-average precipitation years occurred from 2004 to 2010.

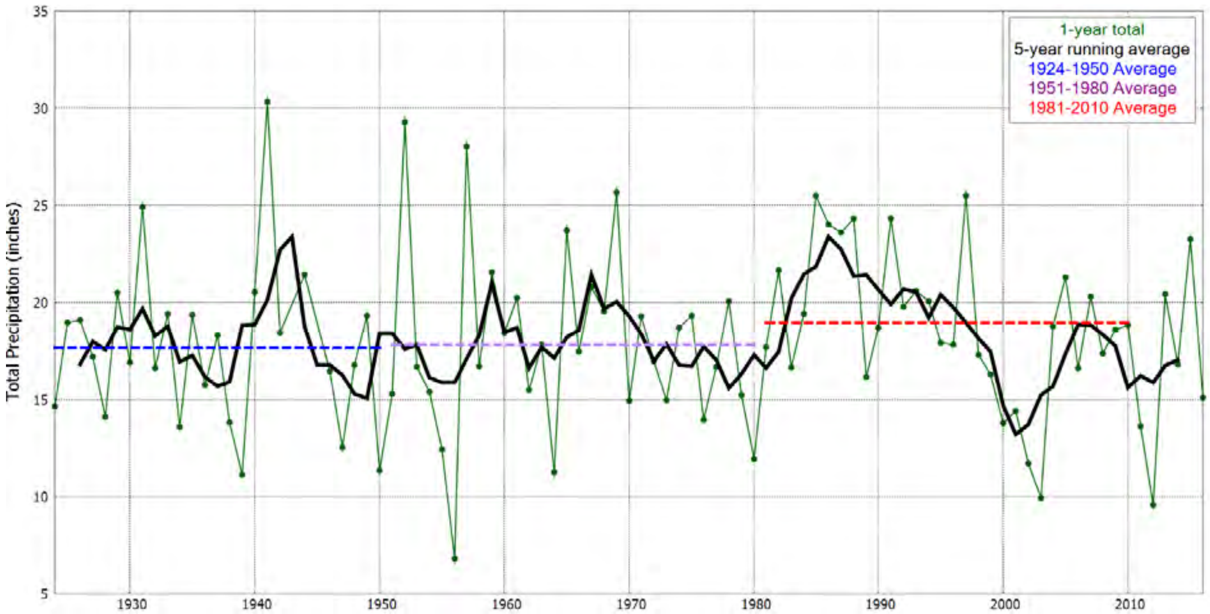


Figure 4-12 Total precipitation history for Los Alamos

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5.0 GROUNDWATER MONITORING

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Los Alamos National Laboratory (the Laboratory) monitors and characterizes groundwater as part of its groundwater protection program. We collect and analyze hundreds of groundwater samples each year for a wide range of organic and inorganic constituents and radionuclides. We also implement measures to control contaminant migration.

Contaminants from historical Laboratory operations are present in perched-intermediate groundwater zones and in the regional aquifer. These contaminants are associated with past liquid effluent releases from Laboratory outfalls (the discharge point of a liquid waste stream into the environment). We use sampling results from some groundwater wells to define the nature and extent of known contaminants and to determine their fate and transport. This information guides remedial actions where needed. We use other wells to monitor for releases. These data are used to ensure compliance with the requirements of the U.S. Department of Energy orders and New Mexico and federal regulations.

Site-wide groundwater characterization and monitoring indicate that there are only two notable areas of groundwater contamination at the Laboratory—RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) beneath Cañon de Valle in the Technical Area 16 area and chromium beneath Sandia and Mortandad Canyons.

RDX, primarily associated with historical machining of high explosives at Technical Area 16, has infiltrated into perched-intermediate groundwater beneath Cañon de Valle and locally exceeds the New Mexico tap water screening level of 7.02 micrograms per liter [μg/L]). No exceedances occur in the regional aquifer.

Hexavalent chromium, from releases that occurred during 1956 to 1972, is present in the regional aquifer beneath Sandia and Mortandad Canyons at concentrations above the 50-μg/L New Mexico groundwater standard.

The regional aquifer is the source of drinking water for Los Alamos County and the Laboratory. Los Alamos County owns and operates the water-supply system. The water supply wells are sampled quarterly and meet all federal and state drinking water standards.

INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor local groundwater quality. A regional aquifer is present below the Laboratory at depths ranging from 600 to 1200 feet below ground surface. 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 (sediment and gravel deposits in canyon bottoms) and within rocks and sediments at intermediate depths between the canyon bottoms and the regional aquifer.

U.S. Department of Energy (DOE) Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, requires operators of DOE facilities discharging or releasing liquids containing radionuclides to conduct monitoring to ensure that radionuclides from DOE activities do not cause private or public drinking water systems to exceed the drinking water maximum contamination limits in 40 Code of Federal Regulations Part 141, National Primary Drinking Water Regulations. Operators must also ensure that baseline conditions of the groundwater quantity and quality are documented.

In 2016, DOE and the New Mexico Environment Department signed a new Compliance Order on Consent that specifies the process for groundwater monitoring at the Laboratory. The 2016 Compliance Order on Consent continues to require the Laboratory to annually submit an Interim Facility-Wide Groundwater Monitoring Plan to the New Mexico Environment Department. The monitoring locations, analytical suites, and frequency of monitoring are updated each year in the plan.

We conducted groundwater monitoring during 2016 in accordance with the 2016 and 2017 Interim Facility-Wide Groundwater Monitoring Plans (LANL 2015a, 2016) approved by the New Mexico Environment Department. The Laboratory's Associate Directorate for Environmental Management collects groundwater samples from wells and from springs within and adjacent to the Laboratory and within the nearby Pueblo de San Ildefonso land.

HYDROGEOLOGIC SETTING

The following section describes the distribution and movement of groundwater at the Laboratory and includes a summary of groundwater contaminant sources and distribution. Additional detail can be found in reports available at the Laboratory's electronic public reading room, located at http://eprr.lanl.gov.

The Laboratory is located in northern New Mexico on the Pajarito Plateau (Figure 5-1). Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from ash and other volcanic materials that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1000 feet thick in the western part of the plateau and thins eastward to about 260 feet adjacent to the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanic deposits (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 beneath the Laboratory. These formations all overlie the sediments of the Santa Fe Group, which extend across the Rio Grande valley and are more than 3300 feet thick.

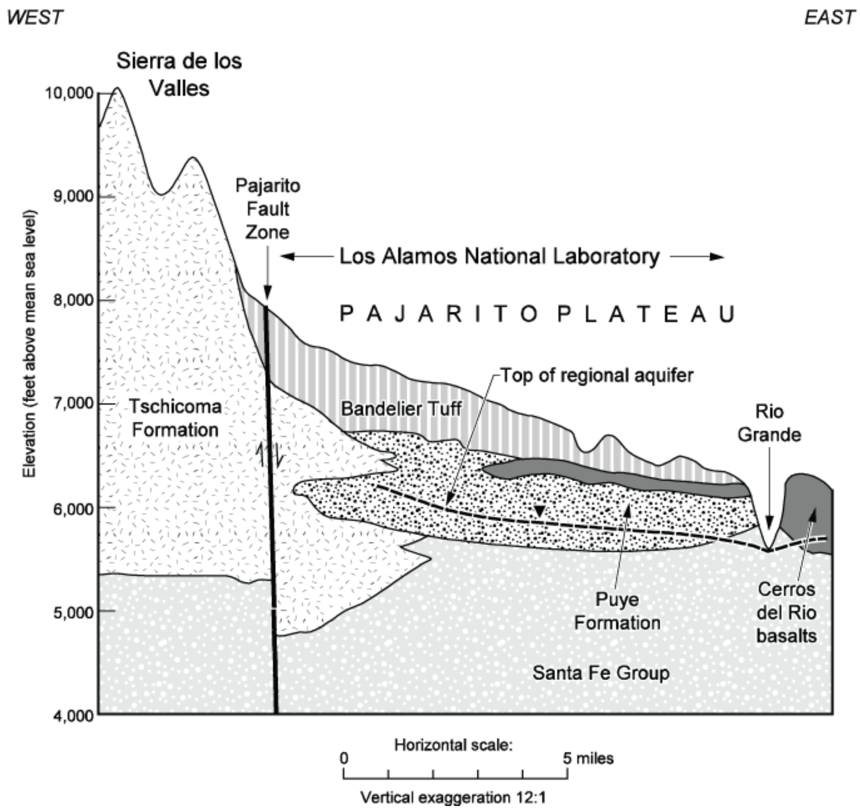


Figure 5-1 **Generalized geologic cross-section of the Pajarito Plateau**

The Laboratory sits atop a thick zone of mainly unsaturated rock and sediments, with the regional aquifer found 600 to 1200 feet below the ground surface. Groundwater beneath the Pajarito Plateau occurs in three modes (Figure 5-2): (1) perched alluvial groundwater in the bottom of some canyons, (2) discontinuous zones of intermediate-depth perched groundwater, and (3) the regional aquifer beneath the Pajarito Plateau.

Perched alluvial groundwater is a limited area of saturated rocks and sediments directly below canyon bottoms. Surface water percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rock, resulting in shallow bodies of groundwater. Perched alluvial groundwater is separated from underlying aquifers by layers of unsaturated rock.

Most of the canyons on the Pajarito Plateau have infrequent surface water flow and, therefore, little or no alluvial groundwater. A few canyons have segments of saturated alluvium in their western ends supported by runoff from the Jemez Mountains. In a few locations, surface water is supplemented or maintained by effluent discharged from Laboratory outfalls. Evapotranspiration and percolation into underlying rocks depletes alluvial groundwater as it moves downcanyon.

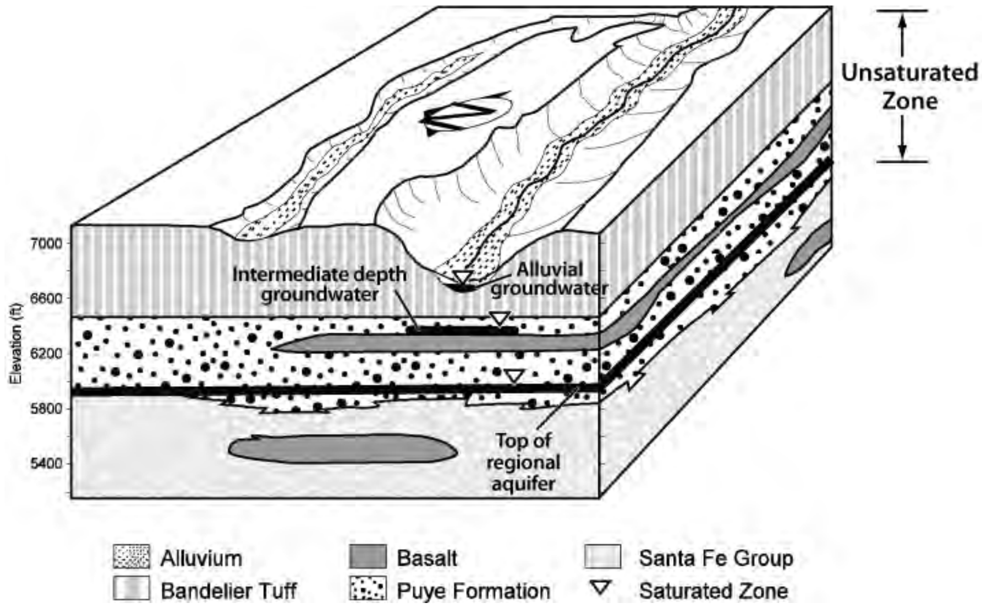


Figure 5-2 **Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence**

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, perched-intermediate 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 water moving downward from the perched alluvial groundwater. These perched-intermediate groundwater zones may extend beneath adjacent mesas. Depths of the perched-intermediate groundwater zones vary. For example, the depth to perched-intermediate groundwater is approximately 120 feet beneath Pueblo Canyon, 450 feet beneath Sandia Canyon, and 500 to 750 feet beneath Mortandad Canyon.

The regional aquifer water table occurs at a depth of approximately 1200 feet below ground surface along the western edge of the plateau and 600 feet below ground surface along the eastern edge (Figures 5-1 and 5-3). Studies indicate that subsurface movement of water originating in the Sierra de los Valles is the main source of recharge for the regional aquifer (LANL 2005a). Groundwater in the regional aquifer generally flows east or southeast. The speed of groundwater flow varies but is typically around 30 feet per year.

The regional aquifer is separated from alluvial and perched-intermediate groundwater by unsaturated tuff, basalt, and sediments with generally low moisture content (<10%). The limited extent of the alluvial and intermediate groundwater bodies, along with unsaturated rock that underlies them, restricts their contribution to recharging the regional aquifer, although locally they are important parts of the complete pathway to the regional aquifer.

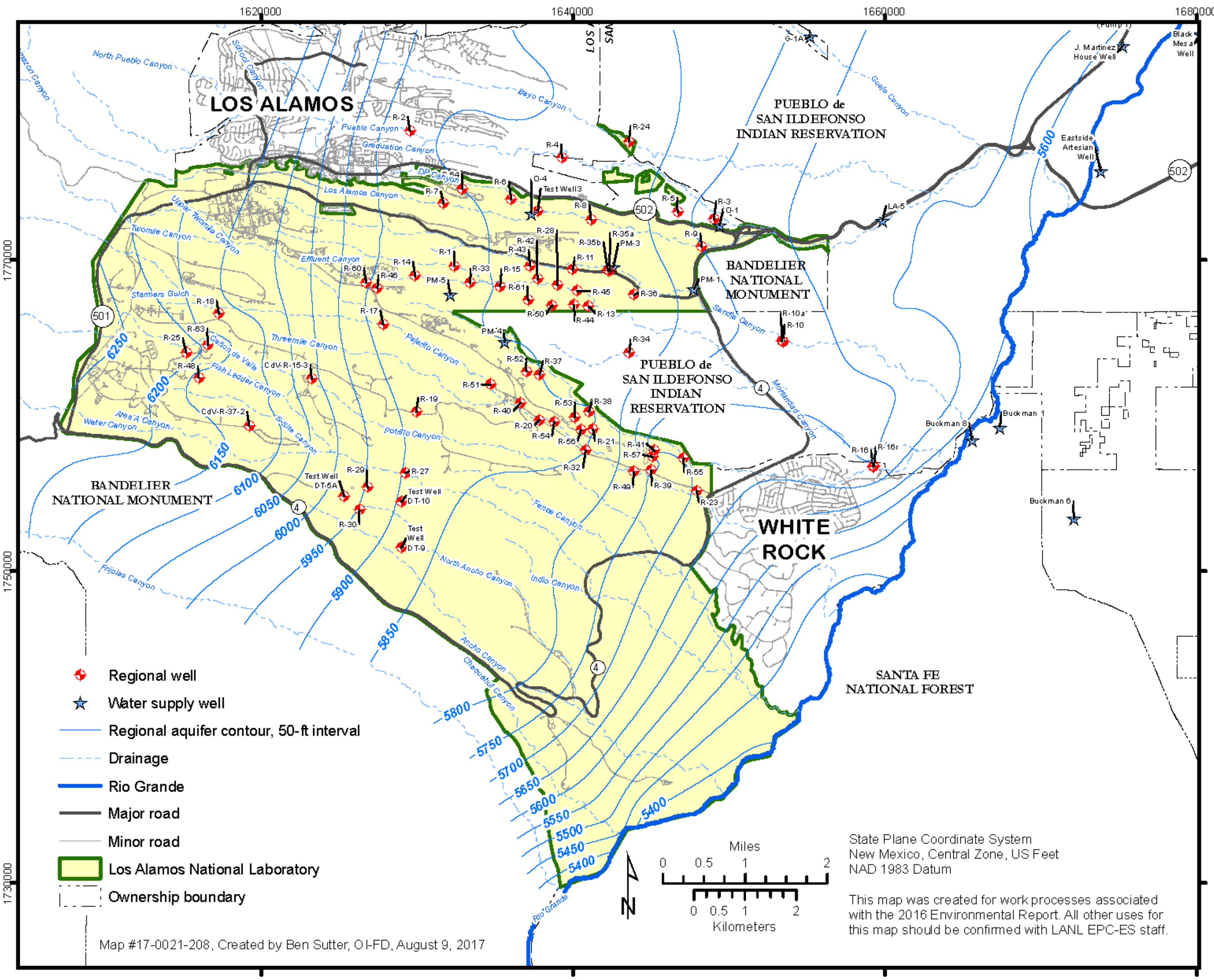


Figure 5-3 Contour map of average water table elevations for the regional aquifer. This map represents a generalization of the data.

GROUNDWATER STANDARDS AND SCREENING LEVELS

Regulatory Overview

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

Groundwater standards and screening levels are established by three regulatory agencies. DOE has authority under the Atomic Energy Act (42 U.S. Code, Sections 2011 to 2259) to set standards for certain nuclear materials. The U.S. Environmental Protection Agency and the New Mexico Water Quality Control Commission set screening levels and standards for other constituents.

DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, establishes dose limits for radiation exposure and provides derived concentration technical standards for radionuclide levels in air and water based on those dose limits. For drinking water, DOE's derived concentration technical standards are calculated based on the U.S. Environmental Protection Agency's 4-millirem per year (mrem/yr) drinking water dose limit.

The U.S. Environmental Protection Agency Safe Drinking Water Act maximum contaminant levels are the maximum permissible level of a contaminant in water delivered to any user of a public water system.

The New Mexico Water Quality Control Commission groundwater standards (Part 20.6.2 of the New Mexico Administrative Code) apply to all groundwater with a total dissolved solids concentration of 10,000 milligrams per liter (mg/L) or less. These standards include numeric criteria for many contaminants. In addition, the standards contain a separate list of toxic pollutants. For the toxic pollutants, numeric criteria are generally set based on the U.S. Environmental Protection Agency regional screening levels for tap water, adjusted to a risk level of more than one excess cancer per 100,000 exposed persons (10^{-5} excess cancer risk).

Section XXVI of the 2016 Compliance Order on Consent requires screening of groundwater data to the lower of either the New Mexico water quality standard or the federal maximum contaminant level. If neither of these standards apply to a given contaminant, the New Mexico Environment Department's tap water screening level is used. If no New Mexico Environment Department tap water standard is available, then the U.S. Environmental Protection Agency's regional human health medium-specific screening level, adjusted to a 10^{-5} excess cancer risk, is used.

The U.S. Environmental Protection Agency updates the regional screening levels for tap water several times each year; the 2016 values were used to prepare this chapter.

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

Sample Type	Constituent	Standards or Screening levels	References	Notes
Water supply wells	Radionuclides	New Mexico groundwater standards DOE's 4-mrem/yr derived concentration technical standards U.S. Environmental Protection Agency maximum contaminant levels	40 Code of Federal Regulations 141–143 DOE Order 458.1 Chg 3 20.6.2 New Mexico Administrative Code	The 4-mrem/yr derived concentration technical standards apply to water provided by DOE-owned drinking water systems. U.S. Environmental Protection Agency maximum contaminant levels apply to drinking water delivered to users from public drinking water systems.
Water supply wells	Nonradionuclides	New Mexico groundwater standards U.S. Environmental Protection Agency maximum contaminant levels	40 Code of Federal Regulations 141–143 20.6.2 New Mexico Administrative Code	U.S. Environmental Protection Agency maximum contaminant levels apply to drinking water delivered to users from public drinking water systems.
Non-water-supply groundwater samples	Radionuclides	New Mexico groundwater standards DOE 4-mrem/yr derived concentration technical standards U.S. Environmental Protection Agency maximum contaminant levels	20.6.2 New Mexico Administrative Code DOE Order 458.1 Chg 3, 40 CFR 141–143	New Mexico groundwater standards apply to all groundwater. The 4-mrem/yr derived concentration technical standards and U.S. Environmental Protection Agency maximum contaminant levels are for comparison only.
Non-water-supply groundwater samples	Nonradionuclides	New Mexico groundwater standards U.S. Environmental Protection Agency maximum contaminant levels U.S. Environmental Protection Agency regional screening levels for tap water	40 Code of Federal Regulations 141–143 20.6.2 New Mexico Administrative Code 2016 Compliance Order on Consent	A hierarchy of standards apply as screening levels for groundwater. See text for explanation.

The New Mexico Water Quality Control Commission numeric criteria mostly apply to the dissolved (filtered) portion of specified constituents; however, the standards for mercury, organic compounds, and nonaqueous phase liquids apply to the total unfiltered concentrations of the constituents. The U.S. Environmental Protection Agency maximum contaminant levels and regional screening levels for tap water are applied to both filtered and unfiltered sample results.

Procedures for Collecting Groundwater Samples

The Laboratory has several standard operating procedures for collecting groundwater samples and samples from springs that discharge groundwater. These procedures are listed in Table 5-2. These procedures (or their equivalent used by sampling subcontractors) are used in accordance with the "Interim Facility-Wide Groundwater Monitoring Plan for the 2016 Monitoring Year, October 2015–September 2016" and the "Interim Facility-Wide Groundwater Monitoring Plan for the 2017 Monitoring Year, October 2016–September 2017" (LANL 2015a, 2016). A more detailed summary of procedures is provided in Appendix B of each monitoring plan. Current versions of the procedures are listed at http://www.lanl.gov/environment/plans-procedures.php and are available in the Laboratory's electronic public reading room at http://eprr.lanl.gov.

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

Procedure Identifier	Procedure Title	Applicability
Collection of Groundwater Samples		
ER-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 [multiport] System	Procedure for sampling groundwater using the Westbay multiport system
EP-ERSS-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		
ER-SOP-20235	Sample Containers, Preservation, and Field Quality Control	Procedure specifying sample containers, collection and preservation techniques, holding times, and collection of field quality control samples, which include field duplicates, equipment rinsate blanks, and trip blanks.
ER-SOP-20236	Handling, Packaging, and Transporting Field Samples	Procedure for sample packaging and shipping
OIO-TP-222	Shipping/Receiving of Environmental Samples by the Sample Management Office (SMO)	Procedure for receiving, packaging, and shipping samples to analytical laboratories

Evaluation of Groundwater Results

For radioactivity in groundwater, we compare sample results with the New Mexico Water Quality Control Commission groundwater standards for combined radium-226 and radium-228, DOE's 4-mrem/yr drinking water derived concentration technical standards, and with the U.S. Environmental Protection Agency maximum contaminant level drinking water standards.

The New Mexico Water Quality Control Commission groundwater standards apply to concentrations of nonradioactive chemicals in all groundwater samples. The U.S. Environmental Protection Agency maximum contaminant level drinking water standards and the adjusted regional screening levels for tap water are used as screening levels for nonradioactive chemicals in most groundwater and are used as standards where appropriate for drinking water.

POTENTIAL SOURCES OF CONTAMINATION

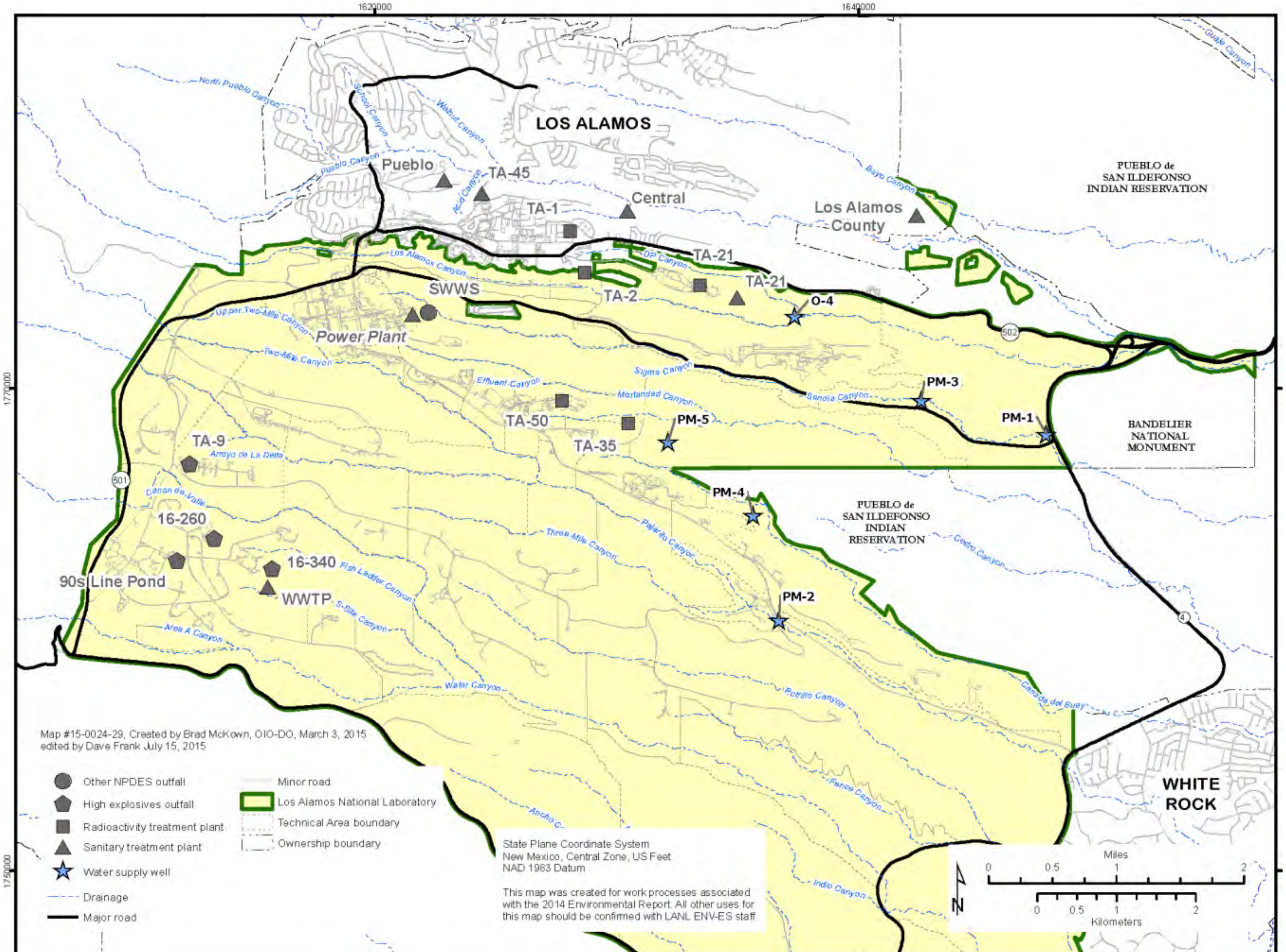
Historical discharges from Laboratory operations have affected all three groundwater zones. Figure 5-4 shows the key locations of historical effluent discharges that may have affected groundwater.

Drainages that received effluent in the past 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 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 2014).

GROUNDWATER MONITORING NETWORK

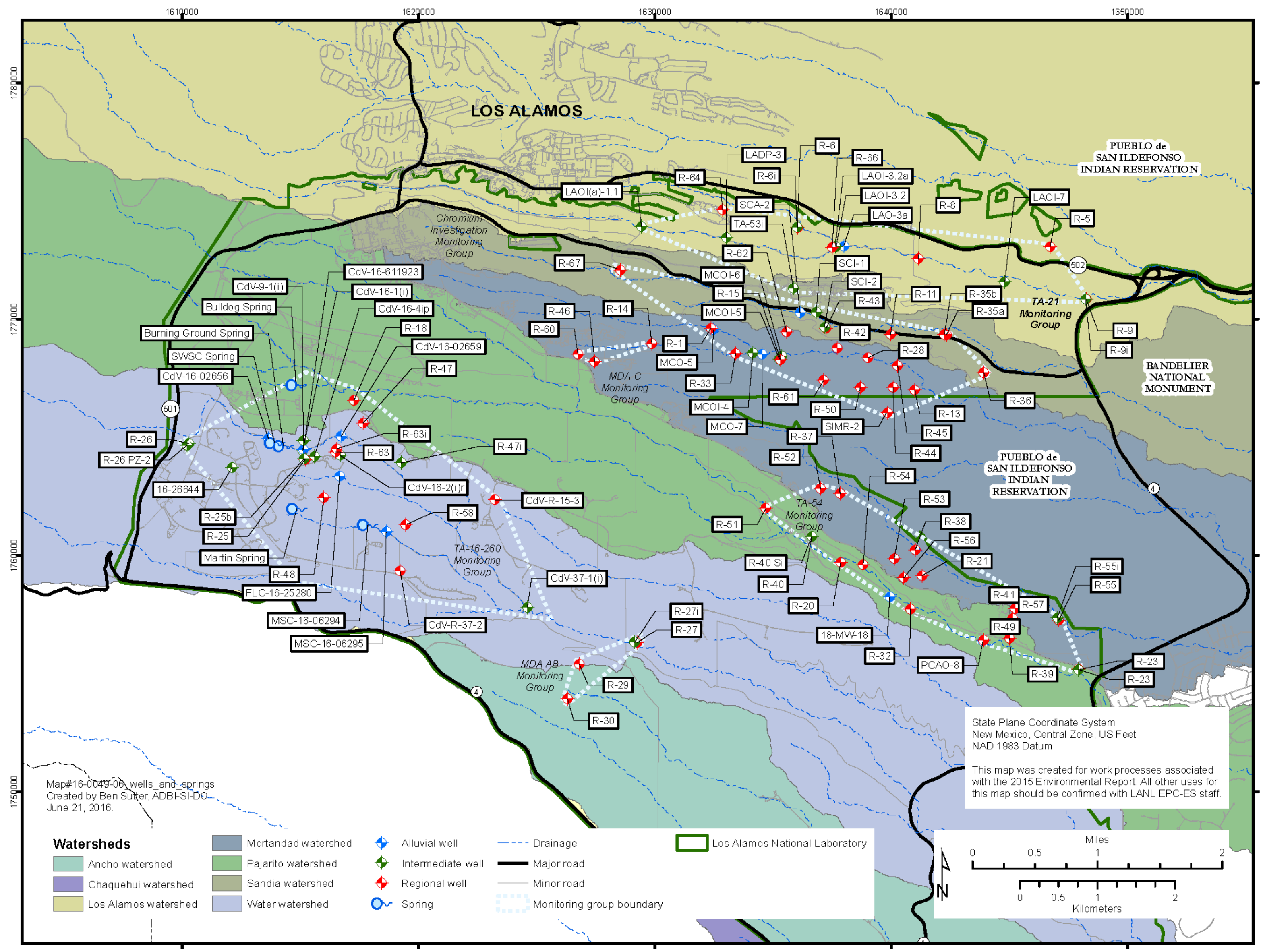
We conduct monitoring at alluvial, perched-intermediate, and regional aquifer well locations and at springs that discharge perched-intermediate and regional aquifer groundwater. Monitoring is primarily organized into area-specific monitoring groups (Figure 5-5). Area-specific monitoring groups are defined for Technical Area 54, Technical Area 21, Material Disposal Area AB, Material Disposal Area C, the Chromium Investigation, and the Technical Area 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 (Figure 5-7; Purtymun et al. 1980).

We also collect samples from 12 Los Alamos County water supply wells (Figure 5-7), from wells located on Pueblo de San Ildefonso lands, and from the Buckman well field operated by the City of Santa Fe. 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.



NPDES = National Permit Discharge Elimination System; SWWS = sanitary wastewater system; TA = technical area; WWTP = wastewater treatment plant.

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



MDA = Material disposal area.

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

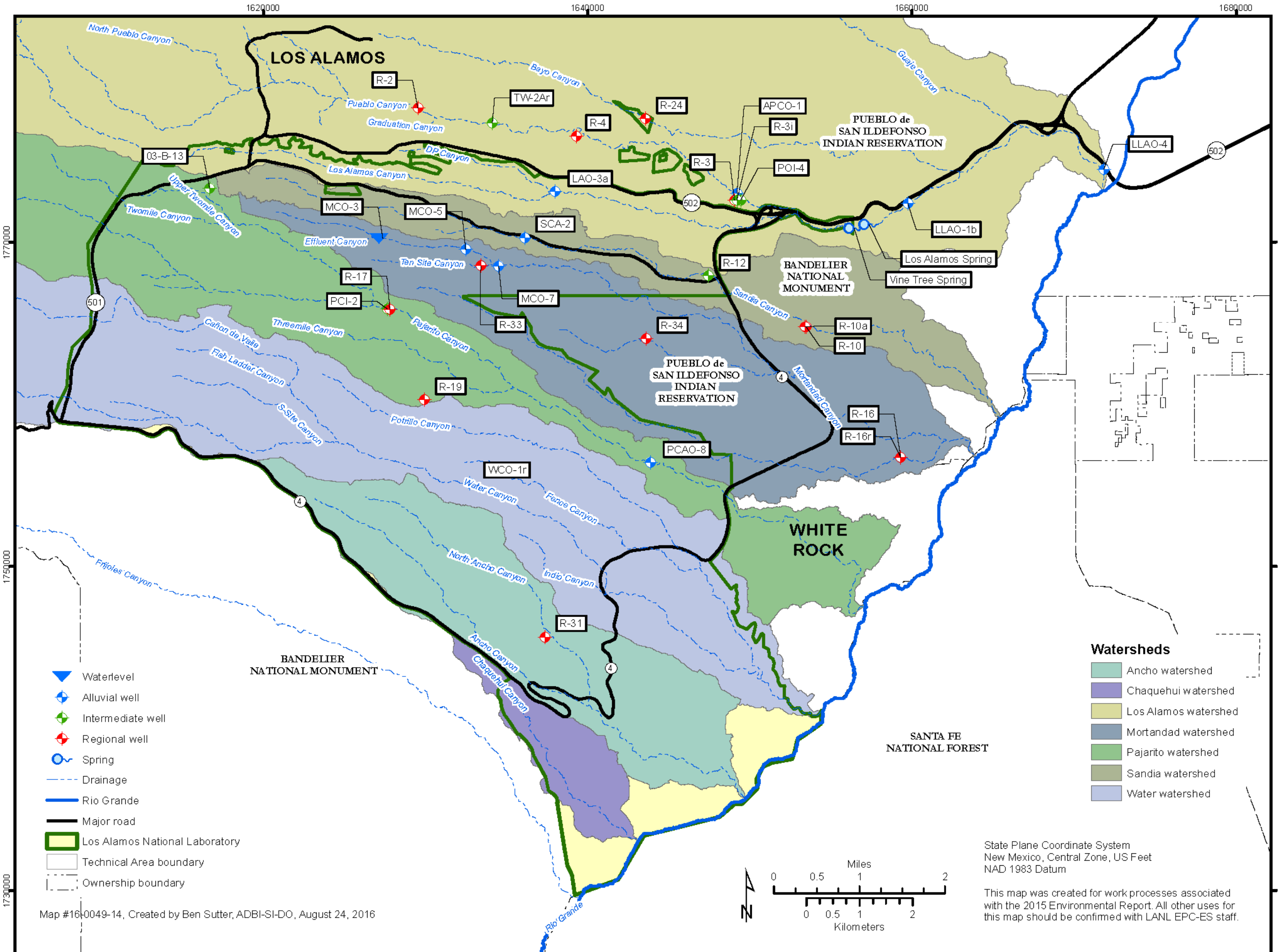


Figure 5-6 Groundwater monitoring wells and springs assigned to watershed-specific portions of the General Surveillance monitoring group

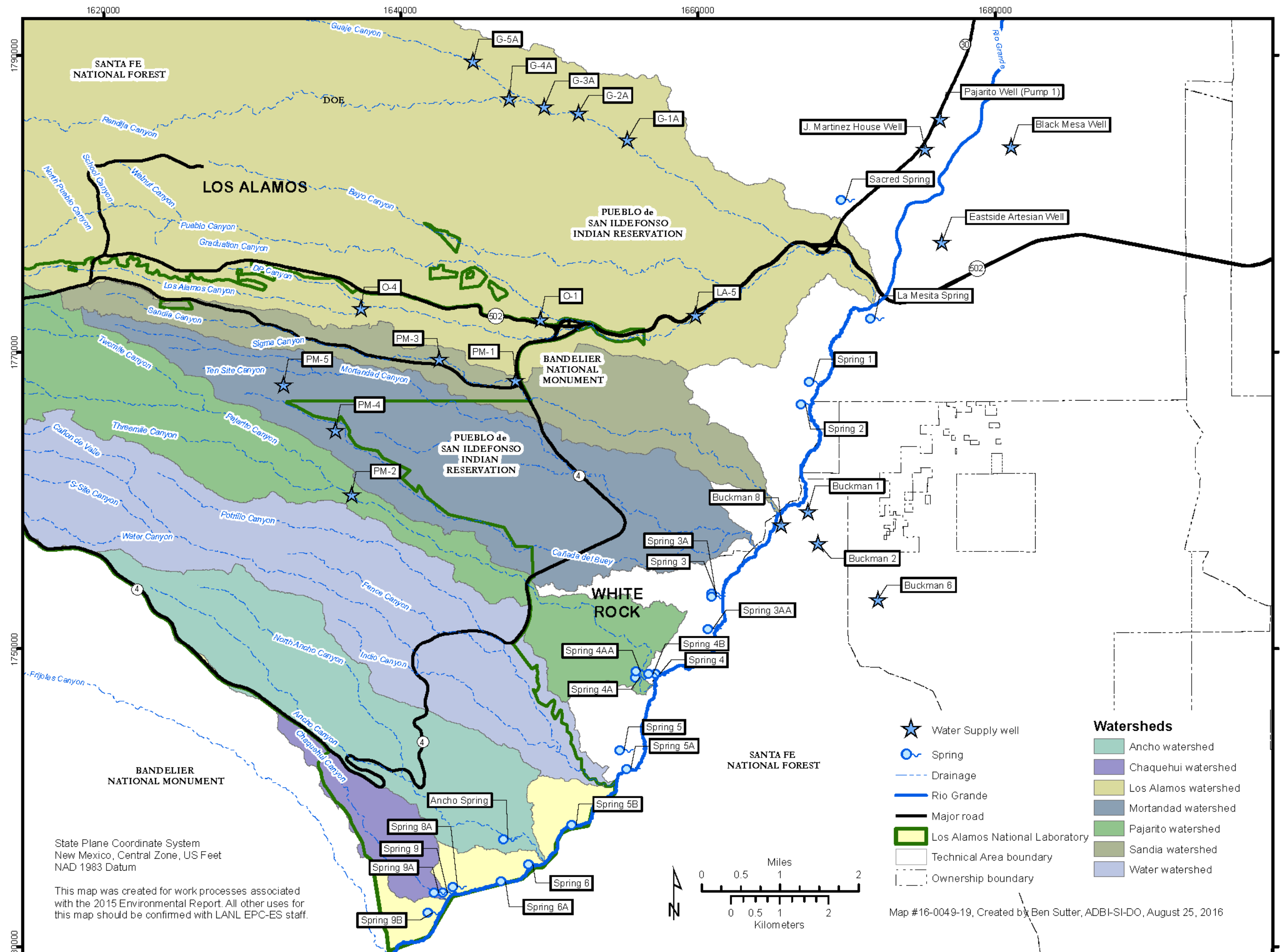


Figure 5-7 **Water supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon**

GROUNDWATER DATA INTERPRETATION

The groundwater quality monitoring data for 2016 are available at http://www.intellusnm.com.

Analytical laboratory results are reported relative to several defined analytical limits. The method detection limit is the minimum concentration of a substance that can be detected with 99% confidence that the concentration is greater than zero. The method detection limit is determined from analysis of a set of standardized samples containing the analyte (40 Code of Federal Regulations Part 136, Appendix B).

A second limit used by analytical laboratories, the practical quantitation limit, is the minimum concentration of an analyte that can be measured with a high degree of confidence. The practical quantitation limit is approximately (but not always) three times the method detection limit, or is the lowest point on the analytical laboratory's calibration curve. Analyte concentrations measured between the method detection limit and the practical quantitation limit are reported as estimated concentrations and marked with a "J" qualifier in the analytical report.

A nondetect result indicates that the analytical laboratory did not detect the analyte in the sample. LANL reports nondetect results as the practical quantitation limit and reports estimated concentrations as their actual estimated value. This convention means that detected but estimated results (results between the method detection limit and the practical quantitation limit) are reported with a lower value than nondetect results for the same substance.

The method detection limit and practical quantitation limit do not apply to radiological measurements. For radiological measurements, the minimum detectable activity is analogous to the method detection limit, though it is calculated for each measurement from radioactive counting statistics. To be considered a detected activity, a radiological measurement must be greater than the minimum detectable activity.

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, and Los Alamos County and City of Santa Fe water supply wells. The tables and discussions are grouped according to groundwater mode, proceeding from deepest (the regional aquifer) to shallowest (the alluvial groundwater).

The accompanying tables and text mainly address constituents 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 radionuclides, general inorganic compounds, metals, and organic compounds for each groundwater zone. The accompanying plots and maps provide temporal and spatial context.

Water-Supply Monitoring

Los Alamos County

We collect samples from 12 Los Alamos County water supply wells that produce water for the Laboratory and the community (Figure 5-7). These samples are supplemental to Los Alamos County's monitoring and specifically address potential Laboratory contaminants. All drinking water produced by the Los Alamos County water-supply system meets federal and state drinking water standards as reported in the county's annual drinking water quality report (available at https://indd.adobe.com/view/bc77e55e-9218-46ee-8194-13ed0f768a79). The water supply wells have long screens (the slotted portion of a well that allows water to enter the well) up to 1600 feet deep within the regional aquifer. Water-quality samples collected from these wells therefore sample water over a large depth range. No water supply wells showed detections of Laboratory-related constituents above an applicable drinking water standard.

City of Santa Fe

In 2016, we sampled three wells, Buckman-1, Buckman-6, and Buckman-8 in the City of Santa Fe's Buckman well field. Samples were also collected from four piezometers (wells typically used to measure water levels) in the well field (LANL 2012a). These samples are supplemental to the City of Santa Fe's monitoring and specifically address potential Laboratory contaminants. No Laboratory-related constituents were present above standards for these locations. The City of Santa Fe publishes an annual water quality report that provides additional information (available at https://www.santafenm.gov/water_quality).

Technical Area 21 Monitoring Group

Technical Area 21 is located on a mesa north of Los Alamos Canyon (Figure 5-4). DP Canyon borders the north side of the mesa and joins Los Alamos Canyon east of the technical area. Technical Area 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 Technical Area 21 into DP Canyon (Figure 5-4).

Sources of potential groundwater contaminants in the vicinity of the Technical Area 21 monitoring group include the effluent outfall [Solid Waste Management Unit 21-011(k)], adsorption beds and disposal shafts at Material Disposal Area T, adsorption beds at Material Disposal Area U, the former Omega West reactor cooling tower (Solid Waste Management Unit 02-005), DP West, DP East, waste lines, an underground diesel fuel line, and sumps.

The monitoring objectives for the Technical Area 21 monitoring group are presented in each annual Interim Facility-Wide Groundwater Monitoring Plan. The Technical Area 21 monitoring group includes monitoring wells in perched-intermediate groundwater and in the regional aquifer.

In 2016, gross alpha was detected in perched-intermediate well LAOI-3.2a at 16.1 picocuries per liter (pCi/L), above the 15-pCi/L maximum contaminant level. This is the first detection of gross alpha above any applicable standard in this well. Prior results have been very low or nondetected. Monitoring will continue at this well to determine whether gross alpha is consistently present or whether the 2016 result is erroneous. Gross-alpha measurements are typically related to naturally occurring uranium and its decay products.

Several perched-intermediate wells have tritium present in groundwater samples (Figure 5-8) that likely originated from the former liquid-waste treatment plant and/or the Omega West Reactor. Samples from perched-intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 2250 pCi/L of tritium in 2016, and 2016 data generally remain consistent with data from recent years. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 pCi/L.

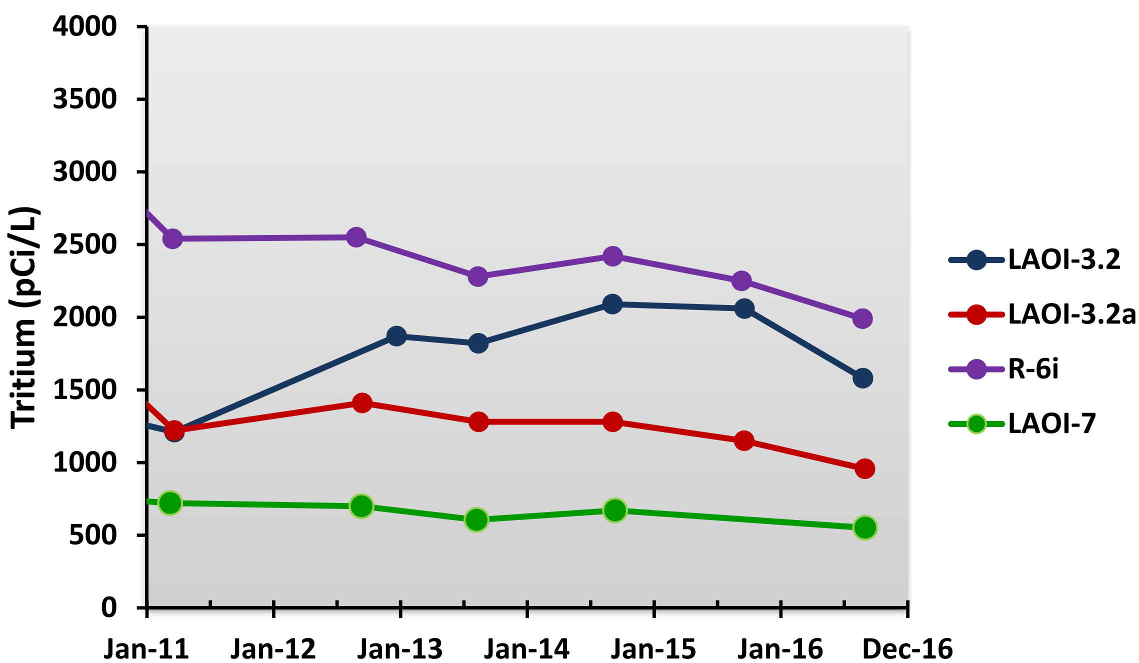


Figure 5-8 **Tritium concentrations in the Technical Area 21 monitoring group in Los Alamos Canyon perched-intermediate groundwater. The U.S. Environmental Protection Agency maximum contaminant level for drinking water is 20,000 pCi/L.**

Chromium Investigation Monitoring Group

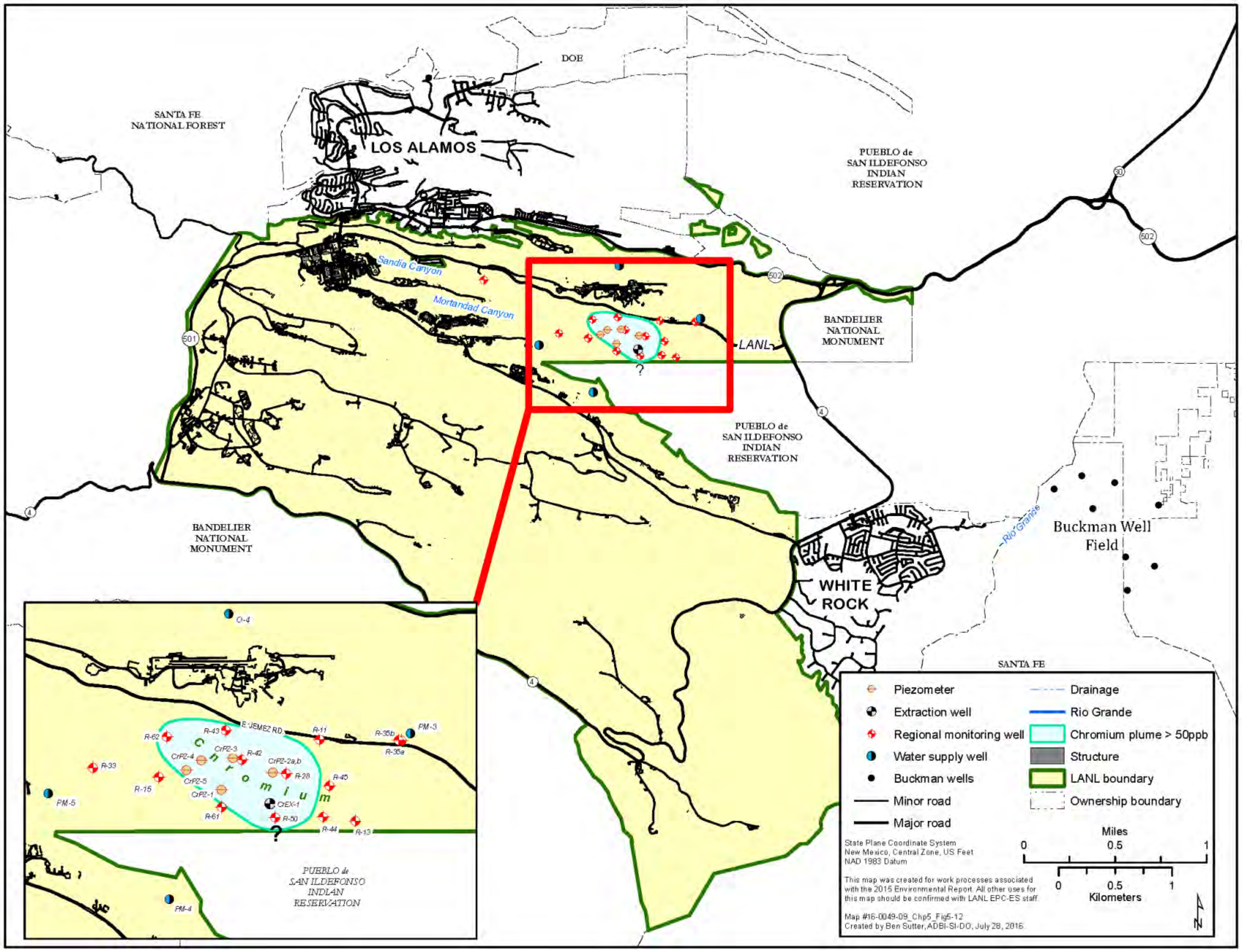
The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons (Figure 5-5). Monitoring in this group in 2016 primarily focused on characterizing and understanding the fate and transport of chromium and related contaminants in perched-intermediate groundwater and within the regional aquifer. Future monitoring will be oriented towards measuring performance of an interim measure expected to reach full operation in 2017. The objective of the interim measure is to contain chromium plume migration while a final remedy for the plume is evaluated.

Sandia Canyon has a small drainage area that heads in Technical Area 03. Through Outfall 001, the canyon receives treated sanitary effluent from the Technical Area 46 sanitary wastewater system plant and cooling tower discharges from computing facilities and the Technical Area 03 power and steam plants. From 1956 to 1972, potassium dichromate was used as a corrosion inhibitor in the cooling system at the power plant (LANL 1973) and was also discharged through Outfall 001. These discharges of potassium dichromate are the source of the elevated concentrations of hexavalent chromium observed in perched-intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons.

Chromium is present in the regional aquifer above the New Mexico Environment Department groundwater standard of 50 micrograms per liter (μg/L) in an area that is approximately 1 mile in length and about 0.5 mile wide (Figure 5-9). The chromium in this area is found within the top 50 feet of the regional aquifer, as determined from a series of two-screen wells that monitor the plume (LANL 2009a, 2012b). The 2016 chromium concentrations exceeded the New Mexico groundwater standard of 50 μg/L in five regional aquifer wells: R-28, R-42, R-62, R-50 screen 1, and R-43 screen 1 (Figure 5-10). The trend in chromium concentrations for these wells is shown in Figure 5-11.

Although showing high annual variability, the wells within the center of the plume (R-42 and R-28) show a relatively flat long-term chromium trend, whereas three wells along the edge of the plume (R-45 screen 1, R-43 screen 1, and R-50 screen 1) are showing gradually increasing concentrations of chromium (Figure 5-12). Two perched-intermediate wells also had chromium concentrations above the standard: SCI-2 and MCOI-6. The trend for chromium in these two wells is shown in Figure 5-13.

A smaller area with perchlorate contamination is also present in groundwater beneath Mortandad Canyon. Perchlorate is above the applicable standard of 13.8 μg/L in two perched-intermediate wells, MCOI-5 and MCOI-6, but is below the standard in all regional aquifer wells. In perched-intermediate well MCOI-6, the perchlorate concentration trends are relatively stable, but increasing concentrations are observed over the last year at MCOI-5 (Figure 5-14). The primary source of perchlorate was effluent discharges from the Radioactive Liquid Waste Treatment Facility that occurred from 1963 until implementation of improvements in perchlorate treatment in March 2002. Ongoing monitoring is being conducted to evaluate whether the elimination of the source of perchlorate in effluent will result in decreasing concentrations in perched-intermediate wells. Another constituent detected in the Chromium Investigation monitoring group is 1,4-dioxane in perched-intermediate wells MCOI-5 and MCOI-6 (Figure 5-15). The trend is flat at MCOI-6 but showed a slight increase in MCOI-5 over the last year. Concentrations of 1,4-dioxane are not present above the screening level of 7.8 μg/L in the regional aquifer.



Note: ppb = Parts per billion.

Figure 5-9 Approximation of chromium plume footprint in the regional aquifer as defined by the 50-µg/L New Mexico Environment Department groundwater standard

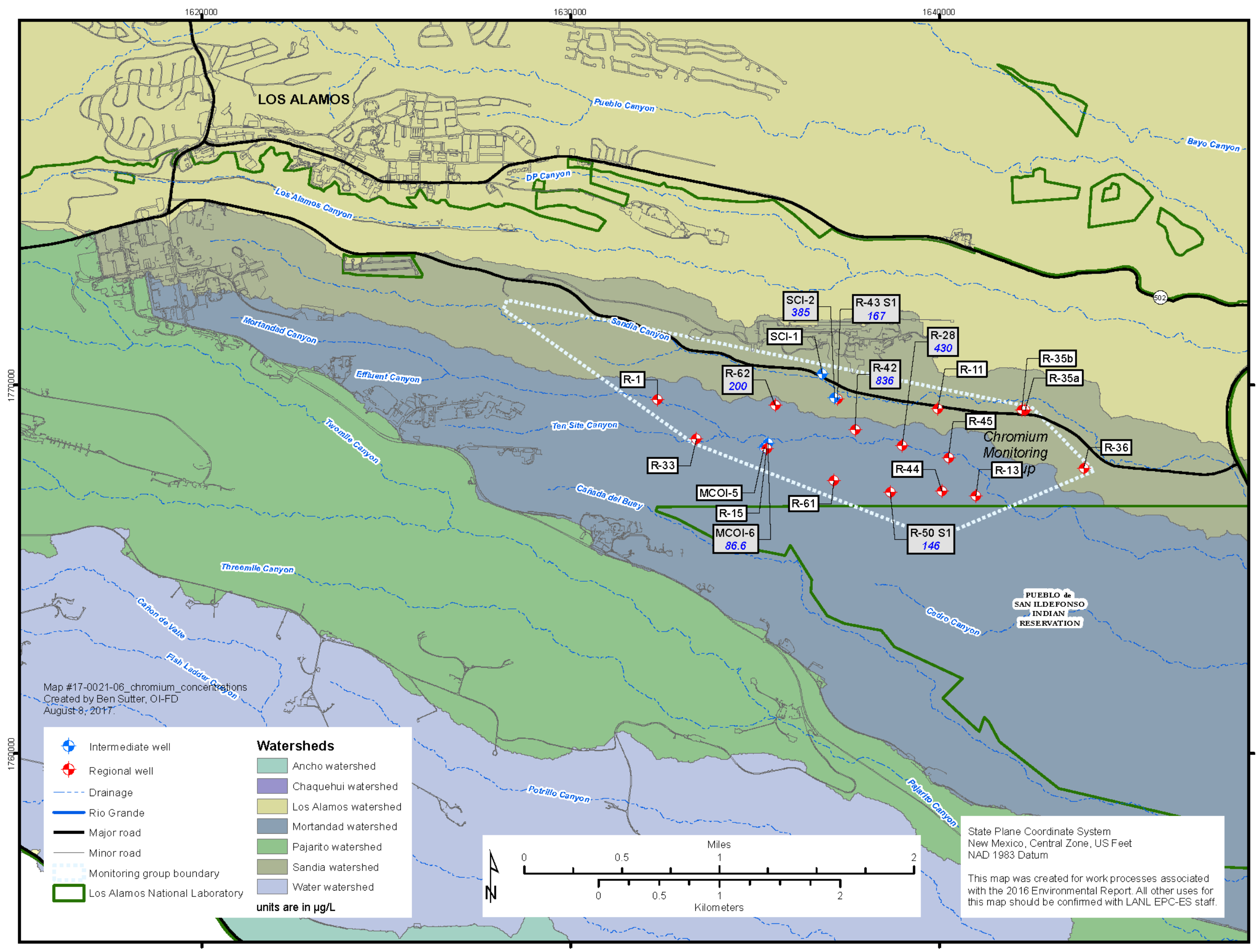


Figure 5-10 **The Chromium Investigation monitoring group perched-intermediate and regional aquifer monitoring wells. The white dashed outline encompasses the wells included in the monitoring group. Labels for the wells include maximum chromium concentrations (in µg/L) detected in 2016 for values greater than the New Mexico groundwater standard of 50 µg/L.**

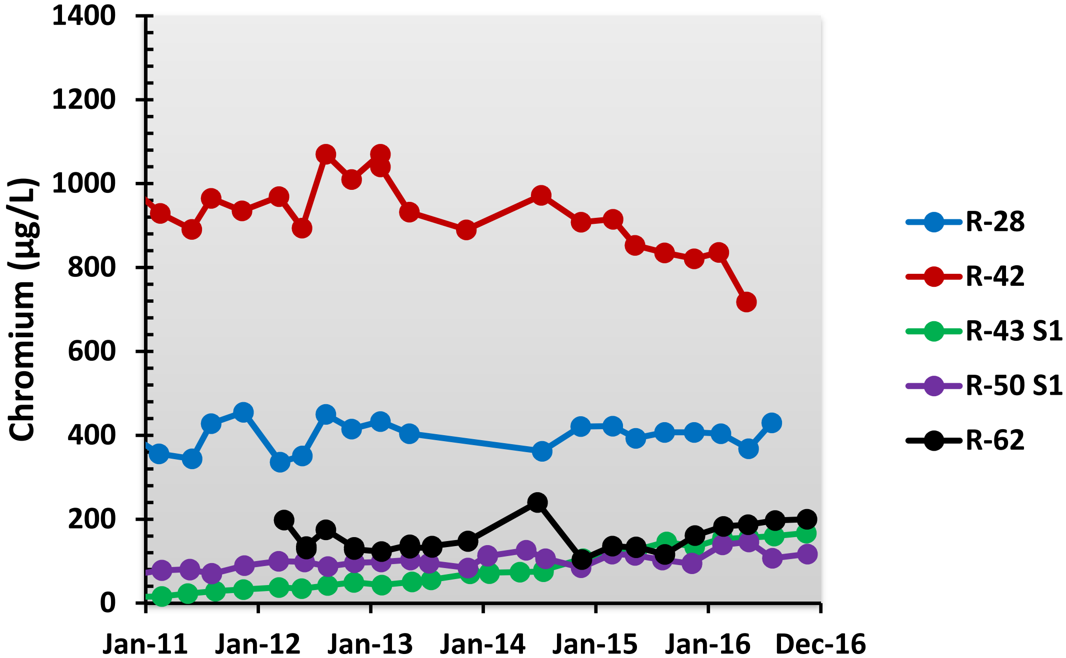


Figure 5-11 Trends in chromium concentrations at five regional aquifer wells that exceeded the chromium standard of 50 µg/L within the Chromium Investigation monitoring group

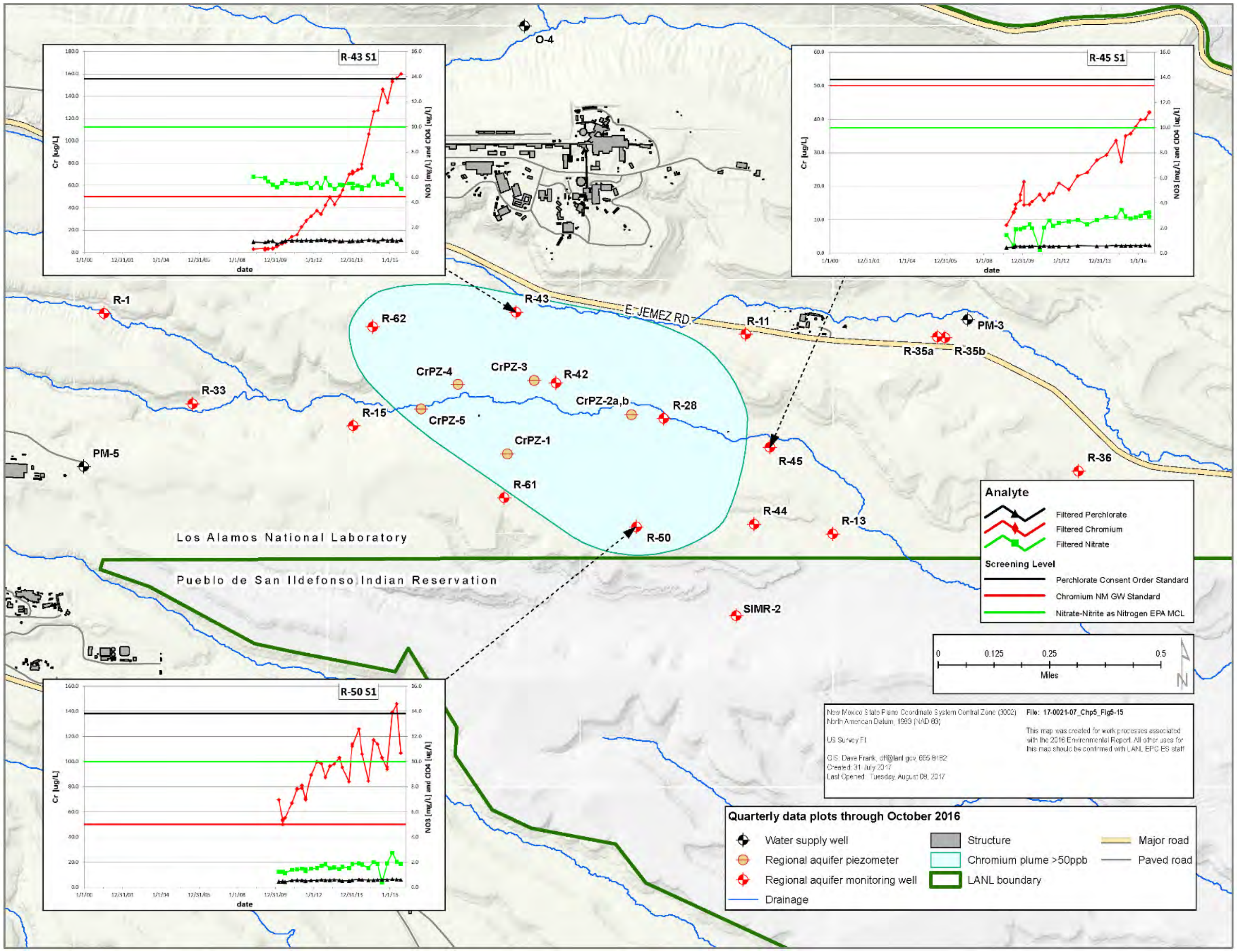


Figure 5-12 **Time-series plots of three regional aquifer wells within the Chromium Investigation monitoring group. Plots show trends for chromium (red), nitrate (green), and perchlorate (black).**

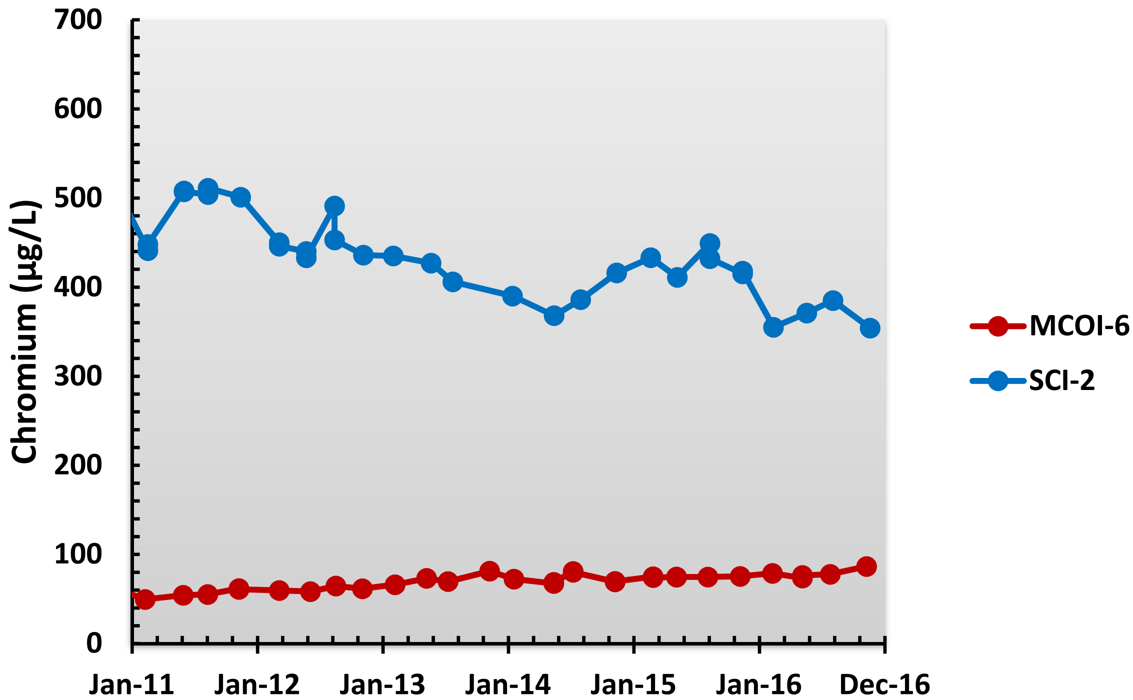


Figure 5-13 Trends in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group

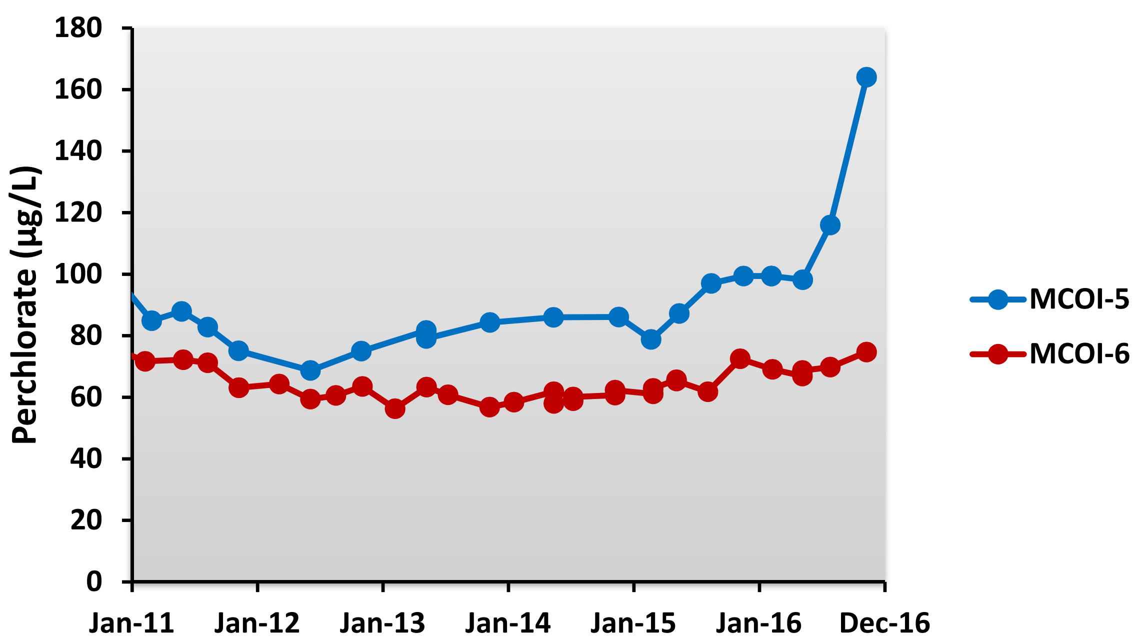


Figure 5-14 Perchlorate concentrations in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group

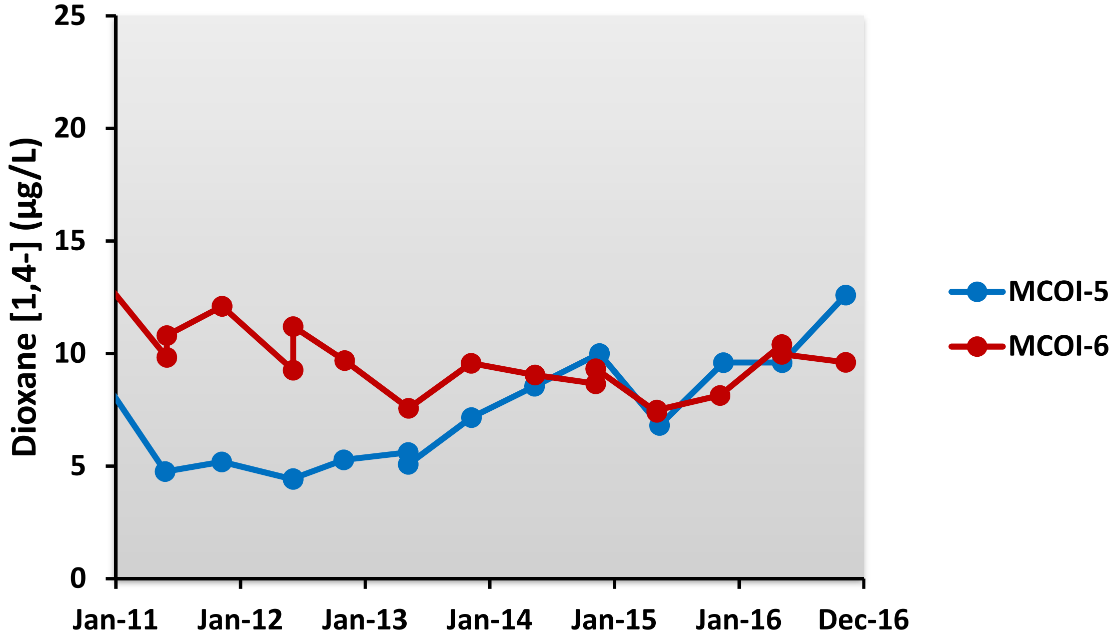


Figure 5-15 **Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group**

Perched-intermediate wells MCOI-5 and MCOI-6 have tritium concentrations far below the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water of 20,000 pCi/L (Figure 5-16). Tritium concentrations in the underlying regional aquifer are generally under 200 pCi/L.

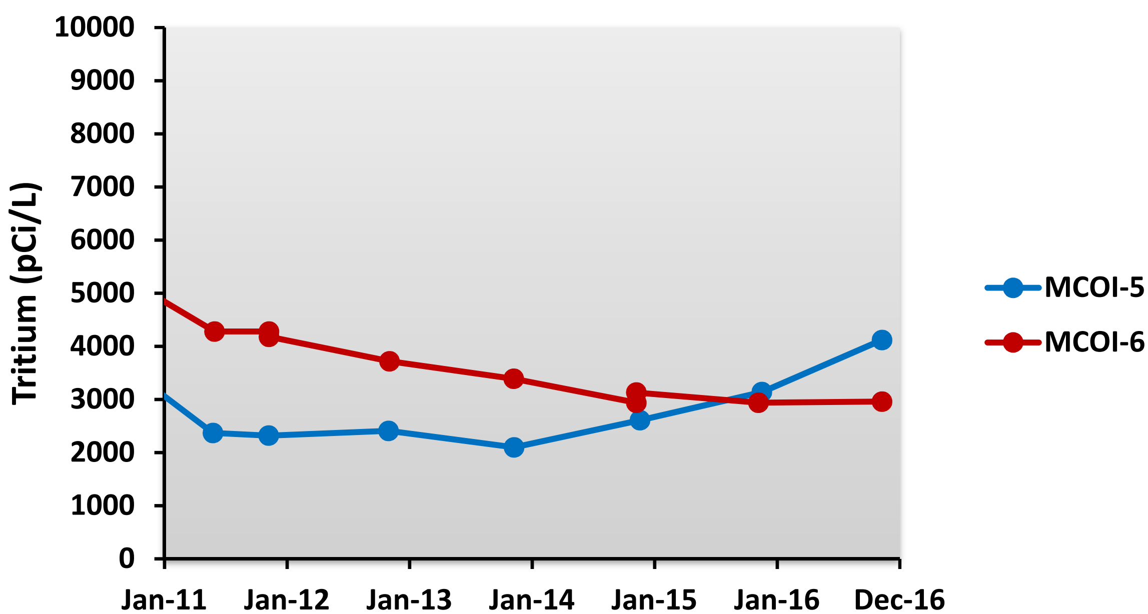


Figure 5-16 **Tritium concentrations in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group**

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 shows that chromium originated from releases into Sandia Canyon and may have migrated in the subsurface along geologic perching horizons to locations in the regional aquifer beneath Mortandad Canyon.

The Interim Measures Work Plan for Chromium Plume Control presents an approach for controlling movement of chromium-contaminated groundwater along the downgradient portions of the plume (LANL 2015b). That approach was analyzed in the Environmental Assessment for Chromium Plume Control Interim Measure and Plume-Center Characterization (DOE 2015). The approach will use one or more extraction wells and a series of injection wells to control plume migration and establish the 50-µg/L level within the Laboratory boundary. Contaminated groundwater will be extracted, treated at the surface using ion exchange, and returned to the aquifer using injection wells. Limited pumping and injection took place in late 2016, and the interim measure is expected to be more fully operational in 2017.

The Investigation Work Plan for Chromium Plume-Center Characterization presents a set of activities to more fully characterize the aquifer and contaminant distribution in support of an eventual recommendation for a remediation strategy (LANL 2015c). Key activities involve pumping from a centroid extraction well and conducting various bench- and field-scale experiments to evaluate the use of chemicals and bio-amendments to treat chromium within the aquifer.

Material Disposal Area C Monitoring Group

Material Disposal Area C is located on Mesita del Buey in Technical Area 50, at the head of Ten Site Canyon. Material Disposal Area 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 and tritium are present in the upper 500 feet of the unsaturated zone beneath Material Disposal Area C (LANL 2011a). The primary vapor-phase constituents beneath Material Disposal Area C are trichloroethene and tritium. The Material Disposal Area C monitoring group includes nearby regional aquifer monitoring wells (Figure 5-5). Monitoring data indicate no groundwater contamination is present in the regional aquifer immediately downgradient of Material Disposal Area C, and no perched-intermediate zones have been encountered in the area. Results from monitoring of vapor-phase substances at Material Disposal Area C are presented in Chapter 3, Environmental Programs.

Technical Area 54 Monitoring Group

Technical Area 54 is situated in the east-central portion of the Laboratory on Mesita del Buey. Technical Area 54 includes four material disposal areas designated as Areas G, H, J, and L; a waste characterization, storage, and transfer facility (Technical Area 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 Technical Area 54, groundwater monitoring is conducted to support both (1) monitoring of solid waste management units and areas of concern (particularly Areas G, H, and L) under the Compliance Order on Consent and (2) the Laboratory's Resource Conservation and Recovery Act Hazardous Waste Facility Permit. The Technical Area 54 monitoring group includes both perched-intermediate and regional wells in the near vicinity (Figure 5-5).

Monitoring data show vapor-phase volatile organic compounds are present in the upper portion of the unsaturated zone beneath Areas G and L. The primary vapor-phase volatile organic compounds at Technical Area 54 are 1,1,1-trichloroethane; trichloroethene; and Freon-113. Tritium is also present (LANL 2005b, 2006, 2007a).

Data from the groundwater monitoring network around Technical Area 54 show a very small number of detections of a variety of substances, including several volatile organic compounds. However, no constituents were detected above applicable standards or screening levels. Tritium was not detected in any of the regional aquifer groundwater monitoring wells in the Technical Area 54 monitoring group. The temporal and spatial nature of the volatile organic compound detections and the lack of tritium suggests that Technical Area 54 may not be the source of the detected compounds (LANL 2009b). Further evaluations of existing groundwater data near Technical Area 54 and detailed descriptions of organic and inorganic constituents detected in perched-intermediate and regional groundwater at Technical Area 54 are presented in the corrective measures evaluation reports for Material Disposal Areas G, H, and L (LANL 2011b, 2011c, 2011d).

Technical Area 16 260 Monitoring Group

Water Canyon and Cañon de Valle (a tributary of Water Canyon) traverse the southern portion of LANL where the Laboratory develops and tests explosives. In the past, the Laboratory released wastewater into both canyons from several high-explosives-processing sites in Technical Areas 16 and 09 (Figure 5-4). In 1997, we consolidated several outfalls into the High Explosives Wastewater Treatment Facility where all treated wastewater has been evaporated since 2007. The Technical Area 16 260 monitoring group was established for the upper Water Canyon/Cañon de Valle watershed to monitor substances released from Consolidated Unit 16-021(c)-99, which includes the Technical Area 16 260 Outfall and associated solid waste management units. The Technical Area 16 260 Outfall discharged high-explosives-bearing water from a high-explosives-machining facility to Cañon de Valle from 1951 through 1996. These discharges served as a primary source of high-explosives and inorganic element contamination in the area (LANL 1998, 2003, 2011e). Data indicate that springs, surface water, alluvial groundwater, and perched-intermediate groundwater contain 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. RDX has been detected in the regional aquifer in wells R-18 and R-63. In addition, the volatile organic compounds 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 wells R-25 (screen 5) and R-18.

The primary transport pathway for these constituents is thought to involve infiltration of effluent from the Technical Area 16 260 Outfall mixed with seasonally variable amounts of naturally occurring surface water and alluvial groundwater in Cañon de Valle and percolation through unsaturated rock layers to perched-intermediate groundwater zones and ultimately into the regional aquifer.

We submitted an initial corrective measures evaluation report for perched-intermediate and regional groundwater in the watershed in July 2007 (LANL 2007b). In April 2008, the New Mexico Environment Department issued a notice of disapproval of the report and required that additional work be conducted to evaluate the feasibility of the remedial alternatives and to further characterize the extent of contamination. We are currently conducting additional characterization, including cross-hole aquifer tests and tracer tests, and refining the conceptual model for the groundwater system. Groundwater monitoring data collected from the Technical Area 16 260 monitoring group will be used to support a revised corrective measures evaluation report. The following discussion presents ongoing results for the area.

RDX is the primary groundwater contaminant. In 2016, no RDX concentrations exceeded the New Mexico tap water screening level of 7.02 µg/L in the regional aquifer. Figures 5-17, 5-18, 5-19, and 5-20 show RDX concentrations in springs, alluvial wells, perched-intermediate zone wells, and regional wells, respectively. The springs represent perched-intermediate groundwater. RDX concentrations in regional monitoring wells R-63 and R-18 were below the adjusted U.S. Environmental Protection Agency regional tap water screening level.

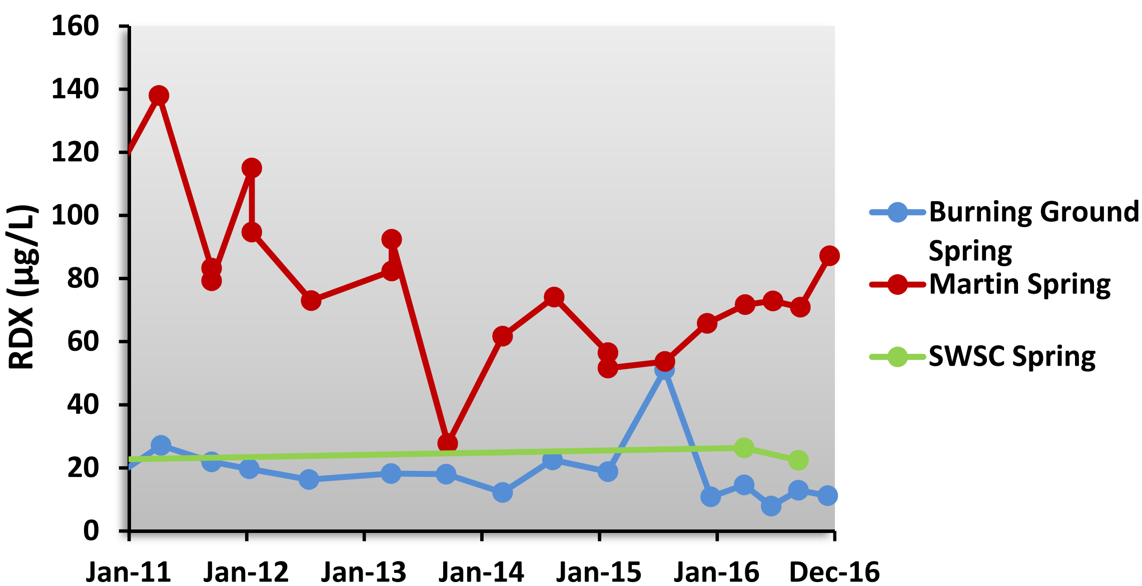


Figure 5-17 RDX concentrations in springs in Cañon de Valle and Martin Spring Canyon

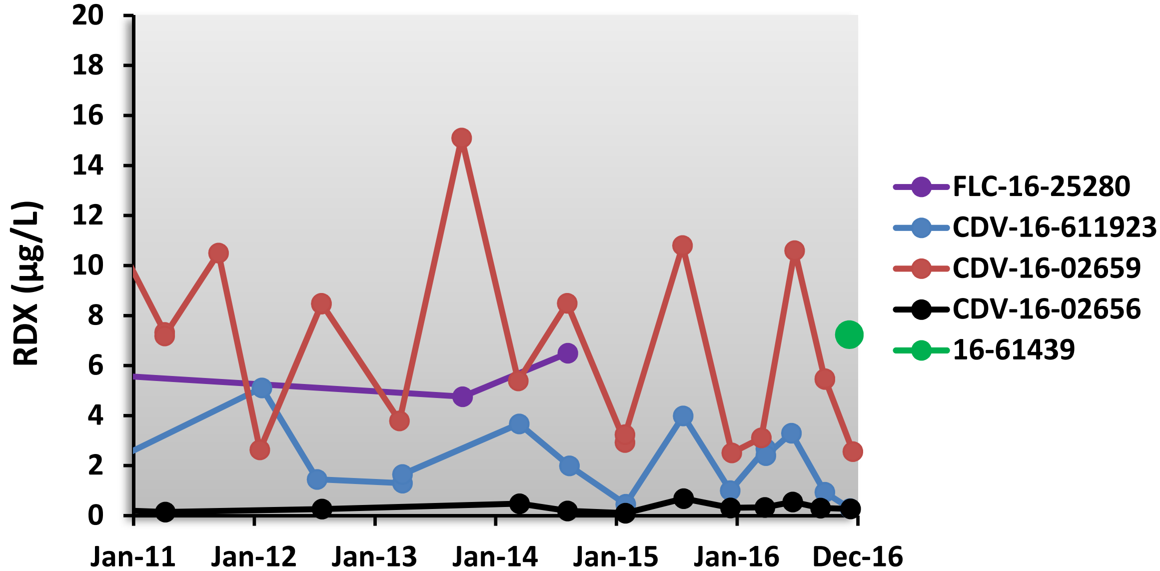


Figure 5-18 RDX concentrations in alluvial wells in Cañon de Valle and Fishladder Canyon

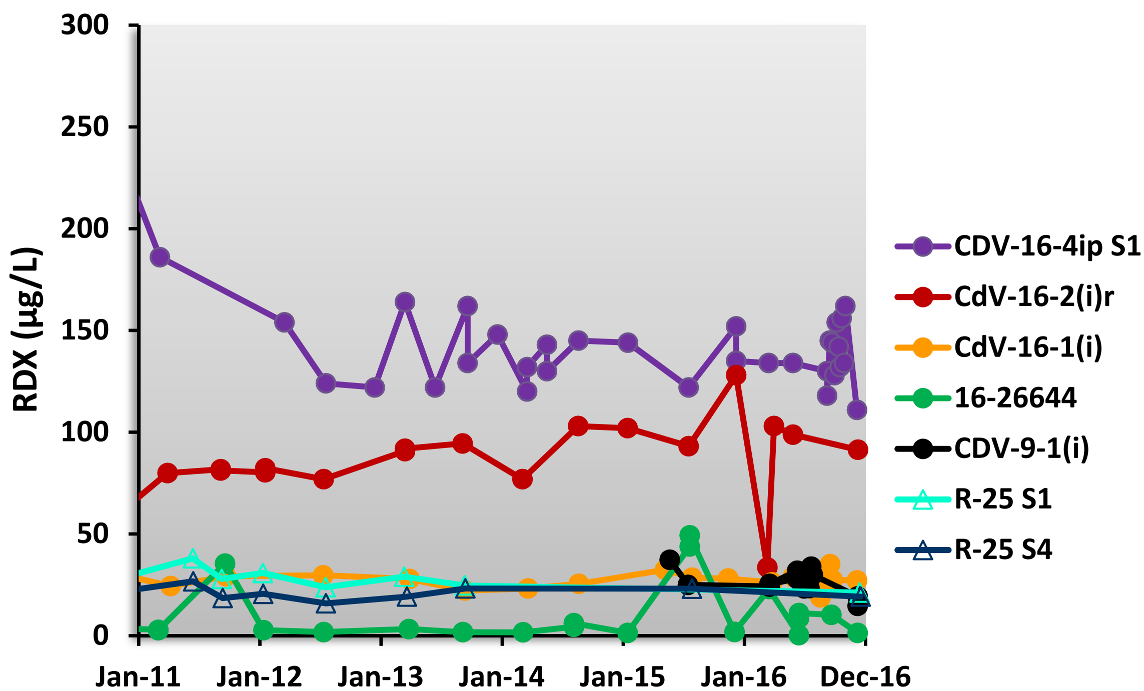


Figure 5-19 RDX concentrations in perched-intermediate groundwater

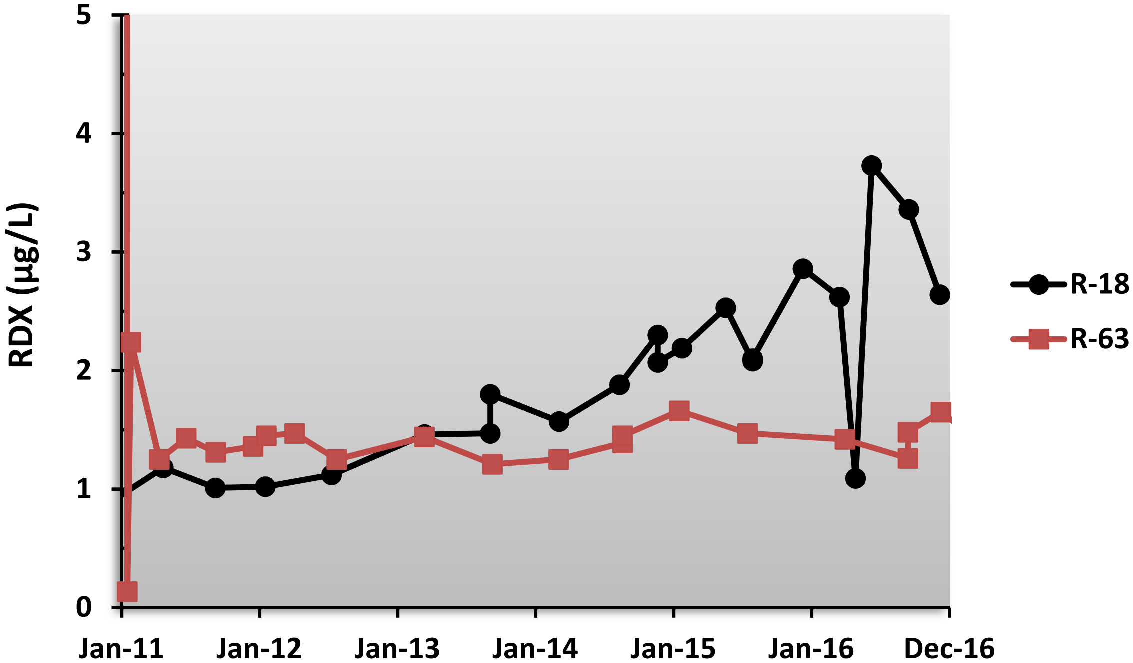


Figure 5-20 RDX concentrations in regional groundwater

The concentrations of RDX are highest in Martin Spring (Figure 5-17). RDX concentrations in samples from Burning Ground Spring are typically lower than concentrations in Martin Spring and have been relatively steady over the last 5 years (Figure 5-17), with the exception of one sample collected in July 2015. SWSC Spring, near the former location of the Technical Area 16 260 Outfall, had not flowed in recent years but began to flow again in 2016. Figure 5-17 shows the historical concentrations at SWSC Spring. RDX concentrations in alluvial monitoring wells show significant variability because of seasonal influences (Figure 5-18).

RDX concentrations at some perched-intermediate groundwater locations are significantly higher than the current RDX concentrations in the Cañon de Valle alluvium. RDX concentrations in each of the perched-intermediate wells are variable but have remained relatively stable in recent years.

RDX is persistently detected in regional monitoring wells R-63 and R-18 at levels below the 7.02-µg/L New Mexico tap water screening level (Figure 5-20). 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. RDX concentrations in R-18 show an increasing trend since the well was installed in 2006 (Figure 5-20).

Other trace contaminants, including tetrachloroethene, trichloroethene, boron, and barium, are present in all groundwater zones but are below applicable standards in the perched-intermediate and regional aquifers (Figures 5-21, 5-22, and 5-23).

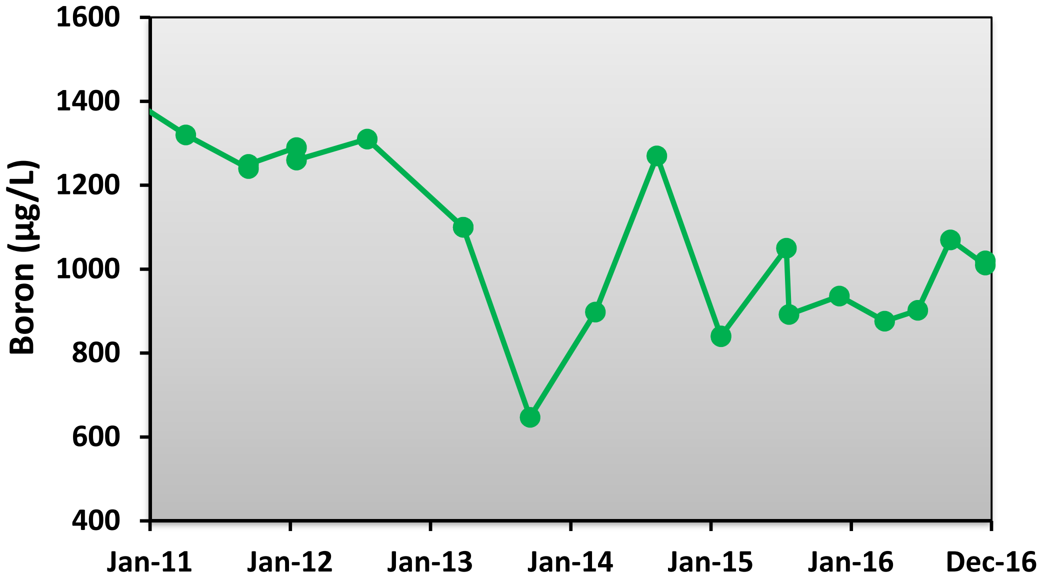


Figure 5-21 Boron concentrations at Martin Spring in Martin Spring Canyon.
The New Mexico groundwater standard for irrigation use is 750 µg/L.

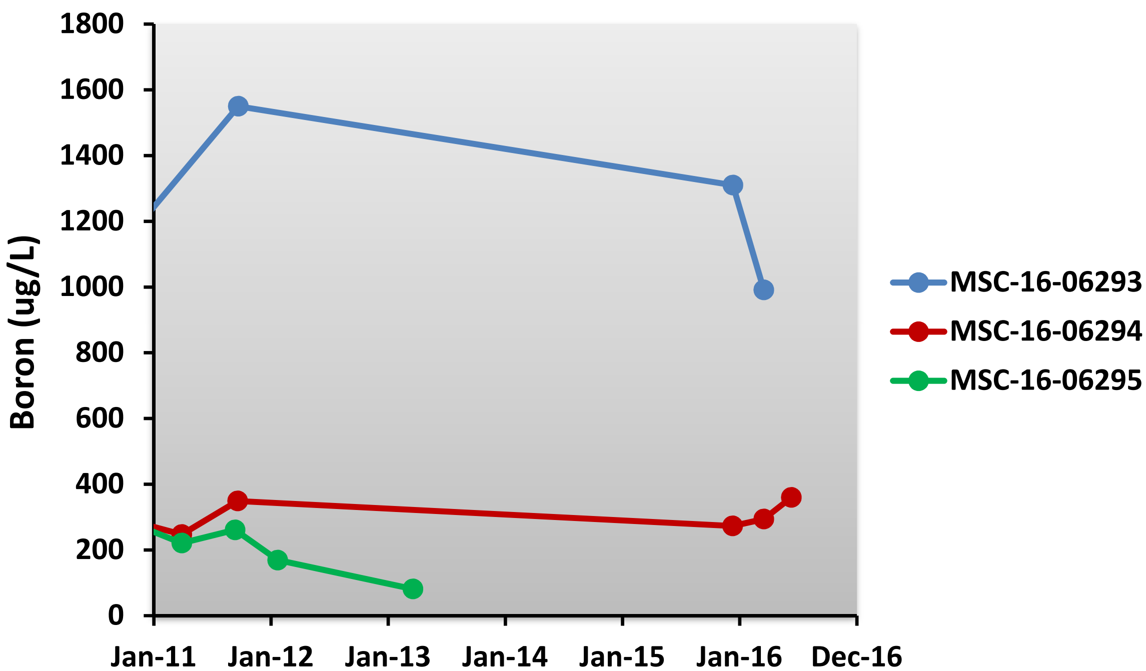


Figure 5-22 Boron concentrations in alluvial wells in Martin Spring Canyon. Well MSC-16-06293 is closest to Martin Spring, and well MSC-16-06295 is the farthest downgradient.

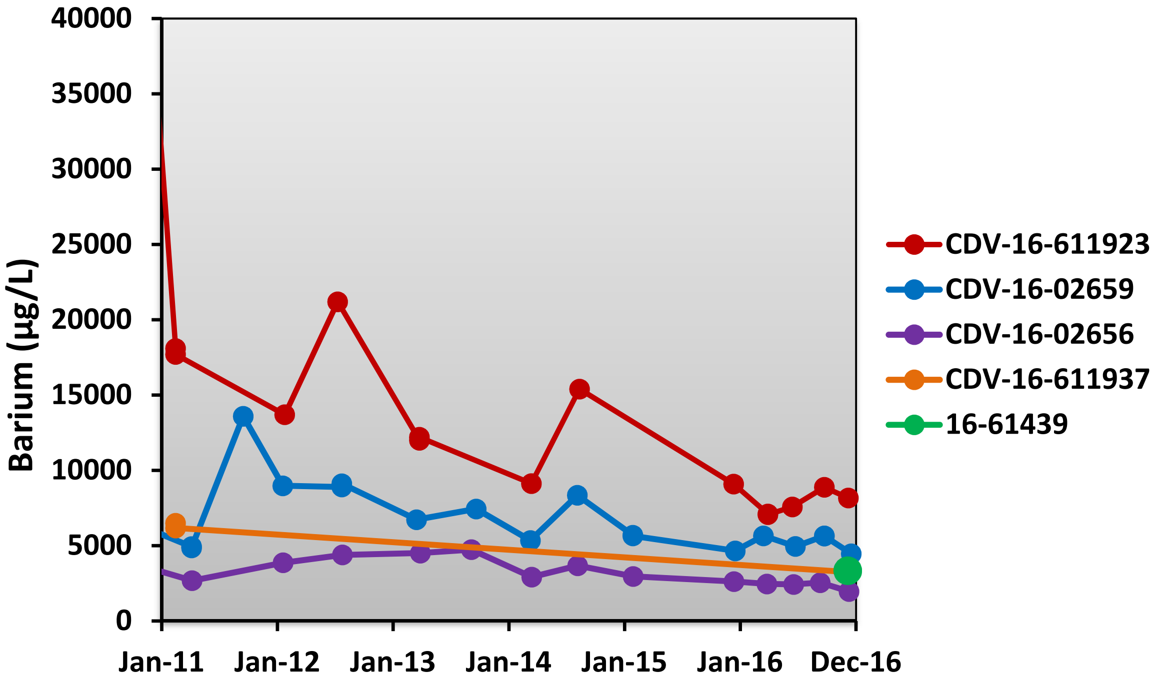


Figure 5-23 **Barium concentrations in the Technical Area 16 260 monitoring group in Cañon de Valle alluvial groundwater**

The source of boron is thought to be the laundry detergent borax, which was used at the former laundry facility at Technical Area 16. Boron is also a component of the explosive compound Boracitol, which was processed in a limited number of facilities.

Barium is present in three alluvial wells in Cañon de Valle: CdV-16-611923, CdV-16-02659, and CdV-16-02656 (Figure 5-23). Barium concentrations in these wells have been fairly steady over the last few years, although in 2010, barium concentrations in CdV-16-611923 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.

Material Disposal Area AB Monitoring Group

The Material Disposal Area AB monitoring group is located in Technical Area 49. Technical Area 49, also known as the Frijoles Mesa Site, is located on a mesa in the upper part of the Ancho Canyon drainage. Part of the area drains into Water Canyon (Figure 5-5). The canyons in the Ancho watershed are mainly dry with no known persistent alluvial groundwater zones and no known perched-intermediate groundwater.

Material Disposal Area AB was the site of nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987, LANL 1988). The testing involved 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, solid waste management units, and areas of concern at Technical Area 49 can be found in recent Laboratory reports (LANL 2010a, 2010b).

In 2016, no contaminants were found in Material Disposal Area AB monitoring group wells at concentrations above standards.

White Rock Canyon Monitoring Group

The springs that issue along and near the Rio Grande in White Rock Canyon discharge predominantly regional aquifer groundwater (Purtymun et al. 1980). A few springs appear to represent discharge of perched-intermediate groundwater. The water discharging at some other springs may be a mixture of regional aquifer groundwater, perched-intermediate groundwater, and percolation of recent precipitation (Longmire et al. 2007).

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). Consistent with prior years' data, no springs that discharge groundwater from beneath the Laboratory into White Rock Canyon have any constituent concentrations above applicable groundwater standards.

General Surveillance Monitoring Group

Los Alamos Canyon on Laboratory Property

Alluvial well LAO-3a in Los Alamos Canyon (Figure 5-6) continues to show strontium-90 activities above the 8-pCi/L U.S. Environmental Protection Agency maximum contaminant level for drinking water (Figure 5-24). Results from filtered and unfiltered samples from the same date are typically similar in the alluvial groundwater setting. The source of strontium-90 is Solid Waste Management Unit 21-011(k), which was an outfall from industrial waste treatment plants at Technical Area 21. Strontium-90 continues to be found in shallow alluvial groundwater samples at this location because it has been adsorbed on the alluvium (LANL 2004).

Lower Los Alamos Canyon

Vine Tree Spring on Pueblo de San Ildefonso land represents discharge of perched-intermediate groundwater. Vine Tree Spring began to be sampled as a replacement for nearby Basalt Spring that had been consistently sampled since the 1950s until it dried up around 2010. The perchlorate concentration in Vine Tree Spring for 2016 is consistent with prior years' data and was below the 13.8 μg/L New Mexico Tap Water limit, which is the lowest applicable value used for comparison purposes under the 2016 Compliance Order on Consent (Figure 5-25).

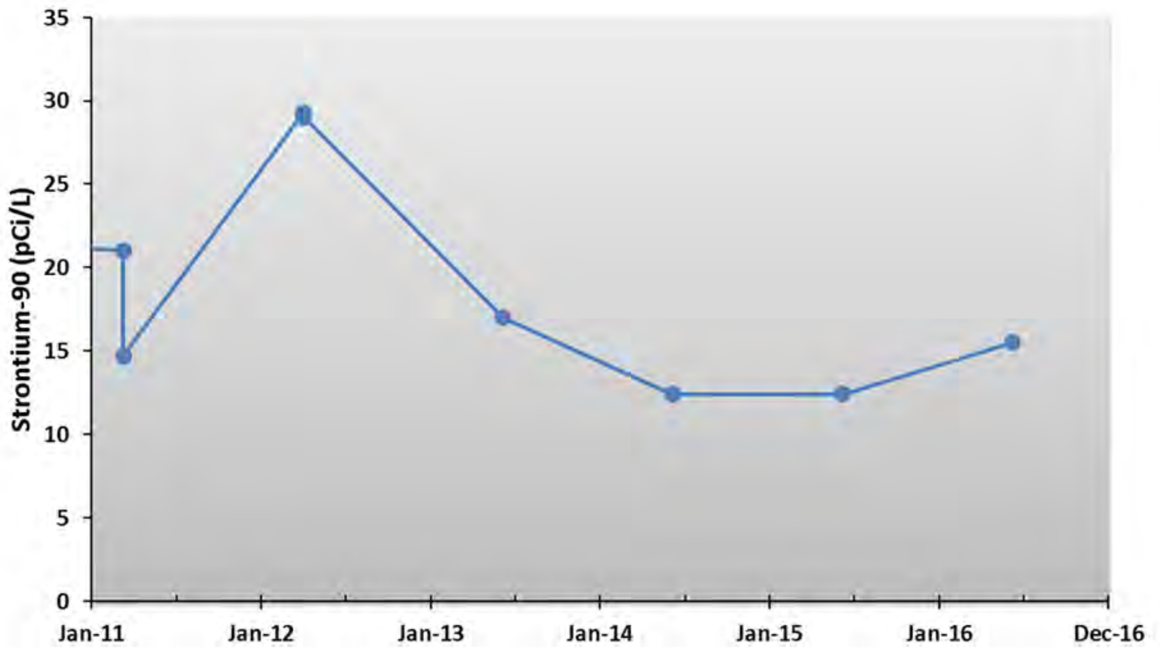


Figure 5-24 Strontium-90 activities at alluvial monitoring well LAO-3a

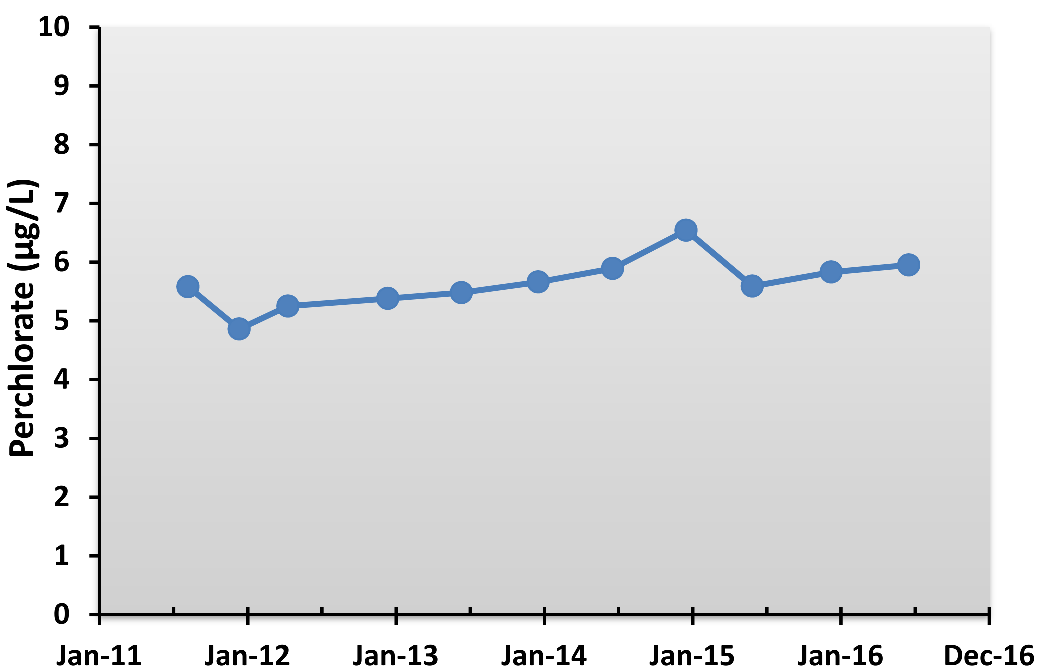


Figure 5-25 Perchlorate concentrations at Vine Tree Spring

Sandia Canyon

The General Surveillance monitoring group 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 perched-intermediate well R-12; wells R-10 and R-10a are on Pueblo de San Ildefonso land. No constituents were measured near or above standards in these wells during 2016.

Mortandad Canyon

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 2016.

Under the groundwater discharge plan application for the Technical Area 50 Radioactive Liquid Waste Treatment Facility outfall, quarterly samples are collected for nitrate, fluoride, perchlorate, and total dissolved solids from three alluvial monitoring wells below the outfall in Mortandad Canyon: MCO-4B, MCO-6, and MCO-7. Perchlorate was detected at all three wells (Figure 5-26). Perchlorate results from the wells since the 2002 Radioactive Liquid Waste Treatment Facility effluent treatment upgrades remain low relative to past perchlorate concentrations in Mortandad Canyon alluvial groundwater. Nitrate, fluoride, and total dissolved solids are far below applicable standards for these alluvial wells.

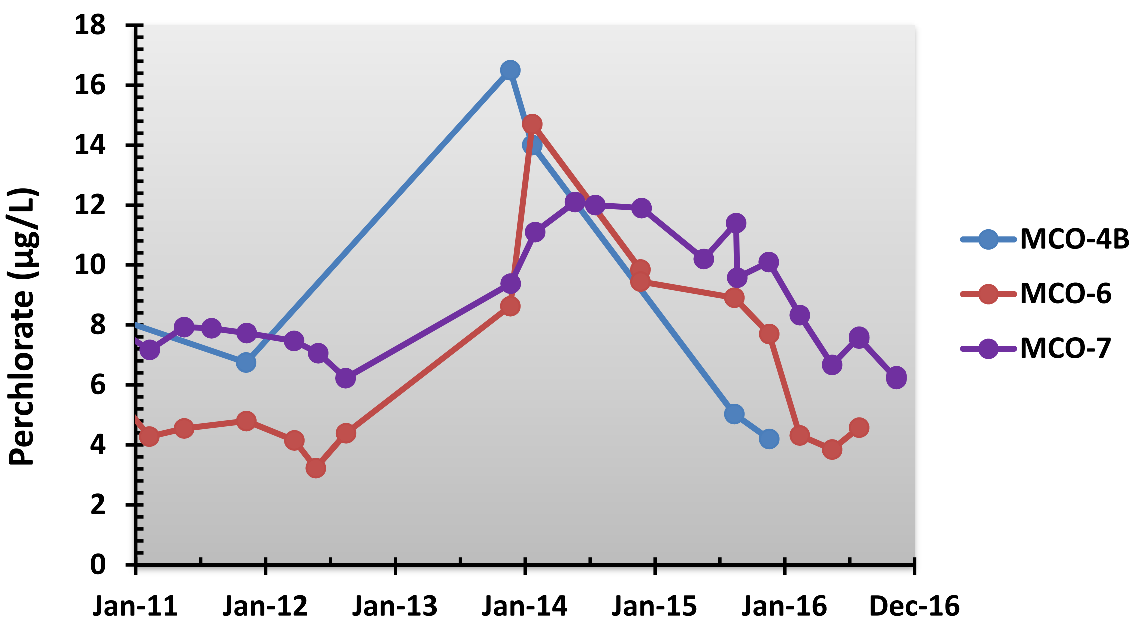


Figure 5-26 **Perchlorate concentrations at General Surveillance monitoring group and groundwater discharge plan monitoring locations MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon alluvial groundwater**

Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was dry in 2016 and therefore not sampled.

Pajarito Canyon

Pajarito Canyon has a watershed that begins in the Sierra de los Valles west of the Laboratory. Twomile and Threemile Canyons at the Laboratory are tributaries of Pajarito Canyon. 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 high-explosives-processing sites at Technical Area 09. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at Technical Area 18. Waste management areas at Technical Area 54 occupy the mesa north of the lower part of the canyon.

Solid Waste Management Unit 03-010(a) is the outfall area from a former vacuum repair shop behind the warehouse at Technical Area 03. The outfall area is located on a small tributary to Twomile Canyon. A small zone of shallow perched-intermediate groundwater in the tributary is apparently recharged by runoff from the parking lot and building roofs. This perched groundwater is sampled at a depth of approximately 21 feet by well 03-B-13. In 2016, samples from this well contained 1,1,1-trichloroethane and 1,4-dioxane above their applicable standards of 60 µg/L and 4.59 µg/L, respectively. Figures 5-27 and 5-28 show the history of these two constituents, respectively. These constituents are not present above applicable standards in any nearby regional aquifer wells.

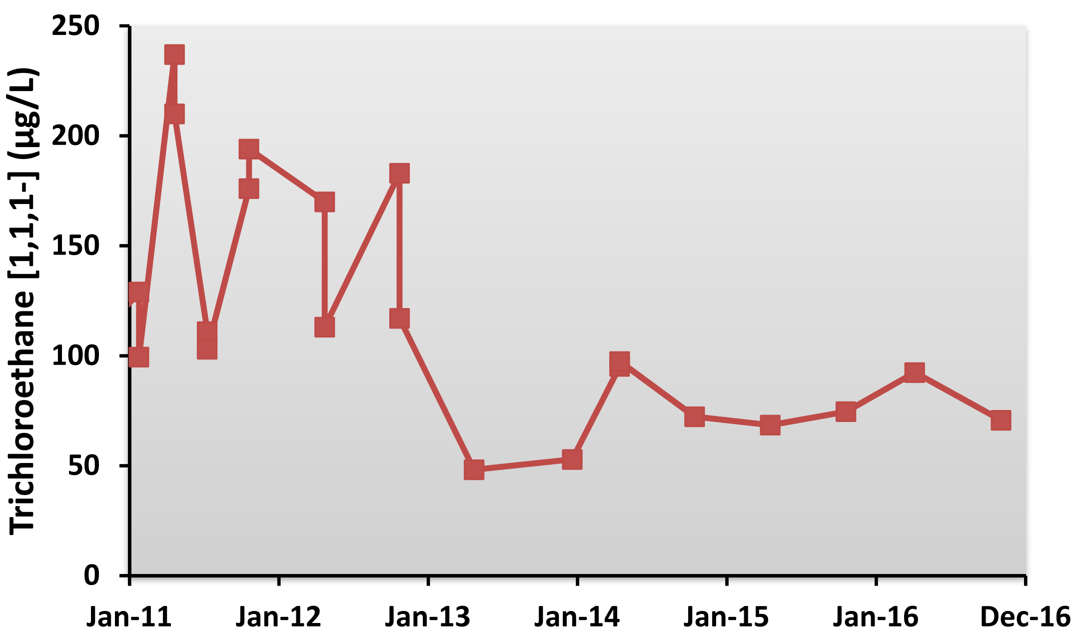


Figure 5-27 Concentrations of 1,1,1-trichloroethane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13

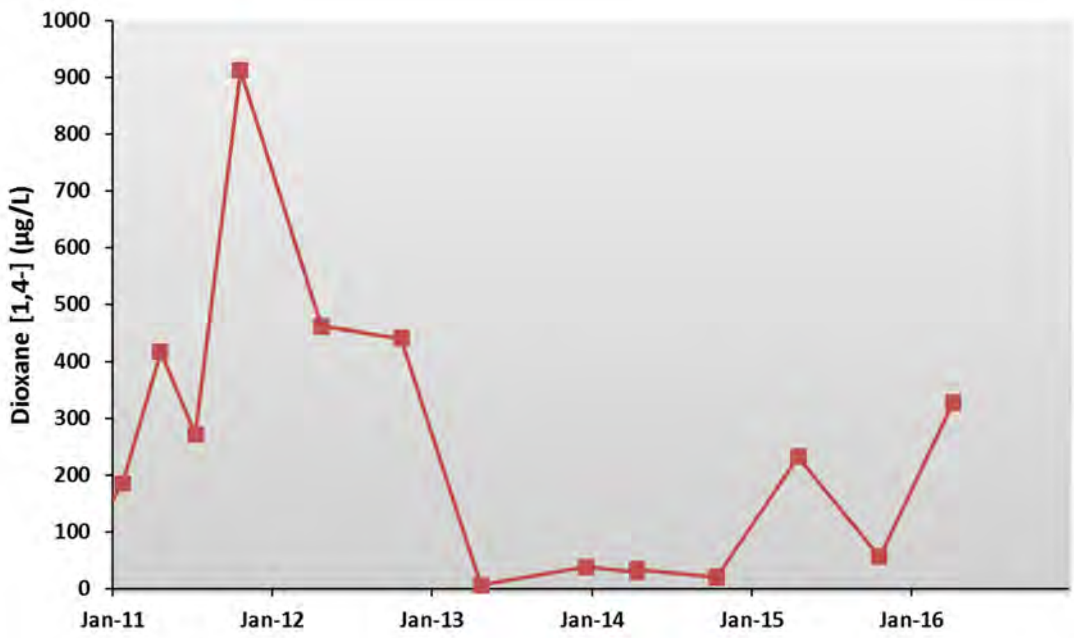


Figure 5-28 Concentrations of 1,4-dioxane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13

Several other alluvial and perched-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 2016.

Water Canyon

Water Canyon has only one General Surveillance monitoring group location, alluvial well WCO-1r. No constituents were detected above applicable standards in this well in 2016.

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 our understanding of the nature and extent of groundwater contamination. As described in this chapter, only two areas are showing groundwater contaminants that are of sufficient extent to warrant interim measures, further characterization, and potential remedial actions: RDX contamination in the Technical Area 16 area and chromium contamination beneath Sandia and Mortandad Canyons. We will continue to implement interim measures in the chromium plume in 2017. Further characterization work and studies to inform an evaluation of groundwater risks and potential remediation strategies are ongoing in both of these areas.

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Hydrologic Setting *6-9*
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Los Alamos National Laboratory (the Laboratory) collects and analyzes storm water runoff for a variety of substances and characteristics, such as chemical and radionuclide levels, the volume and duration of flow, and the total amount of suspended sediment. We also analyze newly deposited sediment samples each year for chemical and radionuclide levels. We compare surface water sampling results with New Mexico water quality standards, target action levels, and radiological dose guidelines and sediment sampling results with human and ecological health screening criteria. The State of New Mexico uses our surface water data in updating its determinations of impaired waters on and near the Laboratory every 2 years.

Human health and ecological risk assessments were performed as part of investigations of each of the canyons conducted during 2004 through 2011 as part of the Laboratory's Environmental Remediation. The human health risk assessments concluded that the chemicals and radionuclides that were present were below levels that would impact human health. The sediment and water data collected in 2016 and presented in this chapter are used to verify that during 2016 storm water-related transport of chemicals or radionuclides did not cause levels of those substances to exceed the levels found during the canyons investigations.

Over time, storm water-related transport of sediments generally results in similar or lower levels of Laboratory-released chemicals and radionuclides than previously existed at the sampling locations. The results of the sediment and surface water data collected in 2016 support the conclusion that the risk assessments presented in the canyons investigation reports represent an upper bound of risks from these substances in the canyons for the foreseeable future. The Laboratory continues to have several impaired stream segments, as defined by the New Mexico Environment Department. Laboratory industrial outfalls are regulated to help minimize these impairments.

INTRODUCTION

Effluents containing radionuclides, inorganic chemicals, and organic chemicals were discharged to canyons around Los Alamos National Laboratory (LANL or the Laboratory) during the early years of operations. Treatments to reduce contaminants in effluents began in the 1950s. Effluent discharges at the Laboratory have been conducted under permits from regulatory agencies since 1978.

There are also natural and other human-related sources of chemicals and radionuclides, such as natural geological occurrences, constituents associated with trees burned during forest fires, atmospheric fallout of radionuclides and chemicals such as polychlorinated biphenyls (PCBs), and releases from developed areas on the Pajarito Plateau. All of the above sources contribute to the levels of chemicals and radionuclides in surface water and sediment across the plateau.

We monitor chemical and radionuclide levels and other water quality characteristics in surface water and sediment in and around the Laboratory to (1) document the water quality in streams within and downstream of the Laboratory and (2) evaluate risks to human and ecosystem health. Sampling results are compared with New Mexico water quality standards, target action levels, radiological dose guidelines, and human and ecosystem health screening criteria. The New Mexico Environment Department Surface Water Quality Bureau uses the surface water results to evaluate if the Laboratory's stream reaches are impaired under Section 303(d) of the Clean Water Act and to update the list of impaired streams on Laboratory property biennially.

The data presented in this chapter originate from three Laboratory programs:

- Annual environmental surveillance sampling (LANL 2016a, 2016b);
- The annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2015a, 2016c), which includes sampling of persistent surface water in streams; and
- Storm water runoff monitoring associated with the Individual Permit (the authorization to discharge [from solid waste management units and areas of concern] under the National Pollutant Discharge Elimination System).

CLASSIFICATIONS FOR STREAM REACHES, STANDARDS, AND SCREENING LEVELS

Under Part 20.6.4 of the New Mexico Administrative Code, stream reaches within the Laboratory boundary are classified as perennial (having water throughout the year), intermittent (having water for extended periods only at certain times of the year), or ephemeral (having water briefly only in direct response to precipitation) and have specified designated uses as follows: coldwater aquatic life, marginal warmwater aquatic life, limited aquatic life, livestock watering, wildlife habitat, primary (human) contact, and secondary (human) contact. The locations of these stream reaches and their classifications are shown in Figure 6-1, and their designated use(s) are provided in Table 6-1.

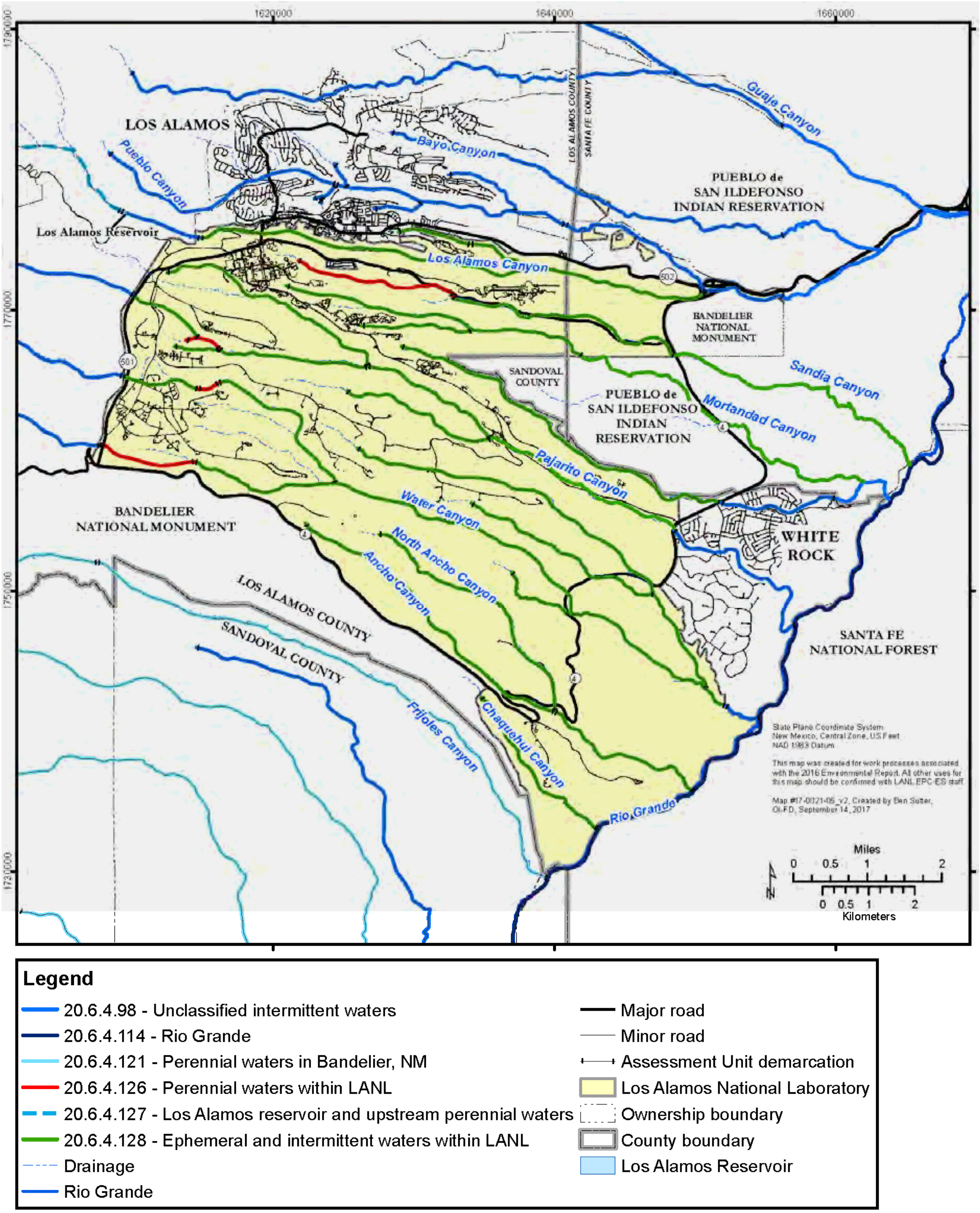


Figure 6-1 Stream reaches within and around the Laboratory showing the classifications of streams per Part 20.6.4 of the New Mexico Administrative Code

Table 6-1
New Mexico Water Quality Control Commission Classifications (Classified Water of the State) and Designated Uses for LANL Streams

Stream Segment Description	Designated Use	Description of Associated Users
Perennial stream segments on Laboratory property, including parts of Cañon de Valle and 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	Fish, aquatic invertebrates, etc. Chronic aquatic life standard applies.
Ephemeral and intermittent stream segments on Laboratory property	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Limited aquatic life	Aquatic invertebrates, etc. Acute aquatic life standard applies.
	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.
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 warm water aquatic life	Limited ability for stream to sustain a natural aquatic life population on a continuous annual basis.
	Primary contact	Recreational or other water use in which there is prolonged and intimate human contact with the water, such as swimming and water skiing. 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.

The New Mexico Water Quality Control Commission establishes surface water quality standards for New Mexico in Part 20.6.4 of the New Mexico Administrative Code. The current standards were approved by the U.S. Environmental Protection Agency on June 5, 2013, and can be found at http://164.64.110.239/nmac/parts/title20/20.006.0004.htm (NMWQCC 2013). We use the protocol employed by the New Mexico Environment Department for assessing surface water quality standard attainment (NMED 2015). In addition, hardness-dependent aquatic life criteria are calculated using water hardness values of concurrent samples, where available, and 30 milligrams calcium carbonate per liter (mg $CaCO_3$/L) where hardness values are not available (EPA 2006a, NMWQCC 2013). Storm water background values from developed and undeveloped areas near the Laboratory are used for reference (LANL 2013).

U.S. Department of Energy (DOE) Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, prescribes total dose limits associated with radionuclides. There are no drinking-water systems on the Pajarito Plateau that rely on surface water. Therefore, the emphasis of the radiological assessment of surface water is on potential exposures of wildlife and aquatic organisms (collectively known as "biota"). We compare radionuclide activities in surface water with the DOE biota concentration guides (DOE 2002, 2004) for water with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for aquatic, riparian, or terrestrial animals are used for evaluation, depending on how persistent water is at the locations being evaluated.

We compare surface water results for gross-alpha radioactivity and radium isotopes with the New Mexico water quality standards. The gross-alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act of 1954. The gross-alpha radioactivity data discussed in this chapter were not adjusted to remove these sources of radioactivity.

We compare surface water results from site monitoring areas with the target action levels specified in the Individual Permit. Additional details for site monitoring area results are provided in the Individual Permit annual report (LANL 2016d).

We compare sediment results for chemicals with the New Mexico Environment Department's risk-based soil screening levels (NMED 2017) and sediment results for radionuclides with the Laboratory's risk-based screening action levels (LANL 2015b). If there are no New Mexico soil screening levels for a particular chemical, the U.S. Environmental Protection Agency's regional screening levels are used (EPA 2016). Soil screening levels for inorganic and organic chemicals and screening action levels for radionuclides are levels considered safe for industrial, construction worker, or residential exposure scenarios. If concentrations of substances are below screening action levels or soil screening levels, then adverse human health effects are highly unlikely. In addition, we use sediment background values from Ryti et al. (1998) for reference. (Note: The New Mexico surface water quality standards only address total PCBs, while the soil screening levels address individual PCB congeners, but not total PCBs.

For protection of biota, we compare levels of radionuclides in sediment with the DOE biota concentration guides (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for riparian and terrestrial animals are used for evaluation.

Each stream within the Laboratory boundary is divided into segments and may be further divided into assessment units, which are used in the state's biennial stream impairment assessment. The findings for each assessment unit on and around Laboratory lands are provided in Table 6-2. An assessment unit is considered impaired when one or more of the New Mexico surface water quality standards are not being met for one or more pollutants.

Table 6-2
LANL Assessment Units, Impairment Cause, and Designated Use(s) That Are Supported, Not Supported, or Not Assessed

Assessment Unit Name	Water Type	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Acid Canyon (Pueblo to headwaters)	Ephemeral	PCBs[a], copper[b], aluminum	Secondary contact	Wildlife habitat, livestock watering, marginal warmwater aquatic life	Primary contact
Ancho Canyon (North Fork to headwaters)	Ephemeral	PCBs	Wildlife habitat	Limited aquatic life	Secondary contact, livestock watering
Ancho Canyon (Rio Grande to North Fork Ancho)	Ephemeral	Aluminum, gross alpha[c], PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Arroyo de la Delfe (Pajarito Canyon to headwaters)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Canada del Buey (within LANL)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Canon de Valle (below LANL gage E256)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Canon de Valle (LANL gage E256 to Burning Ground Spring)	Perennial	Gross alpha, aluminum, PCBs	None	Livestock watering, coldwater aquatic life, wildlife habitat	Secondary contact
Canon de Valle (upper LANL bnd[d] to headwaters)	Intermittent	Gross alpha, aluminum, PCBs	Wildlife habitat	Marginal warmwater aquatic life, livestock watering	Primary contact
Canon de Valle (within LANL above Burning Ground Spring	Ephemeral	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Chaquehui Canyon (within LANL)	Ephemeral	Full support (livestock watering, wildlife habitat, limited aquatic life), not assessed (secondary contact)	Wildlife habitat, livestock watering, limited aquatic life	None	Secondary contact
DP Canyon (Grade Control to upper LANL bnd)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
DP Canyon (Los Alamos Canyon to grade control)	Intermittent	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Fence Canyon (above Potrillo Canyon)	Ephemeral	Not assessed	None	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact

Table 6-2 (continued)

Assessment Unit Name	Water Type	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Graduation Canyon (Pueblo Canyon to headwaters)	Ephemeral	Copper[b], aluminum, PCBs	Livestock watering	Wildlife habitat, marginal warmwater aquatic life	Primary contact
Indio Canyon (above Water Canyon)	Ephemeral	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Kwage Canyon (Pueblo Canyon to headwaters	Ephemeral	Not assessed	Not applicable	Not applicable	Primary contact, wildlife habitat, livestock watering, marginal warmwater aquatic life
Los Alamos Canyon (DP Canyon to upper LANL bnd)	Ephemeral	Aluminum, gross alpha, mercury (total), PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Los Alamos Canyon (NM-4 to DP Canyon)	Ephemeral	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Mortandad Canyon (within LANL)	Ephemeral	Aluminum, copper[b], gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
North Fork Ancho Canyon (Ancho Canyon to headwaters)	Ephemeral	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Pajarito Canyon (Arroyo de La Delfe to Starmers Spring)	Perennial	Aluminum	Livestock watering, wildlife habitat	Coldwater aquatic life	Secondary contact
Pajarito Canyon (lower LANL bnd to Two Mile Canyon)	Ephemeral	Aluminum, PCBs	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
Pajarito Canyon (Two Mile Canyon to Arroyo de La Delfe)	Intermittent	PCBs, copper[b], gross alpha	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
Pajarito Canyon (upper LANL bnd to headwaters)	Perennial	PCBs, selenium, gross alpha, arsenic, aluminum	None	Marginal warmwater aquatic life, livestock watering, wildlife habitat	Primary contact
Pajarito Canyon (within LANL above Starmers Gulch)	Intermittent	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Potrillo Canyon (above Water Canyon)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Pueblo Canyon (Acid Canyon to headwaters)	Ephemeral	PCBs, gross alpha, aluminum	None	Marginal warmwater aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Canyon to Los Alamos WWTP	Ephemeral	PCBs, gross alpha, aluminum	None	Marginal warmwater aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos WWTP to Acid Canyon)	Ephemeral	PCBs, gross alpha	None	Marginal warmwater aquatic life, livestock watering, wildlife habitat	Primary contact

Table 6-2 (continued)

Assessment Unit Name	Water Type	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Sandia Canyon (Sigma Canyon to NPDES outfall 001)	Perennial	PCBs, thallium (dissolved), copper[b] , aluminum, gross alpha	None	Wildlife habitat, livestock watering, coldwater aquatic life	Secondary contact
Sandia Canyon (within LANL below Sigma Canyon)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
South Fork Acid Canyon (Acid Canyon to headwaters)	Ephemeral	Zinc[b], copper[b], PCBs, gross alpha	None	Marginal warmwater aquatic life, livestock watering, wildlife habitat	Primary contact
Ten Site Canyon (Mortandad Canyon to headwaters)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Three Mile Canyon (Pajarito Canyon to headwaters)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Two Mile Canyon (Pajarito to headwaters)	Ephemeral	PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Walnut Canyon (Pueblo Canyon to headwaters)	Ephemeral	Copper[b], PCBs	Wildlife habitat, livestock watering	Marginal warmwater aquatic life	Primary contact
Water Canyon (Area-A Canyon to NM 501)	Perennial	Aluminum	Wildlife habitat, livestock watering	Coldwater aquatic life	Secondary contact
Water Canyon (within LANL above NM 501)	Intermittent	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Water Canyon (within LANL below Area-A Cyn)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

[a] PCBs are total PCBs in the water column.

[b] Levels of these metals are considered an impairment for acute aquatic life standards.

[c] Gross alpha in surface water samples are currently not adjusted to remove sources of radioactivity from source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act of 1954.

[d] bnd = Boundary.

HYDROLOGIC SETTING

Laboratory lands contain all or parts of seven primary watersheds that drain into the Rio Grande (Figure 6-2). Listed from north to south, the major 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, mostly within the Santa Fe National Forest. The remainder of the primary watersheds have their headwaters on the Pajarito Plateau. Only the Ancho Canyon watershed is located entirely on Laboratory land.

In 2016, there was no snowmelt runoff that crossed the downstream (eastern) boundary of the Laboratory. Total storm water runoff for 2016 measured at the downstream Laboratory boundary is estimated at 10.6 acre-feet. Most of this runoff occurred in Pueblo (6.7 acre-feet), Los Alamos (3.0 acre-feet), Water (0.6 acre-feet), and Pajarito Canyons (0.2 acre-feet). Runoff in Cañada del Buey and Potrillo and Chaquehui Canyons was minimal (less than 0.1 acre-feet), and there was no runoff in Sandia, Mortandad, or Ancho Canyons. Figure 6-3 shows the precipitation and storm water runoff volume for the Laboratory for the monsoonal period of June through October during the years 1995 to 2016.

SURFACE WATER AND SEDIMENT SAMPLING

Sampling Locations and Methods

Surface water is sampled in all major canyons and tributaries on current or former Laboratory lands. This includes an emphasis on monitoring close to and downstream of potential sources of Laboratory-released substances, including monitoring at the downstream Laboratory boundaries and east of NM 4.

We maintain 39 stream gaging stations on and near the Laboratory, all of which are equipped with automated samplers that activate at the start of storm water runoff events. Storm water samples are also collected at 7 additional stream channel locations without active gaging stations. The number of gaging stations and sample locations remains fairly constant from year to year. Locations of stream gaging stations and stream channel sampling locations are chosen to monitor surface water flow onto and off of Laboratory and former Laboratory lands and at the confluence of canyons. The number and locations of samples are adjusted in response to events such as major floods, forest fires, and changes to stream impairments.

The automated samplers at gaging stations collect water from the peak of the runoff event, referred to as the "first flush." The year 2016 was the twelfth year that the first flush of storm water was sampled at many gaging stations, which represents a significant change from 2003 and earlier when samples were collected continuously over a 2-hour period. Higher suspended sediment concentrations tend to occur in the first flush compared with the average concentration over a runoff event (Malmon et al. 2004, 2007). As a result, current storm water sampling results are not directly comparable with data from 2003 and earlier (Figure 6-3). Beginning in 2010, we also collected multiple storm water samples during individual runoff events to evaluate changes in suspended sediment and constituent concentrations during the course of a runoff event.

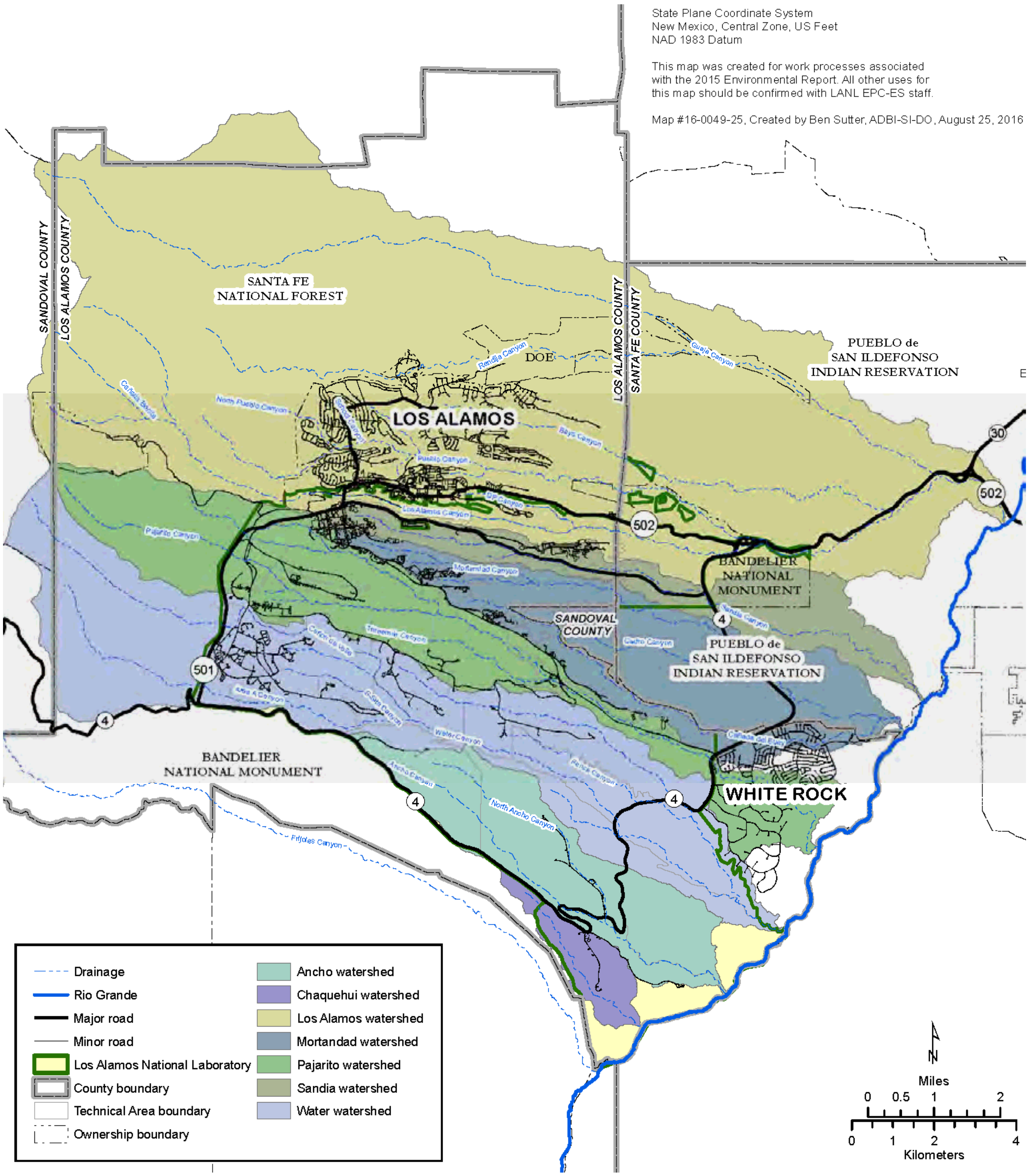


Figure 6-2 Primary watersheds at the Laboratory

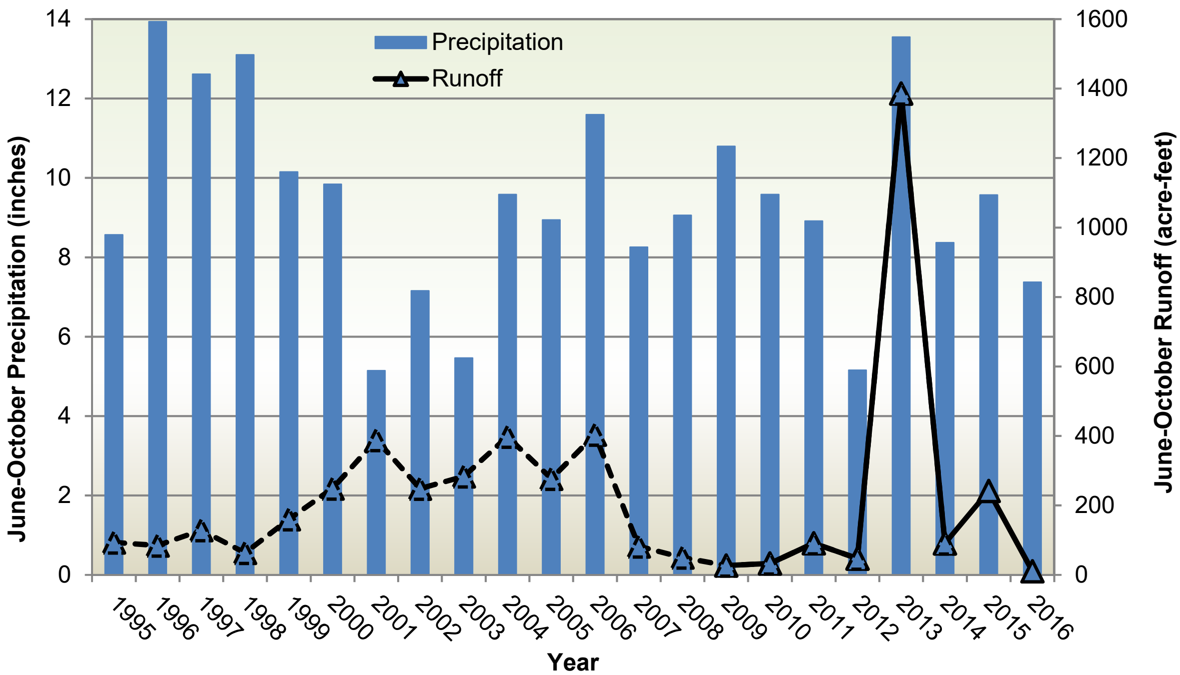


Figure 6-3 Estimated June–October storm water runoff volume in Laboratory canyons from 1995 to 2016 and total June–October precipitation from 1995 to 2016, averaged across the Laboratory's meteorological tower network (Technical Area 06, Technical Area 49, Technical Area 53, Technical Area 54, and northern community). Dashed line indicates data with potential quality issues.

To meet monitoring requirements under the Individual Permit, we have also installed samplers in 250 site monitoring areas to directly sample storm water runoff from 405 solid waste management units and areas of concern. These samplers are not kept open during months with freezing temperatures. Because rain storms on the Pajarito Plateau tend to be localized, not all active Individual Permit sampling locations collect samples each year.

Water discharged from springs is a type of base flow (the portion of stream flow that is not runoff). We collected grab samples of surface water below springs that discharge groundwater at locations identified in the "Interim Facility-Wide Groundwater Monitoring Plan for the 2016 Monitoring Year, October 2015–September 2016" and the "Interim Facility-Wide Groundwater Monitoring Plan for the 2017 Monitoring Year, October 2016–September 2017" (LANL 2015a, 2016a).

Figure 6-4 shows locations sampled in 2016 for storm water at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs. Figure 6-5 shows locations of Individual Permit site monitoring areas where storm water runoff samplers collected compliance samples in 2016.

Figure 6-6 shows locations sampled for sediment in 2016 as part of the annual environmental surveillance program. Sediment samples were collected at a depth of between 0 and 12 inches (depending on the thickness of the uppermost sediment layer). We collected samples from stream channels and flood plains where new sediment was deposited during 2016. For streams with flowing water, sediment samples were collected near the edge of the main channel adjacent to, but not in, the water. During 2016, storm water runoff flowed in every canyon on Laboratory property except for Fence and Indio

Canyons in the Water Canyon watershed; therefore, sediment samples were collected from almost every watershed.

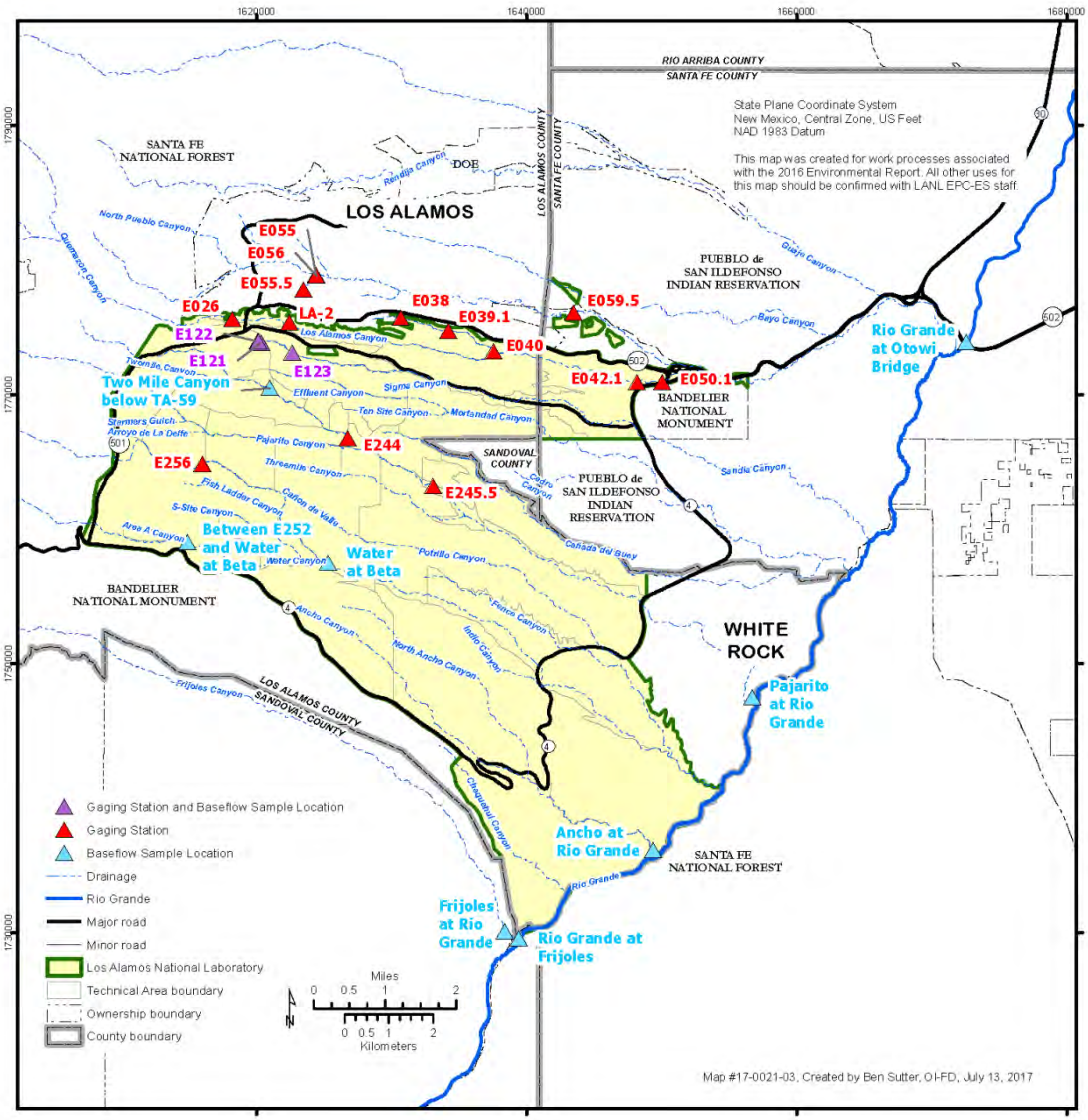


Figure 6-4 **Locations sampled in 2016 for storm water at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs**

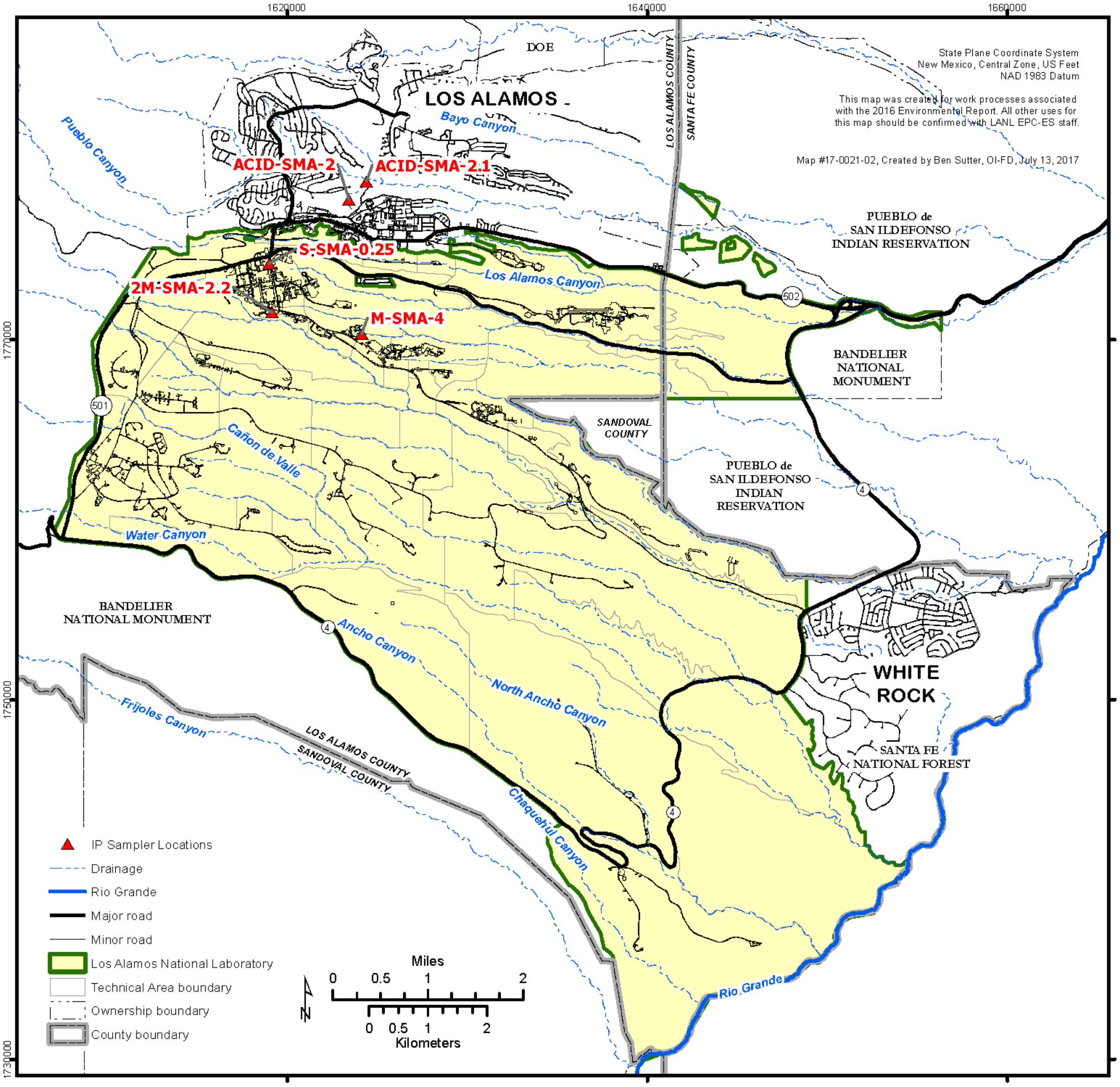


Figure 6-5 Individual Permit site monitoring areas where automated samplers collected compliance storm water samples in 2016

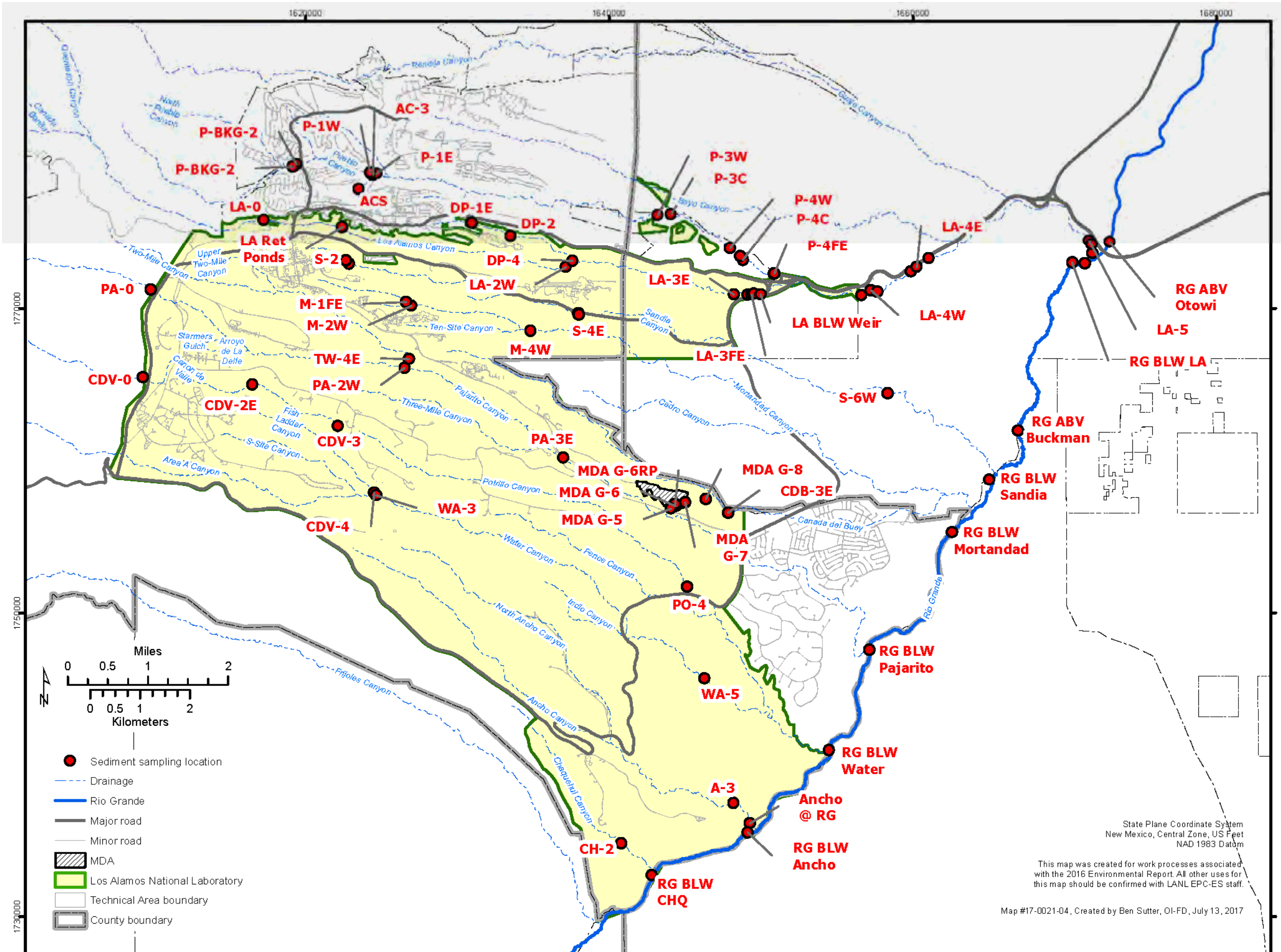


Figure 6-6 Locations sampled in 2016 for sediment as part of the annual environmental surveillance program

Quality Assurance

Sampling of storm water runoff is performed according to written quality assurance and quality control procedures and protocols identified in the following Laboratory standard operating procedures and guides: Installing, Setting Up, and Operating 3700 ISCO Samplers (EP-DIV-SOP-10008); Inspecting ISCO Storm Water Samplers and Retrieving Samples (ER-SOP-10013); and Processing Surface Water Samples (EP-DIV-SOP-20217). Measuring stream flow is performed according to Operation and Maintenance of Gage Stations for Storm Water Projects (EP-DIV-SOP-10005) and Managing Electronic Stage and Discharge Data from Stream Gage Stations (EP-DIR-SOP-10022). Base flow is sampled according to Spring and Surface Water Sampling (SOP-5224). Sediment is sampled according to Geomorphic Characterization (ER-GUIDE-20237) and Soil, Tuff, and Sediment Sampling (ER-SOP-20069). Current versions of all procedures and guides are listed at http://www.lanl.gov/environment/plans-procedures.php and are available in the Laboratory's electronic public reading room at http://eprr.lanl.gov.

These procedures ensure that the collection, processing, and chemical analysis of samples and the validation and verification of analytical data are consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting. We collect all samples under full chain-of-custody procedures. Once collected, sediment samples are hand-delivered to the Laboratory's Sample Management Office, which ships the samples via express delivery directly to an external laboratory. 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 Sample Management Office, which ships the samples via express delivery directly to an external laboratory. 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.

Sampling Results

Table 6-3 summarizes inorganic chemical results for 2016 storm water and base flow samples for locations that had at least one sample result that exceeded screening levels. Table 6-4 summarizes organic chemical and radionuclide results for 2016 storm water and base flow samples for locations that had at least one sample result that exceeded screening levels. Table 6-5 summarizes results for radionuclides and chemicals in 2016 sediment samples for substances that had at least one sample result that exceeded screening levels.

Results from compliance sampling for the Individual Permit are not presented in the tables below but are discussed in the text and included in the figures below. Tables of the Individual Permit sampling results for 2016 are available in the Storm Water Individual Permit Annual Report (LANL 2016d). Tests are not performed for every substance in every Individual Permit sample; the analyses that are requested vary depending on the chemicals or radionuclides present in the solid waste management units and areas of concern within a site monitoring area.

Table 6-3
2016 Storm Water and Base Flow Locations for Inorganic Chemicals Where at Least One Sample Result Exceeded Screening Levels

Location Description	Stream Gage Number	Aluminum			Cadmium			Copper			Lead			Selenium			Zinc		
		Exceedances[a]	Analyses[b]	Detects[c]	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects
CO111041[d]	LA-2	4	4	4	-[e]	-	-	4	4	4	-	-	-	-	-	-	-	-	-
Los Alamos below Ice Rink	E026	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DP above TA-21	E038	3	3	3	-	-	-	2	3	3	3	3	3	-	-	-	-	-	-
DP below grade control structure	E039.1	3	3	3	-	-	-	3	3	3	2	3	2	-	-	-	-	-	-
DP above Los Alamos Canyon	E040	5	5	5	-	-	-	1	5	5	5	5	5	-	-	-	-	-	-
Los Alamos above low-head weir	E042.1	2	2	2	-	-	-	1	2	2	2	2	2	1	2	1	-	-	-
Los Alamos below low-head weir	E050.1	2	2	2	-	-	-	1	2	2	2	2	2	-	-	-	-	-	-
Pueblo above Acid	E055	2	2	2	-	-	-	2	2	2	2	2	2	-	-	-	-	-	-
South Fork of Acid Canyon	E055.5	3	3	3	-	-	-	3	3	3	3	3	3	-	-	-	-	-	-
Pueblo below Los Alamos Canyon	E059.5	1	3	1	-	-	-	1	3	1	1	3	1	-	-	-	-	-	-
Sandia right fork at Power Plant	E121	16	19	19	1	19	2	19	19	19	9	19	10	-	-	-	6	19	19
Sandia right fork at Power Plant[f]	E121	-	-	-	-	-	-	2	4	4	-	-	-	-	-	-	-	-	-
Sandia left fork at Asphalt Plant	E122	2	9	9	1	9	1	9	9	9	6	9	9	-	-	-	9	9	9
South Fork of Sandia at E122[f]	E122	-	-	-	-	-	-	1	2	2	-	-	-	-	-	-	-	-	-
Sandia below Wetlands	E123	15	15	15	-	-	-	15	15	15	11	15	11	-	-	-	-	-	-
Sandia below Wetlands[f]	E123	-	-	-	-	-	-	1	4	4	-	-	-	-	-	-	-	-	-
Twomile above Pajarito	E244	1	1	1	-	-	-	-	-	-	1	1	1	1	1	1	-	-	-
Pajarito above Threemile	E245.5	1	1	1	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1

[a] Exceedances are the number of results that were detected above the screening level.
[b] Analyses are the number of samples analyzed for that constituent.
[c] Detects are the number of samples in which that constituent was detected.
[d] Location CO111041 is the sampler that captures storm water runoff into the upper Los Alamos detention ponds.
[e] A dash (-) indicates either analysis was not performed for the chemical or there were no exceedances of screening levels.
[f] Gray highlighting indicates base flow sampling locations, while no gray highlighting indicates storm water sampling locations.

Table 6-4
2016 Storm Water and Base Flow Locations for Organic Chemicals and Radionuclides Where at Least One Sample Result Exceeded Screening Levels

Location Description	Stream Gage Number	Gross Alpha			Total PCB			Total Dioxin Toxic Equivalent			Benzo(a) anthracene			Benzo(a)pyrene			Benzo(b) fluoranthene			Benzo(k) fluoranthene		
		Exceedances[a]	Analyses[b]	Detects[c]	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects
CO111041[d]	LA-2	2	4	4	4	4	4	-[e]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Los Alamos below Ice Rink	E026	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DP above TA-21	E038	3	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DP below grade ctrl structure	E039.1	2	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DP above Los Alamos Canyon	E040	5	5	5	5	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Los Alamos above low-head weir	E042.1	2	2	2	6	6	6	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Los Alamos below low-head weir	E050.1	1	1	1	3	3	3	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Pueblo above Acid	E055	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Fork of Acid Canyon	E055.5	3	4	4	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E059.5 Pueblo below LAC WWTF	E059.5	1	3	1	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandia right fork at Pwr Plant	E121	1	7	6	21	21	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandia left fork at Asph Plant	E122	-	-	-	9	9	9	-	-	-	1	18	3	1	18	8	1	18	4	1	18	3
South Fork of Sandia at E122[f]	E122	-	-	-	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandia below Wetlands	E123	-	-	-	14	14	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandia below Wetlands[f]	E123	-	-	-	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Twomile above Pajarito	E244	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pajarito above Threemile	E245.5	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canon de Valle below MDA P[f]	E256	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1

[a] Exceedances are the number of results that were detected above the screening level.
[b] Analyses are the number of samples analyzed for that constituent.
[c] Detects are the number of samples in which that constituent was detected.
[d] Location CO111041 is the sampler that captures storm water runoff into the upper Los Alamos detention ponds.
[e] A dash (-) indicates either analysis was not performed for the chemical or there were no exceedances of screening levels.
[f] Gray highlighting indicates base flow sampling locations, while no gray highlighting indicates storm water sampling locations.

Table 6-5
2016 Sediment Locations for Radionuclides and Chemicals Where at Least One Sample Result Exceeded Screening Levels

Location ID	Canyon	Reach Name	Manganese			Chromium			PCB-126			Cesium-137		
			Exceedances[a]	Analyses[b]	Detects[c]	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects
CV-61520	Cañon de Valle	CDV-4	1	1	1	-[d]	-	-	-	-	-	-	-	-
LA-61525	Los Alamos	LA-3FE	1	1	1	-	-	-	-	-	-	-	-	-
LA-61526	Los Alamos	LA-3FE	1	1	1	-	-	-	-	-	-	-	-	-
LA-61529	Los Alamos	LA Det Ponds	1	1	1	-	-	-	-	-	-	-	-	-
LA-61528	Los Alamos	LA Det Ponds	-	-	-	-	-	-	1	1	1	-	-	-
SA-61605	Sandia	S-2	1	1	1	1	1	1	-	-	-	-	-	-
MO-61250	Mortandad	M-2W	-	-	-	-	-	-	-	-	-	1	1	1
MO-61252	Mortandad	M-4W	-	-	-	-	-	-	-	-	-	1	1	1

[a] Exceedances are the number of results that were detected above the screening level.
[b] Analyses are the number of samples analyzed for that constituent.
[c] Detects are the number of samples in which that constituent was detected.
[d] A dash (-) indicates either analysis was not performed for the chemical or there were no exceedances of screening levels.

Discussion of Sampling Results

The screening levels provide a high level of confidence in determining a low probability of adverse risk to human health. They are not designed or intended to provide definitive estimates of actual risk and are not based on site-specific information (EPA 2001). For example, on-site data are compared with residential screening levels, though there are no residences nearby. We evaluate human health effects from exposure to storm water in Chapter 8, Public Dose and Risk Assessment.

Sediment data presented in this report are used to determine if the following conceptual model is still accurate: the process of sediment transport by storm water runoff observed in Laboratory canyons generally results in the same or lower levels of LANL-released substances in new sediment deposits than previously existed in a given reach. The results from 2016 verify this conceptual model and support the idea that the risk assessments presented in the canyons investigation reports (LANL 2004, 2005, 2006, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b, 2011c) represent an upper bound of potential human health risks in the canyons for the foreseeable future.

For sediment samples collected in 2016, there were minimal exceedances of screening levels. The residential screening action level for cesium-137 was exceeded in two sediment samples collected in Mortandad Canyon. Residential soil screening levels were exceeded for PCB-126 in one sediment sample collected in the upper sediment detention ponds in Los Alamos Canyon and for chromium in one sediment sample collected below the wetland in Sandia Canyon. Construction soil screening levels for manganese were exceeded in five sediment samples: three in Los Alamos Canyon, one in Sandia Canyon, and one in Cañon de Valle.

For radionuclides in storm water and base flow samples collected in 2016, no aquatic or terrestrial biota concentration guides for water were exceeded. For chemicals in storm water and base flow, Table 6-6 presents a summary of locations where New Mexico water quality standards or background values were exceeded in at least one location for each chemical.

Constituents Related to Background Sources

Several constituents observed in storm water, base flow, and sediment are associated with both naturally occurring sources in soils and rock and human-derived sources upstream of the Laboratory on the Pajarito Plateau. Chemicals that are mainly or completely naturally occurring are discussed below, but results are not presented in figures. Chemicals from human sources that exceeded screening levels in 2016 more than once at a particular location for storm water and base flow samples are shown in Figures 6-7 through 6-10 for the watersheds in which the exceedances occurred. There were no chemicals from human sources that exceeded screening levels more than once at a particular location in sediment samples.

Table 6-6
Number of Locations
Where New Mexico Water Quality Standards or Background Values were Exceeded for Storm Water and Base Flow Results in 2016 for Constituents with at Least One Exceedance

Analyte	Irrigation	Livestock Watering	Wildlife Habitat	Acute Aquatic Life	Chronic Aquatic Life	Human Health-Organism Only	Undeveloped Area Background	Developed Area Background
Aluminum	1	-*	-	41	61	-	1	57
Cadmium	0	0	-	2	2	-	-	2
Copper	0	0	-	50	66	-	43	2
Lead	0	0	-	0	48	-	-	1
Selenium	-	-	3	0	0	-	-	-
Zinc	0	0	-	10	16	0	5	0
Gross alpha	-	25	-	-	-	-	0	21
Total PCB	-	-	62	4	62	85	66	11
Total dioxin toxic equivalent	-	-	-	-	-	3	-	-
Benzo(a)anthracene	-	-	-	-	-	1	-	-
Benzo(a)pyrene	-	-	-	-	-	1	-	-
Benzo(b)fluoranthene	-	-	-	-	-	1	-	-
Benzo(k)fluoranthene	-	-	-	-	-	2	-	-

*A dash indicates there is no standard for this chemical or radionuclide in this category.

In Figures 6-7 through 6-10, the y-axis is reversed to represent the Rio Grande to the east of the Laboratory. Values are plotted from upstream sampling locations on the left of each figure to downstream locations on the right, with the Rio Grande at zero. Plotted results are from the canyons investigation reports, the annual environmental surveillance program, or the Individual Permit. All results are plotted relative to their along-channel distance from the Rio Grande. Canyon confluences, stream reaches of interest, and particular Laboratory areas are labeled for spatial reference. Pre-2016 results are identified using a unique color for each subwatershed. Results obtained in 2016 are in green. In the surface water figures, results associated with the Individual Permit are identified with a circle, and gaging station results are identified with a triangle.

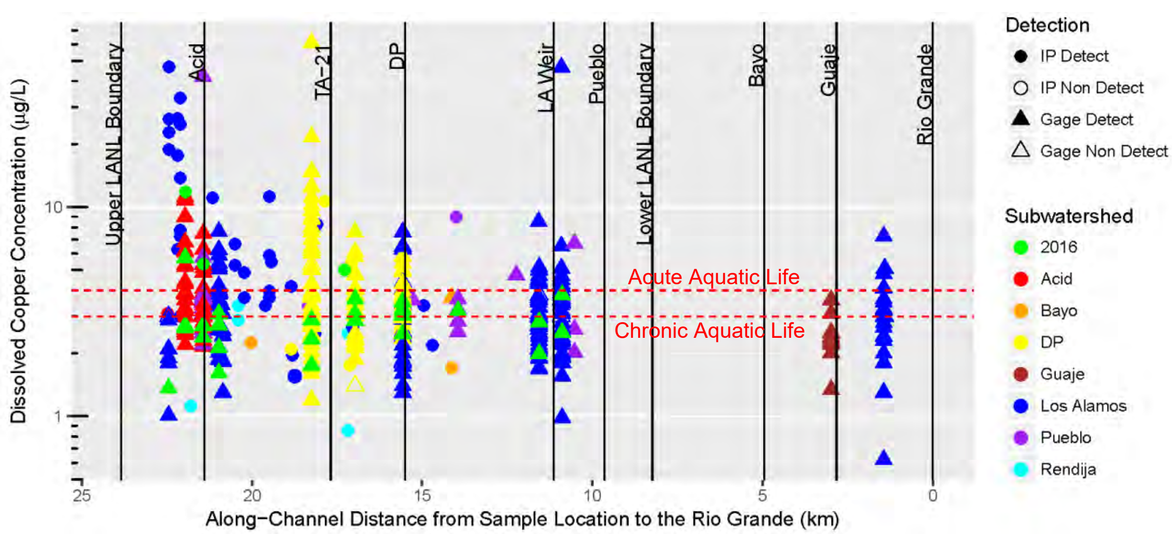
Aluminum. Filtered storm water samples collected on the Pajarito Plateau in 2016 commonly contained aluminum concentrations above New Mexico water quality standards. However, most or all of this aluminum is likely naturally occurring (Reneau et al. 2010). Aluminum is a natural component of soil and Bandelier Tuff and is not known to be derived from Laboratory operations in any significant quantity. As shown in Table 6-6, while there is a large number of exceedances of the aquatic life water quality standards, there is only one exceedance of the undeveloped area background value, indicating that the major source of aluminum is likely the Bandelier Tuff formation. Twenty-six of the 39 assessment units, or stream reaches, on Laboratory or former

Laboratory lands are listed as impaired for aluminum (Table 6-2). However, the New Mexico Environment Department Surface Water Quality Bureau has stated that "the large number of exceedances" for aluminum in surface water on the Pajarito Plateau "may reflect natural sources associated with the geology of the region," and that aluminum also exceeds 658 micrograms per liter (µg/L) (the acute aquatic life standard for a hardness of 30 mg $CaCO_3$/L) in other parts of the Jemez Mountains area (NMED 2009).

Copper. Copper is associated with firing sites, forest fires, developed areas such as buildings and parking lots, and is naturally occurring. Copper sources in developed landscapes include brake pad abrasion and building materials such as flashing, plumbing pipes, and electrical components (TDC Environmental 2004, Göbel et al. 2007). In 2016, copper concentrations in filtered storm water were detected above the acute aquatic life standard in 50 samples, above the chronic aquatic life standard in 66 samples, but above the developed area background value in only 2 samples, indicating that the major sources of copper are likely those associated with developed areas.

Historically, every watershed across the Laboratory has recorded elevated copper concentrations in storm water at some time, including all of the Laboratory's upstream boundary gaging stations. Seven of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for copper (Table 6-2). Since the 2006 implementation of the Individual Permit, every watershed has had a target action level exceedance for copper in Individual Permit–related runoff samples. Figures 6-7a and 6-7b show copper concentrations in filtered storm water and base flow for Los Alamos and Sandia Canyons.

In 2016, copper concentrations in sediment were not detected above the residential soil screening level, and there were only three sample results above the sediment background value for copper.



Note: TA = Technical area; LA = Los Alamos; km = kilometers.

Figure 6-7a Los Alamos Canyon watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

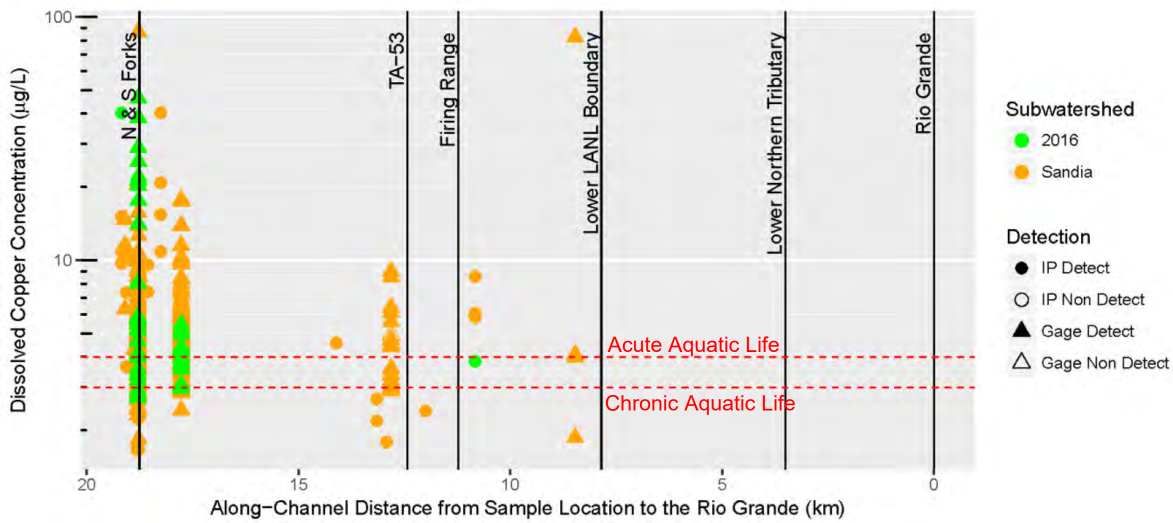


Figure 6-7b Sandia Canyon watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

Lead. Lead is associated with developed areas such as buildings and parking lots (Göbel et al. 2007). The major lead sources in developed landscapes are lead-based paints, building sidings, and the operation of automobiles (Davis and Burns 1999). Lead concentrations in filtered storm water in 2016 were detected above the chronic aquatic life standard in 48 samples but above the developed area background value in only 1 sample, indicating that the major source of lead is likely developed areas. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for lead (Table 6-2). There were three exceedances of target action limits for filtered lead concentrations in Individual Permit-related runoff samples in 2016. Figures 6-8a through 6-8c show lead concentrations in filtered storm water and base flow for Los Alamos, Pajarito, and Sandia Canyons.

In 2016, lead concentrations in sediment were not detected above the residential soil screening level, and there were only seven sample results above the sediment background value for lead.

Manganese. Manganese is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released significant quantities of manganese. Dissolved manganese concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005). Filtered manganese concentrations were not detected above the acute or chronic aquatic life standards in storm water samples collected in 2016. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for manganese (Table 6-2).

In 2016, manganese concentrations in sediment were detected above the construction soil screening level in five samples and above the background value in only three samples.

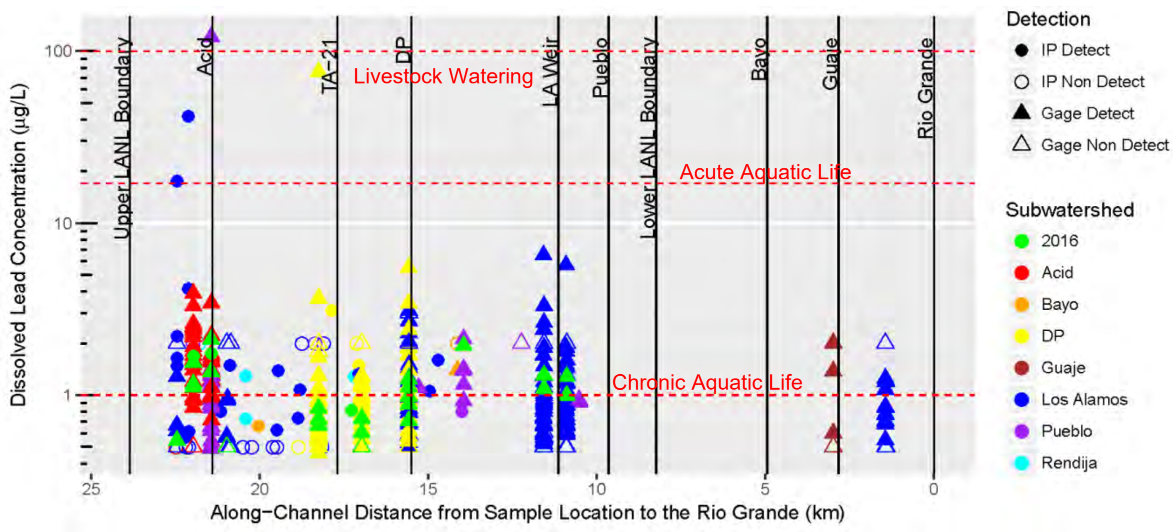


Figure 6-8a Los Alamos Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

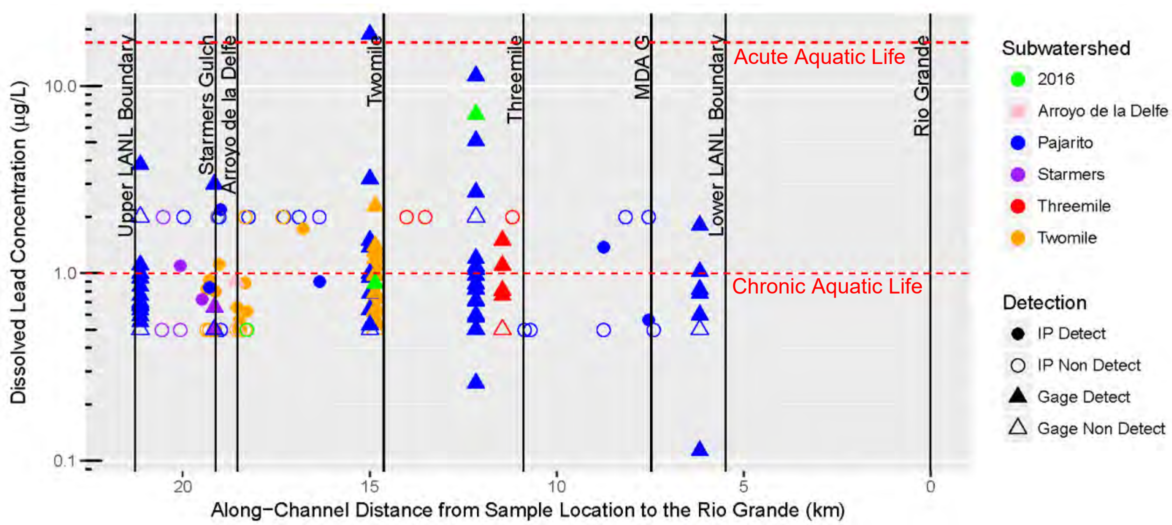


Figure 6-8b Pajarito Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

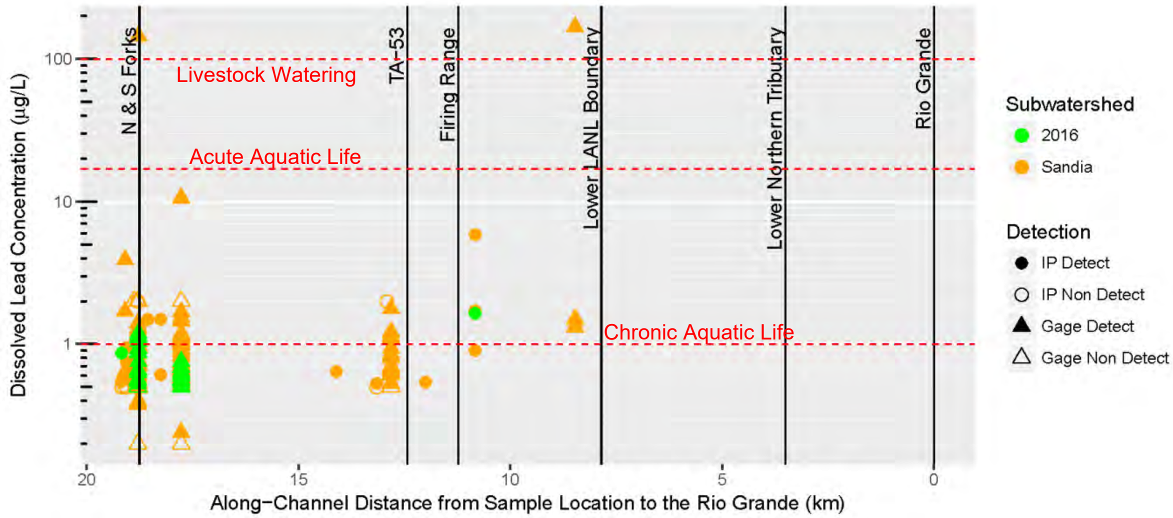


Figure 6-8c **Sandia Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016**

Selenium. Selenium is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released 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). Total selenium concentrations were detected above the wildlife habitat standard in three storm water samples collected in 2016. Total selenium concentrations exceeded the Individual Permit target action level in one of the five samples collected in 2016. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for selenium (Table 6-2), and it is located in upper Pajarito Canyon directly upstream of the Laboratory boundary to the watershed headwaters.

In 2016, selenium concentrations in sediment were not detected above the residential soil screening level.

Zinc. While naturally occurring, zinc can also be associated with developed areas. Zinc sources include automobile tires, galvanized materials, motor oil, and hydraulic fluid (Rose et al. 2001, Washington State Department of Ecology 2006, Councell et al. 2004). In 2016, filtered zinc concentrations in storm water samples were detected above the acute aquatic life standard in 10 samples and above the chronic aquatic life standard in 16 samples but not detected above the developed area background value, indicating that the major source of zinc is most likely developed areas. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for zinc (Table 6-2) and is located in the south fork of Acid Canyon. Since implementation of the Individual Permit, every watershed has had target action level exceedances of zinc concentrations at some point in time, and in 2016, there were five Individual Permit exceedances for zinc. Figure 6-9 shows zinc concentrations in filtered storm water and base flow for Sandia Canyon.

In 2016, zinc concentrations in sediment were not detected above the residential soil screening level.

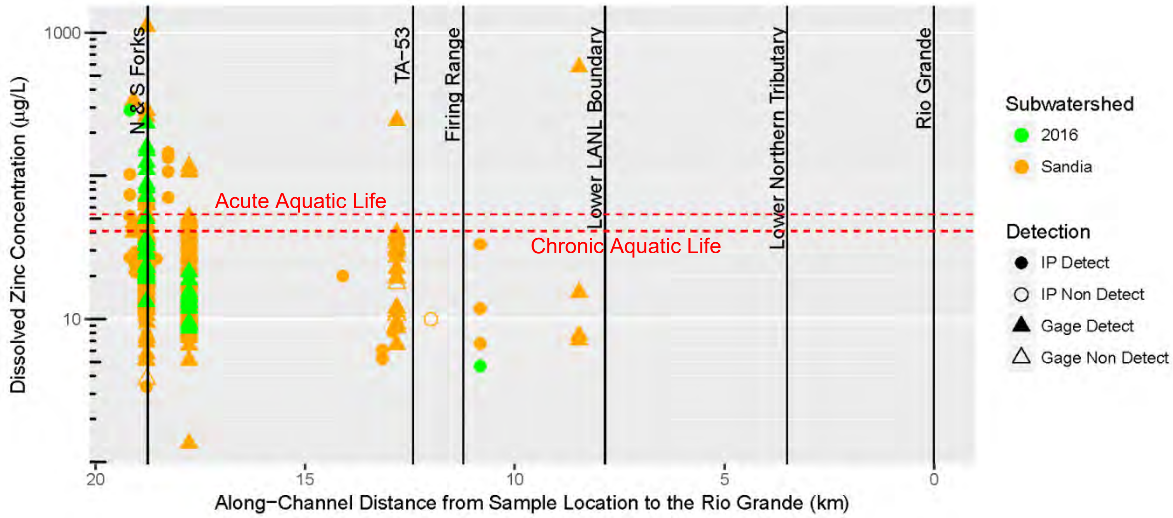


Figure 6-9 **Sandia Canyon watershed zinc concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016**

Gross Alpha. Gross alpha is the sum of the radioactivity from alpha particle emissions from radioactive materials. Alpha particles are released by many naturally occurring radionuclides, such as isotopes of radium, thorium, and uranium and their decay products. In 2016, 25 unfiltered storm water samples had gross-alpha activities above the livestock watering standard, but there were no exceedances of the undeveloped area background value, indicating that the Bandelier Tuff formation is most likely the major source of the gross-alpha exceedances. In 2011, 2012, and 2013, we measured the highest activities of gross alpha in storm water in samples containing ash and sediment from the 2011 Las Conchas fire. Also, the gross-alpha activities were particularly high in runoff samples from the large September 2013 flood event. For sampling under the Individual Permit in 2016, gross-alpha activity was above the target action level in three samples. Twenty-six of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for gross alpha (Table 6-2). However, the analytical results from 2016 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).

Sediment is not analyzed for gross alpha because sediment sampling is targeted to specific radionuclides of concern at a particular location.

Constituents Related to Los Alamos National Laboratory Operations

Several constituents were measured in storm water and sediment that relate to historical Laboratory operations. The nature and extent of the constituents in sediment are described in detail in the canyons investigation reports referenced in the chapter introduction. The following discussion describes the occurrences of key constituents in 2016 storm water and sediment samples. Chemical results that exceeded screening levels or standards in 2016 more than once at a particular sample location for storm water and base flow are shown in the figures associated with each chemical below.

Cadmium. Filtered storm water results from the two gaging stations in upper Sandia Canyon exceeded the acute and chronic aquatic life standards for cadmium in 1 of 19 samples at Sandia right fork at Power Plant, and in 1 of 9 samples at Sandia left fork at Asphalt Plant. Cadmium is associated with combustion of fossil fuel; industrial use such as refinement for nickel-cadmium batteries, metal plating, pigments, and plastics; and activities such as sewage sludge disposal and application of phosphate fertilizers (ATSDR 2012). Both of these locations are downstream of Technical Area 03. These location results exceeded the developed area background value. In addition, in 2016 there was one exceedance of the target action level for cadmium in upper Sandia Canyon in a filtered storm water sample associated with the Individual Permit. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for cadmium (Table 6-2).

In 2016, one sediment sample collected below the Sandia wetlands exceeded the cadmium sediment background value, though it did not exceed any soil screening levels.

Cesium-137. Cesium-137 is a radionuclide that is a byproduct of nuclear fission processes in nuclear reactors and nuclear weapons testing. In 2016, cesium-137 was not detected in any gaging station storm water samples or base flow samples. Individual Permit-related storm water samples are not analyzed for radionuclides.

Cesium-137 activity in sediment samples collected in Mortandad Canyon in 2016 exceeded the residential screening action level in two of four samples and exceeded the background value in three of four samples; therefore, the source is most likely related to historical Laboratory activities associated with Technical Area 50 and Effluent Canyon within the Mortandad Canyon watershed.

Chromium. Chromium is associated with potassium dichromate that was used as a corrosion inhibitor in the cooling system at the Technical Area 03 power plant (LANL 1973) and was discharged through Outfall 001 from 1956 to 1972. Filtered storm water and base flow results did not exceed surface water quality standards in 2016 for chromium or chromium(III). None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for chromium (Table 6-2).

In 2016, sediment results in Sandia Canyon in the reach below the wetlands exceeded the residential and construction soil screening levels for chromium in one of two samples, and both samples exceeded the sediment background value for chromium.

Dioxins/Furans. Dioxins/furans are associated with the incineration of medical, industrial, municipal, and private wastes; municipal wastewater treatment sludge; coal-fired boilers; and diesel fuel emissions (EPA 2006b). Forest fires are also a major, natural source of dioxins (Gullett and Touati 2003). Toxic equivalents are used to report the toxicity-weighted masses of mixtures of dioxins/furans and are more meaningful than reporting the number of grams of dioxins/furans because toxic equivalents provide information on toxicity (EPA 2010). In addition, there are surface water quality standards for a total dioxin toxic equivalent, whereas there are no standards for individual dioxins/furans. In 2016, storm water gaging station results exceeded the human health–organism only aquatic life standard in Los Alamos Canyon in two of two samples above the low-head weir and in one of one sample below the low-head weir. There were no exceedances of the target action level for 2,3,7,8-tetrachlorodibenzodioxin (one of the more toxic compounds) in Individual Permit–related storm water samples. In base flow samples analyzed for dioxins/furans, results were below surface water quality standards along the Rio Grande at the Otowi Bridge and Pajarito, Ancho, and Frijoles Canyons. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for dioxins/furans (Table 6-2).

In 2016, sediment was analyzed for dioxins/furans in 26 samples, 17 of which had detects of one of the 17 types of dioxins/furans. Detects were found throughout Los Alamos and Pajarito Canyons, including in background locations upstream of Laboratory lands. The more toxic dioxin compounds—2,3,7,8-tetrachlorodibenzodioxin and 1,2,3,7,8-pentachlorodibenzodioxin—were detected in sediment samples in the lower Los Alamos Canyon detention basins associated with the low-head weir and in mid-Pajarito Canyon; however, all concentrations were near detection limits and thus very low.

Mercury. Natural sources of mercury include forest fires and fossil fuels such as coal and petroleum, and human activities such as mining and fossil fuel combustion have led to widespread global mercury pollution. While the Four Corners Generating Station coal-fired power plant has contributed to mercury contamination in the surrounding areas, historically, the Laboratory also operated coal-fired power plants. In 2016, none of the filtered or unfiltered gaging station storm water or base flow results exceeded the surface water quality standards for mercury. One of the Individual Permit–related samples exceeded the target action level for mercury in 2016. Only one of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for mercury and is located in upper Los Alamos Canyon above the DP Canyon confluence.

No sediment results exceeded screening levels, and only one location below the Sandia wetlands had a result slightly above the background value in 2016.

Polychlorinated biphenyls (*PCBs*). PCBs are stable, persistent organic compounds that break down slowly in the environment. They were commonly used as plastic and paint stabilizers and coolants in electrical appliances before they were banned in the United States in 1979. Many older construction materials, including caulking, paints, window putty, and electrical components, used PCBs (Durell and Lizotte 1998, Kakareka and Kukharchyk 2006). As these building components weather, PCBs accumulate on the landscape and are redistributed. PCBs are remobilized and distributed throughout the globe, including through atmospheric deposition (Chevreuil et al. 1996, Duinker and Bouchertail 1989, Grainer et al. 1990, LANL 2012).

PCBs are associated with materials used historically by the Laboratory, including transformers, oils/solvents/paints used in industrial activities, and the former asphalt batch plant in Sandia Canyon.

PCBs were detected in every gaging station storm water and base flow sample collected in 2016. Of 87 samples, 85 had concentrations above the human health–organism only standard, 62 had concentrations above the chronic aquatic life standard and wildlife standard (which are numerically equal), and four had concentrations above the acute aquatic life standard. There were 66 exceedances of the undeveloped area background value for total PCBs but only 11 exceedances of the developed area background value, indicating that the major source of PCBs is likely developed areas with minor sources of PCBs associated with Laboratory-related releases. In 2016, all five Individual Permit storm water samples exceeded the target action level for total PCBs. Twenty-six of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for PCBs (Table 6-2). Figures 6-10a through 6-10c show total PCB concentrations in unfiltered storm water and base flow for Los Alamos, Pajarito, and Sandia Canyons.

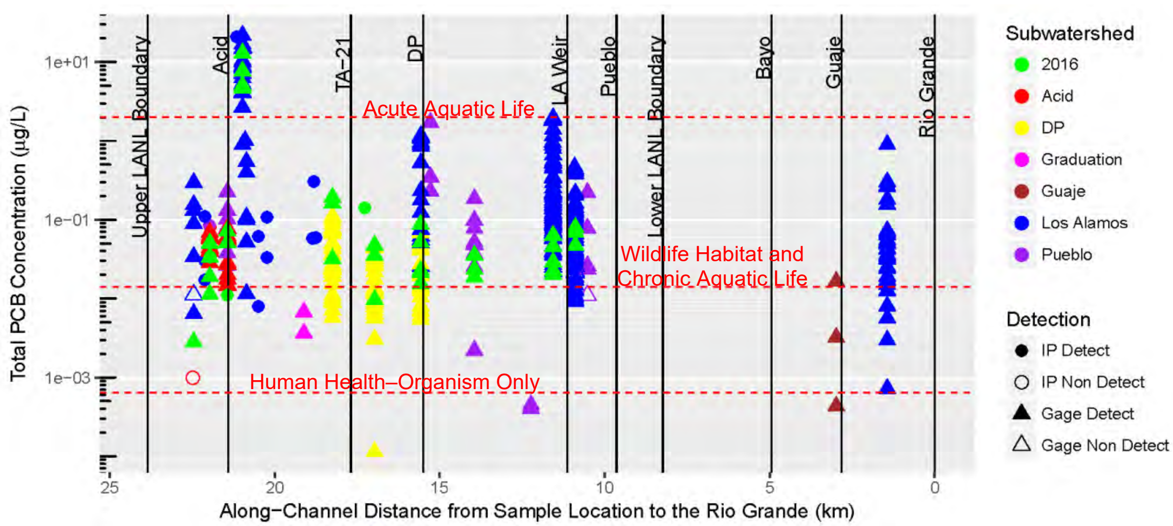


Figure 6-10a Los Alamos Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

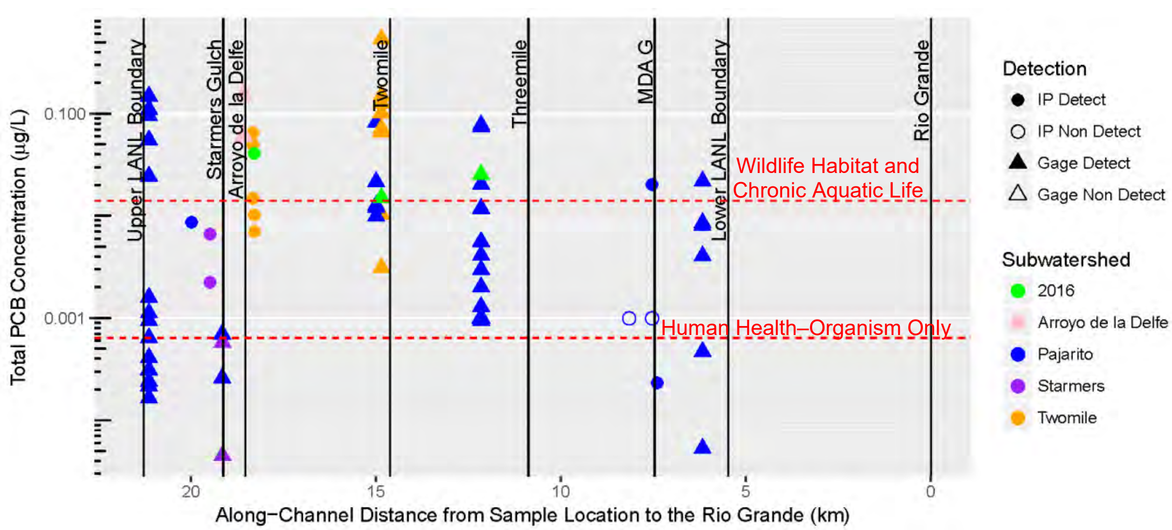


Figure 6-10b Pajarito Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

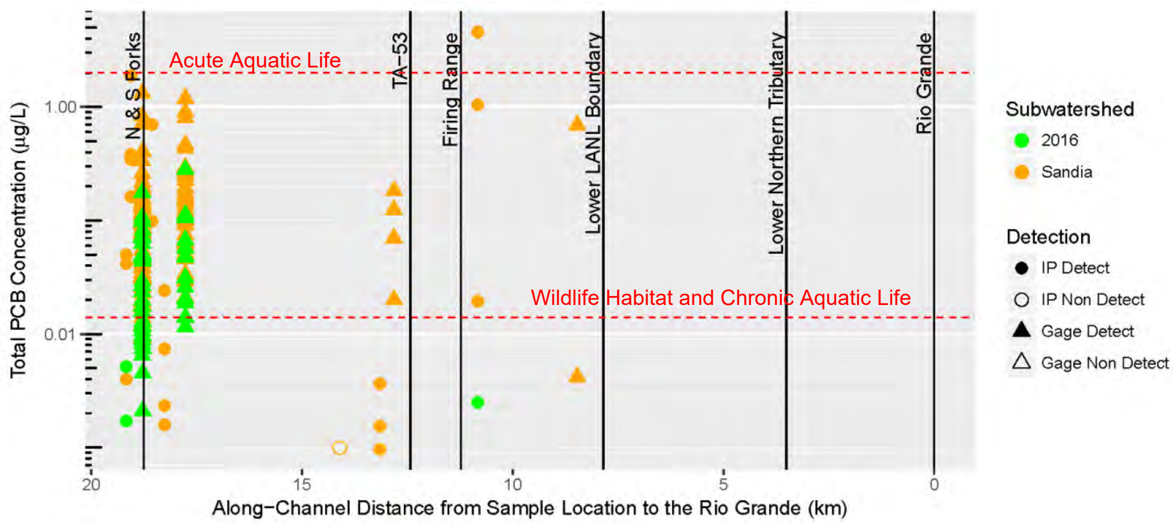


Figure 6-10c Sandia Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2016

In sediment, PCBs were detected in 71 of 87 samples; the only samples with no detection of PCBs were along the Rio Grande (at all the Rio Grande locations except above Otowi Bridge), at background locations in Pajarito Canyon and Cañon de Valle, in Potrillo Canyon near NM 4, in Cañada del Buey near the White Rock Visitor's Center, and along the main branch of Ancho Canyon. The residential soil screening level for PCB-126 (a specific congener of PCBs) was exceeded in one sediment sample in the upper Los Alamos Canyon detention ponds. The hillslope above the detention ponds is associated with historical Laboratory-related PCB contamination, and all of the water captured in the basins in 2016 infiltrated into the ground and did not contribute to downstream runoff.

Polycyclic Aromatic Hydrocarbons. In 2016, storm water results at the gaging station in Sandia Canyon near the former asphalt batch plant exceeded the human health–organism only aquatic life standard for the following polycyclic aromatic hydrocarbons in 1 of 18 samples: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene. Asphalt is prepared using petroleum products that contain polycyclic aromatic hydrocarbons, and operations at the former asphalt batch plant released effluent from operations to the stream. Base flow results in Cañon de Valle below Material Disposal Area P exceeded the human health–organism only aquatic life standard for benzo(k)fluoranthene in one of three samples in 2016. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for polycyclic aromatic hydrocarbons (Table 6-2).

For the 12 of 18 polycyclic aromatic hydrocarbon compounds that have screening levels, none of the sediment results from 2016 exceeded these screening levels.

Thallium. Gaseous emissions from cement factories and coal-fired power plants have led to thallium pollution. While the Four Corners Generating Station coal-fired power plant has contributed to thallium contamination in the surrounding areas, historically, the Laboratory also operated coal-fired power plants. In 2016, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for thallium. One of the Individual Permit-related samples exceeded the target action level for thallium in 2016 and was located in upper Sandia Canyon. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for thallium (Table 6-2) and is located in upper Sandia Canyon from Sigma Canyon to Outfall 001.

No sediment samples exceeded screening levels or background values for thallium in 2016.

CONCLUSIONS

Through the human health risk assessments in the canyons investigation reports and the biota dose assessment (Chapter 7) and human health risk assessment (Chapter 8) in this report, we have concluded that levels of chemicals and radionuclides present in storm water, base flow, and sediments are below levels that would impact human or biota health. The results of the storm water, base flow, and sediment data comparisons from samples collected in 2016 verify the conceptual model that storm-water-related sediment transport observed in Laboratory canyons generally results in lower concentrations of Laboratory-released chemicals in the new sediment deposits than previously existed in deposits in a given reach. The results also support the idea that the risk assessments presented in the investigation reports represent an upper bound of potential human and ecological health risks in the canyons for the foreseeable future. Although some chemicals had concentrations in storm water, base flow, and sediment that were above screening levels in 2016, these transient events do not significantly affect human or biota health.

One notable aspect of the sampling in 2016 is that there was only one location where a sediment sample had a chemical result that exceeded soil screening levels downstream of a surface water sampling location where the same chemical had a result that exceeded surface water quality standards—PCBs in the upper Los Alamos Canyon detention ponds.

Storm water and base flow results from 2016 and 2017 will be used by the New Mexico Environment Department to reassess the impairment status of each assessment unit, or stream reach, on Laboratory and former Laboratory lands. This reassessment will then be used to inform updates to the Laboratory's National Pollutant Discharge Elimination System permits that regulate industrial activities, specifically the effluent outfalls.

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7.0 ECOSYSTEM HEALTH

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In this chapter, we report levels of radionuclides and chemicals (e.g., metals, other inorganic elements, polychlorinated biphenyls, dioxins, furans, and high explosives) in soil, sediment, plants, and animals at Los Alamos National Laboratory (the Laboratory). We also report on the abundance and diversity of birds and small mammals. We calculate biota radiation doses for plants and animals occupying areas around specific Laboratory facilities and sediment-retention structures in canyon bottoms. The calculated doses are compared with background levels of radiation, screening levels, and federal standards for radiation doses to plants and animals.

This year, soil and vegetation samples were collected around the perimeter of Material Disposal Area G at Technical Area 54 and at the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15. Small mammals were collected upstream of sediment control structures within Los Alamos, Pajarito, and Sandia Canyons. Also, road-killed deer, elk, mountain lion, fox, bobcat, and great horned owls collected from various parts of the Laboratory were analyzed. We conducted a special study on sediment and small mammals in the Sandia Canyon wetland.

Most radionuclide activities and chemical concentrations in soil, sediment, plants, and animals from on-site and perimeter locations were either not detected, similar to background, or below screening levels protective of biota. Mean levels of zinc in sediment from the Sandia Canyon wetland were above the no-effect screening level for field mice. Nevertheless, the concentrations of zinc were still below the low-effect screening level for field mice. There were no effects on bird populations and diversity around open firing sites at Technical Areas 36 and 39 and one open-burn site at Technical Area 16 compared with control areas. Two species listed as federally threatened or endangered, the Mexican spotted owl and the Jemez Mountains salamander, were found on Laboratory lands during annual surveys.

Biota dose assessments show that the radiation doses are far below the levels where adverse effects to plants and animals would be expected.

INTRODUCTION

An ecosystem is a community of living organisms (plants, animals, and microorganisms) along with the nonliving components of their environment (such as soil, air, and water) (Smith and Smith 2012). The condition of an ecosystem is affected by environmental disturbances, including wildfire, flooding, drought, invasive species, climate change, chemical spills, construction and vegetation removal, and a host of other factors (Rapport 1998).

Los Alamos National Laboratory (LANL or the Laboratory) is home to many types of plants and animals (collectively called "biota"). The primary objective of the Laboratory's Ecosystem Health Program is to determine if past or current releases of radionuclides and chemicals from Laboratory operations are affecting local plants or animals.

We conduct both institutional (site-wide, perimeter, and regional) monitoring and facility-specific monitoring. Institutional monitoring is used to determine the levels of Laboratory-released radionuclides and chemicals in areas outside of designated solid waste management units and to compare predictions of chemical and radionuclide transport models with actual results. Facility-specific monitoring is used to measure the nature and extent of Laboratory-released radionuclides and chemicals associated with specific facilities, operations, and structures at the Laboratory.

Both institutional and facility-specific results are used to assess effects of Laboratory-released chemicals and radionuclides on ecosystem health. This is accomplished by the following:

- Measuring levels of radionuclides and other chemicals in soil, plants, and animals from areas in the Laboratory (on-site samples) and close to the Laboratory boundary (perimeter samples) and comparing these levels with
    - levels at background sites not affected by Laboratory operations,
    - levels that scientists have determined should trigger further investigation (screening levels), and
    - levels that may cause harm (standards and adverse effect levels).
- Evaluating trends in radionuclide and chemical levels in soil, plants, and animals over time
- Assessing population levels and species diversity of animals in areas potentially affected by Laboratory operations
- Estimating radiation dose and chemical risk to biota based on the collected information

The Laboratory also monitors migratory bird species to meet regulatory commitments.

TERRESTRIAL HEALTH ASSESSMENT

Soil and Biota Comparison Levels Related to Ecosystem Health

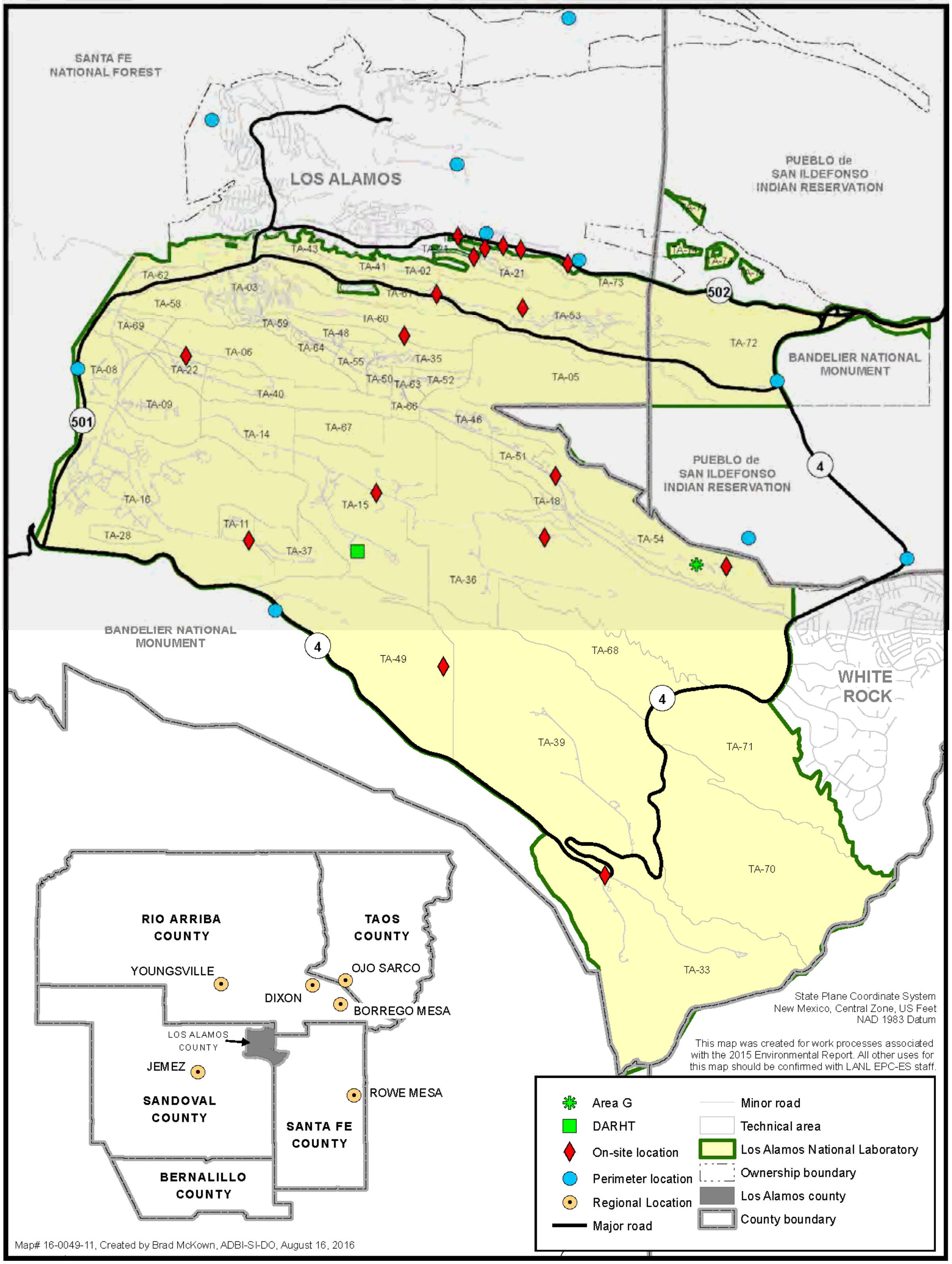
The soil-monitoring program directly measures the long-term trends in levels of radionuclides and chemicals around nuclear facilities (DOE 2015). Soil receives substances that are released in air emissions, particles that are transported by wind, and, in agricultural fields, substances carried in irrigation water. Therefore, soil data can provide information about several modes of chemical and radionuclide transport.

We compare levels of radionuclides and chemicals in soil, plant, and animal samples collected at and near the Laboratory with levels in samples collected from the following regional background locations: near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast of the Laboratory; Rowe Mesa (near Pecos) to the southeast of the Laboratory; Youngsville to the northwest of the Laboratory; and Jemez Springs to the southwest of the Laboratory (Figure 7-1). As required by the U.S. Department of Energy (DOE), all locations are at a similar elevation to the Laboratory, are more than 20 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (DOE 1991).

Radionuclides and chemicals in soil collected from these regional background locations come from naturally occurring elements in the soil, worldwide fallout of radioactive particles from testing of atomic weapons and nuclear facility accidents, and chemical releases from non-Laboratory sources such as power plants and automobile emissions.

Individual results from samples at the Laboratory (on-site) and near the Laboratory (perimeter) are compared with regional statistical reference levels. Regional statistical reference levels are the levels below which 99% of all background samples occur and are statistically calculated. Multiple (replicated) values from on-site and perimeter areas are compared with average levels in background locations using a Mann-Whitney nonparametric statistical test at the 0.05 significance level ($p < 0.05$). Trends over time are tested with a Mann-Kendal nonparametric test at the 0.05 significance level.

For soil samples, if individual or average results in soil exceed background levels, the level is then compared with ecological screening levels. Ecological screening levels are the highest level of a radionuclide or chemical in the soil that is known not to affect selected animals or plants (the no-effect ecological screening level) and the lowest level known to have caused an adverse effect on selected animals or plants (the low-effect ecological screening level) (LANL 2015a). We have soil ecological screening levels for the following receptors: deer mouse (mammalian omnivore), the desert cottontail (mammalian herbivore), the earthworm (soil-dwelling invertebrate), the montane shrew (mammalian terrestrial insectivore), the red fox (mammalian carnivore), American kestrel (avian carnivore), American robin (avian omnivore, herbivore, and insectivore), and a generic plant (terrestrial autotroph-producer).



Note: DARHT = Dual-Axis Radiographic Hydrodynamic Test (facility).

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

Any soil sample result exceeding background is first compared with the no-effect ecological screening level of the most sensitive receptor in the database (usually the earthworm or plant). If the constituent in the soil exceeds the no-effect ecological screening level, then the concentrations are compared with the low-effect ecological screening level for that receptor.

For animal or plant tissue results, the levels of radionuclides and chemicals in the sample are compared with biota dose screening levels for radionuclides and with lowest observable adverse effect levels for chemicals. Radionuclide biota dose screening levels are set at 10% of the DOE limit for radiation doses to biota (McNaughton 2006). A lowest observable adverse effect level is the lowest concentration in tissue that has produced an adverse effect in an exposed population of animals or plants (EPA 2014).

If a radionuclide in soil or in biota is detected at an activity that is higher than the screening levels, then the dose to biota using all of the available data is calculated using RESRAD-BIOTA (version 1.8) (http://web.ead.anl.gov/resrad/home2/biota.cfm), which is DOE's methodology for evaluating radiation doses to aquatic and terrestrial biota. This calculated dose is compared with DOE limits: 1 rad/day for terrestrial plants/aquatic animals and 0.1 rad/day for terrestrial animals (DOE 2002).

Institutional Soil and Vegetation Monitoring

Surface soil and vegetation samples are collected from 17 on-site, 11 perimeter, and 6 regional background locations every third year (Figure 7-2). The last comprehensive soil and vegetation survey occurred in 2015 (Fresquez et al. 2016). The next large-scale soil and vegetation sampling will occur in 2018.

Figure 7-2 Soil collected with a ring sampler

Facility Soil and Vegetation Monitoring

Area G at Technical Area 54

Area G was established in 1957 and is the Laboratory's primary low-level radioactive solid waste burial and storage site (DOE 1979, Martinez 2006; Figure 7-3). Tritium, plutonium, americium, and uranium are the main radioactive waste materials at Area G. The Laboratory has conducted soil, vegetation, and small mammal monitoring at Area G since 1980 to determine whether radionuclides are migrating beyond the waste burial area (LANL 1981, Mayfield and Hansen 1983).

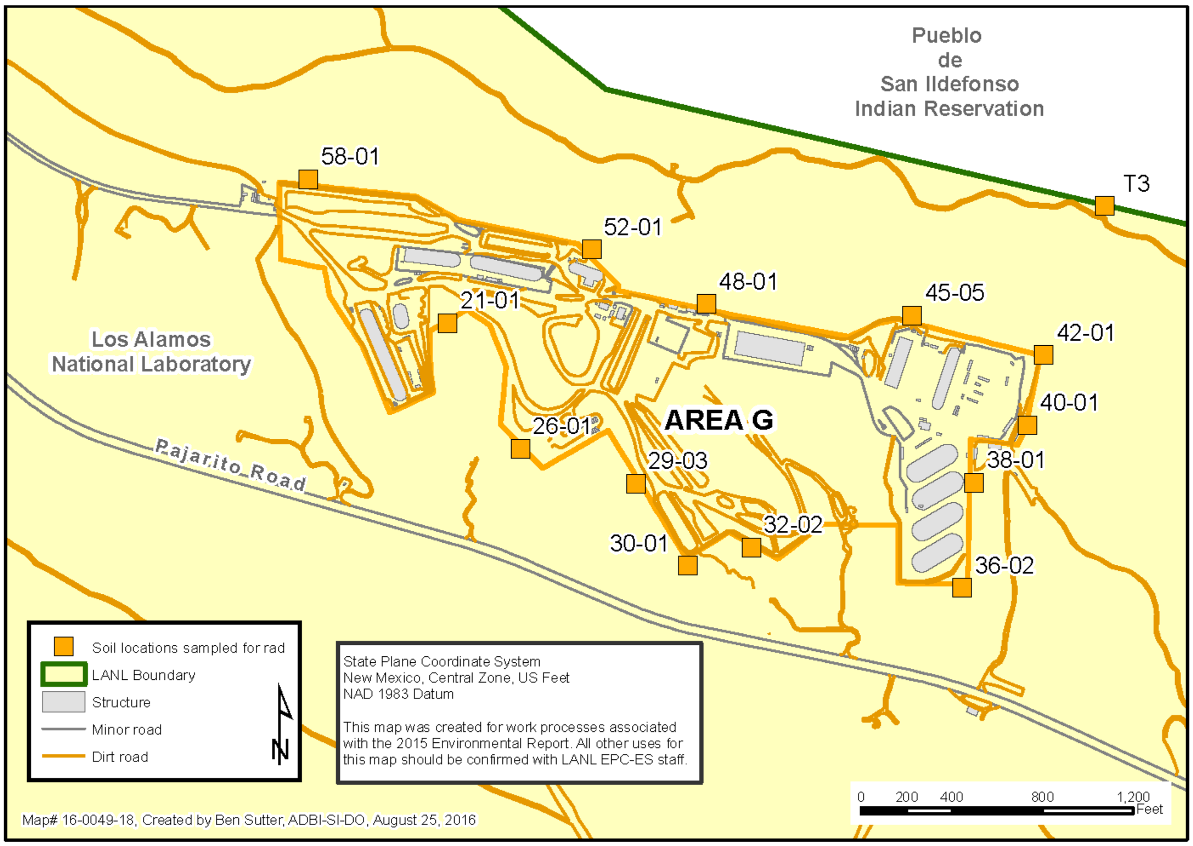


Figure 7-3 Locations of soil and vegetation samples collected around Area G in 2016

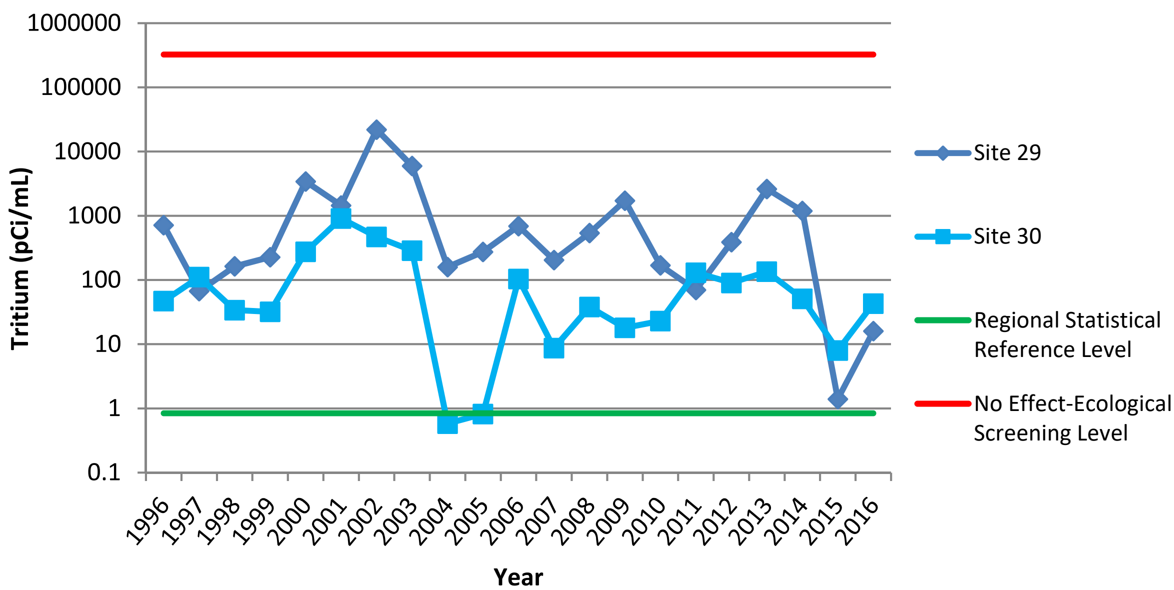
Surface soil grab samples (0- to 6-inch depth) and composite tree samples were collected in April and June 2016, respectively, at 13 designated locations around the perimeter of Area G, and one soil sample and one tree sample were collected at the bottom of Cañada del Buey near the boundary between the Laboratory and the Pueblo de San Ildefonso (site T3), approximately 800 feet northeast of Area G (Figure 7-3). All samples were analyzed for tritium, americium-241, plutonium-238, plutonium-239/240, cesium-137, strontium-90, uranium-234, uranium-235, and uranium-238.

Radionuclides in Soil and Vegetation at Area G

Tritium, americium-241, plutonium-238, and plutonium-239/240 were detected above regional statistical reference levels in many soil locations around the perimeter of Area G in 2016 (Supplemental Table S7-1) (Supplemental tables can be found online accompanying this document at http://www.lanl.gov/environment/environmental-report.php). These levels and locations of detections in soil (tritium on the southern side and americium-241, plutonium-238, and plutonium-239/240 on the north, northeastern, and eastern side of Area G) were consistent with data from previous years and are not statistically increasing over time (Figures 7-4 through 7-7). Most importantly, all radionuclide activities in soil samples from the perimeter of Area G were below all the no-effect ecological screening levels for plant, animal, and invertebrate receptors.

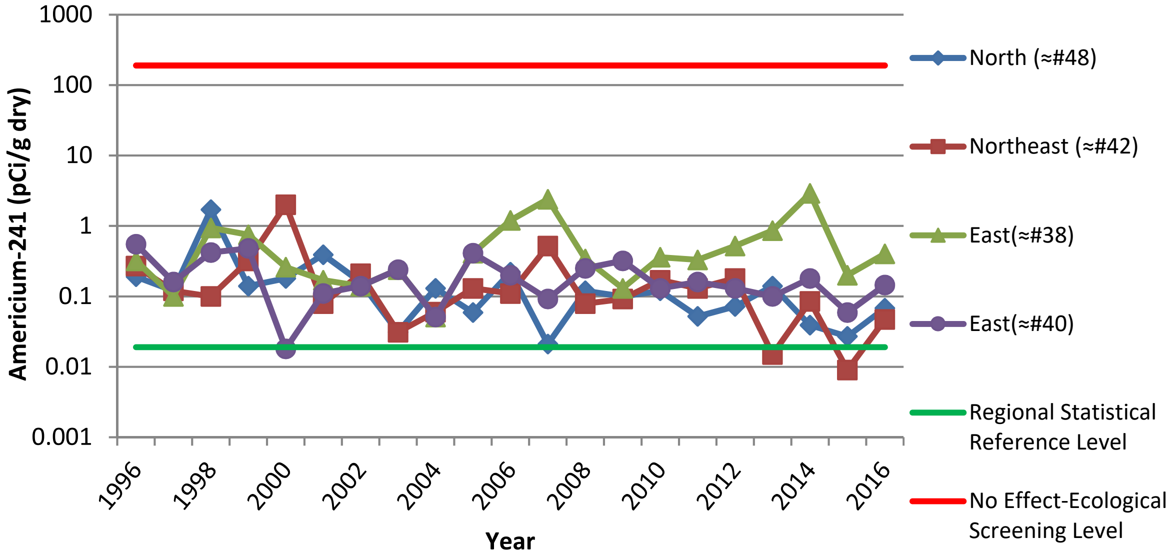
Results from native trees (branches and needles of mostly juniper trees) are an indicator of both deep root uptake (as in the case of tritium) and deposition of radionuclides on the surfaces of leaves and branches. Tree samples were collected at the same general locations as the soil samples (Figure 7-3). However, because of a firebreak between the fenceline and the trees (>10 meters from the fenceline), tree samples are collected at various distances away from the fence around Area G. Results for tritium in vegetation are reported on a picocuries per milliliter basis, and results for the other radionuclides are reported on a picocuries per gram ash weight basis.

In tree samples collected around the perimeter of Area G, most radionuclides at most locations, with the exception of tritium, were below regional statistical reference levels. All radionuclides, including tritium, that were above the regional statistical reference levels were well below the biota dose screening levels for overstory vegetation (Table S7-2).



Note: pCi/mL = Picocuries per milliliter.

Figure 7-4 Tritium activities in surface soil samples collected from the southern portions of Area G at Technical Area 54 (sites 29-03 and 30-01) from 1996 to 2016 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for the plant). Note the logarithmic scale on the vertical axis. Sample locations can be found in Figure 7-3.



Note: pCi/g = Picocuries per gram.

Figure 7-5 **Americium-241 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 1996 to 2016 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.**

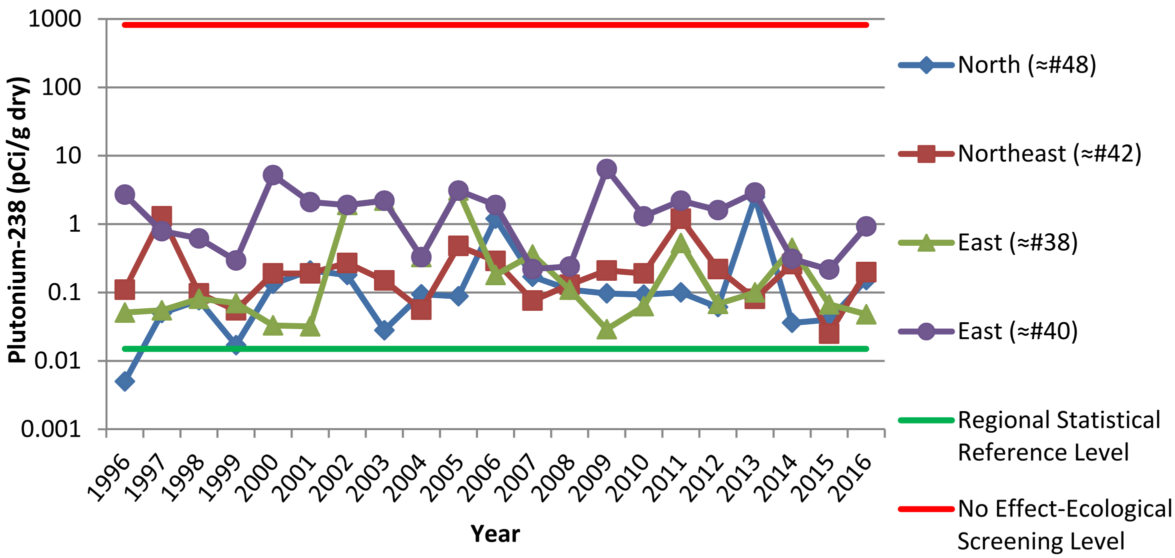


Figure 7-6 **Plutonium-238 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 1996 to 2016 compared with the regional statistical reference level and and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.**

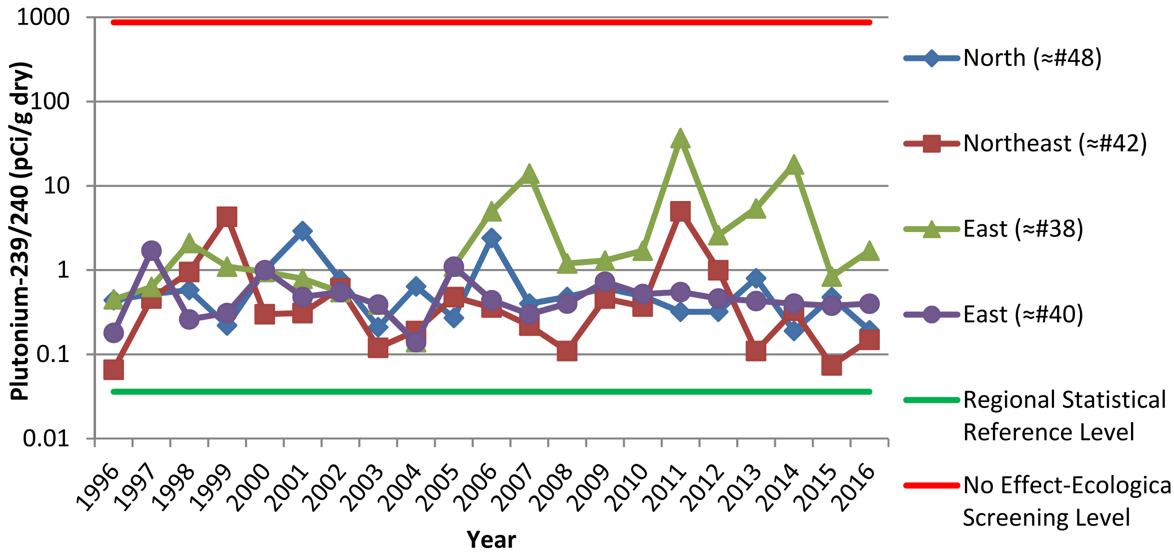


Figure 7-7 **Plutonium-239/240 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 1996 to 2016 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.**

Tritium was detected above background in almost all tree samples collected around the perimeter of Area G, with the highest amounts (up to 500 pCi/mL) occurring in trees growing in the southern perimeter near the tritium disposal shafts. These data are consistent with the soil data. Like the soil data, the overall trend in plant tritium is highly variable from year to year. Tritium levels are not significantly increasing over time (Figure 7-8). Variability in plant tritium levels may be a result of soil moisture, depth of roots, plant transpiration, time of sampling, distance from the perimeter fence, temperature, and/or barometric pressure.

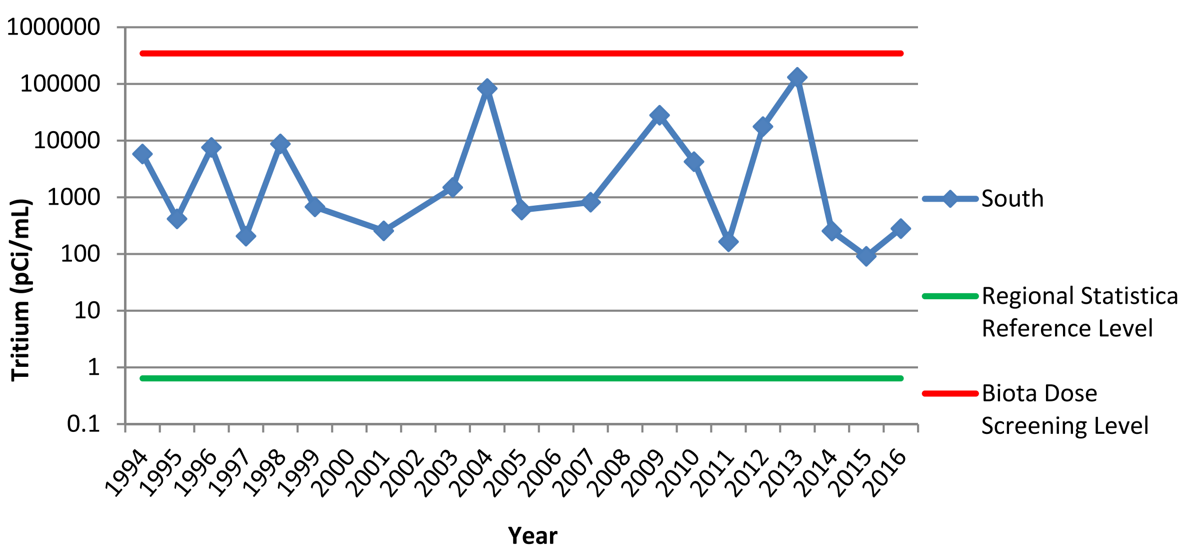


Figure 7-8 **Mean activities of tritium in tree samples collected from the south side of Area G at Technical Area 54 (sites 29-03 and 30-01) from 1994 to 2016 compared with the regional statistical reference level and the biota screening level for overstory vegetation. Note the logarithmic scale on the vertical axis. Sample locations can be found in Figure 7-3.**

Radionuclides in Soil and Vegetation near the Laboratory/Pueblo de San Ildefonso Boundary in Cañada del Buey

Levels of americium-241, plutonium-238, and plutonium-239/240 detected in a soil sample collected near the Laboratory/Pueblo de San Ildefonso boundary northeast of Area G (Figure 7-3, site T3) in 2016 are generally higher than in past years (Figures 7-9, 7-10, and 7-11). The levels of these radionuclides, however, are still very low and far below the no-effect ecological screening levels for plant and animal receptors. The sample site is on Laboratory property at the bottom of Cañada del Buey, approximately 194 feet south of the Pueblo de San Ildefonso fenceline.

Soil samples have also been collected periodically on Pueblo de San Ildefonso Sacred Area lands on the north side of the fenceline across from Area G. The most recent data (2015) show no detectable activities of americium-241 (-0.0097 ± 0.033 pCi/g dry), plutonium-238 (0.0090 ± 0.0104 pCi/g dry) or plutonium-239/240 (0.0090 ± 0.0121 pCi/g dry) (Fresquez et al. 2016, Table S7-1, "San Ildefonso").

All radionuclides, including americium-241, plutonium-238, and plutonium-239/240, measured in samples from trees located northeast of Area G near the Laboratory/Pueblo de San Ildefonso boundary were either not detected, similar to regional statistical reference levels, or below biota dose screening levels (Table S7-2).

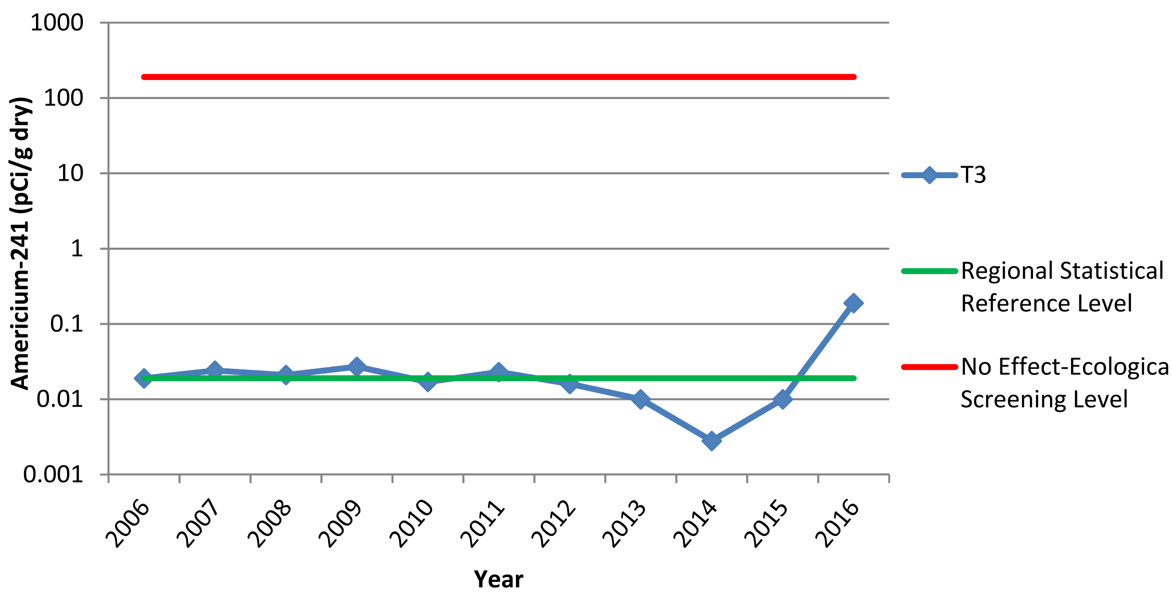


Figure 7-9 Americium-241 (detected and nondetected) activities in surface soil collected near the Laboratory/Pueblo de San Ildefonso boundary (site T3) northeast of Area G at Technical Area 54 from 2006 to 2016 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.

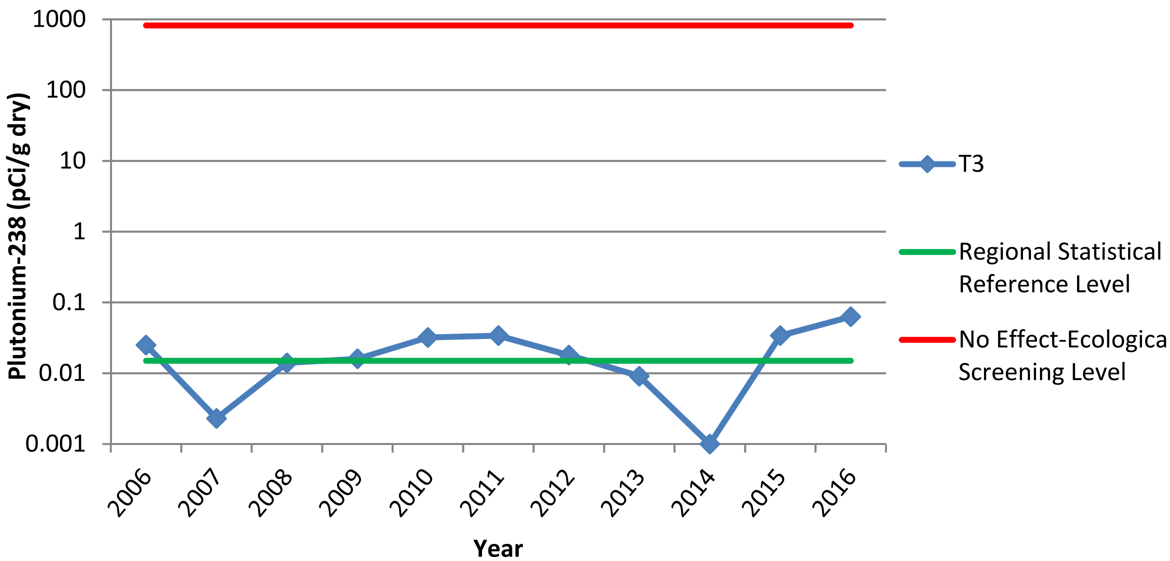


Figure 7-10 **Plutonium-238 (detected and nondetected) activities in surface soil collected near the Laboratory/Pueblo de San Ildefonso boundary (site T3) northeast of Area G at Technical Area 54 from 2006 to 2016 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.**

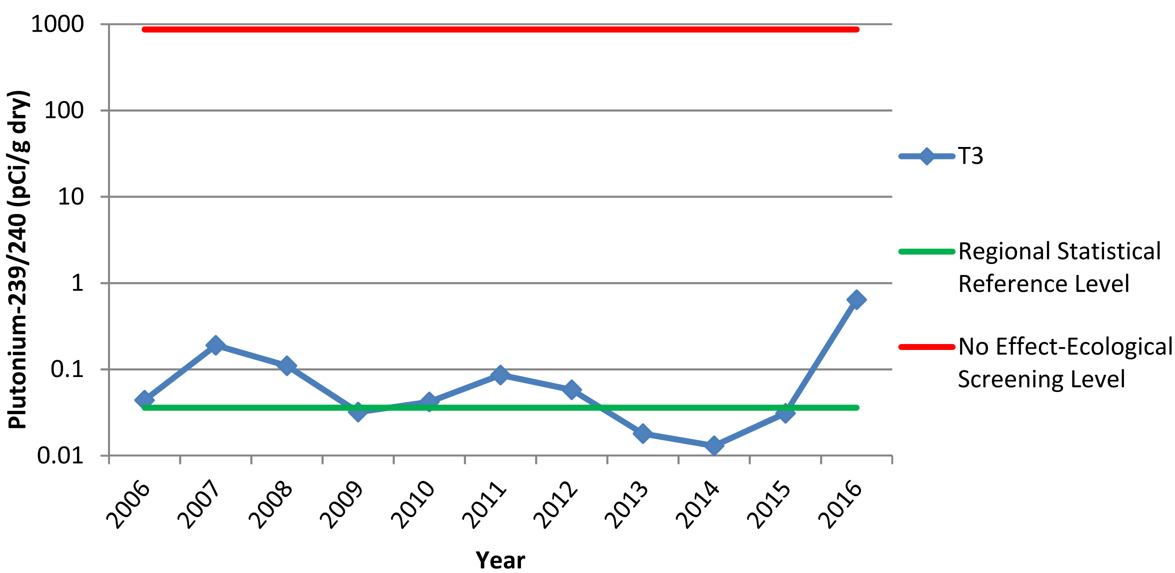


Figure 7-11 **Plutonium-239/240 (detected and nondetected) activities in surface soil collected near the Laboratory/Pueblo de San Ildefonso boundary (site T3) northeast of Area G at Technical Area 54 from 2006 to 2016 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.**

Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15

The Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15 is a principal Laboratory explosives firing site. We monitor soil, sediment from drainages, plants, and animals at the facility to determine whether levels of constituents are affecting plants or animals and are consistent with our expectation of radionuclide or chemical uptake. This monitoring has occurred annually since 1996. The firing site began operations in 2000. 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.

Monitored constituents in soil and sediment include radionuclides, beryllium (and other metals), and organic chemicals such as high explosives, dioxins, and furans. The biota samples collected at the Dual-Axis Radiographic Hydrodynamic Test Facility have included tree branches, small mammals, bees, and birds. Starting in 2014, soil plus one type of biota were collected per year, with the biota type being rotated each year.

Composite soil samples (five subsamples per location) were collected in May 2016 on the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter along the fenceline (Figure 7-12). An additional soil composite sample was collected about 75 feet north of the firing point along the side of the protective berm. Sediment grab samples were collected on the north, east, south, and southwest sides. All soil and sediment samples were analyzed for the radionuclides tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, the inorganic elements aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, potassium, magnesium, manganese, mercury, selenium, silver, sodium, thorium, vanadium, and zinc, and high explosives. The sample nearest the firing point was also analyzed for dioxins and furans.

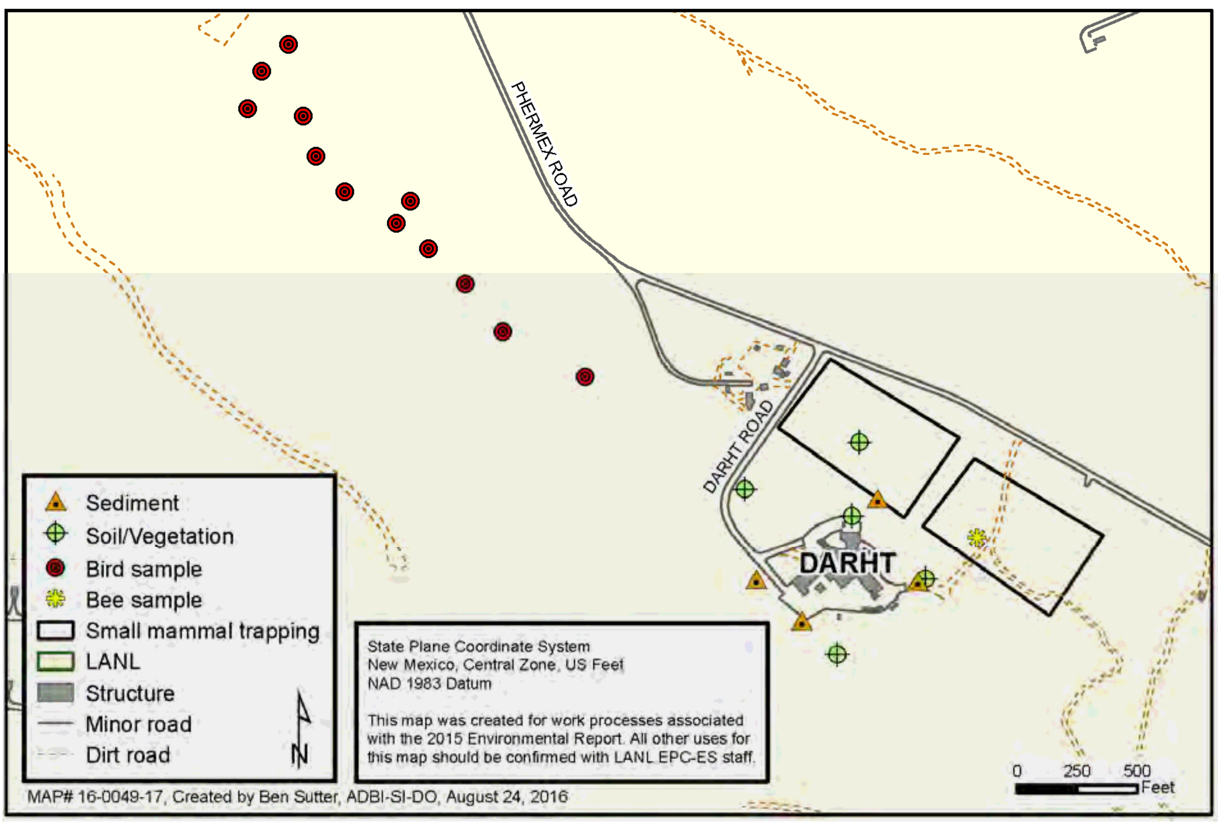


Figure 7-12 Soil, sediment, and biota sample locations at the Dual-Axis Radiographic Hydrodynamic Test Facility

In 2016, overstory vegetation samples (branches plus needles) were collected on four sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter and analyzed for the same radionuclides and inorganic elements as the soil and sediment. Results for tritium are reported on a picocuries per milliliter basis, results for the other radionuclides are reported on a picocuries per gram ash weight basis, and results for the inorganic elements are reported on a milligrams per kilogram (mg/kg) wet weight basis.

Results of most chemical analyses were compared with the baseline statistical reference levels. The baseline statistical reference levels for the Dual-Axis Radiographic Hydrodynamic Test Facility are the levels below which 99% of samples collected at the facility occurred during 1996 to 1999, before the beginning of firing site operations (Nyhan et al. 2001). In cases where there are no baseline statistical reference levels (mostly elements like aluminum, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc), the soil and biota chemical results were compared with regional statistical reference levels.

Radionuclides and Chemicals in Soil, Sediment, and Vegetation at the Dual-Axis Radiographic Hydrodynamic Test Facility

All radionuclides in soil and sediment collected from within and around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility were either not detected (most results), similar to baseline or regional statistical reference levels , or far below the lowest no-effect ecological screening level (Table S7-3).

The only radionuclides in soil and sediment around the Dual-Axis Radiographic Hydrodynamic Test Facility site that have been consistently measured above the baseline or regional statistical reference levels over the years are the uranium isotopes, primarily uranium-238. Based on the uranium-234 to uranium-238 ratio, most of these samples reflect a depleted uranium source. Operations at the Dual-Axis Radiographic Hydrodynamic Test Facility have changed since 2007 to include the use of closed-containment vessels; since 2008, the uranium-238 activity near the firing point has mostly decreased to the baseline statistical reference level (Figure 7-13). In 2016, the firing point sample exhibited a small spike from baseline; this is probably related to residue from past open-air detonations.

With the exception of zinc, the inorganic element concentrations in the soil and sediment samples collected within and around the facility were below either the baseline or regional statistical reference level (Table S7-4). The samples with the highest zinc concentrations (59 mg/kg and 89 mg/kg) were collected on the east side of the Dual-Axis Radiographic Hydrodynamic Test Facility from soil and sediment, respectively. The amounts are above the regional statistical reference level of 49 mg/kg and above the lowest no-effect ecological screening level of 48 mg/kg for the robin. The concentration, however, is below the low-effect ecological screening level of 480 mg/kg for the robin. These levels are not expected to significantly impact the health of birds at the site; the average zinc concentration over the entire site is 36 mg/kg ($n = 9$). Bird abundance and diversity are not negatively impacted at the Dual-Axis Radiographic Hydrodynamic Test Facility based on long-term data (Keller et al. 2015).

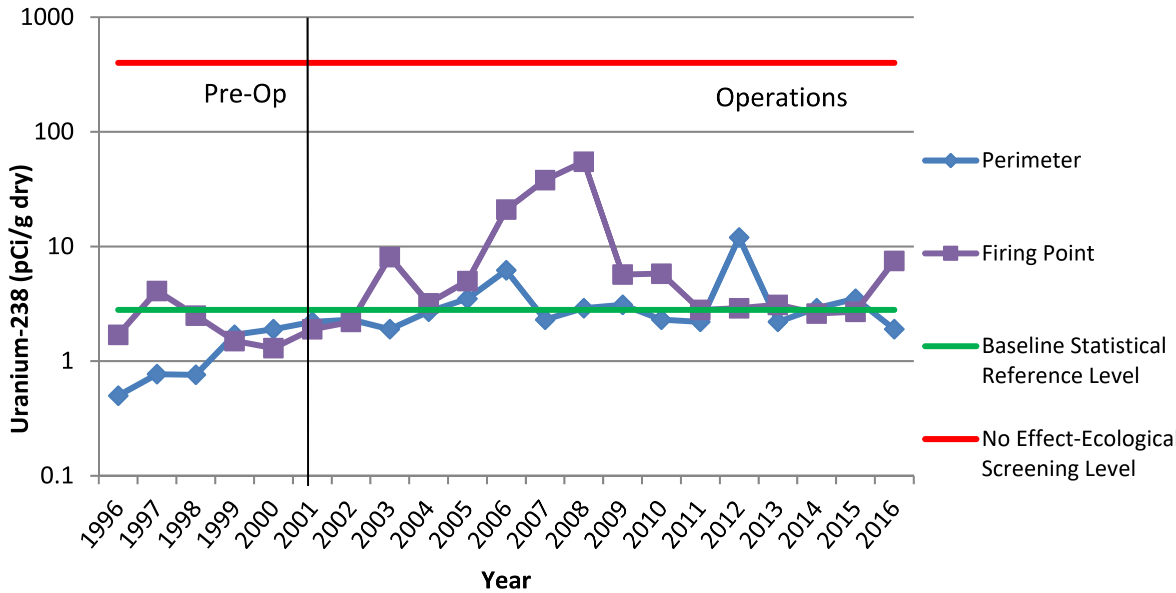


Figure 7-13 **Uranium-238 activities in surface soil collected within (near the firing point) and around the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter (north-, west-, south-, and east-side average) at Technical Area 15 from 1996 to 1999 (preoperations) and from 2000 to 2016 (operations) compared with the baseline statistical reference level and the lowest no-effect ecological screening level (for the plant). Note the logarithmic scale on the vertical axis.**

Beryllium, listed as a chemical of potential concern before the start-up of operations at the facility (DOE 1995), was not detected above the baseline statistical reference level (1.3 mg/kg) in any of the soil or sediment samples during 2016. Beryllium concentrations in soil over the 16-year operations period have mostly remained below the baseline statistical reference level over time.

No high-explosive chemicals were detected in any of the soil or sediment samples collected within or around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility, including the sample closest to the firing point (Table S7-5). Additionally, most dioxins, including 2,3,7,8-tetrachlorodibenzodioxin, and furans were not detected in any of the soil or sediment samples (Table S7-6). The only dioxin that was detected above the detection limit was 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at a concentration of 0.000012 mg/kg. There are no ecological screening levels for this dioxin congener, but the concentration is below the soil ecological screening levels listed for tetrachlorodibenzodioxin, which is about 3000 times more toxic than 1,2,3,4,6,7,8,9-octachlorodibenzodioxin (Van den Berg et al. 2006). The dioxin 1,2,3,4,6,7,8,9-octochlorodibenzodioxin was not detected in whole-body field mice at the Dual-Axis Radiographic Hydrodynamic Test Facility in previous years (Fresquez et al. 2016).

Radionuclide activities in overstory vegetation collected from around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility were either not detected, similar to baseline statistical reference levels, or below the biota dose screening level (Table S7-7). Since 2007, the activities have generally decreased on all sides of the Dual-Axis Radiographic Hydrodynamic Test Facility 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 7-14). The rapid decrease indicates that the uranium-238 was on the surface of the vegetation and has since been washed off by rain and snow or lost during leaf fall.

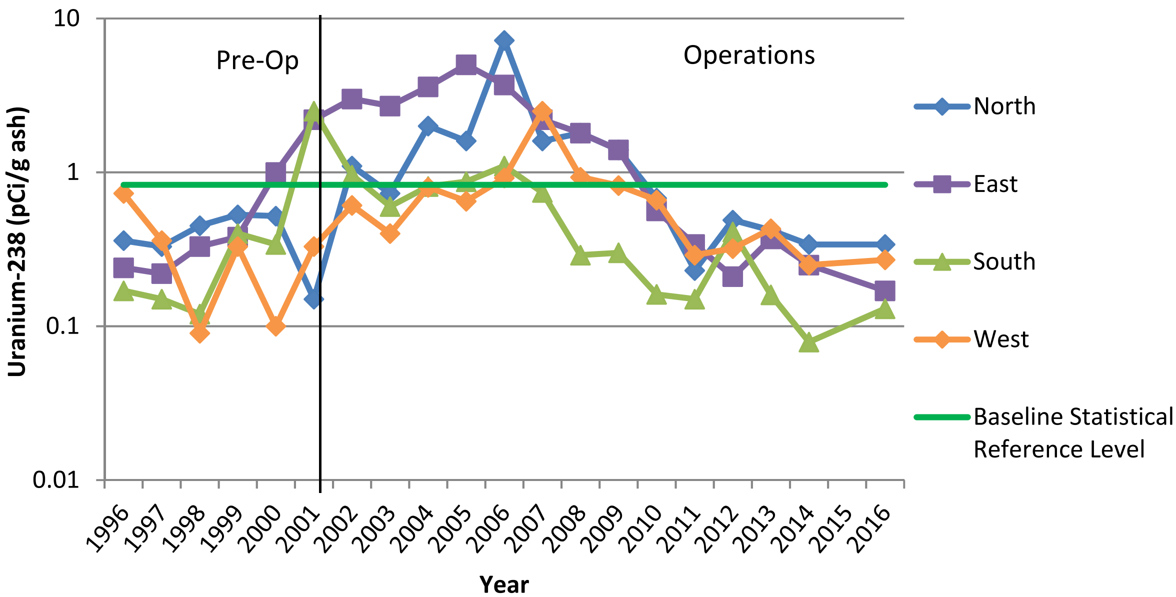


Figure 7-14 Uranium-238 activities in overstory vegetation collected from the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15 from 1996 to 1999 (preoperations) and 2000 to 2016 (operations) compared with the baseline statistical reference level. Note the logarithmic scale on the vertical axis.

The metal and other inorganic element results in overstory vegetation collected from around the Dual-Axis Radiographic Hydrodynamic Test Facility are summarized in Table S7-8. All of the elements were either not detected or were consistent with the baseline or regional statistical reference levels.

Biota Monitoring at Sediment and Flood-Retention Structures

Los Alamos Canyon received wastes from early Laboratory operations at Technical Areas 01 and 21 and from the Los Alamos townsite. Pajarito Canyon received waste from Technical Area 03 and the other technical areas along the Pajarito corridor. Many chemicals and radionuclides in waste products adhere to soil and sediment particles. Storm-water flows can transport these soil and sediment particles downstream in canyon bottoms.

The Laboratory has constructed flood- and sediment-retention structures. The Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure were built following the Cerro Grande fire in 2000. These structures accumulate sediment and/or slow its movement.

As part of an environmental analysis of actions taken in response to the Cerro Grande fire, DOE identified various mitigation measures intended to minimize impacts resulting from the fire (DOE 2000). One of the mitigation measures is the monitoring of soil, surface water, groundwater, and biota upstream of flood-control structures, within sediment-retention basins, and within sediment traps to determine if constituent concentrations in these areas adversely impact plants or animals.

To this end, the Laboratory collects native grasses and forbs and field mice in the retention basins of the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure.

We submitted a composite sample of five whole-body deer mice for radionuclide analyses, three individual field mice for inorganic elements analyses, and three additional field mice for polychlorinated biphenyls (PCBs) (congeners, homologs, and totals) analysis from each sampled location. The following two sections report the 2016 results of this monitoring.

Los Alamos Canyon Weir

The Los Alamos Canyon weir is a water-control structure made of rock-filled wire cages called gabions that was built across the channel in Los Alamos Canyon near the northeastern boundary of the Laboratory (Figure 7-15). The retention basin upstream of the weir covers over 1 acre. The weir and basin prevent over half of the sediments in storm-water runoff from the canyon from reaching the Rio Grande. Accumulated sediment was excavated from the retention basin in 2009, 2011, 2013, and 2014. Sediment excavated in 2009 was placed on the west side of the basin and stabilized, whereas sediment excavated in 2011, 2013, and 2014 was analyzed, placed on a plastic liner, contained within a berm, compacted, and seeded approximately 0.5 miles west of the weir in Los Alamos Canyon.

A composite understory vegetation sample was collected within the Los Alamos Canyon weir retention basin and submitted for radionuclide and inorganic element analyses in June 2016. All radionuclides in the understory vegetation sample either were not detected, similar to regional statistical reference levels, or were far below biota dose screening levels (Table S7-9). These results, particularly for americium-241 and the plutonium isotopes, vary widely from year to year but are not increasing (Figure 7-16). This high variability may be a result of sampling variability; plants are collected at different locations within the basin each year. In addition, because of high-runoff events and water ponding, the stems and leaves of the plants may retain different amounts of sediment each year. Sediment on plant material can alter radionuclide results significantly.

All inorganic elements in understory vegetation were below or similar to the regional statistical reference levels (Table S7-10).

Small mammals were also collected in the retention basin in June 2016. Radionuclides in the whole-body composite samples of field mice collected upstream of the Los Alamos Canyon weir were either not detected, similar to regional statistical reference levels (Fresquez 2015), or below biota dose screening levels (Table S7-11). All radionuclides are similar to past years and are not increasing over time. (Figure 7-17).

Results of inorganic elements in whole-body field mice are in Table S7-12. All mean inorganic element concentrations in field mice collected on the upstream side of the Los Alamos Canyon weir were not statistically different from regional mean background concentrations (Fresquez 2015).

Figure 7-15 Los Alamos Canyon weir before (top photo) and after (bottom photo) storm-water flows

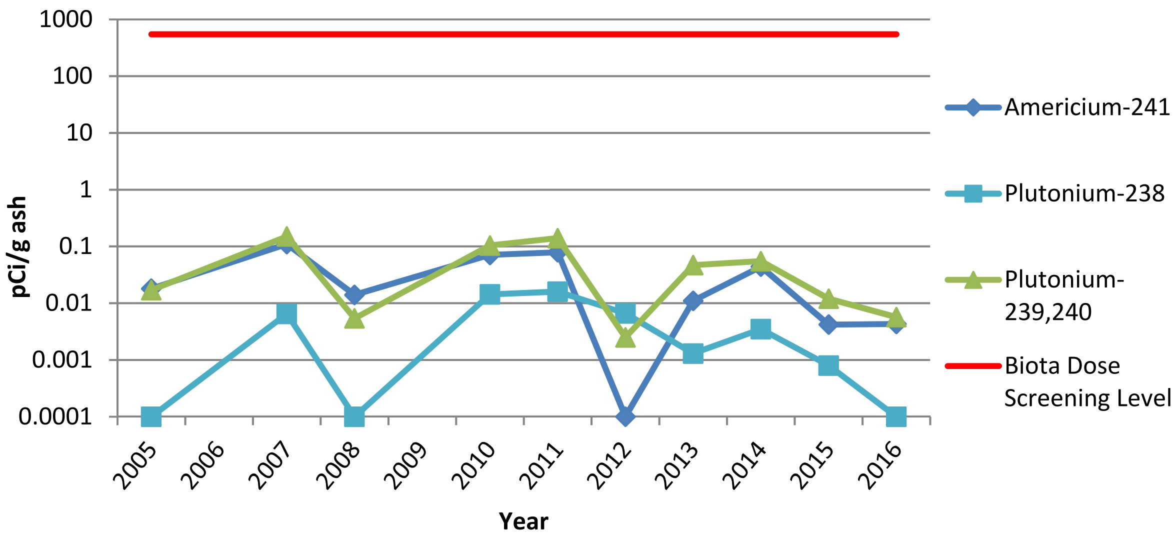


Figure 7-16 **Americium-241, plutonium-238, and plutonium-239/240 activities in understory vegetation collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2005 to 2016 compared with the biota dose screening level. Note the logarithmic scale on the vertical axis.**

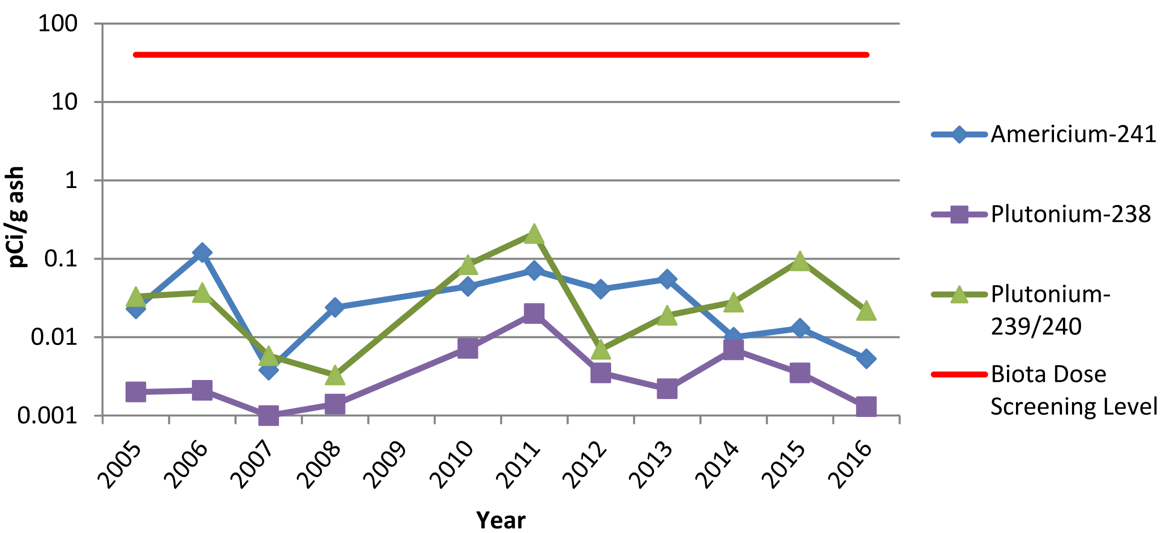


Figure 7-17 **Americium-241, plutonium-238, and plutonium-239/240 activities in composite whole-body field mouse samples (n >5) collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2005 to 2016 compared with the biota dose screening level. Note the logarithmic scale on the vertical axis.**

Concentrations of total PCBs in whole-body field mouse samples collected upstream from the Los Alamos Canyon weir were statistically higher than regional background mean concentrations (Table S7-13). The highest individual total PCB concentration detected in a field mouse sample collected from the retention basin in 2016 (457,000 picograms per gram [pg/g] wet weight or 0.457 mg/kg) was an order of magnitude below the average whole-body amount (2,500,000 pg/g wet weight or 2.5 mg/kg) 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 near the retention basin.

The mean level of total PCBs in whole-body field mice collected from the upstream side of the retention basin decreased from 2008 through early 2013 and then statistically increased over time from regional statistical reference levels from 2014 through 2016 (Figure 7-18). The decline from 2008 to 2013 may have resulted from many sediment-control mitigations (sediment traps, willow plantings, and sediment removal) put in place by the Laboratory in Los Alamos Canyon upstream of the weir (Fresquez 2014) and may also have been related to the removal of sediment from the basin between 2009 and 2014. The increase in PCBs in field mice from 2014 through 2016 may have resulted from the accumulation of sediment during higher-than-normal amounts of rainfall and resultant flooding since 2013 (Dewart et al. 2014, 2015; Bruggeman et al. 2016; Chapter 4 in this document).

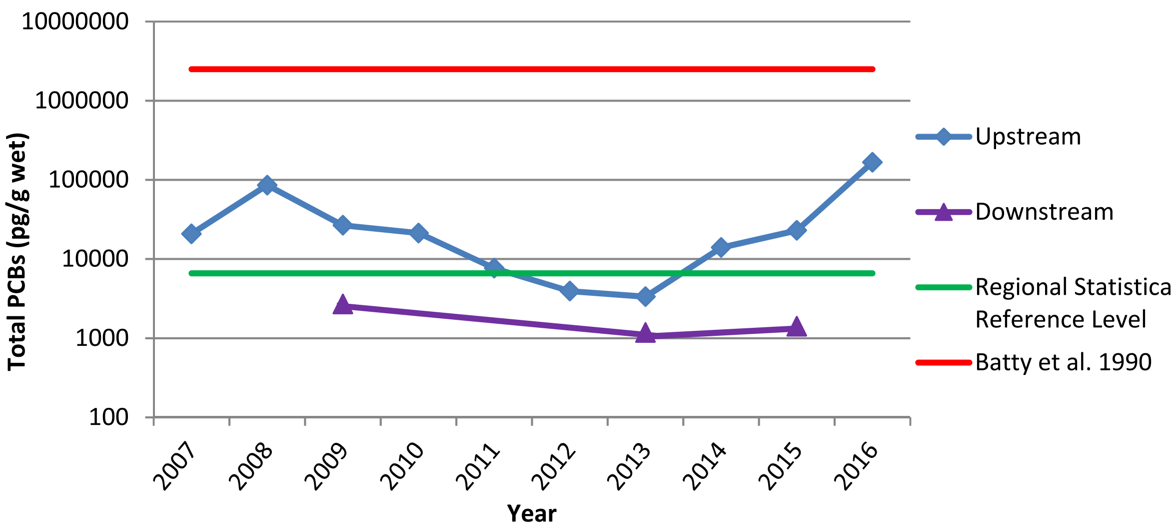


Figure 7-18 **Mean total PCB concentrations in whole-body field mice collected upstream (retention basin) and 4.5 miles downstream of the Los Alamos Canyon weir from 2007 to 2016 compared with the regional statistical reference level and the mean level of an affected population from Batty et al. (1990). Note the logarithmic scale on the vertical axis.**

A plot of the distribution of the PCB compounds with differing numbers of chlorine atoms found in the field mice shows that the pattern is most similar to the commercial mixture Aroclor-1260 (Figure 7-19). Aroclor-1260 has been the most consistently detected PCB formulation in sediment collected upstream of the Los Alamos Canyon weir (Fresquez et al. 2007, Fresquez 2008, Reneau and Koch 2008).

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure is located upstream of Technical Area 18. The structure extends 390 feet across the canyon and is about 70 feet high. The bottom of the retention structure is equipped with one 42-inch-diameter drainage conduit, which allows accumulated storm water to drain. Accumulated water is retained no longer than 96 hours behind the retention structure; water drains naturally into the existing streambed.

In 2016, a composite understory vegetation sample and small mammals were collected on the upstream side of the Pajarito Canyon flood-retention structure.

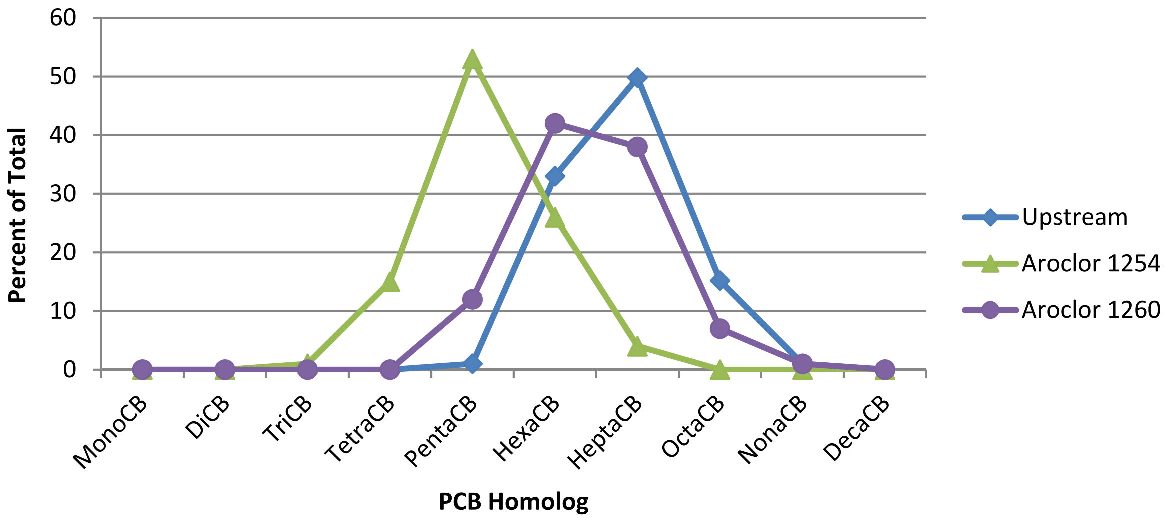


Figure 7-19 The distribution of PCB compounds with differing numbers of chlorine atoms in whole-body field mouse samples collected upstream of the Los Alamos Canyon weir in 2016 compared with the commercial mixtures Aroclor-1254 and Aroclor-1260

Results from analysis of the composite sample show that radionuclides and inorganic elements were either not detected or were detected below the regional statistical reference levels (Tables S7-14 and S7-15). These data are similar to past years.

Radionuclides in whole-body field mice were either not detected, were below regional statistical reference levels, or were below biota dose screening levels (Table S7-16). The mean inorganic element concentrations in whole-body field mice (Table S7-17) were statistically similar to regional background mean concentrations (Fresquez 2015). These data are similar to past years.

The mean concentration of total PCBs in whole-body field mice collected upstream of the Pajarito Canyon flood-retention structure was statistically similar to regional mean background levels (Fresquez 2015; Table S7-18). The highest amount (2410 pg/g wet weight or 0.00241 mg/kg) was orders of magnitude below the average whole-body amount (2,500,000 pg/g wet weight or 2.5 mg/kg) reported at PCB-contaminated sites where field mouse populations were negatively affected (Batty et al. 1990). Since small mammal sampling began in 2007, the whole-body amounts measured were below regional statistical reference levels for the majority of the years (Figure 7-20).

The distribution of the PCB compounds with differing numbers of chlorine atoms in field mice collected from the Pajarito Canyon flood-retention structure mostly overlaps the distribution pattern of Aroclor-1260 (Figure 7-21). These data are similar to past years and have not changed.

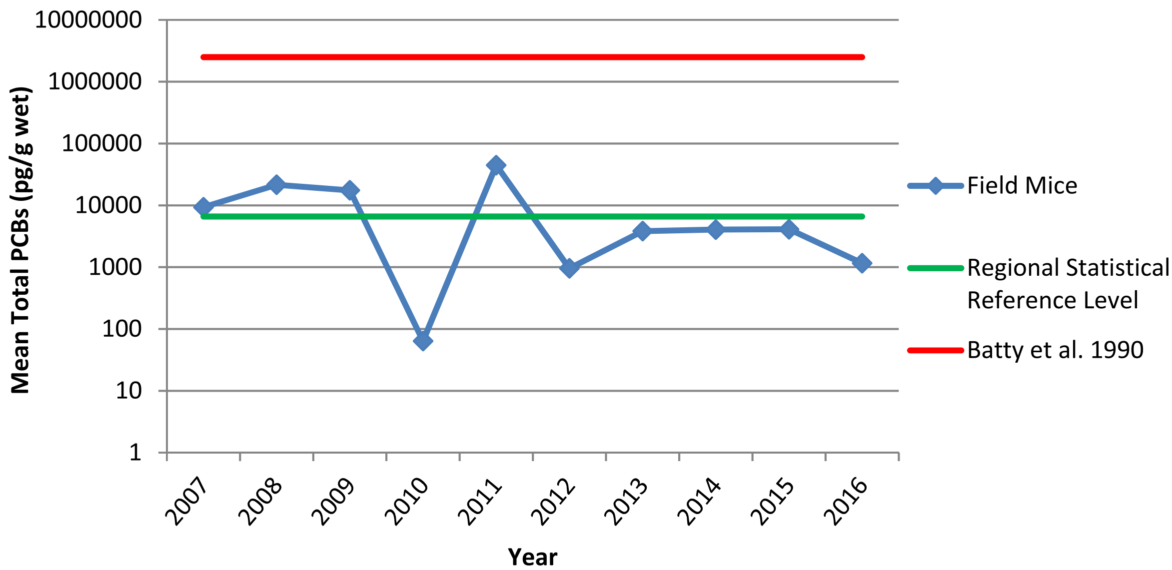


Figure 7-20 **Mean total PCB concentrations in whole-body field mouse samples collected on the upstream side of the Pajarito Canyon flood-retention structure from 2007 to 2016 compared with the regional statistical reference level and the mean level of an affected population from Batty et al. (1990). Note the logarithmic scale on the vertical axis.**

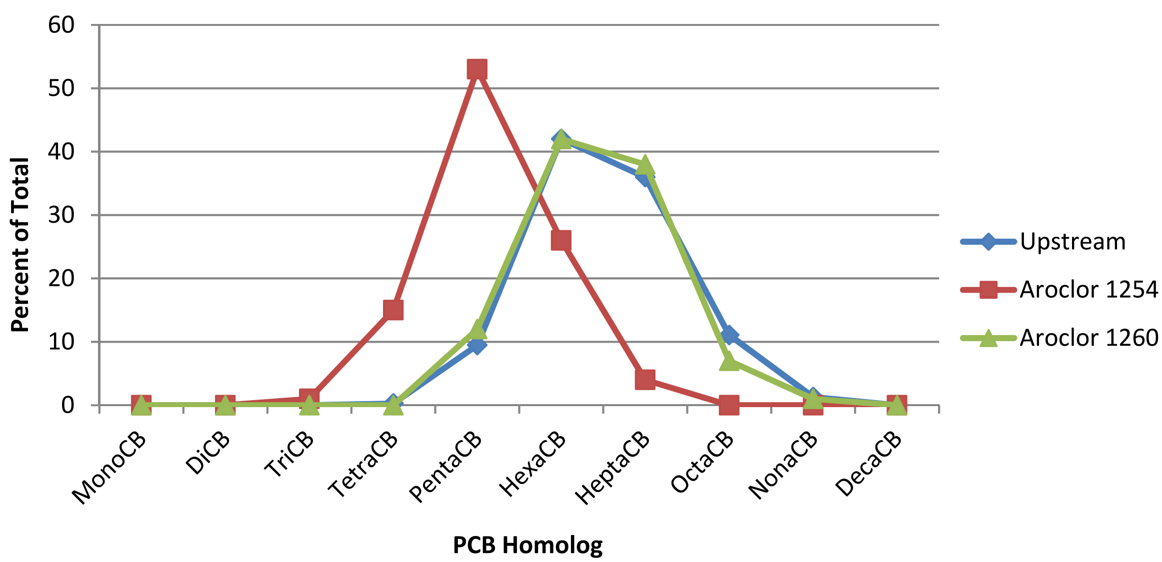


Figure 7-21 **The distribution of PCB compounds with differing numbers of chlorine atoms in whole-body field mouse samples collected on the upstream side of the Pajarito Canyon flood-retention structure in 2016 compared with the commercial mixtures Aroclor-1254 and Aroclor-1260**

Avian Monitoring at Facility Sites

Monitoring at Open-Detonation and Open-Burn Firing Sites

In 2016, as part of the Migratory Bird Treaty Act, we marked the fourth year of avian monitoring at two open-detonation sites at Technical Areas 36 and 39 and one open-burn site at Technical Area 16 to assess whether operations at these sites are impacting bird abundance and diversity. Monitoring results from each site are compared with the results from similar areas without Laboratory operations. Results are also examined over time to identify patterns or trends.

A total of 730 birds representing 54 species was observed at the study sites in 2016 (Hathcock et al. 2017). Results were similar between areas with and without operations. These data agree with the findings in Keller et al. (2015).

Data indicate that bird species present may be changing at Technical Area 36. The cause may be the removal of shrubby and woody species in the area to reduce fuels for wildland fires. The 2016 data also showed that species diversity was significantly less at Technical Area 16 than its control site. This trend is similar to previous years and is likely because of the differences in habitat type; the control site, located at the bottom of Los Alamos Canyon, consists of a closed-canopy mixed-conifer forest, whereas the study site at Technical Area 16 is located on the mesa top and consists of more open mixed-conifer vegetation.

Breeding Season Capture and Banding at Sandia Canyon

Bird banding during breeding season allows the Laboratory to monitor bird populations that breed in specific areas of interest. A breeding season banding station is currently located in the Sandia Canyon wetland and has been operating since 2014. It is composed of 12 mist nets deployed in and around the wetland in upper Sandia Canyon, below the Los Alamos County landfill. This wetland contains primarily broadleaf cattail (*Typha latifolia*) and some tree species, including Rio Grande cottonwood (*Populus deltoids*) and Russian olive (*Elaeagnus angustifolia*).

A total of 667 birds representing 56 species was banded during the breeding seasons of 2014 through 2016. Bird captures have increased from year to year. The site has also produced some captures of birds not previously documented in Los Alamos County, including the golden-winged warbler (*Vermivora chrysoptera*) (Figure 7-22) and orchard oriole (*Icterus spurius*) (Figure 7-23). The bird banding operations follow a specific protocol called "monitoring avian productivity and survivorship," which is part of a continent-wide program (DeSante and Kaschube 2009) managed by the Institute for Bird Populations in Point Reyes, California. Examining key demographic parameters, especially productivity, recruitment, and survival, can enhance the effectiveness of conservation efforts and provide information on avian population health. Minimally, 5 years of data are needed in order to make inferences on population health. Studies like this support the 2013 memorandum of understanding between the U.S. Fish and Wildlife Service and the DOE (DOE 2013).

Figure 7-22 Golden-winged warbler banded and released at the Sandia Canyon wetland in 2016

Figure 7-23 Orchard oriole banded and released at the Sandia Canyon wetland in 2016

Avian Nest-Box Monitoring

The avian nest-box network at the Laboratory was established during the winter of 1997 with 438 boxes and now contains more than 500 boxes. The western bluebird (*Sialia mexicana*) and ash-throated flycatcher (*Myiarchus cinerascens*) are common around the Laboratory and readily nest in manmade nest boxes. Their eggs have been used as a biomonitoring tool at the Laboratory since the late 1990s (Becker 2003). Western bluebird and ash-throated flycatcher eggs have been collected opportunistically (most were nonviable) and have been analyzed for inorganic elements and organic chemicals and/or their metabolites (Gaukler et al. 2016a, 2016b). The data indicate that levels of radionuclides, metals, PCBs, and organochlorine chemicals in the eggs of western bluebirds and ash-throated flycatchers in the areas studied are not likely to cause adverse effects to the avian population.

We are continuing the nest box program and have implemented the following improvements and study sites.

Reference site: In 2016, 92 nest boxes were placed south of the Laboratory in a natural area. These boxes serve as a reference site with which eggs collected from the Laboratory can be compared. Studies utilizing the reference boxes will better determine whether birds on Laboratory property have elevated levels of chemicals in their eggs.

Nest Box Monitoring at the Dual-Axis Radiographic Hydrodynamic Test Facility: Annual monitoring has occurred at the Dual-Axis Radiographic Hydrodynamic Test Facility since 1996 to determine effects of operating the facility (Fresquez et al. 2015, Keller et al. 2015). Biota that have been previously collected for chemical analysis include small mammals, bees, and vegetation. In 2017, nest boxes will be placed around the Dual-Axis Radiographic Hydrodynamic Test Facility to monitor nest success and potential chemicals in nonviable eggs and deceased nestlings.

Nest Box Monitoring at Middle Los Alamos Canyon Aggregate Area: Middle Los Alamos Canyon has housed five early experimental nuclear reactors, and received effluent from Laboratory facility outfalls. Areas of the canyon with chemical concentrations above risk screening levels are undergoing active remediation. Avian nest boxes will be used as part of environmental monitoring of the area. Birds using these boxes will be monitored for nest success and morphological measurements will be collected on nestlings. Any non-viable eggs and deceased nestlings will be retained for chemical analyses.

Threatened and Endangered Species Surveys

We completed surveys in 2016 for four species, subspecies, or distinct population segments protected under the Endangered Species Act: the Mexican spotted owl (*Strix occidentalis lucida*), the Jemez Mountains salamander (*Plethodon neomexicanus*), the southwestern willow flycatcher (*Empidonax trailii extimus*), and the western distinct population segment of yellow-billed cuckoo (*Coccyzus americanus*). Of these four, Mexican spotted owls and Jemez Mountains salamanders were found. Willow flycatchers were found, but of unknown subspecies.

Mexican Spotted Owl

The Mexican spotted owl generally inhabits mixed conifer and ponderosa pine–(*Pinus ponderosa*–) Gambel oak (*Quercus gambelii*) forests in mountains and canyons (USFWS 2012). Mexican spotted owls in the Jemez Mountains of northern New Mexico seem to prefer cliff faces in canyons for their nest sites (Johnson and Johnson 1985). Although seasonal movements vary among owls, adults commonly remain within their summer home ranges throughout the year.

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, Mexican spotted owl habitat at the Laboratory has been identified based on a combination of cliff habitat and forest characteristics (LANL 2015b). Mexican spotted owl habitats are called areas of environmental interest. Currently, there are five Mexican spotted owl areas of environmental interest at the Laboratory spanning seven canyons. Surveys are conducted in each Mexican spotted owl area of environmental interest each year.

During 2016, Mexican spotted owls were found in two areas of environmental interest at the Laboratory, and two Mexican spotted owl chicks fledged from one nest. In addition, a pair of Mexican spotted owls was found near the Laboratory on Los Alamos County property, but no chicks were discovered at this location.

Jemez Mountains Salamander

The Jemez Mountains salamander is found only in the Jemez Mountains. They live mostly at elevations ranging from 7000 to 11,250 feet (2130 to 3430 meters) in mixed-conifer forests (Degenhardt et al. 1996). The Jemez Mountains salamander spends most of its life underground but can be found on the surface when conditions are warm and wet, typically from July through September (USFWS 2013). When on the surface, the salamanders are usually under decaying logs, rocks, or bark or moss mats or inside decaying logs or stumps. They are terrestrial salamanders and do not require free-flowing water to live or reproduce.

Jemez Mountains salamander surveys were conducted adjacent to the Ponderosa Campground within Bandelier National Monument property south of the Laboratory and on United States Forest Service property west of the Laboratory in 2016. One Jemez Mountains salamander was discovered during these surveys in upper Cañon de Valle on United States Forest Service property.

Southwestern Willow Flycatcher

The Southwestern willow flycatcher is found in close association with dense stands of willows (*Salix* spp.), arrowweed (*Pluchea* spp.), buttonbush (*Cephalanthus occidentalis*), tamarisk (*Tamarix ramosissima*), Russian olive (*Elaeagnus angustifolia*), and other riparian vegetation, often with a scattered overstory of cottonwood (*Populous* spp.) (USFWS 2002). The size of vegetation patches used by Southwestern willow flycatchers ranges from as small as 2 acres (0.8 hectares) to several hundred acres.

Southwestern willow flycatcher surveys were conducted during their breeding season within the Sandia and Pajarito Canyons wetlands. Three willow flycatchers of unknown subspecies were found during the first survey period. However, no willow flycatchers were found on subsequent surveys, indicating that they were migrants passing through and did not nest on Laboratory property. Banding stations in the Sandia and Pajarito Canyons wetlands captured three willow flycatchers of unknown subspecies during the spring and fall migration periods in 2016.

Yellow-Billed Cuckoo

The western distinct population segment of yellow-billed cuckoo is found in open riparian woodlands with clearings and dense scrubby vegetation, often along water (USFWS 2014). Yellow-billed cuckoos observed in New Mexico have been found in areas dominated by tamarisk and an overstory of cottonwood. The species may occur along the Rio Grande near the Laboratory.

Cuckoo surveys were conducted in Ancho Canyon in 2016, and no cuckoos were found.

Large Animal Monitoring

Monitoring Network

The environmental monitoring and surveillance program has opportunistically collected road-killed mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus nelson*) from on-site, perimeter, and background sites since the 1970s (LASL 1973). To date, we have collected and analyzed approximately 41 deer and 47 elk.

Recently, the program has expanded by collecting other species such as mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and great horned owls (*Bubo virginianus*) that were killed by vehicles or by other accidents. Animal tissues are useful indicators for environmental contamination because they can be analyzed for chemical concentrations (Keith 1996). These data may also be used for an ongoing effort to assess potential risks, or lack thereof, to individuals and populations.

This year, we report on the radionuclide activities and chemical concentrations in tissues from six deer (one was submitted as a duplicate sample), one elk, one gray fox, one bobcat, one mountain lion, and two great horned owls collected in 2015 and 2016 (Figure 7-24).

The majority of animals collected were road casualties; one great horned owl was collected after being caught in a barbed wire fence. Leg muscle and leg bone were harvested from the deer, elk, gray fox, bobcat, and mountain lion. Muscle tissue was analyzed for radionuclides, metals, other inorganic elements, and PCBs. Bone tissue was analyzed for radionuclides.

Leg muscle was harvested from both great horned owls and analyzed for PCBs; the remaining whole body (feathers included and unwashed) were analyzed for radionuclides, metals, and other inorganic elements.

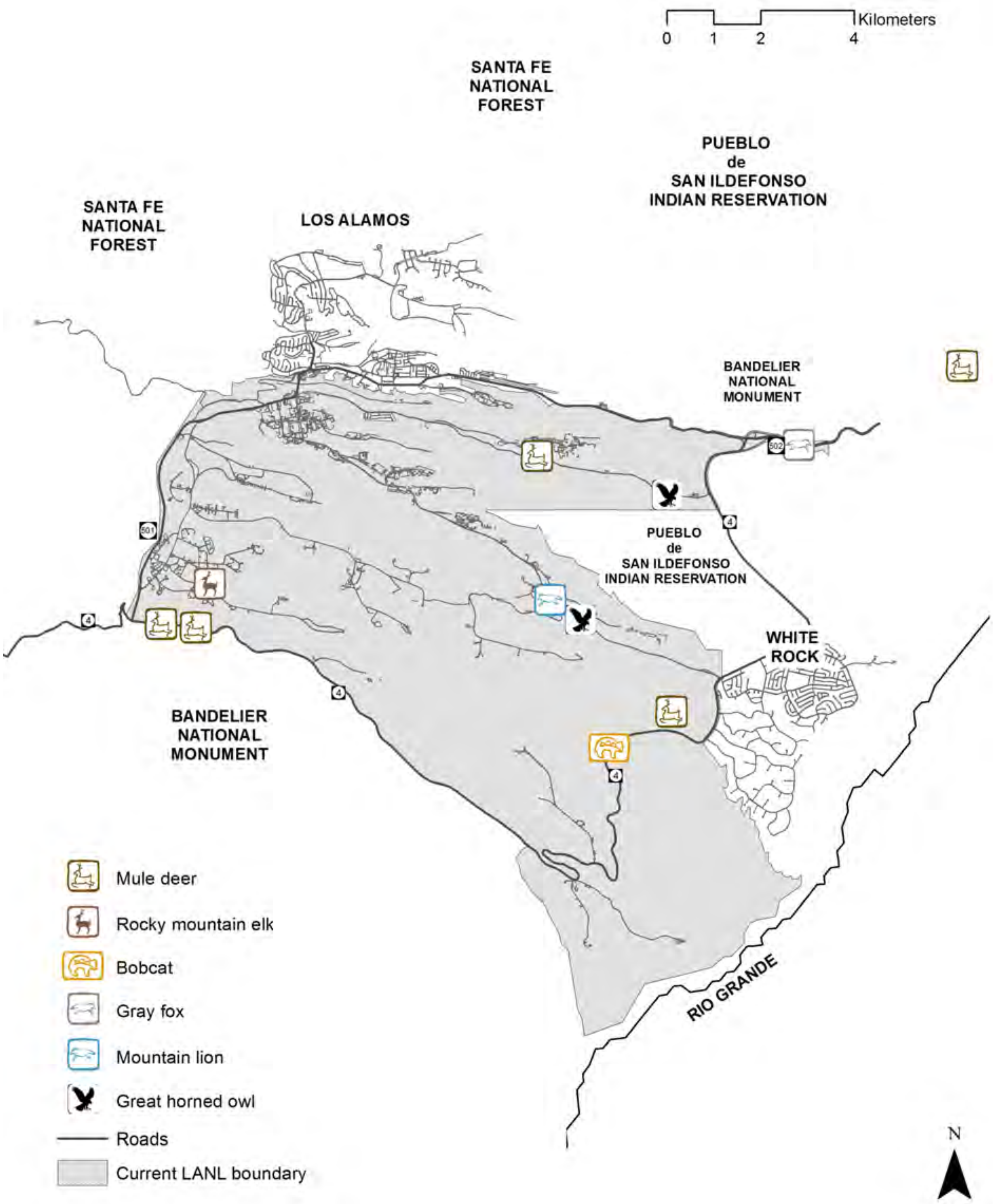


Figure 7-24 Locations of animals collected as roadkill from within and around the perimeter of the Laboratory in 2015 and 2016

Deer and Elk Monitoring

All radionuclides in deer and elk (muscle and bone) collected from on-site and perimeter locations were either below the minimum detectable activity (most results), regional statistical reference level, or biota dose screening level (Table S7-19 and S7-20). These data are similar to past years.

All metals and other inorganic elements in muscle tissues of deer and elk were similar to regional statistical reference levels for deer (Table S7-21).

Total PCBs in deer muscle tissues from on-site and perimeter locations were very low, ranging in concentration from 5 pg/g (0.000005 mg/kg) in a deer collected from Technical Area 16 to 71 pg/g (0.000071 mg/kg) in a deer collected from the Pueblo de San Ildefonso (Table S7-22). All total PCB concentrations were below the regional statistical reference level of 101 pg/g (0.000101 mg/kg).

The elk sample, collected from Technical Area 16, contained 333 pg/g (0.000333 mg/kg) total PCBs and was above the regional statistical reference level for deer. Past values of PCBs in elk on Laboratory lands have ranged from 0.0 pg/g to 318 pg/g (0.000318 mg/kg) (n = 8). No comparison values from background elk are available, and no comparison values in the literature could be found. However, we assume that these concentrations do not indicate risk to the animals because the amount allowable for red meat consumption according to the U.S. Food and Drug Administration standard is 3,000,000 pg/g (3 mg/kg). These data are given at this time for future reference and discussion.

Both Laboratory and non-Laboratory property have sources of PCBs (LANL 2008). Aroclor-1254 and Aroclor-1260 have been detected in soil and sediment in some canyons within and outside of the Laboratory (LANL 2008). PCB homologs from elk and deer muscle collected from on-site and perimeter locations generally follow the Aroclor-1260 pattern (Figures 7-25 and 7-26).

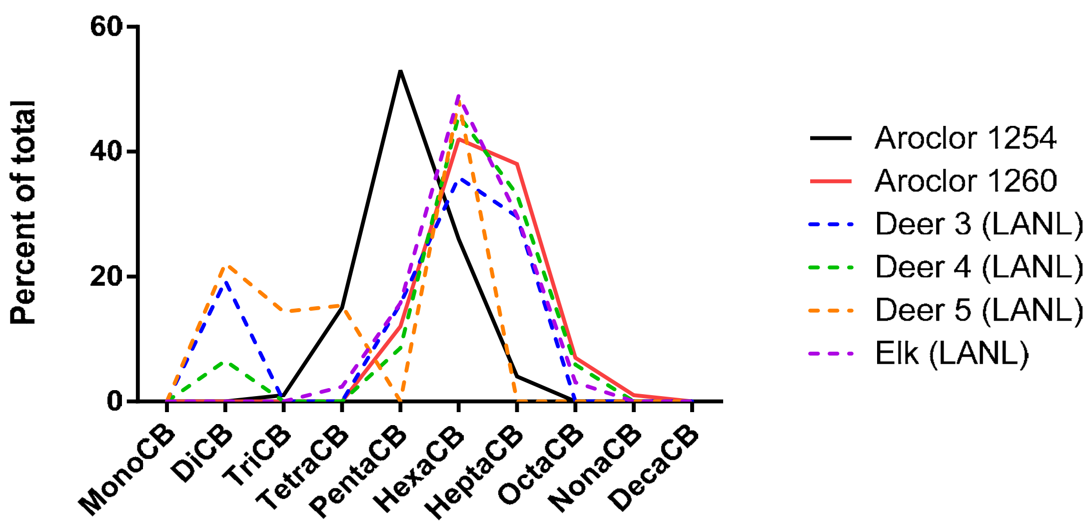


Figure 7-25 **The distribution of PCB homologs in deer and elk muscle collected from the Laboratory in 2015 in relation to commercial mixtures of Aroclor-1254 and Aroclor-1260**

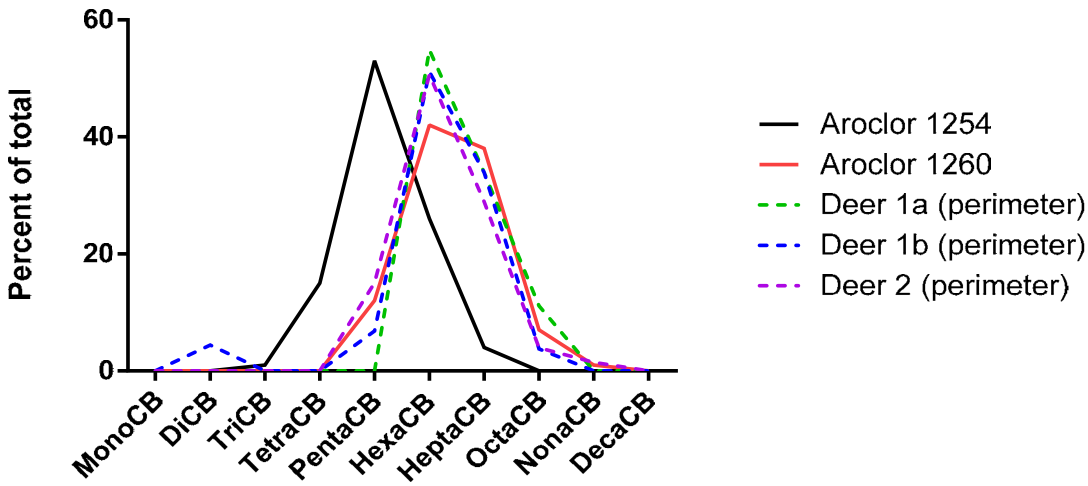


Figure 7-26 **The distribution of PCB homologs in deer leg muscle collected from the perimeter in 2015 in relation to commercial mixtures of Aroclor-1254 and Aroclor-1260**

Mountain Lion, Bobcat, Fox, and Great Horned Owl Monitoring

All radionuclides in tissues of the mountain lion (Table S7-23), bobcat (Table S7-24), fox (Table S7-24), and owl (Table S7-25) were either not detected, similar to background (in the case of the mountain lion), or below biota dose screening levels. The majority of radionuclides were below the minimum detectable activity in muscle, bone, and whole-body samples.

In 2001, one road-killed mountain lion was collected near Llaves, New Mexico (approximately 100 miles northwest of Los Alamos). Because this is only one sample, a regional statistical reference level cannot be calculated; however, all radionuclide levels in mountain lion muscle and bone collected at the Laboratory are similar to levels in this individual (Table S7-23). These data indicate that radionuclides are not of concern for the mountain lion.

Many of the metals and other inorganic elements in muscle tissues of the mountain lion, bobcat, fox, and great horned owl were not detected (Table S7-26). We do not have background reference values for these elements for these animals. The results are presented here for documentation purposes and future comparisons.

Total PCB levels in muscle tissues of the mountain lion (8510 pg/g or 0.00815 mg/kg) and owls (5530 pg/g and 9240 pg/g or 0.00553 mg/kg and 0.00924 mg/kg) collected from Laboratory lands are generally higher than in the bobcat (146 pg/g or 0.000146 mg/kg) and gray fox (466 pg/g or 0.000446 mg/kg) collected from perimeter areas (Table S7-27). The great horned owl collected from Technical Area 18 contained the highest amounts of PCBs (9240 pg/g or 0.00924 mg/kg). Again, as with the metals data, we do not have data from animals collected from background areas. Data from these animals have not previously been collected at the Laboratory and are presented here for documentation and future reference.

PCB homologs detected in both great horned owls follow the same pattern as Aroclor-1260 (Figure 7-27). A PCB homolog pattern similar to Aroclor-1260 was also observed in the gray fox, bobcat, and mountain lion data (Figure 7-28).

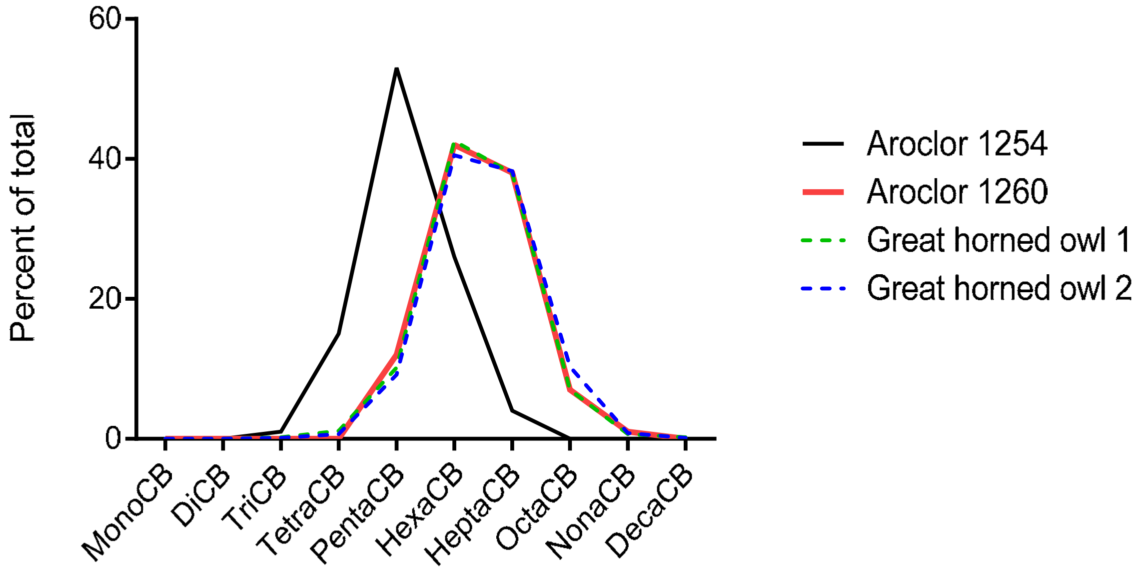


Figure 7-27 The distribution of PCB homologs in leg muscle of great horned owls collected from the Laboratory in 2015 and 2016 in relation to commercial mixtures of Aroclor-1254 and Aroclor-1260

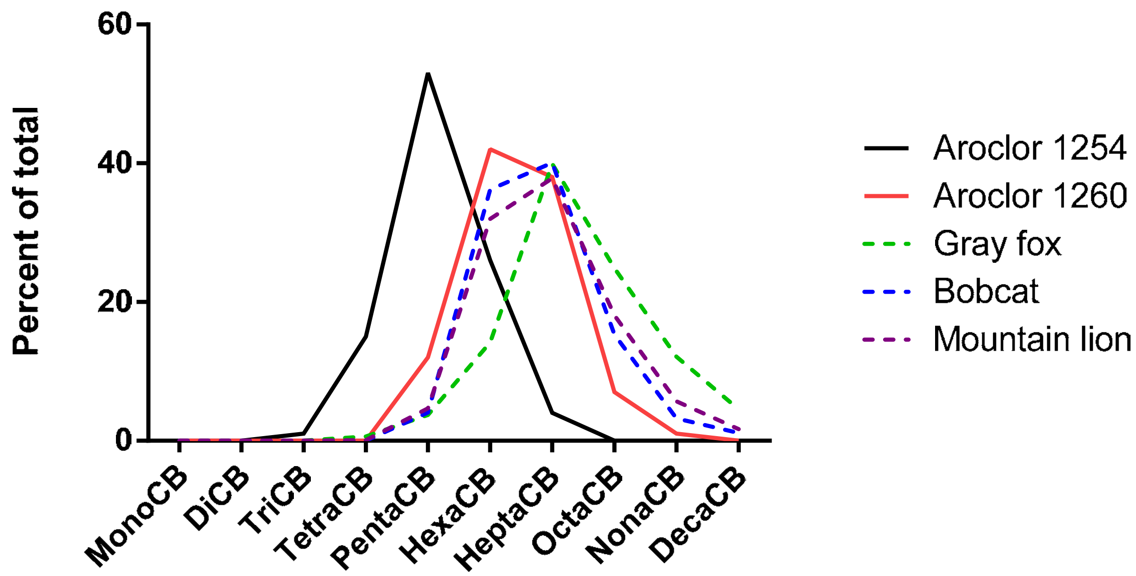


Figure 7-28 The distribution of PCB homologs in gray fox and bobcat leg muscle collected from the perimeter in 2016 and 2015, respectively, and from mountain lion leg muscle collected from the Laboratory in 2015 in relation to commercial mixtures of Aroclor-1254 and Aroclor-1260

The total PCB concentration in a mountain lion sample collected from the Laboratory in 2015 was 675 times higher than the mean total PCB concentrations in deer collected from the Laboratory in 2015. PCB concentrations are frequently higher in predator species because these organic chemicals are lipophilic (absorbed by fats) and they increase in concentration up food chains (Eisler and Belisle 1996, Hornbuckle et al. 2006). Additionally, PCBs with higher degrees of chlorination tend to concentrate up the food chain because of metabolic processes (Hornbuckle et al. 2006). This explains why the greatest percentage of PCBs in the mountain lion sample are of hepta-chlorinated (seven chlorines) biphenyl origin (Figure 7-28), whereas the greatest percentage of PCBs in the on-site and perimeter deer samples are of hexa-chlorinated (six chlorines) biphenyl origin (Figure 7-26).

Sediment and Small Mammal Monitoring within the Sandia Canyon Wetland

The Sandia Canyon wetland is located at the head of Sandia Canyon within Technical Area 03. Industrial and sanitary wastewater effluents maintain year-round stream flow at the top of the canyon, creating saturated sediment conditions in this 3-acre cattail-dominated wetland.

Several studies have reported chromium and PCBs in sediment, small mammal, and cattail samples at levels above background concentrations (LANL 2009, Gonzales et al. 2007).

An active headcut occurred at the downstream end of the wetland and was measured as approximately 10 feet deep in 2007. To prevent erosion from continuing to degrade the wetland and from allowing downstream movement of contaminated sediment, the Laboratory installed a grade-control structure for the wetland in 2013 (LANL 2013; Figure 7-29).

Figure 7-29 Gully erosion in 2007 (left photo) and the affected area in 2016 after installation of the grade-control structure (right photo) at the downstream end of the Sandia Canyon wetland

Three years after the installation of the grade-control structure, we measured population parameters of small mammals within the restored wetland and the levels of metals, other inorganic elements, and PCBs in wetland sediment and in whole-body field mice. We completed a mark-recapture study over four nights to estimate small mammal abundance

(Figure 7-30). We collected sediment (n = 8) and field mice (n = 8) samples at the end of the population study to determine chemical concentrations (Espinoza et al. 2017).

Figure 7-30 Ear tagging a captured field mouse for release in the Sandia Canyon wetland. Researchers wear half-face respirators as a precaution against hantavirus.

The population estimate of small mammals in Sandia wetland was 169 animals in 2016 (Schnabel Index; Schnabel 1938). Cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, zinc, and total PCBs were statistically higher (Mann-Whitney test, $p < 0.05$) in sediment from the Sandia Canyon wetland when compared with sediment from the Fenton Lake wetland. Barium, cadmium, chromium, copper, lead, silver, sodium, zinc, and total PCBs were statistically higher (Mann-Whitney test, $p < 0.05$) in small mammals from Sandia Canyon wetland when compared with small mammals collected from various background locations (Fresquez 2015; Tables S7-28 through S7-31).

Most chemical concentrations, with the exception of zinc, in sediment from the Sandia Canyon wetland were below the no-effect ecological screening level for field mice. The mean concentrations of zinc in sediment (228 mg/kg) were just above the no-effect ecological screening level for the field mouse (170 mg/kg).

Although the amounts of zinc, an essential micronutrient, were higher in both sediment and in field mice from the Sandia Canyon wetland as compared with background, the amount of zinc in sediment was still below the low-effect ecological screening level of 1700 mg/kg. Also, zinc has a relatively low potential for toxicity in mammals, and zinc loadings have been found in species far in excess of immediate needs (Eisler 1993, Batty et al. 1990).

These data indicate that, although some chemicals have accumulated in the Sandia Canyon wetland, the restored wetland provides a highly productive small mammal habitat. This assessment serves as a baseline for future small mammal population studies conducted within the Sandia Canyon wetland.

BIOTA DOSE ASSESSMENT

Introduction

We complete an annual biota dose assessment as required by DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment. The assessment follows the guidance of the DOE standard, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE 2002), and uses the standard DOE dose calculation program RESRAD-BIOTA. As recommended by the DOE standard, background is not subtracted.

Previous biota dose assessments found that the biota doses at the Laboratory are well below the DOE limits of 1 rad/day for terrestrial plants and aquatic animals and 0.1 rad/day for terrestrial animals (DOE 2002). During 2016, there were no events or releases with the potential to significantly increase biota doses, so the previous assessments apply to present conditions. Nevertheless, we conduct updated assessments for the on-site locations where continuing Laboratory operations have the greatest potential for significant increases.

Most material potentially contributing to the biota doses at the Laboratory is legacy waste material. Ongoing remediation and radioactive decay generally result in decreasing trends in radioactivity over time at the Laboratory, so a decreasing trend in biota doses is expected. However, movement of sediment (Chapter 6) may cause an accumulation of radioactive material in areas where sediment is retained. The biota doses at the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure were assessed. Finally, we completed a site-wide assessment of the biota dose from radioactive materials for 2016.

Mesa-Top Facilities

Area G

The Laboratory reported new measurements of soil and vegetation around Area G. The results are generally comparable with previous years.

Area G soil activities vary considerably, so it is difficult to select a representative set of data. As recommended by the DOE standard (DOE 2002), the first assessment is conservative and uses the highest values. These are entered into RESRAD-BIOTA, and the results are reported in Tables 7-1 and 7-2.

Table 7-1
Dose to Terrestrial Animals at Area G for 2016

Nuclide	External Contributions		Internal Contributions		Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Americium-241	1.2E-10	1.2E-06	4.0E-08	9.2E-06	1.0E-05
Tritium	4.1E-05	8.3E-05	8.2E-05	8.2E-05	2.9E-04
Plutonium-238	1.2E-10	4.7E-07	2.4E-07	1.7E-05	1.8E-05
Plutonium-239	1.2E-10	4.8E-07	4.2E-07	2.7E-05	2.8E-05
Uranium-234	6.5E-09	6.5E-07	4.9E-06	1.9E-05	2.4E-05
Uranium-235	6.8E-09	6.8E-07	1.7E-07	6.3E-07	1.5E-06
Uranium-238	4.7E-07	4.7E-05	4.5E-06	1.7E-05	6.9E-05
Total	4.2E-05	1.3E-04	9.2E-05	1.7E-04	**Overall Dose 0.0004**

Note: DOE action level = 0.1 rad/day for terrestrial animals.

Table 7-2
Dose to Terrestrial Plants at Area G for 2016

Nuclide	External Contributions		Internal Contributions	Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Americium-241	1.2E-10	1.2E-06	1.8E-05	1.9E-05
Tritium	4.1E-05	8.3E-05	8.7E-05	2.1E-04
Plutonium-238	1.2E-10	4.7E-07	5.3E-05	5.3E-05
Plutonium-239	1.2E-10	4.8E-07	1.3E-04	1.3E-04
Uranium-234	6.5E-09	6.5E-07	1.9E-05	1.9E-05
Uranium-235	6.8E-09	6.8E-07	6.4E-07	1.3E-06
Uranium-238	4.7E-07	4.7E-05	1.7E-05	6.5E-05
Total	4.2E-05	1.3E-04	3.3E-04	**Overall Dose 0.0005**

Note: DOE action level = 1.0 rad/day for terrestrial plants.

Comparison of soil and biota data provides different perspectives because biota may be affected by underground soil that is inaccessible to humans. For most radionuclides, the doses calculated indirectly from only soil data were slightly higher than doses calculated directly from biota tissue data, showing that the bioaccumulation factors in RESRAD-BIOTA are overestimates. The tritium activities in biota tissue were higher than in soil because plants are exposed to sources with higher underground radioactivities contained in burial shafts. For tritium, biota data were used instead of soil data.

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 water that is produced through their metabolism. They may supplement this water occasionally by drinking from small puddles after rainfall; dose from this additional source of water was calculated using distribution coefficients (K_d) listed in Table 6.5 of the DOE standard (DOE 2002).

As shown in Tables 7-1 and 7-2, the largest dose contribution is from tritium, which is mostly concentrated near locations 29-03 and 30-1 (Figure 7-4). Therefore, the doses reported in Tables 7-1 and 7-2 are conservative overestimates for the entire site.

The results in Table 7-1 show that the biota doses at Area G are well below the DOE limits of 0.1 rad/day for animals, and Table 7-2 shows doses are also below the limit of 1 rad/day for plants. Overall there are no measurable impacts to biota.

Dual-Axis Radiographic Hydrodynamic Test Facility

The Dual-Axis Radiographic Hydrodynamic Test Facility biota dose assessment uses the same conservative methods described in the previous section. The highest doses were calculated from the soil data, indicating that the tissue-to-soil concentration ratios are overestimates. The highest soil activities were entered into RESRAD-BIOTA, and the results are reported in Tables 7-3 and 7-4.

Table 7-3
Dose to Terrestrial Animals at Dual-Axis Radiographic Hydrodynamic Test Facility for 2016

Nuclide	External Contributions		Internal Contributions		Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Americium-241	1.8E-12	1.8E-08	5.9E-10	1.4E-07	1.6E-07
Cesium-137	1.5E-08	1.5E-05	1.9E-09	9.4E-07	1.6E-05
Tritium	5.9E-08	1.2E-07	1.2E-07	1.2E-07	4.1E-07
Plutonium-238	2.0E-12	7.9E-09	4.1E-09	2.9E-07	3.0E-07
Plutonium-239	2.0E-12	8.0E-09	7.0E-09	4.5E-07	4.6E-07
Strontium-90	1.5E-06	8.9E-05	1.2E-05	3.5E-04	4.6E-04
Uranium-234	1.4E-08	1.4E-06	1.0E-05	4.0E-05	5.1E-05
Uranium-235	2.9E-08	2.9E-06	7.3E-07	2.7E-06	6.4E-06
Uranium-238	3.5E-06	3.5E-04	3.3E-05	1.3E-04	5.1E-04
Total	5.1E-06	4.6E-04	5.6E-05	5.2E-04	**Overall Dose 0.001**

Note: DOE action level = 0.1 rad/day for terrestrial animals.

Table 7-4
Dose to Terrestrial Plants at Dual-Axis Radiographic Hydrodynamic Test Facility for 2016

Nuclide	External Contributions		Internal Contributions	Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Americium-241	1.8E-12	1.8E-08	2.6E-07	2.8E-07
Cesium-137	1.5E-08	1.5E-05	9.4E-07	1.6E-05
Tritium	5.9E-08	1.2E-07	1.2E-07	3.0E-07
Plutonium-238	2.0E-12	7.9E-09	8.9E-07	8.9E-07
Plutonium-239	2.0E-12	8.0E-09	2.2E-06	2.2E-06
Strontium-90	1.5E-06	8.9E-05	3.5E-04	4.4E-04
Uranium-234	1.4E-08	1.4E-06	3.9E-05	4.1E-05
Uranium-235	2.9E-08	2.9E-06	2.8E-06	5.7E-06
Uranium-238	3.5E-06	3.5E-04	1.3E-04	4.8E-04
Total	5.1E-06	4.6E-04	5.3E-04	**Overall Dose 0.0009**

Note: DOE action level = 1.0 rad/day for terrestrial plants.

The largest dose contribution is from uranium-238, some of which is a result of Dual-Axis Radiographic Hydrodynamic Test Facility operations. The activities of the other radionuclides are consistent with natural background and global fallout.

Tables 7-3 and 7-4 show that the biota doses from soil at the Dual-Axis Radiographic Hydrodynamic Test Facility are well below the DOE limits of 0.1 rad/day for animals and 1 rad/day for plants.

Sediment-Retention Sites in Canyons

Los Alamos Canyon Weir

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

Animal and plant tissue data were generally consistent with the soil data. For most radionuclides, the doses calculated from the soil data were higher than the tissue doses, showing that the concentration ratios are overestimates. Generally, maximum values were used to calculate a conservative upper limit for the dose. The tritium data were affected by high luminescence and were rejected. However, there are no data, either past or present, that indicate significant tritium concentrations at this location, so the total doses shown in Tables 7-5 and 7-6 are reasonable upper limits.

The highest doses were from naturally occurring uranium. At this location, any contributions from anthropogenic uranium are indistinguishable from the background of naturally occurring uranium.

The total biota doses from soil shown in Table 7-5 (animals) and Table 7-6 (plants) are less than 1% of the DOE limits and are mostly from naturally occurring material.

Table 7-5
Dose to Terrestrial Animals at the Los Alamos Canyon Weir for 2016

Nuclide	External Contributions		Internal Contributions		Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Americium-241	3.0E-10	3.0E-06	1.0E-07	2.3E-05	2.6E-05
Cesium-137	8.0E-08	8.0E-05	5.8E-07	5.2E-06	8.6E-05
Plutonium-238	6.7E-12	2.7E-08	1.4E-08	9.7E-07	1.0E-06
Plutonium-239	5.6E-11	2.2E-07	2.0E-07	1.3E-05	1.3E-05
Strontium-90	2.6E-07	1.6E-05	1.6E-05	6.3E-05	9.6E-05
Uranium-234	1.3E-08	1.3E-06	9.9E-06	3.8E-05	4.9E-05
Uranium-235	1.8E-08	1.8E-06	4.6E-07	1.7E-06	4.0E-06
Uranium-238	9.3E-07	9.3E-05	8.9E-06	3.3E-05	1.4E-04
Total	1.4E-06	2.0E-04	3.7E-05	1.8E-04	**Overall Dose 0.00041**

Note: DOE Action Level: 0.1 rad/day for terrestrial animals.

Table 7-6
Dose to Terrestrial Plants at the Los Alamos Canyon Weir for 2016

Nuclide	External Contributions		Internal Contributions	Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Americium-241	3.0E-10	3.0E-06	4.4E-05	4.7E-05
Cesium-137	8.0E-08	8.0E-05	5.2E-06	8.6E-05
Plutonium-238	6.7E-12	2.7E-08	3.0E-06	3.0E-06
Plutonium-239	5.6E-11	2.2E-07	6.2E-05	6.2E-05
Strontium-90	2.6E-07	1.6E-05	6.3E-05	7.9E-05
Uranium-234	1.3E-08	1.3E-06	3.7E-05	3.9E-05
Uranium-235	1.8E-08	1.8E-06	1.7E-06	3.6E-06
Uranium-238	9.3E-07	9.3E-05	3.4E-05	1.3E-04
Total	1.4E-06	2.0E-04	2.5E-04	**Overall Dose 0.00045**

Note: DOE Action Level: 1 rad/day for terrestrial plants.

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure does not receive significant quantities of LANL-produced radionuclides. The 2016 data confirm that biota doses at this location are almost entirely from naturally occurring material or global fallout. Any contribution from DOE operations is too small to measure and is indistinguishable from background. The total biota dose in Pajarito Canyon is much less than 1% of the DOE limits.

Large Animals

Small animals such as mice have a small home range of <0.247 acres (<0.1 hectares) and may live their whole lives in one area. Large animals such as elk have a large home range, >247 acres (>100 hectares), and spend only a small fraction of their time in any one location. The radiological dose to a small animal is the result of radioactive materials within its small home range, whereas the dose to a large animal is the result of materials over a much larger area. Throughout most of the Laboratory, the activities of radioactive materials are indistinguishable from background, so it would be unusual to detect high activities in a large animal.

Measurements of radioactive materials in large animals are reported in Tables S7-19 (deer), S7-20 (elk), S7-23 (mountain lion), S7-24 (bobcat and gray fox), and S7-25 (owl). In all cases, the activities of radionuclides are indistinguishable from background. The dose is much less than 1% of the DOE limits.

Biota Dose Conclusion

Previous biota dose assessments have shown that the doses are far below the DOE limits. The 2016 data indicate similar results and do not indicate the need for more detailed analysis.

SPECIAL STUDIES AND FUTURE DIRECTIONS

LANL Forest Management Plan and Vegetation Cover Type Map: An Update

In 2014, the Laboratory published a forest management plan (Hansen et al. 2014). The purpose of the forest management plan is to provide guidance to manage the landscape at the Laboratory 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 the Laboratory's overall goals of protecting Laboratory facilities and assets, minimizing off-site sediment transport and achieving water-quality compliance goals, protecting existing plant communities and soil, and minimizing negative impacts of future transitions to new plant communities.

In 2016, we completed an updated land cover map for the Laboratory (Figure 7-31). It was based on satellite imagery acquired in 2014 and used 28 land cover classifications. The land cover map has been made available to interested Laboratory organizations as well as land managers with property adjacent to the Laboratory.

QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

Quality Assurance Program Development

The sampling team collects soil, foodstuffs, and biota 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" (QAPP-0001) and in the following Laboratory procedures:

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program (ENV-ES-TP-003)
- Sampling Soil and Vegetation at Facility Sites (ENV-ES-TP-006)
- Produce Sampling (ENV-ES-TP-004)
- Fish Sampling (ENV-ES-TP-005)
- Game Animal Sampling (ENV-ES-TP-007)
- Collection of Crawfish in the Rio Grande (ENV-ES-TP-008)
- Collection of Benthic Macroinvertebrates in the Rio Grande (ENV-ES-TP-013)

Also, procedures and protocols for biota dose can be found in the "Technical Project Plan for Biota Dose Assessment" (ENV-ES-TPP-002).

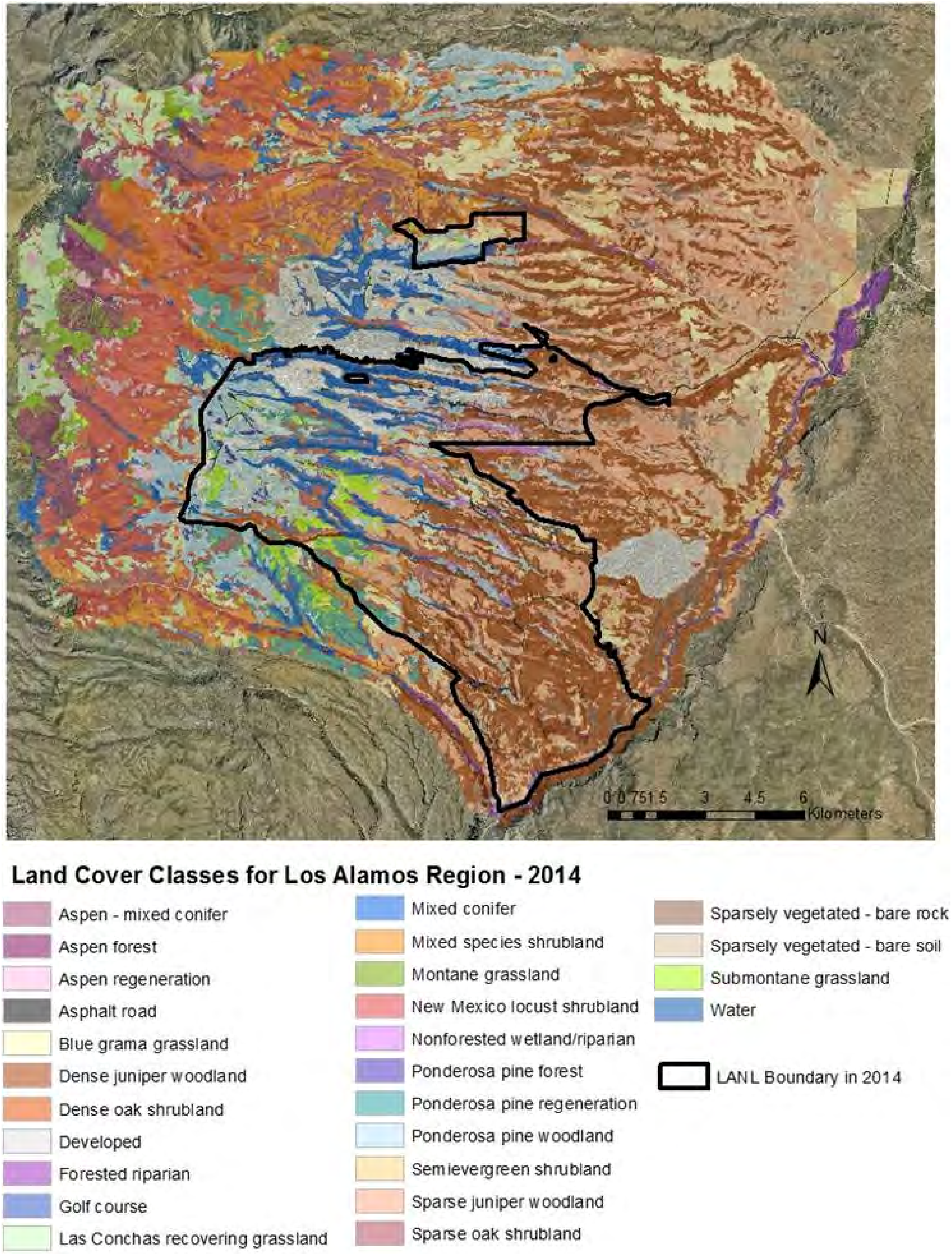


Figure 7-31 Land cover at the Laboratory from 2014 data

These procedures, listed on the Laboratory's public website at http://www.lanl.gov/environment/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.

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 Sample Management Office, which ships the samples via express mail directly to an external analytical laboratory under full chain-of-custody control. Sample Management Office personnel track 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 2016 was 100%.

Analytical Laboratory Quality Assessment

Some of the tritium results for 2016, including those from regional background sites in biota (this chapter) and foodstuffs (Chapter 8), were false positives (n = 29 out of approximately 140 samples = 20%). The ALS Laboratory Group reported very high luminescence in many of these samples, 5%–45%, which is much greater than their control limit of 5%. This high luminescence is likely to cause the sample result to be biased; therefore, all samples that recorded a luminescence greater than 5% were either rejected (n = 11) or reanalyzed (n = 18). The samples that were rejected could not be reanalyzed because the samples had been discarded by the ALS Laboratory Group. The remaining samples and the reanalyzed data were within the luminescence limit.

It is likely that the high luminescence was caused by chemiluminescence, which is the chemical reaction of an organic material when mixed with the liquid scintillation "cocktail." These chemical reactions usually have relatively short half-lives (measured in days) that are much shorter than the half-life of tritium (12 years), so if high luminescence is observed, the recommended procedure is to wait a few weeks between mixing the cocktail and organic material and measuring the mixture in a liquid scintillation counter.

In this case, 18 samples were reanalyzed after several months, at which time the high luminescence was gone. In the future, tritium data should be checked for high luminescence, and if necessary, samples should be reanalyzed after 2 weeks.

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U.S. Department of Energy regulations limit the total annual dose to the public from Los Alamos National Laboratory (the Laboratory) operations to 100 millirem. Furthermore, doses must be as low as reasonably achievable and must not exceed 25 millirem from any one exposure pathway or from the storage of waste. The annual dose received by the public from airborne emissions of radionuclides is limited to 10 millirem by U.S. Environmental Protection Agency regulations.

The objective of this chapter is to use environmental sampling data collected from air, water, soil, and foodstuffs to answer the question, "What are the potential dose and risk to the public from the Laboratory's operations?" The assessments show that during 2016, all doses to the public were far below all regulatory limits and guidance, and the public is well protected. Radiological doses to the public from Laboratory operations are less than 1 millirem per year, and health risks are indistinguishable from zero.

INTRODUCTION

In this chapter, dose and risk from radiological and chemical sources are assessed to ensure the public is protected and to demonstrate compliance with federal regulations and U.S. Department of Energy (DOE) orders. The data reported here and in the previous chapters are considered in the context of public exposure, and standard methods are used to calculate the potential effects. The results are compared with regulatory limits and international standards.

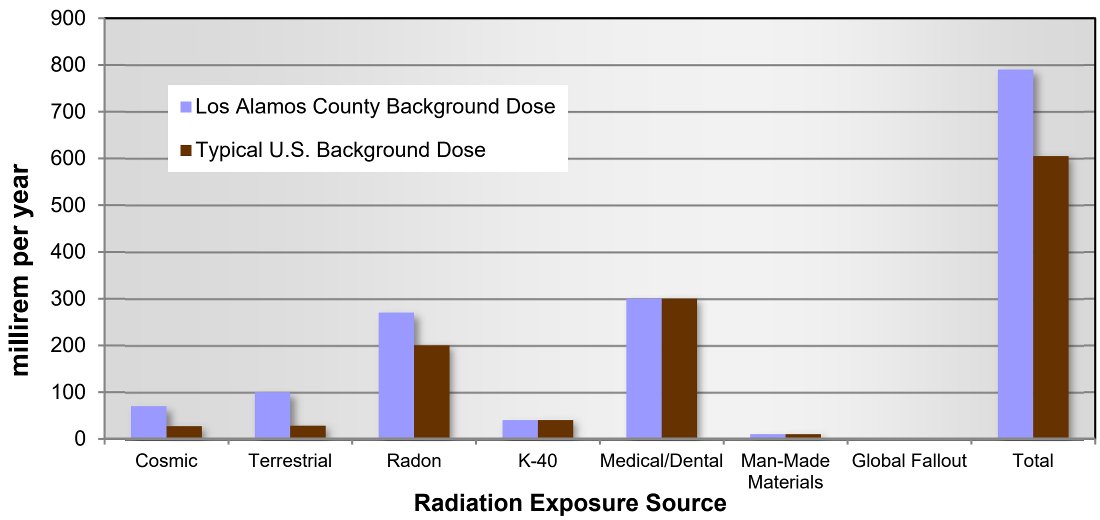
RADIOLOGICAL DOSE ASSESSMENT FOR THE PUBLIC

Overview of Radiological Dose

Radiological dose is the primary measure of harm from radiation. Doses are calculated using the standard methods specified in guidance documents (DOE 1988a, 1988b, 1991, 2011a, 2011b, 2015; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). In this section, we assess doses to the public. Doses to plants and animals are assessed in Chapter 7.

DOE regulations limit the total annual dose to the public from Los Alamos National Laboratory (LANL or the Laboratory) operations to 100 millirem. Furthermore, doses must be as low as reasonably achievable and must not exceed 25 millirem from any one exposure pathway (such as eating food) or from the storage of waste (DOE 1999, 2011a; LANL 2008). The annual dose received by the public from airborne emissions of radionuclides is limited to 10 millirem by U.S. Environmental Protection Agency regulations (EPA 1989). The annual dose from community drinking water supplies is limited by the Safe Drinking Water Act to 4 millirem (EPA 2004).

To place these limits in context, the dose from natural background and medical/dental procedures is about 800 millirem per year (Figure 8-1, Gillis et al. 2014). Doses from Laboratory operations are typically less than 1 millirem per year.



Note: K-40 = Potassium-40.

Figure 8-1 **Average Los Alamos County radiation background dose compared with average U.S. radiation background dose (Gillis et al. 2014)**

Exposure Pathways

Potential doses to the public from radionuclides associated with Laboratory operations are calculated by evaluating all potential exposure pathways. Total dose is the sum of three principal exposure pathways: (1) direct external (photon or neutron) radiation, (2) inhalation of radioactive particles in air, and (3) ingestion of radionuclides in water or food.

Direct Radiation

We monitor direct external radiation from gamma photons and neutrons at 80 locations in and around the Laboratory (see Chapter 4). Direct external radiation from Laboratory sources does not provide a measurable dose more than 1 kilometer from the source. At distances more than 1 kilometer, dispersion, scattering, and absorption reduce the annual dose to much less than 0.1 millirem, which cannot be distinguished from natural background radiation. The only measurable above-background doses from direct radiation originate from Technical Area 53 and Technical Area 54 as reported in Chapter 4.

Inhalation

At distances of more than 1 kilometer from Laboratory sources, any LANL-generated dose is almost entirely from airborne radioactive emissions. Whenever possible, we use airborne radioactivity concentrations measured by the air-sampling network reported in Chapter 4 (the Ambient Air Sampling section) to calculate public doses. Where local levels of airborne radioactivity are too small to measure or cannot be measured by the environmental air-monitoring station methods, 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 dose.

Some of the radionuclide emissions from Technical Area 53 are short-lived and cannot be measured by the environmental air stations. These emissions are measured at the stacks (Chapter 4, the Exhaust Stack Sampling for Radionuclides section), and the resulting estimated doses are calculated with CAP88.

The air-pathway dose assessment is described in detail in an annual air-emissions report (Fuehne 2017) and in Chapter 4.

Ingestion

Ingestion includes drinking water and eating plants and animals. We report measurements from water in Chapters 5 and 6, and measurements from soil, plants, and animals are reported in Chapter 7 and here.

Local drinking water contains no measurable radioactivity 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 "2016 Annual Drinking Water Quality Report" (Los Alamos County 2017).

Local plants and animals are tested regularly and contain no measurable radioactivity. This year, deer and elk meat was tested and also contained no measurable radioactivity.

Dose from Naturally Occurring Radiation

Near Los Alamos, the average annual dose from naturally occurring sources includes cosmic rays, terrestrial radiation, radon, and elements that occur naturally inside the human body such as potassium-40 (Figure 8-1). Additional man-made sources of radiation, including medical/dental uses of radiation and building products such as stone walls, raise the total average annual dose to about 800 millirem (Gillis et al. 2014). Generally, any additional dose of less than 0.1 millirem per year cannot be distinguished from natural background radiation.

Annual doses from cosmic radiation range from 50 millirem at lower elevations near the Rio Grande to about 90 millirem in the higher elevations west of Los Alamos (Bouville and Lowder 1988, Gillis et al. 2014). In addition, annual background doses from external gamma radiation (from terrestrial sources such as the uranium and thorium decay chains) range from about 50 millirem to 150 millirem (DOE 2012).

The inhalation of naturally occurring radon and its decay products constitutes a large proportion of the annual dose for a member of the public. Nationwide, the average annual dose from radon is about 200 millirem to 300 millirem (NCRP 1987). In Los Alamos County, the average residential radon concentration results in an annual dose of about 300 millirem (Whicker 2009a, 2009b).

An additional 30 millirem per year results from naturally occurring radioactive materials in the body, such as potassium-40, which is present in all food and living cells. Members of the U.S. population receive an average annual dose of 300 millirem from medical and dental uses of radiation (NCRP 2009). Another 10 millirem per year comes from man-made products, such as stone or adobe walls.

In total, the average annual dose from sources other than Laboratory operations is about 800 millirem for a typical Los Alamos County resident. Figure 8-1 compares the average radiation background in Los Alamos County with the average background dose in the United States.

Results and Dose Calculations

The objective of this section is to calculate doses to the public from Laboratory operations.

As required by DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, we calculate doses from the Laboratory to the following members of the public:

- The total human population within 80 kilometers (50 miles) of the Laboratory
- The hypothetical "maximally exposed individual"

For the hypothetical maximally exposed individual, the following are considered:

- The air-pathway dose, as required by the Clean Air Act (EPA 1989)
- The on-site dose
- Other locations with measurable dose
- The off-site dose

Dose from Ingestion of Locally Grown Fruit, Vegetables, and Game Animals

During 2016, fruits and vegetables were collected from on-site areas and from gardens located north (Los Alamos townsite), southeast (White Rock/Pajarito Acres), east (Pueblo de San Ildefonso) and south of the Laboratory (Pueblo de Cochiti). Crops from the Pueblo de Cochiti are downstream of the Laboratory and irrigated with Rio Grande water. Produce from these areas were compared with produce from regional locations (>20 miles from the Laboratory). The sampled produce included 10 varieties of fruit as well as green chile, tomatoes, squash, pumpkin, potatoes, kale, and corn. All results were statistically similar with radioactivity levels in regional produce (Table S8-1). The data demonstrate that the dose from eating local or regional fruits and vegetables is well below 0.1 millirem per year.

Goose and chicken eggs were collected locally and regionally in 2016. The results show that there is no significant difference between local and regional eggs (Table S8-2) and that the doses are well below 0.1 millirem per year.

Similarly, goat milk was collected from Los Alamos and compared with goat milk from Santa Cruz, New Mexico, and with the regional statistical reference level. The results demonstrate that there are no significant differences (Table S8-3) and that the dose from drinking goat milk from any local or regional location is well below 0.1 millirem per year.

Road-killed deer and elk were collected from the roads within and adjacent to the Laboratory, and the LANL results were compared with regional data. The results demonstrate that there is no significant difference between local and regional deer and elk (Tables S7-19 and S7-20) and that the dose from consuming deer or elk meat is less than 0.1 millirem per year.

The conclusion is that the ingestion dose is essentially zero.

Collective Dose to the Population within 80 Kilometers

The collective population dose from Laboratory operations is the sum of the doses for each member of the public within an 80-kilometer radius of the Laboratory (DOE 2011a). Outside of Los Alamos County, the doses are too small to measure, so the collective dose was calculated by modeling the transport of radioactive air emissions using CAP88. The doses from the other pathways are even smaller and are either negligible or nonexistent.

The 2016 collective population dose to persons living within 80 kilometers of the Laboratory is 0.10 person-rem (Fuehne 2017). This dose is less than 0.001 millirem per person and is much less than the background doses shown in Figure 8-1.

Tritium contributed 63% of the dose from the Laboratory, and short-lived activation products, such as carbon-11 from the Los Alamos Neutron Science Center, contributed 26%. Collective population doses for recent years are shown in Figure 8-2. The downward trend is the result of improved engineering controls at Los Alamos Neutron Science Center and the tritium facilities.

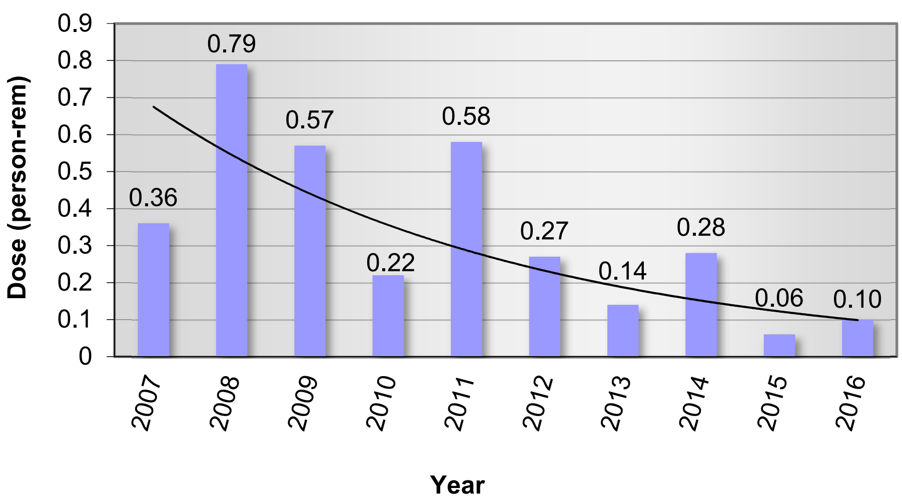


Figure 8-2 **Annual collective dose (person-rem) to the population within 80 kilometers of the Laboratory**

Dose to the Maximally Exposed Individual

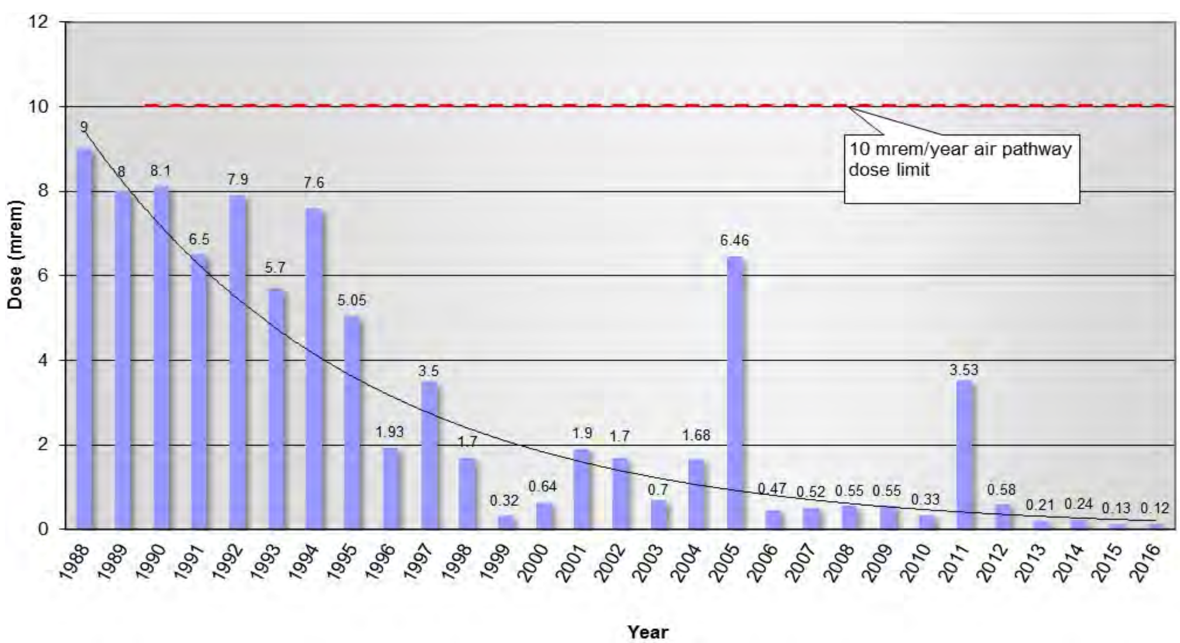
The "maximally exposed individual" is a hypothetical member of the public who receives the greatest possible dose from Laboratory operations (EPA 1989, DOE 2011a). To determine the location where a member of the public would be maximally exposed, we consider all exposure pathways that could cause a dose and all publicly accessible locations, both within the Laboratory boundary (on-site) and outside the boundary (off-site.)

Maximally Exposed Individual Off-Site Dose for 2016

The air-pathway dose calculations are described in an annual air-emissions report (Fuehne 2017). For 2016, the off-site location of the hypothetical maximally exposed individual was at 2470 East Road in the general area known as East Gate, close to environmental air-monitoring stations #157 and #206 (Chapter 4, Figure 4-1). The total off-site dose for a maximally exposed individual during 2016 was 0.12 millirem (Fuehne 2017).

Contributions to this annual dose were from short-lived activation products from the Los Alamos Neutron Science Center stacks (0.05 millirem), diffuse emissions of short-lived activation products from the Los Alamos Neutron Science Center (0.02 millirem), other stack emissions (0.001 millirem), environmental measurements at air-monitoring stations (0.01 millirem), and the potential dose contribution from unmonitored stacks (0.04 millirem) (Fuehne 2017). Doses from ingestion and direct radiation were less than 0.01 millirem.

The calculated off-site doses for the maximally exposed individual each year for recent years are shown in Figure 8-3. As described in previous annual site environmental reports, the 6.46-millirem dose in 2005 resulted from a leak at Technical Area 53, and the 3.53-millirem dose in 2011 was from the remediation of Material Disposal Area B. The general downward trend is the result of improved engineering controls at the Los Alamos Neutron Science Center accelerator.



Note: mrem = Millirem.

Figure 8-3 Annual maximally exposed individual off-site dose

Maximally Exposed Individual On-Site Dose for 2016

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 Technical Area 53. As reported in Chapter 4 (the Gamma and Neutron Radiation Monitoring section), at this location during 2016 the neutron dose was 0.5 millirem, and the gamma dose was 0.1 millirem, for a total of 0.6 millirem. The contribution from stack emissions was less than 0.01 millirem. These are the doses that would be received by a hypothetical individual at this location 24 hours per day and 365 days per year. However, members of the public, such as joggers, bus drivers, or cyclists, spend less than 1% of their time at this location, so the on-site dose for a maximally exposed individual is less than 1% of 0.6 millirem, which is much less than the off-site dose for a maximally exposed individual described in the previous section.

Other Locations with Measurable Dose

As reported in Chapter 4, neutron dose was measured in Cañada del Buey, north of Technical Area 54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, emits neutrons. After subtracting background, the measured neutron dose in Cañada del Buey during 2016 was 1.8 millirem. After applying the standard factor of 1/20 for occasional occupancy (NCRP 2005), the individual neutron dose during 2016 was 1.8/20 ≈ 0.09 millirem.

The contribution from Laboratory stack emissions was less than 0.001 millirem. Within the boundaries of Area G, the average air concentration of transuranic material was 2 attocuries per cubic meter (Chapter 4, Tables 4-3 and 4-4), so using the dose conversion factors from DOE Standard 1196 (DOE 2011b), and assuming 1/20 occupancy, the annual dose both within and near Area G was much less than 0.001 millirem. Thus, during 2016, the total dose in Cañada del Buey was 0.09 millirem.

Maximally Exposed Individual Summary

At the off-site location for the maximally exposed individual (i.e., East Gate), the direct-radiation and ingestion doses are essentially zero, so the largest all-pathway dose for 2016 was the same as the air-pathway dose of 0.12 millirem.

The dose of 0.12 millirem in 2016 is far below the 10-millirem annual limit (EPA 1989) and the 100-millirem DOE limit (DOE 2011a). The dose for the maximally exposed individual is less than 0.1% of the average U.S. background radiation dose shown in Figure 8-1.

Conclusion

The doses to the public from Laboratory operations are summarized in Table 8-1. Doses are far below all regulations and standards and do not cause measurable health effects.

Table 8-1
LANL Radiological Doses for Calendar Year 2016

Pathway	Dose to Maximally Exposed Individual (millirem/year)	Percentage of DOE 100-millirem/year Limit	Estimated Population Dose (person-rem)	Population within 80 kilometers	Estimated Background Radiation Population Dose (person-rem)
Air	0.12	0.12%	0.10	n/a[a]	n/a
Water	<0.1	<0.1%	0	n/a	n/a
Other pathways (foodstuffs, soil, etc.)	<0.1	<0.1%	0	n/a	n/a
All pathways	0.12	0.12%	0.10	~343,000	~268,000[b]

[a] n/a = Not applicable.

[b] Based on 780 millirem per person as shown in Figure 8-1.

NONRADIOLOGICAL MATERIALS

Introduction

This section summarizes the potential human health risk from nonradiological materials released from the Laboratory in 2016. Air emissions are reported in Chapters 2 and 4; groundwater is reported in Chapter 5; surface water and sediment are reported in Chapters 6; and soil, plants, and animals are reported in Chapter 7. The results are summarized below.

Results Summary

Air

The data reported in Chapters 2 and 4 show that the air quality is good and well below all applicable standards. The Laboratory's emissions are below the amounts allowed in LANL's Title V Operating Permit. There are no measurable health effects to the public from Laboratory air emissions.

Groundwater

Groundwater data are reported in Chapter 5.

We analyzed samples from Los Alamos County water supply wells in 2016. No water supply wells showed detections of Laboratory-related constituents above an applicable drinking water standard, and the drinking water supply meets New Mexico Environment Department and U.S. Environmental Protection Agency drinking water standards (Los Alamos County 2017).

Additional water sampling was conducted in the City of Santa Fe's Buckman well field. No Laboratory-related constituents were present above standards in this drinking water supply.

Within Laboratory boundaries, hexavalent chromium from the Laboratory has been detected above the New Mexico groundwater standard (50 micrograms per liter) in Mortandad Canyon regional aquifer monitoring wells. As described in Chapter 5, the

Laboratory has begun work on interim measures to control migration of this chromium plume.

Surface Water and Sediment

The concentrations of chemicals in surface water and sediment for 2016 are reported in Chapter 6. The sediment data verify the conceptual model that deposition of sediment in repeated flood events results in lower concentrations in newer sediment deposits compared with previous deposits. Further data show that the assessments in the canyons investigation reports (see Chapter 6) represent an upper bound of potential risks. Human exposure scenarios were discussed in the investigation reports. The conclusions in the investigation reports, that there were no human health risks, remain accurate because the concentrations decrease with time.

In Chapter 6, we compare unfiltered storm water concentrations with drinking water standards as screening levels, though storm water is not a drinking water source and there is thus no significant pathway to human exposure. The plant and animal measurements reported in Chapter 7 confirm that there is not significant uptake into the food chain.

Polychlorinated biphenyls (PCBs) are discussed in Chapter 6. Because of the limited number of aquatic organisms on the Pajarito Plateau, the amount of PCBs entering the food chain is small.

We conclude there is no risk to the public from exposure to surface water and sediment as a result of either current or legacy Laboratory releases.

Produce

The concentrations of 23 inorganic elements from five produce plants each from on-site and perimeter areas (Los Alamos townsite, White Rock, Pueblo de Cochiti, and Pueblo de San Ildefonso) show no statistical differences with regional produce (Table S8-4).

Soil, Plants, and Animals

Soil and biota sampling results are reported in Chapter 7. The results are similar to previous years. During 2016 and at off-site locations, chemical concentrations above human-health-based screening criteria were not detected.

Conclusion

The environmental data collected in 2016 show that at present there is no measurable risk to the public from materials released from the Laboratory. In all cases, the public doses and risks from Los Alamos National Laboratory operations are much smaller than the regulatory limits and the naturally occurring background levels.

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GENERAL FORMATION OF A STANDARD OR SCREENING LEVEL

An environmental standard is a value, generally defined by a regulator such as the U.S. Environmental Protection Agency, that specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water. A screening level is a value, which may be calculated by a regulator or by another party, that when exceeded in a sample result, indicates the sampled location may warrant further investigation or site cleanup. Standards and screening levels are crafted to protect a target group from chemical exposure when considering a given exposure pathway or scenario for a specific time frame. A target group may refer to the general public, animals, or a sensitive population like children. Pathways of exposure include inhalation of air and ingestion of water, soil, animals, or plants. Length of exposure is important because prolonged exposure to low levels of a potentially hazardous chemical may have adverse health effects, as may a short exposure to high levels. Scenarios describe the activities of people at the site, which influence both the length and likelihood of exposures. Examples of exposure scenarios include residential (living on a site) and construction worker (disturbing soil during construction activities at a site).

Throughout this report, levels of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. For environmental samples that do not have standards or guidelines, levels are compared with screening levels.

RADIATION STANDARDS

The U.S. Department of Energy (DOE) limits the radiation dose that can be received by members of the public as a result of normal operations at Los Alamos National Laboratory (LANL or the Laboratory).

In 2011, DOE issued Order 458.1, which describes the current radiation protection standards for the public, now referred to as public dose limits; limits are listed in Table A-1. DOE's public dose limits apply to the effective dose that a member of the public can receive from DOE operations. For all exposure pathways combined, the total limit is 100 millirem per year (mrem/yr).

Table A-1
DOE Dose Limits
for External and Internal Exposures

Exposure Pathway	Dose Equivalent at Point of Maximum Probable Exposure
Exposure of Any Member of the Public	
All pathways	100 mrem/yr
Air pathway only*	10 mrem/yr
Drinking water	4 mrem/yr

* This level is from the U.S. Environmental Protection Agency's regulations issued under the Clean Air Act (40 Code of Federal Regulations 61, Subpart H).

Radionuclide activities in water are compared with DOE's derived concentration guides to evaluate potential impacts to members of the public. The derived concentration guides for water are those concentrations in water that if consumed at a rate of 730 liters per year, would give a dose of 100 mrem/yr.

Table A-2 shows the derived concentration guides. For comparison with drinking water systems, the derived concentration guides are multiplied by 0.04 to correspond with the U.S. Environmental Protection Agency limit of 4 mrem/yr.

Table A-2
DOE's Derived Concentration Guides for Water[a]

Nuclide	Derived Concentration Guides for Water Ingestion in Uncontrolled Areas (pCi/L[b])	Derived Concentration Guides for Drinking Water Systems[c] (pCi/L)
Hydrogen-3	2,000,000	80,000
Beium-7	1,000,000	40,000
Strontium-89	20,000	800
Strontium-90	1000	40
Cesium-137	3000	120
Uranium-234	500	20
Uranium-235	600	24
Uranium-238	600	24
Plutonium-238	40	1.6
Plutonium-239	30	1.2
Plutonium-240	30	1.2
Americium-241	30	1.2

[a] Derived concentration guides for uncontrolled areas are based on DOE's public dose limit for the general public. Derived concentration guides apply to concentrations in excess of those occurring naturally or from worldwide fallout.

[b] pCi/L = Picocuries per liter.

[c] Drinking water derived concentration guides are 4% of the derived concentration guides for nondrinking water.

In addition to DOE standards, in 1985 and 1989, the U.S. Environmental Protection Agency established the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 Code of Federal Regulations 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). 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 U.S. Environmental Protection Agency and adopted by the New Mexico Environment Department as part of the New Mexico Drinking Water Regulations. To view the New Mexico Drinking Water Regulations, go to http://164.64.110.239/nmac/parts/title20/20.007.0010.pdf.

Radioactivity in drinking water is regulated by U.S. Environmental Protection Agency regulations contained in 40 Code of Federal Regulations 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, U.S. Environmental Protection Agency drinking water standards are limited to activities 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. Derived concentration guides for drinking water systems based on this requirement are in Table A-2.

SURFACE WATER STANDARDS

Activities of radionuclides in surface water samples may be compared with either the DOE derived concentration guides (Table A-2) or the New Mexico Water Quality Control Commission stream standards, which reference the state's radiation protection regulations. The concentrations of nonradioactive constituents may be compared with the New Mexico Water Quality Control Commission livestock watering and wildlife habitat stream standards, available at http://164.64.110.239/nmac/parts/title20/20.006.0004.htm. The New Mexico Water Quality Control Commission groundwater standards can also be applied in cases where discharges may affect groundwater.

SOILS

If chemical or radionuclide levels in soil exceed regional statistical reference levels (regional background levels), the levels are compared with screening levels. The human health screening level for soil is the level that would produce (1) a dose of 15 mrem or greater to an individual for radionuclides, (2) an estimated excess cancer risk of 1×10^{-5} for cancer-causing chemicals, or (3) a hazard quotient greater than 1 for non-cancer-causing but hazardous chemicals. The screening levels are different for different exposure scenarios. Screening levels for radionuclides are found in a Laboratory document (LANL 2015a); screening levels for nonradionuclides are found in a New Mexico Environment Department document (NMED 2015).

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 levels in foodstuffs exceed regional statistical reference levels, they are compared with screening levels and existing standards. The Laboratory has established a screening level of 1 mrem/yr for activities of individual radionuclides in individual foodstuffs (e.g., fish, crops, etc.), assuming a residential scenario. The U.S. Environmental Protection Agency has established screening levels for mercury (EPA 2001) and PCBs (EPA 2007) in fish.

BIOTA

If radionuclide or chemical levels in biota exceed regional statistical reference levels, the levels are compared with screening levels. For radionuclides in biota, screening levels were set at 10% of the DOE standard (which is 1 rad/day for terrestrial plants and aquatic biota and 0.1 rad/day for terrestrial animals) by the Laboratory (DOE 2002). For chemicals, if a chemical in biota tissue exceeds the regional statistical reference level, (1) detected concentrations are compared with lowest observed adverse effect levels reported in published literature, if there is one available, and (2) chemical concentrations in the soil at the place of collection are compared with ecological screening levels (LANL 2015b).

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Throughout this report, the U.S. customary (English) system of measurement has generally been used because U.S. customary units 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, roentgen, rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent units from the International System of Units are the becquerel, coulomb per kilogram, gray, and sievert, respectively. Table B-1 presents factors for converting U.S. customary units into units from the International System of Units.

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

Multiply U.S. Customary Unit	by	to Obtain International System of Units (Metric) Unit
degrees Fahrenheit	5/9 (first subtract 32)	degrees Celsius
inches	2.54	centimeters
cubic feet	0.028	cubic meters
acres	0.4047	hectares
ounces	28.3	grams
pounds	0.453	kilograms
miles	1.61	kilometers
gallons	3.785	liters
feet	0.305	meters
parts per million	1	micrograms per gram
parts per million	1	milligrams per liter
square miles	2.59	square kilometers
picocuries	37	millibecquerel
rad	0.01	gray
millirem	0.01	millisievert

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-2
Prefixes Used with International System of Units (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

DATA HANDLING OF RADIOCHEMICAL SAMPLES

Measurements of radioactivity in 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, and results for individual measurements can be negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the ambient air monitoring network 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 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).

Locations of the technical areas operated by Los Alamos National Laboratory (the Laboratory) 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
00 (off-site facilities)	The Technical Area 00 designation is assigned to structures leased by the U.S. Department of Energy that are located outside the Laboratory's boundaries in the Los Alamos townsite and White Rock.
02 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-megawatt nuclear research reactor, was located at Technical Area 02. The reactor was decontaminated and decommissioned in 2002. It is now the location of the Omega West Monument and interpretive panels. The monument commemorates the historic reactors and other historical events that took place at Technical Area 02.
03 (Core Area or South Mesa Site)	Technical Area 03 is the Laboratory's core scientific and administrative area, with approximately half of the Laboratory's employees and total floor space. It is the location of a number of the Laboratory'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.
05 (Beta Site)	Technical Area 05 is located between East Jemez Road and the Pueblo de San Ildefonso, it contains physical support facilities and an electrical substation. It is also the site of the Associate Directorate for Environmental Management's interim measure to control chromium plume migration in the regional aquifer.
06 (Twomile Mesa Site)	Technical Area 06, located in the northwestern part of the Laboratory, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, and aging vacant buildings that are awaiting demolition.
08 (GT Site [Anchor Site West])	Technical Area 08, located along West Jemez Road, is a testing site where nondestructive dynamic testing techniques are used to ensure 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.
09 (Anchor Site East)	Technical Area 09 is located on the western edge of the Laboratory. Fabrication feasibility and the physical properties of explosives are explored at this technical area, and new organic compounds are investigated for possible use as explosives.
11 (K-Site)	Technical Area 11 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.
14 (Q-Site)	Technical Area 14, located in the northwestern part of the Laboratory, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high-explosives machining, and permitted burning.
15 (R-Site)	Technical Area 15, located in the central portion of the Laboratory, is used for high-explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. Technical Area 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.
16 (S-Site)	Technical Area 16, in the western part of the Laboratory, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. Technical Area 16 is also the location of high-explosives research, development, and testing; the High Explosives Wastewater Treatment Facility; the Tactical Training Facility; and the Indoor Firing Range.
18 (Pajarito Site)	Technical Area 18, located in Pajarito Canyon, was the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. All operations at Technical Area 18 have ceased, and the facility was downgraded to a less-than-Hazard Category 3 nuclear facility. All Security Category I and II materials and activities have been relocated to the Nevada National Security Site.
21 (DP Site)	Technical Area 21 is on the northern border of the Laboratory, next to the Los Alamos townsite. The former radioactive materials (including plutonium) processing facility was located in the western part of Technical Area 21. The Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility were located in the eastern part. Operations from these facilities have been transferred and demolition was completed in 2010.

Technical Area	Activities
22 (TD Site)	Technical Area 22, located in the northwestern portion of the Laboratory, houses the Detonator Production Facility. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
28 (Magazine Area A)	Technical Area 28, located near the southern edge of the Laboratory, was an explosives storage area. Technical Area 28 contains five empty storage magazines that are being decontaminated and decommissioned.
33 (HP Site)	Technical Area 33 is a remotely located technical area at the southeastern boundary of the Laboratory. Technical Area 33 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 technical area.
35 (Ten Site)	Technical Area 35, located in the north-central portion of the Laboratory, 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 Technical Area 35, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at Technical Area 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 Technical Area 35.
36 (Kappa Site)	Technical Area 36, a remotely located area in the eastern portion of the Laboratory, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
37 (Magazine Area C)	Technical Area 37 is used as an explosives storage area. It is located along the eastern perimeter of Technical Area 16.
39 (Ancho Canyon Site)	Technical Area 39 is located at the bottom of Ancho Canyon. Technical Area 39 is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
40 (DF Site)	Technical Area 40, centrally located within the Laboratory, is used for general testing of explosives or other materials and development of special detonators for initiating high-explosives systems.
41 (W-Site)	Technical Area 41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.
43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	Technical Area 43 is adjacent to the Los Alamos Medical Center at the northern border of the Laboratory and is the location of the Bioscience Facilities (formerly called the Health Research Laboratory). The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at the Laboratory. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.
46 (WA Site)	Technical Area 46, located between Pajarito Road and the Pueblo de San Ildefonso, is one of the Laboratory'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 technical area.
48 (Radiochemistry Site)	Technical Area 48, located in the north-central portion of the Laboratory, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
49 (Frijoles Mesa Site)	Technical Area 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. The Interagency Wildfire Center and helipad located near the entrance to the technical area are operated by the National Park Service.
50 (Waste Management Site)	Technical Area 50, located near the center of the Laboratory, 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 technical area.
51 (Environmental Research Site)	Technical Area 51, located on Pajarito Road in the eastern portion of the Laboratory, 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 technical area.
52 (Reactor Development Site)	Technical Area 52 is located in the north-central portion of the Laboratory. 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 technical area.

Technical Area	Activities
53 (Los Alamos Neutron Science Center)	Technical Area 53, located in the northern portion of the Laboratory, includes the Los Alamos Neutron Science Center. This facility 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 contribute to defense programs. The facility also irradiates targets for medical isotope production.
54 (Waste Disposal Site)	Technical Area 54, located on the eastern border of the Laboratory, is one of the largest technical areas at the Laboratory. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage, treatment, and decontamination.
55 (Plutonium Facility Complex Site)	Technical Area 55, located in the center of the Laboratory along Pajarito Road, 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. Construction of the Radiological Laboratory/Utility/Office Building was completed in 2012. Radiological operations began in 2014. Construction of the Chemistry and Metallurgy Research Building Nuclear Facility (formerly the Chemistry and Metallurgy Research Building Replacement) was cancelled in 2014.
57 (Fenton Hill Site)	Technical Area 57 is located about 20 miles (32 kilometers) west of the Laboratory on land administered by the U.S. Forest Service. The site has been used by the Laboratory since 1974, subject to an interagency agreement between the U.S. Department of Energy and the U.S. Forest Service. The site was originally developed for the Hot Dry Rock geothermal energy program, which was terminated in 1995, and subsequently used for astronomical studies. In 2012, the Laboratory demolished and removed several small structures, trailers, equipment pads, and equipment and implemented site stabilization. Some astronomy activities may continue.
58 (Twomile North Site)	Technical Area 58, located near the Laboratory's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to Technical Area 03. The technical area houses the protective force running track, a few Laboratory-owned storage trailers, and a temporary storage area.
59 (Occupational Health Site)	Technical Area 59 is located on the south side of Pajarito Road adjacent to Technical Area 03. Technical Area 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 Technical Area 59 includes a clinical laboratory and provides bioassay sample analytical support.
60 (Sigma Mesa)	Technical Area 60 is located southeast of Technical Area 03. The technical area is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located at Technical Area 60. This facility is now being used as an unmanned aerial systems user facility.
61 (East Jemez Site)	Technical Area 61, located in the northern portion of the Laboratory, contains physical support and infrastructure facilities, including a sanitary landfill operated by Los Alamos County, the photovoltaic array, and sewer pump stations.
62 (Northwest Site)	Technical Area 62, located next to Technical Area 03 and West Jemez Road in the northwest corner of the Laboratory, serves as a forested buffer zone. This technical area is reserved for future use.
63 (Pajarito Service Area)	Technical Area 63, located in the north-central portion of the Laboratory, contains physical support and infrastructure facilities and is the location of the new Transuranic Waste Facility.
64 (Central Guard Site)	Technical Area 64 is located in the north-central portion of the Laboratory and provides offices and storage space.
66 (Central Technical Support Site)	Technical Area 66 is located on the southeast side of Pajarito Road in the center of the Laboratory. The Advanced Technology Assessment Center, the only facility at this technical area, provides office and technical space for technology transfer and other industrial partnership activities.
67 (Pajarito Mesa Site)	Technical Area 67 is a forested buffer zone located in the north-central portion of the Laboratory. No operations or facilities are currently located at the technical area.
68 (Water Canyon Site)	Technical Area 68, located in the southern portion of the Laboratory, is a testing area for dynamic experiments and also contains environmental study areas.
69 (Anchor North Site)	Technical Area 69, located in the northwestern corner of the Laboratory, serves as a forested buffer zone. The Emergency Operations Center is located here.
70 (Rio Grande Site)	Technical Area 70 is located on the southeastern boundary of the Laboratory. It is an undeveloped technical area that serves as a buffer zone.

Technical Area	Activities
71 (Southeast Site)	Technical Area 71 is located on the southeastern boundary of the Laboratory and is adjacent to White Rock to the northeast. It is an undeveloped technical area that serves as a buffer zone for the High Explosives Test Area.
72 (East Entry Site)	Technical Area 72, located along East Jemez Road on the northeastern boundary of the Laboratory, is used by protective force personnel for required firearms training and practice purposes.
73 (Airport Site)	Technical Area 73 is located along the northern boundary of the Laboratory, adjacent to NM 502. Los Alamos County manages, operates, and maintains the community airport under a leasing arrangement with the U.S. Department of Energy. Use of the airport by private individuals is permitted with special restrictions.
74 (Otowi Tract)	Technical Area 74 is a forested area in the northeastern corner of the Laboratory. A large portion of this technical area 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 the Laboratory.

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/environment/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 Environmental Management Los Alamos Field Office website	https://energy.gov/em-la/environmental-management-los-alamos-field-office
U.S. Department of Energy website	http://www.energy.gov/
The Laboratory's air quality pages	http://www.lanl.gov/environment/protection/monitoring/air-quality.php
The Laboratory's water quality pages	http://www.lanl.gov/environment/protection/monitoring/water-quality.php
The Laboratory's environmental stewardship pages	http://www.lanl.gov/environment/index.php
The Laboratory's environmental database	http://www.intellusnmdata.com/

Visitors at the Pond Cabin on Los Alamos National Laboratory property

The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

Associate Directorate for Environment, Safety, and Health
Environmental Protection and Compliance Division
Environmental Stewardship Group, Environmental Compliance Programs Group, Waste Management Programs Group, and Waste Management Services Group
Associate Directorate for Environmental Management
Environmental Remediation Program

Previous reports in this series are LA-UR-16-26788, LA-UR-15-27513, 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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